Agri – (- Perma – and Eco -) – Cultural Themes

(- mainly out of the Book " **Permaculture** " from Bill Mollison / Australia)

☯

1. Panchavati

Panchavati: The Sacred Grove of India

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LECTURES, WORKSHOPS, COURSES, DESIGNS & PLANTING

TIPSY editor Dan Hemenway makes his living, which helps underwrite this publication, by writing articles and giving lectures, workshops, and courses. Dan prefers teaching people to produce their own designs, but he also produces a few designs each year for institutions, groups, and individuals. These services are offered internationally.

Talks and Workshops are heavily illustrated with slides where appropriate:

Permaculture for Cities	Introduction to Permaculture
Permaculture for Suburbs	Permaculture on the Farm
Permaculture for Homesteaders	Permaculture for Vegetarians
Permaculture for Arid Lands	Permaculture for Intentional Communities

and so forth. Other topics:

Alternative Economics — Responsible Self-Reliance — Models for creating responsible, community-based economic structures and arrangements.

The Future is in Question — A talk or discussion on the status of the environment. Global trends in population, air quality, water supply, climate, forests, soil, and economics are examined and a pathway for healing our earth is offered.

Organic Gardening/The Permaculture Perspective — Gardening is an important step in self-reliant living. Techniques of organic gardening are illustrated with slides, and results comparing chemical and organic methods are shown.

Solar Design in Permaculture — Solar energy is a simple, appropriate technology within the reach of any person. Solar season extenders (for gardens), greenhouses, domes, homes, and bioshelters are discussed, as well as other solar energy applications.

Wood Heat, Woodlot Management, and Cordwood Construction — This talk addresses serious design questions around pollution and deforestation. If a woodlot is available, selection, felling, limbing, bucking and splitting can be demonstrated. Pollarding, coppice management, and special fuelwood species are covered.

Useful Woody Plants for Permaculture — Emphasis on plants useful in the workshop area (urban, rural, arid, etc.) helps tailor this presentation for soil building and enrichment. Fuel, fiber, habitat, windbreak, precipitation increase, bee forage, fruit and nuts, are discussed.

Appropriate Technology — Tools for Permaculture — Based on slides taken at the New Alchemy Institute in Massachusetts showing uses of wind, sun, water and earth.

Working with Youth, Inmates, the Elderly, and other Disenfranchized — Gardening is a powerful tool for increasing self-esteem among persons who have been rejected by society. Bring your problems!

PERMACULTURE DESIGN COURSES

Elfin Permaculture Design Courses are a 3-week intensive program with about 150 hours of instruction and design practice. Completion of a Permaculture Design Course (PDC) usually qualifies the participant as a Permaculture Design Apprentice. Procedure for certification as a Permaculture Designer is explained in the course. Special PDC's for urban settings and for intentional communities are offered. Special PDC instruction is also provided in countries where no Permaculture centers now exist, with participation limited to nationals of that country. Design courses for intentional communities and for creation of National Permaculture centers will ordinarily last longer than three weeks.

Permaculture is a self-reliance movement. You may be asked to sponsor or find a sponsor if you wish a talk, workshop or course in your area.

Permaculture Apprentices. Expressly for graduates of the Permaculture Design Course, we have established the American Permaculture Training (APT) Program. Write for information and see the article in the 1985 edition of The International Permaculture Seed Yearbook.

Financial support for persons seeking to study Permaculture is greatly needed. If you are willing to contribute to a scholarship fund, please contact us.

PERMACULTURE DESIGNS

While, as a self-reliance movement, we prefer to train people in the design process, we do offer our service to produce a limited number of designs each year. Permaculture designs include an assessment of the site, evaluation of the client's goals with respect to the site, and design recommendations which attain those goals in ways that enhance the site from the ecological viewpoint. Designs routinely address water supply, food supply, soil building and maintenance, shelter, energy, income, aesthetics, and community interactions. Economic feasibility, client skill and resource levels, and the evolution of the design implementation over time are addressed.

Permaculture slide/script presentations. Elfin Permaculture has in production about a dozen slide/-script presentations on subjects relating to Permaculture. Since these slides are the same collections which we use for Elfin Permaculture and American Permaculture Training (APT) lectures and teaching, availability of slide sets depends on our teaching schedule.

Prices of presentations, subject to change without notice, are as follows:

Introduction to Permaculture	$150
Succession in Nature	$150
The Environment in Mexico	$150
Organic Gardening: 3 parts	
Part I - Soil Management and Gardening Style	$100
Part II - Insect Control and Other Techniques (examples of results, also)	$150
Part III - Design in Gardening; Soil Erosion; Urban Strategies	$150
Special Section on Gypsy Moth	$ 25
Solar Energy in Permaculture:	
Part I - Solar Season Extenders	$ 50
Part II - Greenhouses, Bioshelters and Other Solar Applications	$150
Water	$150
Useful Woody Plants	$250
Deforestation	$250
COMPLETE SET (separately $1725)	$1500

Leaves:

- Young tender leaves used as a vegetable (good source of ascorbic acid).
- Ash of burnt leaves used as a household remedy for burns and scalds.
- Decoction of leaves & bark as an astringent mouthwash.
- Fumes from leaves inhaled for relief from sore throat.

Bark:

- Juice of fresh bark applied to skin for scabies, skin parasites.
- Cold infusion of bark beneficial to mucilaginous membranes. As a tonic for bleeding piles, haemorrhages of the uterus, intestines, lungs.

Flowers:

- Dried flowers are astringent; given for diarrhoea and chronic dysentery.
- Dried, used as a fumigant against mosquitos, burnt with powder of pyrethrum flowers and cow dung.

NEEM TREE (Azadirachta indica) (Meliaceae)

Almost every part of the tree is bitter, and all parts are used in Ayurvedic medicine. Recently, the tree has been investigated for its insecticidal properties; the active insecticidal principle is azadirachtin, which presvents the sloughing of the skin in insects; dealth follows for larvae, pupae, and caterpillars.

Leaves:

- Dried leaves placed in books, paper, rice, and clothes to protect them from moths & other insects (has an unpleasant smell).
- Twigs of the Neem are the toothbrush of India.

Bark:

- Decoction for fevers, nausea, liver complaints, jaundice.
- Poultice for wounds & skin diseases.
- Bark oil is locally used for rheumatism (rubbed in).

Fruit:

- Steeped or crushed, used for urinary complaints, piles, worms.
- Considered a purgative and an emollient.
- Fruit & seeds blended in water as an insecticide.

Oil from the Seeds

- Effective against head lice.
- Sprayed on garden plants, will deter insects (but is not harmful to humans).
- Poured on water, will kill mosquito larvae.
- Rubbed on body as a cure for skin diseases.

Effects of Melia azaderach (white cedar) are very similar to the Neem. White cedars are widely distributed in Australia. Wood from both trees is termite-resistant and useful in building.

Leaves:

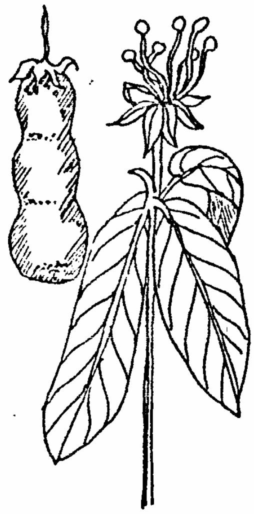
. Fresh, will curdle or sour milk.
. Infusion with fenugreek (*Trigonella foenum-graceum*) for chronic dysentery.
. Decoction as a mouthwash & for sore eyes.
. Excellent alkaline soil mulch or manure; used on cardomon trees.

Bark, Twigs, Root

. Effective in treating diarrhoea.
. Root ferment for jaundice, dyspepsia, cough.

Seeds:

. Ointment of seeds (burnt in oil) for scabies, itch.
. Infusion for fever, nausea, diabetes.



ASHOK (*Saraca indica*) (Leguminaceae)

A small, evergreen tree (6-9 meters) with flowers in dense bunches, at first orange and eventually turning vermillion. The flowers are often used for religious ceremonies and temple decorations.

Bark:

. Cures biliousness, dyspepsia, dysentery, colic, piles, & ulcers.
. Used to stimulate the uterus during contractions.
. Useful in internal bleeding, haemorrhoids, and dysentery (slow but effective).

Flowers:

. Excellent uterine tonic.
. Pounded in water, used in haemorrhagic dysentery.

Leaves:

. Blood purifier; leaves mixed with cumin seeds is used for stomach aches.

Two important trees, the Mango and the Neem (or Nim), can be located near the grove, as these two trees have very important uses.

MANGO (*Mangifera indica*) (Anacardiaceae)

The mango is highly regarded in India, both for its fruits and for its medicinal qualities. It also has great cultural and reglious significance, particularly revolving around births, marriages, and death.

Fruit:

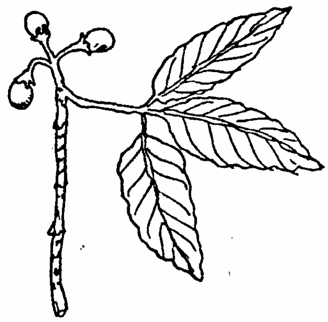
. Unripe fruit used in pickles, chutneys; useful in treatment of scurvy.
. Ripe fruits high in vitamins A & C, to a lesser extent vitamins B & D. Juice is used as a refreshing tonic (for heat stress).

BEL (Aegle marmelos) (Rutaceae)

The bel is an important medicinal tree in India, is sacred to Shiva, and associated with fertility. The fruits are small and sweet, with an orange-coloured, thick, mucilaginous pulp.

Bark:

- Used to stupify fish.
- Decoction of root bark for heat palpitation, fevers.
- Decoction of root bark with sugar and fried rice for gastric diarrhoea in children.



Leaves:

- Much used in religious offerings in temples.
- Decoction for asthma, fevers.
- Fresh leaf juice with black pepper for constipation and jaundice; with honey as a mild laxative.
- Fresh leaf juice for opthalmia, eye diseases.

Fruit:

- Unripe fruit as an astringent; useful in diarrhoea and dysentery.
- Ripe fruit is sweet, aromatic, and cooling. Generally used in the form of a sherbet.
- Dried, powdered pulp as an antiscorbutic.

AMLA or AMALAKI (Emblica officinalis) Indian gooseberry (Euphorbiaceae)

Native to India, this is a small deciduous tree with feathery leaves and 1/2-1" diameter fruits. The fruits are sour and astringent when eaten raw, but are much in demand for making pickles and preserves. The fruit is one of the richest known natural source of vitamin C, containing nearly 20 times as much as orange juice. The fruit contains a tannin responsible for retarding the oxidation of the vitamin; this antiscorbutic value is conserved by preserving the fruits in salt solution or in the form of a dry powder. Often, the fresh fruit is boiled and kept in sugar solution over a summer for medicinal use. Many parts of the tree are useful and held in high esteem in Ayurvedic medicine.

Fruit:

- Is acrid, cooling, diuretic, laxative.
- In combination with iron is used as a remedy for anaemia, jaundice, dyspepsia.
- Dried, useful in haemorrhage & diarrhoea.
- Made into a sherbet with lemon juice arrests acute bacillary dysentery.
- Fresh juice & sugar relieves burning sensation in vagina.
- Used as a liver tonic & in the treatment of tuberculosis.
- Fresh, the fruit aids vermifuge action.
- Juice used for fevers, hiccup, vomiting, indigestion, & chronic constipation.
- Dried & crushed fruit used as a (black) hair wash to preserve hair colour.
- The exudation from incisions on the fruit are useful as an external application for inflammation of the eye.

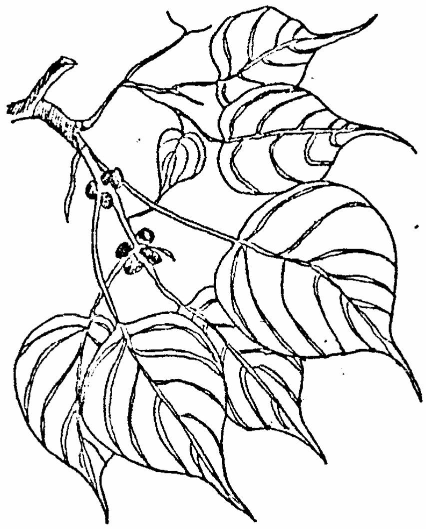
MEDICINAL USES OF THE TREES OF THE SACRED GROVE

PIPAL (Ficus religiosa) (Moraceae)

The pipal is a large tree, epiphytic when young, fast-growing, and easily raised from seed. It is very long-lived; one is said to exist in Sri Lanka which was planted in 288 B.C. The pipal is the tree of knowledge and enlightenment, and is planted all over India as a roadside tree. However, when placed in the sacred grove, it is on a stone platform.

Bark:

- Is an astringent. Decoction & infusion used for ulcers, inflammations, & skin diseases (an aqueous extract of the bark shows anti-bacterial activity against Staphylococcus aurea and E. coli).
- Juice as dressing for cracked feet and for inflammation of gums.
- Powdered root bark on unhealthy sore to aid granulation & healing.



Leaves and Tender Shoots:

- Used as a purgative & in skin diseases.
- Tender shoots boiled in milk & honey as a cooling drink.

Fruit:

- Digestive, laxative; eaten in times of food scarcity.
- Dried fig powder in water for asthma.

BAT (Ficus Bengalensis) Banyan Tree ("Banyas" means "merchants")(Moraceae)

A very large tree, with an indefinite lateral spread, reaching 50-80 feet high. In India, merchants sell wares beneath it. Vishnu was born beneath this tree; it is sacred to Shiva.

Bark:

- Astringent; infusion for diarrhoea, dysentery, diabetes (specific for diabetes, reducing blood sugar).

Latex:

- The milky juice off the stem of the fruit is applied externally for pains & bruises, and as an anodyne in rheumatism. Also used as a remedy for toothache.

Fruit:

- Readily eaten by birds; eaten by humans in times of scarcity.

PANCHAVATI: THE SACRED AYURVEDIC GROVE OF INDIA

Compiled and Illustrated by Bill Mollison & Reny Slay

Sacred trees are planted in holy places. The sacred tree is considered to be the source and sustenance of life, worship, sacrament, and mystic charm closely associated together. In the garden of Lord Indra (Krishna) there were five trees of "wonderful importance", due to their uses in worship and in medicine, their association with the gods, and as places of worship in themselves. In Panchavati, the spirit of the five trees, or sacred grove, is merged into one spirit.

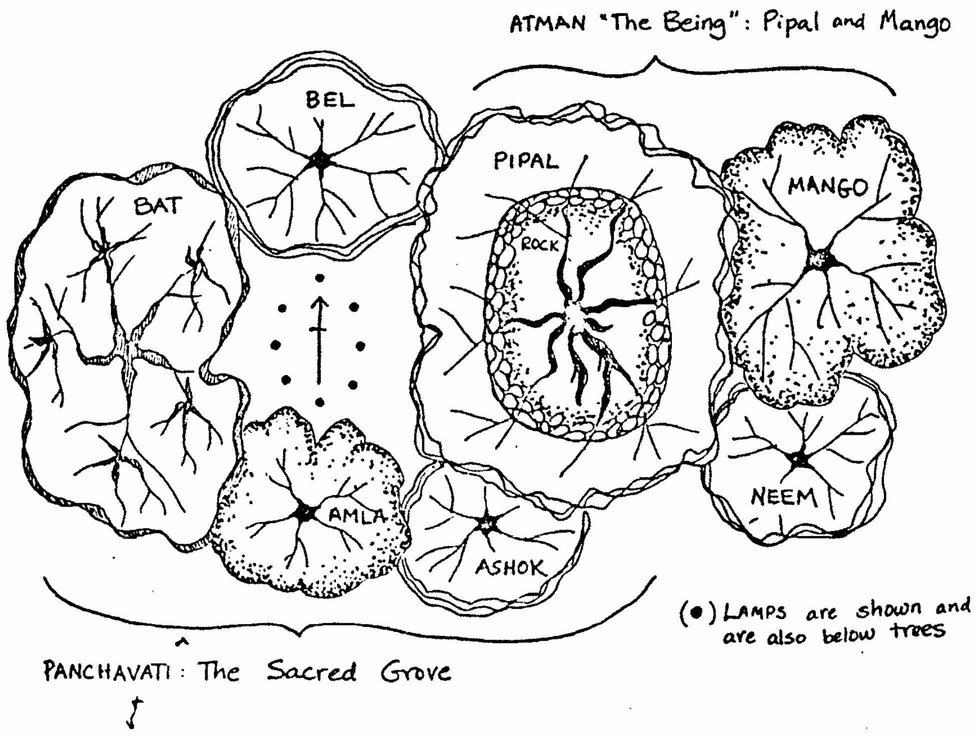
These five trees are recognised as being a sacred and proper place for meditation and self-realization, and their placement in the grove is of particular importance.

To the north is BEL (Aegles marmelos)
To the east is PIPAL (Ficus religiosa)
To the south is AMLA (Emblica officinalis)
To the west is BAT (Ficus bengalensis)
To the southest is ASHOK (Saraca indica)

The pipal, under which Buddha attained enlightenment, is always planted centrally in a large stone and earth platform, about 6 meters square or round, and 2 meters high. These can be seen in many villages throughout India.

As the pipal also unites with the MANGO (Mangifera indica) to form the entity ATMAN, or "The Being", then the mango may also be planted to the east of the grove, with its companion the NEEM TREE (Azadirachta indica). Both are grouped near the pipal, sometimes on the same platform; however, they will soon be overgrown by the pipal, so are best placed off the platform.

Lamps are lit below the trees in worship, or in the eight directions.



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Sacred and Useful Plants and Trees of Nepal, 1978 US $7.00 postage paid

Available from the publisher: Sahayogi Press
Tripureshwar, Kathmandu
NEPAL (Phone: 11489)

2. Council of Scientific and Industrial Research, India
The Wealth of India, 1948-1976 11 volumes
A Dictionary of Indian Raw Material and Industrial Products

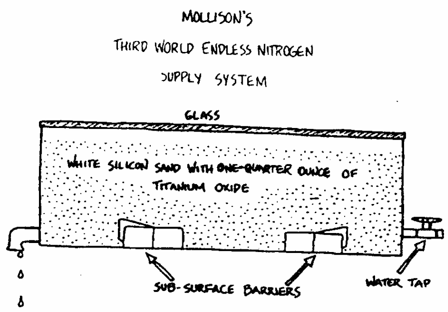
Available from: Sunderdas Gianchard, (Agents: Government Publications)
601, Girgaum Rd., near Princess St.
Bombay 400 002, India (Phone: 31 05 18)

Cost of books between $3.00 and $15 per volume; total cost (not including postage: 700 rupees.

2. Titan – Oxide - Nitrogene – Air – Fertilizer

So what you do is run water pipes through a box of black sand. If your sand isn't black, you blacken it. Put a glass top on 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 nitrogen 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 build-up 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 or 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, that is how you do it.

Want any more inventions?

That will do, that will do.

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. And 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 in it. They have never been able to account for it. And when he considered the amount of dunes and deserts in the world, he said, This is it! And 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 el I took out a bottle of titanium oxide for our vill age. I never made any more of it. You can buy it by the pound if you want to. It is a common fille in white paint, after they got rid of lead. This nitrogen evaporates in the deserts, goes into the atmosphere. That's why it is there. What occasio ally carries it down is rain. That's why deserts grow plants. That's why you can start into a syst 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 that dance across the beach and I was persuaded.

My home town is a good example of a place where it is always working. It has a basaltic coastline wit a lot of little steam holes in the basalt. Some ar quite big. And the sea is crashing in here, and th waves drifting inland, and it is also raining at times. So what really happens is that in these bla basalt holes, you get seawater evaporating. What y have in those holes is a high saline solution, twic the amount of sea salt. When it rains, the rain water sits on it. So you get fresh water sitting o salt water. You can't dip your hand into that pool What happens is, this pool 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 which, you will note, is insulated at the top by water, which is a good insula tor. 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 algae growing in there, violent looking stuff. You have different layers of mosquito larvae belonging to different species of mosquito, but whic are quite specific to that site. 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.

If I were to make one, I would make it out of black concrete and I would put straw right around it. Coo your spuds down in here.

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

Everywhere, all this is happening naturally. A civi 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 on 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 foot 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

3. Hot Water

some of your raspberries and everbearing strawberries. Because they flower all the 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 east or 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 midsky; forget about due south, come to midsky. Don't be so silly as to take a house and align it due south, when from three o'clock in the afternoon 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.

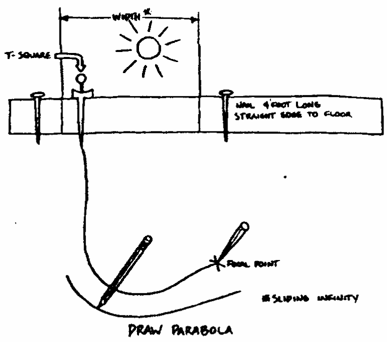
I do think, though, we could build houses that would of themselves be enormous energy collecting surfaces. We accidentally got it in Australia with an office building five stories high, which has these blind windows, copper glazed, or gold glazed windows. But the focal point is about fifteen feet above 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. Pretty 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 heat the house. And 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. Are you picking holes in that?

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 on 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:

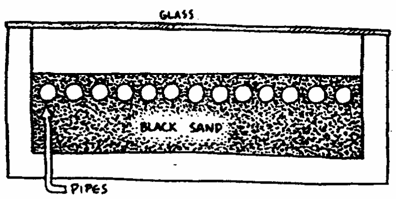
MOLLISON'S SLIDING INFINITY PARABOLIC CALCULATOR



I will give you a few more inventions which 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. And 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. Black sand. It was intolerably hot.

MOLLISON'S
ULTRASOPHISTICATED, CHEAP, FAST
SOLAR HEATER



* East-facing windows are very advantageous horticulturally as plants benefit disproportionately from morning light. - Ed.

4 . Seed – Pelleting and Seed – Balls

elements. In fact, some patents have apparently been granted for mining gold deposits using banana or citrus plants deprived of some common elements (potash, phosphate); their leaves then concentrate sparse deposits of gold.

Oysters will concentrate zinc (to 11% dry weight, an emetic dose), abalone concentrate cadmium, and several large fish concentrate mercury and biological poisons from corals (to inedible levels). There are obvious implications for the removal, collection, or use of such species—element relationships, and lead, cadmium, or mercury levels in fish or plants need careful monitoring for public health reasons.

9. OVERGRAZING AND SOIL COMPACTION. Both the levels of grasshopper and pasture grub activity (high on overgrazed landscapes) and the presence of patches of poisonous, inedible, thorny, and unpalatable plants (e.g. Sodom apple, oxalis, capeweed) indicate an over–stocking problem or range mismanagement. The effect is a synthesis between changing soil conditions, plant stress, and the heavy selection by livestock of palatable species, so favouring the survival and spread of spiny or inedible species. Too often, the pastoralist blames the weeds and seeks a chemical rather than a management solution; too seldom do we find an approach combining the sensible utilisation of grasshoppers and grubs as a valuable dried–protein supplement for fish or food pellets, and a combination of soil conditioning, slashing, and de–stocking or re–seeding to restore species balance.

10. MACROFAUNAL EFFECTS. The site of a sea-bird rookery, a rabbit warren, the ground nest of a goose or eider clutch, the pellet–pile of an owl, or the decay of a large carcass will cause a sudden and often long–term change in the immediate vegetation, as will termite mounds and harvester–ant colonies. Once such sites are recorded, and the plant assembly identified, similar sites can be located and recognised. The data can be used as an aid to conservation, an indication of soil drainage (rabbits choose good drainage), as a result of specific nutrient supply (guano on seabird rookeries), or as a way to establish tree clumps following natural indicators.

A large proportion of wind–blown, nitrogen–loving, and inedible plants, or plants carried by birds as seed, depend on the specific habits of birds or mammals, on their dung, or on soil disturbances. The role of animals in the distribution of plant seed, and plant root associates, is well–recognised; their role in soil change, less commonly noted.

8.16
SEED PELLETING

In pioneering the rehabilitation or stabilisation of soils, many of the local deficiencies in soils can be overcome by seed pelleting, which is a process of embedding seed in a capsule of substances that give it a good chance of establishment despite soil deficiencies in local sites, or microsites.

• SEED PRETREATMENT. If seeds have thick coats, or need heat or cold treatment or scarification to break dormancy, they must be treated before pelleting.

• INOCULATION. Purchase and inoculate legume seed with their appropriate microbial or fungal spores. Soak the seed in inoculant solution, then dry the seed. Mix dried seed with a primary coat as below.

• PELLETING. Use a lime, clay layer, and a trace of fine rock flour, calcium, or phosphate mixed into a damp but plastic slurry around the seed. This is then extruded (e.g. via a meat mincer with the cutting blades removed) to a shaker table or tray covered with dust, and on a slight incline. Dust is added as needed to dry and shape the pellet, or to set a desirable size of pellet **(Figure 12.18)**.

The dust, or outer pellet coat, should incorporate a soil conditioning gel or polymer, a colloid–forming substance (fine graphite), a bird repellent (green dye helps repel birds), an insect repellent such as powdered neem tree leaf (*Azadirachta indica* or *Melia azedarach*) or diatomaceous earth, and perhaps some swelling clay such as bentonite.

Pellets are now dried and scattered, drilled, or sown on sites to await rain. The protected seed germinates when the pellet absorbs water, and the emerging root finds its nutritional needs satisfied, while the root associates also become active in nutrient transfer to the plant.

The same vibrating table that we use to pellet seed serves, when fitted with screens, to clean and sort seed from the soil below trees or from seed and husk mixtures, and the mincer can be returned to the kitchen none the worse for wear. Fukuoka achieves the same result by pressing seed–clay mixes of grains through a coarse sieve, onto a dust–filled pan which is shaken to round off the pellets.

8.17
SOIL EROSION

As all else depends on a stable and productive soil, soil creation is one of the central themes of permaculture. Soil erosion or degradation is, in fact, the loss of production and hence of dependent plants and animals. Soils degrade in these ways:

• Via wind: by dust storm and the blow–out of dunes and foreshores.

• Via water flow by sheet erosion (a generalised surface flow off bare areas and croplands), gully erosion (caused by concentrated flow over deep but unstable sediment), and tunnel erosion (sub–surface scouring of soils below).

• Via soil collapse or deflocculation following increased salt concentrations in clay–fraction soils.

Thus, the placement of windbreaks, tree crops, and fast–spreading grasses stabilises erosion caused by

4 b **Seed – Balls**

Projects: Natural Farming With Seed Balls

Seed balls are very easy to make and are great for seeding waste areas in your yard.

We use a combo of wild flower, mustards, radish seeds and wheat to create a haven for beneficial insects. We sow the balls in winter in our next-door neighbor's yard. They had a long piece of bare ground adjacent to our garden that was full of weeds and bermuda grass *yuck*.

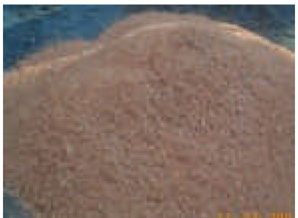
This method has been successful in attracting many beneficial insects into the garden and has transformed the bare and unsightly spot into a beautiful wild garden.

HOW TO MAKE SEED BALLS

Seed balls are a method for distributing seeds by encasing them in a mixture of clay and soil humus. Some native North American tribes used forms of seed balls. More recently natural farmer Masanobu Fukuoka has applied them, as have others inspired by his work.

Seed balls are simply scattered direct onto ground, and not planted. They could be useful for seeding dry, thin and compacted soils and for reclaiming derelict ground. This method takes a fraction of the time or cost of other methods to cover large areas and is also very applicable in small areas.

The clay and humus ball prevents the seeds from the drying out in the sun, getting eaten by predators like mice and birds, or from blowing away. When sufficient rain has permeated the clay and the seeds inside sprout they are protected within the ball that contains nutrients and beneficial soil microbes. Seed balls are particularly useful in dry and arid areas where rainfall is highly unpredictable. www.primalseeds.org



STEP ONE: INGREDIENTS

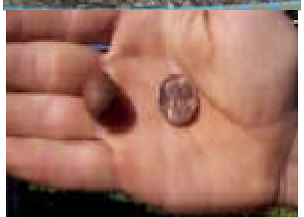
A. Dry terracotta clay, finely ground and sifted through a strainer to remove large chunks of clay. Amount: 1 1/4 cup

B. Dry organic compost. Amount: 3/4 cup

C. 1/4 cup assorted seeds. Various wildflower & vegetable seeds can be used.

STEP TWO: Mix **B & C** together. (Seed mixed with dry compost.)

STEP THREE: Add **A** to **B & C** mix. Blend everything together well. Next, mist water onto the mixture while stirring. Spray just enough water to allow the mixture to stick/bind together.

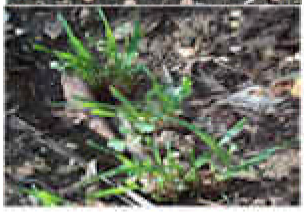


STEP FOUR: Take a pinch of the finished mixture and roll (in the palm of your hand) into penny-sized round balls.

STEP FIVE: Put seed balls in the sun to dry completely for a day or two.

STEP SIX: Broadcast seed balls onto dirt area. Water or wait for rain to allow seeds to germinate.

Makes approximately 30-40 balls



Seeds are starting to come up…

ENJOY THE RESULTS!!!

Suggested seeds to attract beneficial insects:
Clover, alfalfa, alyssum, nasturtium, yarrow, carrot, dill, daikon, celery, radish, fennel, caraway, chervil, gypsophila, coriander, calendula, mustard, anise hyssop, phacelia, agastache, and amaranth.

*Note: Please be advised to check with your local nursery or agriculture agency to determine which beneficial, native plant species would best serve the habitat which you are trying to restore. Nonnative invader species that are proven voracious spreaders should **never** be used as a tool of ecological restoration.*

Application rate
A minimum of ten seed balls per square metre, a higher density may be required to reclaim derelict land.

6 . Edge – Cropping / Plus - 30 %

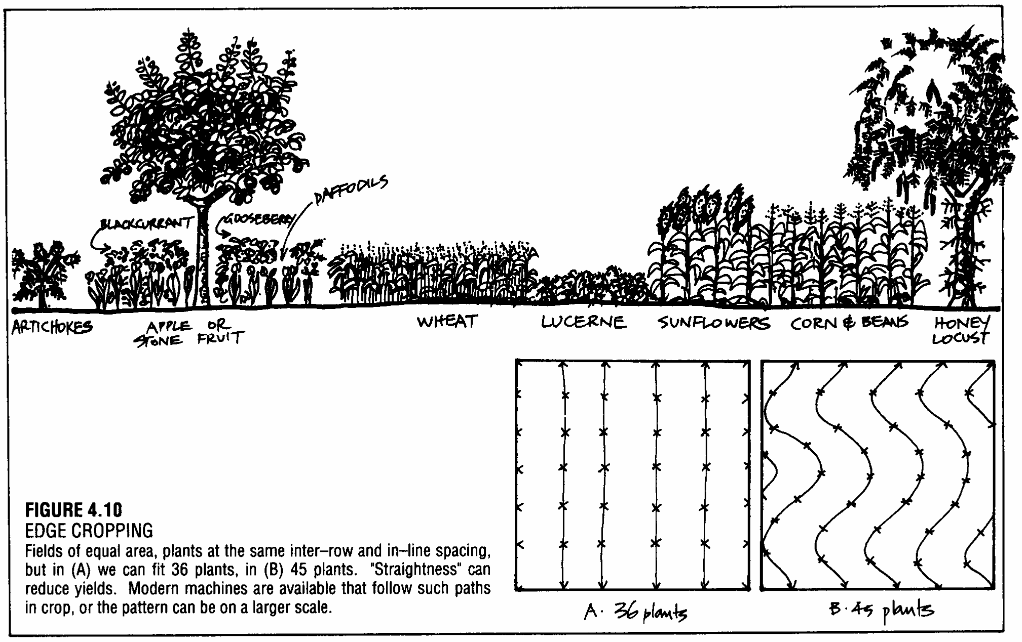


FIGURE 4.10
EDGE CROPPING
Fields of equal area, plants at the same inter–row and in–line spacing, but in (A) we can fit 36 plants, in (B) 45 plants. "Straightness" can reduce yields. Modern machines are available that follow such paths in crop, or the pattern can be on a larger scale.

7. Keyline - or Chisel – Ploughing (highly effective)

SOIL TREATMENT ON COMPACTED SITES—
SOIL CONDITIONING
On the common degraded soils of marginal areas, we can observe compacted, eroded, lifeless soils; they are overgrazed and often invaded by flatweeds and non–forage species of plants. They are boggy and wet in winter, and they are dry, cracked and bony in summer, having little depth. The reconstitution proceeds as follows:

At the end of winter, or in autumn after some rain, when the soil will carry a tractor, a chisel plough is pulled 5–10 cm (2–4 inches) deep over the area, either on contour parallels or on low slopes, starting in the high valley bottoms and driving slightly downhill to the ridges. Unless there are absolutely no legumes or grasses already growing, no extra seed is applied. The response is increased penetration of roots, germination of seed, and a top–growth of pasture.

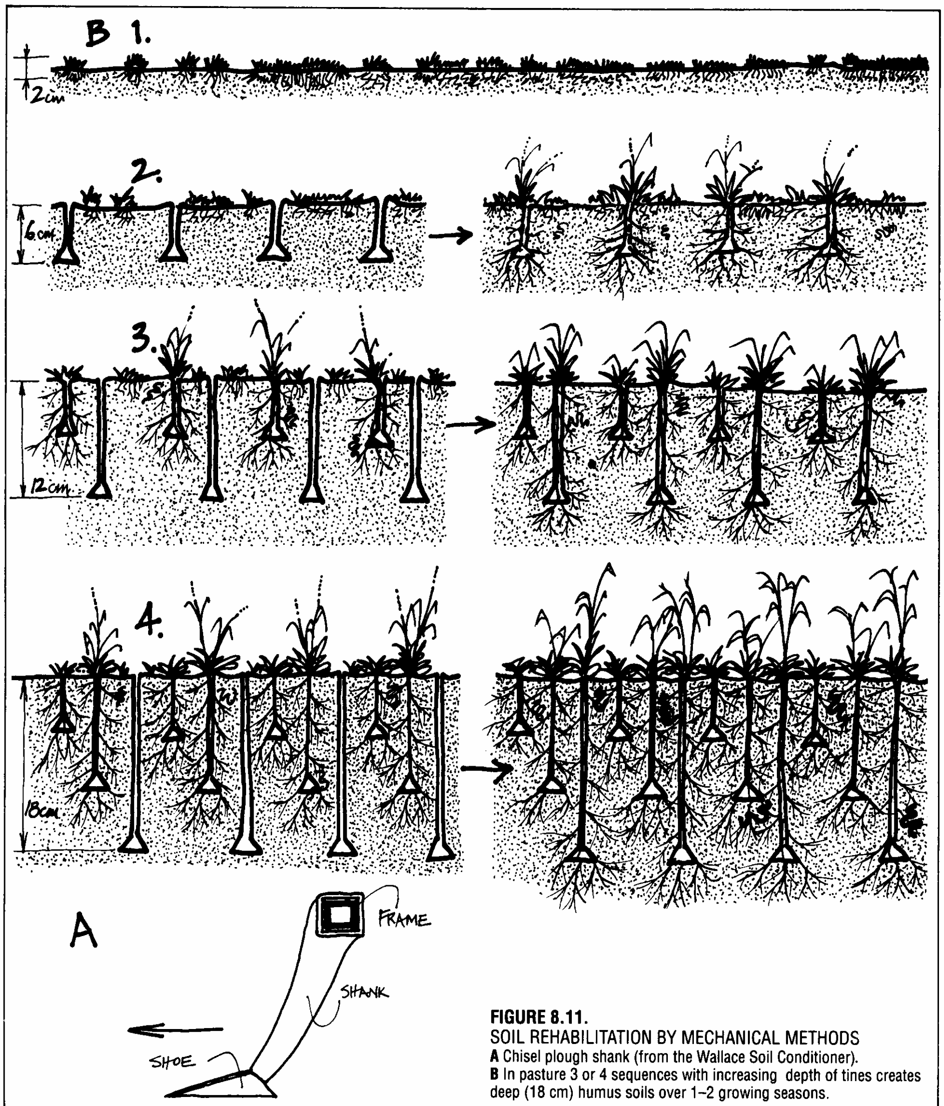


FIGURE 8.11.
SOIL REHABILITATION BY MECHANICAL METHODS
A Chisel plough shank (from the Wallace Soil Conditioner).
B In pasture 3 or 4 sequences with increasing depth of tines creates deep (18 cm) humus soils over 1–2 growing seasons.

A chisel plough or soil conditioner is a rectangular steel frame (tool bar) towed by tractor or draught animals, to which a number of shanks are attached. These are narrow-edge (axe-edged) forward-curved vertical flat bars to the point of which a slip-on steel shoe is attached. The shanks clamp to the tool-bar frame, and the points to the shank. Even one implement of 5 shanks (25–50 b.h.p. tractor) covers a lot of country. There are now at least six or seven makers of soil-loosening machines, in the USA, Europe, and Australia.

Geoff Wallace has produced a soil conditioner of great effectiveness. A circular coulter slits the ground, which must be neither too dry nor too wet, and the slit is followed by a steel shoe which opens the ground up to form an air pocket without turning the soil over. Seed can be dropped in thin furrows, and beans or corn seeded in this way grow through the existing grass. No fertiliser or top-dressing is needed, only the beneficial effect of entrapped air beneath the earth, and the follow-up work of soil life and plant roots on the re-opened soil.

This new growth is then hard-grazed, or cut and left to lie. The plants, shocked, lose most of their root mass and seal their wounds. The dead roots add compost to the soil, as does the cut foliage or animal droppings, giving food to the soil bacteria and earthworms, and softening the surface. As soon as the grazing or cutting is finished, chisel again at 23–30 cm (9–12 inches), on the same pattern as before. Graze or cut again, chisel again at 23–30 cm. Graze or cut.

During this process, often a matter of a one-year cycle, the pasture thickens, weeds are swamped with grasses and legumes, myriad roots have died and added humus, and thousands of subsurface tunnels lead from valley to ridge, so that all water flows down into the soil and out to the ridges. Earthworms breed in the green manure, bacteria multiply, and both add manures and tunnels to the soil. A 23 cm (9 inch) blanket of aerated and living soil covers the earth.

Dust, deep roots, rain, and the bodies of soil organisms all add essential nutrients. The composted soil is, in essence, an enormous sponge which retains air and water, and it only needs a watchful eye and an occasional chiselling in pasture (or a forest to be planted) to maintain this condition.

If tree seed, soybeans, millet or other crop is to be planted, the sequence is as follows: after a few hard grazings or mowings, a seed box is mounted on the chisel plough frame, and the seed placed in the chisel furrow; the grazing or mowing follows germination of the seed. These new plants (sunflowers, millet, melons) grow faster than the shocked pasture, and can be let go, headed, or combine-harvested before the grasses recover. There is never any bare cultivation, and grain growers can move to a minimum tillage method of cropping, with fallows of pasture between crops.

Soil temperature is greatly modified, as is soil water retention. Geoff Wallace (*pers.comm.*) recorded as much as 13°C (25°F) increase on treated versus untreated soils in autumn. This increased temperature is generated both by the biological activity of the soil and the air pockets left by the chisel-points at various depths, and enables earlier and more frost-sensitive crops to be grown.

Nodulation (of nitrogen-fixing bacteria) is greatly increased, as is the breakdown of subsoil and rock particles by carbonic acid and the humic acids of root decay. Methane generated from decay aids seed germination, and water (even in downpours) freely passes into, not off, the soil. After a year or so, vehicles can be taken on the previously boggy country without sinking in. Drought effects are greatly reduced by soil water storage.

Water, filtered through soil and living roots, runs clear into dams and rivers, and trees make greatly increased growth due to the combined factors of increased warmth, water, root run, and deep nutrients.

Fukuoka[3] (in Japan) uses radish and *Acacia*; Africans use *Acacia albida* or *Glyricidia*; New Guineans use *Casuarina*; and Mediterranean famers use *Tamarix* for biological "chisel ploughs" where land is too steep and stony for implements. Otherwise the "graze or cut and let lie" method is still followed. On such difficult terrain as boulder fields, dunes, steep slopes, and laterites, forests of mixed legume/non-legume crops (citrus, olive, pine, oak) are the best permanent solution to soil conservation.

No matter how we aerate soil (or condition it), whether with humble implements like a garden fork levered slightly, by planting a daikon radish, or by sheer mechanical power, we can soon lose the advantage of looseness and penetrability by over-stocking, cropping, heavy traffic, or heavy-hooved animals stocked in wet weather. All of these pug or compress the soil into a solid state again. Final solutions lie only in following on with permanent and deep-rooted plants (forests or prairies), and by maintaining good management (minimum tillage) cropping.

Any reduction in cultivation saves energy and soils, and wherever no-tillage systems can be devised, and heavy hoofed animals kept to a minimum, soil structure can be repaired.

Intense fire, intense stocking, intense cropping, and intensive production all threaten soils. Thus, mechanical soil rehabilitation can be a one-time and beneficial process, or another way to waste energy every year. It is the usages that follow on re-habilitation that are beneficial or destructive to soils in the long term.

Mechanical loosening of soils is appropriate (on the broad scale) to almost all agricultural soils that have been compacted. Soils with coarse particles, of cinder, or dunes do not benefit from or need loosening, and very stony or boulder-soil mixtures are appropriately rehabilitated not by mechanical but by organic (root penetration) methods, as are soils on steep slopes. Some soils (like volcanic soils with permanent pastures) may never lose structure, and will maintain

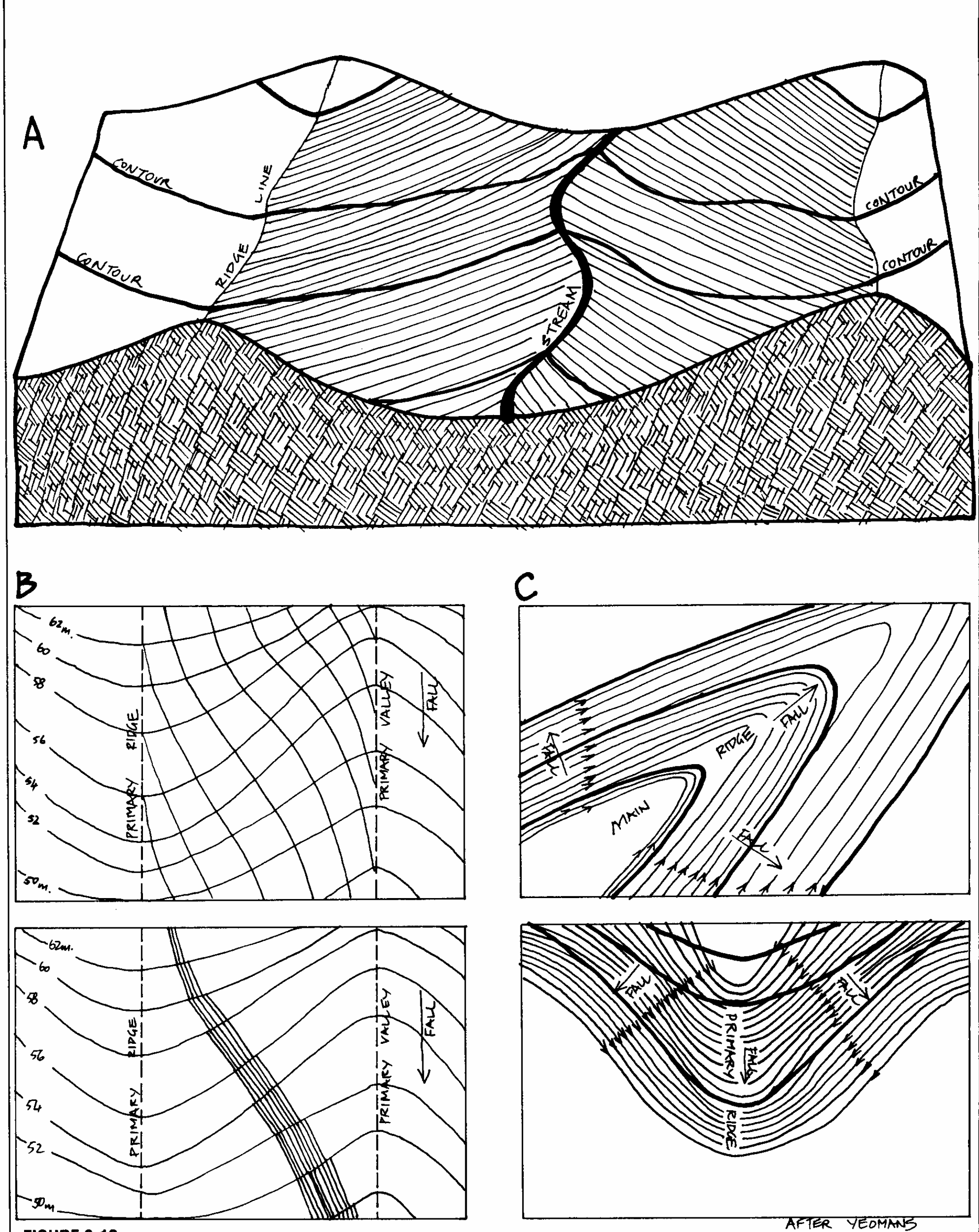


FIGURE 8.12
SOIL CONDITIONING
A Ideally, chisel lines run "downhill" from valley to ridges.
B Here, water flow crosses contours at right angles (no chisel lines) and creates sigmoid (S) curves in the landscape.
C In conditioned landscapes, chisel lines prevent fast run–off and absorb overland flow, leading water to ridges.

free internal drainage after years or centuries of grazing. Thus, we use rehabilitative energy only where it is appropriate.

Soil conditioning can be sequential, allowing a year between treatments, or all–at–once at 20 cm or so, in order to prepare for tree crop planted immediately. The time to use implements is also critical, and early spring or at the end of a gentle rainy period is ideal, as the soil is not then brought up to the surface as dry clods, nor collapses back as being too wet.

There is only one rule in the pattern of this sort of ploughing and that is to drive the tractor or team slightly downhill, making herring–bones of the land: the spines are the valleys and the ribs slope out and down–slope (**Figure 8.12**). The soil channels, many hundreds of them, thus become the easiest way for water to move, and it moves *out* from the valleys and below the surface of the soil. Because the surface is little disturbed, roots hold against erosion even after fresh chisel ploughing, water soaks in and life processes are speeded up. A profile of soil conditioned by this process is illustrated by **Figure 8.11**.

There is no point in going more than 10 cm in first treatment, and to 15–23 cm in subsequent treatments. The roots of plants, nourished by warmth and air, will then penetrate to 30 cm or 50 cm in pasture, more in forests. For disposal of massive sewage waste–water, Yeomans[(5)] recommends ripping to 90 cm or 1.5 m, using deep–rooted trees or legumes to take up wastes.

I have scarcely seen a property that would not benefit by soil conditioning as a first step before any further input. Pasture and crop do not go out of production as they do under bare earth ploughing with conventional tools, and the life processes suffer very little interruption.

In small gardens, the aeration effect is obtained in two ways:

- By driving in a fork and levering gently, then removing it.
- By thick surface sheet–mulch; worms do the work.

To summarise briefly, the results of soil rehabilitation are as follows:

- Living soil: earthworms add alkaline manure and act as living plungers, sucking down air and hence nitrogen;
- Friable and open soil through which water penetrates easily as weak carbonic and humic acid, freeing soil elements for plants, and buffering pH changes;
- Aerated soil, which stays warmer in winter and cooler in summer;
- The absorbent soil itself is a great water–retaining blanket, preventing run–off and rapid evaporation to the air. Plant material soaks up night moisture for later use;
- Dead roots as plant and animal food, making more air spaces and tunnels in the soil, and fixing nitrogen as part of the decomposition cycle;
- Easy root penetration of new plantings, whether these are annual or perennial crops; and
- A permanent change in the soil, if it is not again trodden, rolled, pounded, ploughed or chemicalised into lifelessness.

