PERMACULTURE TECHNIQUES

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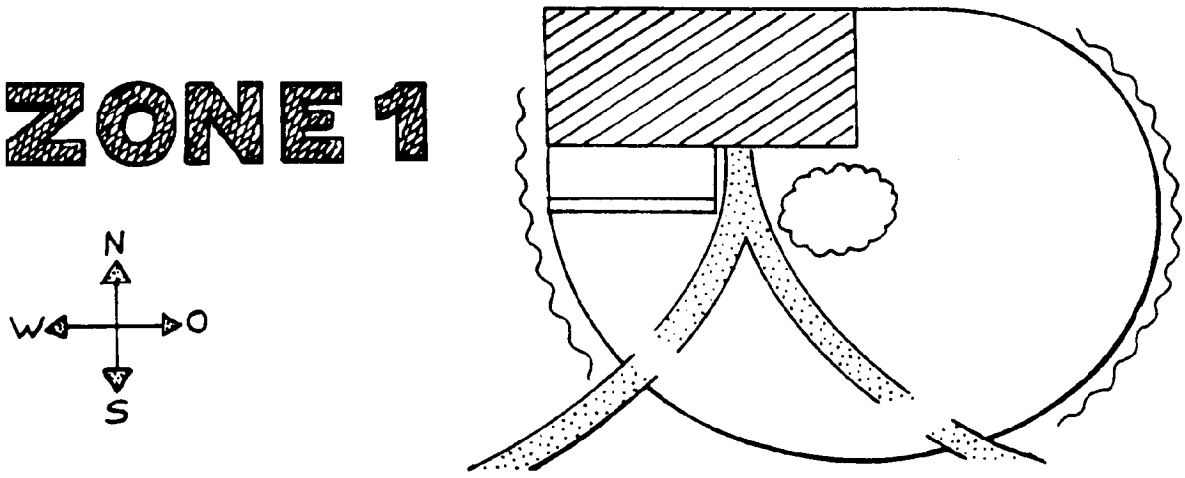
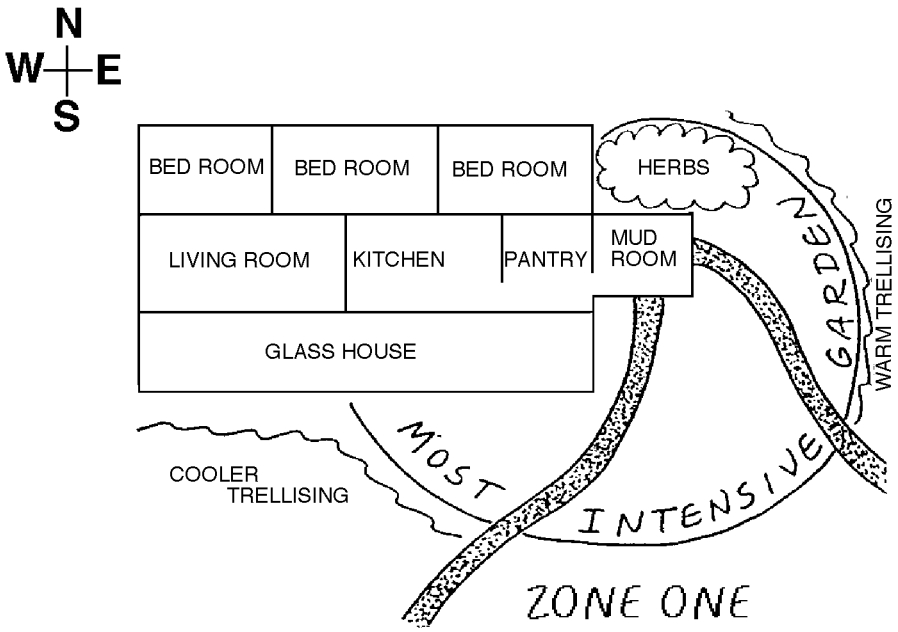


PLANNING IN ZONE ONE



You are very likely to do more zone one planning than anything else. If your architects are half way capable, and often they are not, what you have is a set up something like this.

You have mud room, pantry, kitchen, living room, bed, bed, bed--or bed, bed, bed upstairs, each with an *en suite* toilet, of course!

The set-up of the house has to be like this for the functions to follow the zone. You can't depart very much from it. You can play around with ins and outs, jog it in, extend it out, screen it, trellis it; but, basically, your set-up is like that. It is the only efficient set-up. Yet, you are very likely to find kitchens on the north side, living rooms on the north side, and beds on the south, where you can't sleep at night because of the heat.

But let's assume we've had some say in the layout here, and often we do.

In that case, the most intensive garden section is around the garden entries. In there, place a little herb spiral, and then a great mass of parsley. You can't have too much parsley. Chives also go here. They are your two critical herbs. Garlic is a crop that you pull at the end of the summer, and it can go in just everywhere that nothing else fits. If you have a hole, put in a clove of garlic, and that's it. Then plot the common herbs--there are only three or four of them. They are tarragon, thyme, rosemary and sage. That's it. Add a couple of pots of mint. Dill does well here and there throughout the garden. If you only gather the seed, it doesn't have to be close to the door.

There are three or four sorts of chives, the Chinese chives, the ordinary chives with the little purple top, and the fine-leaf blue ones. They are all worth planting. They have slightly different yields in time.

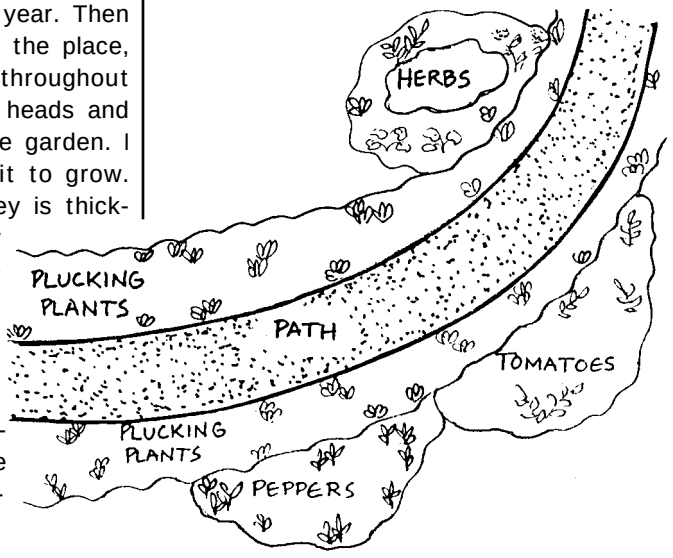
As for parsley, what I do is start a bed of it going, and let that go to seed. I start a bed the following year. Then I pepper the heads all over the place, so that I get parsley throughout everything. I just take the heads and shake them out all over the garden. I throw it out where I want it to grow. I use it as mulch. So parsley is thickish. Once you get parsley thick, you never have to worry about it again. You always get parsley thick where you had a parsley bed.

Our winter is not as severe as yours. What we have been doing successfully is to put out our bell peppers in pots -- at least six or eight of them. Prune them in the fall and bring them in over the winter, and put them out again in the spring. You will have big, strong plants. We have had them going five years.

You will have worked out pathways out of this system, where you come from parking, paths to the barn, wherever you come and go. Take a section of this tract, and start to zone your plants along that track. Then start putting your beds in. Afterward, this will get messy in the ideal Permaculture garden. You can start putting crops in rows in there, rows of lettuce, rows of cabbage, your plucking herbs, the plants you are continually pulling from, that are long standing. They may include celery, a minor quantity of tomatoes, New Zealand spinach, broccoli, zucchini and patty-pan squash. Typically, you have a path with some chives or celery. Put celery here, too. Scatter chard along there, because it stands a long time. Peppers and tomatoes go further along. Radishes are a catch crop everywhere. Everything has radishes planted with it.

I don't think it is worth growing anything but trellising peas and beans.

Now your common root crops go further out, except, occasionally, things like beets from which you take some greens. Then comes the main crop, which will include the winter keeping squashes, corn, some carrots, main crop onions, parsnips, long



term cabbages. I always put a nasturtium in here and there. The leaves are tasty in salad.

By summer, the Jerusalem artichoke is really up and out of the ground, forming a quick barrier hedge. Within the garden, you will have a few oddities scattered here and there. Cucumbers are part of the trellising system, and probably need to be on the hot side. There will be other things that can go on the cool side, like those scarlet runner beans. They are just about the best beans in the world.

You can establish conditions for a particular plant, or plants, and you keep that plant going in this spot year after year.

If you are dealing with a really small garden, it will pay you to set up a straw-box of potatoes, which is permanent. Board up an area something like eight feet by five feet. Throw some straw or seaweed into it. Set your potatoes 9" x 9". Scatter a bit of ashes on, then fill up the box with straw, and let your client just pick potatoes from the straw. Some will grow green on top. Just push them down underneath. Keep the whole thing ticking all the time. No soil, no bottom. Poles make a very good frame. The bark rots off and adds nutrient. Never use much sawdust, unless it is quite scattered. It tends to cut off all the air. If you put in much leaf material, it mats, and you get an anaerobic condition. Use the same straw-box every year for your potatoes. We have had potatoes growing for 12 years in straw boxes. Some of the people I know, for as long as I can remember, have had their straw beds of potatoes. It doesn't matter if it is on concrete.

Near that, you grow a couple of comfrey plants, because for later plantings you should always include a comfrey leaf. Pick a comfrey leaf, put your potato in it, wrap it up, put it under the straw, and that is your potash and nutrients. Another thing you grow near the potato box is a little pot of mint to cook with your potato. As you are picking your potato, you pick your mint. Grow it in a pot to keep it from spreading.

The base of your straw box is a good environment for horseradish, which is a good companion plant for potatoes. You can make a special place for your horseradish. Get four old broken earthenware pots and sink them in the ground, leaving them out a little bit at the top. Every year, you refill these with good Earth and stick your horseradish root in it. Otherwise, you can't dig your horseradish. It grows straight, is easy to break, and very easy to lift.

Now let me tell you about composting as against mulch. Every time you compost, you decrease the nutrients, sometimes to one 20th of the original. Usually, though, you get about a 12th of the nutrient out of compost that you get out of mulch. So what have you done by composting? You have worked hard to decrease the nutrients badly. Most of them go into the air. Composting consumes them. We want to get right out of composting. We want to get back into sheet mulching. In composting, you are taking a lot of material, putting it into a small place, and letting the whole of the decomposition activity happen under hot conditions which can be appropriate for some things. When you mulch, you are spreading those materials and letting the process occur much more slowly on the surface of the soil. Any leach loss goes into the soil, and the general level of activity spreads across the whole of it. By the time the mulch has reduced to compost, most of the action has finished. If you want to get maximum value out of what you have, sheet mulch it. If you want to increase your nutrient base, do it efficiently.

There are some items that are good to compost, but you need a very, very small amount of compost, maybe a cubic yard, a four cubic foot box. That's for a king size gardener. For an average household, they need one of those drums. Just strew a little bit of compost on the seed bed, a little bit in seed trays, a little bit in your glass house. That is all you need. Most compost that you eventually get comes off your box of mulch. It incorporates into the Earth's surface.

Nearly everything we measure in compost is less that what we measure in the soil after sheet mulching. What you tend to have is a hyper-rich area around your compost heap, but you do not have that on your garden when you apply compost.

The best thing to do with mulch is to put it somewhere dry until you need it. If you are piling up leaves, pile them up underneath pine trees. They stay dry there, undecomposed. I mulch up to two-inch thick branches. Just lay them between the peas and the mulch. I use all the large bark sheets off trees. This creates a thick mulched area where you are going to put in plants. You can't put small seeds in a thick mulch.

Kitchen wastes can go directly to the garden. Just pick up a handful of mulch, scatter the garbage around a bit and put the mulch back. In winter, I freeze kitchen wastes into blocks. You can take a lot of tea leaves out and put it on the mulch and go back the next morning and they will have disappeared. It is the same with banana peels. I just take fat out and pour it on the ground.

Deal with weeds the same as with kitchen wastes. They lift out easily, even docks. I reverse them so their roots are in the air. Lift up the straw and drop it back on the top of the weed. I let those weeds grow big, too. They're good.

If you dig this material into your soil, you'll rob the soil of nitrogen. If you mulch with it, you will never see nitrogen deficiency. Your mulch is permeated with 70% nitrogen. Everything that wants nitrogen takes it right out of the air. The soils with this acid rain are getting nitric acids falling on them.

Worm manure, which is the highest tonnage per acre, is the best manure. Again, that's a good reason for not composting. Instead of the material burning down in the composting bin, the worms are eating it all over the surface, and you have a lot of worm manure. It takes three days, probably, in most gardens for worm cast to completely cover the layer of saw-

dust. You are getting high nitrogen, high potash, high phosphate. Worm castings test alkaline, which might be of interest to you, so that your mulch stratification after two or three years may go from a pH 6 to pH 3, if you are using some pine needles. What you have is a stratification of pH. If somebody says, "What pH have you got?", you say, "Everything." You will find plants putting out feeder roots at completely different levels, and you will find high alkaline and high acid plants side by side.

You have mussels in your creek. You can scatter the shells under your mulch and slowly they will all disappear. It takes three years. They just disappear on demand. I mulch oyster shells, scallop shells, pine needles, seaweed, hay, straw. We mulch some tin cans, particularly around our citrus.

Algae, a lot of lawn clippings, a lot of hops- these things get slimy. Don't apply a thick mulch of anything that is wet. You will get good gley, but it is not good for your garden. It must have air. Hay should first be put through chicken pens; straw you put straight on.

Now what you do is set up proper, permanent, well-designed small systems for each plant you are going to grow. If you are going to grow cucumbers, you make these holes, put up a wire mesh cylinder, about four feet high, and it's permanent, and you always grow your cucumbers there. You work all this out. In the general garden, you do a sort of spot rotation. Wherever you are manuring, as in cucumbers, potatoes, and things like your asparagus bed, you never rotate. For tomatoes, rotation is disadvantageous. Tomatoes grow better on the same spot. So you set up a permanent tomato bed. You treat each vegetable as a design problem.

