



PERMACULTURE DESIGN CERTIFICATE COURSE

COURSE OUTLINE

Section 1: Introduction

Permaculture Ethics:

“Care of the Earth” — includes all living and non-living things, such as animals, plants, land, water, and air.

“Care of People” — promotes self-reliance and community responsibility.

“Give Away Surplus” — pass on anything surplus to our needs (labor, money, information) for the above aims.

Implicit in the above is the “Life Ethic”: all living organisms are not only means but ends. In addition to their instrumental value to humans and other living organisms, they have an **intrinsic** worth.

Permaculture is an ethical system, stressing positivism and cooperation.

Section 2: Principles of Natural Systems and Design

Guiding principles of permaculture design:

- Everything is connected to everything else
- Every function is supported by many elements
- Every element should serve many functions

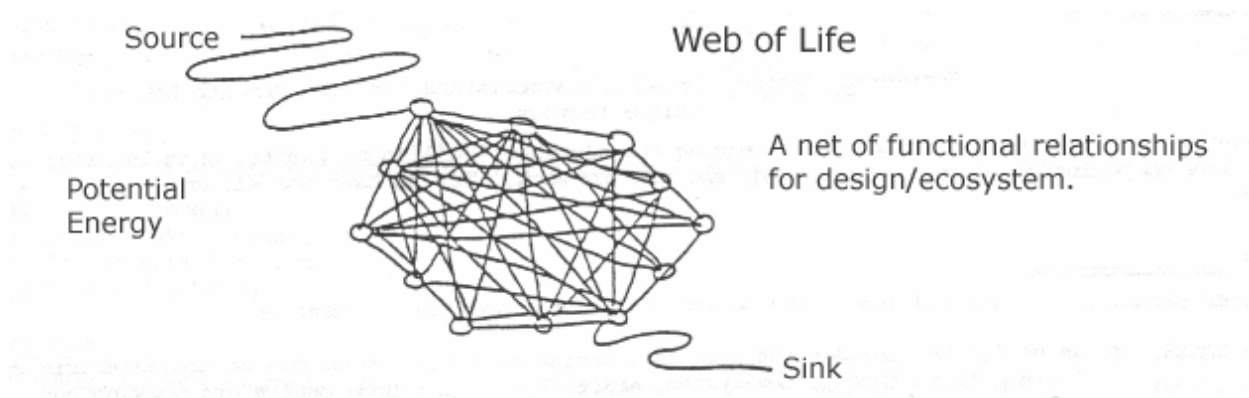
What is design? It is composed of two elements: aesthetics and function. Permaculture design concentrates on **function**.

Functional design is:

1. Sustainable — it provides for its own needs
2. Provides good product yield, or even surplus yield. This happens when elements have no product unused by other elements, and they have their own needs supplied by other elements in the system.

If these criteria are not met, then **pollution** and **work** result. Pollution is a product not used by something else; it is an over-abundance of a resource. Work results when there is a deficiency of resources and when an element in the system does not aid another element. Any system will become chaotic if it receives more resources than it can **productively** use (e.g. too much fertilizer can result in pollution).

A resource is any energy storage which assists yield. The work of the permaculture designer is to maximize useful energy storages in any system on which they are working, be it house, urban property, rural



lands, or gardens. A successful design contains enough useful storages to serve the needs of people. Diversity is related to stability. It is not, however, the number of diverse elements you can pack into a system, but rather the **useful connections** you can make between these elements.

From source to sink:

- Diversity increases
- Energy stores increase
- Organizational complexity increases

Chaos or Disorder Principle: If resources are added beyond the capacity of the system to productively use them, then that system becomes disordered (goes into chaos).

Chaos or disorder is the opposite of harmony, as competition is the opposite of cooperation. In disorder much useful energy is canceled out by the use of opposing energy, thus creating entropy or bound energy.

Society, gardens, whole systems and human lives are wasted in disorder and opposition. The aim of the designer is therefore two-fold:

- To use only that amount of energy that can be productively absorbed by the system.
- To build harmony, as cooperation, into the functional organization of the system.

Methodologies of Design

Permaculture design emphasizes **patterning** of landscape, function, and species assemblies. It asks the question, “**Where** does this (element) go? How is it placed for maximum benefit in the system?”

Permaculture is made up of techniques and strategies:

- Techniques: concerned with **how** to do things (one dimensional) e.g. organic gardening
- Strategies: concerned with **how** and **when** (two dimensional) e.g. Fukuoka system
- Design: concerned with **patterning** (multi-dimensional) e.g. permaculture

Approaches to Design:

1. Maps (“Where is everything?”)
2. Analysis of elements (“How do these things connect?”)
3. Sector planning (“Where do we put things?”)
4. Observational
5. Experiential

1) Maps (be careful- the “map” is not the territory) **Must make observations.**

Sequence of maps valuable to see clearly where to place many elements. Clear overlays to plan: Access, Water, Buildings, Topology.

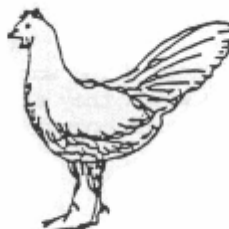
2) Analysis of Elements

An analytical approach: list the needs, products, and the intrinsic characteristics of each element. This is done on paper. Lists are made to try to supply (by some other element in the system) the needs of any

Example: Analysis of the Chicken

Needs:

food water
shelter protection
dust grit
air control
other chickens



Products:

manure eggs
heat gas
meat feathers

Intrinsic factors: breed characteristics (color, range habits) and unique factors

particular element.