Trees, of course, act as long–term or inbuilt nutrient pumps, laying down their minerals as leaves and bark on the soil, where fungi and soil crustacea make the leaves into humus.

8.19
SOILS IN HOUSE FOUNDATIONS

Soils cause perhaps 60–80% of all house cracks and insurance claims for faulty construction and "tree damage". About 20% of the soils we build on will subside or heave depending on water content. Specifically, black cracking clay, surface clays, and red–brown clay loams are subject to swelling and shrinking. Solid stone and brick houses are most subject to structural failure, with wood–frame and veneer less so.

Over–irrigation of gardens, causing the water table to rise, is a primary cause of soil swelling. The removal of trees assists this process, as do paved areas, and burst or leaking sewage and water pipes. Some notorious white or yellow clays collapse as dam walls when wetted. It is as well to consult your local soil expert for large constructions as trials can be expensive.

While the effects are most noticed to 2 m deep, probes to 10 m deep need to be monitored for ground-water levels. Soils subside and shrink with excessive drying (too many trees too near the house) and swell and heave with excessive watering and no trees. Adelaide (Australia) is an area where most damaged houses are on blacksoil clays, but several other areas also suffer these effects, and in some, large buildings need to be built on foundations capping deep piles (to

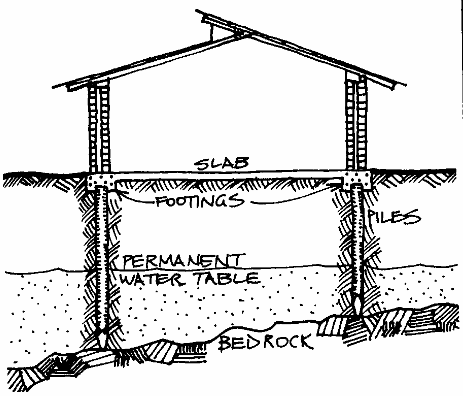


FIGURE 8.13
PILES SUNK INTO WATER TABLE OR BEDROCK
to stabilise house foundations in swelling clay soils.

7. b Keyline - or Chisel – Ploughing (highly effective)

Keyline Cultivation

A mechanical means for improving soil structure and water retention works well with remineralization, energizing and revitalizing soil while increasing fertility

by Dan Hemenway

In context of the current fad to develop and execute a "sustainable agriculture," I propound an unpopular view. Whenever the term "sustainable agriculture" comes up in lectures, workshops, and courses, I'm the person who decries it as an oxymoron — a phrase like "military intelligence" or "ethical rape," so rife with warring internal meanings that its use reflects a minor madness.

Nevertheless, we need a bridge from the broadscale destructiveness of contemporary agriculture to sustainable food systems. This might include home gardens, food parks featuring edible landscaping and community gardens, constructed and restored forage (hunter/gatherer) opportunities, modest home-scale livestock operations based on converting waste to food and so forth – all integrated with provision of other basic needs and amenities according to the model of ecosystem design — all wedded to the energies and flows of specific place, and all integrated into the ambient ecosystem. This wholistic bioregional approach is sometimes called permaculture.

Dan Hemenway is a permaculture designer and teacher who makes his living designing home and community habitats that are ecologically sustainable. He lectures, leading workshops and teaching courses on permaculture and forest ecosystem rescue. He has worked in many parts of the world from northern Ontario, Canada to the Philippines, in most types of ecosystems. He will lead an intensive three-week course in permaculture design from October 18 to Nov. 9, 1991, near Jacksonville, Florida, USA. For details on the course, consulting, or a workshop in your region, you may reach him at: Elfin Permaculture, 7781 Lenox Ave., Jacksonville FL 32221 USA. A self-addressed stamped envelope or international return mail coupon is appreciated.

Agriculture Versus Gardening

The distinction between "gardening" and "farming" eludes some people. Try the phrase "The farm of Eden," or better, "The agriculture of Eden," compared to "The garden of Eden."

Most people apprehend here a broad qualitative distinction. The gardener is highly interactive with the garden, while the farmer tends to operate upon the farm, although I know of no absolute cases either way.

Gardens tend toward polyculture, intensive soil management, high efficiency of resource use, large per-unit-area yields, labor intensiveness, and high efficiency of product utilization. Gardeners typically build soil.

Farms tend toward monoculture, extensive soil management or outright mining of soil nutrients, low efficiency of resource use, low per-unit-area yields, capital intensiveness, and considerable waste of product due to mechanization and cosmetic standards. Farmers invariably destroy soil. The distinction is certainly not crisp. One can garden a small farm or farm (abuse) a backyard garden. Yet the distinction is real and useful.

Dan Hemenway

The system of keyline and keyline cultivation developed in Australia by P.A. Yeomans, author of *Water For Every Farm and the Keyline Method,* utilizes conventional equipment and is compatible with conventional farm practice, attitude and economic realities. Yet the keyline approach builds soil on farms where soil was previously mined of nutrients and lost to erosion. The prospect of remineralization with appropriate rock powders promises to make keyline an even more effective tool for restoring fertility, not only to agricultural soils but to lands to be subsequently reforested.

Soil Health Reviewed[1]

Soil requires four constituents to achieve health:

1) air
2) water
3) mineral particles
4) organic matter.

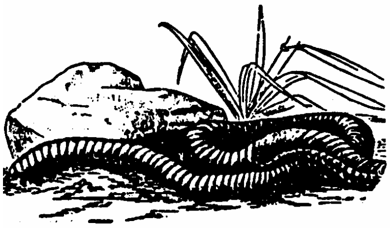
When these four components are properly organized into good soil structure, soil life — fungi, bacteria, yeasts, algae, protozoa, earthworms, insects, etc. – releases fertility to photosynthetic plants which harvest the sun's energy and makes it available to the other soil organisms who eat live or decaying plant and/or animals (which feed on plants) and their wastes.

About one half the volume of healthy soil consists of openings such as pores, earthworm tunnels, etc., which are sometimes filled with air and sometimes filled with water, according to the cycles of rainfall or irrigation and dry weather. This pulse expels air when soil is saturated with water, and inhales fresh air as water empties from spaces due to percolation, evaporation, and transpiration. The tidal effect produced by alternate saturation with water and air in soil spaces energizes soil life and promotes release and uptake of nutrients.

The mineral and organic content of the soil help determine its physical structure, which ideally allows for percolation of water while blotting up enough moisture to sustain soil life between dry periods. A mix of fine (clay), intermediate (silt), and coarse (sand and gravel) soil particles promotes good structure, nutrient holding capability, and drainage. However, both dead organic matter and the action and exudates of live soil organisms can promote productive soil structure even where particles tend toward clayey or sandy conditions.

Compaction of soil — where equipment, high density of hooved animals, and/or excessive tillage have compressed soil, eliminating air and water spaces — is a major problem on agricultural lands or on lands where construction or tree harvesting equipment has been used. Much soil life dies in compacted soil, and the remaining soil life tends to be anaerobic — thriving in the absence of oxygen — whereas both anaerobic and aerobic life forms thrive cyclically in porous soils.

On compacted soils, water, which penetrates such soils very slowly, mostly runs off the surface, causing erosion and washing away organic matter, and especially soluble organic compounds of value to soil. Buried organic matter tends to putrify. Root



systems are stunted because of the difficulty of penetrating compacted soil, and plants are drastically affected by the suppression of soil organisms that release nutrients, as well as the very limited foraging ability of stunted roots. Nitrogen fixing also is drastically curtailed because the nitrogen-bearing air is very scarce in the compressed soil. The issues are more complex, of course, but from this discussion it is clear that compacted soil is a bad thing.

The Keyline Method[2]

Earlier in this century, P.A. Yeomans, who supported his work from farming income, developed a system of cultivating soil and storing water for crop production during rainless periods. The water storage techniques, which are greatly amplified in the permaculture literature[3], are not pertinent here, except to note that supplementary water is often easily harvested and stored, and its availablity can be critical in restoring soil health and productivity.

The basis of keyline is creation of channels in the soil to receive and guide water. These channels, when not saturated with water, also allow air to penetrate the soil.

The channels are produced by plowing with a special kind of implement. A wedge- or torpedo-shaped shoe is attached to the bottom of a sturdy knife. When pulled through the soil, the shoe produces an underground channel or tunnel connected to the surface by the slit made by the knife. A number of these knife-and-shoe implements are attached to a draw bar typically pulled by a tractor. (Horses, mules, water buffalo, etc., can do this, of course.) The resultant plowing combs the soil

Keyline cultivation offers an ideal way to rapidly remineralize large acreages of cultivated and pasture land.

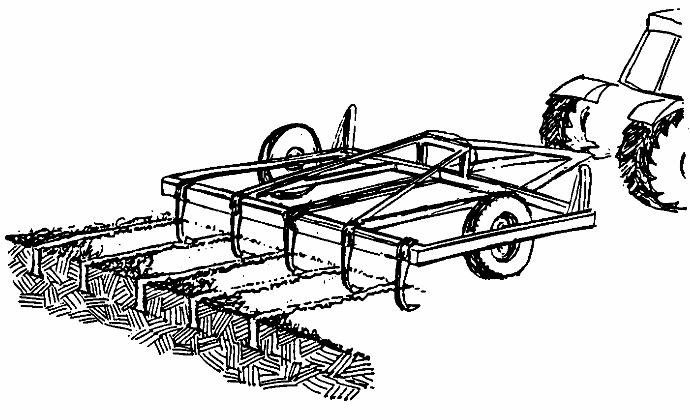
with parallel slits, each leading down to a channel at the bottom of the slit.

Yeomans devised a technique for keyline plowing at an oblique angle to most of the coutours on the land so that water usually drifts away from wet spots to drier areas. This is achieved by knife-and-shoe plowing parallel to one contour line—designated the "keyline"—or, when a parcel does not contain a keyline, to a contour line called the "guide line." Because contour lines are almost never strictly parallel, the plowing proceeds at a slightly off-level angle except right at the guide or contour lines. See Yeomans' book for details.

Plowing in parallel passes is easy compared to contour plowing. And the keyline cultivation can be done in combination with any other soil preparation technique that the farmer favors. Furthermore, Yeomans provides practical information to the level of detail that includes the most profitable speed at which to drive the tractor! Hence this is a technique which requires little change in attitude or practice from a farmer who adopts it, and which respects the farmer's need to make a profit to continue in business.

The soil receives conditioning which permits penetration of large amounts of water (avoiding erosion) and air. When organic matter is present, air and moisture permit the soil life to proliferate, and this soil life releases nutrients locked in the mineral particles of the soil.

In broadscale agriculture, the organic matter can be provided by a plowdown green manure crop or by a crop with a large root mass, such as rye. Use of chemical fertilizer in judicious amounts may save years in soil building by providing good quantities of organic matter on worn-out soil. Yeomans claims, and I believe it, that over time the activation of the soil by keyline cultivation builds fertility to the point where even ordinary agriculturalists can phase out chemical fertilizers.



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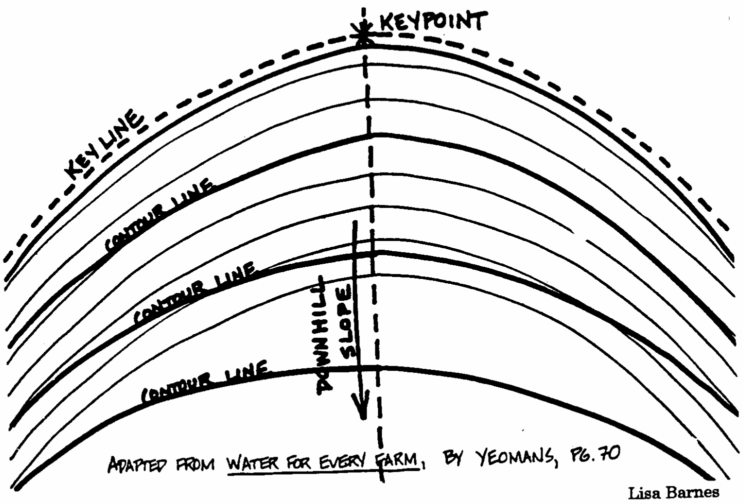

Lisa Barnes

In summary, then, by allowing penetration and storage of water as well as aeration, keyline cultivation stimulates soil fertility, arrests erosion, and improves soil structure. More properly stated, keyline cultivation enables soil life to accomplish these things. To be effective, soil cultivated by the keyline method must be "fed" organic matter to fuel the transformation.

Remineralization and Keyline

Keyline cultivation by itself can restore fertility only to the extent that the necessary minerals are available in the soil particles. While worn out soil may surprise us with the amount of fertility that can be released by keyline alone, it is obvious that the addition of a supply of fresh minerals in the form of rock dust will enable faster and more complete development, *providing that the rock dust actually contains minerals needed by that soil.* Equally obvious is the conclusion that keyline cultivation offers an ideal way to rapidly remineralize large acreages of cultivated and pasture land. The ability of the Earth to absorb rainfall and inhale air, and the energy provided by the ever-necessary organic matter, together, set up ideal conditions for soil life, particularly fungi, to harvest minerals from the dust and make them available to photosynthetic plants. These, in turn, improve soil texture with their roots and feed the soil additional amounts of organic matter. By taking the time to develop soil structure and life through combined remineralization and keyline cultivation, we can greatly increase the rate of tree growth in reforestation projects designed to absorb carbon dioxide from the atmosphere.

Cropland which has been keyline cultivated for three years and then reforested will so favor trees that the time lost in tree growth will be more than made up in another three years. Meanwhile, we have produced food by conventional means while moving on other fronts toward sustainable food systems.

Would keyline cultivation and remineralization constitute a sustainable food system by themselves? Probably not. A sustainable food system must produce more energy than it consumes. Tractors and rock crushers are unlikely to do this. And even if they somehow did produce more energy than they consumed, we still need to operate them with fuels that are renewable. No use of fossil fuels is sustainable.

Less energy-intensive technologies such as use of draft animals for cultivation and application of solar-powered steam engines[4] to drive rock crushers may, in theory, make an agriculture based on keyline cultivation and remineralization sustainable. However, the real value of keyline and remineralization, in my opinion, is that they are techniques we can practically apply *now* to buy time, in the hope that we are not already past the point of no return for ecological collapse.

We can use that time to design for ourselves lifestyles which are in balance and harmony with our bioregions, and which include as a major component healing of the planet's forests, oceans, fresh waters, soils, and atmosphere. *Only when every part of our lives is lived in conscious interconnection with the health of Mother Earth can any aspect of our lives be called "sustainable."* By then we'll probably just use that word when we want to be silly.

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Notes

[1] I have written a more extensive treatment of soil health to appear in a forthcoming issue of *The International Permaculture Solutions Journal,* Vol. 1, available from Yankee Permaculture, 7781 Lenox Ave., Jacksonville, FL 32221, USA. Postpaid subscription for 4 issues: $27.50 in the U.S. and Mexico; $30 U.S. elsewhere.

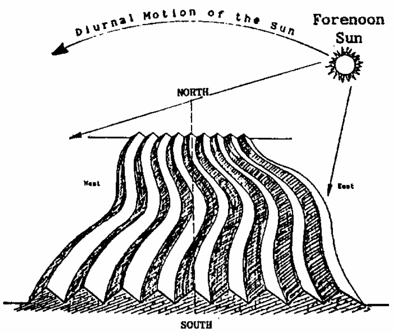
[2] For full details of the keyline method, read *Water for Every Farm and the Keyline Method* available from Yankee Permaculture, address above. Price postpaid to U.S. and Mexico: $16.50; elsewhere $18 U.S.

[3] For details on permaculture see *Permaculture Design Course Pamphlets II* and *XI* as well as *Permaculture, A Designer's Manual* by Bill Mollison, available from Yankee Permaculture, address above.

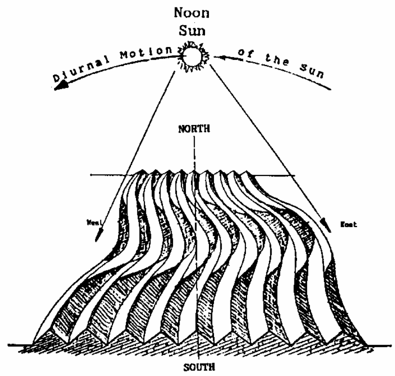
[4] J. Vanek has designed steam engines for irrigation. These could be scaled-up and applied to rock crushing. For details write: J. Vanek, S.T.E.V.E.N. Foundation, 414 Triphammer Rd., Ithaca, NY 14850, U.S.A.

Elfin Permaculture

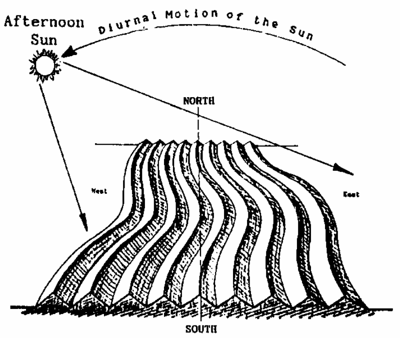
8. Sun – Ploughing **(- only if other methods (- like airing the soil or Chisel – Ploughing) are not possible !!!)** , North – South , for not drying out Soils



1. No portion of the soil has continuous, uninterrrupted exposure of direct sunlight.



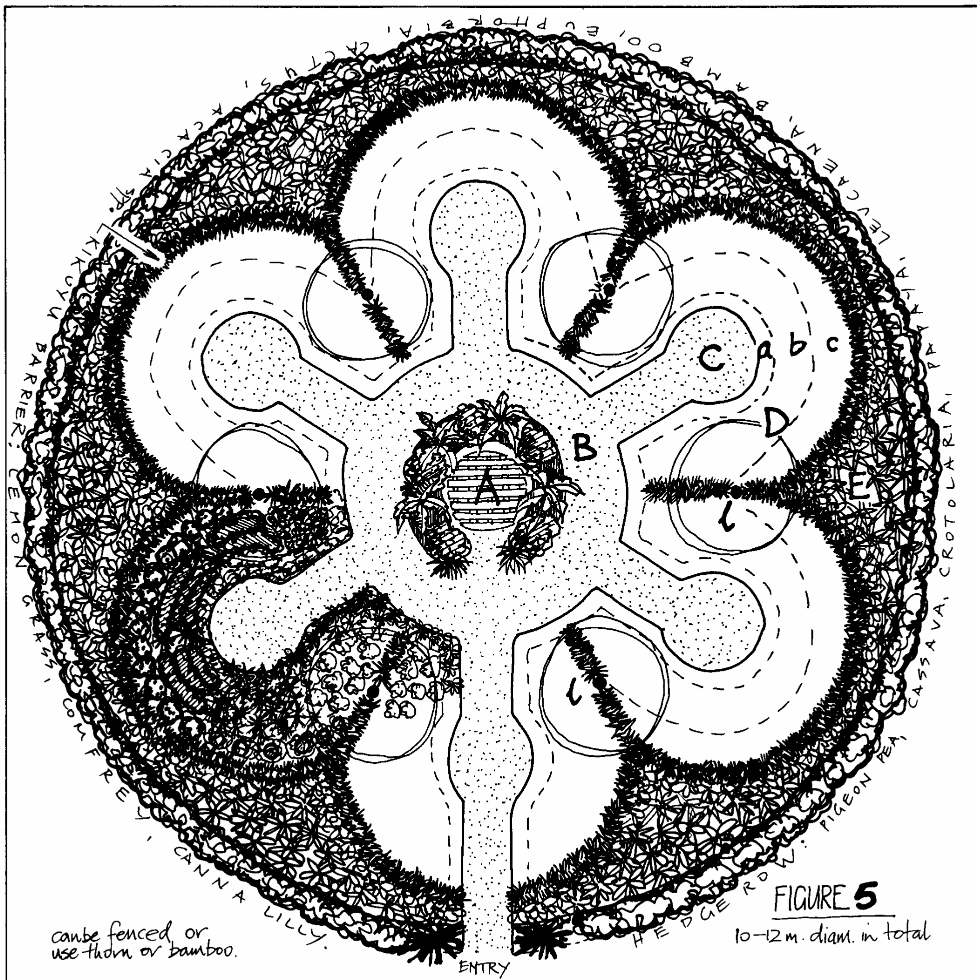
2. Shadow areas vary with the time of day and the seasonal height of the sun.



3. Plants and crops have even distribution of solar radiation.

Fig. 19.8 **Advantages of Sun Ploughing**

9. Gardens , Gangammas Mandala



·G·A·N·G·A·M·M·A'S · M·A·N·D·A·L·A·

A Banana– Papaya circle with shower-wash grid fitted.
B Sawdusted, rice husks, or gravel paths
C Keyhole paths as B above
D Keyhole beds **a** pathside plants **b** narrow bed plants **c** one visit plants
E Weed, wind, animal barrier hedge sequence, e.g.: (inner → outer) Vetiver or lemon grass, comfrey, arrowroot; taller hedge of cassava, papaya, crotalaria, leucaena, pigeon pea, and banana.
l In garden trees are leucaena or palms for shade in hot regions.

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FIGURE 10.26
GANGAMMA'S MANDALA.
An ideal "least path", zero–runoff, acessible layout for tropical home gardens. FIGURE 10.26.4 shows how this mandala can be scaled up for group gardens at schools, villages, etc. Gangamma is an Indian permaculture student.

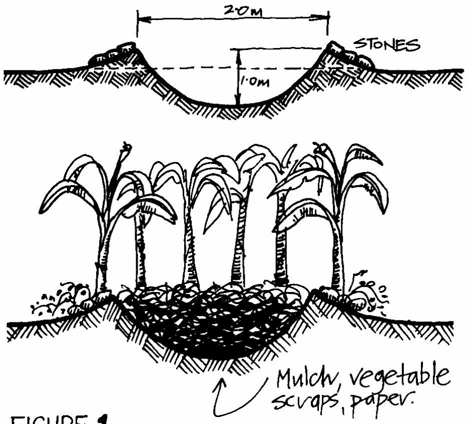


FIGURE 1
Sectional elevation of banana/papaya circle.

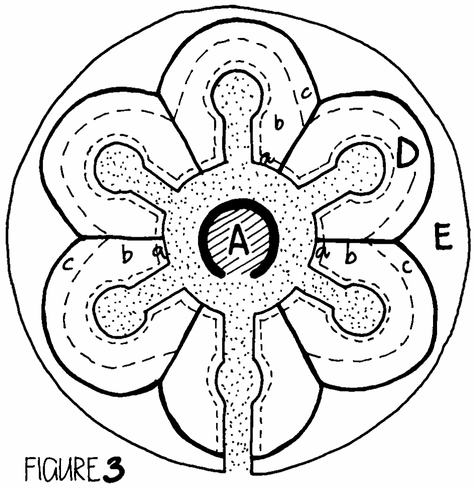


FIGURE 3
D Keyhole beds about 1·5m across.
E Hedgerow & barrier plants.
ZONES IN KEYHOLE BEDS:
a Pathside greens.
b Narrow bed plants.
c One visit crops.

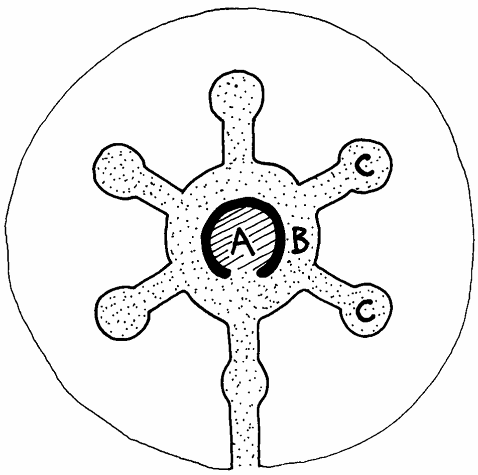


FIGURE 2
A Mulch or circle garden = "banana circle."
B The annular path.
C The keyhole paths.

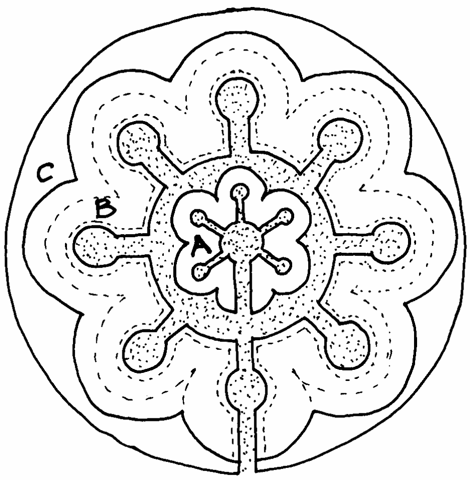


FIGURE 4
A 5 "Banana circles"
B 8 Keyhole beds
C Hedge and barrier.

9 b Keyhole - Garden

STAPLE FOODS

A staple food is defined as one supplying 50% or more of the diet when in season. Today, some 70% of the food eaten in western societies are supplied by 8 staple crops. No European family has 20–30 basic staple foods. Few have a choice of as many as 62–100 foods in all, and a very good home garden and livestock situation would produce about 20 vegetables, 6–9 fruits, and ~~3–6 meats~~ (well beyond the choice range of an average western family). Of these, 2–4 would be considered staples, depending on the culture.

The very basic question we must therefore ask is how have we improved the Australian desert yield for people? By introducing cattle and sheep, and releasing the rabbit, we have destroyed the bulk of the useful vegetation, and almost every common marsupial or desert–adapted mammal of medium size (although kangaroos and mice survive). We have destroyed the harmless way of living and the profound knowledge of thousands of integrated tribal people for an undeserved ownership by a very few, essentially disintegrated, pastoralists.

This makes no ecological, economic, genetic, informational, or social sense and it is a denial of human rights. We have replaced commonsense with a situation of downright exploitation and rapid loss. Broadscale commercial herding is, to the desert, what broadscale sugar cane cropping is to the tropical rainforest, and broadscale soybeans to floodplain forests—a disaster in every way.

People who managed desert well for 10,000–40,000 years may have known a little about it. We have suppressed this knowledge and its right to continue to exist. Those who were teachers have become fringe–dwellers. Both genetic resources and information on management have been destroyed by "the–right–to–ruin" mentality claimed by private owners and governments.

Even the plants developed by the Papago and Hopi Indians are being lost as store foods replace desert foods. And yet it is clear from desert plant lists that there is a present potential for several staple foods, and an untapped potential for developing better cultivars of many desert plants.

Several hardy seeds were stored to extend the staple over more than one season. In Nevada, Sho-shone Indians gathered, in about 6 days, a year's supply of *Pinus edulis*, and buried unripe cones for later use if needed. Rice–grass seed *(Oryzoides)* was a similar easy staple to gather and store. Thus, staples in deserts (excluding animal foods) seem to be plentiful. It is a question not so much of gardening or farming, but of placing and managing a set of hardy foods in the best situation for later gathering.

As almost every desert garden with modest water can supply 60 or more vegetable species, and as the cultivated fruits of deserts number 30 or more in common use, and as all domestic livestock (including

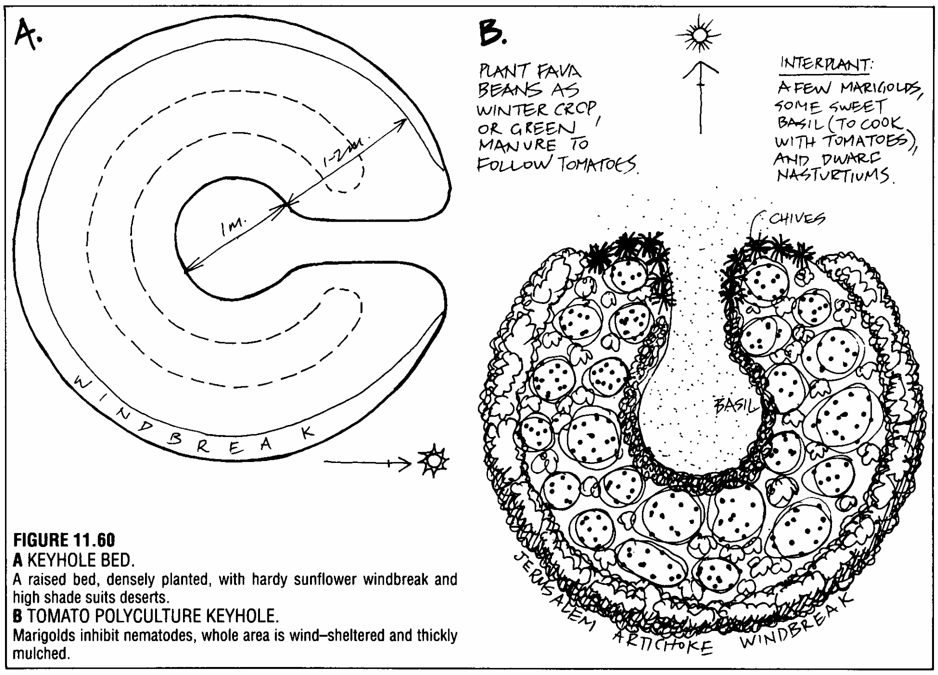


FIGURE 11.60
A KEYHOLE BED.
A raised bed, densely planted, with hardy sunflower windbreak and high shade suits deserts.
B TOMATO POLYCULTURE KEYHOLE.
Marigolds inhibit nematodes, whole area is wind–sheltered and thickly mulched.

9 c Gardens , Pot - System

water appears. Slotted pipe can be used to carry wastewater along the plastic base of the garden beds (**Figure 11.67**).

• ARBOR SYSTEM: commercially available in South Australia, wastewater pipes will not fill with tree roots and can be used without gravel seepage beds in ordinary soils. Ideal for productive trees like citrus, apricot, and palms (**Figure 11.68**).

• POT SYSTEM is excellent for village gardens, with or without dripline. Combines well with circle gardens (**Figure 11.69**).

• HOME SLOT–PIPE SYTEM. The top of the pipe (3–5 cm diameter) has slots cut to one level, nylon mesh or old stockings bound around these, and wastewater led in from handbasins or sinks past a grease trap or crude sieve to catch solid particles. These are excellent too, for small–fruit beds, with the slots at correct spacing for plants. Pipes should be laid to one side of the plants for periodic checks as they do eventually block up. A half–pipe is sometimes used in the same way as the perforated pipe (**Figure 11.67**).

• NUTRIENT FILM AND INJECTION TECHNIQUES. There are at least techniques in use to prevent any water loss by soil absorption; both are essentially hydroponic–intensive. In Israel, direct infusion of water and nutrients into tree or vine stems (a nutrient drip) is in use, and in India a plastic film technique is used to grow Napier grass (*Pennisetum*) for forage, with part of the root mass in earth, part in a nutrient solution in the plastic gullies (**Figure 11.71.A**).

It should also be possible to "wick water" with a slotted pipe, using hessian or nylon wicks to nearby plant roots (**Figure 11.71.B**). In either case, little or no water is lost to soil, and plant roots can explore both the soil itself and the nutrient solution. In view of the obvious maintenance problems of such systems, drip irrigation in open fields and true hydroponics in glasshouses may be preferable if labour is not available for layout, maintenance, and harvest.

Sea or brackish–water can also be used at high tide level in lagoon for garden irrigation (**Figure 11.72**).

• AUTOMATIC IRRIGATION. In areas where electronic sensors are impractical or expensive, some such mechanical apparatus as that sketched in **Figure 11.73** would, in effect, permit automatic watering and self–regulate in rain, and ensure that irrigation is sufficient. Any capable local firm could make such reliable equipment. Rain automatically switches off the tap after 3 cm of downpour. **Figure 11.73** is designed from data from Kevin Handreck, CSIRO, Australia.

CONDENSATION STRATEGIES

Where no piped water is available, and where water is in seriously short supply, trees and gardens need condensation strategies. The aim is to condense water either from night air, from transpired water, or from weeds and trimmings, and return it to root level for re–use. The following methodologies are used:

1. Plant shields of plastic, mesh, or metal.
2. Stone mulches.
3. Sheet plastic sub– or surface mulches.
4. Organic mulches.
5. Pit evaporation systems.
6. Closed recycling systems.

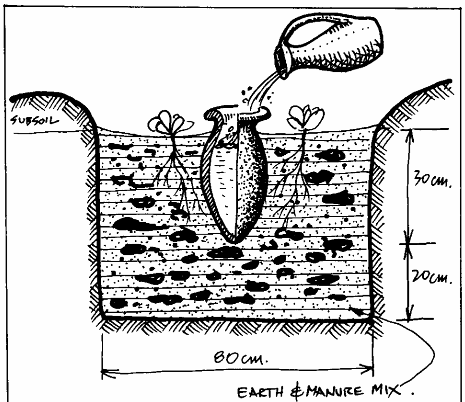


FIGURE 11.69
POT SYSTEM.
An unglazed pot in a humus pit waters a circle of vegetables in circle gardens.

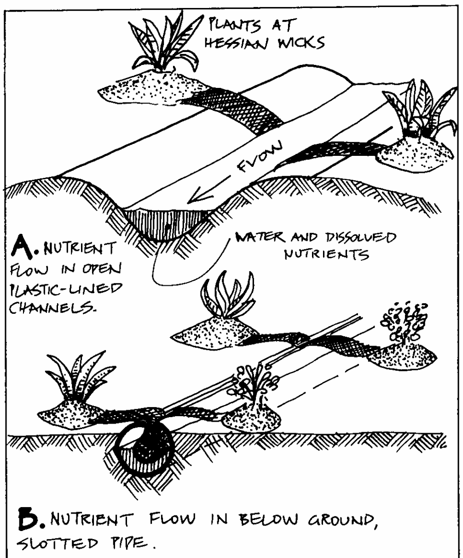


FIGURE 11.71
NUTRIENT FILM TECHNIQUES.
Hessian wicks part–irrigate plants from plastic trough or slotted pipe; used for valuable crop, somewhat salty water.

9 d Dry – Land Garden

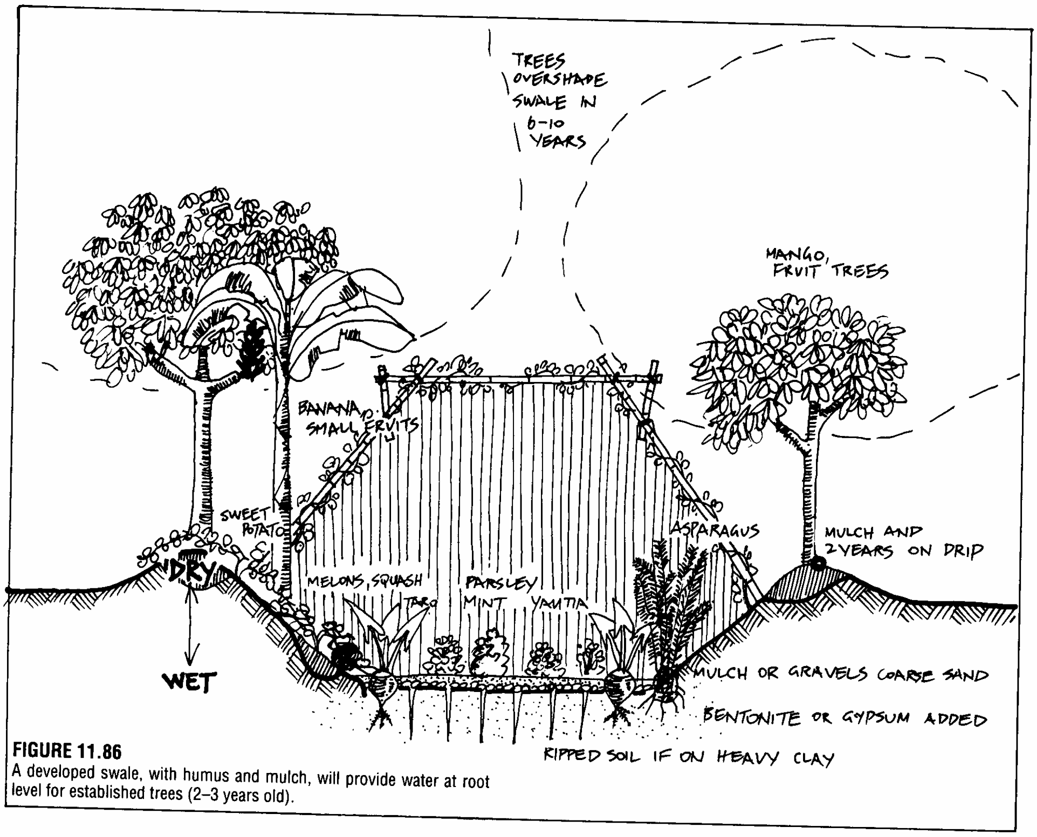


FIGURE 11.86
A developed swale, with humus and mulch, will provide water at root level for established trees (2–3 years old).

9 e

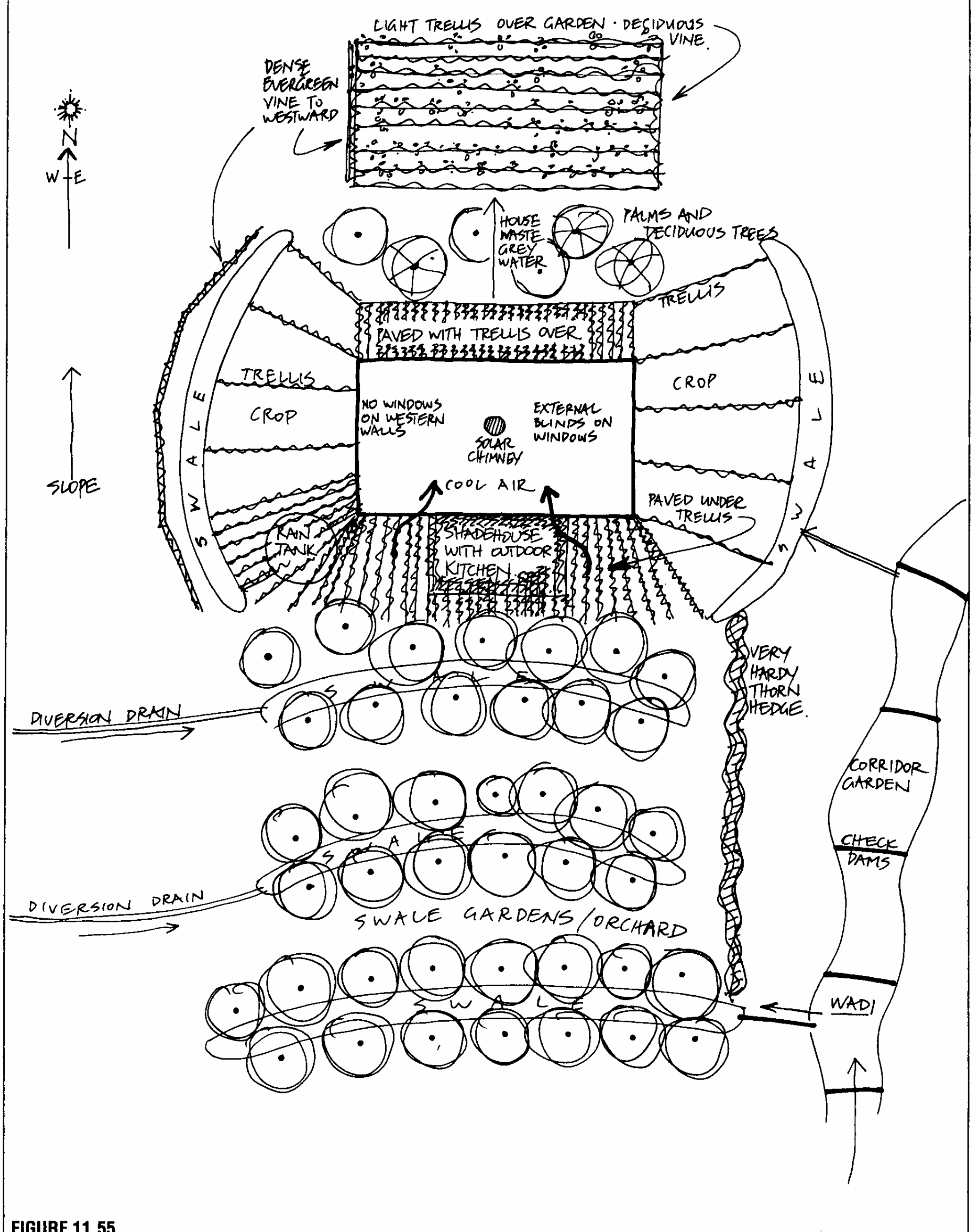
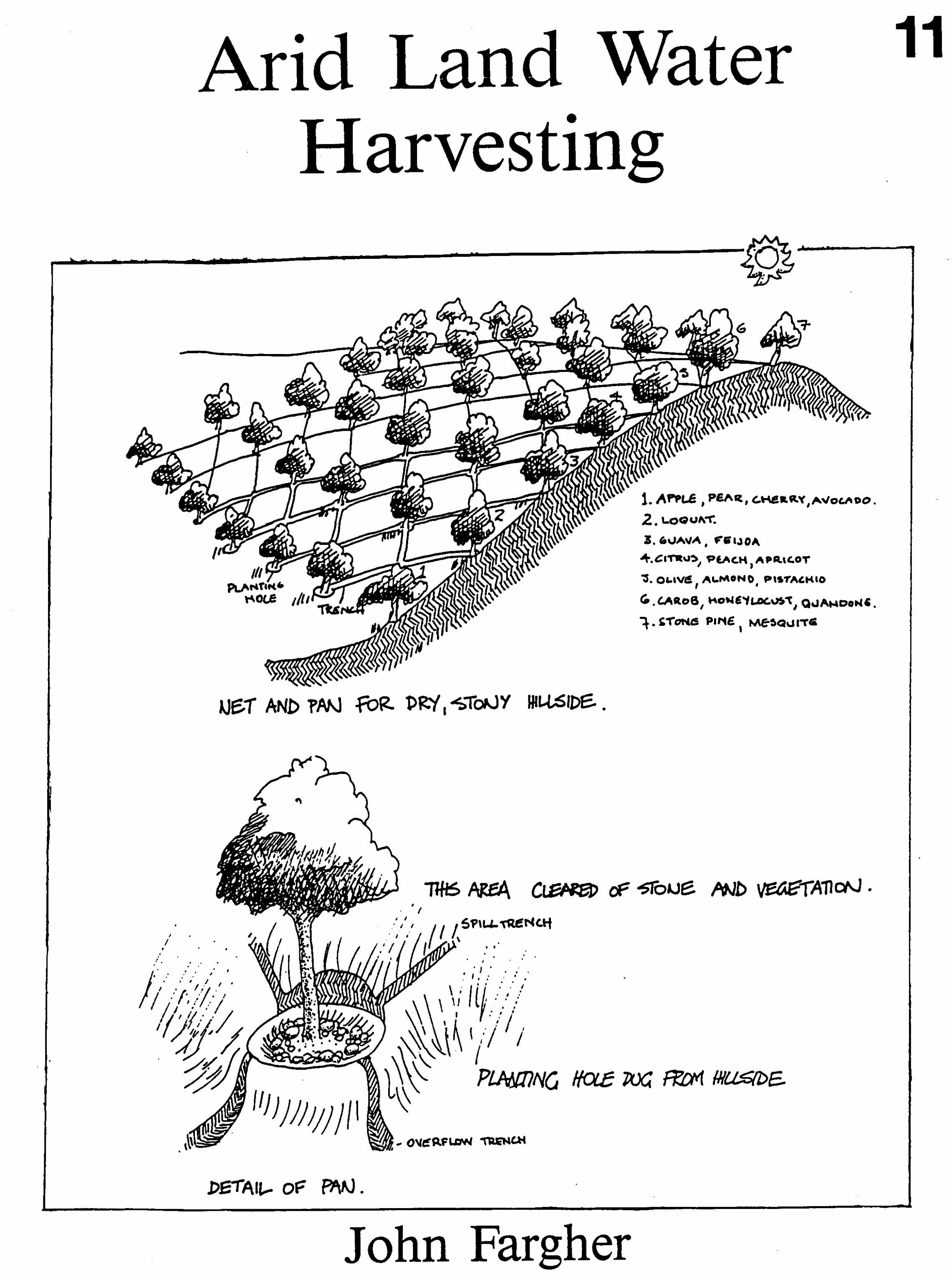


FIGURE 11.55
CORRECT PLACEMENT OF SYSTEMS AROUND THE HOUSE.

10 . Arid Land – and Water Harvesting



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ARID LAND WATER HARVESTING

STANDARD DESIGNS FOR ARID AREAS

BY JOHN FARGHER

INTRODUCTION

By definition, the limiting factor in arid areas is the shortage of water, yet all arid regions receive some precipitation; even though its occurance is usually unpredictable and sporadic. In areas where salinity is a problem, the collection and storage of fresh rain water is of vital importance for the success of any agricultural system.

People have lived successfully in arid areas for millenia. Many of the design techniques outlined here have been gleaned from history. Such techniques have evolved in areas which have low precipitation rates or high salinities. Most of the emphasis in these designs will be directed towards the hot, arid zones as distinct from the cold arid zones where temperature is the main limiting factor.

The key principles in all these techniques are the concentration of precipitation onto areas of cultivation or use and the storage of this collected water, either in a form available to animals, including man, or plants.

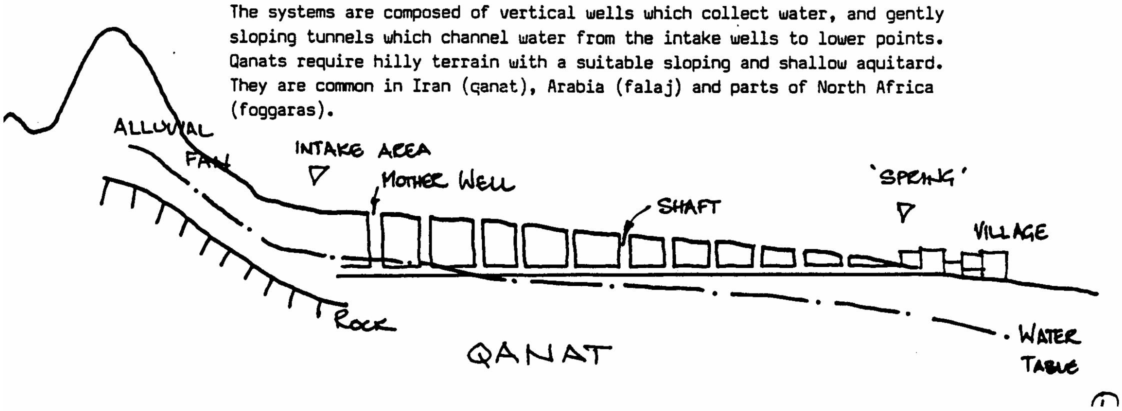
With their abundant insolation and often fertile soils, water is the only element missing for a modest agricultural system to be developed in arid areas, using appropriate species.

MACRO-HARVESTING

These techniques are for use in broad acre designs. Most techniques require special topographical or geological conditions.

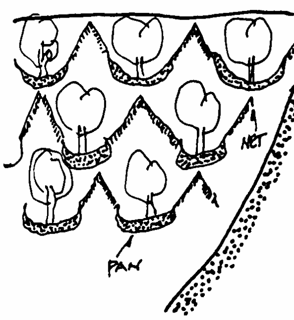
QANAT: This is an ancient water harvesting technique that collects the groundwater flow near its intake area and brings it to the surface in concentrated form on the plains below the intake area.

The systems are composed of vertical wells which collect water, and gently sloping tunnels which channel water from the intake wells to lower points. Qanats require hilly terrain with a suitable sloping and shallow aquitard. They are common in Iran (qanat), Arabia (falaj) and parts of North Africa (foggaras).



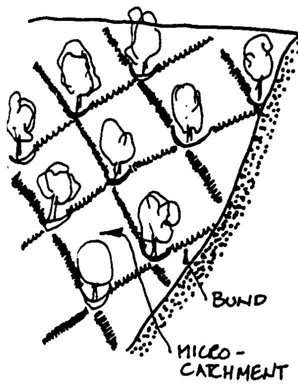
QANAT

RUNOFF: Most water harvesting techniques for arid areas aim to collect rain water runoff, either as it comes off the land or as it streams down water courses and flood plains. The following techniques generally aim to harvest runoff by increasing infiltration or trapping water in dams and silt traps. In most situations, the cheapest and most effective storage place for precipitation is in the soil itself. This principle should be remembered for all aridland design.