In any community situation, it is a very good idea to give responsibility to different individuals for different areas. As an example, I never replant leeks. I let a certain number of them go to seed, then I take the bulbs off and set them straight out. I just did this before I left. Then some well-intentioned idiot comes into your garden and pulls your leeks out because they are running to seed. So you are two years behind again. They pull your lettuce out because it is going to seed. Of course, that is why you had it growing there. They plant something over the top of an area that you had pre-planted and were waiting for it to come up. So you are a long way behind. You can be up to four years behind; and if they destroy something you have been working on over a long time, they can set back 10 years of work.

If you can point out what you are doing, and if you have a very sympathetic friend and you work closely together, that's all right too. If you break functions up, one person attending to the compost, the other doing the planting, it is possible to work together over the same spot. However, it should be in different functions, one measuring and supplying, the other doing the actual structuring.

If you are going to mulch, you plant a quick-maturing lettuce leaf seed. You seed down an area and just put out seedlings. If you are growing seedlings in trays, just seize the opportunity to put them in anywhere.

Hay is full of seeds. You don't want to throw those seeds in your garden. So undo your bales of hay in your chicken run. The chickens can eat the seed. They also help to shred the hay, and add some manurial coating. After they have kicked it all over the place, you fork it out and put it on as mulch. If you are mulching in this way, maybe you won't need much manure.

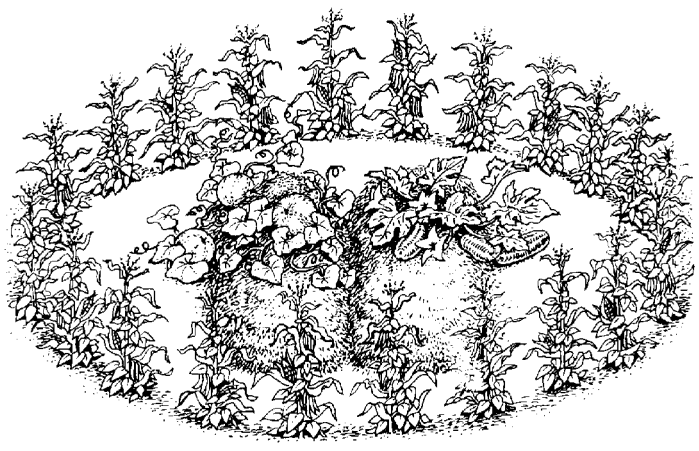
In the future, we will become more sophisticated about mulch, and will be growing certain trees for their mulch. I am yet not certain which ones. We know some of them. We know some produce an alkaline mulch, some acid, and some have high potash, and some a nitrogen leaf litter. It is the work of a few months study to determine which ones suit a particular site. In the dessert, we grow tamarisk and casuarina for their mulch. All bark is high in calcium.

If the area where you want to start your garden has heavy wet clay, you are in a happy situation. You are in for real trouble where there is siliceous sand. Clay is fantastic for water retention. Because you are mulching, your roots are well up in surface area, and don't have to encounter the clay. The clay holds enormous quantities of water. Sturdy clay gardens make the best mulch gardens.

If you wish to start a garden on lawn, just go straight on to it. At home, we have people who keep mulching across their lawn. This year, you decide that a bit of lawn is going to be a garden, so you mulch straight across it, and in a small handful of soil you plant all your little plants through the mulch. Put your potatoes at the base, and go straight into garden.

If you want to convert a lawn, it's a day's work. You never dig it. Here is one way to do it: You get a number of old tick mattresses. Take them home and just flop them on to the lawn. Cut little holes in these mattresses and drop potatoes through them. Put a handful of hay over them and that's all there is to it.

You work things out for each plant. There are certain crops that are traditionally planted with corn. Throughout the whole of Yugoslavia and southern Europe, and where there is a hot summer sun, corn goes with cucur-



bits. In the cornfields of southern Europe, manure and compost is shoveled off oxcarts in random little mounds three feet in diameter and two feet high. These little garden compost heaps may run right over a hundred acre area. Corn is planted in rows. But in these mounds they put runner pumpkins, melons, watermelons, and all sorts of cucurbits. The corn comes up and is harvested and the melons drop off. They are sitting all over the field like a million footballs.

Climbing beans are a second group of companion plants to corn. There may very well be others. In the event you are growing sweet corn, and are not interested in the cobs drying off, you will have to go out and get them. You also have to pick the beans. How are you going to wade through that crop?

Work out a band of corn about four feet across, hollow in the middle. In there, put your manure pile and plant your cucurbits. This way, you have also set up what is basically an edge. Plant your beans around it. Now you can pick all the corn and beans, and when it is time to harvest the pumpkins, your corn is finished up and you can get to them. That is a rich little area there, and you can keep it for your corn patch. If some of the beans get away, there is your bean seed. If some of your corn gets away, there is your corn seed.

The tomato won't stand the wind. It doesn't like it at all. So it needs a little shelter around it. It needs to be a south-facing shelter. Grow Jerusalem artichokes around the outside. They are well up before the tomatoes are in trouble with the wind. You can stake the tomatoes, if you want to.

Basil and parsley are good companion plants for tomatoes. So plant some parsley in there and quite a lot of basil in the hot spots. Your basil goes in on the south facing edge. Parsley doesn't care, it can go on the cold edge.

For white fly, we want nasturtium, which gives the essential root contact. There is an all-yellow, bunching nasturtium that doesn't run; it is a small plant and a fixed species. You can put a few in among your tomatoes.

If you worry about eelworm (nematodes) in tomato, you will need marigolds--*Tagetes minutia.* Gooseberries are good for the control of specific tomato pests. So if you want to grow a few gooseberries, do that just outside, on the cool side of the tires.

We have our basil on the hot side, parsley on the cool side, marigolds in random little clumps, windbreak of Jerusalem artichoke, and cool wide windbreak of gooseberries. That is a good tomato production system.

As we close up in the autumn, we take some good tomatoes and put them whole under mulch. You get about 200 plants at each spot. This enclosure is thick with seedlings. Every remaining tomato is just remulched annually.

When I started my bed, I just brought a carpet out, mulched the top of it, and planted tomatoes in little mounds on top of the total. Plastic superphosphate bags, cut in half, slipped over four sticks, made a greenhouse for the newly transplanted tomato.

Never re-buy your tomato seed. I never bought but one lot of tomato seed. When you throw your tomatoes under mulch, there is always the starting of your main crop tomato. Tomatoes from these seedlings always ripen in time.

If you pinch out the tomato axil shoots and plant them right away, you can also have a whole succession of plants going. At the end of the session, if you have a good tomato plant, take its axil shoots out, plant these in peat pots and put them in the glass house. In the spring, you can plant them out.

We give our plants their culinary associates, which have a secondary effect of being weed barriers. When you go for your tomatoes, you get some basil and parsley right in the same basket.

If you want to put a couple of comfrey plants out there, do it. A comfrey leaf under the mulch near the root of your tomato will supply potash.

Try to deal with each thing in your annual garden system. Set up a system for your area, tune it up. Then write up a standard design, which can be printed and tucked in with every subsequent report, when it suits. It would suit an acre garden; it would not suit a 20-acre garden. You won't have to keep on telling people how to grow their tomatoes.

I will continue to insist that a pond, probably central, in some of these non-eroded areas is worth its place. A little pond in the herb spot is worth its place. After just a little bit of research, and going on data that is already extracted, we can find a great many very high yielding pond plants. These plants are in fairly constant production, because they are in a constant environment. Some of those belong in the annual garden. They belong in the high turnover garden. Some of the perennial pond plants belong in the annual garden of course.

So put in a couple of small ponds, perhaps four feet across and 18 inches deep. Some of them filled with about 12 inches of soil, and some of them filled with about four or five inches of soil.

A pond that size will turn out about two hundred or three hundred frogs about twice a summer. The tadpoles live in the pond, and the frogs live in the cabbages, lettuces, and mulch. They return to the pond and you must make a place for them to get out. A good sort of pond is one that is slightly higher than the surrounding soil level, built up and paved with stones. We put sweet alyssum and thyme and garlic between the stones. The alyssum trails into the edge of the water, and the little frogs climb out on it. Another thing you can do is to build up a little stone pile in the pond. Frogs will drown if they can't get out of ponds, so let them have a way out.

Mosquito control is accomplished in two ways. I always put a bit of garlic around the pond and just squeeze the bulbs out into it. That is the best. That kills the larva. Just float off your garlic oils. It's about 100% kill. The garlic doesn't kill tadpoles. The tadpoles eat some mosquitoes, but they

are not a control measure. The second mosquito control measure is backswimmers. They, again, don't affect the tadpoles. Backswimmers fly in. If they don't, go and get them and put them in--not the big ones, not assassin bugs, but backswimmers. We have mosquito control standard design that we have never printed up. It was written by a Ph.D. in mosquito control. Garlic is a lot more efficient than oil, and it leaves other organisms.

Ponds can be constructed from old stock tanks, an old bath, or, it's what you have. You can also make them on site, brick up the sides, plaster them inside. All sorts of variations are possible. In some areas where we work, we just dig a pond in the clay, and get a rammer and just ram it in.

Hot exposures around the house are good trellising situations. Trellis can effectively contribute to climate control. Use trellis right around to the kitchen windows. It should be deciduous trellis, up in summer and gone in winter: hops, grapes, runner beans. The hop is a noble vine, excellent for light pillows for children. It puts them off to sleep without a whimper, and a child can not choke on a hop pillow.

You don't want a cold wind across your house. You can control that with trellis. We continue our trellis systems, but for different reasons. Now we can go to evergreen climbers.

Use aromatic plants around the entry--honeysuckles, jasmine, lilac. A garden should smell like a garden. It is pleasant to step out on a quiet evening into good smells. Stick some lily of the valley among your chives, right near the door. The formal entry should be visually pleasing, but also work in some things that need that reflection off the walls. It may be a good place for a few peppers.

There is a whole category of plants that will live in shade, but they won't yield as understory. Nearly all the small fruits will do reasonably well in the shade pattern of a small tree. The raspberry and strawberry bed will go there, and black currents, if you are permitted to grow them. Gooseberries do perfectly well in shade, particularly the green gooseberry group.

If you are dealing with a retrofit on a brick house, give them ivy on the north facing walls. It makes a difference. It is 40% efficient against heat escape, and it cuts that wind drag against the wall right out. It also preserves the wall marvelously. A brick wall under ivy is in much better condition after a hundred years than it would be without it. This does not apply to wood, just to brick. However, if you want to go to the trouble of putting up a trellis just out from your wood walls, you can use ivy on the trellis. It will still the air flow. Many people won't go to that sort of trouble, so you can use trellising systems.

It is a very good idea, though, just to back up your trellis with something permanent, so that the trellis becomes a permanent part of the garden. If you are going to use stone, use something that comes above the stone that is not stone, because stone causes high turbulence. If you are going to use stone walling, pick flat stones and give it 40% penetrability. Have lots of holes right through it--not for the lower two feet, but thereafter. It is much better to soften a stone wall with a plant that is higher than the wall and softish; otherwise you get real turbulence, low pressure zones, quick evaporation--all the things you don't want.

Trellising can be horizontal as well as vertical. Often when you retrofit you can use horizontal trellising very effectively. You will be trying to prevent excess summer heating. Horizontal trellising is the way to go about that. On the horizontal trellis you will need summer green crops, winter deciduous crops. It is easy to adjust a trellis to cut out the summer sun and let the winter sun right in. As soon as you get to deserts, you can start to use the horizontal trellis as your major trellis. A horizontal trellis placed close in against the house gives a place to go when the weather gets bad. There are little animals that might come in there: pigeons, quail, rabbits in hutches, doves and pigeons in lofts; bees. Bees are best put up above pedestrian traffic, up on a shelf, so they are flying out above your head.

Then you must think where your weed barriers, paths, car park, entry, and mulch dump with go. The access paths will probably be established.

Once you have the garden set up into those little productive units, then your work is routine, easily achieved, almost self-done. The potatoes keep on potatoing, the tomatoes keep on tomatoing; your corn is an established system that continues to produce.

If our design is for an eighth acre with a large building on it, we would need to throw out all low yielding plants, such as globe artichokes, which take up a square meter and give three teaspoonsful of food. However, if we move out into a quarter acre, we could include a few low-yielding plants here and there. In limited space don't use sunflower, use Jerusalem artichoke. The Jerusalem artichoke is a really high yielding plant compared to sunflowers.

Into this area of permanent, undisturbed garden will come your little hedgerows. Fennel and other perennial umbelliferae ought to be dotted here and there for their value to wasps. Other things to build in around there are things that we have previously discussed, the weed barriers, the fire barrier plants, little permanent places where wrens can nest and wasps can winter over. Put in the sort of fruits you would normally be picking frequently, some of your raspberries and everbearing strawberries. Because they flower all year, I always put a few fuchsias outside the bedroom window. They are nice to look at when you first look out in the morning.

You can sit down and take a vegetable list from any good vegetable book and throw half of them out and put the rest of them in here. List the ones you are going to put in here, and exactly where you are going to put them. Your glass house space is reserved and structured. It can wrap around a bit. We don't put any west windows in the glass house. Those are insulated walls. There is absolutely no (net) gain from windows in those walls. We

use them as storage walls, a heat base.

Look at your house. If you have a thousand foot hill on the west, swing the whole glasshouse to mid-sky; forget about due south, come to mid-sky. Don't be so silly as to take a house and align it due south, when from 3 p.m. there is not going to be any sun on it, because your sun time is from eight to three. So put it in the middle of the sun time.