Experiment on paper with connecting and combining the elements (buildings, plants, animals, etc) to achieve no pollution (excess of product) and minimum work. Try to have one element fulfill the needs of another element.

3) Sector Planning

Sector planning includes (a) zones, (b) sector, (c) slope, and (d) orientation

- (a) Zones: It is useful to consider the site as a series of zones (which can be concentric rings) that form a single pathway through the system that moves outward from the home center. The placement of elements in each zone depends on importance, priorities, and number of visits needed for each element. E.g. a chicken house is visited every day, so it needs to be close (but not necessarily next to the house). A herb garden would be close to the kitchen.

Zone I:

- Home center
- Herbs, vegetable garden
- Most structures
- Very intensive
- Starts with "back steps"

Zone II:

- Intensively cultivated
- Heavily mulched orchard
- Well maintained
- Mainly grafted and selected species
- Dense Planting
- Use stacking; storeys
- Some animals: chickens, ducks, pigeon, quail
- Multi-purpose walks: collect eggs, milk, distribute greens and scraps

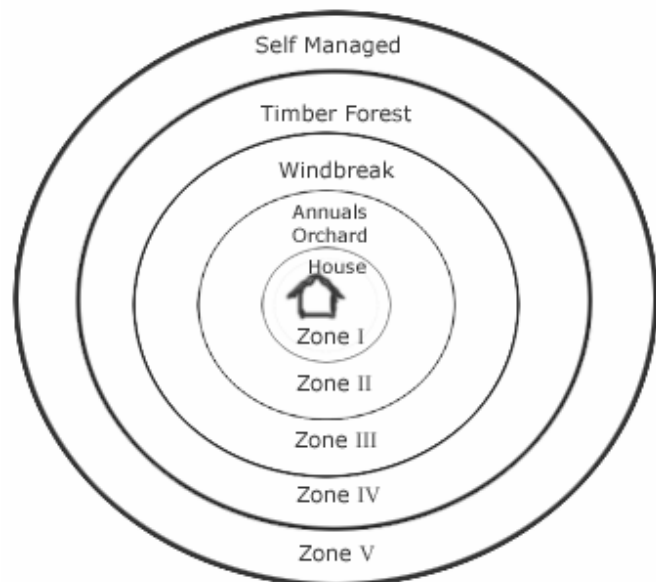
Zone III:

Connect to Zone I and II for easy access.

- May add goats, geese, sheep, bees
- Plant hardy trees and bush species
- Ungrafted for later selection, later grafting
- Animal forage
- Self-forage system: poultry forest, etc
- Windbreaks, firebreaks
- Spot mulching, rough mulching
- Trees protected with cages, strip-fencing
- Nut tree forests

Zone IV:

- Long term development
- Timber for building
- Timber for firewood
- Watering minimal
- Feeding minimal
- Some introduced animals: cattle, deer, pigs

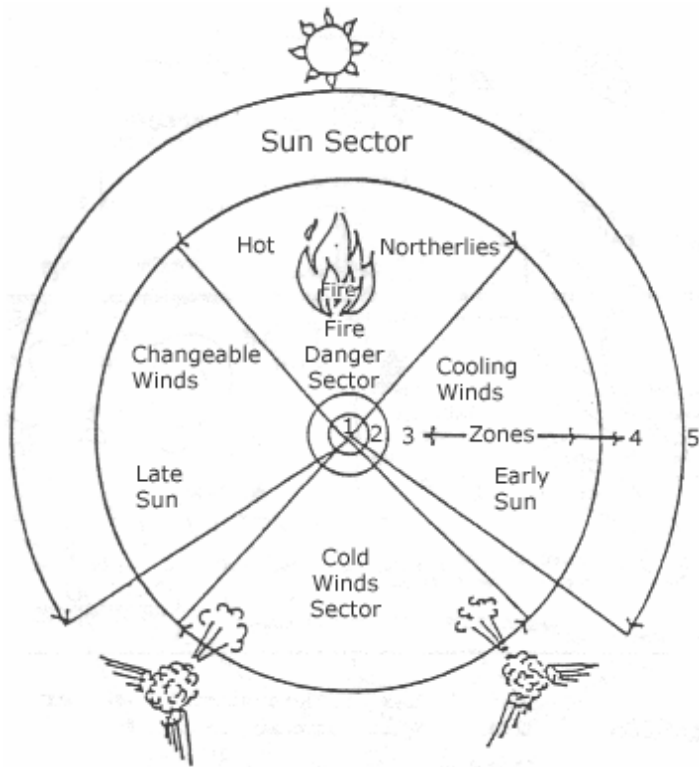


Zone V:

- Uncultivated bush
- Re-growth

Species, elements, and strategies change in each zone.

- (a) Sectors: the aim of sector planning is to channel external energies (wind, sun, fire) into or away from the system. The zone and sector factors together regulate the placement of particular plant species and structures.
- (b) Slope: placement of an element on slope so that gravity is used to maximum capacity.
- Water storages
 - Mulch and other materials (kick-down)
 - Cold air fall; warm air rise
- (c) Orientation: placement of an element so that it faces sun-side or shade-side depending on its function and needs.