NET AND PAN: The net and pan system, with all its modifications, has been in existance for thousands of years. It is a technique most suited to moderate slopes.

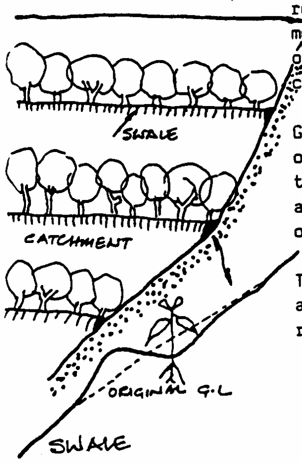
Trees are planted in pits which have shallow channels running between them to collect runoff and direct it to the tree pits. Trees are mulched and the pits, in which trees are planted, are deep enough to collect the water from an average rainfall.



PAN GRID: This is a modified net and pan system. Sloping ground is divided into a grid system of micro catchments. At the lowest corner of each catchment a tree is planted. The size of each micro catchment will vary in relation to the size of the tree area depending on ambient rainfall and the water requirement of the tree. Generally, ratios for arid areas range from 1:15 to 1:25. This ratio is the basis of most of the runoff design in arid areas.

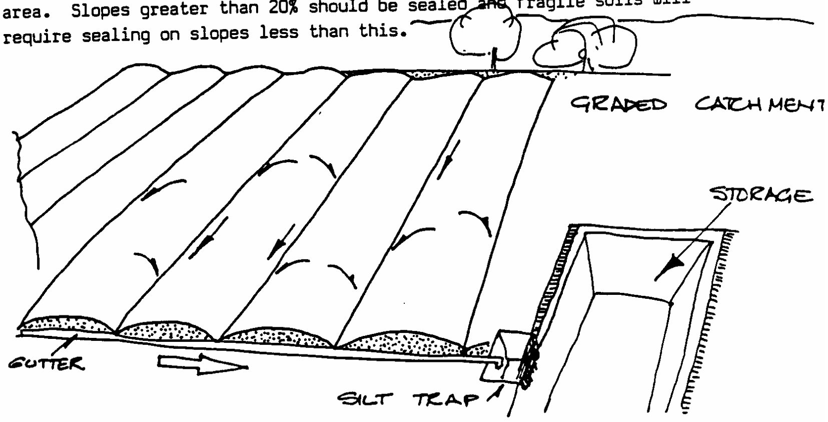
CONTOURED SWALE: The pan grid system can be modified for very large projects to become a system of strategically spaced contour swales which become the collection pans for large parallel run off areas. Trees and other plants grow in the swales.

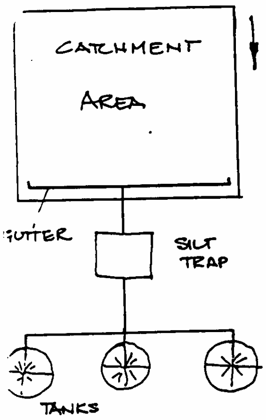
In suitable soils, inter swale areas can be deep ripped with a soil conditioner, or similar, to improve infiltration for mature tree crops. For shallow rooted crops and young trees, runoff collecting in the swale is the best means of irrigation because of the restricted root area. Thus this type of design consists of both spacial and temporal componants which must be carefully outlined for each site individually.



GRADED CATCHMENTS: When water is harvested for consumption by humans or other animals, a graded catchment or macro collection pan can be designed to direct runoff into tanks, dams or underground storages. In all cases a system of silt traps and gutters is necessary to minimize degradation of the storage facility and to avoid erosion.

The type of catchment will depend on the slope and soil type of the catchment area. Slopes greater than 20% should be sealed and fragile soils will require sealing on slopes less than this.



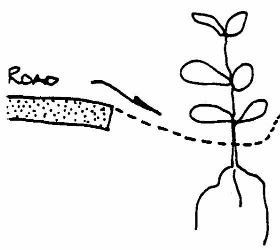


Sealants include rolled clay, emulsified asphalt, concrete, lichen cultures, rocks or sheets of butyl rubber and polyethylene. The type of sealant used will depend on the client group, available resources and the type of catchment being designed.

RUNOFF = K.P.A

WHERE K = runoff coeffecient
P = precipitation
A = area of catchment
(i.e 25mm falling on a catchment of $100M^2$ yields 2,500l of water if K is 100%)

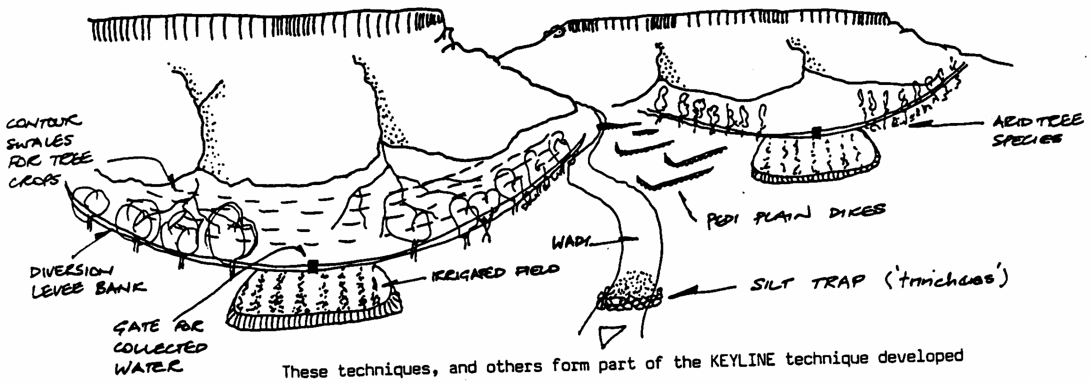
FLAT CATCHMENTS: Flat areas can also be designed as catchments by constructing roaded catchments from them. Roaded catchments are most successful with 'road' slopes of 8% and gutter slopes of 0.5 to 1%. Such catchments are most effective if kept free of vegetation (i.e maximize K) and should always incorporate a silt trap upstream from the storage area. This silt becomes a source of high grade potting soil.



ROADS: Roads, airstrips and firebreaks are all potential catchments if so designed. These can be designed to concentrate water in storage structures such as roadside tanks (called ahar in India), or to irrigate trees alongside the catchments. Interstate highways in most countries are estimated to yield about 1 Ha. of catchment area per kilometer of road.

MACRO RUNOFF: Very large runoff can be harvested from the general topography by careful design and intelligent engineering. In most cases the scale of design requires some understanding of engineering but the principles are set out here.

Where large areas of land are unsuitable for planting or catch large quantities of water, the resultant runoff can be directed towards arable land or other plantings with designed stearing banks and swales. Escarpments and pedi-plains are perfectly suited to this type of system. This design technique combines water harvesting with the broadscale concentration of water into an arable area, thus increasing the effective rainfall.



These techniques, and others form part of the KEYLINE technique developed by P.A.Yeomans.

TANKS: See below under Microharvesting.

DAMS: There are many types of dams which have applications in terrain with suitable catchments and soil types. For details on types of dams consult Yeomans 1978. For arid areas the important design principles that must be remembered for dams include:

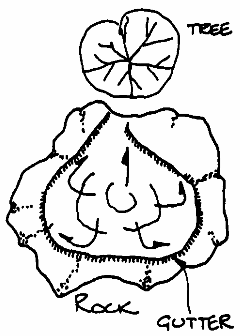
- high depth to surface area ratio
- ensure that soils will hold water again after drying out
- dams should never be allowed to dry out completely
- design spillway carefully to account for storm events
- try and locate above area of use and include lock pipe for easy distribution.

MICRO-HARVESTING

In some areas water should be collected off every available surface to make maximum use of the precipitation on the rare occasions that it does occur. All surfaces collect runoff when rain comes and most collect condensation.

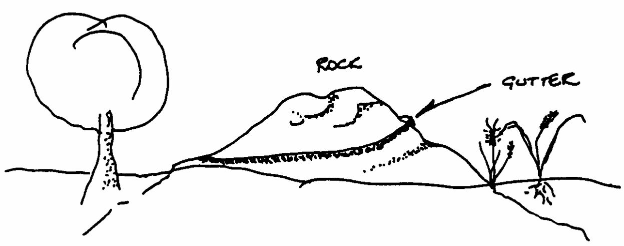
BUILDING RUNOFF: Water collected from buildings is best used for drinking water and should be stored in tanks, cisterns or covered reservoirs. Where runoff cannot be directed to storage structures it should be concentrated into designed plantings to make full use of it. Plantings for shade, food and shelter are priorities in arid areas.

TANKS can be made of corrugated iron (add a little limestone to the tank to increase water pH and thus reduce corrosion), concrete, steel (squatter's tanks are easy to build, transportable and relatively cheap), wood and slate. Underground tanks can be made in stages with outside backfill put in place as the walls rise. Fibreglass tanks are available but may not be resistant to degradation by the sun. Tanks should have mosquito controls designed into them, either as aquacultural biocontrol or sealed vents.



ROCKHOLES: In arid areas, rock holes are frequently regarded as sites of significance by the aboriginal population. This is due, at least in part, to their water harvesting potential.

Rockhole runoff can be harvested by designing concrete gutters to direct water to plantings next to the rockhole. Large rockholes such as that at Burra near Kalgoorlie, W.A., can be treated like this to concentrate runoff into dams or arable areas. The number of trees that a rockhole can support will be related to the ratio between catchment area and tree area (usually 15:1 to 25:1), which is dependant on ambient rainfall and species.



DEW AND MIST: Many arid areas have periodic high humidity air flows which can yield small but useful quantities of water. Gausu Province, China is an area with extremely low precipitation where melons are traditionally grown in gravel pits. These pits of gravel 10-15 cm thick, not only act as a mulch but condense airborne moisture at night, which then filters down to the soil and the plant's roots.

In the Canary Islands, where rainfall is almost unknown, small depressions lined with black, volcanic gravel grow trees and vegetables on the dew that condenses on the gravel mulch.

Trees can also be used to intercept dew and mist in arid regions. Trees used for this purpose should have large leaf surface areas, low allelopathic leachate content and suitable leaf shapes. Some Eucalyptus and Ficus sp. are used for this type of collection.

Ideal conditions for dew formation are clear night skies and a light ground wind of aroung 2 M/s. The wind factor can be designed for.

MULCHED WATERSHEDS: Modified swales with a vertical mulch slot can greatly increase water penetration and reduce evaporation. Combined with broadscale mulching, this design technique can produce considerable results with small quantities of presipitation. The technique is particularly suited to undulating country with trees and tall vegetables such as corn, okra, sorgham and rosella.

TERRACES AND BORDOS: This is a similar technique to the contour swales described above. Contour terracing and bordos catch runoff, silt and increase the infiltration rate to terraced fields. In high storm event areas, terraces can also have drâinage canals on the downslope side to catch extra runoff and excess drainage. Terraces can be planted with small trees, shrubs and other plants for reinforcment.

As with swales, terraces should follow contours. The spacing will depend on slope, storm precipitation and crop type. This is a very useful method for revegetating and repairing badly eroded and denuded land.

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11 . Arid Lands

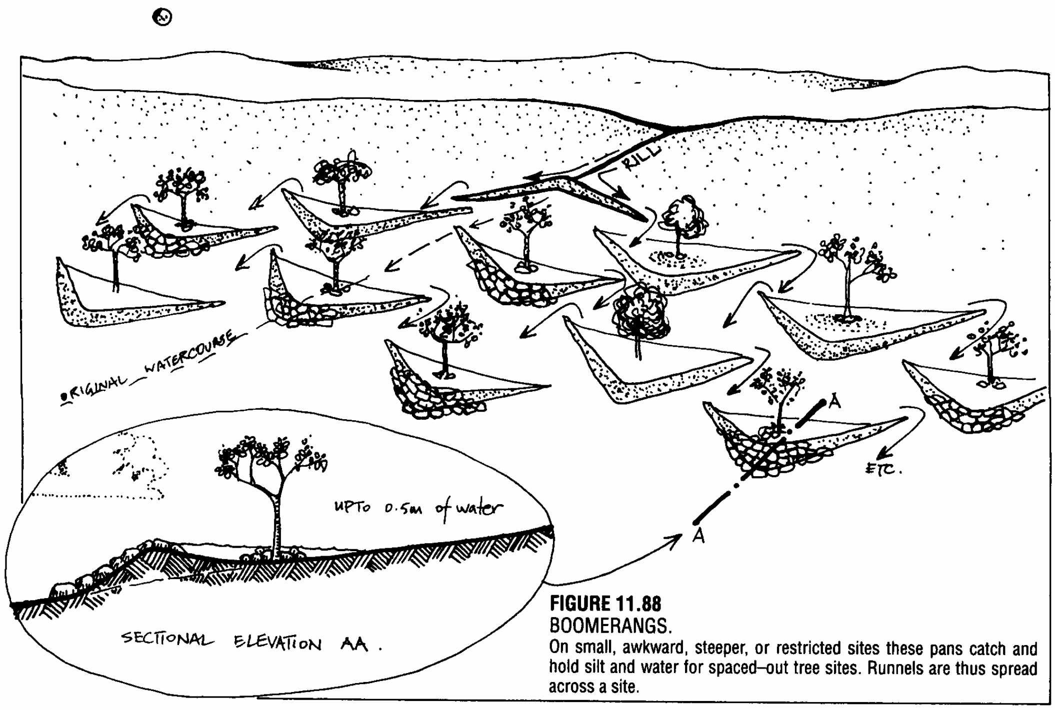

FIGURE 11.88
BOOMERANGS.
On small, awkward, steeper, or restricted sites these pans catch and hold silt and water for spaced–out tree sites. Runnels are thus spread across a site.

one–fourth (some say one–seventh) of the area free of stock at any one time, and to let the area regenerate if rains occur, perhaps assisting with a spring fire, pelleted seed, or broadscale water harvesting.

It is also possible to set up core areas of more carefully tended trees that can expand at their perimeter if seasons permit, which supply seed, and where re-forestation trials (and fire trials) can be controlled.

WRAITHS AND GOLEMS

Whole plants, seed–heads, leaves, dried manurial pellets, seed pods, and dust blow with the wind across desert plains, and are trapped in depressions, pits, swales, and against fences and tree–lines. Brush fences can be buried by drift, and need to be vertically extended if sand is unstable. A set of plants depend on the wind for dispersal, seen as substantial rolling balls (golems) or dry, light, airy panicles (wraiths). Some of the species involved are:

Black roly–poly (*Bassia quinquecuspi*), a short–lived perennial shrub which breaks off and rolls, distributing the spiny seeds. A nuisance to graziers, it occurs thickly only where overgrazing occurs, and protects a wide range of soils as a defending pioneer, under which more palatable or useful species can grow. It is "noxious", of course, although what is really noxious is the state of mind which ignores its useful function. Several copperburrs *(Bassis spp)* and salt bushes try to repair scalds (areas where topsoil is gone). Most of these species have thorny seeds, and form a dense mat under rubber sandals, which must be discarded as the seeds get everywhere!

Tumbleweed *(Amaranthus albus)* is a more effete invader, a stiff wraith preferring towns and settled areas, rarely abundant. *A. viridis* (cooked as a vegetable) is also found in arid–area towns as a "weed". A mustard *(Sisymbrium officinale)*, of some forage and medicinal value, is usually found only in cultivated (wheat) areas, and also spreads its dry seed stems as a wraith in dust–storms.

ARID–AREA GRASSES AND FORBS

A very careful selection of perennial and annual grasses can greatly increase the number and condition of animals on range. There are good grasses for every situation from sandseas to gilgais (natural swales developed from pockets of expanding clays). They cover a range of uses from human food to poultry and waterfowl forage, thatch, and green forage or hay.

Coarse tussock grasses become unpalatable if left unbrowsed (when dry material accumulates), or at flowering and after, when the food value is low. Thus, mown or managed swale fields are the most productive. Like all green crop, leaf material may contain dangerous levels of nitrates (dangerous to people and domestic animals) if over–manured or grown in heavily manure–polluted waters. This factor does not so much worry us if the hay is used as pit mulch for trees, but tests of garden greens should be made periodically for this factor.

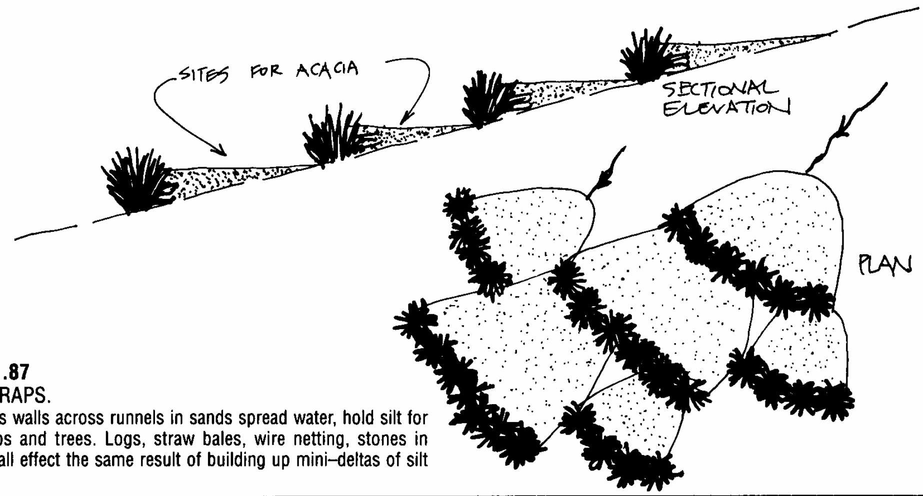

FIGURE 11.87
RUNNEL TRAPS.
Vetiver grass walls across runnels in sands spread water, hold silt for hardy shrubs and trees. Logs, straw bales, wire netting, stones in straw beds all effect the same result of building up mini–deltas of silt and leaves.

In the calcrete soils of coasts and islands, the concreted layer must be broken open at every important tree site (as it is with coconut and date crop) and a mulch pit (plus a scatter of elemental sulphur and mineral elements) prepared for the tree. A few fibrous–rooted species will sit on calcrete, but they are then at risk from drought and windthrow. Tree growth keeps the *platin* open and cracked for interplant. A fast way to do this is with an auger and about one–third of a plug of dynamite. The same technique can be used to place fence posts, or to shatter concretions for tree holes in shales and mudstones.

Sometimes a bulldozer is available, and rip–lines can be made for the tree lines. In this case companion crop of small legumes can be seeded between trees along the rip. Desert fenugreek, lucerne, tagasaste, and gourds can be intercropped with palms, *Casuarina*, or jujube.

Just as gypsum helps roots to penetrate clay, bentonite assists sands to hold moisture. Dried seaweed crumble added to planting holes forms a gel in rain, and enables the seedlings to penetrate to deeper levels in the first season. Commercial soil gel additives are also available for adding to the soils of potted plants in the nursery, and some of these function for many dry–wet cycles in field conditions.

THE REVEGETATION OF HOSTILE AREAS

It is certain that we will need to reclaim dry, salted, deflected, and pest–invaded areas in the course of developing a permaculture. Let us return to the practical experience of people who try to re–establish native bush on disturbed areas covered with weeds. The lesson is to start with *small* nucleii and to gradu-

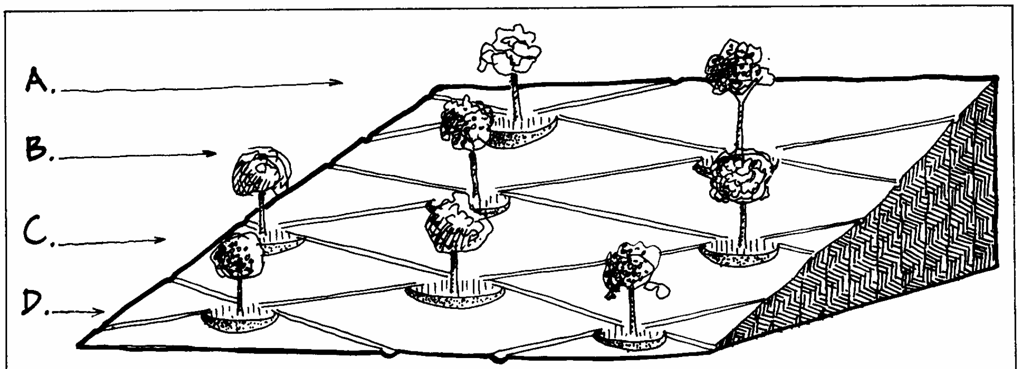

FIGURE 11.84
NET AND PAN (Plan).
Stony hillsides suit "net and pan" tree planting; hardier trees are planted in up–slope skeletal soils, less hardy trees on lower slopes.

A. Crest trees: hardy needle–leaf species and narrow–leaf trees to suit thin soils, e.g. stone pine, olive, *Casuarina*, *Callitris*, *Acacia*, quandong.

B. Hardy trees with known drought resistance, e.g. fig, pomegranate, *Acacia*.

C–D. Midslope and deeper soils suited to citrus, fig, *Acacia*, pistachio.

E–F. Deep base soils with some humus suited to chestnut, mulberry, raintree, citrus.

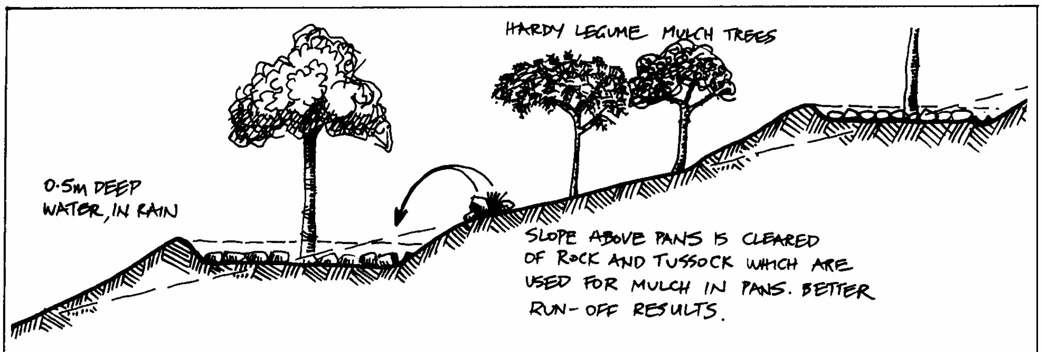

FIGURE 11.85
NET AND PAN (Elevation).

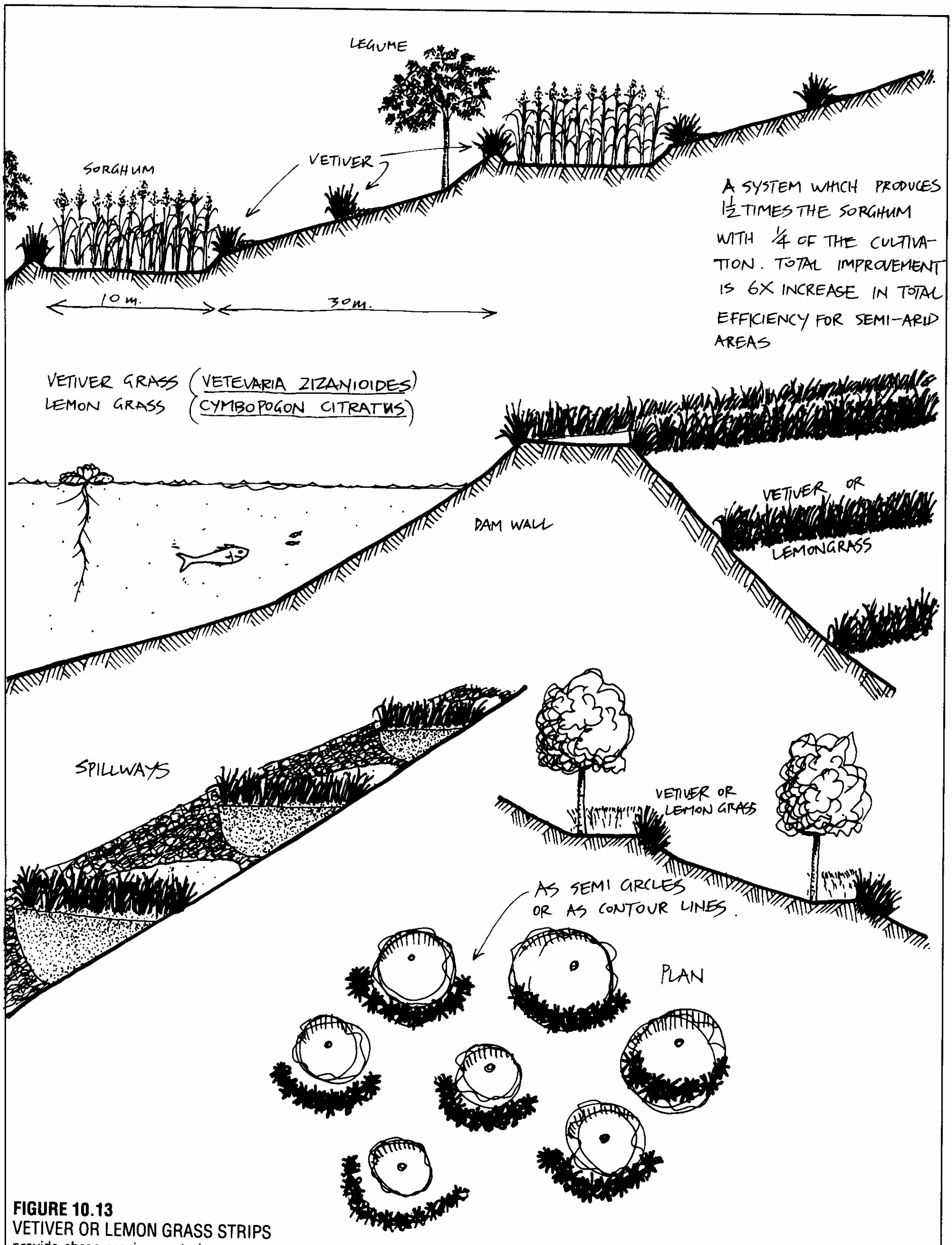

FIGURE 10.13
VETIVER OR LEMON GRASS STRIPS
provide cheap erosion control on contour or bund stabilisation; both these grasses clump readily, have few seeds, provide mulch, and hold soil movement.

12. Fire - Control

Permaculture for Fire Control
&
Permaculture for Millionaires

VII & XV

BY BILL MOLLISON

Pamphlet VII & XV in the Permaculture Design Course Series

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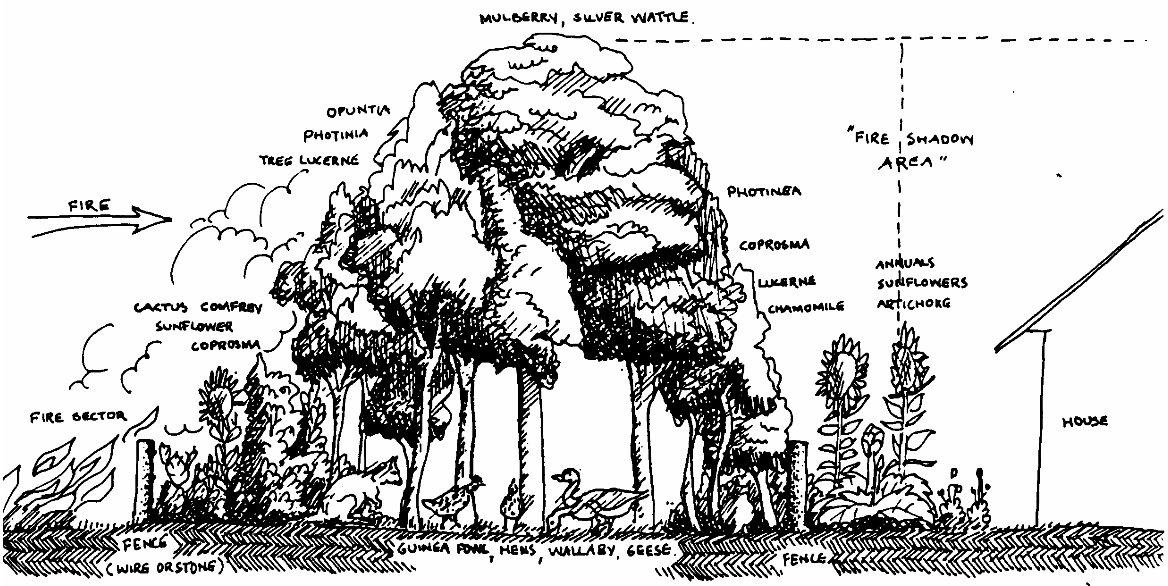

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Permaculture for Fire Control

Fire in landscape is a subject which I want to treat very seriously. It is a common hazard in almost any landscape.

Fire has a periodicity specific to the site. This fire periodicity depends on two factors: First, the rate of fuel accumulation on site. This is a critical factor. The second factor is the amount of moisture contained on site. Any ridge top is far more fire prone than its valley systems. Typically, the vegetation of ridge tops may even be fire-dependent, with species which germinate well after fire occupying the ridges. In the valley, on the other hand, you may get species that burn and may be killed by fire, but which burn very sullenly. While ridges are more fire-prone than their adjoining valleys, so are the sun-facing sites more fire prone than shaded slopes.

It is possible to work out the fire periodicity on site by examining the through cut of an old tree in the area, or even from historical records of fire in the area. With a rainfall of thirty to forty inches, a catastrophic fire will occur about every twenty-five or thirty years. I am not talking about a local spot fire. I am talking about a fire that races through a large area.

A lot can be done to change that cycle. Advantage is gained if it can be delayed even one period. The less a site is burned, the less it is likely to burn, because there will be more humus and more moisture incorporated into the site. On the other hand, the more it is burned, the more likely it is to burn again soon. This is because fire removes a lot of moisture-retaining humus and kills a lot more than it consumes, resulting in a fire-prone litter build-up. So the periodicity can be changed to a very short term if an area continues to burn. Areas which naturally experience fire every thirty years will burn every eighth or tenth year, once they are being burned at shorter intervals. Fire is a very destructive influence.

In Permaculture landscapes, there are sequences of defense that you must throw up. What you must do is reduce fuel. That must be the primary aim. You can do this by creating non-fuel surfaces, such as roads and ponds, by constructing swales and doing pit mulching, and reducing fuel by means of browsing or grazing.

It is very simple to protect the house site. You only need a hundred feet of non-fuel systems between the house and the forest. That is not very far; it is a raking job. Select plant species for this area that have fire-resistant characteristics, such as very high ash content, a very high water content, very low total bulk, and which grow densely. The ice plant, the Coprosmas, some of the thick-leaf evergreen plants, whose litter decomposes very fast, have leaves that are highly nutritious and don't last very long on the ground. A list of plant species useful for fire control in any area varies with the climate. Fire departments in fire-prone areas are often able to make recommendations.

Some trees, particularly the pines, and many of the leaf species, are litter accumulators. They form a hard and volatile litter which simply builds up and carries very large ground fire. Do not use plants to the fire danger side - the downhill side - which have high volatile oil content. Eucalypts are a positive no-no, and so are pine trees. Both are to some extent fire weeds. Both carry cones and hard fruits that often don't open until fires. After fires, you will see a widespread covering of new growth from the seed of these trees. That is what they are waiting for, a fire to enable them to extend their range a little farther.

So you halt fires by working from the valleys upward with plantings of low fuel vegetation. Re-establish the rain forest that would be on the site if it did not burn. Bring in a lot of species which naturally occur in the valleys.

Now let us look at the fire itself. What does the fire do? It doesn't burn anything much. It burns a few leaves, and perhaps buildings in its path. The real danger of fire is radiation. Four hundred feet in front of a fire, your hair catches alight. Two hundred feet, your body starts to split and your fat catches alight. At one hundred feet, you are a torch. It is radiation that kills birds hundreds of feet from the fire. They just fall out of the air. Fire kills pigs very quickly. They don't stand radiation. Goats survive quite well. They just lean into it. And human beings are good at surviving a fire because they dodge about and hide behind shadows.

So we need to throw fire shadows over the central part of the system which contains our client. We do it with earth banks, and we do it with trees like willows and poplars, which have high water content and which throw out a black cloud of steam, and don't let radiation through. So on many sites that you will strike, where fire will be a future hazard, you pay a lot of attention to setting up fire-protection. In California, almost every plant depends on fire, and all have high oils, because they have been selected through a long history of fires. Greece was once a land of wet rain forests, with enormous oaks and columnar beeches. It has become a skeleton of its former self, and its fire frequency is up and up. Now you really can't burn Greece because the dirt is burned, the plants are burned, the hills are burned, the rocks slip down hill and you can't burn rocks. The whole of the Mediterranean and much of North Africa has reached this condition.

What we must do is start reversing the process.

But if your client is in that chaparral, then you must pay particular attention to fire protection. You will have to give him somewhere to go to when a fire comes. You really can't save him on the surface. So you dig a T-shaped or L-shaped pit and earth it all up. It can be a length of road conduit, earthed over. Then your clients can hop underground and wait it out. When they are out of the radiation, they are out of trouble. In Coventry and other areas that were burnt in war, there would be fire storms. Standing in a fire shelter, I have watched the glass pouring out of the windows in my car. It is hot out there, you think. It melts out the bearings in your car. You can't drive. Always duck behind things in a fire. Just get out of that radiation. And keep your mouth shut. Don't breathe. Otherwise, your lungs burn out. So if you don't breathe until you get behind things, you are all right. The main thing is not to be in direct radiation. Often you can dig a fire shelter into a bank with a backhoe. In some areas, this work of a few minutes may be the critical factor for survival.

Otherwise, give good advice to your clients: Go behind the house and sit down till the front of the house is alight. Then walk around to the front of the house, because the fire will have gone past. Instruct clients about the need for litter reduction on the ground. Give them lots of instruction for pit mulching and swaleing. If you have a real bad fire site, construct a few big swales, and cover the swales with old carpet so that you get a very fast rot down. Put in a whole lot of plants which are quite fire-proof. You can stand behind a Coprosma, and you don't even feel the fire, just a hot steam bath.

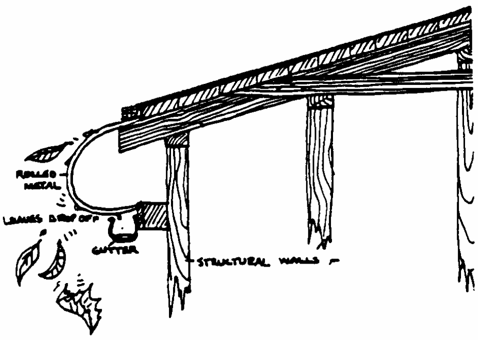
You can take advantage of the normal attributes of the raking animals, such as chickens. They break up that ground litter and mix it with oxygen so that it really breaks down. Short grazers, such as sheep and wallaby, on the fire side, will reduce the standing litter to one inch, and you will not need to worry about ground fire.

Just experimentally, I have lit around mulches, and they are not a risk. Sawdust, too, is a good safe mulch. Actually, you may get a half inch fire across the top. It starts to smolder burn, but it doesn't go anywhere. It can be quickly put out. You don't need to worry about mulches.

The primary protection in fire is to have good sprinklers down hill. If you can turn on a couple of those, you can sit on the front verandah and enjoy the sight of water pouring over the landscape before the fire gets there. I've seen water from the fireman's hose coming six foot out of the nozzle and going up in the air as steam. But before a fire gets there, if you've got your sprinklers on, and the ground is wet, the fire won't cross that ground. If the fire is already there when you put the sprinklers on, then the water doesn't get very far out of the sprinkler. So you must start your defenses before the fire.

Sprinkler systems on roofs are very critical. A house is lost when ashes fall all over the roof, slide down it, prop against chimneys and fill gutters. The wind is blowing; the heat returns in under the roof and catches tar paper in insulation, and starts burning from the ceiling under the roofing. That is the way 99% of houses are lost.

The safest houses in fire are wooden. They have a thirteen to fifteen percent higher survival than stone or brick, which is a surprise, of course. In analysis of some houses of equal risk that didn't survive, the brick outnumbered wood. Almost without exception, stone houses are taken up in fire. Stone transmits heat rapidly to the inner surfaces. Bricks are equally fast heat transmitters. You can burn a wood house with a blow torch if you go around catching it in a lot of places. But a wooden house is very resistant. Basically, wooden houses won't transmit heat through the fabric, and their drafting systems are better than in brick houses. White painted wooden houses, and paint generally, anything that will reflect that radiation, is a protection.



Rolled Roof Section

Illustration from Permaculture II by Bill Mollison. Published by Tagari, Stanley, TAS, Australia, 1979. Reproduced with permission.

When you are planning for fire, you must specify the use of screens and fine hardware mesh, so that large particles cannot enter the house system. The gutters should also be screened. Wherever you are experiencing snow, fire, or heavy leaf drop on the roof, it becomes necessary to put a rolled-under section on the bottom edge of the roof, and put the gutter back under, below that. Leaves will fall off. They can't get in the gutter. Snow will slide off. When snow melts, the melt will go into the gutter. Fire ash will slide down and fall off. It won't get caught in the gutter, either. That is a good device, and it can be fitted to existing roofs.

Put a monsoon sprinkler on the ridge of the roof. It is only going to operate for a short period while the ash is falling. It will be the most sensible fixture that you can put on a house. The tap to it should be outside. Turn it on, and the whole house is being washed down for an essential half hour. The roof is continually washed, and the gutters are flowing. For this, you will need a gravity feeding system, and it needs to be yours, because if it is part of a public system, everybody will be drawing on it, and likely, the system will be inadequate.

You must say to your client, "Well, look, we will give you a few simple specifics in housing design, and you must watch how you lay out your roads and ponds. That will give you a much better chance of survival." You also go ahead and give your client advice about how to proceed in case of fire.

Fire builds up to high intensity about 2:00 to 3:00 p.m. Inevitably, the people at home are people with young children. Mostly, they won't have a vehicle. They are a pretty vulnerable group, and they must be told what to do. If the fire comes from this side, they have to stand here with their woolies on, woolen jackets, blankets over them, and a bucket of water so wool won't burn. Then go into this little shelter that we have provided and have a drink of water. We should try to get water in there. It's worth it. Just walk in there and sit down, and leave your woolen blanket in water. Dig that shelter into a little hill just at the back of the house, normally away from the fire, on the slope. Go maybe six feet deep. Open your back door, and hop down into your little root cellar, which is also a fire shelter. We must look after the people in ways like that.

Advise people never to jump into water in fire. That is another no-no. There is no oxygen left in the water and they will faint straight away. It is like painting somebody's body. We breathe a lot through our skins. The fish already are dying from oxygen loss before fires ever get there. The people in the water will faint and drown. So jumping in the pond is a no-no.

There are some areas in which we will totally ignore this whole business, because for most of their history those areas have never been involved in fire, and the prospects of a sweeping fire are remote.

But, even in humid climates, high forested areas in the continental interior are not invulnerable to fire. When things dry up, and the wind whips about at fifty to sixty miles an hour, just a backfire from a car can set the whole area aflame. And fire travels about four hundred miles an hour. There is no running away from it, no driving away from it. When fire starts, it spirals up, and increases in breadth at the base. You will be looking up at the sky, and there is half of somebody's house, way ahead of the fire - an incredible sight. You will be looking up at a blue sky, an upstream of smoke, and there goes that burning house, a great fire in the sky. Then it drops. And at that point another spiral starts up. These big spirals go up, taking up everything that is burning with them, then drop it out, to start new spirals. A fire will cover a thousand square miles in an hour. So most people who are in it are in it. You can't go away from it. You have to just hold your place and sit it out. Don't start running. Don't try to run ahead of it. You have more chance of surviving a fire if you run straight at it. If you run away from it you are dead. You can't drive your car, because the petrol will evaporate. Unlike Hollywood, gas tanks never blow up; cars never catch alight; only the tires do.

The sensible thing to do with high explosives, like drums of fuel and the like, is to store them away from a living situation, have them in a separate shed, and a bit separated out, so when one ignites, it doesn't ignite the others.

Don't put your poor client at the head of a converging valley in the saddle. Don't put your client where you would normally put an efficient windmill. Don't put him where the ridges converge. No, no!

I witnessed an example of landscape architecture in an Australian fire-prone site. I was driving by this place, and I looked at this house - I couldn't believe it! There was an acre of fire-consuming vegetation just across the way, converging eucalyptus trees with pampas grass. And it had been constructed by a landscape architect. While a lot of the aesthetics were reasonable; the function could actually be fatal.

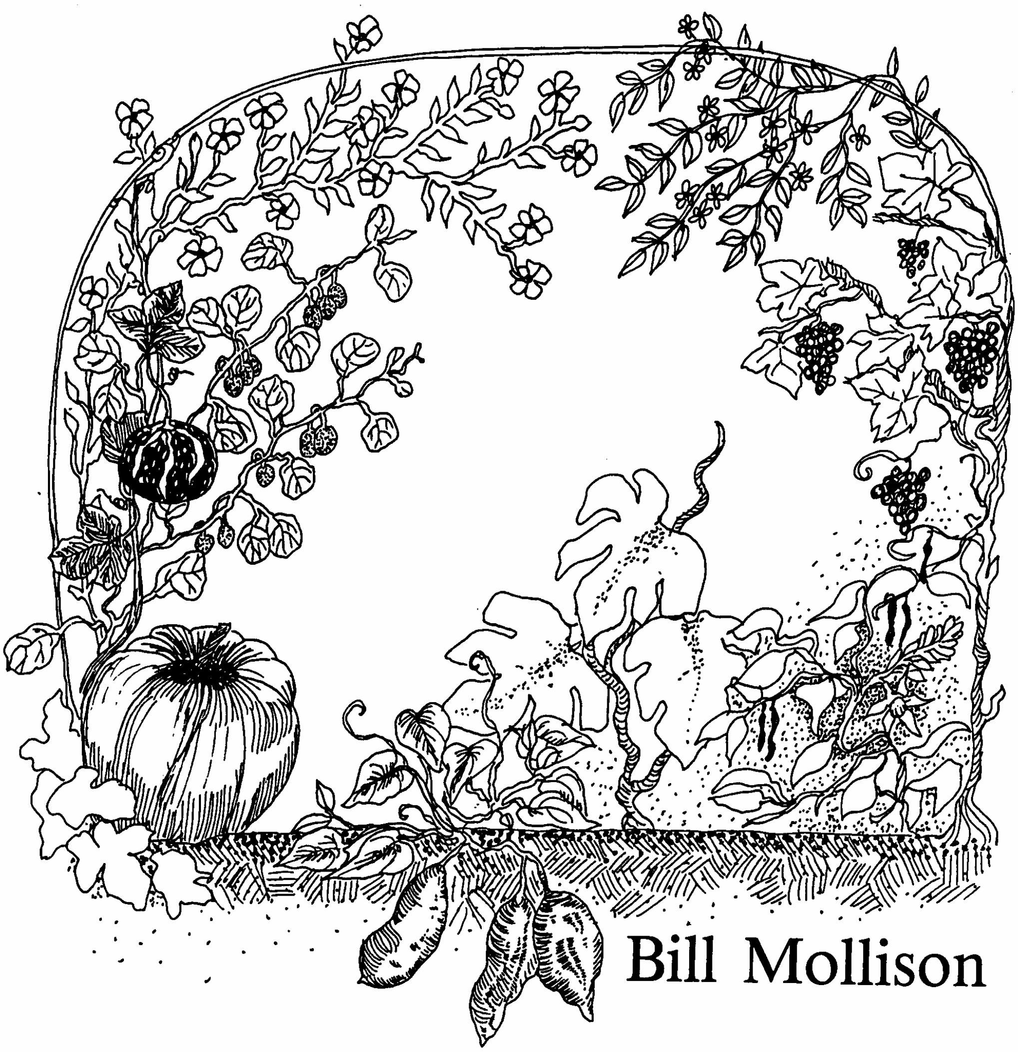
So in my mind, function always comes first, then aesthetics. A good function is often a very pleasing aesthetic. He could have had a couple of fire banks up the driveway, and we could have given him a pond in there, and a Coprosma hedge downhill, just below the pond.

When you construct a pond in front of the house, with your road along the side of it, the bank of the pond that you take out should be raised toward the fire side. You will find that there isn't any conflict between real good fire control and good placement of your elements. But if you don't have the initial planning, all sorts of things can go wrong.

13 . Useful Climbing Plants

5

Useful Climbing Plants



Bill Mollison

Distributed by Yankee Permaculture, P.O. Box 672, Dahlonega GA 30533-0672 USA, publisher of more than 25 permaculture papers, a series of 15 pamphlets based on Bill Mollison's Permaculture Design Course and *The International Permaculture Solutions Journal.* Write for a complete list of publications.

USEFUL CLIMBING PLANTS

COMPILED BY BILL MOLLISON. ILLUSTRATED BY RENY SLAY AND ANDREW JEEVES

There are a great many vines, in many plant families. Vine and liane forest develop in very humid rainforests, either in the tropics or in temperate rainforest (Chile). While most vines appreciate waterside localities and humus-rich soils, a few tolerate alkaline and salty soils, seafront conditions, and drought. A combination barrier of low fence and vine is termed a "fedge", and fedges are often needed to shelter gardens in extreme conditions.

Apart from their intrinsic product use, vines are excellent modifiers of extreme heat or cold, and can be intimately used on and around buildings to produce cool shade or to carpet walls as an insulator. Where many roof structures are too slight to support a turf roof, vines will scramble over homes to protect them from extreme heat or cold, trapping air and adjusting leaves to ventilate or seal off walls.

Few books exist on the uses of vines, and any additions to the lists that follow would be appreciated; even uses by bees are not commonly noted. The arrangement is in families, alphabetically, with notations to enable selection for sites and uses.

PART A. VINES IN PLANT FAMILIES

Fam. ACANTHACEAE : Perennial, semi-hardy evergreen vines.
Sky flower (Thunbergia grandifolia). A blanketing vine of tropical valleys. Three inch blue flowers. Eaten as a steamed vegetable in the Caribbean.
Black-eyed Susan (T. alata). Flaring orange flowers, black centre. A common fence-hedge of semi-arid sub-tropics to Mediterranean climates.
Bengal clock (T. gregorii). Sub-tropical fence cover or cascade over walls.

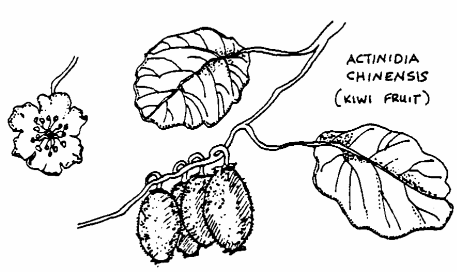
Fam. ACTINIDIACEAE : About 40 species of vigorous woody vines, mostly dioecious. Propagated by seed, cuttings. Deciduous and hardy to frost.
Kiwi fruit (Actinidia chinensis). Superior fruit cultivars developed in New Zealand. Needs strong trellis or tree to support fruit. Will withstand light frosts, and is hardy to 43° latitude in temperate climates. Fruits are a valuable source of Vitamin C.
Silverberry (A. arguta). Extremely vigorous vine, hardy to arctic circle, prolific edible fruits. Hybridises with kiwi fruit, and enables the latter to be grown in cold climates (e.g. New Hampshire).
All allied are: A. kolomikta, A. coriaceae, A. rubricaulis (cultivated in China), A. polygama (leaves edible, eaten boiled).

Genus Clematoclethra (about 25 spp.) resemble above plants.

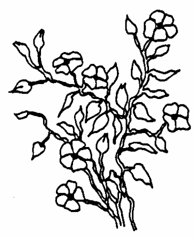
Fam. AIZOACEAE : Hardy evergreen (includes trailing iceplants).
Bower spinach (Tetragonia implexicona). Evergreen, hardy, coastal dune vine which also trails down walls. Used boiled as a spinach. Excellent sea-side fedge.
New Zealand spinach (T. tetragonioides) is a perennial creeping edible spinach of gardens.

Fam. APOCYNACEAE : Semi-hardy evergreen.
Star jasmine (Trachelospermum jasminoides). Grown for ground covers or climbers, and prized for perfumes, as is Mandevillia suaveolens (about 100 species of Mandevillia exist in South America).