MOLLISON'S SOLUTIONS TO ENERGY PROBLEMS

You build a glass house front as a focusing system. Then you beg, buy or borrow sun reflecting mirror systems and place them under the eaves so the focus is about eight feet off the ground out front of the house, and there's your driveway. You run your car under there, put a magnet on it and bring it up into focus and it melts. You have a hole in the ground and a copper pipe around the hole. Your car melts and drips in this hole. That's at the end of autumn. Then you cover the hole up, and this copper pipe heats all your house and your hot water, and that runs all winter because you have molten metal down there. I reckon that is the solution to the American energy dilemma. Melt your car.

I do think, though, we could build houses that would of themselves be enormous energy collecting surfaces. We accidentally got it in Australia with an office building five stories high, which has these blind windows, copper glazed, or gold glazed windows. Its focal point is about 15 feet above the heads of pedestrians. You have a column of hot air just constantly ascending and the cold air is just rushing in and going up. Very rapidly, they didn't like the bottom floors.

I have other solutions to your energy dilemma. The best one is this. You have a stone used by the Indians--soapstone--with a fantastic thermal capacity. Heat it up, put it inside the house structure where we need it most to cook and to heat the house. We will lead a little tube into it and plug it in. Any sunny day that you are running low, we will come along with our pickup truck and we will take out of our pickup truck a big fold-out focusing mirror. We will fire that heat back into your soapstone block. We have our meter. We will read the amount of calories we give you, and make it a little bit cheaper than oil. Now that is practical, easily done.

It seems to me that the technological society seems to be looking for the technological solution, whereas this isn't really a high technology solution. It is more like an old Indian trick. The Indian used to stick a slab of it up top of the communal fire and cart it back somewhere where they wanted to cook, and cook on it. They cooked on it for a couple of hours, then carried it back on a couple of green branches. I reckon that is a non-polluting system that is eminently practical, easily applied. Imagine a block of that in your glass house.

Do you want me to digress for a minute? I will give you another free invention, called "Mollison's sliding infinity parabolic calculator." I was the man that made the 35¢-Geiger counter. The sun, infinity, parabolic ray--it came to me. I took it down to the physics professors. They swore and cursed. There is always a mechanical solution, always a simple solution. Do you want to throw a proper bamboo screen up at the right curve? No problem. I will give you a few more inventions that are critical Permaculture inventions.

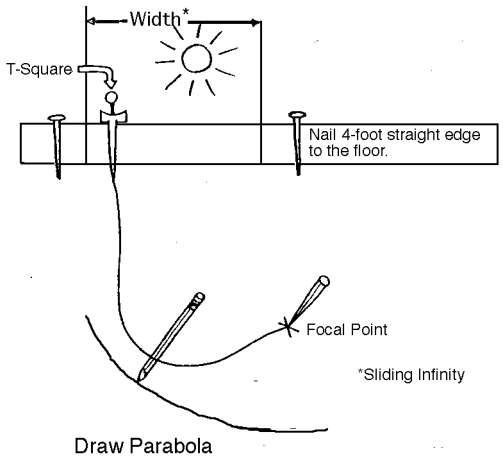
"Mollison's ultra-sophisticated, cheap, fast, solar heater." This invention came to me as I was walking along the beach at Molokai in my thongs, looking at the golf course. I thought I would head up into the bush to look at some date trees. I took off my thongs and started wandering across the sand. My feet started to cook. I was hopping from foot to foot. In agony, I put my thongs back on, and thought: My feet would cook here. The black sand was intolerably hot.

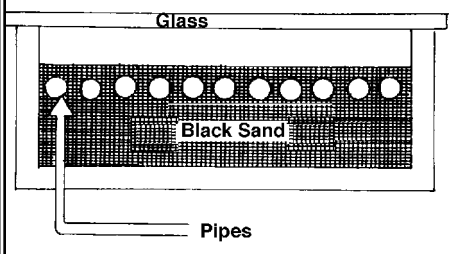
So what you do is run water pipes through a box of black sand. If your sand isn't black, you blacken it. Put some glass on top of it. What you have is something far more efficient than these metal collectors. You have a fantastic transmission of heat, endless hot water, at no cost.

You want another invention?

"Mollison's third world endless ni-

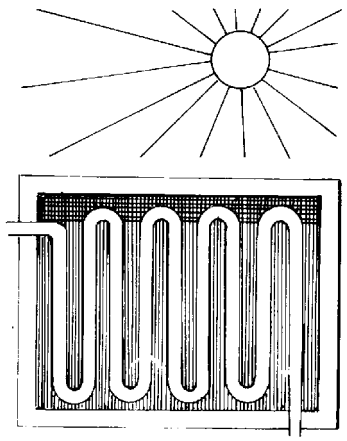
Mollison's Sliding Infinity Parabolic Calculator





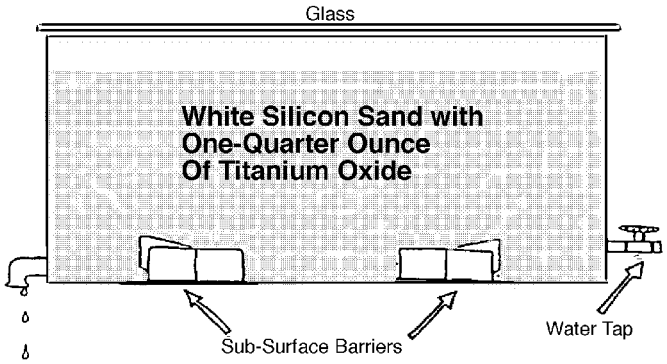
Side View, Cross Section

Mollison's Cheap, Fast, Solar Hot Water Heater



Top View
Sand Removed to Show Pipes

Mollison's Third World Endless Nitrogen Supply System



trogen fertilizer supply system." You will need a sand box, with a trickle-in system of water, and a couple of subsurface barriers to make the water dodge about. Fill the box with white sand and about a quarter ounce of titanium oxide (a common paint pigment). In the presence of sunlight, titanium oxide catalyzes atmospheric nitrogen into ammonia, endlessly. You don't use up any sand or titanium oxide in this reaction. It is a catalytic reaction. Ammonia is highly water soluble. You run this ammonia solution off and cork the system up again. You don't run it continuously, because you don't want an algae buildup in the sand. You just flush out the system with water. Water your garden with it. Endless nitrogen fertilizer. If you have a situation where you want to plant in sand dunes, use a pound or two of titanium oxide. You will quickly establish plants in the sand, because nitrogen is continually produced after a rain. This solution is carried down into the sand. If you are going to lay down a clover patch on a sand dune, this is how you do it.

What I am saying is that everywhere around us, in the natural condition, these factories are working. That black sand has been cooking and dehydrating materials for ages. Just get a fish, split it, put it between two banana leaves, put it out there on the beach. Dehydrated fish. No flies. You can cook in it. That's better than your $3,000 metal collectors. Those things are applicable everywhere. Good permaculture technology.

You are asking me whether people use titanium oxide to create this reaction? No, they don't. They just haven't thought of it. In chemical abstracts, around 1977, a researcher noted this, and then went to a discussion of the whole atmospheric circulation. One of the mysteries of the atmosphere is that it has an excess of ammonia. They have never accounted for it. When he considered the amount of dunes and deserts in the world, he said, "This is it!" Where do we get titanic oxide from? Sands. So he calculated it. Three acres of desert under this system would supply as much as a commercial fertilizer plant.

But we are not really interested in three acres of desert. We are interested in three square feet in some peasant's garden in Guatemala, or somewhere else. I obtained a bottle of titanium oxide for our village. I never got any more of it. You can buy it by the pound if you want to. It is a common filler in white paint, after they got rid of lead. In the deserts, his nitrogen evaporates into the atmosphere. That's why it is there. Rain occasionally carries it down. That's why deserts grow plants. That's why you can start into a system in a desert without necessarily starting off with nitrogen fixing plants.

But, look! I have no time to try anything. I just know that it works. I never tried that black sand box as a water heater, but I did a dance across the beach and I was persuaded.

My home is a good example of a place where it is always working. It has a basaltic coastline with many little steam holes in the basalt. Some are quite big. The sea is crashing in here, and the waves drifting inland, and it is also raining at times. So what really happens is that in these black basalt holes, you get seawater evaporating. What you have in those holes is a high saline solution, twice the amount of sea salt. When it rains, the rain water sits on it. So you get fresh water sitting on salt water. You can't dip your hand into that pool. It is a total sky focuser, a lens. The whole sky of light is focusing into this hole. Down there in that hole you have a high heat capacity solution that, you will note, is insulated at the top by water, which is a good insulator. So heat gathers in there, and it 's in basalt. All this is hot.

If you look in there, it is fascinating. You have a hot saline alga growing in there, violent looking stuff. You have different layers of mosquito larvae, belonging to different species of mosquito, but which are quite specific to that stratum. This demonstrates how common those sites must have been, over ages of time, when species have adapted just to that particular condition. It is real interesting.

It I were to make one, I would make it out of black concrete and I would put a straw right around it. Cook your spuds down in there.

Again, the body is a sensor. If you are playing around with a situation and you find a peculiar condition, you know, where your finger suddenly gets burned, or your feet get cooked, take note, take note! You think, as you are cooking away at the base, Eureka!

Everywhere, all this is happening naturally. A civil engineer on Molokai has a thermometer stuck in this beach, and he is busy with the idea. We could build these black sand heat collectors on top of people's water tanks. You wouldn't even need a glass top of it.

Well, well, well, where were we? We were just concluding planning in zone one. Parabolic house--that's how we got there. Right on the edge of zone one, you can recommend growing multi-graft fruit, a mini-orchard. There is some validity in cordon fruit--just single cordons, perhaps four feet long, each one a different apple. It's whip graft here. Just a little cordon fence made up of five sorts of apples. There's a man in California that has set up a cordon system in his back yard. He gets bushels and bushels of apples out of a tiny back yard. He

grows 150 varieties. That is an extraordinarily high-value quarter acre. Dwarf fruit trees are very good in this zone, particularly peaches and citrus. This is the only area where I would recommend this. I would go to the cordon for pear and apple, and to the dwarfs for most the rest.

THE GREENHOUSE

While we are still in zone one, we might look inside the glass house. This glass house is adjusted to use the reflection of the winter snow. It would not have to be the winter snow, though; it could be white quartzite.

As soon as that system is a little larger, we put up two or three glass houses for different reasons. It seems to me that the glass house is a very sensible thing. However, they are not being sensibly used. Often, they are only used to extend the season with the same crops you would in any case grow in your garden and store. You want a minimal amount of that sort of crop in your glass house. Maybe just one of the glass houses you build will have that crop. One alone should supply enough winter greens.

Now what other sort of crops would be appropriate? There are really two groups. There is a set of critical species, and there is an income set.

One of the reasons that we are a heavy load on other parts of the world is that we keep turning their peasant economies into production economies for species out of our climate range, and much of our food is of that sort. Many spices and beverages fall into that category. Although some of them are beginning to be home grown, they need a high labor input. I have a list that I have extracted for Tasmania, which I thought out very carefully, and which you can think out for your area, which isn't so very different. Just look through your grocery list and your shelves. Maybe you use 20 fresh ginger roots a year. You put a green ginger root in a small tub and away it grows. You have a continuous ginger supply. You might--and I would doubt it--eat as many as 20 pineapples a year. This is another plant that is very easily grown, not only within the glass house, but within the house. It was the ordinary sort of indoor plant of the 1850's in England.

The pineapple needs a little technique. It needs ethylene to set fruit. Apples produce ethylene. You have to enclose the pineapple with an apple. Have a few apples ready as the pineapple flowers. Put them down at the base of the plant. Another thing you might do is to plant a single dandelion plant in a pot nearby, because it has constant ethylene production.

Vanilla is a fairly hardy orchid. It will grow up the rear wall of any greenhouse, any place that has some heat in it.

Cinnamon is a very easily propagated tree that grows from cuttings, and it coppices. When you cut a cinnamon stick off, you get four more. It is a two-year cycle crop. In a pot, it takes up about a square foot in a glass house. You can produce cinnamon for everybody in your area with one pot. Cinnamon is a very common roadside plant of the near tropics. You can distill the leaves for cinnamon oils. The leaves are a very high value fertilizer. It's a useful little plant.

Tea is a small shrub, which is a *Camellia*, a fairly cold-hardy shrub. In the tropics, it is a high altitude shrub. It is better as a green tea, but you can ferment it. Again, one plant gives you all the *Camellia* tea you want. It will grow in the open up to a latitude of about 40 degrees. Wherever *Camellias* grow, you can grow tea.

Coffee is a very shade tolerant indoor shrub that has beautiful flowers and a nice aroma. It will live in offices quite well, in just a well-lighted office, under fairly artificial light conditions. It bears heavy crops of berries. You can eat the berries. Spit out pits and take them home and roast them. You will get pounds and pounds of coffee berries off a single plant. It is a kind of weed tree of the shade.

To the extent that we import tea, coffee, cinnamon and ginger, we lay waste to a lot of distant peasant economies, cutting into their available land, using their land to grow this food for us, rather than growing food for themselves. We do that just so we can have non-food items.

So I think it is time we built some glasshouses to produce these items ourselves, and take our weight off other people. If somebody igrows five or six tea plants in their glasshouse, they will have enough tea to supply 20 or 30 households. If you grow cinnamon, you can grow enough for 100 households. These are species that I think we are morally obligated to grow in some of our animal heated or solar heated glasshouses.

In inland Australia, where I put in two story glasshouses, there is no problem with growing bananas. Two banana plants would normally supply all the bananas that you would use for a family. You can get the necessary height in two ways. One is to build a single story glass house and drop the floor of it a story to make room for these tall plants. The other way is to build a two-story glass house. It is very effective, however, to drop it a story below ground, providing it is drained. It is good heat buffer, and your plants will get up to the light fast enough. You could grow vanilla beans and bananas in a pit glass house with just one story at ground level. Grow the dwarf cavendish banana. [There are several other dwarf varieties such as Raja Puri, Dwarf Orinoco, etc. Also, beware of severe thermal stratification problems in 2-story greenhouses. One story with dwarfs performs much better. --DH]

Turmeric is equally easy to grow.