4) Observational

Free thinking or thematic thinking (e.g. on blackberry or bracken)

- (a) Note phenomenon
(b) Infer (make guesses)
(c) Investigate (research)
(d) Devise a strategy

5) Experiential

Become conscious of yourself, feelings, environment. Can be free-conscious or thematically-conscious. Zazen- walking without thinking, unreflective.

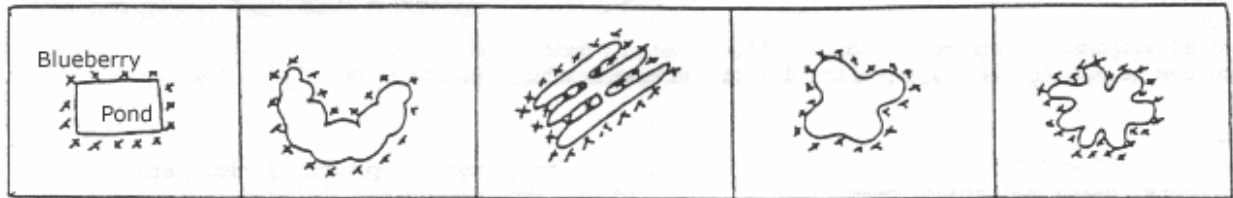
Putting It Together: Use all the methodologies of design.
Select elements - pattern assembly
(line cutoff)

Section 3: Pattern In Design

The world is a sequence of events within a pattern. All things spiral through the pattern. In pattern application, there are two aspects: 1) the perception of the patterns that already exist (and how these function), and 2) the imposition of pattern on sites in order to achieve specific needs.

Zone and sector planning are examples of pattern application.

A) Edge effects and harmonics



Edge effect: the interface between two ecosystems represents a third, more complex system which combines both. The interface, or edge, receives more light and nutrients and so is more productive.

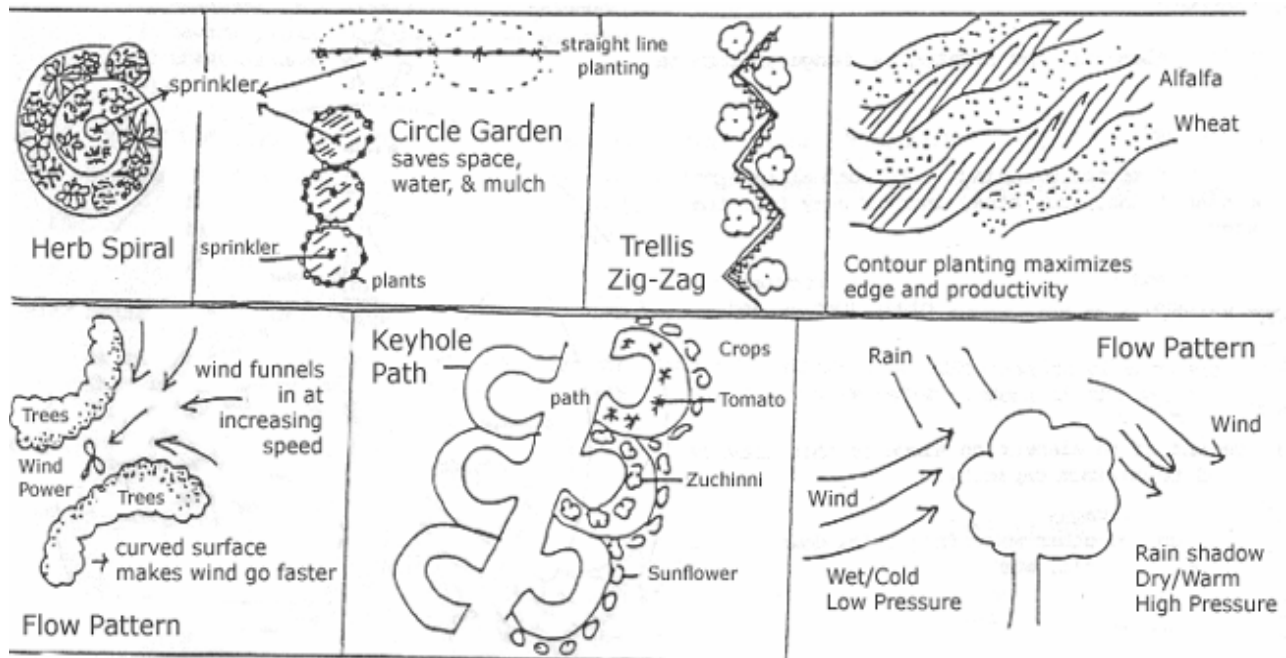
Harmonics and area: increase in linear effects while the area is constrained.

Low productivity (square, circle pond)

Productivity increase as the shape of the pond is changed to produce more "margin" or edge. The number of plants around the edge may almost double, and so may the number of fish since they are mainly marginal feeders.