Gargaloo (Parsonia eucalyptophylla). Dryland, fragrant; foliage used for fodder in droughts (Australia).



ACTINIDIA CHINENSIS (KIWI FRUIT)



THUNBERGIA ALATA (BLACK-EYED SUSAN VINE)

TRACHELOSPERMUM JASMINOIDES (STAR JASMINE)

Fam. ARACEAE : Ceriman (Monstera deliciosa). Tall, scrambling evergreen, sub-tropic broad-leaf vine ascending on forest edges and bearing large edible fruit, mostly juiced to avoid acidic spicules. Grown in the open to the sub-tropics, and under glass in cooler climates (is also a popular houseplant, but doesn't often flower or fruit). Fruit is of an excellent flavour.

Fam. ARALIACEAE : English ivy (Hedera helix). Many varieties and some hybrid forms. A valuable insulating species of cool climates, producing bird fodder as berries and saponins used for soaps. Bees make some use of flowers. Used also as a ground-cover in moist areas. Related: H. colchica (cool areas), H. canariensis (dry areas).

Fam. ARISTOLOCHIACEAE: Vigorous deciduous vines.
California Dutchman's pipe (Aristolochia californica). Some tropical species of this genus attract and trap flies in flowers equipped with one-way bristles. Several species have medicinal uses, e.g. Dutchman's pipe (A. macrophylla) and related species. Plants used for vermifuges, abortifacients, antiseptics, febrifuges, diuretics, control of menstruation.

Fam. ASCLEPIADACEAE : Genera Wattakaka, Araujia, vigorous evergreen ornamentals. Cionura (=Marsdenia) semi-deciduous climbers to 20 feet. Metaplexis, Hoya, frost-tender evergreens.
Caustic vine (Sarcostemma australe) leafless vining tangle of the coasts, open forests, with irritant caustic sap.
Doubah (Leichardtia australis). Slender desert vine of Australia. Buds, shoots, and pods (fruit) eaten by Australian aborigines, as for related Cynanchium floribundum. Pods edible green or roasted. Worth a place in desert gardens.

Fam. ASTERACEAE : Soft ivy (Senecio mikanoides). Dense evergreen, sometimes killed by drought or frost. Flowers used by bees. Smothers low plants in cool coastal areas, resists fire and often spreads after fires. Useful as fire barrier plant on fences.

Fam. BIGNONIACEAE : Few uses noted; decorative, but useful for cooling buildings and canal banks or wells.
Cross vine (Bignonia capreolata). Vigorous semi-deciduous hardy tendril climber, orange-red flowers. (One species).
Scarlet trumpet vine (Campsis radicans, C. grandiflora). Hardy, vigorous deciduous vines, orange or scarlet corolla. Needs some support on walls.
Eccremocarpus scaber, semi-hardy climber, red corolla.
Yellow trumpet vine (Anemopaegma chamberlaynii). Evergreen tendril climber; needs support. Semi-hardy.
Violet trumpet vine (Clytostoma callistegoides). Evergreen, hardy to 20°F.
Red trumpet vine (Distictis buccinatoria). Vigorous tendril evergreen to 30 feet; hardy to 24°F. Many species.
Cats claw (Macfadyena unguis-cati). Evergreen hook-claw tendrils, part deciduous. Stands severe heat, needs little water, climbs most surfaces. A dryland species.
Bower vine (Pandorea jasminoides). Evergreen twiner. P. pandorana (=Tecoma) used in dryland areas, on fences and trellis.
Wonga vine (P. pandorana). Rocky skeletal arid soils of Australia. Wood used as spear shafts by Australian aborigines. Browsed by stock but not very palatable. Brilliant fox-glove-like flowers in winter/spring.
Cape honeysuckle (Tecomaria capense). To 25 feet; drought resistant, exposure-tolerant barrier and bank cover plant. Orange-red tubular flowers. Needs support on walls.

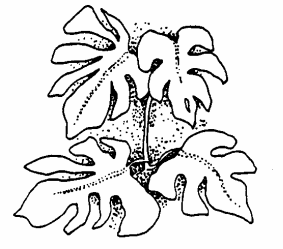
All the above species are decorative insulators or cool shadehouse covers.

Fam. CANNABACEAE : Hops (Humulus lupus). Bottomland and waterside herbaceous perennial; hops are grown mainly for beer flavouring, but also used as a pillow filling and mild narcotic (in sherry). Shoots and tips used as a steamed green. Propagate from root cutting (3-4 buds); older hop plants yield best, and in gardens will persist for 80-100 years. Naturalises on swamp edges and river banks, scrambles in trees or can be wound on hanging cords. Dies down in winter to root buds. If roots are rotary-hoed, they can become a tough pest species. Browsed by sheep, geese when young, but sheep can be used in plantations from late spring to winter to browse the grass beneath the hops.

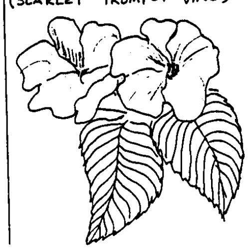
Fam. CAPPARIDACEAE : Nipan (Capparis lasiantha). Coarse spring dryland climbing shrub (Australia), masses of pale yellow, sweet-smelling flowers. Leaves very palatable to stock and berries

HUMULUS LUPUS (HOPS)

MONSTERA DELICIOSA (CERIMAN)



CAMPSIS RADICANS (SCARLET TRUMPET VINE)



HEDERA HELIX (ENGLISH IVY)

edible and quite palatable. A poultry forage plant for drier areas.

Fam. CAPRIFOLIACEAE : Honeysuckles or woodbines. About 100 spp. Vigorous evergreen or deciduous species, best supported on trellis. Grows over trees in forests.
Japanese honeysuckle (Lonicera japonica). Sub-tropics to temperate. Young leaves steamed as a vegetable; leaves, buds, and flowers as tea. Can become rampant in cool moist forests, smothering vegetation.
Also, L. periclymenum, L. caprifolium; edibility unknown, but useful bird-attracting plants.

Fam. CELASTRACEAE : 40 spp. mainly tropics; woody vines. Also hardy deciduous species. Many vines but few secondary uses known. Seeds or layers used in propagation.
Bittersweet (Celastrus paniculata). Leaf-juice used as a tonic, stimulant. Tropics.
C. flacellaris, C. orbiculatus, C. dependens, C. rugosa, C. angulatus all adapt to cool areas; most to 15-30 feet.
Tripterygium regelii, T. hypoglaucum may have insecticidal properties. These adapt to cool areas and are deciduous; 10-30 foot scrambler.
Euonymus fortunei. Broadleaf evergreen (to below 0^{o}F). Climbs by rootlets, stands full sun, good bank stabiliser.
Salacia chinensis (Australia). Tropical vigorous evergreen woody coastal and mangrove vine with deciduous edible fruits, about 3 cm across (also, S. prinoides).

Fam. COMPOSITAE : Evergreens. Temperate to tropical, suited to warm temperate areas. Very vigorous and can be smothering. About 60 spp. with no useages reported. Mutisia clematis and M. decurrens, the latter hardy to frost.

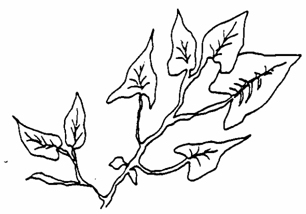
Fam. CONVOLVULACEAE : The sweet potato and morning glory group. Vines and ground scramblers of the genus Ipomoea are used for the food stored in the starchy rootstocks or tubers.
I. angustifolia; root eaten roasted, Japan.
Moonflower (I. aculeata =calynyction). Annual; young leaves and fleshy calices used as vegetable. Juice used to coagulate latex.
Kangkong (I. aquatica). Green vegetable; China, tropics generally (see also "Useful Plants of Wetlands"). A very important tropical leaf crop for high-nutrient greens.
Sweet potato (I. batatas). A staple food of drier tropics. Hundreds of cultivars; withstands high wind with low protecting walls.
I. cairica; stems as cordage, roots as famine food (also I. pes-caprae). A rampant weed in subtropics.
I. polymorpha; dry dune annual. Tuberous roots eaten by Australian aborigines.
I. mammosa; roots eaten (Philippines).
Purple morning glory (I. indica). Roots used as pig food. Vigorous semi-arid vine which can become a weed.
Ghiabaro (I. eriocarpa). Roots eaten.

Just as we have a few important and basic foods in this group, so we also have some invasive and persistent weeds:

Greater bindweed (Calystegia silvatica). A creeping, deep-rooted coastal weed, with white "trumpet" flowers.
Bindweed (Convolvulus arvensis). "One of the worst weeds in the world". Roots "cork-screw" and will not pull up, so the plant must be dug out.
Purple morning glory (Ipomoea congesta). A vigorous rampant climber of the subtropics, smothering other vegetation. Common in coastal subtropics.
Spanish flag (Mina lobata). Perennial in warm climates. Fast twining (20 feet a year); covers buildings quickly.

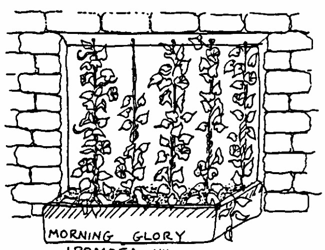
Cultivated convolvulus find an unusual use in urban window-boxes and are trained up multiple cords to form summer screens across windows and patios. New York City has many such "screens" growing in summer.

Fam. CUCURBITACEAE : Gourds, melons, squashes, pumpkins, bryony, cucumber, chayote. There are many genera and species in this family, of which a great many are cultivated or wild-gathered. Crossing between genera or species is rare; one garden can grow a dozen or more useful but different plants and still save seed that comes true to type.



IMPOMOEA AQUATICA (KANGKONG)

IMPOMOEA BATATAS (SWEET POTATO)



MORNING GLORY
IPOMOEA NIL

4

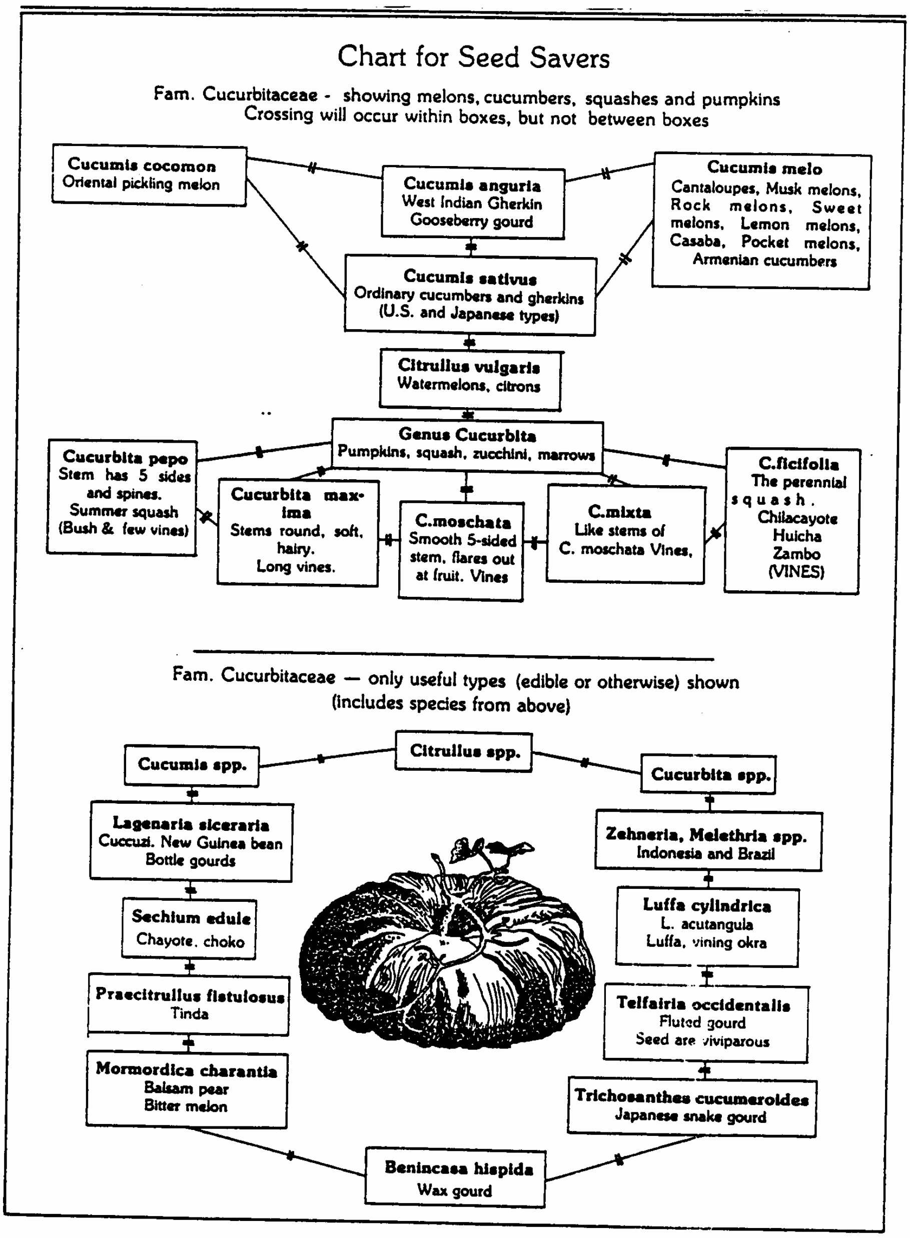


Chart for Seed Savers
Fam. Cucurbitaceae - showing melons, cucumbers, squashes and pumpkins
Crossing will occur within boxes, but not between boxes
Cucumis cocomon
Oriental pickling melon
Cucumis anguria
West Indian Gherkin
Gooseberry gourd
Cucumis melo
Cantaloupes, Musk melons, Rock melons, Sweet melons, Lemon melons, Casaba, Pocket melons, Armenian cucumbers
Cucumis sativus
Ordinary cucumbers and gherkins
(U.S. and Japanese types)
Citrullus vulgaris
Watermelons, citrons
Genus Cucurbita
Pumpkins, squash, zucchini, marrows
Cucurbita pepo
Stem has 5 sides and spines.
Summer squash
(Bush & few vines)
Cucurbita maxima
Stems round, soft, hairy.
Long vines.
C.moschata
Smooth 5-sided stem, flares out at fruit. Vines
C.mixta
Like stems of C. moschata Vines.
C.ficifolia
The perennial squash.
Chilacayote
Huicha
Zambo
(VINES)
Fam. Cucurbitaceae — only useful types (edible or otherwise) shown
(includes species from above)
Cucumis spp.
Citrullus spp.
Cucurbita spp.
Lagenaria siceraria
Cuccuzi. New Guinea bean
Bottle gourds
Zehneria, Melothria spp.
Indonesia and Brazil
Sechium edule
Chayote, choko
Luffa cylindrica
L. acutangula
Luffa, vining okra
Praecitrullus fistulosus
Tinda
Telfairia occidentalis
Fluted gourd
Seed are viviparous
Mormordica charantia
Balsam pear
Bitter melon
Trichosanthes cucumeroides
Japanese snake gourd
Benincasa hispida
Wax gourd

Climbing or twining is more common in the group than otherwise; and most of the plants produce tendrils. Uses vary from those grown as vegetables, to those grown for seed, root crop, gourds, or even as bee forage. Most cultivated cucurbits are annuals, while others arise annually from tuberous rootstocks, which themselves may be edible; many have edible growing tips and flowers, and these are an important (if neglected) part of the food yield of cucurbits. Of the cultivated squashes and melons, there are hundreds of varieties, some favoured locally because of yields, soil type, or keeping qualities.
Cucurbits are an important food of semi-arid regions and oases, withstanding great heat if some soil water is available; they can also be grown as a summer trellis crop over strong horizontal trellis, and are very colourful grown in this way. Seeds are of high nutritive value, and are usually eaten roasted or salted. Some selected genera and species:

Chayote (Sechium edule). Subtropic to tropics. Herbaceous scrambler, vigorous, perennial on thick rootstock which is also edible and can be used for starch, boiled or baked. Young shoots and tips eaten as a salad, steamed. Fruits grown either for seed (a small fruited form) which is used as a "chestnut", baked, or grown for normal large fruit which are dried, baked or boiled fresh, and are an important food. Chayote can be used to smother less vigorous plants such as Lantana, and is a good roof covering for summer, pig food, poultry food, and a general-purpose vegetable. Not hardy to frost, and fruit poorly outside Lat. 35°.

Ivy gourd (Coccinea cordifolia). Perennial, tropics. Leaves and immature fruit eaten cooked. A valuable tropical climber.

Snake gourds (Trichosanthes cucumeroides). Fruits used as a soap, roots for starch. T. anguina and T. japonica are used a vegetable in Japan. T. palmata (Australia) roots are eaten by Aust. aborigines, in dry seasons (sub-tropics). T. pentaphylla (tropics) attracts butterflies. Most bear decorative fruit. All are perennial.

Malabar gourd (Cucurbita ficifolia). Flesh sweetened to syrup and eaten, as are matured seeds. Flesh also fermented to alcohol (Mexico). Fruits eaten boiled.

Buffalo gourd (C. foetidissima). An arid-land perennial, frost tender but developing a large starchy root to 100 kilos, up to 2-5 tons of high oil content seed at 35% protein per acre. Roots are washed in salted water before cooking. Both these species deserve serious development as dryland crop.

Bryony (Bryonia dioica) and related species provide excellent bee forage, berry-like fruit for birds, medicinals for dropsy and as a pergative.

Oyster nut (Telfairia occidentalis). Africa. Cultivated for excellent seed 'nut' and as a green vegetable.

Zanzibar oil wine (T. pedata). Oil from seed used in soaps and candles.

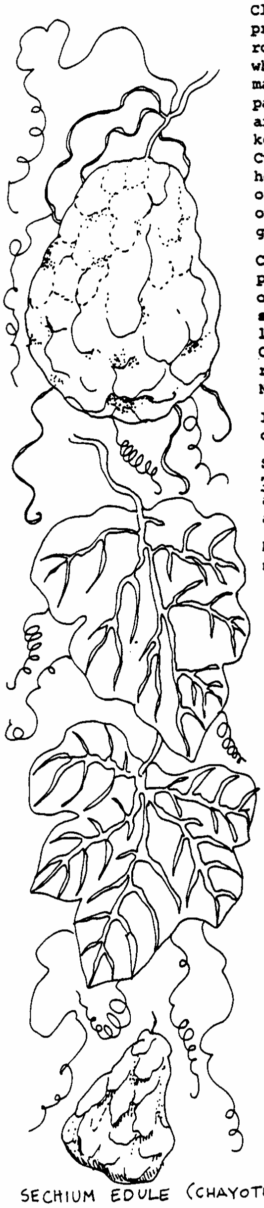
Calabash gourd (Lagenaria vulgaris =L.sicearia). Vigorous tropical vine of which the young fruits are eaten, the older fruits used for a great variety of containers, utensils, musical instruments. There are many shapes of these gourds, and they last for a century or more if well cured.

Loofah (Luffa acutangula). Vigorous vines; young fruits eaten, older fruits rotted and fibrous skeleton used as a bath sponge, for soles of sandals, and scrubbing brushes. Subtropics.

Wax gourd (Benicasa hispida). Fruits eaten at any stage, flesh cooked with syrup at maturity. Leaves and tips, flowers a vegetable. Frequently trellised out over water or canals to save ground space (China).

The commonly-cultivated annual cucurbits, in hundreds of cultivars, are:

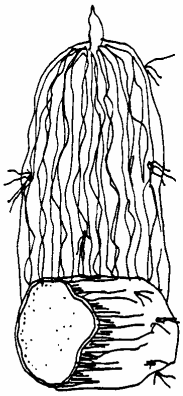
Cucumbers	Cucumis sativus and gherkins (also, C. anguria).
Canteloupes	C. melo and rock melons.
Winter squash	Cucurbita maxima. Also turban squash.
Pumpkins	C. moschata
	C. mixta
Marrows	C. pepo. Also, bush (summer) squash.



SECHIUM EDULE (CHAYOTE)

CUCUMBERS & SQUASH

Fam. DIOSCORACEAE



: The true yams; a staple food of the tropics. Yams are tuberous-rooted vines that climb in tropical and subtropical forests. They are grown in deep-mulched pits or log "boxes" filled with compost of rotted leaves and forest soil. There are several species, of which the most important are given. All tubers should be peeled and cooked to make them edible (they can be baked in their skin like sweet potatoes). They are stored in dry dark sheds on wooden slats, or in baskets. Flesh is of various colours. They are a good trellis crop in tropics, and are best grown in forest edges or in cut-over forest.

Winged yam (Dioscorus alata) is the most important economic root crop, and comes in many shades and colours. Also:
White Guinea yam or eboe yam (D. rotundata).
Yellow Guinea yam (D. cayenensis).
Chinese yam (D. esculenta); a year to mature. D. oppositifolia.
Aerial yam (D. bulbifera); stem tubers are preferred to root tubers.
D. trifida; the only American species.
D. transversa (Australia); can be eaten raw or cooked.
D. sativa
Composite yam (D. composita)
Convolvus yam (D. convolvulaceae)
Floribunda yam (D. floribunda)

Other minor species of this family have edible roots, but some need cooking or washing to make them palatable. Yams are the origin of "the pill" and were so used by Amazon tribes to control births and even to totally prevent menstruation.

Fam. ELEAGNACEAE

: Eleagnus latifolia. A tropical shrub or vigorous woody climber bearing edible (2 cm) fruits much appreciated by wildlife, birds, pigeons; a trifle dry and mealy for human food, but quite edible. Related to other valuable tree fodders for turkey, chickens.

Fam. FABACEAE

: The vine legume family (Papilionaceae, Leguminaceae).

Burny bean (Mucuna gigantea). Woody perennial climber with irritating hairs; tropics. Flowers yield copious nectar and are food for birds, bats, possum, moths, and butterflies. Pods with flanges are per four-winged bean. Aborigines eat dried beans after grinding, washing, cooking. Also velvet bean (M. deeringiana).

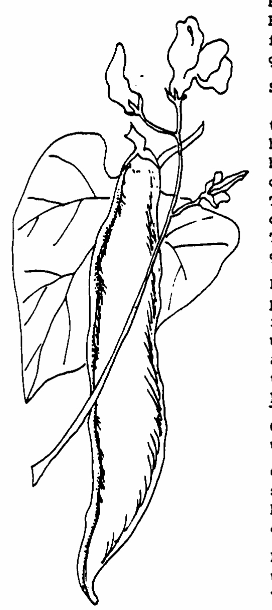
Scarlet runner bean (Phaseolus coccineus; P. multiflorus). Herbaceous perennial (some annual varieties) with thick root stock, frost and cold tolerant, and grown to 50^{o} N. Latitude in mild coastal or island climates. Needs cool periods to fruit heavily, or a water spray on flowers. Many cultivars. One of the most popular green beans of Europe; little grown in the U.S.A. except for the flowers. Also used as a dried bean. One of the few temperate perennial beans, of ancient culture in Mexico. Tubers can be boiled as a vegetable. Beans may be all-black, all-white (Czar variety or snail bean), or are normally black and red-streaked (robin's egg).
Tepary bean (Ph. acutifolius); high value dryland species. Lima bean (Ph. lunulatus) good tropical low hedge on fences. Both are useful dried beans of high value.

Kudzu (Pueraria thunbergiana; also = Dolichos hirsutus, D. japanicus). A rampant, powerful evergreen of the subtropics and tropics. Wide uses: seed for poultry, roots for starch and pig food, fodder for cattle, stems for fibre and textiles. Dried beans used as a potherb. Seeds can be eaten after preparation. A cattle forage, but can be a rampant smothering crop if not browsed or harvested. Pigs can be penned in plantations to dig out roots, as for chayote. Also P. lobata for cooler areas (13-26^{o}C) and P. phaseoloides for tropical areas (23-27^{o}C).

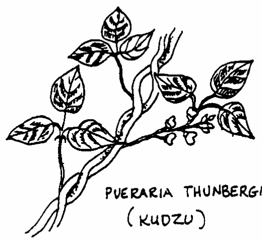
Climbing jack bean (Canavalia plagiosperma). Peruvian bean of ancient culture, still used in South America. Also C. ensiformis, C. gladiata.

Greenleaf (Desmodium spp.). Subtropics and tropics. There are carpeting and climbing species, many used as green manures or soil covers. Some scramble into supporting bushes, and can be a nuisance in young orchards; prostrate forms are a preferred ground cover. Many species are under trial by the USDA on Molokai, Hawaii.

Edible or garden pea (Pisum sativum). Temperate to sub-tropic crop. Almost all will use supports and are tendril climbers, but some are developed as taller climbing varieties (telephone, sugarsnap). Of ancient (Egyptian) cultivation. Used as whole pods (snow and sugar peans), greenpeas, dried, and split. Field or grey peas grown as pigeon fodder crop.

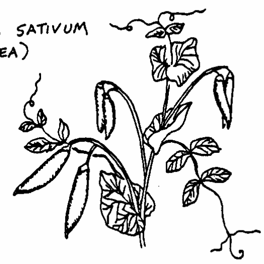


PHASEOLUS COCCINEUS
(SCARLET RUNNER BEAN)

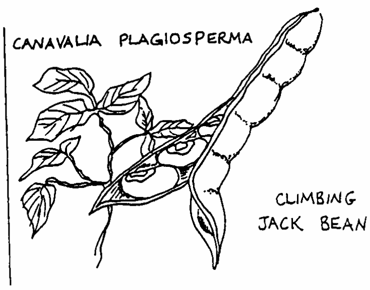


PUERARIA THUNBERGIANA
(KUDZU)

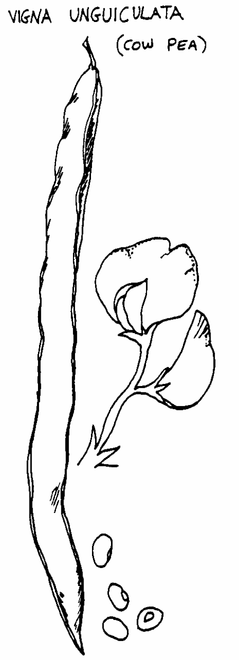
PISUM SATIVUM
(PEA)



CANAVALIA PLAGIOSPERMA



CLIMBING
JACK BEAN



Chickling vetch (Lathyrus sativa). Tropical fodder and dahl (dried seed) crop; needs thorough cooking, and is often thrice-cooked (parched, boiled, pasted, fried) to eliminate poisonous principles. Common vetch seed can cause permanent paralysis or "lathyrism" in humans.

Trefoils (Lotus spp.) Valuable fodders of temperate and subtropic areas, dune. Low scramblers. Lotus tetragonolobus, the asparagus pea, is a small bush pea, not now much grown, which has edible four-winged pods and scarlet flowers.

Bodi bean (snake or yardlong bean) Vigna unguiculata, V. sesquipedalis. Trellis vines with long beans, much grown in India. Selected to V. sinensis (black-eyed bean), which is a vine in subtropics, a bush bean in temperate areas. "Cow pea" (V. unguiculata) is a valuable pioneer legume in cut-over areas, preceding tree planting; it is an ideal pioneer crop after clearing Lantana.

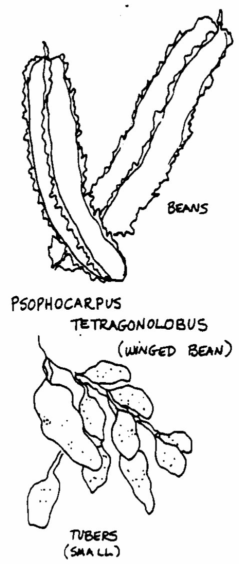
Queens slipper, butterfly bean (Clitorea ternata). Useful forage, ground cover, edible pods. Will suppress weeds. Flowers used as blue food dye. Soil-improving legume.

Rosary vine (Abrus prelatorius). Seeds, used in rosaries, have a toxic albumen (in bloodstream). Roots are used as a licorice substitute.

Matchbox bean (Entada phaseoloides). Seeds used as fish poison, also eaten after washing and pounding. Pods (to 120 cm long) used as small containers.

Dune bean (Dolichos lignosus). A rampant evergreen climber of wet hollows behind dunes, temperate to tropical areas. Profuse production of small beans, about the size of mung beans, which shatter by late summer to provide excellent poultry forage. Naturalises and germinates freely after fire. Flowers may be white or pink-mauve. Can be useful to smother broom, gorse, lupin species; most plants serve as a "trellis" for the beans. Also widely used to cover and cool small outbuildings, and to shield walls from excessive sun. Swollen root stocks a source of starches. Perennial, usually persisting 8-12 years.

Hyacinth bean (Dolichos lab-lab =Lab-lab niger). Subtropical to tropical evergreen or summer herbaceous climber, widely used as green crop and (when watered) as a dryland trellis crop for a sun shield. Dries off in dry summers and can therefore be interplanted with grains. Young leaves eaten raw or cooked, ripe seeds used as split peas, or sprouted, boiled and mashed to a paste, then fried. Hardy to 30° Lat.



Four-winged bean (Psophocarpus tetragonolobus). Valuable tropical garden bean for human food; hundreds of cultivars. Immature pods eaten green, seeds roasted ripe, or parched. Young leaves, shoots, flowers as vegetable, tuberous roots eaten raw or cooked. Becoming popular in most tropical areas. Can be used as soya beans for processing to curd, bean cake.

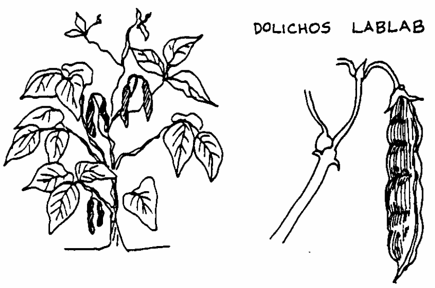
Wisteria (Wisteria floribunda). Ornamental vigorous screening vine, 100-150 feet, hardy, deciduous, but needs arbor or trellis support; a high horizontal strong trellis is the best. Much used by bees and selected for centuries for flowers, whose trusses can reach 5 feet long. Many close-related species, e.g. W. sinensis, W. brachybotris is cultivated as a cloth fibre in Japan.

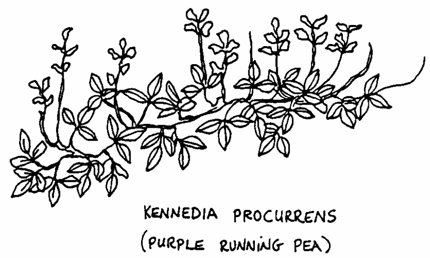
Parrot beak (Clianthus puniceus). Hardy evergreen with red pea-like flowers. Can be supported on walls. Native to New Zealand.

Hardenbergia spp. Evergreen twiners for fence screens. Roots of H. retusa are roasted and pounded for food by Australian aborigines. This vine forms dense thickets after fire or disturbance in the tropics. H. violacea of dry hillsides is used as sarsparilla (roots) and leaves are boiled as sweet tea.

Snail vine (Vigna caracalla). Perennial, frost-killed to rootstock. Like the scarlet runner bean, a good "runner" heat shield for windows, glasshouses, but stands more heat and will act as a bank cover. Climbs 10-20 feet.

Kennedias: shrubbery or vining species much used in Australia as ground covers, fedges, or decorative plants. Kennedia species proliferate after fires and improve soils (K. coccinea and K. rubicunda, for example). This genus is the largest group of climbing legumes in Australia, of which K. rubicunda, K. nigricans, K. macrophylla, and K. retrorsa are vigorous woody climbers. Most tolerate dry sunny conditions, and resist fire.





Glycine. This genus is that of the soya bean (Glycine max), but several Australian species are vines and are receiving attention as a potential crop, e.g. G. canescens, G. clandestina, G. latrobeana, G. tabacina. The perennial soybean is G. wightii. Soya bean culture is responsible for enormous forest clearing, and any domestic garden substitute is preferable.

The yam beans. Pchyrhizus erosus; P. tuberosus. Jicama, in Mexico. Widely cultivated.

Fam. GERANIACEAE : Vigorous flowering and scented Geranium and Pelargonium spp. are used as aromatic fence-hedges for windbreak in dry areas; also on screens to reduce heat on verandah areas.

Fam. GESNERIACEAE : Temperate evergreen rainforest species to 40°S. Propagate by cuttings, divisions.
Asteranthera ovata, profuse flowers.
Mitraria coccinea, prostrate or climbing evergreen of moist shady places. To 18 feet.

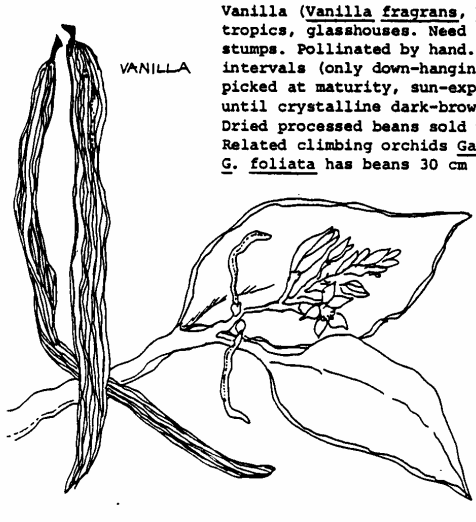
Fam. HYDRANGEACEA : Deciduous, hardy, woody vines grown in Europe and Japan. Stem climbers on trees; useful on facades and walls as an insulator.
Schizophragma hydrangeoides and S. integrifolium. Aerial roots attach like ivy to surfaces. Frost and snow hardy. Used as facade insulation in Europe.
Hydrangea anomala. Deciduous, hardy, adherent to facades.
Decumaria barbara, D. sinensis. Ivy-like roots cling to facades.

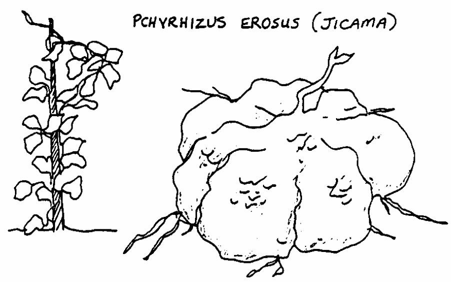
Fam. LARDIZABALACEAE : 15 spp; many temperate.
Staunton vine (Stauntonia hexaphylla). A cultivated vine used for fruit yield in Japan. Evergreen, hardy, luxuriant, part dioecious. Quality of fruit not known.
Sindfranchetia chinensis. Hardy, deciduous climber to 40 feet.
Akebia (Akebia quinata). Vigorous evergreen climber, fragrant. A. trifoliata, deciduous. A. lobata is used as a tea and the leaves and fruit are eaten in Japan. Shoots are bleached and used as basket material.
Holboellia coriacea. Vigorous evergreens. H. latifolia, fragrant.
Lardizabala biternata. Vigorous evergreens. Fruits are sweet, pulpy, edible, 2-3 inches long; semi-hardy and with unisexual flowers. Worth developing in gardens.

Fam. MENISPERMACEAE : About 20 spp. Woody vines, mainly tropics, 12-20 feet.
Moonseeds (Cocculus cebatha). Arabia. Fruits are fermented, with raisins, for an alcoholic drink. C. laurifolrus, bark alkaloids used as muscle relaxants.
C. carolinianus, C. trilobus for cool areas.
Menispermum canadense, M. dahuricum (Lake Baikal). Deciduous. Roots used as a tonic, diuretic. Spreads by suckers and needs control.
Sinomemium acutum. Hardy, deciduous, to 20 feet.

Fam. MORACEAE : Figs, mulberries. Many of the figs twine or ascend as climbers, then may adopt a tree form once free of the support. A few are cultivated as creepers or climbers on buildings in the tropics to warm temperate areas. Most wild fig species are good wildlife food.
Creeping fig (Ficus pumila). An adherent evergreen fig commonly used on walls and fences. A good insulator and screening plant. Propagate by cuttings. Juice of ripe fruit is cooked, cooled to a white gel, and eaten with syrup in the West Indies. Vine is almost unlimited in area (given time) and must be controlled on houses by removal of fruiting (tree-like) branches, but makes a solid fenced screen. Semi-hardy.

Fam. ORCHIDACEAE : The orchids.
Vanilla (Vanilla fragrans, V. planifolia, V. phaentha). Adherent vines of tree trunks, tropics, glasshouses. Need thick mulch, manure, and are often grown on coconut, palms, stumps. Pollinated by hand. The vine is stopped and leaders weighted to droop at intervals (only down-hanging branches flower). Natural pollinator unknown. Beans picked at maturity, sun-exposed and then "sweated" nightly in a woolen cloth (blanket) until crystalline dark-brown vanillin crystallizes out. Valuable for flavouring. Dried processed beans sold whole or as alcohol extract.
Related climbing orchids Galeola also produce long beans, palatable to wildlife.
G. foliata has beans 30 cm long.





Fam. OLEACEAE : Loose twiners, evergreen or deciduous, increased from cuttings and used in perfume trade.
Jasmines (about 200 species). Few uses noted, other than perfumery. Common jasmine (Jasminum officinale), semi-hardy. Will create a good windshelter on a strong fence but tends to sprawl; withstands sea-winds. Dense evergreen.
J. nodiflorum used in India for perfume; mostly extracted by "enfleurage" on lard, but also distilled to perfume.

Fam. PALMAE : The palms (see "Useful Palms of the World" list). Calamus and other rattans are the basis of whole tropical economies as a structural material. A candidate for innovative forestry, as wild canes are becoming rare.
Rangoon cane (Quisqualis indica) has edible shoots, as do some Calamus species.

Fam. PASSIFLORACEAE : The passionfruits.
Black passionfruit (Passiflora edulis). Vigorous tendril climber of temperate to tropical areas. Naturalises in moist forests and along streams. Often cultivated on fixed fence trellis systems, cropping from 4-8 years (some varieties last longer). Ideal for chicken-range fencing systems, as trellis crop on open-foliage acacia. Frost tender in early growth. Several cultivars, e.g. P. edulis flavicarpa, a yellow form, preferred in the West Indies.
Banana passionfruit (P. mollissima). Very vigorous, dense tendril climber of cool moist areas, temperate and western maritime climates. No cultivars, rarely cultivated because of vine vigour. Yields from late autumn to late spring, early summer. A valuable poultry-seed fodder. Quite perennial and evergreen, surviving heavy frost once established. Grows well in sheltered moist soils, over strong natural trellis such as Acacia, Lycium, and will ascend into canopies in forests. An under-used fruit for winter fresh food, more easily peeled than P. edulis.
Waterlemon (P. laurifolia). Does not grow in water and is not a lemon but a species of edible passionfruit!
Granadilla or Berbadine (P. quadrangularis). Perennial, vigorous, tropics; may need some hand pollination. Unripe fruit eaten cooked as a vegetable. Ripe fruit eaten raw or combined with wine into a syrup.
Sweet granadilla (P. ligularis) is a preferred fruit.
Tagua passionfruit (P. foetida). Naturalised edible passionfruit of subtropics and tropics. Fruit and young leaves cooked and eaten with rice. Usually wild-gathered but cultivated in the West Indies.
P. "incense" (ex P. incamata) has good fruit hardy to 0°F.

Many Passiflora species have no fruit, or small, barely-edible fruit.

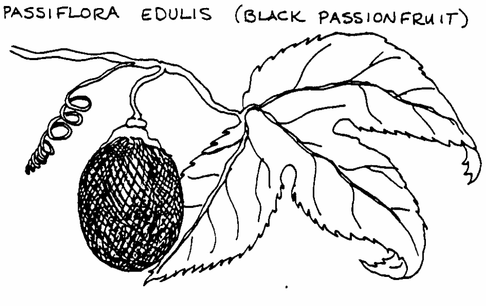
Fam. PERIPLOCACEAE : 10 species. Woody vines. Africa to Asia.
Silk vine (Periploca graeca). Bark produces an alkaloid used like digitalin for heart stimulation.

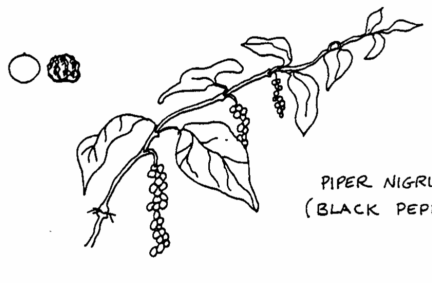
Fam. PHILESIACEAE : Chilean bell flower (Lapageria rosea). 10-18 feet; to 41°S. Lat. Propagated by seeds or layering. Evergreen.
Wombat berry (Eustrephus latifolius). Slender sub-tropical coastal to rainforest climber, trusses of orange berries and sweet edible roots. Very long-lived. Australia.

Fam. PIPERACEAE : The pepper vines (tree peppers).
Black pepper (Piper nigrum). Hot humid tropics (20-27°C). Grows in light shade, scrambles in leguminous trees. Dried fruits as a condiment. Expressed oils as seasoning, herbs ground to milder "white" pepper.
Kava (P. methysticum), Javanese long pepper (P. retrofractum), betel pepper (P. betle), and Indian long pepper (P. longum) are all used locally in curries or as a pepper seasoning for food or masticories (betel).

Fam. PITTOSPORACEAE : Mountain blueberry (Billardieria longifolia). Weak evergreen hardy climber with edible but pithy blue (or white) berries; grow in forest edges in cool moist climates. Abundant seed grown mainly for colour of berries (not food value) as berries are insipid; Australia. Suitable for potted climber (to 2 meters). Seeds may be a useful bird forage in cool forests.

PASSIFLORA EDULIS (BLACK PASSIONFRUIT)





PIPER NIGRUM (BLACK PEPPER)

Fam. POLYGONACEAE (Knotweeds) : Mountain rose (Antigonon leptopus). Vigorous subtropical deciduous perennial. Invasive in wet areas. Tubers used as pig fodder, human food. Good for dry hot areas. Hardy to 25°F. Terrace shade for dry areas, dry-deciduous.
Muehlenbeckia spp. (15 spp) no recorded uses; variable forms.
Silver lace vine (Polygonum auberti). Deciduous, rapid grower; can be hand-pruned, needs deep watering once a year. Similar to P. baldschuanicum. Can cover large areas or buildings in short periods, and can replace turf roof on weaker structures. Useful for dry areas.

Fam. RHAMNACEA : Deciduous, non-spiny climbers. Propagated by cuttings. Hardy. 10-20 feet high, e.g. Berchemia flavescens, B. giraldiana, B. scandens (supplejack); shoots of supplejack eaten boiled, otherwise few uses noted.

Fam. RANUNCULACEAE : Clematis (Clematis). Good bee forage plants, vigorous, evergreen and semi-deciduous climbers temperate to subtropics. About 250 species known. Young shoots and leaves of C. vitalba eaten as a vegetable, and some species are listed for pharmaceutical uses, but few other uses are specified for this very large and widespread group. Very common in forest edges temperate to tropical distribution. Windblown seeds colonise disturbed sites, roadsides.

Fam. ROSACEAE : Roses, blackberries. Genus Rubus 250-300 species.
Blackberry (Rubus fruticosus). Vigorous, part-deciduous thorny vine, partly cane-like, and extending by tip-rooting to form dense tangles in cool moist valleys. Spread by birds. Biological control by rusts. There are hundreds of varieties and crosses, and a dozen or so commercial berries grown on trellis. Rampant in temperate valley forests. Needs tight control on trellis, but can be "marooned" on small islands in water. Thornless varieties have been developed. Propagated by seed, layering, cuttings, root division. R. lanciniatus is a preferred fruit, and has a thornless variety--"Oregon Thornless"--which is the best and safest garden species.
There are about 8 species of blackberry in wild thickets, each with a specific rust or biological control potential. Seeds are spread by birds, mice eat the seeds, and snakes pursue the mice! Natural hybrids may form.

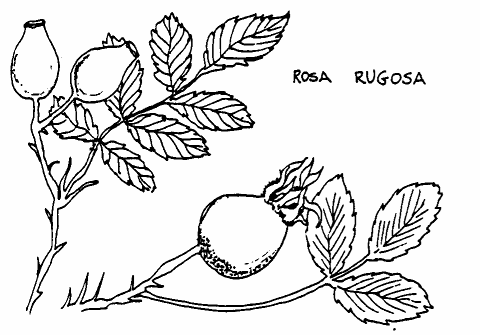
Climbing roses (Rosa gigantea). To 40 feet; many cultivated arbor species. Young shoots are edible and attar of roses can be made from scented flowers. See Ref. 6 for a full list. Rose-hips used to make a syrup rich in Vitamin C.

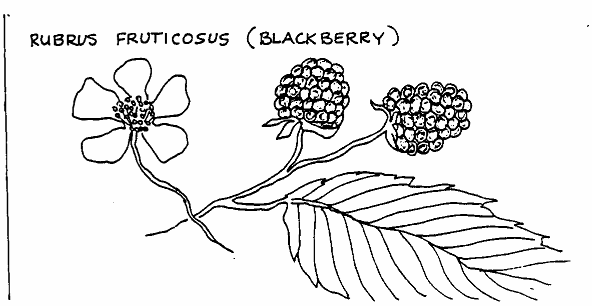
Goats find Rosaceae irresistible and will (if fenced) eventually rid an acre of blackberry; these and roses are useful goat forages. Pigs will dig and eat roots and (like goats) can clean out an infested area while finding up to 60% of their food from edible parts of the plant. Single clumps can be mulched out by a heavy carpet, followed by clear plastic to "cook" roots.

Where there are cattle, bales of hay (untried) tempt them to tread out blackberries. A farmer in Victoria (Australia) has eliminated them by planting clump edges with quince, apple, fig, and citrus which later attract cattle. Apples and pears grow very well out of blackberries.

Fam. SAPINDACEAE : Guarana (Paullinia cupana). Woody tropical liane. Seeds used for high-caffeine drink. Ground seeds are mixed with cassava flour, and then paste is smoke-dried: a popular Brazilian drink. Dried paste keeps forever. In plantations, it forms a small shrub. Drinks are commonly sold aerated, and sweetened, as a commercial cooling beverage throughout Brazil.
Yoco (P. yoco). Not cultivated, but caffeine drinks are made from scraped bark, and this is widely used by Indians of Brazil. Both of these drinks used as stimulants and may become semi-addictive.

Fam. SCHIZANDRACEAE : 22 species; climbers.
Kadsura coccinea (=Schizandra chinensis). Plant used as a tonic and aphrodisiac by the Chinese. K. japonica, to 12 feet; semi-hardy, berries in winter.
Schizandra chinensis, S. henryi; the mucilaginous carpels are used as a food (S.henryi). There are several fruit or berry-bearing species, edibility unknown but probably good bird forages.





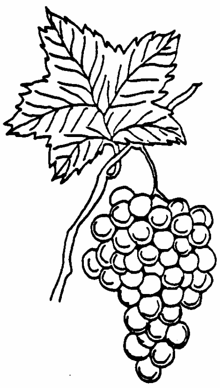
11

Fam. SMILACACAEAE : 350 species; tropics to temperate; usually dioecious. Tuberous roots, divide to propagate. Genus Smilax the source of sarsparilla (4-6 species used for production). Sarsparilla (S. aristolochiaefolia). Roots are the main source of natural sarsparilla. The plant is cultivated and the rhizome used medicinally for digestive disorders, as a tonic, for rheumatism, and also as a beverage flavour.
Cat brier. S. rotundifolia, S. auriculata, S. beyrichii occur in cool areas, are vigorous, hardy, 30-40 feet; roots used as starch food (N.America) for bread, soup.
S. china; sarsparilla and a gout tonic made from this vine. Fleshy, edible root.
S. herbacea var. nipponicum; cultivated for edible leaves.
S. laurifolia; young shoots used as a vegetable.
S.megacaroa; rhizomes and preserved fruits eaten; tropics (Java).
S. ornata, S. relegi, S. spruceana; used as a source for sarsparilla locally; tropics and temperate (Med.) areas.
S. australis; roots eaten by Australian aborigines.