There are many opportunities at present for deriving an income from plants grown in the glass house. The highest return is from flowers, bulbs, ferns and indoor plants. But you might profitably grow vanilla beans. These have to be hand pollinated. You do it with a feather. You really have to make but three trips to the vanilla bean, one to cut it and bend it down, one to pollinate it when it flowers, and one to clip the beans. You sweat the beans in a woolen blanket, and that's it. One plant gives you hundreds of beans. It is a better commercial crop than tomatoes. It is up to your ingenuity, really.

The alienation of third world land from food production is increasing. So if you can start into these crops, you will be doing a good job. Most of them are vegetatively reproduced.

The banana sends up four shoots. Give these to your friends. Cut off your spice plant and stick it in the ground, and off it grows. So will the papaw [papaya]. Anyhow, papaws are really self-seeding. They will come up all over the place. In cool areas they last for 30 or 40 years; whereas, in the real tropics, a papaw only lives for about four years.

So I would think about this aspect of glass house production. You have an opportunity to provide more than cabbages, you know. You can be supplying foods otherwise that you bring from a great distance at a great human cost.

I haven't given much thought to the interior of the glass house. It would be good to do so. I can simply point out to you that there are strategies. Quail are good inside the glass house. They keep cockroaches and whitefly down. Bring them into the house to clean up cockroaches periodically. The ideal nesting place for quail is under the curve of a pineapple plant. They will eat tiny insects; they eat whitefly.

Run a pipe from the outside pond to a small pond inside the glass house. Fish will come in and overwinter in the glass house.

I had a thought about taro production. Taro is a very ordinary root crop. It grows in water. But it is no use trying to grow it where it is frozen. So we can move our four or five taro plants indoors.

One critical plant that must be moved in is the *Azolla*, a nitrogen-fixing fern that grows on water. So we bring Azolla in, and, grateful plant that it is, it starts spreading all over within a week or two. There are 18 species of Azolla. They run right up to the Canadian border and right down to the equator. Sometimes it's red; most species are green.

Everything in the greenhouse is waste high. Underneath is rubble. So why not put a pond there? One thing that does well rooted in a pond is salable bulbs. Suspend them on mesh above the water.

I'll tell you what my friend does in Melbourne. He rents people's swimming pools and grows all of his spring bulbs in them before they start using the pools for swimming. He grows them on rafts.

Retrofit a swimming pool for biological production, with blueberry edges and frogs.

I don't feel we have got very excited about glasshouses yet. We have the technology. We have the uses right, the construction right, and we have started to get some of the crops right. But I think we have a long way to go. It should not take us long; but still, we have a long way to go.

KEEPING THE ANNUALS PERENNIAL

You may be able to get a system going so that there is no reason to buy seed again. Keep little bits of purple ribbon right by the door, and tie a piece of it around the plant you don't want to pull. Everyone should know what the sign is.

Just keep bringing the seeds in, or even hanging the plants up to dry without ever shelling them out. I think this is becoming critically important to us all.

You have, maybe, eight species of non cross-pollinating squash. If you are smart, you settle on a really satisfactory long-keeping pumpkin, a good cucumber, and agree with your friends that they set seed of one of a slightly different group. There is a perennial squash that just does not cross pollinate; it is quite a different species. There is a wide variety of species of squash--Chinese and Japanese. You have a very large selection. You could grow nine sorts of squash that are not going to worry each other. We have dealt with pinching out the axillary shoots of tomatoes and peppers and bringing them in over winter, either under glass or just as a sill plant.

Leeks should be permanent in the system. You should let some go to seed and plant from bulbs all around the base, then sell the seed to someone else.

If you don't already know how to cross cut your cabbage stems, start in. Cut your cabbage, cross cut the stem, and you get four good little heads growing off that. I've gone further. I have cut right through, let the heads spread out, separate the four things and replant them as plants.

Celery is an interesting plant. It is a perennial plant, not an annual. In all Tasmanian gardens, they still have the perennial variety. Just keep pulling bunches off the side of it.

The trade has made annuals of many perennials because they are into seed production. I have found a wild lovage in Tasmania that tastes as celery and that is perennial.

With many plants, I just take the seed heads and shake them all over the garden in autumn. They fall through the mulch. I get celery, parsley, lettuces, and all that, coming up at random. It is very wasteful of seed. The same amount of seed would sell for $20. I am trying to shortcut this whole business of buying seed, growing and purchasing seedlings, transplanting them out, cutting off the whole plant at harvest, and buying more seed every year. We are trying to get plants suited to the site, and reduce the seed packet buying as much as we can.

In Tasmania, we have found that we get many apple seedlings from apple pips that have been tossed out along roadsides. Every seedling apple we grow is a good apple, so we never bother to graft. They are already heavily selected apples, and we grow them from seed. All the deciduous trees that we have were imported. There are no wild apple species.

We got a frost resistant orange from pips. Nectarines are always good from pips. Lemon will take frost. So will mandarin oranges. I've been running around New South Wales when all the mandarins were frosted to the ground. Break them off the ground, and their skins would be stuck on the ground. These trees don't mind frosting up of a night, a few degrees below.

A seed bed should be incorporated into the annual garden--a little five square meter place for putting out seedlings. You want them coming all the time.

We save almost all the seeds of the fruit we eat, the pips. We let them dry, just along the windowsills. At the end of summer, when we have accumulated many of them, we pack them in sawdust and put them outside in a box. The rains fall on them and the frosts attack them. From then on, we start lifting the sawdust up and looking at it, and as soon as shoots start to peep out, we start putting them out all over the place. They are on their way. The more fruit you eat, the more fruit you grow. You catch up with yourself in about seven years.

FORAGE SYSTEMS AND ANIMALS IN ZONE TWO

Never in the history of the world has anybody designed and implemented animal forage systems.

White mulberry as chicken forage is as good as a double crop of grain. It is 17% protein. The mulberry crop is a very good chicken food for the period of bearing in which it occurs, and beyond it; because the chickens are getting seed long after the mulberries are gone. You can put in quite large mulberry plants from cuttings. You can put in four foot cuttings of about one and one half inch diameter. In the first autumn, take a rooting, and you can get several trees. You can completely fill the area and be into full mulberry production next year. In the United States, you have one of the very best black mulberries in the world. Two or three varieties will extend your harvest season.

The hawthorn group are great winter forage. So is the mountain ash.

When we come to the period of summer drought, we look to greens--to comfrey, cleavers, and any amount of chard. There are gardeners at home who grow more chard for their chickens than they grow for themselves. In this part of your garden you might have some throw-overs, like chard, or weeds.

Really, what we should look to carry us through a drought would be the Siberian pea tree. They are common here; and they are very good nitrogen fixers, producing a lot of seed. The peasants of Siberia fed their poultry on this tree alone. This sort of seed is always there. The chickens will go on and off it. They don't pay it much attention when they are chasing mulberries. And they eat a lot of greens in the summer. But at some periods when maybe there is no other seed, they hit it. It is doing handy things for them, like growing sprouts on its own.

With an acre of black locust, which is your best fence post material, you may look forward to a 10,000 pound drop, minimal. Just outside this acre, you have a little Fukuoka plot producing another 2,000 pounds of grain, in case we made some wrong guesses in here.

Wherever there's frost heave, and we want to stabilize the soil, we drop some sunflower seed in mud balls so the birds don't eat them. You have lots of opportunity with frost heave. Sow those little patches to clover or sunflower seed.

Now you can bring tubers in; you can bring in some Jerusalem artichoke.

Say we have a half acre of this--as a modest estimate, you may have 5,000 pounds of chicken forage in there, much higher in protein value than wheat, and a much more variable food. This would keep 40 chickens a year.

We have certain advantages here. We will have straw yards where we can grow lots of grain, by alternating a couple of yards to chickens. We have 5,000 pounds of fodder, at present, there. This would keep chickens for seven months a year. No need to go threshing and bagging your grains. You hang the sheaves up. The chickens will do all the husking and the threshing. Now that is without considering the forages and grasses, and the insects in this situation. I reckon we might have at least another 2,000 or 3,000 pounds of just protein.

Just before you plant, let the chickens and ducks in to dig out the slugs and clean up the ground. They won't get many of the seeds. Slugs and worms are much more delicious.

If we want to set up a new sort of chicken farm, we separate the chicken houses by about 150 feet. If you want to make it 200 feet, go right ahead. That's as far as a group of chickens range. You won't get any mixing up of the flocks.

Here's another fact for you. If you don't run any more than 400 chickens to an acre, you still have an entire herb and regrowth, with no bare soil. Four hundred is about the break even point. Three hundred is all right. It is good not to exceed 80 per flock. They are happier with about 50 to 60 per flock. It suits their social conditions best. You will need about five roosters to the flock, otherwise, the hens wander. So on an acre of ground you can set out four sorts of 60-chicken flocks, running roosters. You can have four entirely different breeds of chicken. The heavy breeds lay better in winter. The light breeds are spring and summer layers. For details, consult your chicken fancier, not your poultryman. You have good fanciers in America. You have a pheasant society; you have a duck fancier--all those ecological bandits. They are sort of oil millionaires. Five acres under wire. They go out and pinch very rare ducks off everybody, and escape illegally, if necessary, in their own yachts. They are nuts.

By calculations I have made at home, I have enough food on there for 800 chickens now, off the shrub growth. That's based on something more than intuition. It's based on an actual plot. Now, I don't want to put 800 chickens on there, because I don't want bare ground.

Your conditions are different, because you have a winter close-down period, and you have some of your food in store. So grow more sunflowers, or whatever, but not all sunflowers, because if the chickens get too much sunflower seed, their feathers drop out. That's because there is too much oil in their body, and the feath-

ers are very loosely attached in their sockets.

We wouldn't argue but that we are going to get cheaper eggs. We wouldn't argue but that we probably are going to get healthier chickens. Certainly I wouldn't argue but that we are going to get happier chickens, because what you have is a chicken out there really doing its own thing. We don't seem to get much disease in these chickens. They seem to maintain good health and they lay until they die. It's not one of these three-year systems. They often die at roost, having laid the day before. Some of them go six years in this. So no need to kill the layers. It is a cheap system. You can bring out a cart of eggs every day, and they don't cost a lot.

Get the system going with very large cuttings and pot planted things. Chickens cannot disturb little plants if you get them going in wire mesh, mulch or brush piles. Later in the season, when we get it going, we can load the area with two hundred chickens. In a few seasons of tuning and adjusting, we can bring it right up here to where we want it.

A pasture with above 400 chickens will show two effects. The amount of nitrogen starts to weaken the pasture, and the chickens will probably eat it out.

What we are really setting out is a much stronger root system than pasture, and we are setting up leaf mulch. It doesn't all have to be chicken food in there. Chinese chestnuts and hazelnuts can go in there. You will double and quadruple your yield of hazelnuts. What we have in there is high nitrogen demand, high commercial value crop dotted through the area. Chickens are cutting down the grass competition, and they are also eating the windfalls from apples and other fruits. So it is a chicken-orchard: chicken plus orchard, including vine crop.

A grain-fed animal itself keeps four chickens on just the grain in manure. Ducks with sheep are excellent. Ducks eat two things fatal to sheep: One is shallow water snails that carry fluke, and they also eat the fluke eggs. It doesn't hurt ducks or infest ducks. Ducks don't compete with the sheep. So in this way, you set up a high hygienic situation. The same goes for chickens and grain-eating herbivores. The chickens don't just eat grain. They eat encysted parasite eggs. Anything that has died, an animal that has been run over on the highway, just hang it up in the chicken run, convert it into larvae. That will sharply reduce the flies in your area, because these larvae will drop into the chicken pen and be eaten before they can hatch flies. Ducks are great fly catchers, too. If you bait the flies in, ducks will catch many of them. We can bring insects in to them by planting insect attracting plants.

Chickens with plum and cherries sharply reduce crawling, flying pests. All the pests that go into the soil and re-emerge are sharply reduced.

With chickens given the shelter of trees, the depredation situation is practically nil.

What we are doing here is playing a new game, which nobody has ever played. They have played little bits of this game here and there. The people of Siberia and the tundra have played a little bit of it. In West Australia you can identify the old chicken yards by the fact that they contain the Canary Island tree lucerne, which, among the old timers, was the number one chicken seed forage. You can find every old Tasmanian pig sty, because it will contain oak trees. The British brought their oaks with their pigs and their poultry--sensible people! Now all that remains of the pig sty is the ancient oak trees. The pigs are over there being fed grain, and the oaks are over here with nobody feeding on them. Because the grandchildren of these people went to the university and got educated, they found out from the agricultural department how to grow pigs. The old systems all went into decay. But there remained little bits of it.

I think it is good to run our chickens with the other animals. Then we have animal heat and the enormous heat of the decomposition of manures out there in the barn. If we build a glass house around it, we can use the heat; and if we use the methane, and the ammonia, and the CO_2, then it is starting to look very good.

You want a few piles of quartzite gravel in range; and you will need broken shell. The crushed shells of fresh water mussels are good for that.

In North America you have a large continent with large marshes. You had a large wildfowl population. Your country has wildfowl-specific forages. You had your turkey ranges, your pigeon ranges, and your duck ranges. Among these enormous forage ranges, there are going to be critical forage species, very good ones. Long ago, we should have started using these systems, and not have been relying on the wheat fields to produce disease-stricken cows and poultry. I simply point out your grand opportunities here. If you go back and read the accounts of your early explorers, you will find that as they were coming up the river, they weren't looking at a flock of ducks every half mile; they were looking at ducks by the thousands. They were looking at flocks of passenger pigeons that darkened the sky from dawn to evening. There was a lot more nobility in the environment then. Just imagine the transfer of phosphates across this country.