Other examples of patterning with edge include:

- Circle garden rather than linear garden (saves space and water)
- Trellis on zig-zag pattern rather than straight line

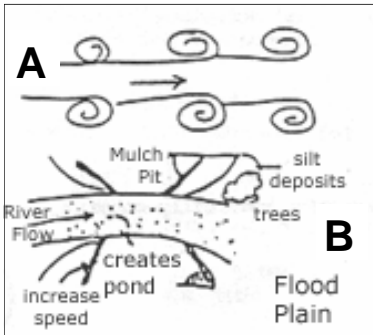


- Crops planted in strips and contours with companionable crop in between strips (crops receive more light for photosynthesis and yield is high for both)
- Windbreak can be planted either to deflect wind or to funnel it into a gap for wind power.
- Gardens can make use of "keyhole" pattern to maximize space and yield.

Species edge possibilities are determined by whether plants/animals are compatible. E.g. wheat planted with Lucerne (alfalfa) will increase yield, while yields decrease if planted with Brassica.

B) Flow Patterns

Can use pattern in river flow to scour deep ponds, to accumulate mulch on edges, and to build up a layer of silt. (A)



Mulch and silt accumulates during the flood phase of the river, but trees must be planted to catch this accumulation. (B)

Aboriginal tribal song pattern shows a map of desert with wadis and salt-bushes. Pattern and song are used together to find one's way in a desert landscape. (C)

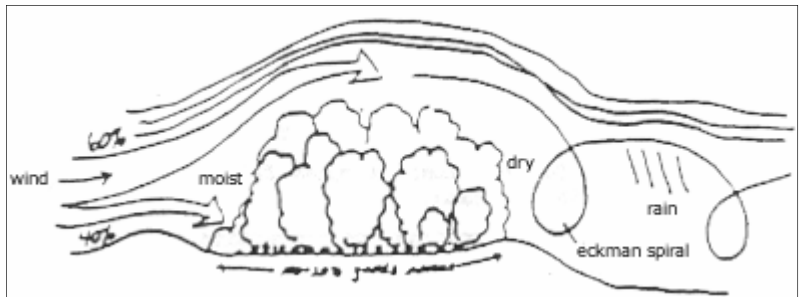


Section 4: Forests and Trees

Trees as Energy Transducers: Wind, Sun, and Rainfall

Wind

1. 40% of incoming wind is forced through the trees, friction causes heat inside the forest (no frost). Outside trees have thicker trunks due to wind force; inner trunks are thinner.
2. Wind brings in dust and insects: at edge of forest there is fallout of these, so forest at wind edge receives more "fertilizer". Rain run-off also more plentiful at windward edge (high pressure of wind keeps the moisture in).
3. 60% of wind is forced up over the trees, forms and falls as Ekman spirals. Rain is caused by spirals if there is any moisture in the air. Trees can cause the moisture to drop because of the upward, forced spiraling of the wind. The spirals change direction depending on the hemisphere (to the left in Southern hemisphere).



Light

1. Light is absorbed, transmitted through, or reflected by the tree, depending on trunk color, leaf shape and color, and canopy (and also depending on climate).
2. Light absorption is mainly on crown for photosynthesis. A high light absorption tree is a radiator and is mainly found in low heat conditions (temperate climates).
3. Light reflection is also on the crown (in dense plantings) or all over the tree in the form of silver leaves. A reflecting tree is a light "producer" and is usually in low light conditions. In trees where bark is white, heat is reflected away from the trunk.
4. Transmitted light is red light, stimulates root growth.

Rain

1. Impact on crown causes some immediate evaporation (but in a dense planting, there is no impact on the ground, and so prevents erosion under the trees).
2. Each leaf is wetted. No water falls through the crown until all leaves are wet- tree intercepts rain.

3. Throughfall: water begins to drip off the leaves towards the branches and trunk. Water now contains nutrients (dust, insects, plant's nutrients).
4. Canopy drip feeds the surface roots. Trunk drip feeds deeper ladder or tap root systems. Function of tap roots is mainly mining. Minerals brought up to leaves and then washed off during rain to be used by the surface feeding roots.
5. Litter under tree impedes water absorption (3 inches of litter holds 1 inch of water). Roots are then able to absorb what they need before water infiltrates the ground.
6. Infiltration: water coats all the soil crumbs (the tree roots can also soak the water up from the soil crumbs).
7. When ground reaches field capacity or saturation, water then slowly percolates to groundwater area.

Transpiration occurs when the process reverses from deep groundwaters, goes back up through the trees, and are released into the air as clouds. 60% of clouds inland (after the first rainfall of 100% moisture from the sea) are formed by trees.

The dust that rises off the trees is made from bits of leaves and pollen, two sorts of bacteria that live on the leaves, and certain oils and waxes that exude off the leaves. At the center of every raindrop inland (nucleus) is a dust particle off trees.

More water that comes to earth is **condensation** rather than rain. One tree can be as much as 20-40 acres of leaf area. Moisture is condensed at night because it is relatively cooler than the air or wind.

Trees put out negative ions (which attract positive ions, usually dust and pollution) so air around trees is healthy. Need a lot of trees in cities to counteract the positive ions in the air which cause depression.

In forests ground water run-off is zero (100% vegetative cover). At 80% vegetative cover = 5% run-off; at 60% cover = 35% run-off; at 20% cover = 60% run-off. Severe soil loss occurs as vegetative cover is removed.

Types of Forest: fuel, food, forage, natural, structural, conservation, shelter/animal barrier.