Fam. SOLONACEAE : Tomatos, peppers (see "Useful Solonaceae of the World" list).
Chalice vine (Solandra grandiflora). Ornamental vine with edible fruits.
Cup of gold vine (S. maxima). Many cultivars climb if supported; in some dry summer areas of the tropics, tomato plants form perennial self-seeding vines and climb into low bushes of Leucaena (west Molokai). Some tropical forms persist 2-3 years. Most are grown as annuals. Propagate from axil shoots or seed. Grafts to kangaroo apple (Solanum) for temperate perennial (frost-tender) crop.
Potato vine (Solanum jasminoides). Climb on trellis to 30 feet. Hardy to mild frosts. Flowers for most of year. Good for light overhead shade.
Costa Rica nightshade (S. wendlandii). Sensitive to low temperature, deciduous; prickly stems. Climbs in trees or on pergolas.

Most Solanum fruits are preferred poultry foods.

Fam. VITACEAE =VITIDACEAE : The grape family.
Wine grape (Vitis vinifera). Very long-lived deciduous perennial, preferring some chill factor for fruiting, but adapted to a wide climatic and soil range. Although rarely grown on natural trellis today, it was so grown in older times, using the mulberry, fig, elder, and several other strong but not competitive trees. Grapes prefer waterside planting, and could be trellised on many tree species for domestic use.
Almost all grapes are grown from cuttings of selected varieties, and due to constant selection, there are now grapes for tropical conditions, and they are grown to 45° Lat. Young leaves are used a food wrapping in cooking (dolmas) and fruits used fresh, for juice, wine, and vinegar. Seeds are used for an excellent cooking oil. In all, about 60 varieties are in common use.
Wild grapes, some useful to birds or as shade trellis, include V. aestivum, V. amurensis, V. labrusca, V. riparia, V. sylvestris, and the fox grape, V. vulpina. Many of these are resistant to Phylloxera and some are in common use as stockstocks, or as hybrids with V. vinifera. V. labrusca and V. vulpina are cultivated in their own right in the U.S.A. Cold area vines (Ampelopsis) are also in this group.


VITIS VINIFERA (WINE GRAPE)

Genus Ampelopsis. Deciduous, vigorous, hardy tendril climbers, easy to cultivate and grown from cuttings, e.g. A. japonica, A. arborea ("pepper vine"), A. brevipedunculata.

Genus Parthenocissus. Adherent tips to vine; applies itself to walls and is a valuable insulator on brick or stone buildings, or as trellis crop over buildings.
Virginia creeper (P. quinquefolium). Fruits used as dye, bark to treat dropsy. Also P. tricuspidata, P. vitaceae. Excellent insulator on solid walls, masonry.

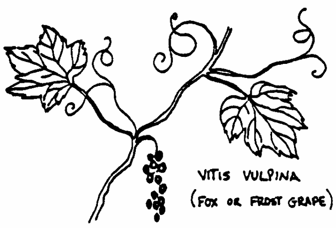
Genus Cissus. About 250 deciduous and evergreen species, some dryland and hardy species, e.g. C. antarctica, C. hypoglauca. Most produce storage organs at the ground surface, and C. opaca roots are used as a roasted food by Australian aborigines.
Uruguay ivy (Cissus striata). Mild area wall cover.

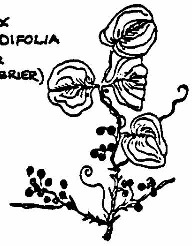
Genus Ampelocissus. Some, such as A. acetosa, produce edible storage organs.

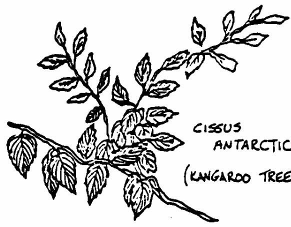
Genus Cayratia. C. clematidea and C. trifolia were among those in which storage organs were eaten by aborigines.

Tetrastigma (=Cissus). These are evergreen tendril climbers with fleshy stems, needing ample water; semi-hardy.

(The edibility of ground storage organs is widespread in this whole group.)


VITIS VULPINA (FOX OR FROST GRAPE)


SMILAX ROTUNDIFOLIA (CAT OR GREENBRIER)


CISSUS ANTARCTICA (KANGAROO TREEBINE)

12.

Fam. VERBENACEAE : Lantana camarra. A rampant evergreen shrub-scrambler in almost all tropical climates. Has a good effect on soils, and can be shaded out by succeeding forests or rampant "soft" vines such as chayote. For gardeners, it is more easily controlled by clearing and interplant, but it closes off large areas of grazing lands, and would be better returned to forest in most cases, as only steep, neglected, or over-grazed areas are heavily affected. Non-rampant beyond Lat. 35°, where in temperate areas it is grown as a flowering shrub. Spread by berries, which are a bird food.

Genus Clerodendron. Many species in tropics; uses not noted in literature consulted.

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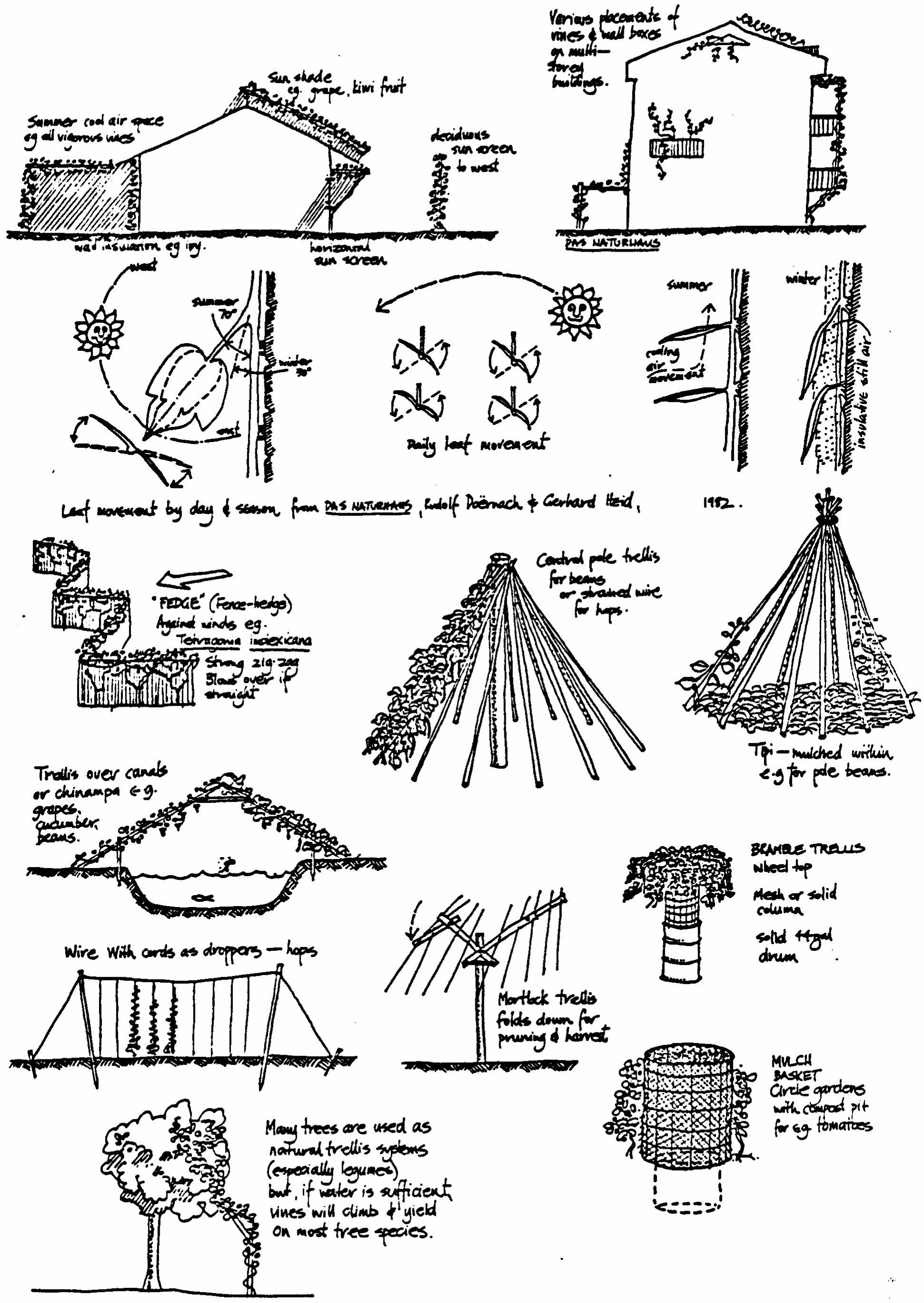
13.
B. USES OF VINES ON AND AROUND BUILDINGS



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14 . Palm – Dominated Polyculture

comfrey and *Tradescantia* if needed (the latter plants also control grasses if planted as part of a weed barrier).

Perhaps the main function of animal species in the tropics is to "recycle" plant wastes and to help control the rampant growth of ground cover. The usual domestic species, often penned, are pigs, chickens, geese, guinea pigs, rabbits, pigeons, and milking goats, cattle, or buffalo. Horses and bullocks or oxen perform draught animal functions.

Moreover, useful endemic animal species (and especially island species of restricted natural range) need to be more widely examined for their particular uses, and selected for their functions in a wider set of trials out of their normal range.

In the established tropical system, geese control pond–edge grasses, and wallaby or small grazers keep forest clearings and paths open; both are encouraged by feeding–out bran or pollard in the areas to be clipped.

Where no foxes or pythons threaten poultry, flocks of guinea fowl and hens, ducks and bantams perform invaluable pest–control and manurial/scavenging roles. Where predators are a problem, special housing, or pigeons in safe elevated roosts, may be the only way to keep fowl. The effects of electric fences in tropical areas, if not within forest edges, are often nullified by the rank growth of coarse grasses, and become inoperative for repelling python, pig, bandicoots and foxes. For this reason, fence lines must be planted with a dense perennial ground carpet of low herbaceous plants to exclude grasses, or overshaded by tree canopies.

10.10

THEMES ON A COCONUT OR PALM–DOMINANT POLYCULTURE

There are many considerations to bring to the planning of a coconut or palm–dominant polyculture; they can dealt with in the following themes:

- Structure and zoning.
- Species selection.
- Patterning.
- Economics.
- Re–working old plantations.
- The effects of plantation monoculture.

STRUCTURE

Any humid tropical polyculture that duplicates or imitates the normal structure of a tropical forest is likely to succeed. The structure of the system refers to the final cross–sectional appearance of any polyculture. Near large markets, or mass transport systems, it is quite feasible to introduce large tree species into the palm system, and to use the fruits and nuts as a supplementary market crop. Around villages, a far more complex and species–rich approach is needed, with fuel, fodder, structural materials and basic foods, oils, and medicinals in a complex intercrop. Remote from settlement or market, some livestock ranging (pigs, cattle) can be contemplated, with the intercrop selected to assist animals on range over dry periods, as ground forage, or as a drop from fodder trees such as figs, breadfruit, papaya, or *Inga edulis*.

Proximity to village or settlement decides species complexity and (by implication), structure, in that labour–intensive systems are best placed close to the village. Zoning out, we might place:

- Productive trees in palms (total species: 6–12) **Figure 10.31.A**.
- Palms within crop and avenue cropping between palms (total species: 30–35) **Figure 10.31.B**.
- Animal forage and free range in palms (total species: 8–20) **Figure 10.31.C**.
- Village garden and trellis, roof crop, greens (total species: 100–150) **Figure 10.31.D**.
- Fuel–wood in dwarf palm (total species: 3–4) **Figure 10.31.E**.
- Forest and tree reserves.

It is in and around the village that small livestock, fungi culture, padi crop and terrace is appropriate.

CRITERIA FOR SPECIES SELECTION

For any one site a selection of species that go with a palm polyculture has to be made. Some criteria are:

<u>In village</u>: A mosaic of the full range of food, craft, and medicinals is needed. Special intensive crop such as fungi, padi, and even algae can be planned. Experimental plots can be located here.

<u>In palms</u>, species are selected according to a general zoning/use–plan. It is helpful if:

- Species are suited to soils. A mosaic approach is indicated based on soil drainage and nutrient status. If the site is complex, then so should be the main crop.
- Species are locally acceptable, or are very similar to local types. New introductions need trials and instruction as to processing.
- Species chosen have a wide potential for processing. Coconuts have hundreds of known products or uses; this gives market flexibility.
- Species do not become rampant (unless they are controlled by livestock or cultivation).
- There is good information, some varietal types, and assured yield or low management input for the species used.
- Species are compatible, such as those listed herein.
- Species serve a present and future essential use (as thatch, fuels, oils, dry–stored food).

<u>Considerations for Varietal Selection</u>

For coconuts, and many other species (guava, yam, taro, banana, papaya) there are dozens of varieties developed for quite specific sites, soils, microclimates, or uses. There are coconut palms ideally suited to oil production, while others produce very fine quality cup copra for temple use, and others are ideal for shredded coconut, coconut milk, fresh nut markets, and so on.

There are dwarf, medium–height and tall varietes.

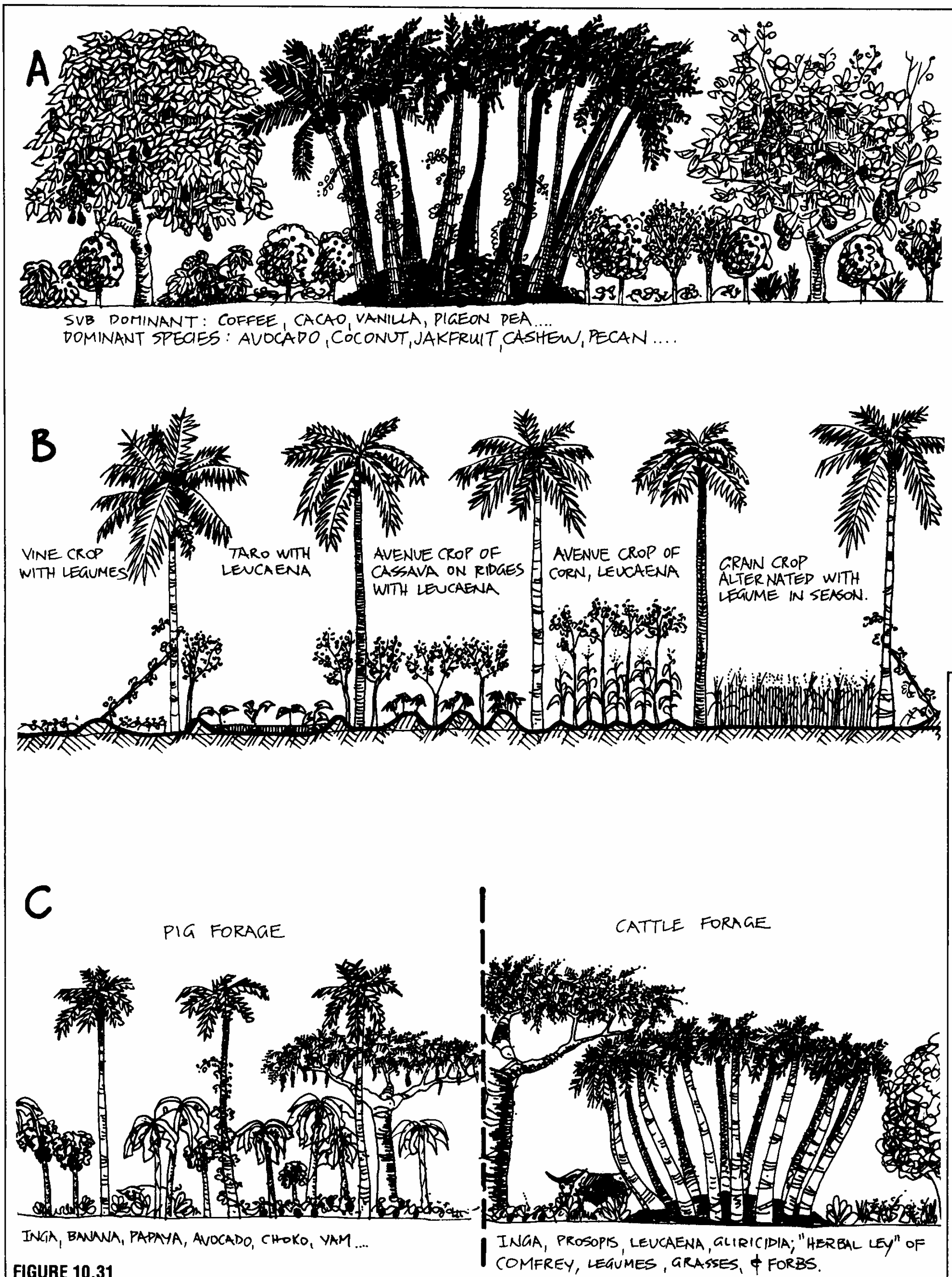
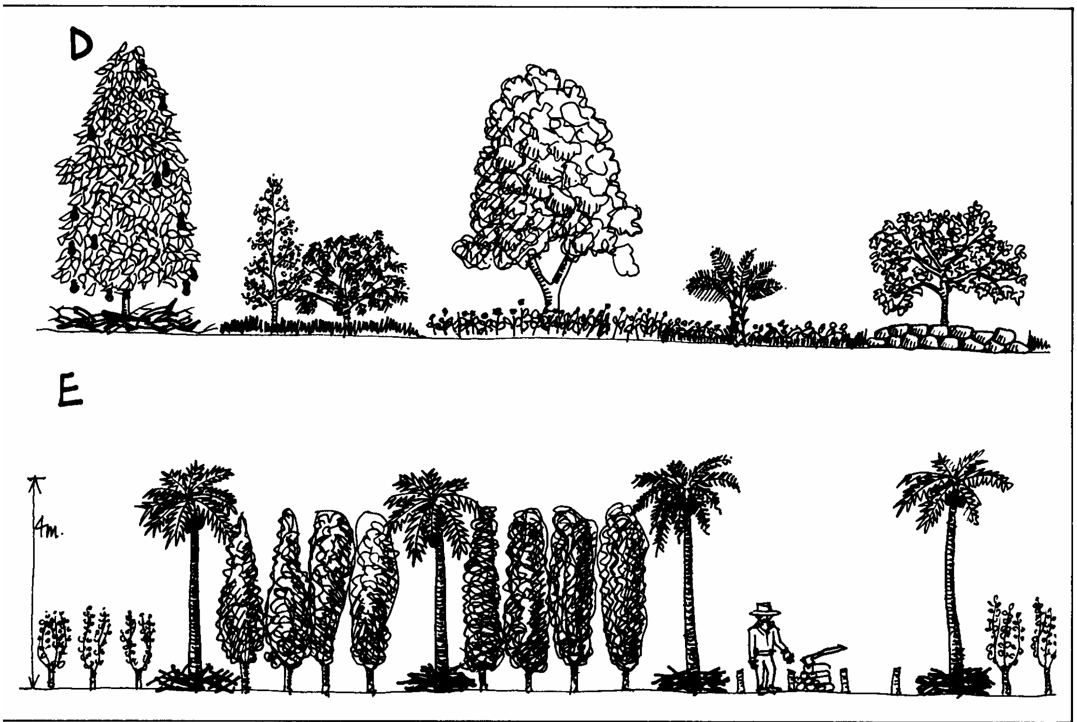


FIGURE 10.31
A–E STRUCTURAL VARIATION IN PALM POLYCULTURE.
A - Palms–fruit layout; B - Palm row crop; C - Palm–pig forage or cattle forage; D - grassland evolution; E - Fuelwood plus palms. All can be zoned around a village.



The former are ideal for village surrounds, especially in windy areas (where there are dozens of deaths each year from falling coconuts). Dwarf varieties (Philippine, Samoan) are easily accessible, have large nuts, good eating characeristics, and will not damage people or buildings if the nuts fall. Pest resistance and soil type must also influence cultivar selection.

In older plantation areas, selected and well-tested local species will be available. For areas with no plantation history, it is perhaps wise to build up a small arboretum of many varieties, and select a range of cultivars suited to the end-product aims. In every country, the cooperation of local agricultural authorities, and their assistance with varietal selection will be needed. Once a nursery is established (either as large containers or open bed planting, later as field plantings where rainfall permits), the site planning can go forward, but every plantation needs a mulched, shaded nursery, no matter how modest. Shade is most cheaply provided by light-foliaged legumes at wide spacing (e.g. *Acacia, Albizzia*).

Natural Variation

As almost all coconuts must be seed-grown, we can expect a variation in all crop characteristics, subject to later selection, culling, and new selections for site. Even if we grow from root tips in tissue culture, meristem and single-cell mutations are very high. In seed-grown crop, we might expect about one in twenty trees to show some very different characteristics, and of these perhaps one-third will be favourable for site, giving a limited set of new characteristics for selection.

Thus, it is unlikely that seed-grown *or* culture-grown palm plantation will demonstrate a very uniform genetic resource, and this will later lead us to "cull and select" options in management. This indicates a need for initial over-planting to allow for a 2-4% cull within the first 7 years (when we can make a fair estimate of vigour, nut production, bearing, and pest resistance) and another 2-4% cull in years 7-14, when the tree is mature. Final culling (14-60 years) should be in the nature of a replant and renewal process. Culling and replanting in palm crop can be a continuous process, so that plantation vigour (and overall design) is updated.

Species Suited to Co-processing

In special planation intended for (e.g.) ethanol or biogas fuel production, the same ferment and distillation equipment will serve a complex of crops that can form a "special use" polyculture.

In alcohol-oriented (fuel) palm crop, interplant of cane sugar, century plant (*Agave*), beet or sorghum sugar may add to the total sugar crop and suit the processing or distillation unit, while oil palms may be interplanted with mustards, sunflower, rapeseed, etc. to take advantage of oil press equipment and to increase honey production for bees, which themselves increase oilseed crop.

Similarly, wetlands suit many swamp palms (*Nypa*, trees appreciate ground water reserves.

A hillside patterned as per **Figure 10.33** suits clump plantings of palms. Swales are illustrated and exemplified in Chapter 9.

Planting Patterns of Palms (Clumps vs Grids)

Without altering too much the appearance, spacing, and amount of coconuts, **Figures 10.34.A–C** illustrate some of the possible plantation layouts. While **A** and **B** are "normal", **C** arises from several independent observations I have made on densely–planted coconut

Ten to twelve coconuts planted in a circle, and each only a few feet apart, do in fact quickly adopt a divergent growth habit something like that in **Figure 10.35.**

Not only do nut counts compare favourably with trees planted on a square grid pattern, and nuts drop cleanly to the ground, but a third (probably more important) factor emerges, to do with mulching. Coconuts in plantation mulched with their own fronds and husks show better growth and bearing, but in normal plantation, husks are left at one tree in 10–30, because

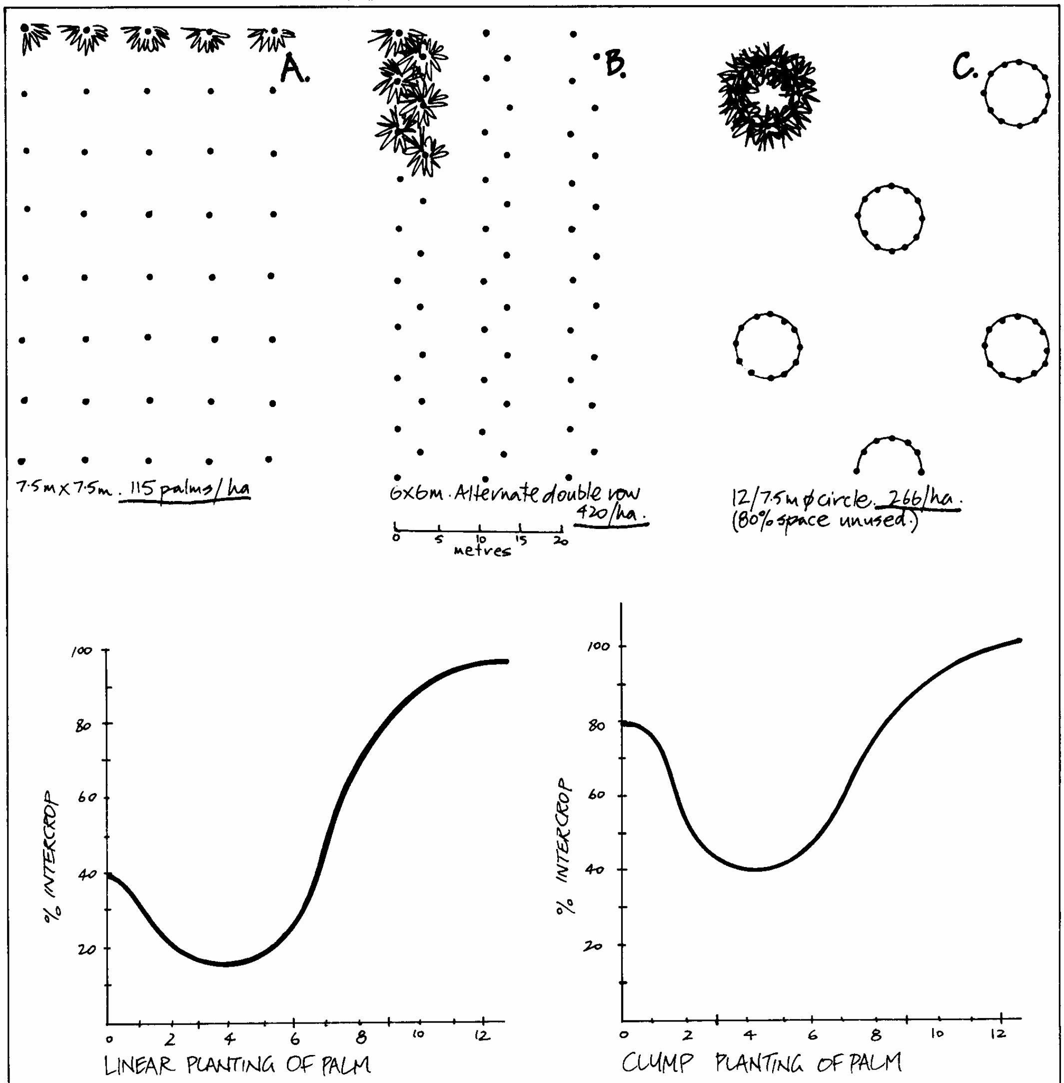


FIGURE 10.34
COMPARISON OF LINEAR AND CLUMP LAYOUTS.
Schematic of intercrop yields over years 1–12; clump palm layout allows more, and earlier, crop yields. Plan shows how various palm layouts frees up ground space, enables easier access, easier mulching and irrigation.

the labour of first gathering and then distributing the mulch is too great. However, with the circle clumps, it is easy to both gather and husk the coconuts in one place, and thus mulch the base of *all* trees, conserving water and returning nutrients to every tree. A little care in turning husks face-down prevents mosquito breeding in these mulch heaps.

Any other nutrient (manure, blood and bone) is equally easily applied to clumps. Clumps also form more suitable trellis for vanilla, black pepper, and other vine crop, are very economical for watering, and leave a large area of ground free (although lightly shaded). The wide spacing of circles enables replanting to take place in discrete sets of 10–12 palms without gross linear disturbance to the system as a whole.

Although I originally saw such clumping as a convenient way to apply mulch, it later became clear that broad areas of clear ground for grazing and intercrop are also available. Such patterning frees up to 60% of the ground area, as against 30% for linear planting. Clump planting is ideal for run-off harvesting of water in circular swales (**Figure 10.33**) or in coconut-circle pits.

As for the spacing of palms in lines, a very good rule is to space at twice the frond length for that site plus two feet. This allows full crown development without abrasion damage to the fronds from wind-sway. Intercrop spacing is as usual: cacao 2 x 3 m, banana 3 x 3 m, cassava 1 x 1 m, velvet beans 0.5 x 0.5 m, maize 1 x 0.5 m in rows, citrus 9 x 9 m and so on (local agricultural people can advise). Coconuts on new sites are normally 6 x 6 m.

Access and Mulch Provision

Sensible roading or grassed access ways are necessary for gathering or handling heavy crop, and some provision for these must be made even where horses or donkeys with panniers are used. More importantly, a careful assessment of mulch sources is essential wherever mulch-loving crop (avocado, banana) or mulched short-term crop (dryland taro, ginger, yams) are planned.

A layout such as **Figure 10.36** ensures mulch sources for the system itself and for short-term crop. Natural fall from palm fronds, and husk or nut shell will line-mulch about one in 8–12 rows of palms with about 2 m wide x 0.5 m high mulch beds.

In clumps, 10–12 palms will provide about 0.5 m

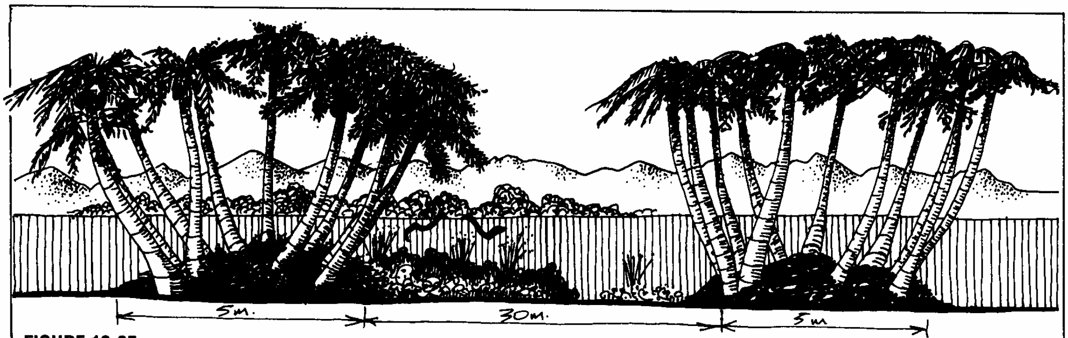


FIGURE 10.35
PALMS PLANTED IN CLUMPS.
Palms, bananas, macadamia nuts and many other useful species yield well in clump plantings, freeing space for intercrop and concentrating mulch and irrigation needs.

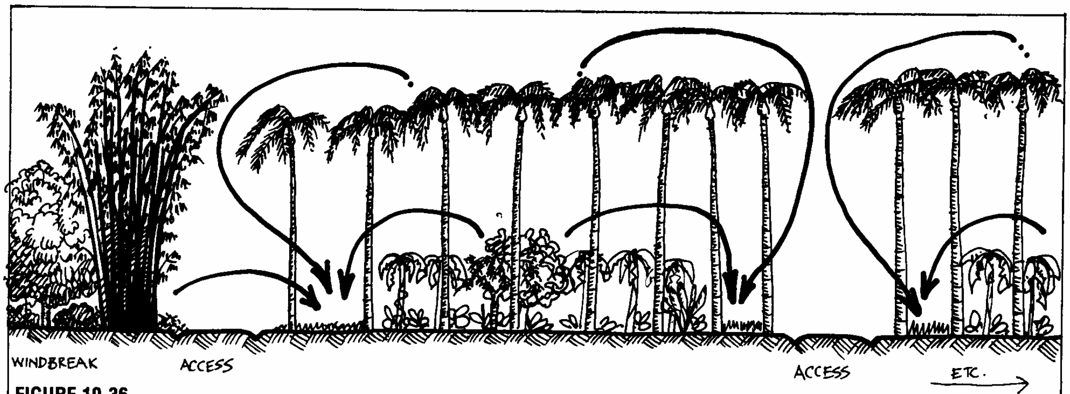


FIGURE 10.36
LAYOUT OF PLANTATION FOR MULCH.
Palm fronds, nut husks, hedge foliage, and intercrop leaf all suffice to heavily mulch every 4-5th strip each year for high yield annual crop.

deep of mulch for the inner circle of mulch. This is easier to gather and keep in place in windy areas. The addition of bananas, especially with avocado, has become standard in many planations, as the banana plants at harvest (with root mass) provide about 25 t/ha of organic matter, a key resource for a healthy fruit and palm crop (Penn, J., *New Scientist* 20 May '85). Small tree legumes (*Cassia, Calliandra, Leucaena*) also help. Bananas in legume crop may be regarded as "pioneer" mulch in grassland reclamation.

The layout in **Figure 10.36**:

- Reduces the labour of harvest by providing regular access.
- Provides sources of mulch for short–term crop.
- Enables mulch accumulation by long–term crop as interplant.

Earth Shaping for Intercrop

Earth shaping is worthwhile for several reasons, not only to assist water infiltration and run–off, but to give a free root run, to retain mulch in wind, to effect better drainage in over–wet areas, and to provide microclimate benefits with respect to wind shelter and ground warmth.

Briefly, earth MOUNDING for root crop and cucurbits is beneficial in humid tropics, and earth TRENCHING is best in dry tropics. Earthworking is discussed in Chapter 9, but some relevant data is given here.

RIDGES. Ridges of 0.5 x 1 m increase yields in cassava, sweet potato, potato, and yam crop. Mulch and green crop can be grown between the ridges. Pineapple and ginger also prefer ridges in wet areas. In **Figure 10.37**, *Leucaena* intercrop for mulch is on mounds, while maize and green mulch (beans) occupy hollows. Ridges permit deep mulching for low crop such as pineapple, the mulch being applied between ridges.

MOUNDS and volcano–shaped mounds with hollow centres are good cucurbit sites if enriched with manures. A stone or two helps heat the earth to germination temperature for cucurbit and melon crop.

FURROWS assist mulch retention for ginger and pineapple in dry areas. They are best covered with mulch, and will carry subsurface water seepage lines.

BASINS, even shallow basins, aid dryland taro and banana, or patches of Chinese water chestnut. Soil is more easily saturated, and deep mulch assists this process.

BOXES of palm trunks are ideal mulch–holders for yams, banana, and vanilla orchid, vines generally, and borders of beds in home gardens. Such log boxes can be 1–3 logs high, and greatly assist weeding if mulch–filled.

Yields Over Time

Plantation can be cropped with short–term grains for a season or two, but by years 2–4, the palm fronds (of linear plantings, not so much of clumps) cause mech-

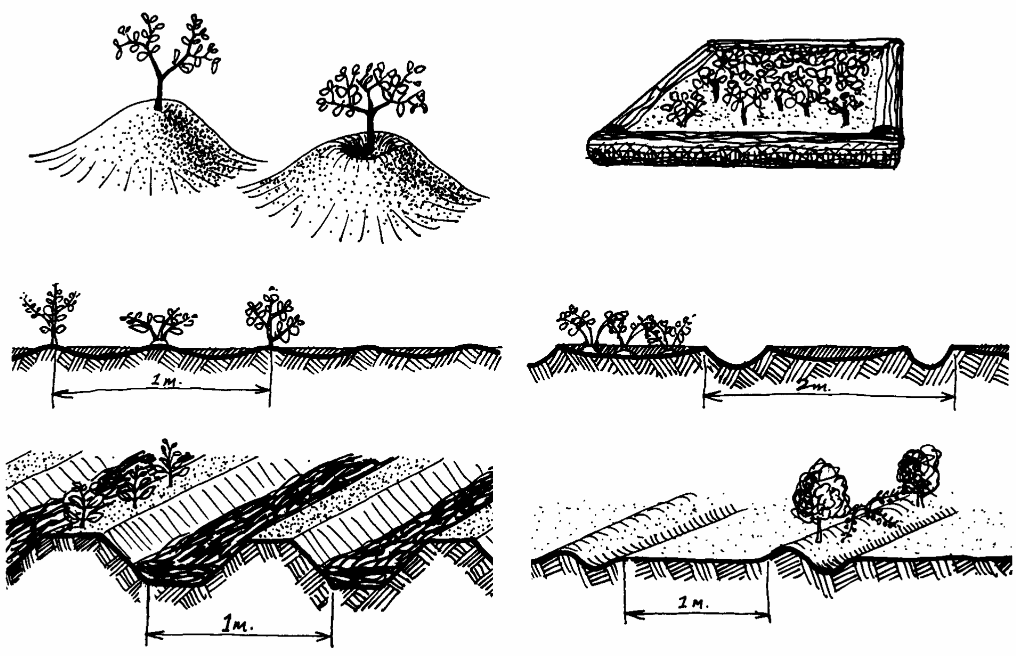


FIGURE 10.37
RIDGES, MOUNDS, FURROWS, BOXES.
Appropriate earth–shaping specific to crop type or soil (drainage) precedes all planting operations and increases yields.

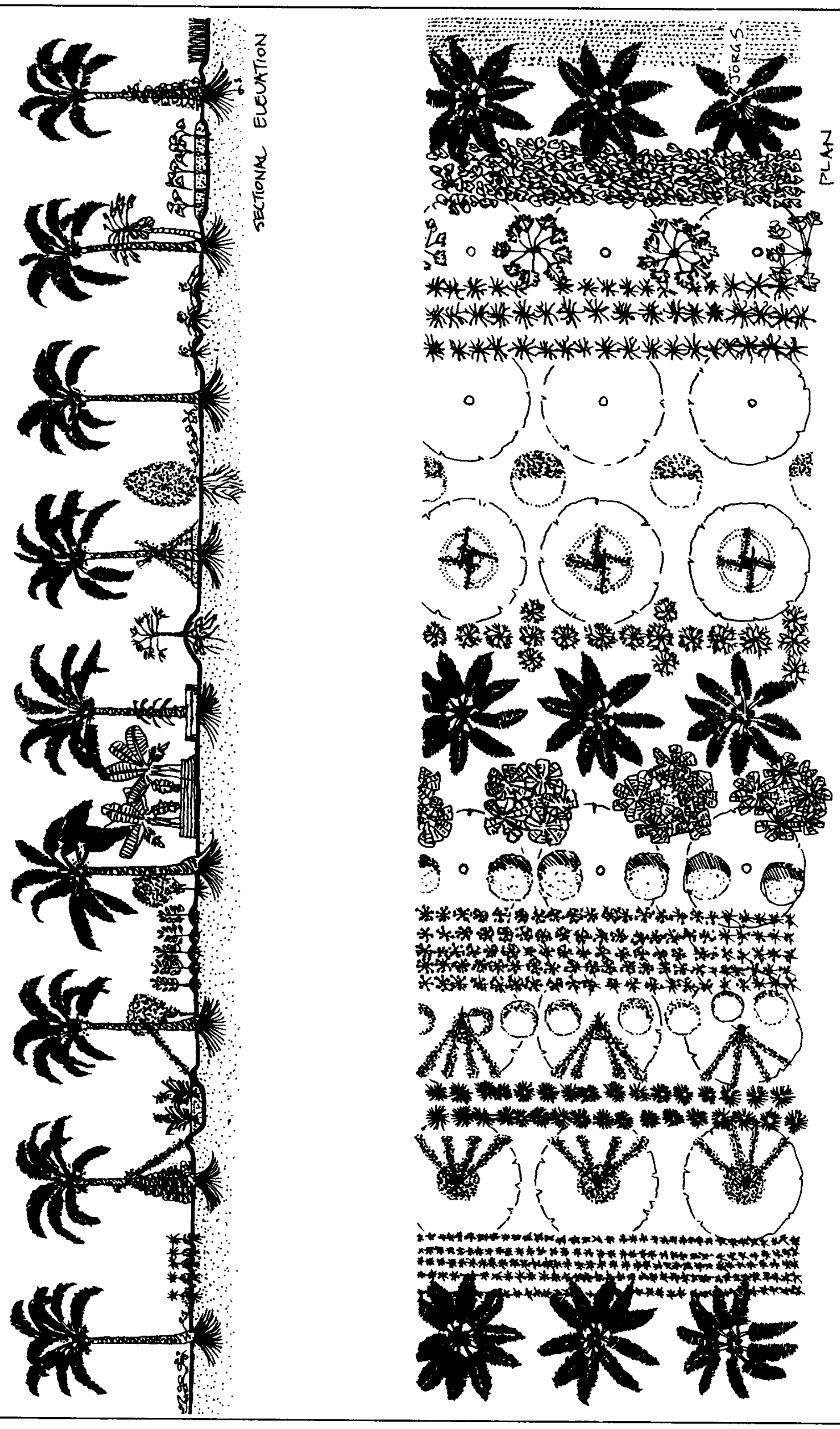


FIGURE 10.38
PALM INTERCROP.
A wide variety of crop, and accessory earth, or trellis, structures can be integrated with palms after years 4–7. [Jörg Schultz].

anical damage and obscure the ground. After years 4–6, a stem forms, and from 6–14 years, complex perennial intercrop (not short-term grains) can be placed in linear systems. In clump systems, the early ground effect is less marked.

ECONOMICS

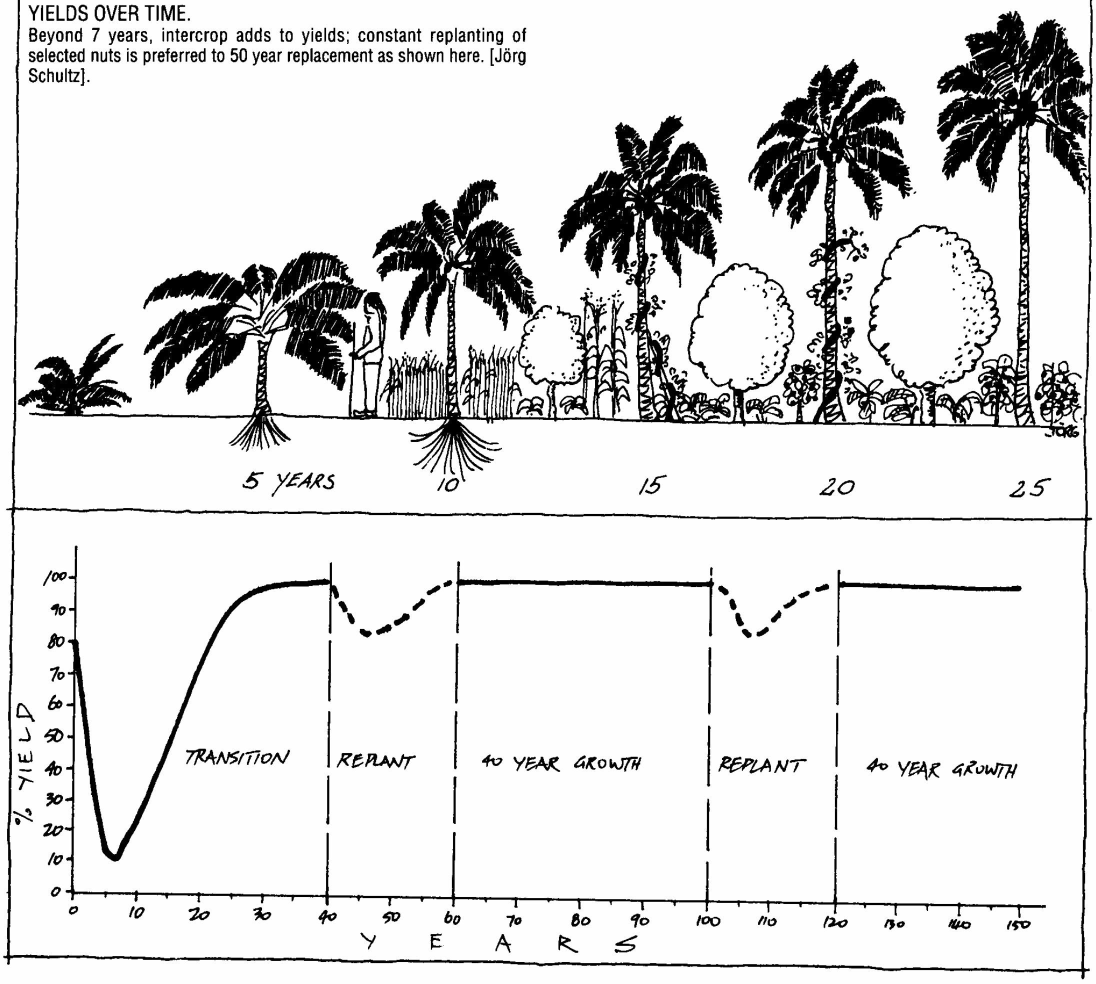
Nair (1975) gives convincing economic analyses for coconut, showing a 50% increase in yield for irrigation alone and a trebling of the yield for complex intercrop of two or more species, effectively doubling the cash return to the grower on the same area. Costs of irrigation and intercrop (plant or animal) never exceed returns if care is taken to select beneficial plant and animal species for available soil, water supply, and climate. Often, the cheapest irrigation system is to pattern the ground to hold wet-season run-off for tree crop use in dry seasons.

On Nair's anlaysis, where 1 unit = 4 rupees, the net income from coconut was as **Table 10.2**. Adding three species and increasing net yield by 3–9 times increases costs by 3.1 times. This is a clear implication for smallholders that much less area, polycultured, would give as much return (3 to 8 times) for *far less expense* (as expense is also a function of expanded area under crop). Irrigation of any sort is obviously a key factor. There would be a point, however, where more species added, even if very carefully selected, would push labour, harvest, and control costs past sensible limits, as per the schematic in **Figure 10.40**. So it is also clear that a complex polyculture must be managed by many more people if expanded to a wider scale.

RE-WORKING OLD PLANTATIONS

People who inherit or buy old stands of coconut or other palm crop need to undertake clearing and

FIGURE 10.39
YIELDS OVER TIME.
Beyond 7 years, intercrop adds to yields; constant replanting of selected nuts is preferred to 50 year replacement as shown here. [Jörg Schultz].



16. Poly - Culture

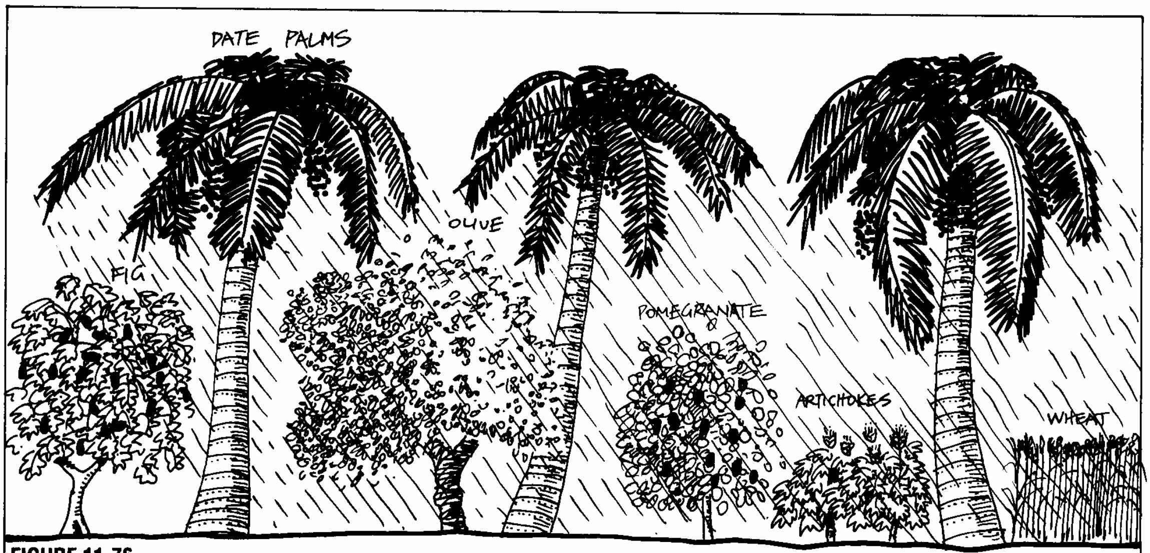
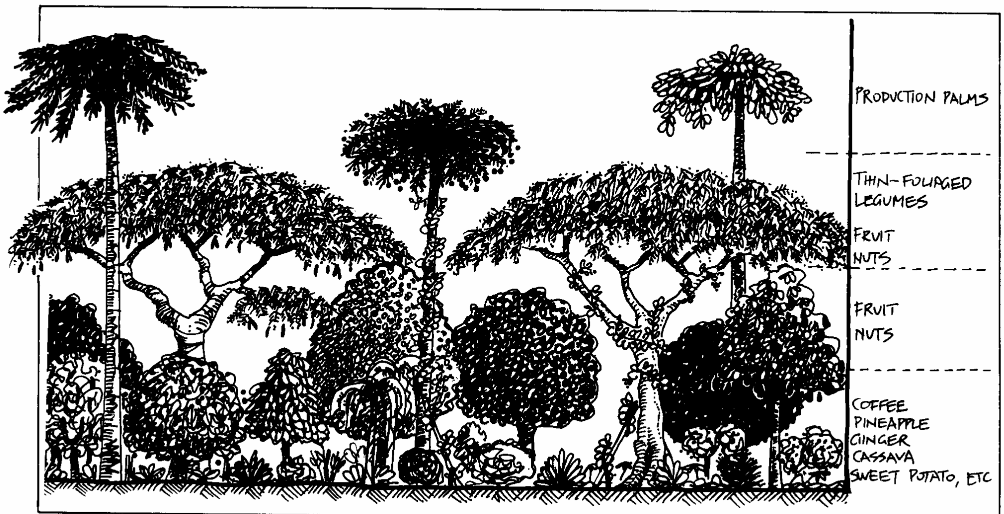


FIGURE 11.76
WILLIAMS' DESCRIPTION OF NORTH AFRICAN POLYCULTURES.
Palms as high shade over other tree and surface crop.



based on a tree-species polyculture; the two combine very well to reduce climatic extremes.