We can take some of the native animals like the turkey, and start to manage those forests into turkey ranges, or we can bring in other species closely allied. In these wildlife forages we find many of the pioneer plants, the plants that step out into the grassland, plants that are not fussy, do not require all the mulching and harrowing and digging. They prepare the site for your following plants. I would pioneer with bird ranges across the country, and transfer into larger tree species.

If you have existing forest of low-forage species, you can adjust maybe five acres of it one way, five acres of it another way. You have great opportunities. You have no establishment problem. All you have is tuning problems. You worry about what vines to put up those oak trees. Where there

are no forests, our concern is how we are going to get the oak tree up there.

Sixty per cent of the world's grains are fed to livestock. In the United States, not only are you doing that, but you are bringing in something like 100% of the produce of the South American fisheries. You are importing an enormous amount of protein from overseas. America does not feed the world. The peasant farmer of the third world feeds the world, including America. All the fish concentrate, the entire crop from the Chilean coast, comes into America as animal feed. That alone makes America a net importer of protein. They had put in a fish concentrate factory on our east coast in Tasmania. Certain whole fish stocks were wiped out this way.

We credit *Melaleuca*, which grows in most climates, with attracting about 60 per cent of our inland fish food. This grows all along our inland waterways. It attracts a great variety of honey-loving beetles and moths. So we can bring insects in. We can bias the whole situation toward the desired product. At the same time, we are not stuck on that product--the fish, the chicken, the duck. We can move into mulberry jam, apples. I have seen hazelnuts growing inside and outside a chicken pen. Inside the chicken pen, the bushes are about three times as big, and they have at least twice the amount of leaves per cubic foot, as compared with the ones outside the pen. The nut crops easily quadruple the ones outside the pens.

I suspect that we removed an enormous amount of biomass from this landscape when we took away the chisel plow--the marmots, gophers, moles; when we took away the free-flying pigeons. They were our phosphate mobilizers. The forest produced them and sent them out, saying "Feed me." In this way, the forest attracted the phosphate to itself. The animals are the mobile part of the forest, an aspect of the trees. Those birds are planting those trees; they are gardening those trees. You cannot take them away and expect to have a healthy forest. You can't. You can't have a healthy society, either. What you have is unhealthy plants, because their essential mobile components are missing. The animals are needed. I think when we start to balance these systems, you will see it reflected in tree health and tree growth. You may even see a big tree again one day.

I have seen an English walnut growing in a chicken pen, an old chicken pen, not now active, between one and two hundred feet across the crown, and still only 60 feet high, and that tree is only 120 years old. It yields bags and bags of walnuts. These trees around here don't look as if they are ever going to be big. They will get sick before they get big.

You have conditions here that are good for ground birds. There are all sorts of places to start up these activities, to create the little ecological islands. I don't think we need 70 per cent of this corn. If we could work out these little alternative systems, there would be no need for carting in all of this protein.

There is a film that we have seen in Australia; you may have seen it here. It shows the fishing operation of Chile, which has a desert coast. Off the coast, there are islands that were very high nitrate islands and phosphate. Here the westerly drift comes up, and with it billions of fish. Those fish are being taken and processed into fish protein concentrate for U.S. pigs.

Under the conveyor belt that goes from the holds of the fishing vessels up to the fish factories is a God--awful mess; and for a while you can't figure out what is happening. All you can see is arms and wings. It is the peasant women and the pelicans fighting for dropped fish, because both are starving. The pelicans are invading towns 200 miles inland, fighting with people for the remaining food that there is. That film indicates something is bloody awful.

So I think we must go into forage systems seriously. These forage forest situations are fantastic fire control situations. We usually have a high growth rate, really good plants, very little ground cover, hardly any litter accumulation. Because there is more nitrogen going into this forest through its animal populations, there is a very rapid break down of litter. It would be reasonable to choose hardy animals and these pioneer forage species to prepare for the following forest.

Time and gain I have set up a situation, and then discovered that this ecology is working, and I hadn't realized it until I designed it. Somebody had been in there before, a good Designer!

Yet it is not quite the same old game we have to play. We have to play a new game. We are not into the game of shoving the continents together, and pulling them apart, arranging all sorts of new combinations, just to see what happens.

We have been impoverishing the globe, and we are into the greatest, most intensive phase of impoverishment right now. We know that as a result we are going to wipe out tens of thousands of plant and animal species. Whole elements are dropping out of ecologies everywhere.

The only way we can begin to make amends for that is to bring other elements into those ecologies, in an attempt to restore their function. The chestnuts were 80 per cent of the forest cover. They are gone, killed. What do we put back? What amends are we going to make to every animal dependent on that forest cover? Are you going to make amends with the Chinese chestnuts, or what are we going to do? Acid rain will knock out many of the species in northeast America. We may not be able to get those species back in that area, but we have to make amends. We have the potential to enrich the system. The chances are more than equal that we can enrich it.

Some of you keep returning to the rationale that there is an inherent danger involved in introducing plants not native to an area. I have a rationale, too. I use only native plants; they are native to the planet Earth. I am using indigenous plants; they are indigenous to this part of the Universe.

Speciation is not something that is happening all the time. I believe that

many of our systems are becoming time-saturated. I believe that too much time can accumulate in this system. It closes up. A forest that is rich, complex, with many other things in it, gradually evolves into a big old closed system, dominated by a few species. It is a bit like a free economy society that has resulted in a few old savage people accumulating everything. The die-off starts at the bottom, and you loose a lot of genetic diversity. Then it's the time to overturn it. Any social system that lasts too long seems to get time polluted--chronically ill.

There is a man who had a 14-year-old sow. He fed it a lot of good things, including apples. He had pigs before her. About 17 years ago, in the corner of the pig pen there was a blackberry clump. An apple tree started there, and up it came. Then the apples started to fall, and the pigs got into the blackberries and moved them out, ripped them all out and left the apple tree. This fellow was a man of great sagacity. He went out and got a lot of apple trees, waded into the middle of his blackberries and planted trees in every blackberry clump he could find. He also planted peaches and quinces and figs and pears. He had a lot of blackberry on his farm; he was in fairly heavy rainfall foothill country. Blackberries there are not the weak undersized things you see around here. They are violently rampant blackberries. They will fill gullies and be level across the top of them with the hills. The water flows down below. So he waded in and put in a grafted sometimes, but often seedling trees.

What happens in this situation is that the tree grows straight up to the light. It doesn't make any low branches. It grows very fast. It is the fastest growing situation you can find for fruit trees. The tree doesn't have any branches for maybe nine feet, and then it crowns out. When the apples start to fall, there will not be enough of them to attract anything except three or four rabbits, and they eat them. Then, in a couple of seasons, maybe, a lot of apples start to fall, and they start smelling good and getting lost in the blackberries and fermenting. At that point the cattle can't stand it. They wade into the blackberries up to their chest, picking out apples, and they tread heavy on the blackberries. Then the tree gets bigger, and it drops 30 bushels of apples. It is now partially shading the blackberries out. It also becomes absolutely impossible for the cattle to stay out. They smash the blackberries flat, and you have this gigantic apple tree with the big thick trunk, eight feet clear of branches. One of those trees is 70 feet across, and 60 feet high, yielding 70 bushels of apples. The cattle get about 40 bushels, and you can pick 30. At just 17 years old, it's a phenomenal tree.

I don't know whether you can imagine this farm; but you should see it. It has patches of eucalyptus and wattles, and here and there a gigantic fig tree, a gigantic apple tree, and an enormous pear tree. Twelve pear trees growing under similar conditions yield almost seven tons of fruit per tree. They are big. They are approaching 160 feet high. There is a flood plain with blackberries there, and these pear trees haven't any brambles at all under them. You can get on your ladder and pick the first 20 feet. The rest, from there on up, drop to the sheep and cattle.

I keep seeing this happening all the time. I thought, Of course! Here is the old European forest, in which lived the white ox, the old European white ox. On the edge of that forest, sneaking out into the plains, step after step, is the bramble. On the edge of this forest, the only place where it is doing any good, is the apple. Its fruit falls into the brambles. The seedlings come up and begin fruiting. Then comes the white ox. He comes and rescues the forest. That is how the forest advanced. Here comes your little boar out of the forest, rooting around in the blackberries for apples, and they will change the soil condition. They will make a high manurial situation, and will stimulate this edge growth of plants. Then on the forest will go, with apples out in front of it. You will find this happening like that all over the place. Geoff Wallace is doing this deliberately. He has run completely out of blackberries, wiped blackberries right off his property.

The main value of blackberry to tree is that it prevents grass competition at the roots. Grasses produce chemicals hostile to trees. There is a fight on between grassland and trees. Fire helps the grasses; brambles help the trees. Hence there is a whole conflict of pioneer species in grasslands. The bramble is really continually mulching the tree, keeping its root system free of grass. The tree grows much better there than in an open situation. A secondary effect is that the bramble growth pre-prunes the tree to a standard, prevents low branching, and the tree crowns out into a really classical old British type crown--round, with a strong trunk. By the time the bramble is smashed, the bark is coming up from the root of the tree. It has all been timed. We couldn't have designed it better.

Somebody designed that for us. I just keep on this way, discovering something; then I go and have a look. It was there anyhow. After the forest is gone, when we are trying to grow the apple tree away from the forest, without the cattle, without the pigs, without the blackberries, we are going to have a lot of apple trees that are very unhealthy. In California, a lot of iris and fennel grow under apple trees. What you are looking for now is the tree's garden, the situation in which the tree can stand against the grass and still be very healthy. Now these are an interesting group of plants. Their main characteristic is that they are not surface fibrous-rooted plants. They do not set up that mat that intercepts light, rain, and prevents the percolation of water.

The nasturtium and any of the root thistles are very good plants. They are tap-rooted, large-leafed. They are clumped or have feathery fronds. Those are the sort of plants that do well under trees. You can design the apple garden, in which the apple will thrive according to its shade and sun requirements. If you start planting

this garden with your apples, you get healthy, fast growing, non-cultivated trees.

We are building up a set of plants from which we can derive characteristics that will enable us to add plants with specific traits. These are very good grass barrier plants with a very fast rotting leaf crop, quick turnover plants. You can start to garden your orchard over with these species. At home, daffodils often grow under apple trees. You may want to sell daffodils and apples; or you may want to sell fennel and apples.

Go and take a look at where the mulberry, the fig, the pear, the apple and the quince have survived the ebb and flow of human settlement. Work out the characteristics of the understory. You are seeking a tree with about a nine to 12 inch incremental growth annually, continuously self-pruning at the crown, so that branches are not overlaying and smashing, and the fruit will not be small and crowded. In the blackberry patch, the tree is protected until it starts to bear. When the blackberries are removed, growth slows .

Another remarkable sight is avocados about 60 to 80 feet high, bearing three to four tons per tree. They have a lot of cattle manure under them, because cattle love avocados.

You are looking under the tree that you are scoring, and you are setting as an ideal that the tree makes the amount of increment a year that it would make if we are actively pruning. But you wouldn't be pruning. Instead, you might put a wedge of grass under it, and let that prune it back. You would disfavor growth just a bit.

At Tagari, we've been only two years on site, and I don't spend much time at home. When I am there, I'm out stacking Russell lupines, comfrey, thistles, and bamboo in under my orchard. I'm trying to bring in more nasturtium. We are not inviting cattle into our orchard. We are doing the gardening there.

Some of these situations are appropriate for chickens for forages; some are appropriate for garden productivity; and some may also be appropriate for wildlife or domesticated stock. We want a whole set of these gardens, isolated from one another.

Another good thing under trees is a proportion of slab stone. I don't know how much of the surface should be covered with slab. It may be the stone slab is doing the pruning. Stone slab is ideal watering--instant run-off. It is not going to absorb and of the rainfall. It is high worm cast--all the characteristics that we want.

Now for the fig, the rock pile is the perfect condition. I feel that by adding or removing more stone, we could prune those trees, because that is a very manageable proportion of the ground cover. If we want to lengthen the shoots, put stone on.

There are biological books that will give you the perching characteristics of birds. Most all open country birds require perches. All insectivores are perchers. Put a bird perch by that little tree and you will find instant mobilization of the insects around that point, and a substantial fall of phosphate there. It will make a difference. We have done it, and those trees where we have done it are healthy; and the trees where we have not done it are not. Those birds are eating seeds and insects and providing phosphorus for the tree. We throw these perches away after the tree is up and providing its own perching situation.

In a tropical location, there is a person who has done a beautiful thing. His trees are lychee trees, and grasses are really hostile to lychee trees. Those trees in grass will die. He put at the base of each tree a little five gallon can with a hole in it, and in each can he put four guinea pigs. Guinea pigs run around under the grass for a very good reason: There are a lot of owls. Those guinea pigs would leave one stick in a hundred of grass. They build up a high and low litter. They manure the tree. They cut most of the grass off, allowing free water penetration. All his trees with guinea pigs are doing very well. Now here is a cheap cultivation method. He has an army of guinea pigs there working for him, and it costs him very little. Yet he gets a very high growth rate in his lychees. During the four years that they have been working, those guinea pigs are about to make a millionaire out of him. So that is another applied plant-animal relationship that is a governing relationship.

Occasionally a python comes through. He lowers the guinea pig population. But guinea pigs breed up. Well, pythons are harmless, really.

It's that sort of situation that we are trying to set up. We are attempting to beat the grasses against the forest, preferably in a productive way.

THE BEE

I don't know about America, but in Australia flowering is unpredictable, and forests are being rapidly reduced to islands of plants. The average beekeeper knocks out well over a thousand kilometers a week. Some do 1500 a week, just shifting bees and getting water to them, traveling to them, and carrying off the honey. It has already reached the point where, if beekeepers stayed home and started planting forage systems, they would be infinitely better off.