1. Fuel: Essentials are that least use should be made of solid fuels; barks and leaves should be returned to the soil or the system will degrade.
 - Liquid fuels: species yielding sugars for conversion to alcohol (toddy palm, carobs, fruit trees), or directly to fuel (copaiba). These are permanent trees.
 - Solid fuels: either as cones from nut pines, fallen wood, thinnings, or short term forest for soil creation (acacia, laucana).
 - Gas fuels: coppicing for conversion of biomass via composting for methane collection.
2. Food: Orchards- usually intercrop (fruits, nuts). Use of food trees to support vine crop.
3. Forage: Design forage trees into zones II, III, & IV for small livestock, sheep, cattle. Livestock will eat leaves, fruits, nuts off many trees (some need to be fenced off or allowed to grow large before livestock are put in). Trees include those that drop fruit (mulberry, coprosma, boxthorn, fig, etc.); nuts (oak, chestnut, etc.); pods (acacia, carob, honey locust); and green leaves (pampas grass, banna grass, tagasaste)
4. Shelterbelt and animal barrier
 - Windbreak around house and farm site
 - Select species that provide forage, shelter, and act as a barrier hedge (e.g. pampas grass, coprosma)
 - Shelter for animals and as protection for crop (can put 20% of ground into shelter without loss of productivity)
5. Structural: range from bamboo to black walnut, and short to long term cycles. Use for:
 - Round pole (poplar, locust)

- Milled timber (long term and old forests)
 - Industrial (cellulose yields)
 - Craft uses (rattan, bamboo)
6. Natural and Conservation: forests have an intrinsic worth: beauty, nesting sites for birds, creators of oxygen, clean water supply, rain & moisture, soil. Prevent erosion, deflect winds, bring nutrients up from the ground.

Establishment of Forest

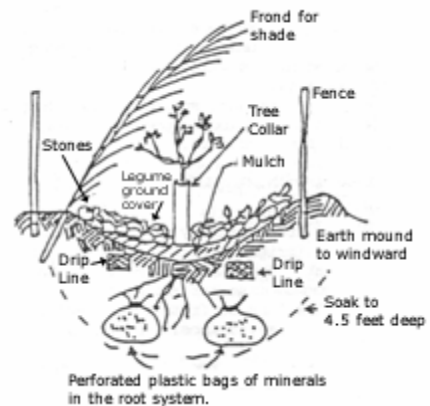
- Select species and use (timber forest, fuel, etc.) and design for placement (crown bearers and flower bearers on outside of clump, stem and forest inside). Shrubs may last only 10 years, pioneers may last only 20.
- Pioneer species can establish essential conditions for forest (nitrogen-fixation, nutrient build-up) on poor soils.
- Important to establish trees in a clump (fed by several drip points if necessary) as these will support one another. Individual plantings tend to get ignored, and are often droughted, wind-pruned, and smothered by grass competition.

Forest Management: thinning, fire, coppice, standards, selection, nutrients

Section 5: Establishment of Vegetation and Trees

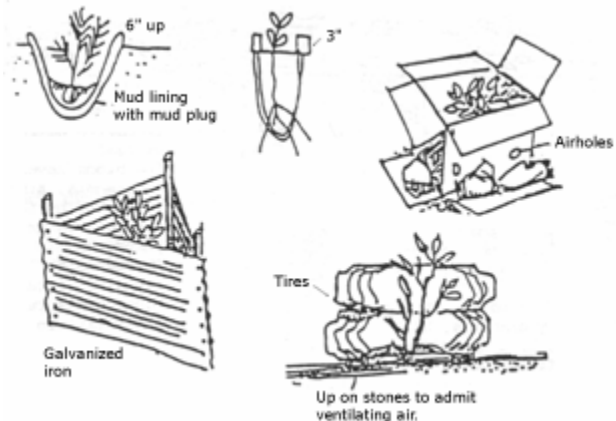
Orchard Systems

- Food trees mixed in with non-food trees to confuse pests and encourage pest predators
- Nitrogen-fixing trees should also be included, e.g. leucaena, acacia
- Combine poultry and ground cover planting for manure resources
- Mulch species



Tree Planting Tips

- Site: find nuclei to start from which will end up being covered by vegetation
- Pest control around nucleus. 1) thorn fences (spiny jujube), living fence (boma) and 2) paint blood & bone or sheep grease & kerosene on stems
- Shelter: 1) plant near rock or tussock, dune to protect from wind & sun and 2) use a guard-rail to collect dust, manure, & fine vegetation
- Plant in old stockyards to start a nucleus of trees, a source of nutrients
- Sudanese technique; Lanzarote technique: dig hole in sand & line with mud. Mud holds water and provides moist microclimate, wind protection
- Polystyrene tubes (developed in W. Australia) 75mm lip protects from rabbits (don't like to bite through plastic). Will nip off tops, but plant lives.
- Net and pan system on a slope gives trees water & prevents erosion and run-off
- Plastic sheet underground. Catches the water or prevents it draining away.