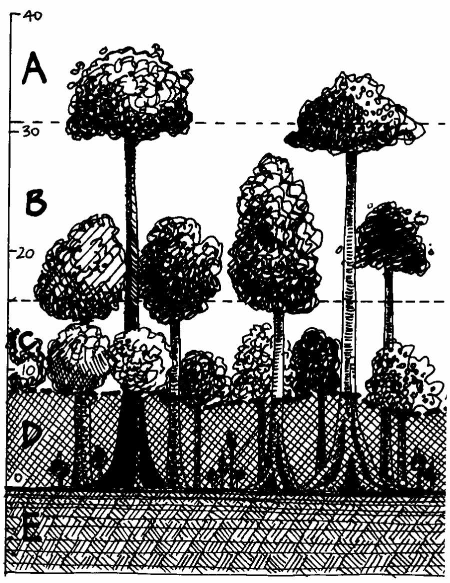
We can largely emulate the tropical forests themselves in our garden systems, establishing a dominant series of legumes, palms and useful trees with a complex understory and ground layer of useful herbaceous and leguminous food and fodder plants; vines and epiphytes can complex this situation as it evolves. In the wet-dry tropics, more open palm polycultures are appropriate; the excesses of heat, light and rain are best modified by an open canopy of palm fronds and the fern-like leaves of tree legumes.

10.2
CLIMATIC TYPES
(Based on Trewartha, 1954)

WET TROPICS

These are the river basins and wet coasts from Latitudes 0–25°. Major localities are the Amazon and Congo basins, Central America, Sri Lanka, Malaya, Borneo coasts, and New Guinea. This climate covers about 10% of the earth's surface (5% of the human population). It is heavily occupied only where terraced alkaline volcanic soils enable sustained cultivation (Java). It contains remnant tribes of hunter–gatherers (often pygmoid) in remaining forests, and is rapidly being ruined by over–exploitation of forests, mining and extensive cattle rearing, mostly developed by large corporations. Hence, there is a recent tendency for catastrophic wildfires to develop in logged areas such as Borneo, and for soils to be leached to low fertility, or eroded to ferricrete or silcrete subsoils.

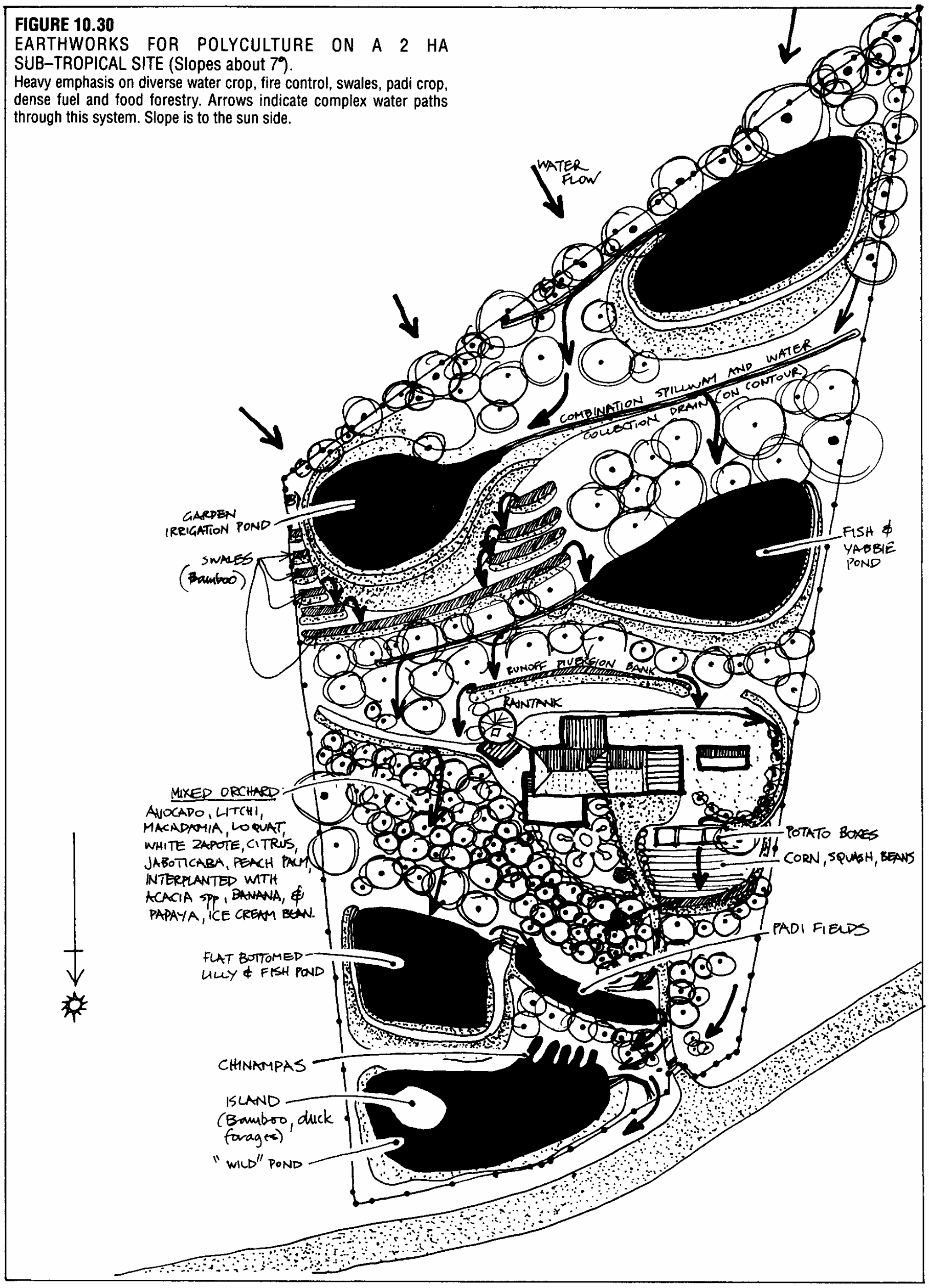
The sun is mostly overhead, with temperature fluctuating little at about 21–32°C (70–90°F). Humidity is



A·B·C: Zones of direct sunlight.
D: Zone of reflected or transmitted light.
E: Root zone.

FIGURE 10.1
STRUCTURE OF A WET TROPICAL FOREST
Dense planting is possible, and beneficial near villages; species assemblies are simplified on the broadscale. Levels in natural forests are also indicated (after Moore, *New Scientist*, 21/8/86).

FIGURE 10.30
EARTHWORKS FOR POLYCULTURE ON A 2 HA SUB–TROPICAL SITE (Slopes about 7°).
Heavy emphasis on diverse water crop, fire control, swales, padi crop, dense fuel and food forestry. Arrows indicate complex water paths through this system. Slope is to the sun side.



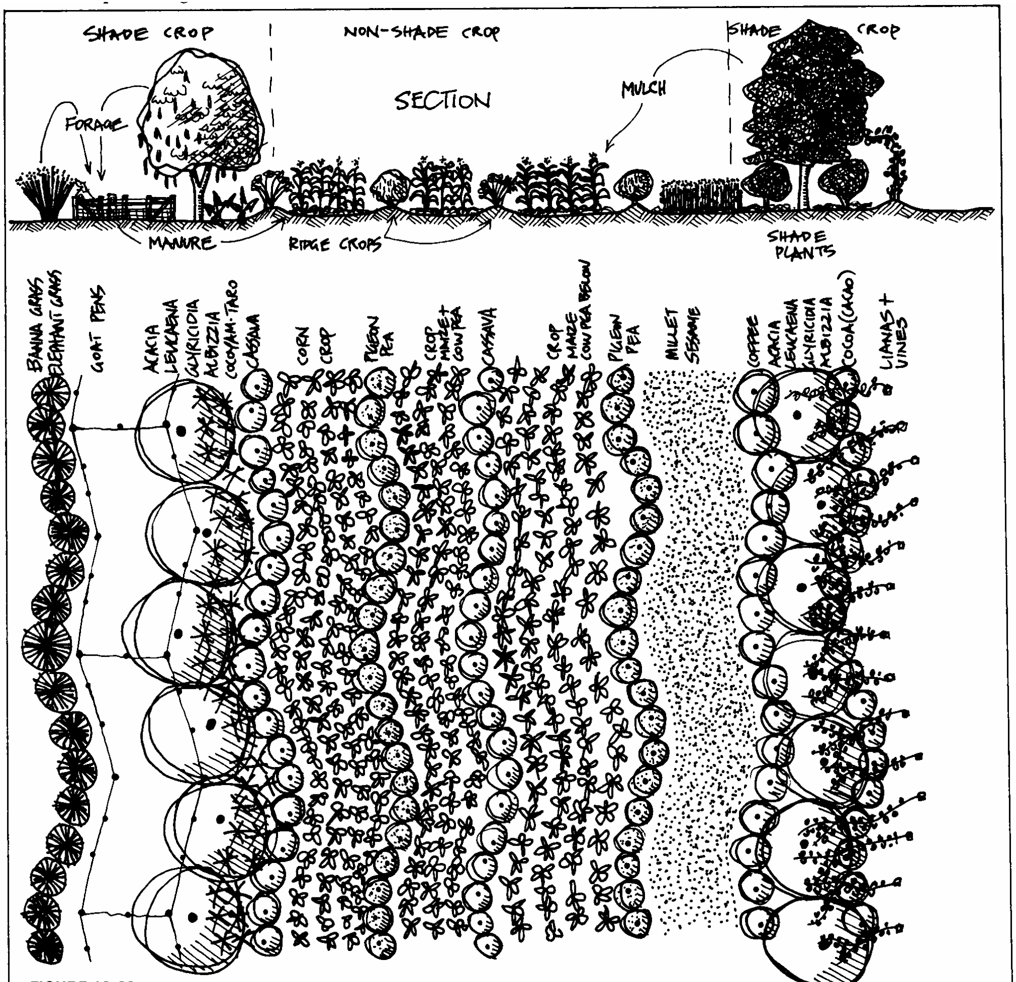


FIGURE 10.29
NIGERIAN POLYCULTURE FOR HUMID TROPICS.
Includes pig or goat pen and forage crops appropriate ridges for cassava, strip crop, zero runoff; contour layout. [Data from Gkiebo and Lal].

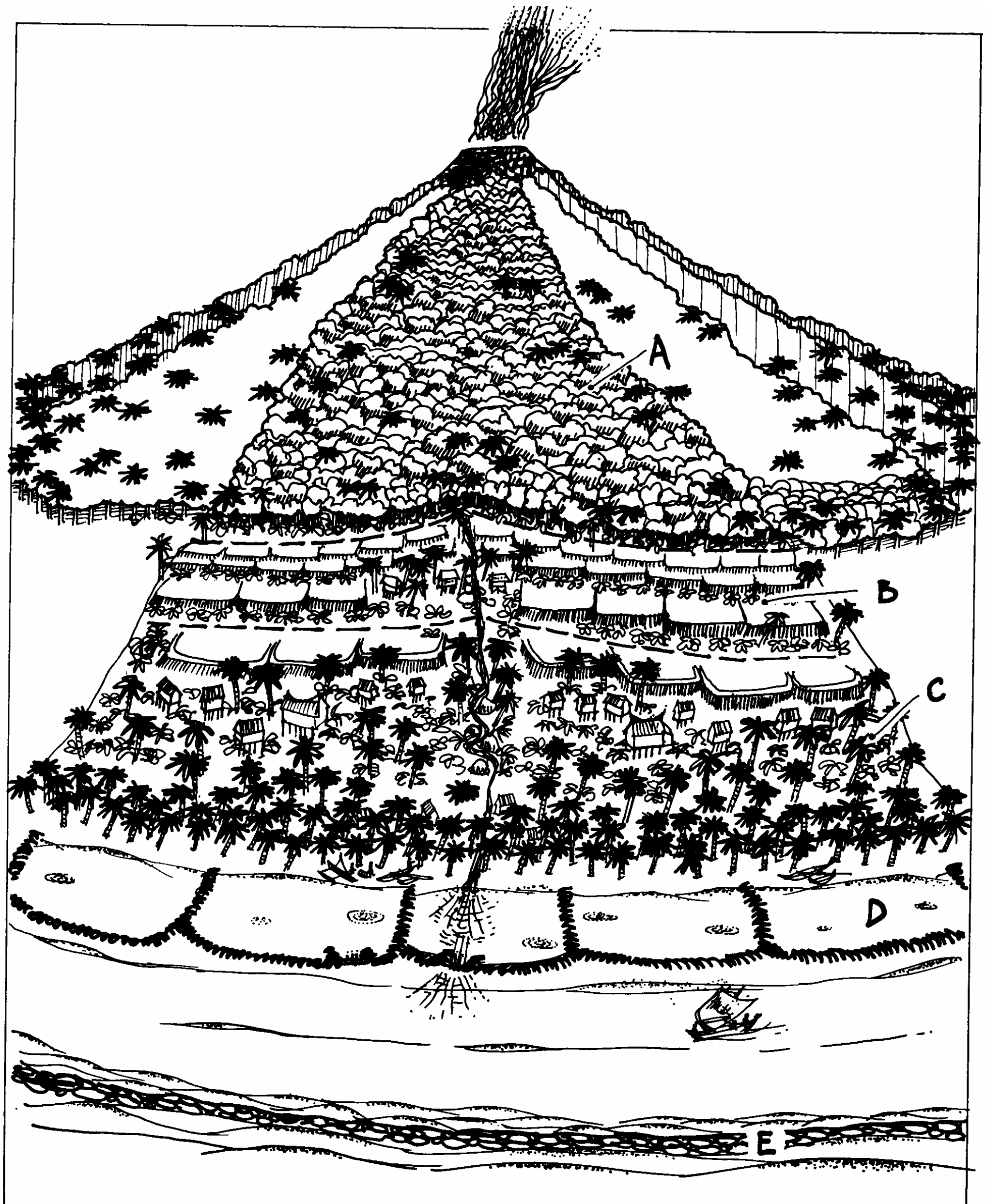


FIGURE 10.28
OHANA SYSTEM (Hawaii).
One radial valley of a volcanic island. A - "taboo" forest of upper slopes; B - stream diversion to ridge or high terraces, main village; C - sacrificial forests of palm to modify hurricanes; D - reef fish ponds to retain leached nutrients, growing mullet and shellfish; E - reef modified with coral blocks to shelter crayfish, fish.

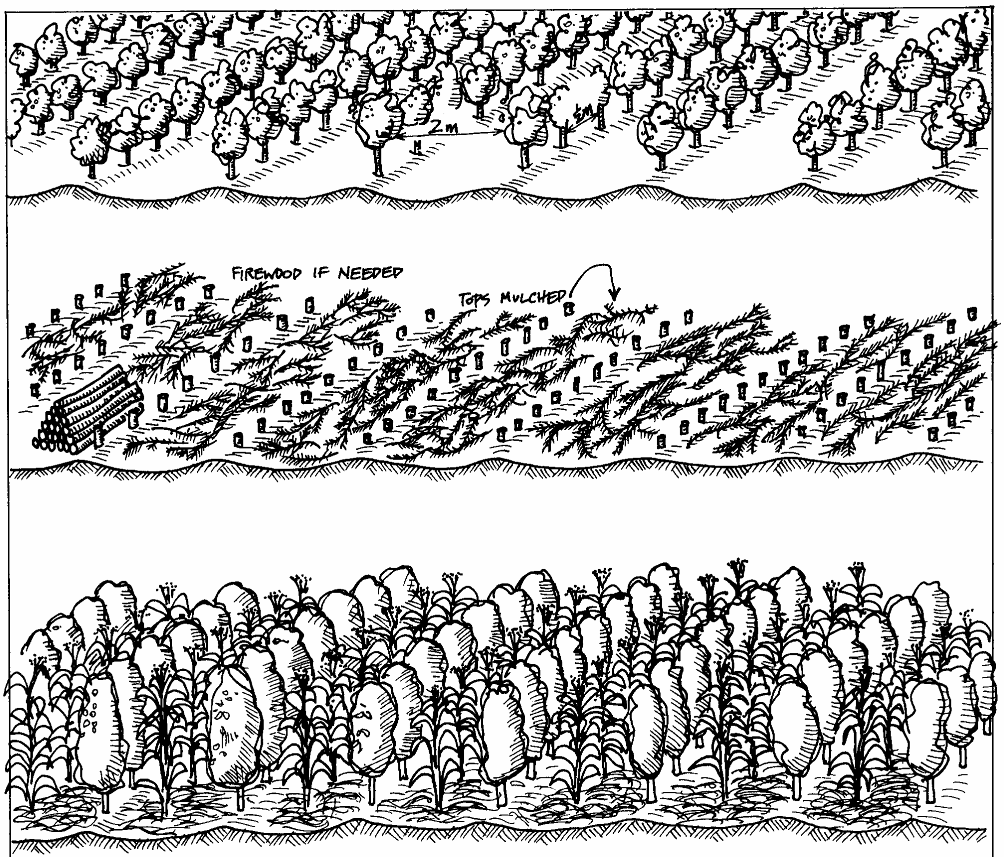


FIGURE 10.27
AVENUE CROPPING.
Coppicing legumes (*Leucaena, Cassia, Acacia, Glyricidia*, etc) cut annually provide nitrogen and mulch for intercrop such as maize, sweet potato. ginger, pineapple; crop wastes are returned to field; firewood is a by–product.

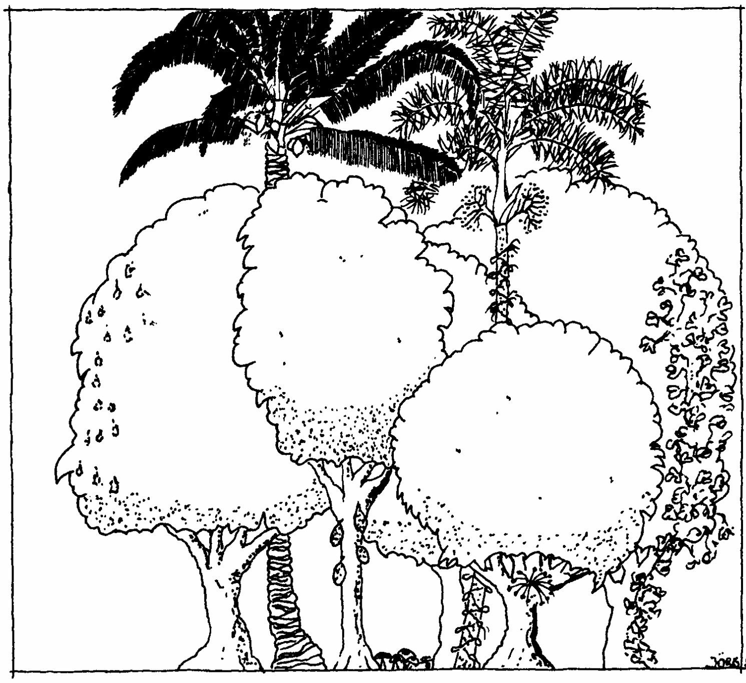
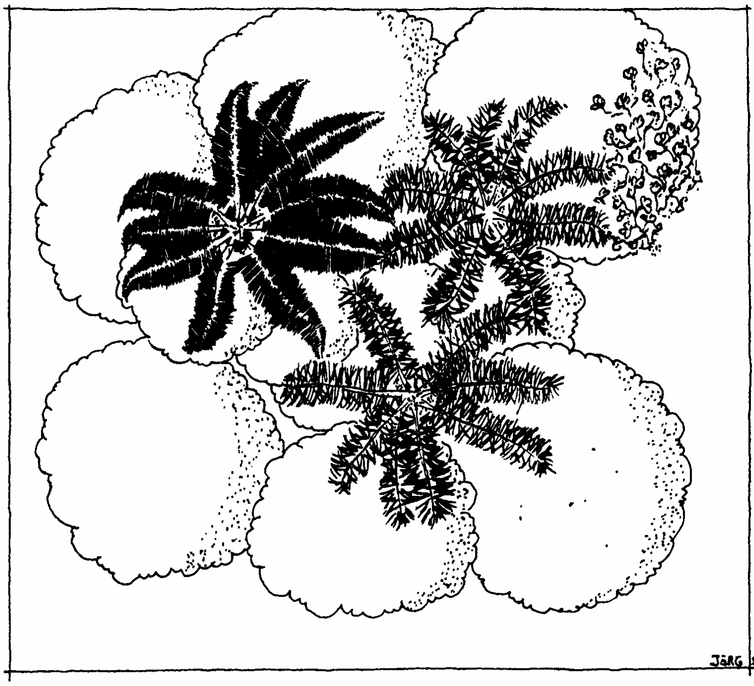


FIGURE 10.45
COMPONENTS OF THE TROPICAL FOREST TREE POLYCULTURE
Palms, lianas (vines), crown–bearers to the outside and stem–bearers inside clumps; fungi and shade species below.
A. Elevation.
[Jörg Schultz].



COMPONENTS OF THE TROPICAL FOREST TREE POLYCULTURE
B. Plan.
[Jörg Schultz].

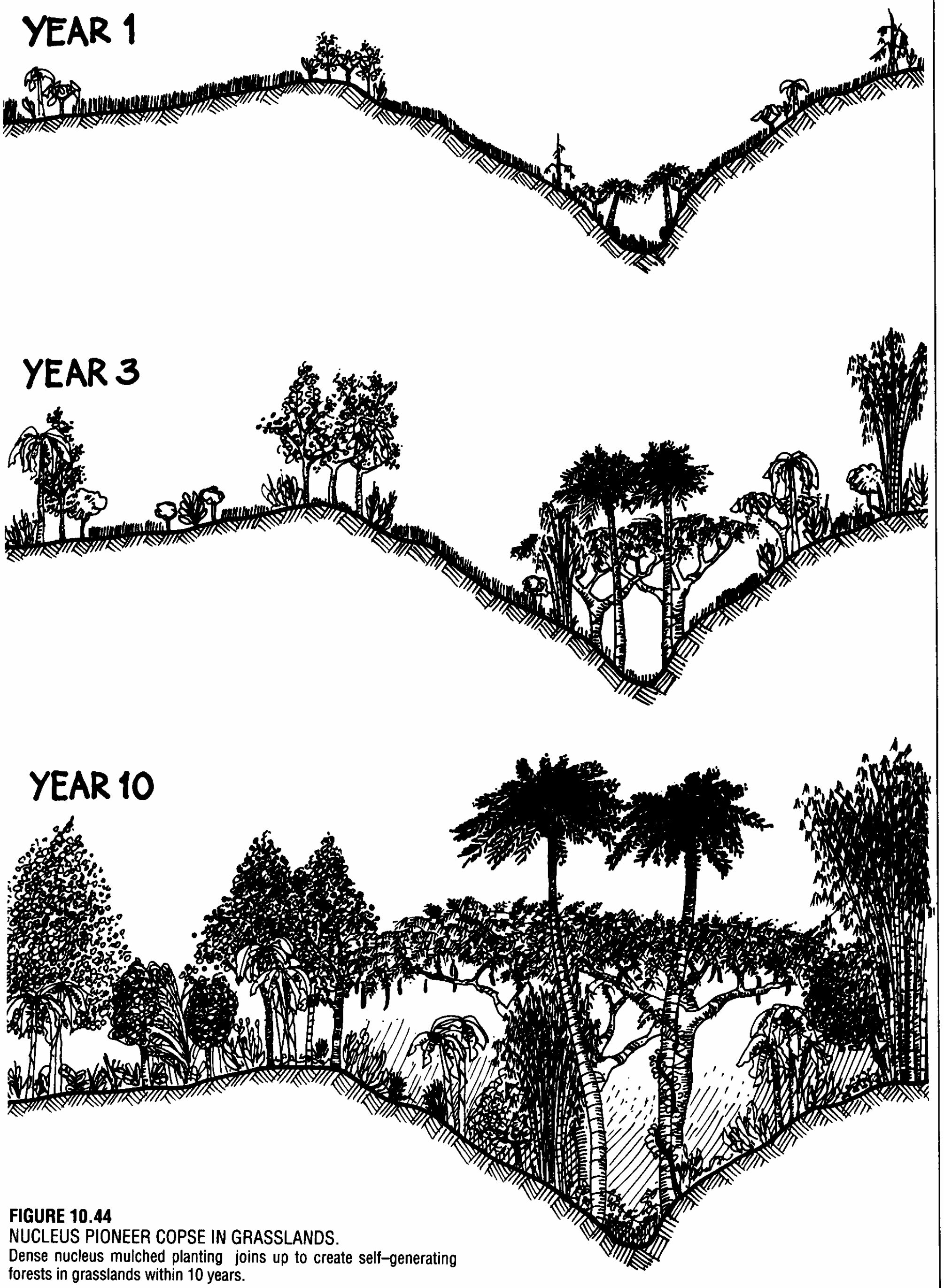


FIGURE 10.44
NUCLEUS PIONEER COPSE IN GRASSLANDS.
Dense nucleus mulched planting joins up to create self–generating forests in grasslands within 10 years.

• Managed forestry or rehabilitative forestry for perpetual yields.

Or, more probably, we would plan for all of these in appropriate combinations for site.

TROPICAL GRASSLANDS

The management of deforested grassland areas is the main problem of the wet–dry tropics: soil erosion, rank grasses in the wet, and inflammable or low–nutrition feed in drought result from burning and over–grazing. Once deforested, the pastures are open to summer winds, and the nutrient cycle of trees/grass/ browsing is broken. Fire, often out of control, only accelerates the process. Although there are very few trees which can survive in tropical grasslands, it is essential to re–establish tree legumes.

Some vigorous grassland cover crop legumes (*Desmodium, Suratro*) will help reduce the grasses and eventually lay down a mulch. Under trees, a short–stemmed *Desmodium* will defeat the grasses, but it is then essential to be able to supply dry–season water, as the legume also competes with the young trees for moisture. Some fast–growing leguminous trees (*Albizzia, Acacia, Inga, Leucaena*) will quickly establish, and can be grown in the shelter of banna grass or elephant grass (*Pennisetum*). If these grow vigorously, they also provide green mulch.

Heavy cattle browsing is a major cause of pasture deterioration and soil loss. Their extensive grazing is probably the most common destructive use of tropical lands. The first step is therefore to relieve the land of the weight of too many cattle. No nation, nor the globe, can support destructive grazing agriculture on the agribusiness/cowboy/pyromaniac model so general in tropical countries, in America, and wherever "cheap" beef is produced. The long term cost makes such systems uneconomic in any terms.

A positive approach is to re–establish either a multi–species system ecology (trees and a variety of browsers), or to intensify cattle rearing. Cliff Adam, Chief Research Officer at Grand Anse, Mahe, in the Seychelles has grown *Pennisetum atropurpureum* (7 parts) plus *leucaena leucocephala*—the low–mimosin type available in Australia—(1 part), and may add the Bocking strain of comfrey. This "pasture", cut and fed to cows, supports seven milk cows to the acre. All manure and washings from stable/dairy are returned to the irrigated field. Imported artificial manures have been reduced to one–tenth, and he hopes to further reduce this import by building soil. Meanwhile, in the same climate in Australia, one cow per square mile is enough to lay waste to the land.

A friend who bought a degraded cattle property north of the Daintree River (Queensland, Australia) gathers a load of coconut from the beaches, and (travelling the ridges of old fields just before the wet season) throws dozens of coconuts at intervals into the stream–lines and gullies. About 4% take root and grow into sheltered and pioneering palms. Not far south of there, another innovator rolls down the monsoon grasses as they begin to die off in the dry season, and broadcasts tall–stalk rye and field legumes (Fava, *Dolichos, Vigna*) into the thick resulting mulch. Enough moisture persists over the dry winter season to grow these crops; after harvest, the monsoon grasses regrow for next year's rye crop.

This clever use of seasons and growth is possible for the establishment of many species, some of which become permanent and grass–defeating pioneers for later evolutions. Consolidation of the area for regenerative forestry, however, proceeds more surely as a scattered set of pioneer tree and herbaceous nucleii; that is, the steady establishment of CLUMPED pioneer trees in open grassland. This is a "natural" process which duplicates the seeding of grasslands by fruit pigeons

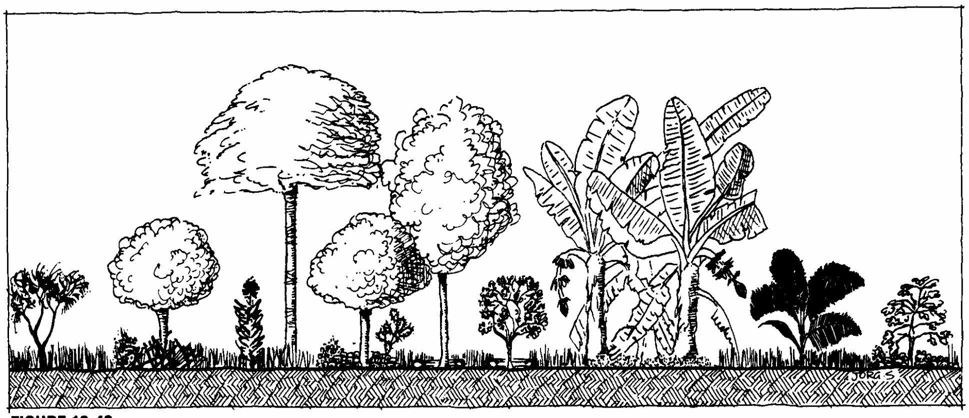


FIGURE 10.43
PLANTING IN GRASSLANDS.
A dense (2 x 2 m) planting on "nucleii" of legumes, palms, shrubs, ground covers, and bulbs plus stone or stick mulch quickly shades out grasses and produces a closed canopy. [Jörg Schultz].

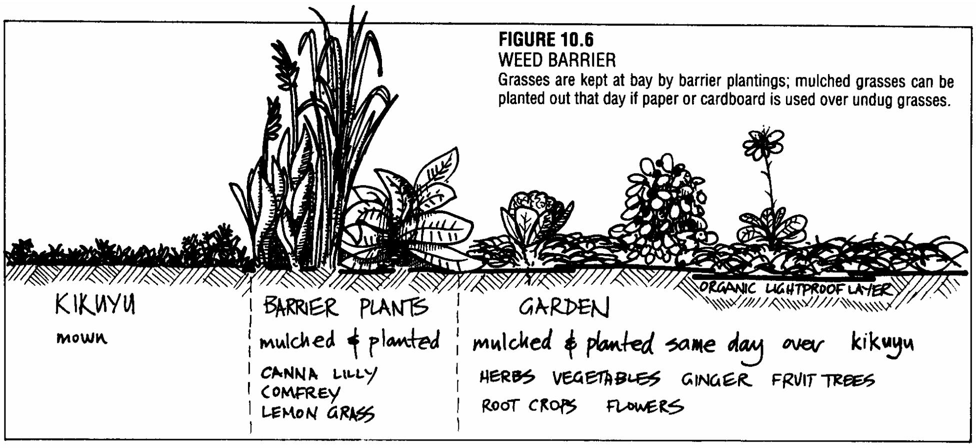


FIGURE 10.6
WEED BARRIER
Grasses are kept at bay by barrier plantings; mulched grasses can be planted out that day if paper or cardboard is used over undug grasses.

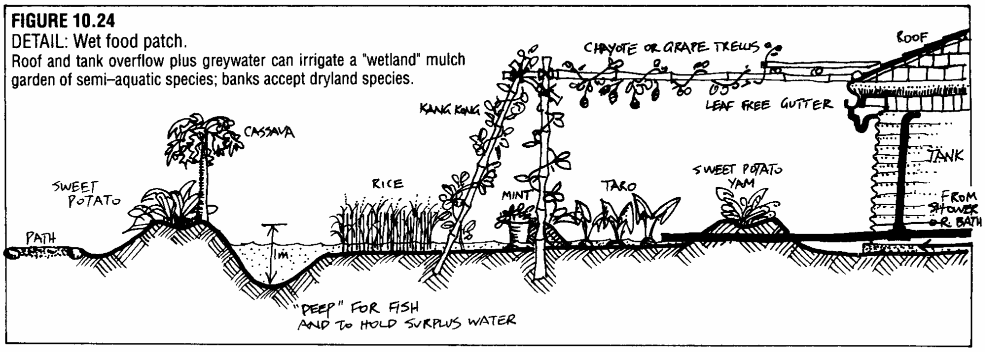


FIGURE 10.24
DETAIL: Wet food patch.
Roof and tank overflow plus greywater can irrigate a "wetland" mulch garden of semi-aquatic species; banks accept dryland species.

17 . Vines

ducks and geese) are thriving in arid areas, there is no basic problem for nutrition. Yet adequate food and good nutrition are denied many desert peoples because of the lack of basic seed and plant resources, and the denudation of the total environment by livestock.

For designers, small intensive trial systems within and around settlements are the essential precursors to wider Zone 2 and 3 trials along favourable corridors of better soils and water. The selection of existing plants, and the further addition of new species for the area, greatly assist this "nucleus of small successes" that demonstrates how larger or more extensive systems can also develop, using fewer but well–tested species.

It is always essential to build–in humus and mulch production into crops, and species used for this purpose can range from such edible plants such as *Dolichos*, edible lupin, *Leucaena*, or edible–seeded *Acacias*, to shelter, edge, weed barrier, and hedgerow species such as *Echium fastuosum*, *Acacia*, *Pennisetum*, comfrey, lemongrass, and Vetiver grass. Many trees such as *Casuarina*, some figs, *Acacia victoriae*, *Pongamia* and clump species such as bamboo also provide shelter and leaf mulch, while hardy ground covers suppress grasses and cool the roots of vines and young trees. Good "soft" ground covers outside Zone 1 are vetches, nasturtium, a variety of runner legumes, comfrey, annual lupins, and daikon radish.

The spacing of fruit trees in Zones 1 and 2 can be as usual; it is, however, essential to provide *high shade* from interplants of tall thin foliage legumes or palms, to also interplant fast–growing small and large woody legumes that either die out (pigeon pea) or can be coppiced (tagasaste) or felled or ring–barked to rot to humus (many *Acacia* species).

Such well–planned systems are very productive, drought resistant, cool, and eventually humus–rich. They demonstrate how quickly a barren or hard soil area can be brought into production as a result of intensive biomass production and wastewater use. Thus, the role of teachers and designers is to help plan and place such systems as trials in villages, to locate and provide seeds and propagules of new species, to teach the benefits of soil humus and rainwater harvest, and to stress food preparation and good nutrition.

- VINES

Vines have a key role to play in desert gardens. Correctly spaced and pruned they provide both a productive crop and shade cover to mulched and watered gardens. They are also a key element in moderating climate in designed houses, or in retrofitting uncomfortably hot homes. These basic uses can all be applied in the domestic situation. There are special vines for broadscale work, and for selected niches in the desert property. We can deal with each in turn.

<u>Vine Over Garden</u>

Horizontal trellis bars at 1–2 m spacing and furnished with grape vines can throw a shade system over the greater part of the vegetable garden, relieving light saturation. The sides of this trellis can also be more completely closed with herbaceous vines (beans, climbing tomatoes, yams, cucurbits). It is more important to defend from the early (eastern) sun, as dew, distillation, and guttation moisture is important to plants early in the day, and soil temperatures then remain cooler for longer periods. The western side of the trellis needs fleshy vines, as great heat can build up

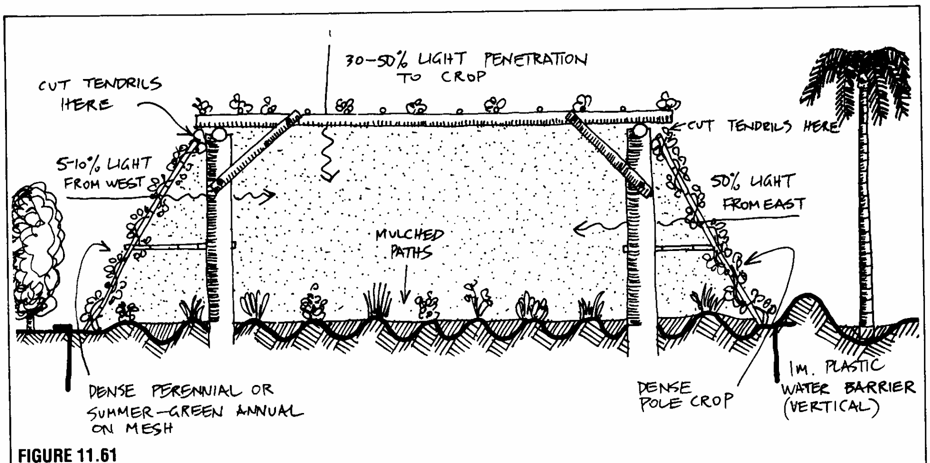


FIGURE 11.61
PLAN OF VINES OVER GARDEN.
50% or more shade helps gardens in hot clear deserts; side trellis is spaced to shut out most of the westerly sun; palms can serve as shade providers; mulch is of great benefit in all deserts.

on the western aspect late in the afternoon. A vine such as *Mikania* (mile–a–minute) is ideal. Only the shady aspect of trellis needs to be left quite open, while the sun side can be of wide–spaced pole crop. A plan is as in **Figure 11.61**.

Vine as a House Retrofit

Considerable comfort can be brought to over–hot homes by attaching trellis. The best results are achieved by:

- Standing dense evergreen vine crop out from west walls (*Mikania, Dolichos, Pelargonium*), and a vine awning above and out from any existing west windows.
- Growing vines (winter deciduous or summer herbaceous) in a screen fixed out from the eastern sun walls. These are well placed at the edge of a verandah if such exists. Washing down the verandah and spraying the vines with water rapidly cools the shaded verandah area.
- Building extensive closed trellis over the rear door, on the shade side to provide a cool air source, preferably with a thick bark mulch below the vine and fine sprays to damp it down. In this case, roof vents via the indoor ceiling or a small sunside glass-house are necessary to draw in the cool air of the trellis.
- Running a perennial non–invasive vine (*Mikania, Pyrostegia*) completely across the roof.
- Placing a water tank under the vine crop to keep the garden air cool, and to cool the water.

Vines as Mulch and Forage Sources

Vines can be vigorous producers of foliage for garden mulch and for feeding small domestic livestock. Well–chosen, shade vines can also provide some stick fuel woods for efficient cook–stoves.

Vines in the Desert Itself

Several vine crops are desert–adapted; if we include the gourds and yam legumes (ground vines), some very basic reserve foods can be set out in shaded, moist, wastewater, or soakage situations. Some vines survive dry, harsh, stony, or dune conditions. All, however, thrive and yield better if a few cubic feet of humus is pitted below the plant when it is set out. Valuable vines grown in large containers can await rains, or the soakage from water harvesting, before being placed out for permanent field growth.

FENCING

Over much of the world's drylands, the great impediment to home garden production of food is the presence of wild, feral, and domestic browsing animals. It is much cheaper to fence out these devastating and ever–hungry animals from settlements and gardens than it is to airlift emergency food aid to starving people, or to withstand the social costs of poverty and famine.

Fencing is thus a primary requisite for intensive food production in deserts. Fenced corridors or "stock routes" can permit milk and draft animals to enter some restricted areas of settlements, but it needs sound fences (preferably electrified) to exclude goats, camels, cattle, donkeys, and sheep from home gardens.

Within fenced areas, sometimes surprising natural regeneration of trees can occur, and hardy food plants can be set out in unirrigated areas if fencing is provided. These form a firewood, mulch, and medicinal resource for hard times. Poultry, domestic rabbits, bees, guinea pigs, and pigeons are all relatively harmless livestock for dryland homes.

Where there is no money available for post–and–wire fencing, more laborious alternatives are used, ranging from ditch and bank systems, either rock–faced or thorn–crowned, to woven or living fences of plant materials (reeds in the Caspian area, cactus in Mexico, *Euphorbia antiquorum* in India, *Euphorbia tirucalli* and *Lycium ferocissimum* in Africa and now parts of Australia). Combinations of stone walls, rock, thorny shrubs, and steel pickets or wires are frequently seen. In affluent societies burnt brick walls, and in Afghanistan and Iran unburnt mud brick walls, are erected around large gardens; even within urban areas of the third world, domestic animals range and destroy vegetation. Where hunting will support dogs, large domestic dogs will defend a house area (at the cost of feeding the dog). It is a matter of adapting to local materials, labour costs, and customs.

SOILS

In drylands, any soil humus can rapidly decompose (in dry–cracked soils) to nitrates with heat and water, giving a sometimes lethal flush of nitrate to new seedlings. Dry cultivated soils exacerbates this effect. Mulches or litter on top of the soil prevents both soil cracking and the lethal effect of rapid temperature gains that cook feeder roots at the surface, so that in subsequent rains there are less roots to absorb water.

Fire is destructive of this protective litter. After fire and cultivation, most of the soil nitrogen, sulphur, and phosphorus is lost, and even a cool fire loses plant nutrients to soil water and leaching. When we know more of the effects of fire in drylands, it is my opinion that we will use any other method (slashing, rolling, even light grazing) to reduce fire litter to soil mulch. It now seems probable that Aboriginal burning has not only gravely depleted soil nutrients, but caused a breakdown in soil structure, and perhaps has been in great part responsible for the saltpans that preceded agriculture. However, agriculture itself is a monstrously effective way to speed up this process and intensify it.

Soil Treatments in Dryland Home Gardens

Where free–draining or non–wetting sand is the problem, bentonite (a volcanic fine clay which swells up and holds water) is a great help in flood–irrigated beds. Conversely, where clay is causing problems with

18 . Hurricane – and Coast - Protection

AVOIDING AND REDUCING HURRICANE DAMAGE

Access to atolls is traditionally by boats in reef gaps and today by light planes. When blowing a gap for a reef entry, or clearing a landing strip for a plane, great care must be taken not to open a wave or wind gap to gales, or any atoll can literally wash away. Thus, reef entries are cut on the slant through the reef at the east or west quarters (winds blow southeast to northwest south of the equator, northeast to southwest north or the equator). In fact, reef gaps should be in the most sheltered sector of the reef in any winds, and also just wide enough (6–10 m) to admit a vessel or barge.

Airstrips are also aligned about 20° off prevailing winds, and both ends and sides should be of tall palms and trees, especially those borders on the coast, so that light planes drop in, using their rudders to straighten up below tree crown level. Airstrips carelessly made have destroyed whole islands when hurricane winds have cut them in two following the line of the air strip.

For the same reasons, the sandy coasts of all atolls and cays need a sequence of perennial shelterbelt to hold the shoreline against hurricanes. This starts on the beach as convolvulus (*Ipomoea pescaprae*) and beach pea, rise on the beach berm to a dense shrubbery of vines, *Tournefortia*, *Scaevola*, and in sheltered bays mangroves, and is backed by a 5–6 tree deep layer of coconut palm, *Casuarina*, *Coccifera*, *Barringtonia* and other hardy beach trees (**Figure 10.51**). It is behind this dense frontline windbreak that we site houses, gardens, and productive trees, which will produce in shelter but not as exposed systems.

EXTENDING DIET

People who live on small islands, and indeed small traditional villages generally, may exist eating a very few starchy root foods plus banana, with fish for protein. It is quite probable that mineral deficiencies and low vitamin/high carbohydrate diets can impair health. Thus, a well–mulched pit garden, and a well–selected introduction of tree fruits (guava, citrus generally, vine fruits, and a polyculture of minor fruits and nuts) greatly extends and buffers the diet. The addition of (in particular) zinc and iron to mulched soils, and periodic tests of leaf content of such minerals serves to eliminate problems due to restricted diets and highly alkaline soils. Even on high islands, soils can be devoid of, or have, very limited mineral rocks, and soils may need trace elements.

Almost every island group has unique plant and animal species, some of great value directly, others of value in that they exist and demonstrate new forms and behaviours. Such groups as land crabs (derived from ghost crabs, shore crabs, and hermit crabs) do special work as mulch shredders, scavengers, larval insect eaters, and may form a valued food resource. Giant tortoises are also excellent scavengers of fallen fruits, and keep grasses below palms neatly–trimmed, while putting on a considerable annual growth. Marine iguanas, giant lizards (the Komodo dragon), flightless or specialised birds, and rare plant and animal survivors of older land masses are not only common but usual on islands. All need careful preservation and assessment for their special values, and many provide useful functions in polycultures.

At low tide (even the usual tides of about 1 m variation) atolls may almost double their "dry" area. It is thus possible to modify lagoon and reef for better

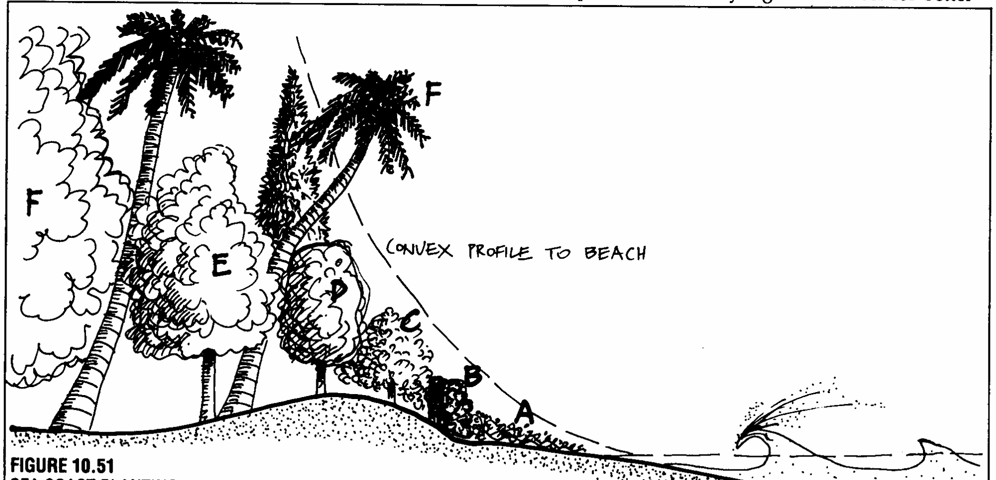


FIGURE 10.51
SEA COAST PLANTING
A. Beach convolvulus. **B**. *Scaevola*. **C**. *Tournefortia*. **D**. *Barringtonia*. **E**. Sea grape (*Coccoloba*). **F**. Date or coconut palm, Casuarina behind beach berm. This profile is stable.