There is a whole set of bee forages. They range from useful crop, such as rape and buckwheat, to marshland trees, the water tupelo, and marshland plants such as purple loosestrife and *Caltha*, the marsh marigold. There are very reliable honey trees, such as basswood, *Tilia americana.* There are many basswoods, not confined to America. The Tilia are elsewhere called lime trees. Purple loosestrife is a problem to marshes, but if it is there, it is good bee fodder. If you have it around you here, you might as well be using it as bee fodder. The Tasmanian leatherwood might grow in this climate. It has a super-high-quality honey. It has the interesting characteristic that the cherry laurel has. It produces nectar from its leaves, and from its flowers. Leatherwood has very active leaf nectaries. Just before the end of the season, empty the hives out and carry them into the leatherwood, and they will put out 100 pounds of honey every

three days. Leatherwood will grow up with the forest and flower in it at crown, or flower as an interface. It is an indigenous species in Tasmania. This plant is a really fine tree in itself. It is good wood, a fine forest, a beautiful tree, and an incredible bee plant. In a two mile range it is customary to put in about 150 to 200 hives. Within this range, every one of these hives puts out 100 pounds of honey every three days, and all the time. Here, you would probably be lucky to hit 60 pounds in a season, unless you have a lot of Tilia. Leatherwood is an evergreen that grows in wet, snowy forests. It flowers the last of the season, mid-January with us. So it is going to be mid-July here.

What happens to a tree when it is moved from Australia to North America? It keeps its wits about it. It operates on day lengths as usual. We have shipped everything down, and it all grows. You send us autumn fruits from these oaks; we put them in and they don't drop till autumn. If it is springtime, we just plant them right away. Often we just give them a chill factor and plant them.

If you are planting for bees, there are a few rules. You plant a lot of the forage together. Clump your forages. It is not good to dot these things about the landscape. If you are going to put in leatherwoods, put 30 of them together in 10 different places. Put them in full sunlight, or on the sunny side of the situation. Don't put them near the hive. Keep them at least 100 yards or more from the hives. If you put them closer, the bees won't work them. I don't know why this is, but they don't. It is impossible to have too much low hedgerow between your hive sites and your forage sites. I mean as low as four feet. This enables the bees to work in unfavorable conditions. In very bad weather, the bees fly along the very low hedgerows that lead to the forage systems. These hedgerows are windbreaks, so they might as well be productive. Start out with thyme, rosemary, or whatever, and go on to low forage.

Wetland plants are excellent bee plants. People with wetlands might profitably go into apiary work. Conventional hives are built to shift bees around. Now we could re-think beehiving altogether, given that we don't have to lift hives around. I imagine what we might build is the bee barn, in which we pay far less attention to the weatherproofing and insulating individual hives. We would insulate the whole structure and have a whole set of exits for bees. We would work inside it and have a high light escape to which we can switch off. We unload, store, and process inside. So the whole operation becomes a sedentary operation with a sliding in and out of our bee clothes. You always put in a bee processing shed that steps down. Because honey is heavy stuff, your extractor has to be no more than waist level, and your storage drums below. Honey is a flow-down thing. That shed is always a step-down system--three levels.

You say that in Czechoslovakia they are using this sort of system! I didn't know it already existed! I had to reinvent it! Great!

We must pay attention to the fitting out of pollen traps in the beehives. There are periods when they can be used, and periods when they are not used. Bee pollen is the best tree-grown flour for protein we can get. So we are right out of grain growing. The plants are already growing that grain, and it's hull-less. It has many good minerals, and is high in protein. You get as much pollen as you do honey. If you get 60 pounds of honey, you get 60 pounds of pollen. So it looks as if we might just shift right out of our grain growing situation. From a hundred hives, you will get pollen way beyond our individual needs.

Now we can figure that about 60 hives is a family's living. Moreover, those bees and the apiarist and his family are advantageous to any other system. They increase the apple crop; they increase the buckwheat; they increase the seed set in our gardens.

Again, we are into an interesting thing. We can go from crop and annuals into perennials in a staged system, which keeps our flow constant. We don't have to start with *Tilia americana.* We would wait four years before we can get a blossom on it. So, we start with rape, buckwheat, sunflowers, and all the other good things. There is a manifold system we can play with.

It is easy to choose your mid-season and late-flow plants. The flowering periods are generally known. Your beekeeper certainly knows them. The whole thing we are trying to do is to bring the food to the animals.

CATTLE FORAGE

It is very impressive to look at an ancient pasture, of which there are not many in the world. It is like going out and looking at the unplowed prairie. There are a few in Yugoslavia, and in other southern European countries where it hasn't been their habit to plow all the land. I took a picture of about two square meters of pasture on which I can count 18 flowering plants; but there are many not in flower. Some of those pastures would have some 30 or 40 species of plants per square meter. It is a pleasant day watching a cow going through those pastures. It is totally different from the grab and eat, grab and eat thing. The cow seeks her way through this complex. Inevitably, as she eats a good clover, she gets a mouthful, or half her mouth full of a bad tasting thing. So you have an interesting effect. Cattle are unlikely to browse that pasture severely, because many plants are protecting others, and many semi-dangerous, or semi-poisonous plants are in with the preferred plants. Newman Turner, whose books have recently been reprinted, points out in *Fertility Pastures* that whether she likes it or not, the cow takes her medicines all the time. The cows in those pastures are shiny and glossy and have nice washed noses and luminous eyes. The herdsmen go with them. They just sit with them. It's a pleasant occupation.

Most of the people who handle their own cattle never use dogs or horses or chase the cattle. Whenever they want to change 3,000 head, they yell "Comeon cow!" and all the cows put

their heads down and follow him through into the next field.

Another friend of mine owns 700 acres. He is an organic gardener and a renowned pasturist. He hasn't used super-phosphate for 17 years. The health of his cattle's has improved out of sight.

Now you get all sorts of problems with over-fertilization of grasslands. You get infertility; you get a rather pulpy kidney; you get many diseases as a result of locking up certain elements. The cattle look peaked. They chew on barns. They eat trees. They obviously suffer from lack of elements.

New Zealand, much more than Australia, is looking very much to tree crops for cattle pasturage--to willows and poplars, and some eucalyptus. Cattle love the bark of these trees. It is quite possible to have enclosures of maybe five acres of tree leaves, which is much better than having a barn full of hay.

If you want fat cows, you plant rye grass and clover, but you will still get cows with worms and cows with deficiency symptoms. Newman Turner recommends a whole lot of perennial herbs that should be put along hedgerows. We know, for instance, that when cows can just browse along hazel tips and buds, the butterfat content in milk increases, and the cows are healthier. Cows will always eat some comfrey, though it is not a preferred plant.

You can go nutty about something like comfrey or dandelions. But as a component in food, these things are good. Some people were urging on everybody to feed their children, chickens, horses and cows on comfrey, until another gentleman said, "Look, be careful!"

Once a nut starts urging nutrition on someone, they are going to do it. They get their blenders down and start drinking green glue. It's stupid! Of course it is possible, under certain conditions, to damage the liver. So there has been a note of caution sounded. Nobody has found that comfrey will kill you; we are already certain it won't. Everybody I know eats comfrey and a few borage leaves, and we put borage leaves in our drinks. The main thing is, don't go to your garden and eat comfrey as your main food, like a lot of those people were doing. It is not the complete food; nothing is. Everything you do like that is stupid. The next thing you know, somebody will start the great cucumber scandal--the cucumber diet. If you eat a hundred things, you are not very likely to die of it; and you will get everything you ever need. What you don't need, you spit out. The point is, in a varied diet you add a component where that component was short. Chicory is a marvelous plant for cattle.

A friend of mine in rural Tasmania has 8,000 acres. He plants about 500 acres a year. He doesn't buy clover and grass seed. He buys the weed seed. He gets the dandelion and the thistles. He got a pasture chicory from France. His pastures are remarkable pastures. There is grass and clover, but at a very low rate. He sows clover at about one and a half pounds per acre, and some of the gasses. But the main part is herbal pasture. He gets his herb seed form other people's weeds. His cattle look fantastic. These are very successful pastures. He has never cultivated more than one and a half inches deep, just scratches the soil and dribbles the seed along. He doesn't own any machinery. He contracts a man in with a soil scratcher and a seeder, and does the rest on foot. You turn the cattle in on it; they can bite down and smash it about. Turn them out, and it all comes out again.

Let's have a look at the actual cycle of pastures in a climate which goes through the year, even though it does have a hard winter. Let's look at an annual grass. It carries on to midsummer, falls away, has a blip in autumn and falls away, and comes up in the spring. It is mid-spring before the herbs start. Their peak is summer. The perennials to some extent duplicate this. They hang on much later in the summer. They collapse a bit, and they have a better winter fodder value. The perennial grasses are better grasses for winter. If we are going to raise the whole carrying capacity, we store the spring and summer excess, using haymaking as a strategy. However, these perennial pastures, which are of more value for that than the annual pastures, are quite critical as to the time when their food value is good. The dry stalks off the grasses when the seed is gone are really poor feed, just cellulose. The only way a ruminant can deal with cellulose is by additional input of two things: urea and molasses (sugar and a high nitrogen). Farmers in the dry marginal area float a half-full 40 gallon drum in a trough made from a from a 55 gallon drum cut in half lengthwise. In the trough made from the larger drum, there is a mixture of molasses and urea. The cattle lick this from the floating drum that turns within the mixture. It tastes horrible. They actually detest it. However, that supplies them with the basics that the bacteria in the ruminant require to break down cellulose.

If you put that out, you can feed your cattle on sawdust, newspapers, and cardboard. People do. They often bring loads of sawdust or any kind of cellulose they can get. Feedlots in the American West feed newspaper and urea. That's the American beef. You are eating your own newspapers, and a lot of bad news, too! They get the urea from chicken manure--6% chicken manure with molasses. It is the molasses that gets the bacteria active.

The sugar pod group, the mesquites, the honey locusts, carobs, and the sugary tips of such trees as striped maple, will help cattle take advantage of the dry perennial grasses. In a winter climate, the demand is really for carbohydrate fuels. So you design oaks and chestnuts. What you then find, to your surprise, is that this is the way it works. You don't have to design it in. God did that. Cattle grew up to take advantage of what was actually seasonal.

There are plants like Tagasaste and Coprosma--evergreen and highly nutritious plants that go all year. Even though you let the cattle browse

them, while they don't respond as fast over winter as they do in other seasons, they still regrow again. So you have three strategies, then, with these cattle and deer and goats and sheep. One is, instead of just relying on annual pastures, have areas of permanent, high-mineral mobilization herbs throughout all your pastures--dandelion, chicory, comfrey. Have evergreens, standing, high-nutrition tree crop within forage range that the cattle will coppice. Have high-sugar summer pods that will carry cattle through the semi-arid seasons. This group is critically important to range capacity. Also, you must have a winter high carbohydrate source--large nuts and acorns.

These are the truly perennial components--the fruit of trees that stand in pasture.

In Sholro Douglas' book on forest farming, he describes an experiment in which he took part in East Africa, growing carob trees in big baskets, planting them out on an East African cattle range. The carrying capacity of the range went from one cow to 12 acres to 12 cows to an acre.

Let's face it, what happens is, you add correct components at the right time of the year. If animals are eating carob pods, they can then eat dry grass and utilize it.

One of the people in west Australia has milking goats. He feeds each goat three carob pods per day. He has one carob tree and it maintains eight goats for the year. It is not a particularly high yielding carob tree; it is 17 years old. What's more, he doesn't pick up all the pods; he just picks up enough pods to give his goats three a day, they can go out and chomp on very rough forage--and the forage is very rough indeed where he is, for he is on a laterite cap. These goats milk well and do very well.

So it is obvious that if you have a food, which is a concentrate, and of which a small amount will allow the sheep or cattle to satisfactorily process range plants, then you lift the range capacity very abruptly.

The willows and poplars are good cattle-forage. If you are dealing with goats, you have to go into self-defended plants. That is where you use mesquite and honey locust instead of carob or apple. Apple is a good sugar plant. The plum is a good sugar plant. Plums are good summer browse. However, you can't let goats into plum or apple.

The British orchards used to have massive trees, not a branch up to eight or 10 feet, and then a big crown. Cattle and horses could run around underneath them, quietly fermenting their own alcohol in their stomachs.

There are the root crops, too. If you can't grow oats, grow turnips and fodder beets. So you have swap-offs. Unless you are in severe conditions, in which winter comes crashing down on you, there is absolutely no need to go into hay pressing and baling.

The dreaded pampas grass is ideal shading grass. Instead of shearing the sheep and turning them out into a barren landscape, you put them in three acres of pampas, and the survival rates are about the same as if you put them in insulated sheds. You need places for animals to shelter at critical periods. So you must plant dense shelter. The losses of milk or meat products can reach 20% in unsheltered environments. Cattle and sheep are simply unthrifty where they can't get shelter. You all have a mental image of cattle and horses standing back to the cold winds and just shivering away. They will lose eight or 10 pounds in a bad day. They look so miserable. They are miserable. So design a dense shading or shelter block, and I don't mean just a hedgerow. It must be a big clump of dense trees, or tall grasses. Many forage plants, once they mature, protect themselves. Another thing, cattle plant all those plants, particularly sugar pod plants. If you read your propagation manuals, you will see: "Treat this seed with sulfuric acid, hot water, chip it, or grind it." When cattle eat honey locust pods, they chip and grind the seeds. They can't break them, because they are too tough for their teeth. These seeds immerse in an acid bath in the cow's stomach, heat for a time, get packaged in manure, and are usually placed in a little hole that is stamped out near water. That's the best place to get your honey locust seed from--right from the back of the cow. Those seeds have 90% to 100% germination. So the way to plant your range is to feed the animals going on to the range with those pods. They plant the range. In the Hawaiian Islands, in Australia, and in Argentina, cattle mainly propagate their own range plants.

When you look closely, you will see that each animal, whether it is a turkey or a bluejay, extends its own garden. Bluejays, being slightly short of connections in the brain, often put 50 to 60 acorns in somewhere, and forget where they put them. They plant acorns quite well. Squirrels accumulate nuts in places they often don't remember. By stuffing a few acorns down into a rotting log, they kick the oak forest along quite well. Nearly every animal is at work planting its own garden, shifting its own materials about in a forgetful and sloppy manner. Humans plant melons, apples, tomatoes--all sorts of things.