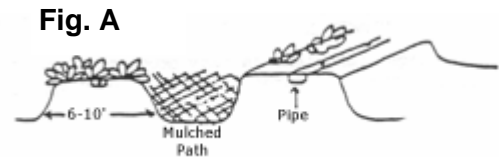
Laying Down the Garden

Approach #1: The Instant Garden

- a) Sprinkle some manure, nutrients on the ground (or grass) to encourage worms to come up. Water fully.
- b) Lay down thick wet newspaper, cardboard, carpet underfelt, or carpet (not with plastic backing).
- c) Cover with thick layer of mulch (straw, old compost, any seedless mulch). Water fully.
- d) For transplanting potted plants, uncover mulch, cut through cardboard, and fill area with a couple of handfuls of soil. Transplant and water fully.
- e) For large seeds (broad beans, sunflowers, peas, etc.) simply plant under the mulch and water every day.
- f) Small seeds: prepare area of soil, plant, water and lay board over the area. Remove board and water daily.
- g) Potatoes: simply plant under the mulch.

Approach #2 (see figure A): Rows, Pipes, and Mulch (for large area market garden)

- a) Make level beds
- b) Lay $\frac{3}{4}$ " pipe down the bed and drill holes every 4 feet. Wrap stocking around hole
- c) Mulch entire area, even the footpaths.



Zone I: Intensive Animals

- Pigeons
- Guinea pigs
- Bees
- Quail (can be in glasshouse to control insects)
- Rabbits
- Worms

Zone II: Orchards and Small Livestock

Orchard System:

- Food trees mixed in with non-food trees to confuse pests and encourage pest predators
- Nitrogen-fixing trees should also be included. (leucaena, acacia)
- Combined poultry/ground cover planting for manure resources
- Ground mulch plant species
- Barrier plants around trees to compete with grasses
- Fire and wind protection needed (select appropriate species).

Small livestock for Zone II:

- Bees
- Poultry
- Ducks
- Geese
- Pigs

Bees

- Careful placement to avoid stings, windblast
- Mid-season honey (Buddleia, brambles)
- Pollen and early honey (willow, rosemary, Echium)
- Late flows (leatherwood, forest trees)

Poultry

- Placement of poultry house and range for best advantage (manures, scratching for insects)
- Seed species
- Pod and acorn species (Lucerne, coprosma, lycium, oak, locust, carob)
- Cover from predators (thorn and shelter)
- Choice of breed for situation (light breeds, heavy breeds, color, behavior differences)
- Greens (comfrey, oxalis, chicory, cleavers)
- Vines (passionfruit)
- Fruits (all fruits)
- "Medicines" (oxalis, cleavers, dandelion)
- Grit/sand/shell
- Water
- Chicken "tractor" in fallow gardens or fields to remove pests, scratch out seeds, deposit manure, help in fire control (making bare ground)

Pigs

- Forage: jerusalem artichoke, comfrey, Lucerne
- Kitchen and market scraps
- Oak: acorns

Zone III: Extensive Free Range, Wildlife, Broadscale Systems

Broadscale and Forage Systems

- Fukuoka "no tillage" system of sequential rotation and sustainable soil building
- Use of leguminous trees (acacia, leucaena) as pioneer species to improve soils for later orchard plantings
- Self-forage for sheep, cattle
- Windbreak systems
- Water systems development (large impoundments)
- Fences and gates

Feeding Cycle of Beef

- Annual grasses, carbohydrates(winter), perennial grasses, winter twigs and bark, sugar pods (summer)
- Browsing animals like coprosma, tagasaste, pampas grass, banna grass (Pennisetum purpureum), leucaena, comfrey, willows, poplars, honey locust, and carob pods
- On intensive tree forage systems, stocking rate can be up to 14 animals per acre, rather than 1 per 20 acres. Watch out for compaction, especially on low country in winter.
- Goats and peacocks are a "no-no" on farms. If must have goats use Rosa rugosa, roses, blackberries, tagasaste, and boxthorn.
- Important book: "Fertility Pastures and Cover Crops" by Newman Turner available from Bargyla and Gylver Rateaver, Pauma Valley, California 92061. Discusses herbal pastures, particularly for dairy cows. Also "Herbal Handbook for Farm and Stable" by J. de Barclay-Levy, published by Faber & Faber, London.

Rangeland Management: Well managed rangeland is very productive, contains wildlife, fodder trees, windbreaks and shelterbelts, herbal pastures, rotated pastures, and is fenced appropriately. Must not be overstocked.

Urban Permaculture (more Urban Strategies in section on "Settlement Design")

- Take over the lawns in urban back and front yards for fruit trees and vegetable production
- Use dwarf varieties of fruit trees, or espalier prune against fences

- Put glasshouses onto sun side of house for vegetables. Quail can also be kept there.
- Small animals can be kept if local ordinances allow it (poultry, quail, guinea pigs, bees, rabbits)
- Reduce lead levels by screen planting of non-edibles near roads
- Plant in small areas: window boxes, porches, near door outside, on roof if flat.
- Organize with like-minded people to plant in a local community garden

Themes

Rampancy (species which become troublesome by occupying large areas or occurring in great number)

Plants: Reasons for Rampancy

- Response to damaged or vacant niches in environment
- Often species which are efficient & drought resistant

Specific response:

- To grazing: lantana, Patterson's curse, thistle
- To fire: Erechthites, fireweed, bracken
- To chemical changes in soil: sedges, sour-grasses
- To exhaustion of soil: bracken, moss, pioneer species such as blackberry, thistle

Dealing with rampant species with assisted evolution:

- Use succession plants, e.g. groundse/wattle/gum. Help succession by slashing/fertilizing/ planting of suitable species and spreading seeds
- Interplant fruit trees and cattle grazing (extensive); goat/pig grazing (local); carpet mulch on small areas (garden); e.g. blackberry/bramble.
- Slash and interplant, e.g. lantana, especially shade species (pigeon pea, plantain, mango) and vines (chayote, passionfruit).