19 . Terasses

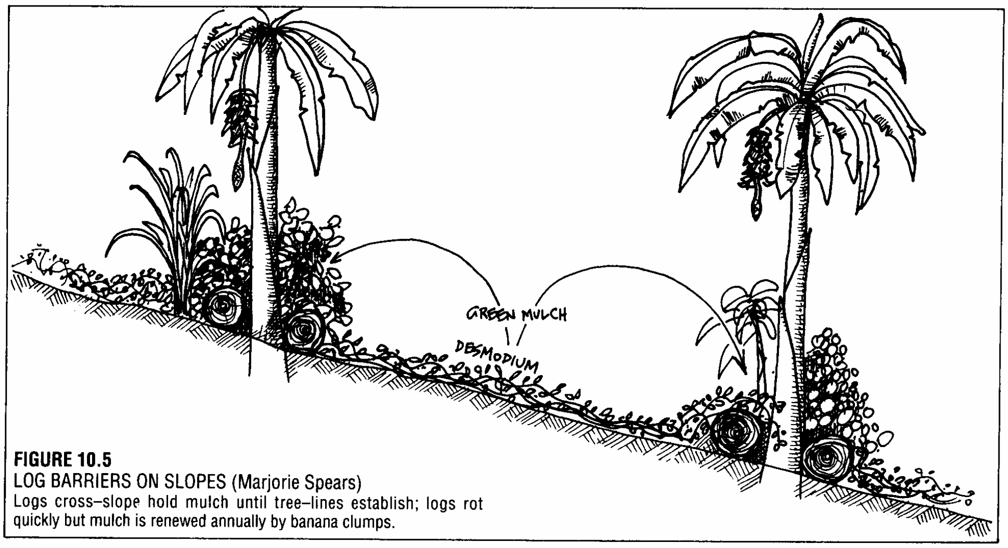


FIGURE 10.5
LOG BARRIERS ON SLOPES (Marjorie Spears)
Logs cross–slope hold mulch until tree–lines establish; logs rot quickly but mulch is renewed annually by banana clumps.

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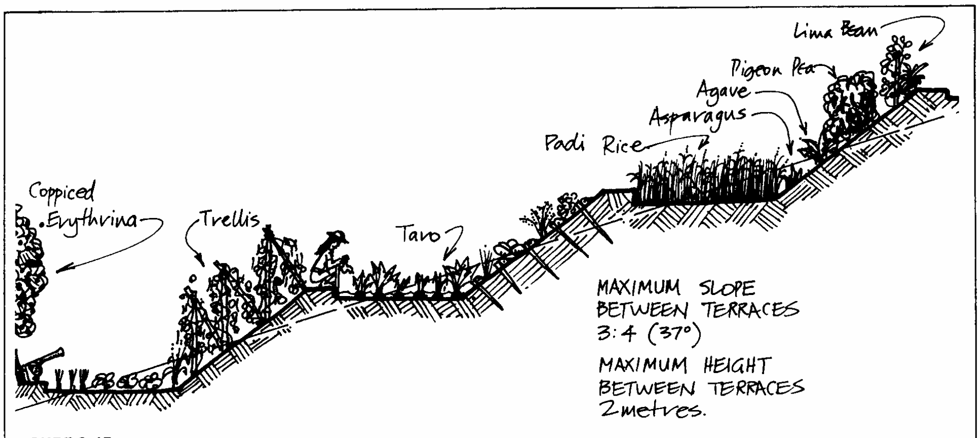


FIGURE 9.15
TERRACE SERIES
Stable garden terraces of earth provide a total growing surface.

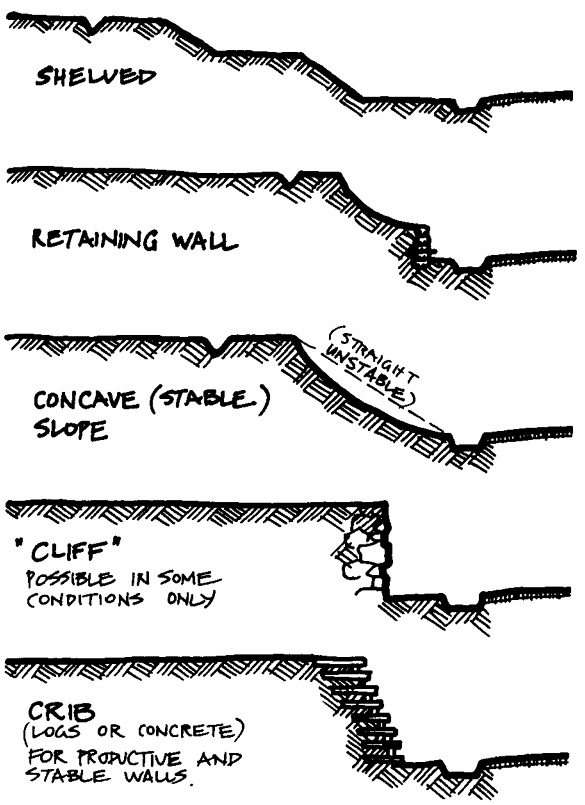


FIGURE 9.10
ESSENTIALS OF WATER AND SOIL SLUMP CONTROL.
Many methods can be used to prevent slump from cuts above terraces or roads; vegetation helps all these systems.

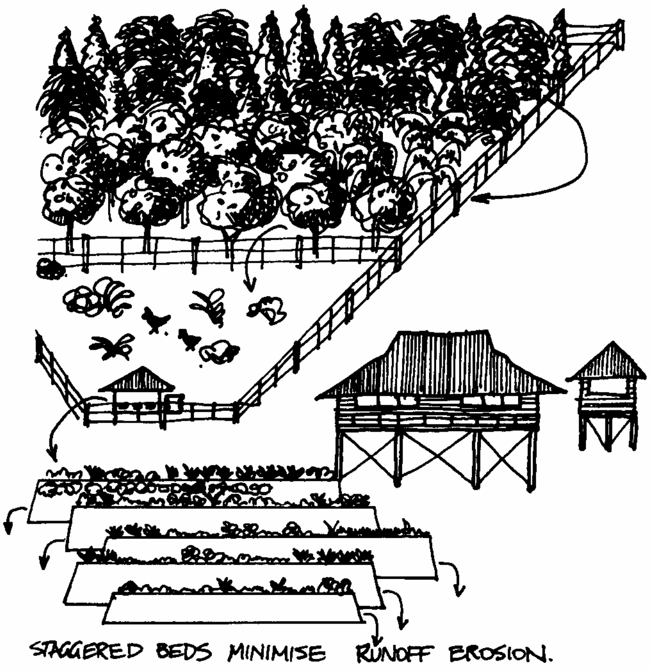


FIGURE 9.13
KICK-DOWN SYSTEMS AND STEEP TERRACES
Using steep slopes to assist the movement of nutrients and water.

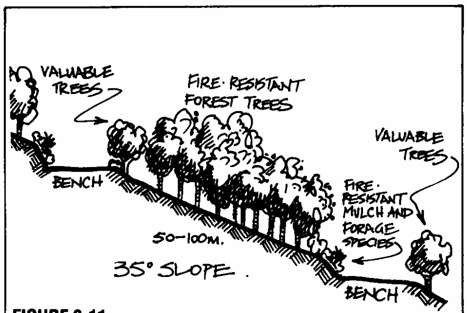


FIGURE 9.11
BENCHES ON STEEP SLOPES
offer good harvest and management access to steep slope forests. Trees stabilise bench areas, fill, or slope.

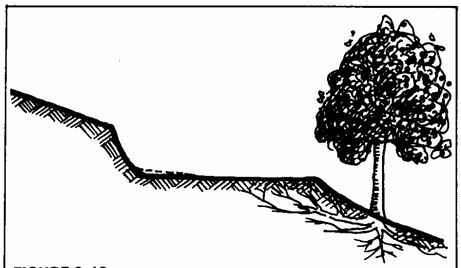


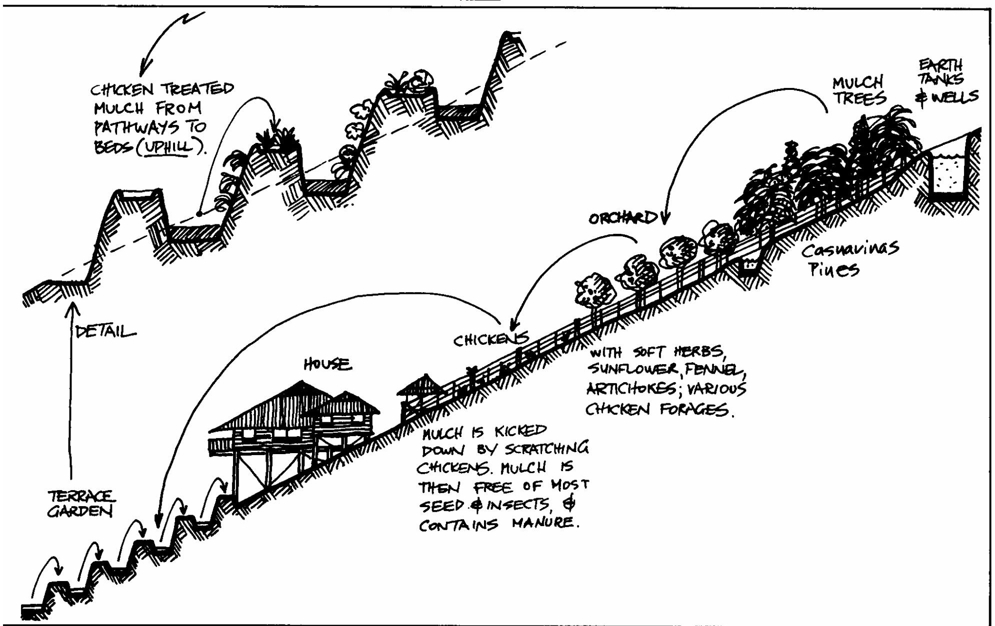
FIGURE 9.12
BENCHES CUT INTO HILLSIDES ON CONTOUR

ground. All normal soils with some clay and stony banks are fairly stable, given that the angle of rest of these materials is preserved, the banks cut somewhat concave, and drainage fitted. In severe slump areas, re-routing of roads or expensive drainage and concrete retaining walls may be last resorts, but **Figure 9.10** shows the essentials of water and slump control; only some may be needed but all can be used.

BENCHING

A bench is a flat, near-contoured cut made in a slope. Very severe slopes of 30–40° can be bench-cut if a bulldozer can start on safe ground (typically, from a ridge of 20° or so). Benches are used to make roads and house sites, and are very useful in long-term forestry if a steep hill is benched every 100 m or so (**Figure 9.11**). Benches greatly aid access, planting, and eventually harvest. The first fast-growing trees to plant are those on the lower (loose soil) side of the benches; these can be nut or fruit trees, for harvest, or for seed crop.

Small-holders on very steep hillsides must work with the slopes, or expend much energy on carrying water and fertiliser. Orchard and mulch *above* poultry *above* garden is the easiest system. All the better if the ridge or hill above that system is planted to mulch-producing trees such as *Casuarina* and pine, oak and beech. Thus, mulch and bedding is thrown down-hill as greenfeed and seed for chickens, and they kick-down to the lower fence where the gardener accepts the manured and shredded mulch for the essential (terraced) garden



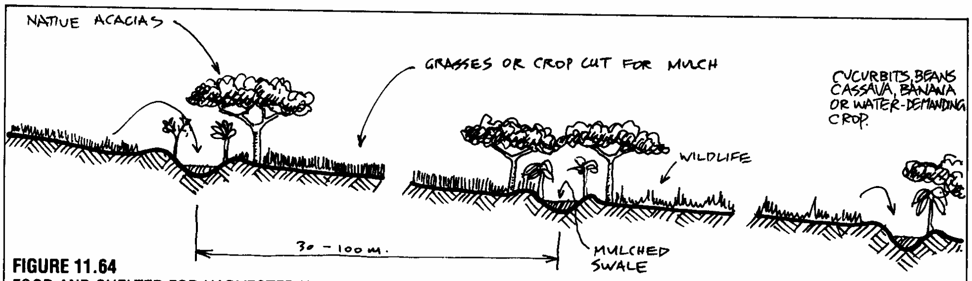
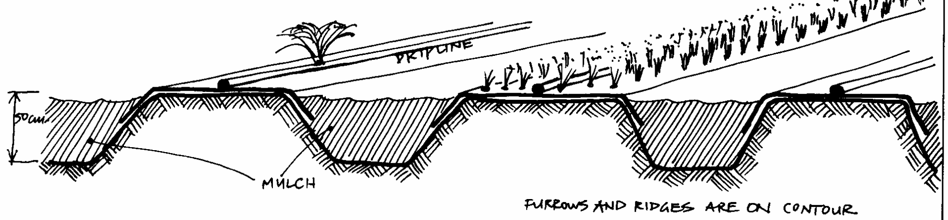


FIGURE 11.64
FOOD AND SHELTER FOR HARVESTED WILDLIFE, CROP.
Swales on headwater slopes grow fodder legumes, hardy trees, and are mulched for high value crop. Grasses or grains can be cropped after rains on ripped soils between swales.

FIGURE 11.65
MICROPORE AND SEEPAGE LINES.



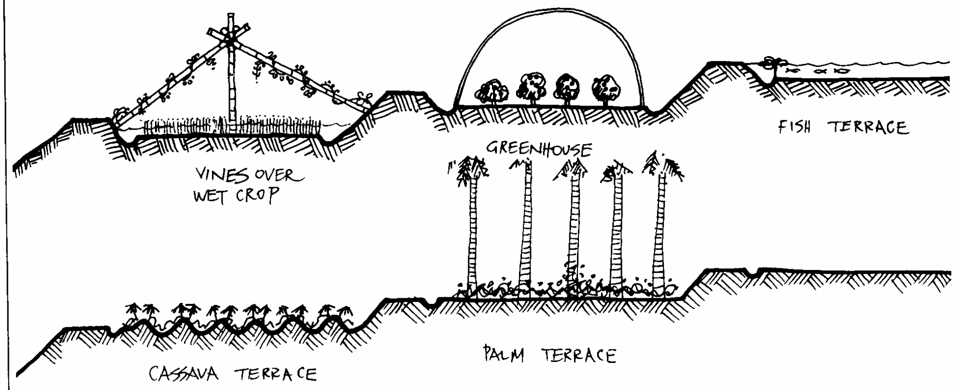


FIGURE 10.14
VARIATIONS ON TERRACE CULTURE.
Wet terrace (padi), fish crop, shadehouse or grow–tunnel, ridge crop, palm, and grain culture vary production and stabilise terrace cultures; alternate dryland and wet (padi) crop suits summer–wet sub tropics.

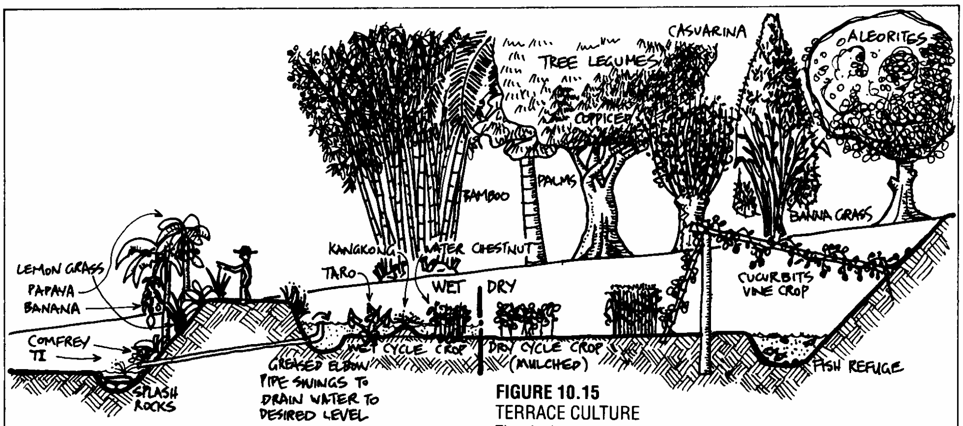


FIGURE 10.15
TERRACE CULTURE
The sloping side–bank here is shown planted to ideal mulch trees, cut or coppiced to enrich terrace crop production. Drain pipes are adjustable to dry out terraces.

problem).

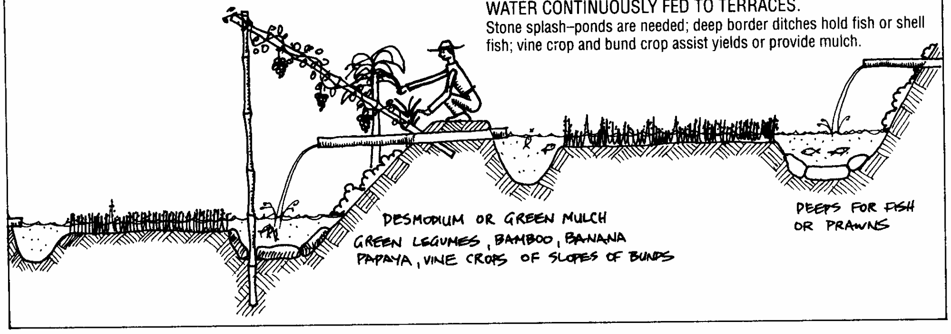


FIGURE 10.12
WATER CONTINUOUSLY FED TO TERRACES.
Stone splash–ponds are needed; deep border ditches hold fish or shell fish; vine crop and bund crop assist yields or provide mulch.

of starting small and expanding the system at the periphery. Dense planting of nucleus areas plus mulch is the key strategy.

10.4
EARTH–SHAPING IN THE TROPICS

On level ground or gentle slopes (2–8°) in the wet–dry tropics, a series of large contour banks or swales have an excellent soil preservation effect. Coupled with the gradual development of a terrace, the retention of wet–season water, and mulch–providing hedgerow, this ensures a stable situation. Between the main hedges, mulch hedgerow and borders can be developed in crop, or the terraces can be flooded seasonally for irrigated crops (**Figure 10.8**).

On very flat sites (less than 4°), a series of raised mounds or ridges can operate to drain crops in very wet areas, or to impound water for absorption in drier areas. Pits can also be used only where rainfall is less than 76 cm (30 inches), or where soil drainage is good. Thus, cassava, yam, and cucurbits are mounded in areas where drainage is a problem and rainfall intense, and pitted in dry areas or savannah–dry seasons. Pits retain mulch and moisture, as they do in desert areas.

Almost every slope benefits from earth–shaping for soil conservation. Hand–made slope terraces need to be narrower (to 3.5–6.5 m—12–15 feet) than machine–made systems.

Garden terraces on *very* steep humid slopes must be kept narrow, and in sets of 6–8 downslope, otherwise instability may result. Borders can be kept vegetated with trees (**Figure 10.11**).

Classical wet rice and taro terrace has water continuously led into the top terrace of the series, and each has a drain and sump to regulate water level. Fish

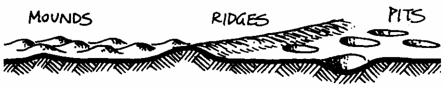


FIGURE 10.9
MOUNDS, RIDGES, PITS
Mounds increase yields of yams; ridges of cassava and sweet potato; pits for taro, arrowroot, and mulch grasses. Terraces need such detailed earthworks.

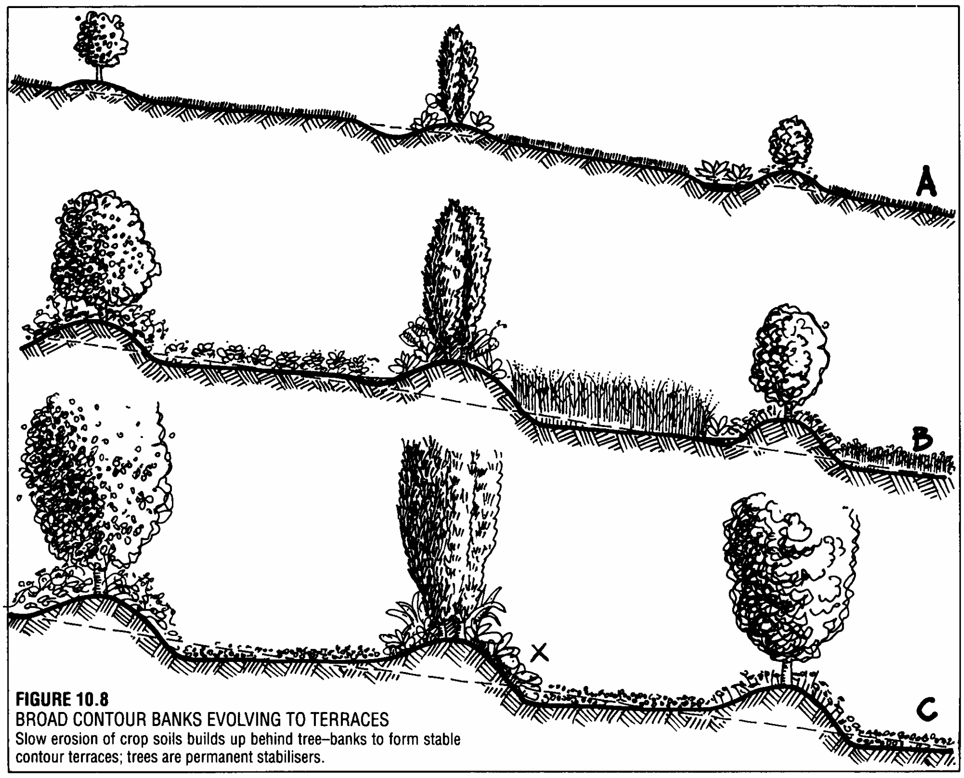


FIGURE 10.8
BROAD CONTOUR BANKS EVOLVING TO TERRACES
Slow erosion of crop soils builds up behind tree–banks to form stable contour terraces; trees are permanent stabilisers.

banana, papaya, melons, chilies, peppers, cucur-

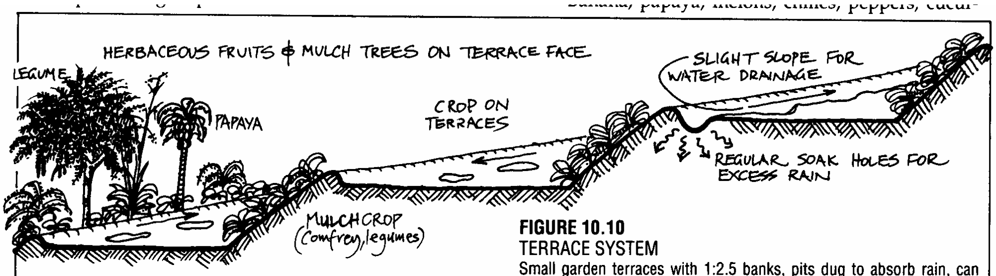
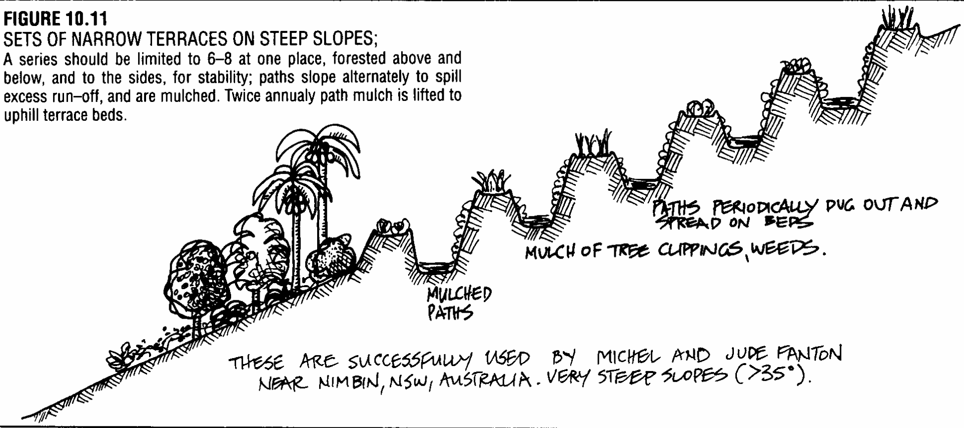


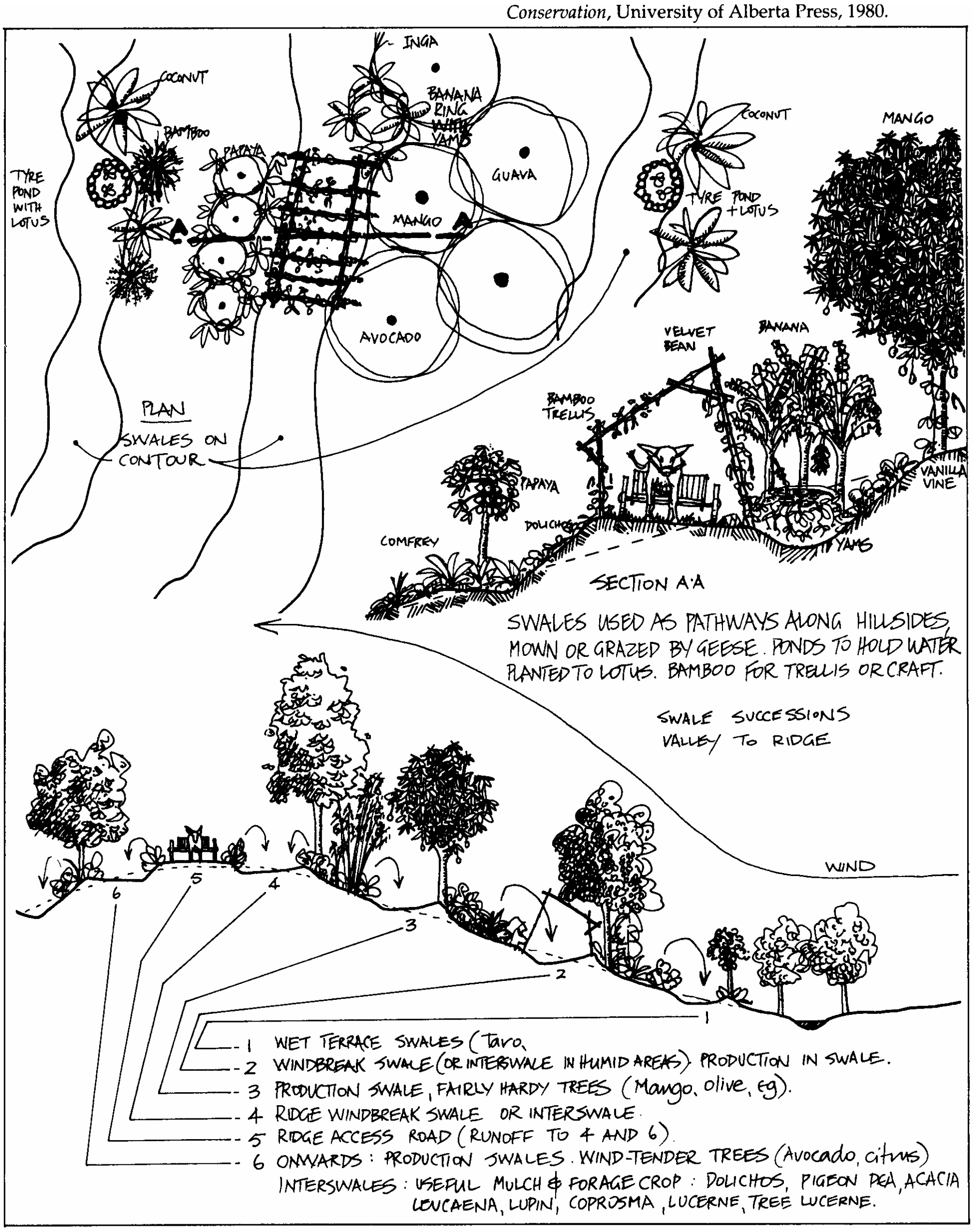
FIGURE 10.10
TERRACE SYSTEM
Small garden terraces with 1:2.5 banks, pits dug to absorb rain, can be fully planted to vegetable and herbaceous perennial crop.

FIGURE 10.11
SETS OF NARROW TERRACES ON STEEP SLOPES;
A series should be limited to 6–8 at one place, forested above and below, and to the sides, for stability; paths slope alternately to spill excess run–off, and are mulched. Twice annualy path mulch is lifted to uphill terrace beds.



20 . Roads

Conservation, University of Alberta Press, 1980.



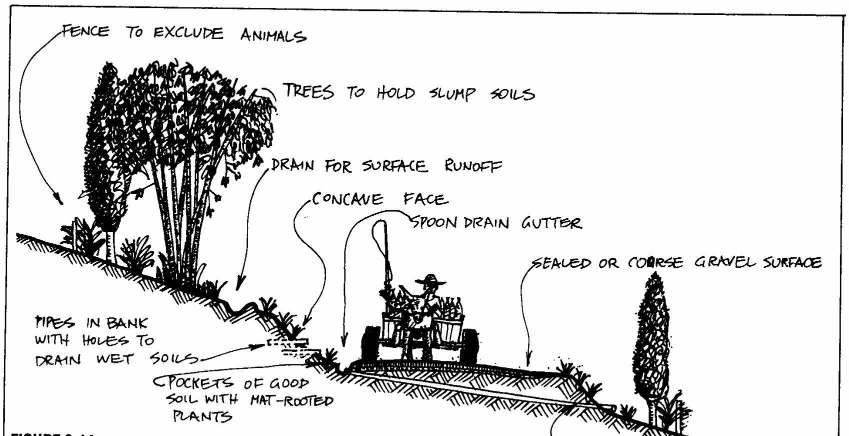


FIGURE 9.14
ROAD CUT ON MILD SLOPE;
Benches greatly assist slope access if well–drained and stabilised.

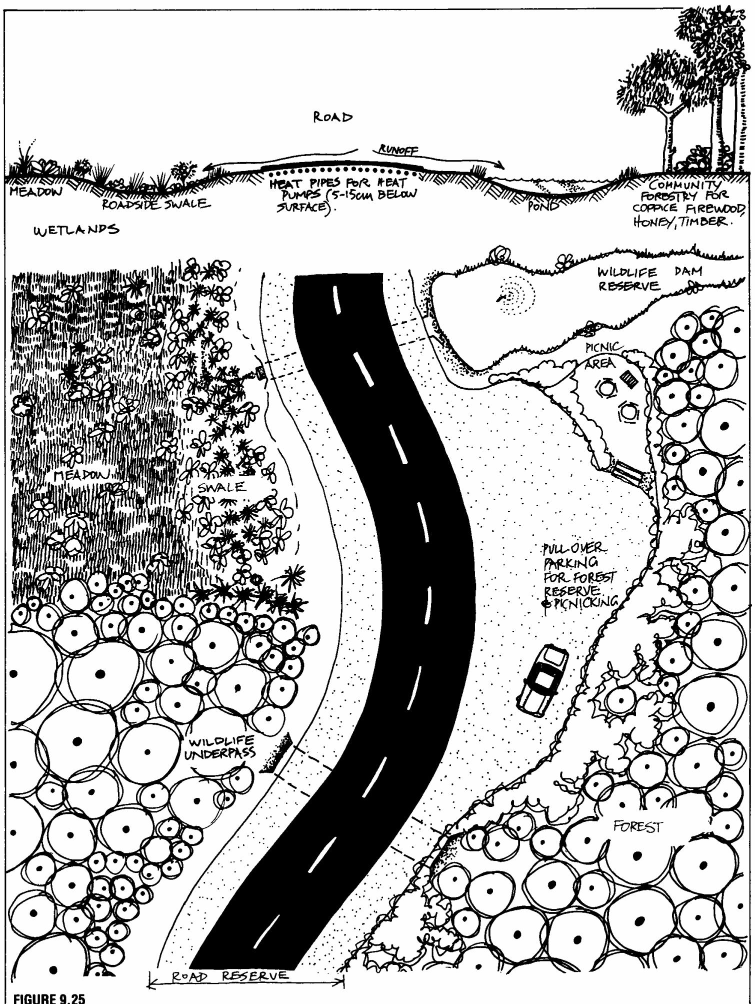


FIGURE 9.25
DESIGN FOR ROAD ENHANCEMENT
Biological planners can make many productive accessories to roadways; roads can provide energy benefits and conservation plantings.

21. Atolls and Coral - Sands

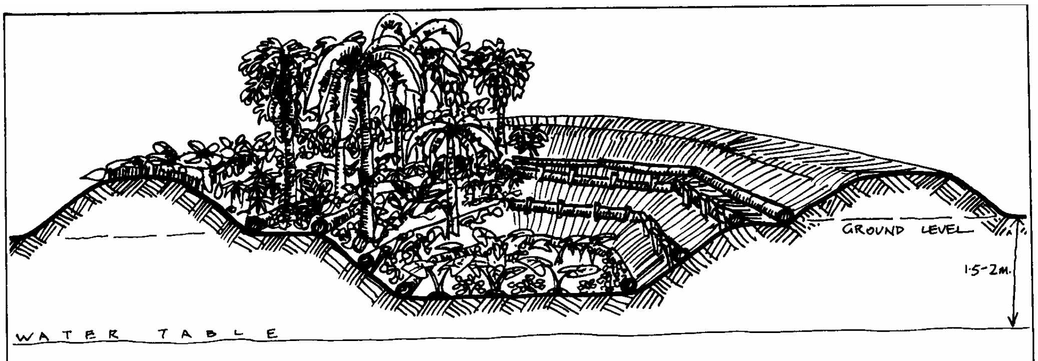


FIGURE 10.41
PLANTING BENCHES IN PITS ON CORAL ISLANDS.
Grow–pits 1–2 m deep and 8–12 m wide are ideal in coral sands; lower levels are close to permanent water table. Mulch reduces pH to 7–7.5.

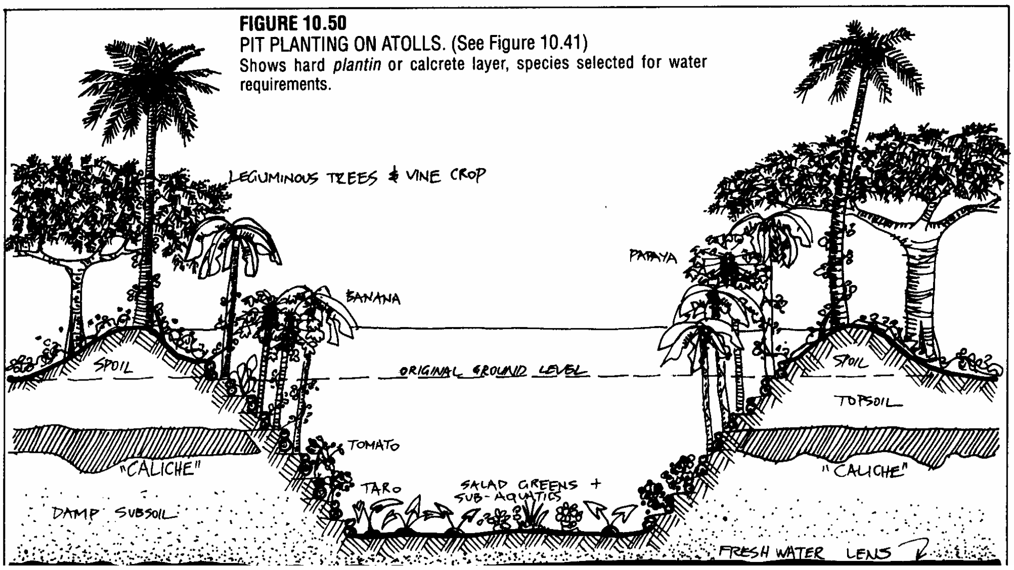


FIGURE 10.50
PIT PLANTING ON ATOLLS. (See Figure 10.41)
Shows hard *plantin* or calcrete layer, species selected for water requirements.

22 . Mulch

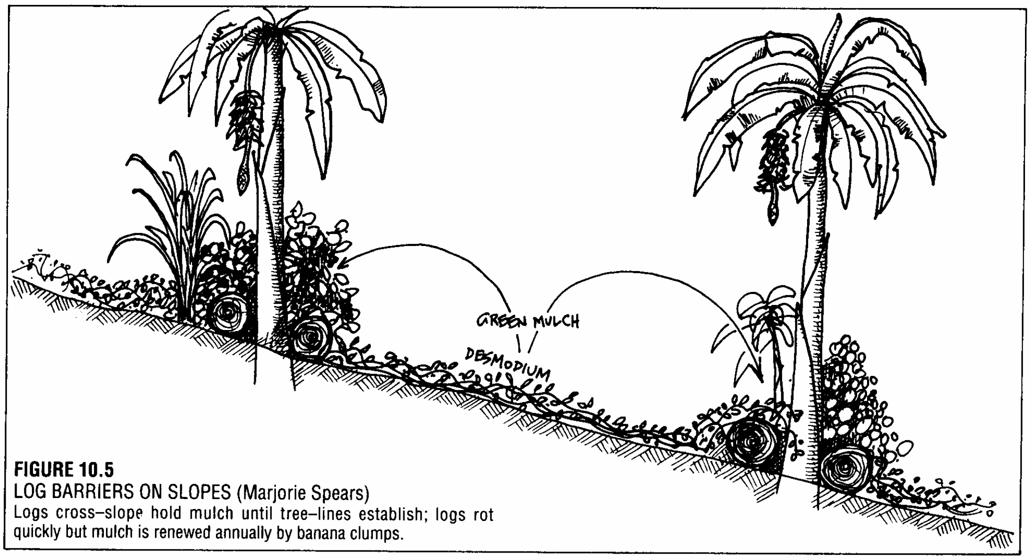


FIGURE 10.5
LOG BARRIERS ON SLOPES (Marjorie Spears)
Logs cross–slope hold mulch until tree–lines establish; logs rot quickly but mulch is renewed annually by banana clumps.

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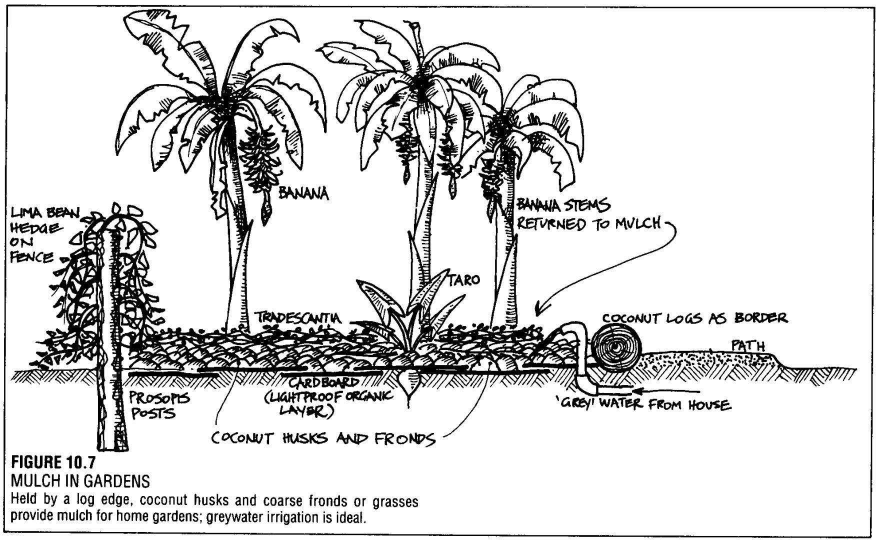

FIGURE 10.7
MULCH IN GARDENS
Held by a log edge, coconut husks and coarse fronds or grasses provide mulch for home gardens; greywater irrigation is ideal.

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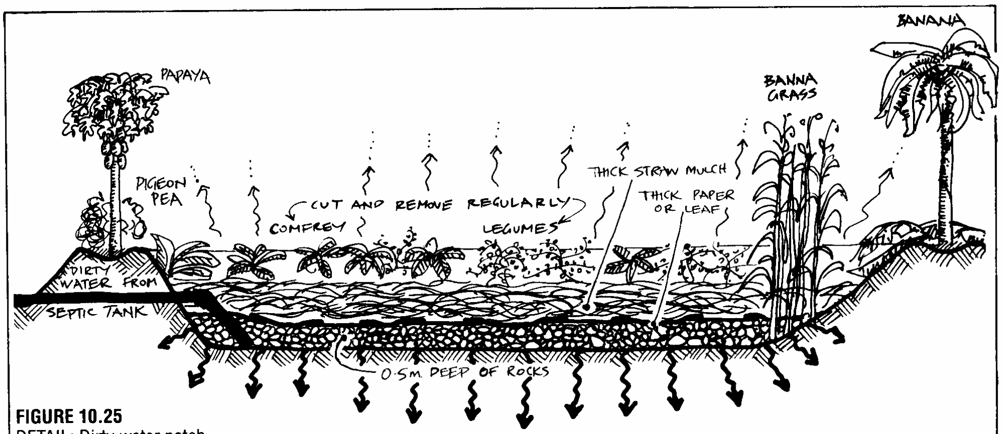


FIGURE 10.25
DETAIL: Dirty water patch.
Sewage fed to a mulched 5 x 8 m stone–pit allows a surround of useful species; mulch can be grown in the pit.

23 . Cool Houses

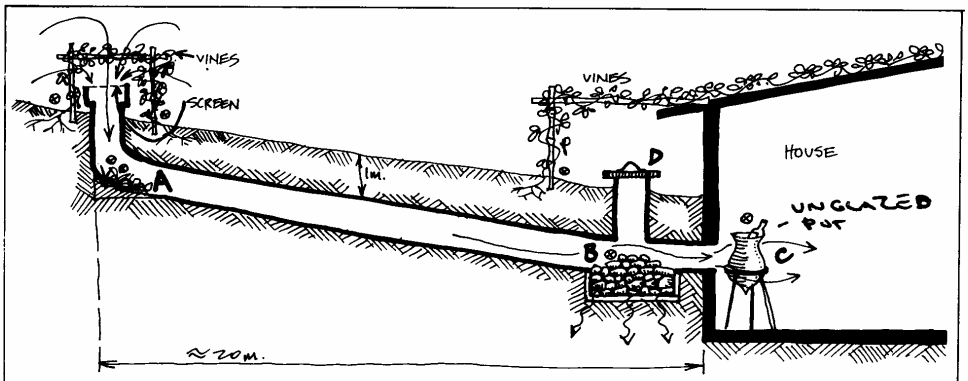


FIGURE 11.54
COOL AIR TUNNEL.
Slopes *down* to house, has shaded intake, moist coke or cinder bed, unglazed pot of water at outlet; length 20 m, depth 1 m. This tunnel provides cool humid air to dry desert houses, food storages, hospitals, etc.

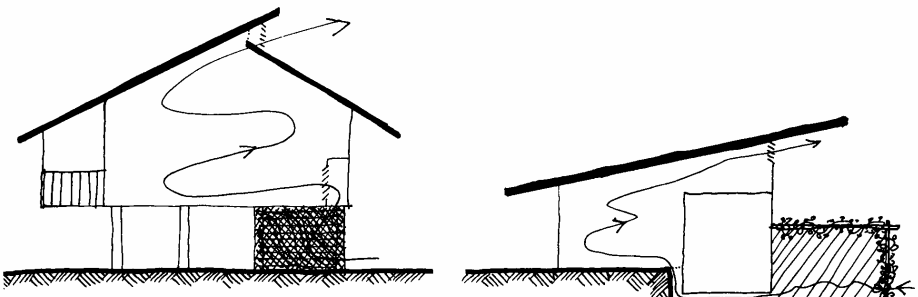


FIGURE 10.16
CROSS–VENTILATION FOR HOUSES
Vented ceiling slopes allow hot room air to escape, and cool trellis air to enter.

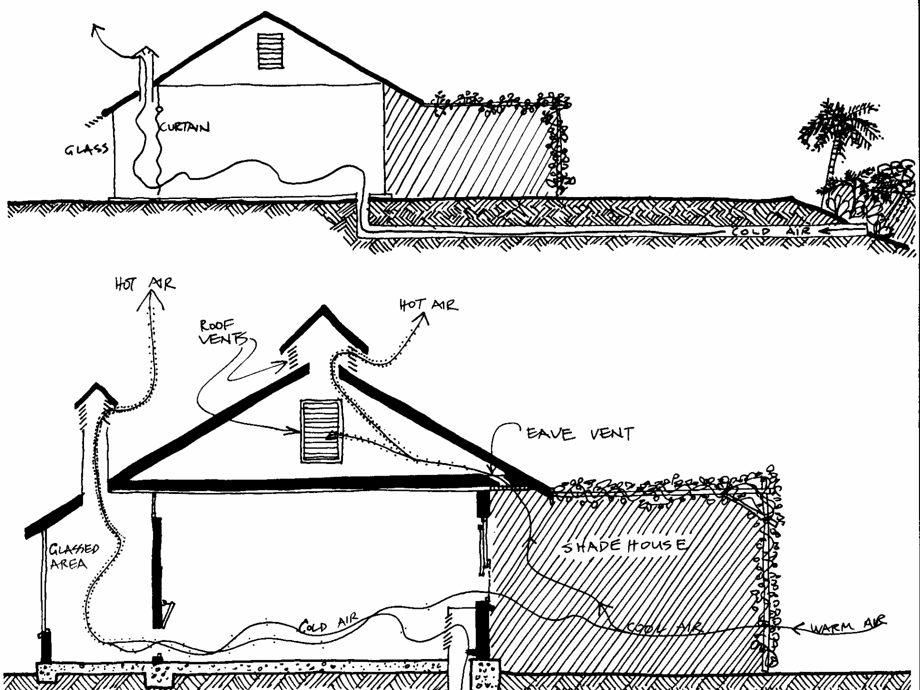
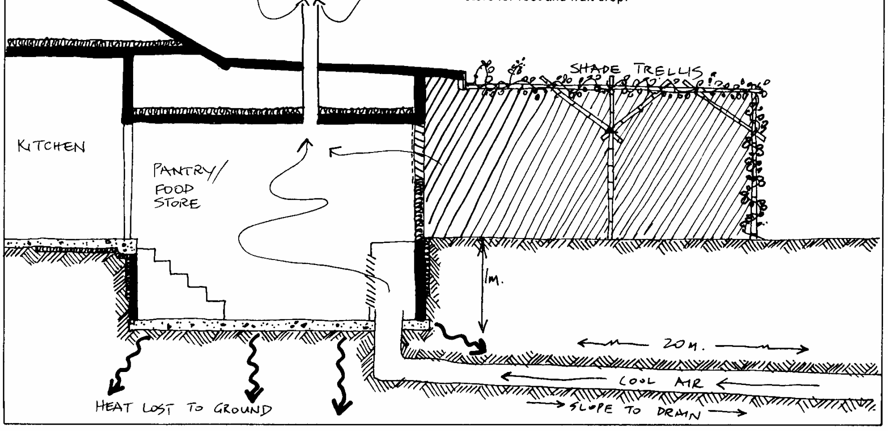


FIGURE 10.17
COOL AIR FROM SHADEHOUSE AND BURIED PIPE.
A 0.5 x 0.5 m tunnel 1 m deep and 20 m long sloping to the outside intake to de–humidify and cool equatorial air, with a solar chimney to draw air through the house.

FIGURE 10.18
COOL STORAGE STRATEGIES.
A cold air tunnel can open first into a pantry area, or a half–buried cool store for root and fruit crop.



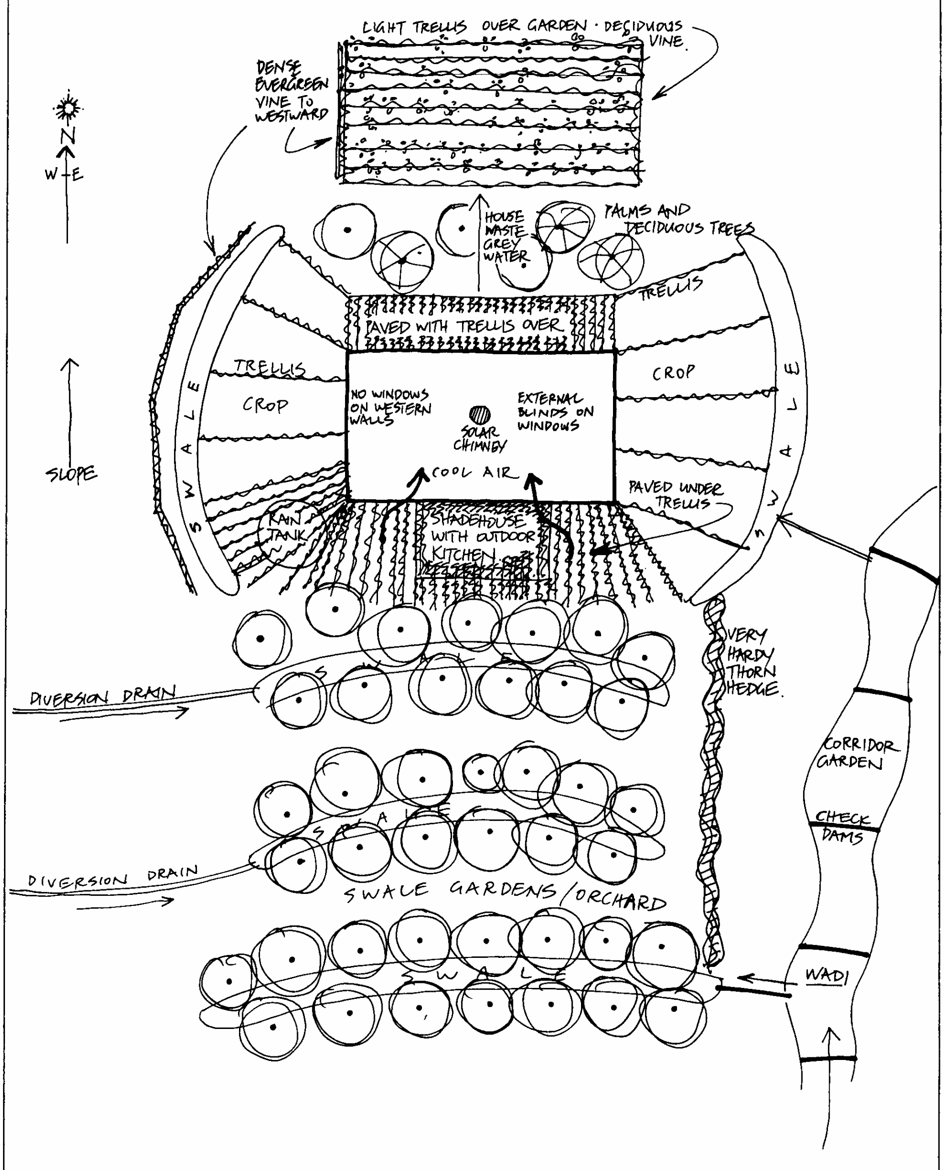


FIGURE 11.55
CORRECT PLACEMENT OF SYSTEMS AROUND THE HOUSE.