There is no point in trying to push cattle beyond their range. The sensible thing is to swap over into moose or reindeer, and as soon as you get to below 18 inches rainfall, go to black buffalo, antelope, or gazelles. Antelope range is on those dry savannas. In America, you had a higher stocking rate with your natural animals. There were the buffalo, and add white tail deer, the ground hogs, and prairie dogs. You had single colonies of prairie dogs a hundred miles in diameter. These were your chisel plows, and a mighty chisel plow. The high plains in Kenya, with scattered bunch grass and acacias, had maybe 20 common herds, all of which were perfectly good beef. Now people get the chain saw out and whack all the trees down, fence it all off, plow it, sow it down to high yielding pasture or perennial rye and white clover, and put up a lot of buildings. They bring in highly selected Hereford or King Ranch crosses and start running them. What they have is one-60th of the yield that

they had before they went to that trouble.

That's exactly what's happened here in America. If you do your sums on your passenger pigeons and your marmots and your prairie dogs and your white tail deer, you will have 10 to 20 times the yield that you presently have in a stable situation, and your standing crop was enormously greater. We are not very intelligent. You had a situation in which you had a full on herd of swan, duck, deer, quail, turkey. Now if you had started to manage this situation, to maintain it, you would have been well below food ceilings.

What you have to do now is to encourage the smaller animals, because you now have property cut up by fences. Buffalo can't move with their seasons; therefore they can't maintain the bunch grasses. Their habit was to act to maintain their pasture. Cattle have a place. Cattle are forest animals. They are not pasture animals. You have to chase them out on to pastures. Really, cattle belong in cool forest swamplands. They love it. In summer, they spend all their time up to their bellies out in swamps, eating the swamp grasses. In winter they will come back into the forest edges.

That is where we got them from. That was their habit--the white ox of the forests of northern Europe. We are talking here of beef cattle. Dairy cattle are much more highly evolved than most beef cattle. I think, though, that we consume too much milk and dairy products for too long. It has a place for a while.

If you let an animal go into a range where there is highly preferred food, it eats the highly preferred food and leaves less and less of it. This is particularly true if you stock a range heavily.

If we have a pond in which we put a fish that breeds up--say a large-mouthed bass--and that pond has a certain capacity, as the fish breed up, you can get 100 one-pound fish, 200 half-pound fish, 400 quarter-pound fish At one-quarter pound, they are hardly pan fish. At this point, your pond is heavily overstocked. One rule of fishing is never throw a small fish back. Always throw it over your shoulder to your chickens. Always return the large breeding fish, and eat the medium sized fish. Don't ever throw little fish back into the water; throw them up the bank.

We have trout in Tasmania in heavily fished waters, where the legal limit for trout is seven and one half inches. These trout breed and die at seven and one quarter inches. You have deer population in the United States, where you are allowed to shoot antlered deer, and the only kind of deer you have left are antlerless. We have heavily fished lobster populations that originally had reasonably slender foreparts and a rostrum. The legal measure was four and one quarter inches, point to point. It must have been a rostral fish. Now, nearly all our crayfish do not have rostrums, and those that do are still undersized.

This is like putting an electric wire across the street, set at five feet, two inches. If you are more than five feet, two inches, it cuts you off. It isn't long before everybody is five feet, one and a half inches, or else very tall people who are walking doubled over.

What we really need to do with any sedentary population of animals is to leave the large, fast-growers. We don't need a minimum size; what we need is a maximum size. We need to leave the very large, successful, healthy, fast-growing animals. Eat the young and half-grown animals. If people started eating cows and bulls and leaving the calves, they would be in a ridiculous position. The thing to do with crayfish is to make pots that only catch small crayfish and then you will always have tons of crayfish.

If you want to fill this pond up with fish, put in your bluegill or whatever, and there will be a million little fish, and the pond goes out of fishing. Put a screen across the pond, and put a couple of brown trout or a pike or two in there. They will keep those little fish out of the system, because the small fish can swim through to the pike. That is sort of reverse escapement. You can't let those pike into that pond, but we can let the little fish in to the pike, and you will always have pan fish in the pond. When they get too big to get through to the pike, they are right for us. You set that limit by putting in a two and one-quarter or two and tree-quarter inch mesh. Anything that can't go through a two and one-quarter inch mesh is good enough for you.

Now we have a chicken range. Hawks like chickens. If we are going to breed chickens, put a very thorny, brambly patch in each range in which we permit hens to raise chicks. We will get a high proportion of chickens from that. At home, we have a bush called the African boxthorn. It reaches the ground; it has millions of spines, and they go straight through your boots. Even cats can't prey within boxthorn. Dogs have no hope; they can't get within the crown.

Cats, if they get in there, want to move real slow. Chickens just slip through it fast, because they have little hard scaly legs. So escapement governs populations there; it protects breeders. You must give the same protection to highly selected foods. You have to put them in protected positions. Cut limbs with slashhooks, and throw a patch of them on the ground in an animal's range, and put in a tree. Your food plant gets up and growing before the animal can get at it. That's exactly what Geoff Wallace did with his apple trees.

Some plants grow their own thorns, have their own protection; but many don't, so we must give it to them. So wherever we are dealing with range, and range management, we always have to think of this as a factor. We have to give our preferred animals some chance of not reducing their range, and a place to escape from predators.

I want to talk briefly about animals that are not normally considered in systems. I will just give you a few examples, so that you can get an idea of the range.

On the Hawaiian Islands, and only on the Hawaiian Islands, there is a sea mollusk that comes crawling up into

the fast streams. It is real good eating. There is no other mollusk that I know of anywhere else in the world that lives in hot streams, crawling over rocks, browsing on algae and converting it into good food. It exists only on a few islands. But it is obviously transferable to that particular sort of niche, and could be a food source.

The coconut crab does all that shredding work and provides a lot of insect control.

The slender blue-tongue lizard eats slugs--nothing else, just slugs.

The whole group of tiliqua in Australia are snail eaters. There are desert snail eaters, sub-tropical snail eaters, and cool to cold temperate snail eating lizards.

Then the geckos as a group are very good little pest controllers for glass houses.

We have mentioned the frogs and some of their characteristics that are beneficial in the control of quite specific pests that are otherwise chemically controlled.

Get the woodpecker on the bark, and the bantams under the trees, and the coddling moth incidence drops down to its usual about 1%.

A specific orchard pig, the Gloucester, is bred as an orchard forager. That's its place. The little wallaby, which are short browsers and live in dark thickets, maintain fantastic lawn systems. They are very soft in the system. They don't worry plants over 24 inches high. Geese are very similar, but a little harder than the wallabies when it comes to doing sward under nut trees. Geese-and-walnuts is an ancient combination.

The ideal farm: Sit there looking at your geese, and looking at your walnuts. Once a year you clip both of them (the geese, twice a year).

Some of the large land tortoises in sub-tropical or semi-tropical areas are short browsers and fast growers. They put on about 40 pounds in two or three years. They roll your lawns while they crop them. A herd of land tortoises would be much better for the grand Taj Mahal than 34 widows on their knees, cutting the grass with little knives. Turtles are easily controlled. Fencing is minimal.

Tasmania has perhaps 60 species of a strange little thing called a phreatocid, a pedestrian amphipod. It has a circular body section, and it walks slowly just below the mud and leaf surfaces. They are primarily decomposers in cold waters. They will be active all the time. Under the ice, they will be chomping up leaves. They don't occur anywhere else in the world except right down on the tip of South America. They are an Antarctic edge species; they follow the ice caps up and down. The only place they can do that is in Tasmania and a little bit of South America. They have also adapted. Some of them have come down the mountains a bit. In the Devonian ice age, you had them over here. You find them as fossil.

Where they exist, they are a major food of the introduced trout. Trout eat far more insect here in America. In Tasmania, they may eat 20% insect and 80% phreatocide to trout, skipping a whole lot of intermediate steps.

Again, in Tasmania, because it is an oceanic island, because it is the remnant of an old continent, we have extraordinarily large fresh water limpets. These occur only in one lake, and they are the only ones of their sort. They are cold water limpets and, again, a major food of fish in the waters where they occur, where there are rocky bottoms on the lakes. They are algae browsers, and where they occur, there is a very fast conversion to fish protein.

Now if we, at least on paper, figure some of the possible short cuts through the trophic pyramid, we always look for our primary decomposer, the algae browser groups, the diatom eaters. That's why grey mullet is such a fantastically important fish. It browses diatoms and it weighs 15 pounds. For brown trout, we begin with leaf algae, go to zooplankton, diatom, shrimp, and then up to another whole group of cold water fishes, the galaxid fish, then the trout. We will give it a 10 factor. It takes 10,000 pounds of leaf to make a pound of brown trout.

But if we go from leaf to phreatocide to brown trout, we only need 100 pounds of leaf to produce a pound of brown trout. So we get a hundred times more brown trout by way of the phreatocide food chain. Every time you go up a trophic step, the conversion consumes nine parts of every 10 of your food. Therefore, what we should be actively seeking out is these short-cuts, and particularly the large, low-level decomposers, chomping on leaf and algae and diatoms.

The role of the mussels is in phosphate fixation, and in calcium fixation. Now in your area, you should not eat those. It is better than you get that phosphate and calcium stopped before it goes to the sea, because it is phosphate and calcium that you are low on around here.

The phreatocide is really too valuable to eat because it may be the only thing we can use to get those leaves mobile again. It would be like eating all the worms out of your field.

I am pointing out that if you don't start maintaining these systems, you are in real trouble, and many of these things will be wiped out. Let us not pussy-foot around. There are enormous processes of destruction. As far as we know now, in the Adirondacks there is no more cycling of nutrient. You better get busy and find an acid decomposer, and quickly. What's gone is gone. What we are trying to do is accommodate millions of people in places where a degraded and degrading environment can support but thousands. We must make pretty smart moves. Other than that, we can continue pussy-footing around until the whole system falls on your head.

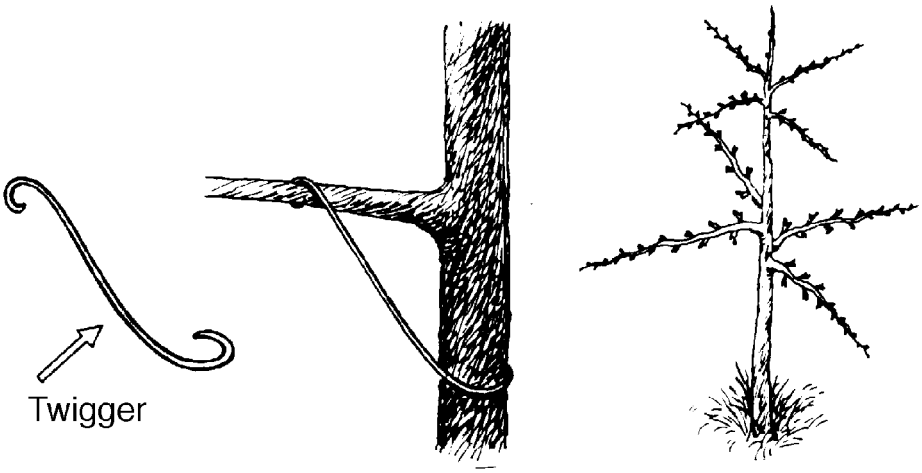
What I am saying is that we should look far more closely at the functions of animals that are not normally considered as integral parts of constructed or even agricultural or aquatic systems, and see what particular value, what particular niche they might occupy to increase the number of useful nets in the energy flux. The phreatocide is a fine example. We have many, many species of them,

because in the Devonian there were billions of phreatocides of varied sorts. Their pH range, too, is enormous. They did not come towards high alkali. They go towards high acid. The normal data reading in some of our rivers is pH 3.5. It is too acid for mollusks.

Consider your guard animals, too--animals that give adequate alarms to other animals--guinea fowl for example. They are great for spotting practically any danger, and their alarms work for your other domestic poultry.

PRUNING SYSTEMS

You only prune very close to houses, or on very small properties. You all know of ordinary cut pruning: A very low tree; keep the thing going out as a low open situation. It is a good form of pruning for light, for easy picking, for easy handling of pest control, and so on. It would be a fairly normal thing to do. It is the form of pruning that most nurserymen can show you. It varies from place to place, and from species to species. But as a general method, it is perfectly adequate. Props between these branches keep them spread. You just pull a branch out when it is young and prop it into position to keep it spread. The main thing is to decrease the number of joints that are sharp, and to increase those in the main stem that come out fairly broad. These are the strongest ones. The idea is to force that branch out from the tree like that when it is young. It will be much stronger.



One additional thing, looking down on that tree as a system, we are apt to find that apples, pears, and most things are biennial bearing, so that you have heavy on, heavy off years. Now what you do is this: Think of the tree crown as divided into three sections. Start to prune around the tree, pruning heavily, lightly, and not at all, on your three separate sections. Then next year, the section that was previously lightly pruned gets heavily pruned. The unpruned section gets a light pruning, and the heavily pruned gets no pruning at all. You will find then that you don't have a biennial bearing tree any more, and can fairly competently predict the amount of fruit per annum that you will get. What you will get is a fair number of small fruit on the unpruned portion, a small number of large fruit on the heavily pruned portion, a small number of large fruit on the heavily pruned portion, and the most fruit, of medium size, on your lightly pruned portion. This cuts the pruning down, as you can see, to less than half the cuts you used to make. Moreover, it makes your crop far more predictable, so that you can govern the market much better, or even light domestic demand. In total, you get slightly more fruit than as if you let the thing run biennially. So you don't lose any fruit. But you get a variety of sizes.