Rampant species protect and mulch soils, provide bee forage, and protect subsequent evolutions/ successions.

Functions of Animals in the System

- ??? elements of the forest
- As pollinators, many are specialized for species (bees, wasps, butterflies, moths, flies)
- Are seed distributors (ducks: algae & sedges; cattle: seeds of sugary pods; dogs and foxes: loquat, grape, lychees; jays: oaks)
- Are regulators: 1) of forests ("weeder" species in evolution of forests) and of 2) other animals (predation to regulate population)

Practical Establishment Problems

Losses in establishment often greatest cost to client. Design to minimize.

- Water (critical factor) needs first priority
- Wind shelter may be critical in the case of citrus, avocado, etc.
- Nutrients: e.g. phosphates for young pines; leguminous trees recommended
- Soils: better to rehabilitate and lose a year than to move forward with poor soils
- Species choice, especially in grassland competition, e.g. tagasaste, pines, oaks more successful than cultivated fruits
- Protection needed from browsers (thorn, fence, stone, electric barriers)

Section 6: Garden Strategies

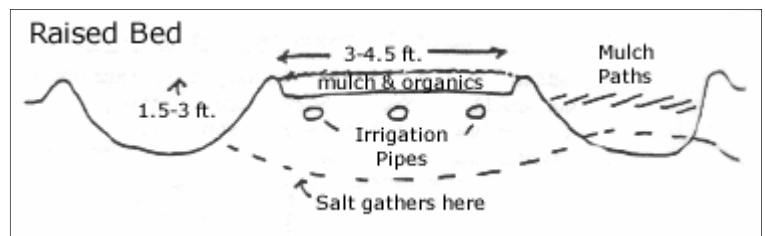
These are some important approaches to food supply:

- A series of small, intensive gardens, vines, and tree crop areas closely associated with water use in settlement, and sometimes irrigated (Domestic food).
- Corridors or dependable local niches for adapted, hardy drought-tolerant yams, cucurbits, vines, palms, and trees along dune bases, sandy river beds, valley floors, and in boulder fields or rock-strew areas (extensive and semi-wild food).
- A series of flood fields in standby to sow quick crops of grains, oil seeds, grain legumes & catch crop for long term storage as a famine or drought buffer (Opportunistic cropping)

Garden Beds

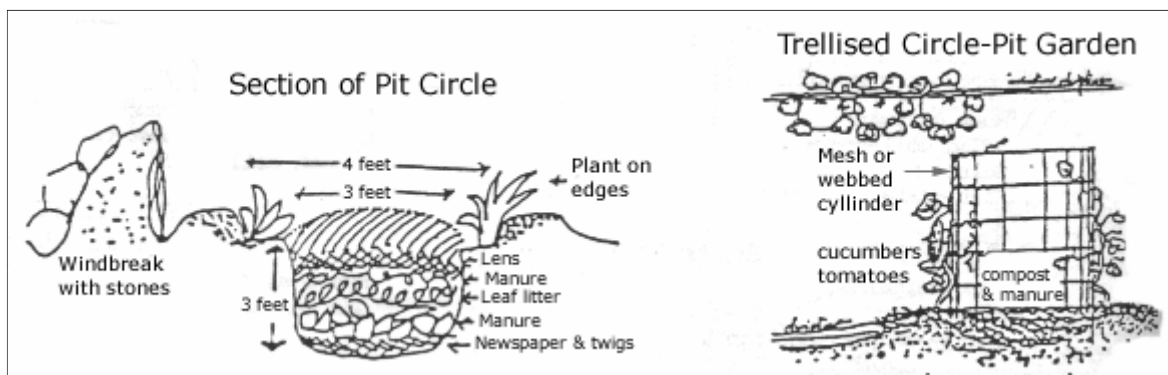
Raised Beds:

- Preferably 0.5 meters above paths or grade
- Fill with sands, organic matter, and add gels (artificial) to hold water
- Mulch surface with "hard" mulch to shade soil; also mulch paths.
- Lay "leaky" pipes 15cm down in beds & time the flow to wet 0.5-1.0 meter depth of soil (to 1.5m for trees)
- Give beds deep watering to flush salt to below root levels.



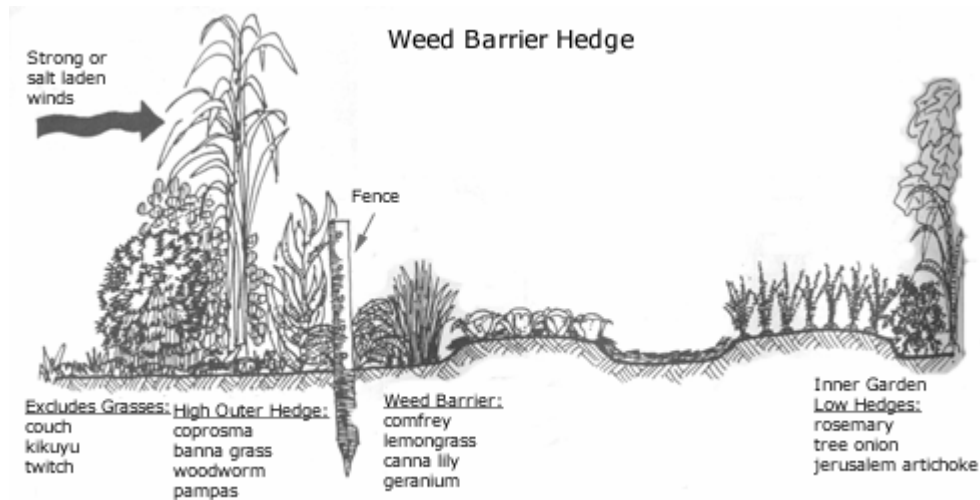
Circle Beds (raised):