24 . Grain Storage - System

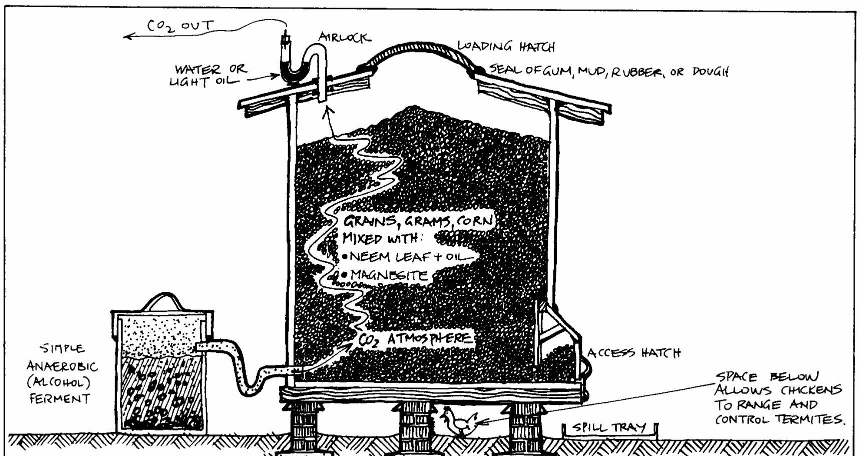


FIGURE 10.19
GRAIN STORAGE SYSTEM.
With its lid sealed with mud or tar, and with an air–lock for carbon dioxide escape; a nearby ferment provides CO_2 which kills pests. Store is raised on stones to allow chicken control of termites.

25 . Soil - Analysis

8.5

SOIL AND WATER ELEMENTS

Of the 103 known elements, only some are commonly dealt with in the literature on soils and water. Soil itself is predominantly composed of aluminium, silica, iron, and (in certain shell, sand, or limestone areas) calcium. Only mineral ore deposits have large quantities of other elements.

The modified form of the periodic table is given in the centrefold of the colour section and a more extensive annotation on specific elements is given in **Table 8.1**. It is essential that designers in any field have a basic knowledge of nutrients, poisons, and tolerable or essential levels of trace elements in food, water, and the built environment.

The health of plants, animals, and the environment of soils and buildings are all dependent on the balance of elements, radioactive substances, radiation generally, and water quality. Of particular concern in recent times is the level of radioactives in clays, bricks, paints, and stone, and both the emissions from domestic appliances (TV, microwave ovens) and microwave radiation from TV transmission and power lines.

Thus, the annotations in **Table 8.1** cover a range of topics, including short comments on human health. In this case we are using the periodic table not as an aid to chemistry but as a guide to understanding the role of the elements in soil, water, plants and animal tissue, and nutrition.

The colour–coding and the dots on the periodic table (**see centrefold**), plus the following annotations of

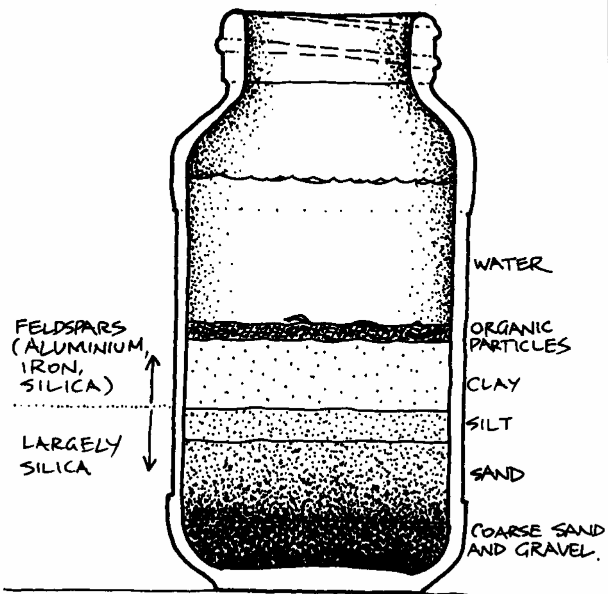


FIGURE 8.2
JAR METHOD
of assessing crude soil composition; useful for classification, uses for mud brick or pisé work. Soil sample is shaken in water and allowed to stand until layers form (1–20 days). The volume of each fraction determines uses and a texture classification (see **FIGURE 8.1**).

26 . Soil - Rehabilitation

8.18
SOIL REHABILITATION

Careful gardeners take care not to break up, overturn, or compact their valuable soils, using instead raised beds and recessed paths to avoid a destruction of crumb structure. Responsible farmers try to govern the speed and effect of their implements in order to preserve the soil structure, and can get quite enthusiastic about a dark, humus-rich, crumbly soil. We seldom give farmers time or money to create or preserve soil, but expect them to live on low incomes to serve a commodity market, whose controllers care little for soil, nutrition, or national well-being.

No matter ρn what substrate we start, we can create rich and well-structured soils in gardens, often with some input of labour, and always as a result of adding organic material or green manures (cut crop). No matter how rich a soil is, it can be ruined by bad cultivation practices and by exposure to the elements: wind, sun, and torrential rain.

Worms, termites, grubs, and burrowers create soil crumbs as little bolus or manure piles, and they will eventually recreate loose soils if we leave them to it in pasture. But we also have other tools to help relieve compaction; they can be explosives, special implements, or roots.

We use the expansive and explosive method rarely, perhaps to plant a few valuable trees in iron-hard ground by shattering. People like Masanobu Fukuoka[3,4] are more patient and effective, casting out strong-rooted radish seed (daikon varieties), tree legume seed, and deep-rooted plants such as comfrey, lucerne, *Acacias*, and eventually forest trees. Much the same subsurface shattering occurs, but slowly and noiselessly. The soil regains structure, aeration, and permits water infiltration.

A measure of the change wrought by green manures, mulch, and permanent windrow is recorded by Erik van der Werf (*Permaculture Nambour Newsletter*, Queensland, Dec. 1985 and Mar/Apr 1986). Working in Ghana at the Agomeda Agricultural Project, he reports on the improvement of crumb structure by measuring the bulk density {weight per volume ratio (g/cc) of soil samples} is given in **Table 8.8**.

TABLE 8.8
Improvement in Crumb Structure

Soil Treatment g/cc	Bulk Density
Annually burnt bush	1.35
Bush left 2 years without fire	1.27
Farmland, cultivated 2 years	1.29
Farmland, permanently mulched and cropped for 3 years	0.92*

*Even with cropping, the mulched soils show how humus alone restores good aeration; soil temperatures were lower by 10°C, and both crop grain yields and a three times increase in organic matter production were noted.

We can use rehabilitative technology on a large scale, followed by the organic or root method, by pulling a shank and steel shoe through the soil at depths of from 18 cm (usual and often sufficient) to 30 or even 80 cm (heroic but seldom necessary unless caliche or compacted earth is all we have left as "soil").

In field or whole site planning, a soil map delineating soil types can either be purchased or made based on local knowledge and field observation. In designing, it helps future management if uses, fencing, and recommendations for soil treatment and crop can be adjusted to such natural formation as soil types. An aid to SOIL TYPING can be found in basic books on soils. These publications give practical guides to landform, floristics (structural) typing, and soil typing and taxonomy (categories or classes of soils).

We can recommend low–tillage systems, pay close attention to water control during establishment, and get soil or leaf analyses done. We can also make careful trials of foliar sprays, the additions of cheap colloids to sands, the frequency and timing of critical fertiliser applications (often and little on sands, rarely or as foliar sprays on clays). Crops suited to natural pH (it is often expensive to greatly modify this factor) and rainfall should be selected for trials. Close attention needs to be paid to the soil stability and thus the appropriate use for soils on slope.

In particular, priorities should be set for erosion control in any specific soil or on specific sites or slopes, and earthworks or planting sequences designed to establish soil stability, for if we allow soil losses to continue or worsen, all else is at risk. The next stage in the design is to assess the capacity of soils for dams, swales, foundations, or specific crops (this may need further analysis, test holes by auger, or soil pit inspection).

Thus, if we have adopted a pre–determined set of values based on soil and water conservation and appropriate uses of sites versus erosion and high energy use, any site with its water lines and soil types noted starts to define itself in usages.

How we need to proceed in soil rehabilitation is roughly as follows:

1. WATER CONTROL. Drainage and sophisticated irrigation are needed to rehabilitate salted areas, and soil mounding or shaping to enable gardening in salted lands (as explained in Chapter 11 on arid lands). We need to rely much more on natural rainfall and water harvest than on groundwaters. Drought is only a problem where poor (or no) water storage has been developed, where tree crops have been sacrificed for fodder or fuel, and where grain crops are dependent on annual rains.

Although many sands and deeply weathered soils are free–draining, waterlogging can occur wherever soil water lies over an impermeable soil layer or where water backs up behind a clay or rock barrier; anaerobic soil results. Remedies lie in any of three techniques:

1. Raised garden beds: paths are dug down for drains, and beds raised; in very wet areas give paths a 1:500 slope to prevent erosion. **Figure 8.10.A**

2. Deep open drains every 10–80 m (clay–sands) upslope and downslope or on either side of garden beds. **Figure 8.10.B**

3. Underground pipes (tile drains; fluted plastic pipes are best) laid in 1.5 m deep trenches and backfilled at 1.5 m (4.5 feet) deep and from 10–80 m (32–262 feet) apart, starting on a drain or stream and with a gentle fall (1:1000–1:600) to the ridge. **Figure 8.10.C**

Water retention in soil is now greatly aided by long–term soil additives. These are gels which absorb and release water over many cycles of rain. This is a practical system only for gardens or high–value tree crop (where the cost amortises).

2. SOIL CONDITIONING. Compacted, collapsed, and eroded soils need rehabilitative aeration, and a change in land use.

3. FERTILISATION. We can reduce and replace past wasteful or polluting fertilisation by sensible light trace element adjustment via foliage sprays *if* undisturbed soil systems and permanent crop have been developed. Foliar spray of very small amounts of key elements greatly assists plant establishment, as does seed pelleting using key elements deficient in plants locally. We may then be able to utilise much of the phosphate that is locked up in clays, and using legumes, create sufficient nitrogen for food crops from sophisticated interplant and green manures.

4. CROP AND PLANT SPECIES SELECTION. Many older varieties of both annual and perennial crops will yield with less fertiliser and water applications than will more recently–developed varieties. There is a growing trend amongst farmers and gardeners to preserve and cultivate these varieties not only for the reasons above, but also for flavour. Many older apple varieties, such as some of the Pippin and Russet types, are more flavourful than, say, the market–variety Red Delicious. There is still a large diversity of food crops left in the world; the key is to grow them and to develop a regional demand. Many older apple or wheat species are not only pest–resistant, but have higher nutritive value, and can produce well in less than optimum conditions.

There are different species of plants that can live in almost any type of soil, starting the process back to rehabilitation. It is often the case that so–called noxious weeds will colonise eroded landscapes, beginning a slow march towards stabilisation; these can be used as mulches.

Soils can be created or rehabilitated by these basic methods:

- Building a soil (at garden scale);
- Mechanical conditioning; and
- Life form management (plants and macro– or micro–fauna).

BUILDING A SOIL

Gardeners normally build soil by a combination of

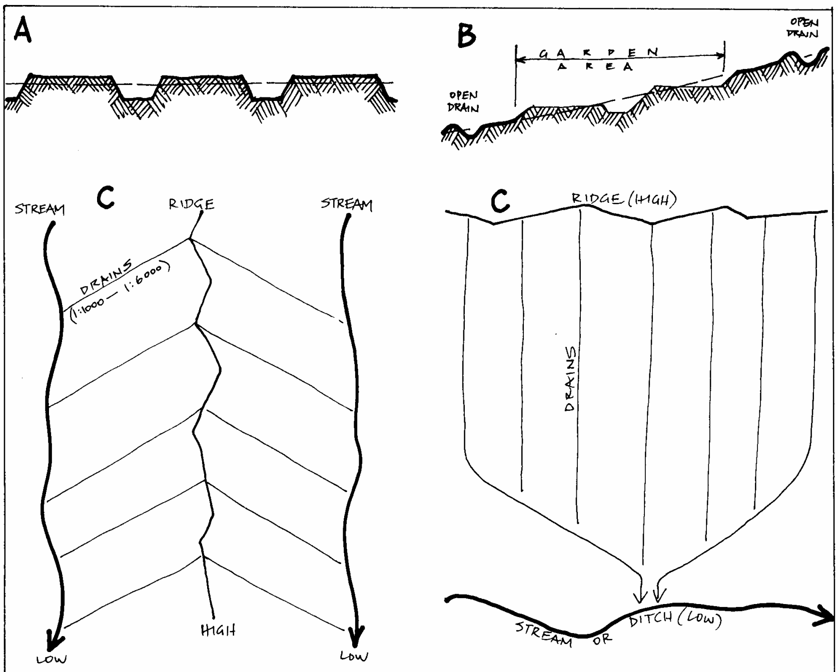


FIGURE 8.10
DRAINAGE OF WET SOILS
A Raised garden beds
B Deep open drains
C Underground pipes or ditches at about 1:200 slope will drain fields.

three processes:

1 Raise or lower beds (shape the earth) to facilitate watering or drainage, and sometimes carefully level the bed surface;

2 Mix compost or humus materials in the soil, and also supply clay, sand, or nutrients to bring it to balance; and

3 Mulch to reduce water loss and sun effect, or erosion.

Gardeners can, by these methods, create soils anywhere. Accessory systems involve growing such compost materials as hedgerow, herbs, or soft–leaf plots, or as plantation within or around the garden, and by using a combination of trellis, shadecloth (or palm fronds), glass–house, and trickle irrigation to assist specific crops, and to regulate wind, light, or heat effect.

By observing plant health, gardeners can then adjust the system for healthy food production. Many gardeners keep small livestock, or buy manures, for this reason.

Large–scale systems (small farms) cannot be treated in the above way unless they are producing high–value product. Normally, farmers create soils by broadscale drainage or by soil "conditioning". As most degraded soils are compacted, eroded, or waterlogged, they need primary aeration (by one of the many available modern machines, or by biological agents), then careful plant and livestock management to keep the soil open and provided with humus.

Daikon radish, tree or shrub legumes, earthworms, root associates for plants (rhizobia) all aerate, supply soil nutrient, or build soil by leaf fall and root action. The management of livestock for least compaction and over–grazing is part of the skill of soil building and preservation. Many organic farmers introduce worm species to pastures as part of their operation, and sow deep–rooted chicory, radish, or comfrey for green manures.

27 . Key – To Mineral Deficiencies (- Attention please , be carefull !!)

TABLE 8.7
KEY TO MINERAL DEFICIENCIES

How to use: Read the first set of choices (A), make one, and follow on to the letter group in the righthand column. Then make a second choice (or find the answer). Some remedies follow, and are given under the numbers in brackets { }.

First Choices: **Go to**

A. • Leaves, stems, or leaf stalks are affected ....**B**
• Flowers or fruits are affected ....**M**
• Underground storage organs (roots, bulbs, tubers, etc.) are affected ....**N**
• Whole field or row shows patchy or variable yields ....**O**

B. • **Youngest** leaves show most effect, or early effects ....**C**
• **Oldest** leaves or later whole plant affected ....**I**

C. • Pale yellowish or white patches on the leaves ....**D**
• Pale patches not the worst symptom, but death of tips or growing points, or storage organs affected ....**H**

D. • Leaves uniformly colour–affected (yellowish or pale), even the veins, poor and spindly plants (especially in heavily cropped or poor leached sandy areas, acid **or** alkaline ....**{1}**
• Leaves not uniformly affected, veins or centres still green .... **E**

E. • Leaves wilted, then light–coloured, then start to die. If onions, crop is undersized. If peas, seed in pods barely formed, matchhead size. Coastal sands. Black sheep in flocks may show a brown tinge to wool and are often used as "testers"....................................**{2}**
• Wilted and dying leaves not the problem......**F**

F. • At first, colour loss is interveinal (between veins), and only later may include veins. Mature leaves little affected, dying not a feature, and common on calcareous or coral atolls, desert soils. Distinct yellowing (See also J) ....**{3}**
• Veins remain green, pale areas not so yellow, often whitish or lack colour. ....**G**

G. • Areas near veins still green, affected leaf areas become transparent, brown, or start to die. Young leaves first affected. Peas and beans germinating in soil show brown roots and central brown area on leaf cotyledons. pH usually >7.0..................................**{4}**
• Leaves smaller than normal, stems shortened, growth retarded. Beans and sweet corn, several tree seedlings most affected. Soils acid, leached sands, alkaline, high in humus, coastal. Leaves may develop a rosette appearance, bunchy tops ....**{5}**

H. • Plants brittle, leaves die or are distorted, growing points die, stems cracked, rough, short between leaves, split lengthwise (cabbages), cracked (celery). Probable on acidic sands, or on heavily–limed high–humus soils..**{6}**
• Plants not brittle, but stunted, tips dying, feeder roots die, and leaf tips and terminal bud margins dying. Cabbage or cauliflower have young cupped or dead margins; old leaves all right. Young infolded leaves brown–edged, rotting (jelly–like decay). Check on over–watering, excess Na, K, Mg in water, or in or dolomite. Tomatoes show blossom end rot. ......**{7}**

I. • Plant with marked yellow (chlorosis)............ **J**
• Yellowing not the main problem; leaves brown–edged or purple ....**L**

J. • Yellowing between veins or on margins of leaf...**K**
• Yellowing affecting whole plant, ranging from light green to yellow; plant gets spindly, older leaves drop off. Prevalent in cold peaty soils, leached sands, soils subject to waterlogging. Turnips show purpling on leaves. Plants flower or mature early....................**{8}**

K. • **Margins** yellow, or blotched areas which later join up. Leaves can be yellowed or reddish, purple, progressing to death of leaf area. Later, younger leaves affected. Affected areas curl or become brittle, brownish. Common on acid sandy or soil with high K or Ca readings. Growth slow, plant stunted. ....**{9}**
• **Interveinal** yellowing, looks at first like N deficiency . Old leaves blotched, veins pale green, leaf margins rolled or curled, progresses to younger leaves. Leaf margins of cabbage, cauliflower can die, leaving central tissue only ("whiptail"); cauliflower will not form curds. Common on acid or leached alkaline soils, e.g. shellsand dunes, corals. Difficulty in establishing clover, legumes...**{10}**

L. • Leaf margins brown, scorched, can cup downwards, dying target **spots** appear in leaves; spots have dark centres, yellow edges; general mottled appearance. Growth reduced, first on young matured and then on older leaves, finally to young leaves. May appear late in plant's growth if a root crop (K is translocated to roots). Leached acidic or organic clay soils. Tomato leaf margin pale. ....**{11}**
• Leaves wilt, droop, die at tips and edges: **Sodium excess.**
• Leaves dull, dark green or red–purple, especially below (under–surface) and at the mid ribs. Veins and stems may also purple, growth is much reduced. Common in very acid, alkaline, dry, cold, or peaty soils ....**{12}**
• Leaves at tips wilt early as soil dries out, then become bronze, then die. Not often seen. Check water supply, salt content of soil: **Chlorine excess.**

M • Fruit rough, cracked, spotted, few flowers. Tomatoes with internal browning, seed chamber open, uneven or blotchy ripening, stem end reddening. On acid soils, leached sands, humus–rich and limed soils. Terminal buds may die and laterals then develop. Top leaves thicken, can roll from tip to base. ....**{6}**
• Fruits rot on blossom end (opposite stalk), or show sunburnt dark areas there. Affects tomato, peppers, watermelons ....**{7}**

N. • Internal dying or water–soaked areas, uneven in shape (in beet, turnip, rutabaga if soil acid, leached, or with free lime. ....**{6}**

• Cavities in root core, then outside collapses as pits; common in carrots, parsnips on acid leached soils. Roots may split open. ....**{7}**

O • Areas of affected crop test acid: soils may be sandy; pH < 5.5: Acid: **Try lime**

• Areas of crop test alkaline: pH > 7.5 : Alkaline: **Try Sulphur.**

• Soil at depth mottled, smells of sulphur: waterlogged: **Arrange drainage.**

• Leaves tattered and dying at crown. Salt winds: **Try shelter.**

• Check for viral disease in grasses: **Try a plant pathologist.**

REMEDIES FROM THE KEY
(FOR GARDENS)

First, keep a fertiliser **diary** for your garden, and leave it for the next person. Tell them what you have done for the soil.

• If you are on leached (washed out) sands, dig up your garden beds, place a plastic sheet liner below, then add a bucket or so of clay and a handful of dolomite per square metre. Also, try a soil gel. Then add compost, and a complete fertiliser like blood and bone. Mulch thickly and replant, then return to the Key if symptoms recur.

• If you are on peats, or have piled on the compost, add some urea or blood and bone, raise your beds, and lime the area.

• If you have lots of lime in the soil, or are on coral sands or dry desert coasts with calcrete, spray weak zinc and copper sulphates **on** plants, iron sulphates in **very** dilute solutions (12 g/10 square metres with lots of water), or add it to a liquid manure. Make pits of compost and grow on the edges of these, use sulphur at about a handful per square metre, or add trace elements and sulphur to compost pits. Or, lay a sheet of plastic on the ground, build up logs around this to 25 cm high, and fill the area with humus (compost plus 50% sand), then mulch heavily. Add blood and bone. On atolls, dig down to near water table and then mulch thickly (make a big growpit 3–4 m wide by 10–12 m long by 3 m deep). Use **any** mulch, especially *Casuarina*, palm, house wastes.

{1} Sulphur. Add plain sulphur (not of medical quality) at one handful per square metre. If you are near a city, you could have enough from fallout!

{2} Copper. Add as fine–crushed ore, or in water as copper sulphate at 7 kg/hectare or spread (1 g/square metre) every 5–7 years.

{3} Iron. Try sulphur first, then if necessary add iron sulphate or spray foliage with very dilute iron solution. Bury old iron in humus pits near trees (e.g. pieces of galvanised iron, old wire or car parts).

{4} Manganese. Try sulphur first, then use very dilute foliar spray of manganese sulphate.

{5} Zinc. Add zinc oxide in acid areas, sulphate in alkaline, also sulphur in alkaline areas. Zinc at 7 kg/hectare or equivalent every 7–10 years.

{6} Boron. Be careful not to add too much; it is poisonous in large quantity. First, lime acid areas and peats, and add sulphur to alkaline areas. If this doesn't work, add borax (sodium borate) at 1 gram/square metre and try cabbages to test reaction. Try not to buy detergents with "borates"; they can poison your soil. **Boron excess** (poisoning) can occur on sea sediments, and are common in reclaimed marine areas (Holland). Raise garden beds, lime, and flush out with fresh water.

{7} Calcium. Use lime as limestone in areas where manganese is plentiful, dolomite if not, or as cement powder in deep red hot tropical soils, then continue to add mulch and use lime only if deficiencies occur. Use gypsum in alkaline salty soils, then flush with fresh tank water and continue to use lime. Bone, bamboo mulch, buckwheat straw are all calcium sources.

{8} Nitrogen. Make sure the soil is well drained to 0.5 m for vegetables, 1–2 m for trees. Check for cobalt levels, deficiency. If legumes are used, make sure they are innoculated, and that manganese levels are not too high. If all this is satisfactory, add dilute urine (20 parts water:1 part urine), ammonium sulphate in alkaline areas, or use legume mulches or interplant (about 48 small *acacia* or tagasaste trees per one fourth acre will do). Use compost, then surface mulch. Build up **worms** and soil life, use dilute bird manure. Don't overdo it, or nitrates will build up in green plants and kill your kids or piglets with bluebaby syndrome. Just relieve the symptoms, then get good soil life going.

Use cobalt for severe nitrogen deficiency, poor clover growth or establishment in peaty or coastal soils. If manganese is high, just add lime to balance this soil (one handful per square metre), or in **alkaline soils** spray on at very low dilutions at 1 g/10 square metres every 10 years or so.

{9} Magnesium. Check if potash is not too high, or add clay to sandy acid soils (plenty of magnesium in most clays). Use **dolomite** for first dressing, then limestone. Epsom salts were used around citrus by old–timers. Or dilute it in water for foliar spray in very severe deficiency situations.

{10} Molybdenum. Get some sodium molybdate, about 10 g, and mix well with 5 kg of sand. Take 1/100 of this (weigh the sand), and put it on per square metre every 10 years.

{11} Potassium. Use ashes on green crop, diluted urine in early growth, then build up mulches, including dried or fresh seaweeds, flue dusts from cement works (fly ash), also "teas" of bird manures, comfrey. Potassium is found in the mineral kainite (20–25% potassium) in evaporite deposits of deserts.

{12} Phosphorus. Bring pH to 6–6.5 or thereabouts, using lime in acid soils and humus in alkaline. Use bone meal, bury bones, or use tested rock phosphate free of cadmium or uranium. **Stop deep digging** and start mulching with least soil disturbance (build up narrow beds). Encourage soil life, add mulch on top, water with comfrey "tea", dilute bird manure on the **leaves** of plants. Keep this up each time symptoms appear; they will eventually disappear if you have clay in the beds (add some if not). If you have high–iron clays, you will need a lot of bone meal to start with, but it will slowly release later on. If desperate, use a few handfuls of superphosphate per square metre, then continue with other sources. Feed a patch of comfrey with bird manure and make a comfrey tea in a drum of cold water. Water the plants with this. All animal manures (including yours) contain some phosphorus. Calcined (roasted) rock phosphate is effective on acid soils in high rainfall.

{13} Chlorine poisoning. Sue your Council, or let tap water stand with a handful of lime in it for a day, then use on the garden. Don't take a shower!

{Developed and modified after a format developed by English, Jean E. and Don N. Maynard, *Hortscience* **13**(1), Feb. '78, and with data from the author and Handreck, Kevin A., 1978, *Food for Plants*, CSIRO Division of Soils.}

MINERAL FERTILISERS OR SOIL AMENDMENTS

The present testing method used on specific soil types is to sow down mixed legume (clover), *Brassica*, and grass crop (or any important crop that may be grown). This sowing is then divided into TRIAL PLOTS which are treated at varying levels, and with soil or foliar spray amendments, to test plant health and response, based on a soil test for pH and mineral availability, or on a leaf analysis such as given in **Table 8.7**.

For the home gardener, or keen observer, a deliberate wander through the system, and a good key to mineral deficiencies may be all that is needed to spot specific problems. Problems are in any case rare in well–drained garden beds using composts and organic moulds, and where one–species cropping is not constantly practised.

On a broader scale, as in prairie or forest re–establishment and erosion control, land reclamation, or plantation, every practical farmer and forester uses TEST STRIPS of light to heavy soil treatments (from soil loosening to fertiliser, micronutrient, and grazing, cutting, or culling trials). When such field trials (as side–by–side strips) are run, it is wise to include typical areas of soil and drainage, and to avoid areas under trees, on the sites of old stockyards or hay-stacks, intense fire scars, watering points, and gateways and roads (all of which have minor but special features and need a separate assessment from the open field situation). I have often noted, for instance, the colonisation of chicory, thistles, and tough and deep–rooted weeds on the inhospitable areas of old roads and trafficked areas; this sort of data is of use for some cases, but does not need to suggest that we compact a whole field in order to grow chicory, rather that chicory is a useful pioneer of compacted soils.

Plant response on the test strips, which can be as little as 1% of the total acreage, may quickly indicate how modest and innovative soil treatment, minute amounts of micronutrients, or the timing of grazing or browsing can be managed to give good effects at least cost. There is no assurance as certain as the actual, assessed plant response. To see two small plots of pines, coconuts, or cabbages side by side, the one healthy, vigorous, and productive, and the other (lacking a key nutrient or on compacted soils) stunted, sickly, and unproductive, is a definite guide to future treatments. The same sort of trials are applied to plant mixtures or polycultures, pest controls, and the benefits or otherwise of mulch for a specific soil or crop.

Assessment can be casual (in clear–cut cases), or analytic and careful where only slight differences appear. Such test strips are best securely marked by stout pegs for long–term visits, as effects of some treatments persist, or become evident, over several seasons.

Not until trials are assessed is it wise to widen the area treated, although in commonsense it may always be wise to add humus or manures to non–peaty soils, or dolomite to acid sands. In alkaline and heavy clay soils, trace elements may become insoluble, and these are best added as foliar sprays to mulch or green crop, or to trees.

8.15
BIOLOGICAL INDICATORS OF SOIL AND SITE CONDITIONS

In any local area, the composition, shape or size, and distribution of the plants give many clues to soil type, depth, and extrinsic factors. Some specific factors indicated are:

SOILS:
1 Depth
2 Water reserves
3 pH
4 Mineral status (see preceeding section)

SITE:
5 Fire frequency
6 Frost
7 Drainage
8 Mineral deposits and rock type
9 Overgrazing and compaction of soil
10 Animal (macrofauna) effects

1 SOIL DEPTH: Shallow soils dry out quickly and hold few nutrients. A very good indication of soil depth is to look at one species of tree (e.g. *Acacia*, *Prosopis*, honey locust) over a range of sites; a "height and spread" estimate will reveal areas of deeper soils where the largest specimens grow. The same species will be dwarfish on shallow soils of the same derivation or rock type.

2. WATER RESERVES. Deep–rooted trees which need water—the large nut trees and candlenuts (*Aleurites*) are good examples which occur naturally only in well–drained but water–conserving sites—often show water–lines not associated with valleys, and stand over springs or aquifer discharge areas.

In sands, a great variety of deep–rooted shrubs and trees indicate where a clay base lies at 1–2 m down. This situation is common on desert borders and hills in drylands. In brief, large tree stems reveal well–

28 . Elephant – and Big – Animal – Protection - Fence

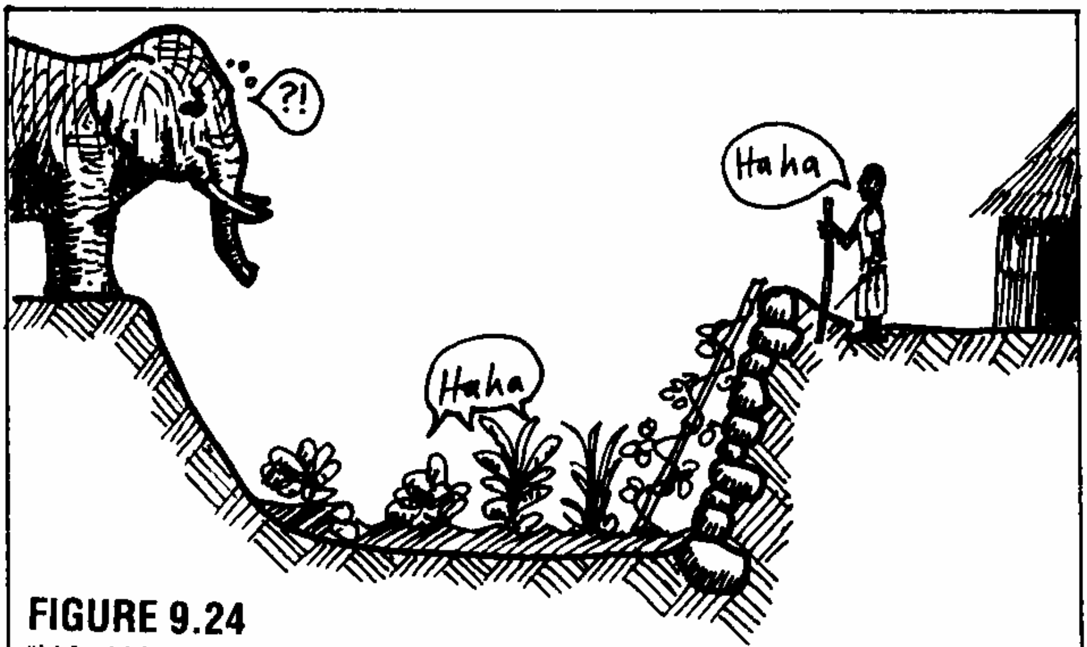
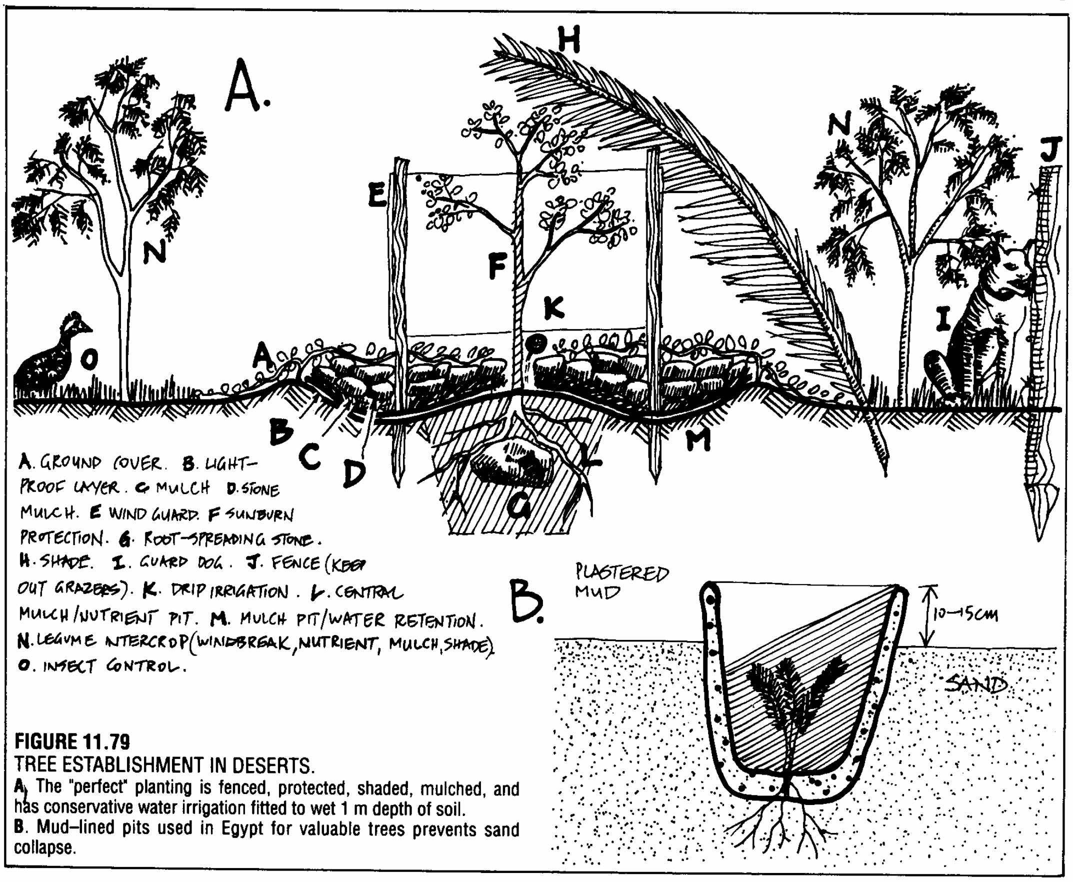


FIGURE 9.24
"HA–HA" FENCE
Much used in areas where post and wire fencing is unavailable or expensive.

29 . Tree – Establishment in Deserts



✓ **FIGURE 11.79**
TREE ESTABLISHMENT IN DESERTS.
A. The "perfect" planting is fenced, protected, shaded, mulched, and has conservative water irrigation fitted to wet 1 m depth of soil.
B. Mud–lined pits used in Egypt for valuable trees prevents sand collapse.

30 . Wet Food – and Weed – Barrier - Method

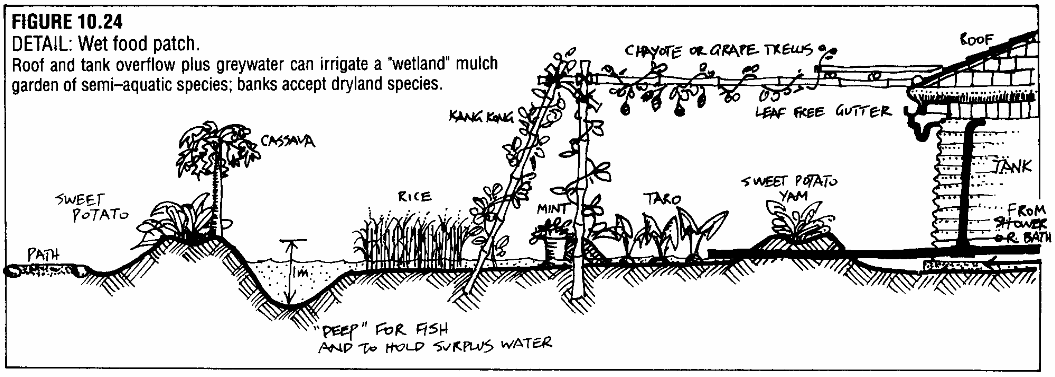


FIGURE 10.24
DETAIL: Wet food patch.
Roof and tank overflow plus greywater can irrigate a "wetland" mulch garden of semi–aquatic species; banks accept dryland species.

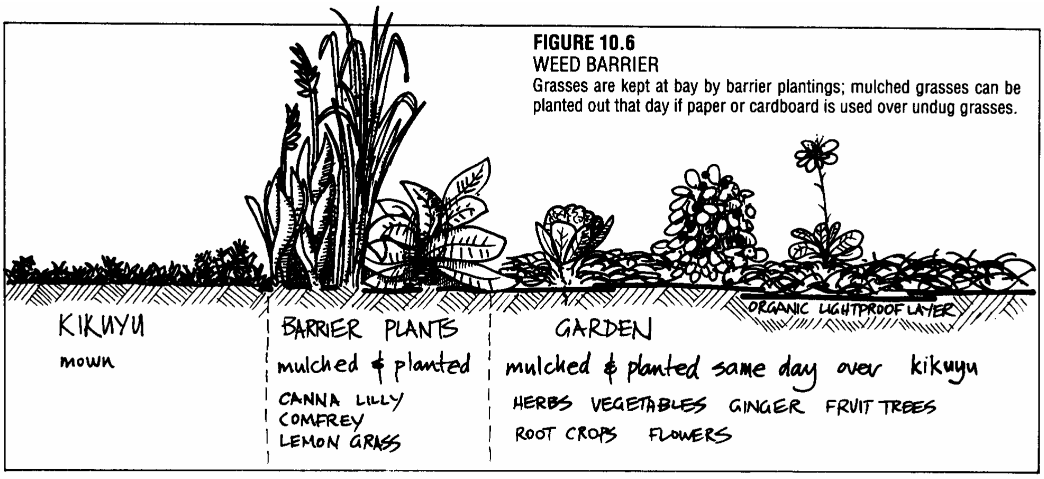


FIGURE 10.6
WEED BARRIER
Grasses are kept at bay by barrier plantings; mulched grasses can be planted out that day if paper or cardboard is used over undug grasses.

31 . Arsenic – poisoned Water

Fern eats up arsenic

The arsenic builds up in the leaves of the plant

Scientists have discovered a fern that thrives on arsenic.They suggest the plant, (Pteris vittata), could be used to clean up land and water that has been contaminated with the toxic element or its compounds.

Dr Lena Ma, of the University of Florida, US, and colleagues found the brake fern growing on a disused wood-preservation site that had been poisoned with arsenic.

When they examined its leaves, they found the concentration of arsenic to be up to 200 times higher than in the surrounding soil.

The brake fern, say the researchers, is hardy, versatile and fast growing. It has "great potential for the remediation of arsenic-contaminated soils", they write in the journal Nature.

Safely burnt

Brake fern is native to Africa, Asia and Australia, and is now widely naturalized in warm parts of the Americas. Unusually for a fern, it actually likes a sunny, open position.

The plants growing in uncontaminated soil were found by Dr Ma's team to have arsenic levels ranging from 11.8 to 64.0 parts per million.

But those growing in contaminated soil at a site in central Florida had arsenic levels of between 1,442 and 7,526 parts per million, most of which was found in the plants' long-fingered green leaves, or fronds.

The fern is able to absorb arsenic and its compounds very quickly, the team discovered. In lab tests, arsenic levels in ferns rose by a factor of 126 in as little as two weeks when they were transplanted into contaminated soil.

Research is now under way to devise a method of safely burning arsenic-enriched ferns that have been grown on contaminated sites. This would provide a source of energy and enable the element to be recovered in the form of a gas.

Water problems

Arsenic has wide industrial applications: it is used to remove iron impurities during glass-making, to manufacture semi-conductor wafers and even in the production of some fireworks.

But if the element or its compounds leak into the environment, their toxicity can cause health problems.

Dr Ma said that brake fern held out promise for helping Bangladesh,where between 35 and 77 million people out of a population of 125 million are at risk of being exposed to arsenic in their drinking water. Many have developed painful skin lesions; some cancers are also linked to the problem

.

It all stems from the creation over the past two decades of tube wells that have been drilled into shallow rock containing naturally-occurring arsenic.

Dr Ma suggests the water in Bangladesh could flow through reservoirs planted with brake fern to filter out the arsenic.

Eine Farnpflanze soll das tödliche Arsen aus verseuchten Böden ziehen. Der natürliche Bodensanierer nehme anorganische Arsenverbindungen aus verseuchtem Erdreich auf und speichere die Gifte in den Blättern, schreiben US-Forscher im britischen Fachblatt "Nature" (Bd. 409, S. 579) vom Donnerstag. Die Arsenkonzentration in den Blättern des Saumfarns ***Pteris vittata*** sei dann 200 Mal so hoch wie im Boden. Lena Ma und Mitarbeiter der University of Florida in Gainesville entdeckten den Farn auf einem verseuchten Areal in Zentral-Florida.

Eine derart große Speicherfähigkeit ist nach Angaben der Wissenschaftler bislang noch bei keiner Pflanze festgestellt worden. Außerdem ist dieser Saumfarn eine ausdauernde und schnellwüchsige Pflanze, die sogar an sonnigen Stellen gedeiht, was für Farne ungewöhnlich ist. All das macht ihn zu einem idealen Sanierer von arsenverseuchten Böden.

www . SOS - arsenic . net

DAS PROJEKT ZUR BESEITIGUNG VON ARSEN

Es sind verschiedene Arsentrennungsverfahren auf dem Markt. All diese Filter oder Trennhilfen haben jedoch eine Reihe von Nachteilen. Sie sind zu teuer, schwer zu handhaben, lassen den Wasserfluss nach kurzer Zeit stocken und ersetzen oft nur das eine Gift durch ein anderes.
Forscher in Australien haben nun eine sehr einfach Methode entwickelt, Arsen aus verseuchtem Trinkwasser oder aus Minenresten zu entfernen: Bakterien, Eisen, Sonnenlicht und Luft.(Young, 1996).

Faridpur - die fast 100 Jahre alte Anlage senkt den Arsengehalt in Trinkwasser von 220 µg/l auf 42µg/l.

Zwischen 1998 und 1999 wurde in Bangladesh die in Australien entwickelte Methode in verschiedenen Experimenten angewandt. Lediglich Sonnenlicht, Luft, wo nötig Eisen, Tontöpfe und Sandfilter wurden eingesetzt. Die Resultate zeigten Werte, die erstaunlich niedriger lagen, als der Standard vorgab. Die durch UV ausgefällten Arsenrückstände wurden mit Kuhdung vermischt und in Erdlöchern durch Mikroorganismen in ungefährliches, gasförmiges Arsine umgewandelt.

Diese Sonnenlicht/Luft/Ton-Methode kostest fast nichts.
Sie kann überall in Bangladesh durchgeführt werden, ohne dass ausländische Technologie eingesetzt werden müsste.
Aber eine billige Lösung, die vor allem darin besteht, zu den Leuten zu gehen, und ihnen sie die einfache Methode zu lehren, - bringt kein Geld. Und scheint daher ungeeignet, NGO's und Regierungsorganisationen zum Handeln zu bewegen.

Es ist das erste Ziel dieses Projekts, diese kostengünstige, so effiziente wie angemessene Methode der Wasserreinigung zu propagieren. D.h. konkret:

- **die Bildung von Dorfkomittees, die die Wasserreinigung beaufsichtigen und in Gesundheits- und Umweltfragen beraten können.**
- **traditionelles Wissen wieder zu erwerben oder zu stärken und traditionelles Handwerk wie etwa Töpferei oder die Herstellung von Jutetaschen zu fördern**
- **den Gebrauch von Plastik stoppen und den Gebrauch von traditionellen biologischen Pestiziden wie "Neem" (Azadirachita indica) u.ä. fördern**
- **die Wassereinigung von 1000 Brunnen (für den Anfang)**
- **die Einführung von preiswerten Sandfiltern, bei Gebrauch von vor Ort gegebener Tonerde und von Sand (gegebenenfalls auch Kohle, sofern das Wasser mit Pestiziden verseucht ist).**
- **die Herstellung, die Reinigung und der Unterhalt von Sandfiltern**
- **die verstürkte Herstellung von Tontöpfen als optimalen Wasserbehältern**
- **die Verbringung von ausgefälltem Arsen in mit Kuhdung gefüllten Erdlöchern**
- **wenn ein Brunnen keine oder eine nur niedrige Arsenkonzentration aufweist, dazu aufzufordern, andere Brunnen in seine Nähe zu verlegen**
- **die Konstruktion von Wassertanks, die Sonnenlicht einlassen und das Wasser durch Sandfilter passieren - für 500-800 Schulkinder**
- **kulturelle und soziale Meetings vor Ort, die der Vermittlung von Wissen dienen.<**

Die Bevölkerung des Subkontinents kannte seit Tausenden von Jahren die desinfizierende Kraft des Sonnenlichts und den Einsatz von Kohlefiltern zur Reinigung von Wasser. Wenn die Dorfbewohner unter den gegebenen Umständen ihre aussterbende Fähigkeit wiedererlangen, kleine Wasserreinigungseinheiten herzustellen und zu unterhalten, gibt es eine Hoffnung auf die Rettung der dortigen Bevölkerung.
Syed Marghub Morshed, Staatssekretär im Ministerium für Umwelt und Wälder schrieb am 11.06. 2000:

Dieses Projekt unterscheidet sich von allen anderen Projekten zur Bekämpfung von Arsen. Denn die Dorfbewohner werden Tontöpfe, Sandfilter und dergleichen herstellen, und anschliessend an andere Dorfbewohner verteilen. Diese einfache und schnelle Beseitigung von Arsen kann in ganz Bangladesh angewandt werden. Zudem ist dieses Projekt das einzige, das Arsenschlamm bei sehr niedrigen, aber gleichwohl effektiven Kosten mikrobakteriell entsorgt.

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