If you are going to make this the central tree in beds, you can also follow in the beds a rotation around it, so that you are treating your bed sections on thirds as well; and you garden from high demand, to medium demand, to root crop, to high demand. You mulch on thirds: heavy mulch, light mulch, no mulch. You sort of make for yourself a little wheel that you keep spinning. There is no reason not to have that tree in the center of a garden plot, with its rosemary and other plant associates under it, many of which are specifically chosen to be the host species for wasps, which help the garden situation.

Now we go into zone two. Here you would not even bother to prune peaches, except to cut out dead wood, because the least pruning you give the whole group of peaches, cherries, and apricots, the better. The only reason you prune is to cut out dead wood and die-back, and to start branches around them. In zone two, continue to prune the pear and apple groups, and very vigorous, tall growing trees.

This is how you do it. Let the stem grow to two or three feet high. Then you select four buds at right angles to each other, and you tie them down to the stem, using a thing called a twigger. Looking down the stem, you are going to have four branches set out at right angles to each other, spread out to maybe fifteen inches. Tie these down. Then let the stem grow on two feet clear, rubbing out any branches that come, and do it again. In 18 months to two years, you usually have a couple of those done. About the time you have done it four times, you won't have any main trunk left. You have taken the tree right out.

What you have now is a tree very thick at the butt, tapering very suddenly, a very strong thing. We are talking here about powerful trees that normally grow strongly and which would otherwise get very high on you. We stop them from getting high; we suddenly pinch them off.

It is almost impossible to break those branches with fruit load. They are very powerful. Once you have it like that, you never bother with it again. Just cut off any water shoots. It is an immensely strong and durable tree that will last many years. You take out the branches after the first

season's growth but sometimes you need to adjust them for part of the next season. What you have is 16 leaders; for each of these side branches is also a leader. So the tree is quite happy. It doesn't attempt to get away from the pattern. It gets fatter, produces more buds, but it doesn't break out of that pattern. Eventually, all these leaders turn into very large systems. Broadly speaking, there is very little pruning to this tree. It is a little-cared-for tree. Just use this method on large pears, apples, and plums that are very vigorous. It is cheaper to buy from the nurseryman a whip-graft tree the first year and start doing what you want.

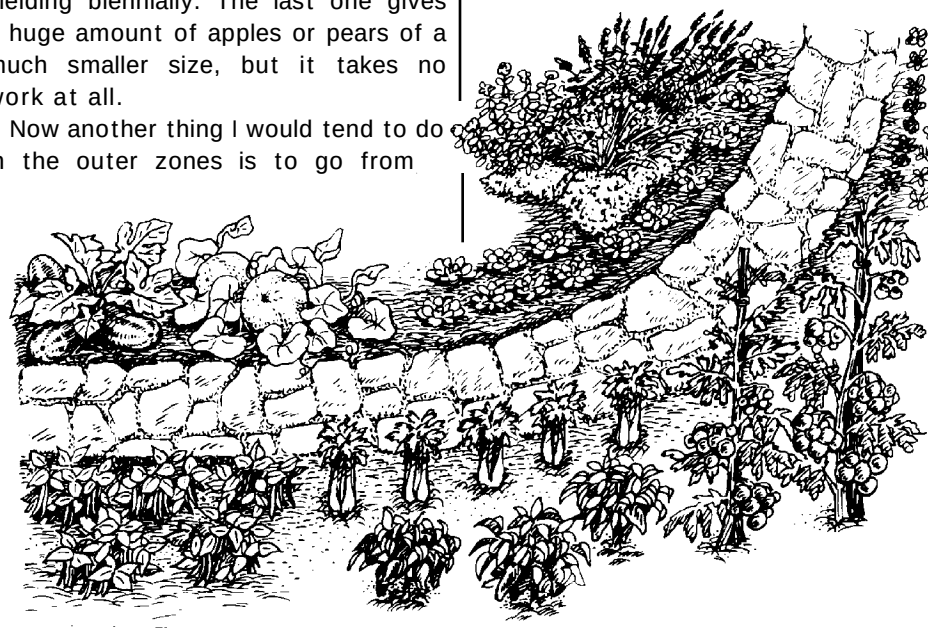
The zone three form of tree is even simpler. There is only one thing to do. You see this all over Britain: Drive a very strong large stake and tie it up for eight feet, or plant it in the back of the bush and keep the trunk completely free of branches for eight feet. It takes four or five years. Then let it go, and it matures very rapidly into a very dome. You never prune that; you never even look at it. It will stand animals browsing around it and under it and through it, quite heavy animals.

So what you really have is three sorts of trees, all the same species. One needs a fair bit of attention, giving very predictable yields; the second one needs very little attention, yielding biennially. The last one gives a huge amount of apples or pears of a much smaller size, but it takes no work at all.

Now another thing I would tend to do in the outer zones is to go from grafted to seedling trees. It's too far to get to in the summer, and particularly in spring. Drive down the roadsides and mark all the apple seedlings this winter. Go back in spring and find out from the flower what variety they are. In mid-winter, go and lift them out of the roadside hedgerows. They would eventually only be graded out or smashed down by the road crew. We plant those trees out, sometimes by the hundreds. People keep throwing apples out of cars and renewing the stock. Good plums, too. You root prune and top prune, and if you are going to put it in near the dwelling, you graft. If you are going to put it farther out, just plant it out there, put a stake in it, take five branches off, and up grows its leader.

Anything we have grown from seed gives us a very good fruit. We only want a whole lot of fruit, good fruit.

In summary, around our fruit trees, we put in crops that will give secondary yields, maybe commercial yields. That ranges from flowers to edible products. Put in crops that will support the foraging animals, reduce pests, and increase manure. Bring in the right animals. Put in structures like the little ponds and rock piles that will invite the right animals. Put in flat rock to decrease grass competition, and to stop soil compaction. And, finally, put in the plant's culinary associates.



Notes from the Editor

I'd like to elaborate on some of the topics Bill addresses here and in a few places disagree. One of the topics that I'd most like to comment on is the use of poultry in permaculture systems.

• Bill's designs for poultry escapement will not work in most of the Western Hemisphere because we have a predator that is unreasonably competent, the racoon. Moreover, unlike most wild animal species, the racoon will slaughter as many chickens as possible, just for fun.

Racoons swim very well. Islands will not protect poultry. Waterfowl are among their favorite victims. They can climb fences, dig under them, or simply unlatch gates and walk in. They can turn door knobs, un-hook hook-and-eye catches and slide barrel bolts, though they need a way to reach these devices. If deep water is present, racoons will drown dogs 10 to 20 times their size.

In this environment, poultry must be secure at night, when racoons are active. Fortunately, racoons are good to eat. Never trap a racoon and release it, however, as it will never be fooled by that type trap again and will be an intractable problem for you and/or others. Racoons are lazy and will walk into box traps to get husked corn, even if there is a cornfield nearby. In fact, they will go for the husked corn right in the cornfield itself. Barrel traps are reputed to work, but I've never encountered a racoon stupid enough to go into one. If you want to try, put a cull hen at the bottom of an open 55 gal. drum. Place a plank leading from a ground up to the open top of the drum. Supposedly, the racoon will go up the plank and jump in to get at the chicken. It can't get out.

If you hear a racoon struggle in a trap, do not wait until morning to deal with it. Other racoons will work to help it escape and often they succeed, particularly in live traps which otherwise minimize suffering of the animals.

• In addition to the seed, chickens eat Caragana leaves. The same is true for honey locust leaves, and probably hose of other useful tree crop forage plants. If they are set out in the chicken run, be sure to protect them thoroughly. Otherwise, they can be planted a foot or more outside the fence. When the plants are large enough to tolerate loss of leaves up to two or three feet from the ground, you can move the fence back to include them in the range. Or just let the chickens out.

Geese, though they eat mainly grass, are death to seedling and sapling trees. They will ring the bark from them and kill them. Probably they are protecting their own forage. Once trees and shrubs are too tough for this damage, geese effectively suppress grass competition.

For more detailed information on poultry forage, see The International Permaculture Seed Yearbook (**TIPSY**) #2, which features a special poultry forage section. The same issue also has a bee forage section, with lists and ratings of bee forage plants.

If you are interested in Caragana, in particular, **TIPSY #1** carries a very good article on that genus by Thelma Snell. Thelma's piece is probably the best that has been written in English. (Most material on Caragana is in Russian.)

Vol. I, No. 3 of The International Permaculture Solutions **(TIPS)** Journal contains a extensive survey of methods for managing soil in permaculture systems. Readers of this pamphlet may be especially interested in my comments on using chickens in conjunction with mulch. In temperate climates, chickens are let into the mulch before and after annual crops are grown. In tropical situations, they are rotated. I have observed that chickens get most of their food from the invertebrates that live in mulch. I suspect that chickens also eat raw compost.

An ideal plant for poultry forages is the black raspberry (Rubus occidentalis), at least in regions where raspberries are native. (Brambles can be rampant and should not be introduced as exotics.) The tip-layering black raspberries provide excellent cover for brooding hens, and they escape the depredations of racoons and skunks **while nesting.** Once chicks are hatched, steps must be taken to protect the family at night. Where tip-layering blackberries grow, these may be even more effective. Rubus does very well in conjunction with chickens.

Black raspberries spontaneously associated with umbrella-shaped fruit trees such as apples, growing at the drip line where they are very productive. As Bill notes regarding blackberries, they benefit the tree. Of course, there is more to it than he goes into, having to do with the ability of the blackberries to suppress grass, mobilize trace elements, and attract various kinds of animal life, from soil dwellers to birds. Raspberries do the same, though not as robustly. Chickens fit these systems well. They take the lower berries, about eight inches above their height (they jump), but leave the ones easiest for people to pick. They get some berries, but you get more than if they were not there. A happy chicken is a wonderful asset.

• Watch out for Bill's admonition to mulch clay. It is easily overdone. The interface can be too moist, causing an anaerobic souring of soil and mulch that promotes diseases that, for example, kill tomato plants. Sandy soil greatly benefits from mulch because far less moisture is lost to evaporation. Sandy soil does not hold nutrients well, so the propensity of plants to feed at the mulch/soil boundary enables crops to take nutrient as it is released, before it leaches out of reach. Plan crop densities to fully utilize this release. It will take some experimentation with specific conditions, including mulch type.

Seaweed is a particularly valuable mulch for sandy and coarse soils because it forms a gel that holds moisture between soil particles. Grass clippings, which could not be used on other soils because they form a gley, suit sandy soils almost as well.

• Note that there is one major drawback to mulch. In fall, mulch holds heat in the soil. On clear nights, particularly when there is a sudden temperature drop, even hardy plants such as broccoli will receive frost damage because the soil heat is unavailable to them. Annual plants must be mulched completely over their tops during cold snaps, to mitigate this effect. (Old bedspreads are easier to remove in the daytime than ordinary mulch.)

The effect is mainly with lower annuals. Trees reach past the effective benefit of soil radiation. They benefit from having soil temperatures more stable due to the insulating effects of mulch. Roots grow longer into the season and chance of frost heave is much less.

• With Jerusalem artichokes, be aware that they are allelopathic–they poison some other plants as do all other types or sunflowers. They can also be difficult to exterminate from a place, unless you have access to pigs. Pigs love them, can smell them underground, and, released in an unwanted patch **after tubers have formed,** they eliminate these plants entirely.

• Pigs control grubs, slugs, and even poison snakes when let to forage in a garden after harvest. They are easily contained by electric fence, just inside a lightweight temporary woven wire fence. (The temporary fence slows them, and the electric repels them.)

By the way, you can also keep racoons from an area by putting a strand of electric fence about four inches above the top strand of woven wire. They climb the wire fence, which is perfectly grounded, and then reach for the top, electric strand. Zowie! They aren't seriously hurt physically, but they may never return. This is very effective.

Back to the pigs, they can be let in closer gardens as the cool weather closes them down. Cool weather means fewer smells. Pigs smell only when overcrowded or fed kinds of garbage they won't eat. (Its the garbage that smells.) They completely eliminate witch (quack) grass and other rampant grass weeds. They root out and eat the stolons, underground stems by which the grasses spread. Pig foraging is an excellent rotation in the permaculture garden.

Of course, they also do good things in the orchard/tree crops situation. As Bill points out, they will brave those brambles that have been doing other jobs for us, and get the fallen fruit from them. This prevents pests from overwintering in the fruit, and of course feeds the pigs. Pigs can fatten on fruit as well as on corn, but they need a lot more fruit. Bill has written a special paper on pig forage, available as Yankee Permaculture Paper #19, Pig Raising and Free Range Forage Species.

• If you are following Bills advice on how to prune your tomatoes, make sure that they are indeterminate varieties, not determinate varieties. The first just keep on growing until something kills them. The determinate types (sometimes called bush varieties) have only so many shoots. If you remove shoots, you cut yield. Don't prune determinate tomatoes. They are good for dense plantings and have a high yield per unit area. Indeterminate tomatoes lend to trellising in various systems and have more design and companion planting potential.

• Use alyssum around your plants to attract the "beneficial" insects that require pollen and nectar in their adult stages. It is perfect, and blossoms over a very long period.

• Bill says, don't feed sunflowers to chickens because they make the feathers fall out easily. Thelma Snell, reading this after initiation into the joys of chicken plucking, suggested that we should save our sunflower seed to feed to those chickens we are about to slaughter. It will make the feather removal operation much easier! That's permaculture thinking folks. Just stand limitations on their heads to create opportunities.

• Other Yankee Permaculture publications related to permaculture techniques discussed here include:

YPC 5. Useful Climbing Plants. Mollison.

YPC 16. Gardening Articles, by Dan Hemenway, reprints.

YPC 20. Circle Garden Patterns, Webb & Hemenway.

YPC 30. Articles about soil by Dan Hemenway, reprints.

YPC 31. Plants for Use In Permaculture in the Tropics, Frank Martin.

YPC 36. Patiofarming in the Tropics and Subtropics by Frank Martin.

And all Yankee Permaculture journal issues, which are packed full of practical information that will make permaculture techniques work better.

Yankee Permaculture's address is on the cover of this pamphlet.