- Deep pit filled with organic matter and manure
- Plant on edges of pits.
- Stack stones for low windbreak on windward side
- Drip irrigate under mulch



Garden Plans:

- Plan garden to be very compact; few paths
- Use all domestic waste water in soakage pits to grow trees, bananas, palms
- Light (sun) excess can be reduced by vine shading of up to 70% shadow, and trellis over garden (grape, passionfruit) can run north/south to overshadow garden.
- Thin foliage acacia can be set out in crop for shade
- Shadecloth needed over nursery areas, slatted or frond (palms) cover to seedling beds.
- Maximize fruits, root crops; minimize green leaf crop if nitrate levels are high in the water.
- Add zinc, iron, trace elements to water if these test absent.



Supply of Nutrients: soils lock up many minerals that can best be supplied:

- In aqueous solution, to foliage, or as drip

As seed coatings for broadscale planting

- As broadscale additives in soluble form
- As slow-release “frits” or pellets
- In perforated plastic bags at root level
- From mulches & organic material, composts, & manure

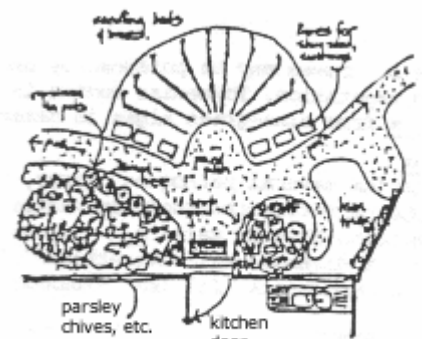
Mulch Sources in Drylands:

- Tumbleweeds & wisps of plants blown by wind which will settle in pits, swales, or be trapped by fences
- Grown mulch in gardens and orchards
- Derived from plants such as casuarina, bamboo, tamarisk, comfrey, and some species of acacia on dunes and hills
- Forage grasses and legumes that have been planted for their mulch value or nitrogenous soil fixation in specific situations
- Some desert vines and hedge species which also provide good mulch from trimmings
- Household and town wastes (a major source of mulch)
- Grazing animals on range (if regularly penned), providing mulch-manure resources.
- Old clothes, mattresses, paper wastes

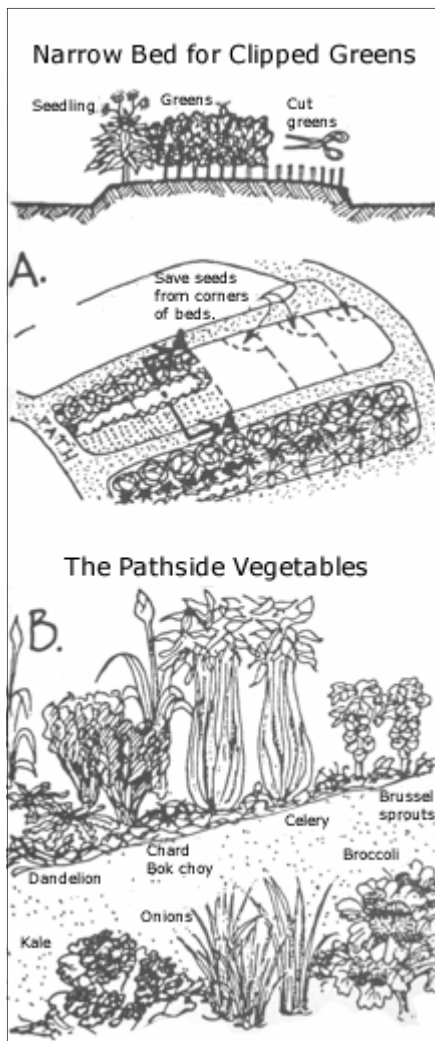
Zone One

Needs very careful design, particularly focusing on **access** and **schedules**. Starting from kitchen steps:

- 1) The Herb Spiral: 1 meter high, contains plants which are constantly used. Herbs- mints, thyme, marjoram, rosemary, sage, basil, etc.
- 2) The Lemon or Lime Tree: must be close to the house as it is often used; can stay ripe on the tree a long time.
- 3) The Clipping Beds: for small salads: chives, parsley, mustard greens, corn salad, garden cress.
- 4) The Pathside Plucking Vegetables: Long bearing vegetables for salads and cooking that can be cut or have leaves pulled for months of yield. E.g.



At the Kitchen Door Plan



Chard, Brussels sprouts, celery, kale, dill, bell pepper, bunching onions, broccoli, spinach, zucchini, rhubarb.

5) Narrow Bed Plants: Must be able to move easily around the bed for easy harvest. Vegetables include asparagus, peas, beans, carrots, eggplant, lettuce, tomatoes.

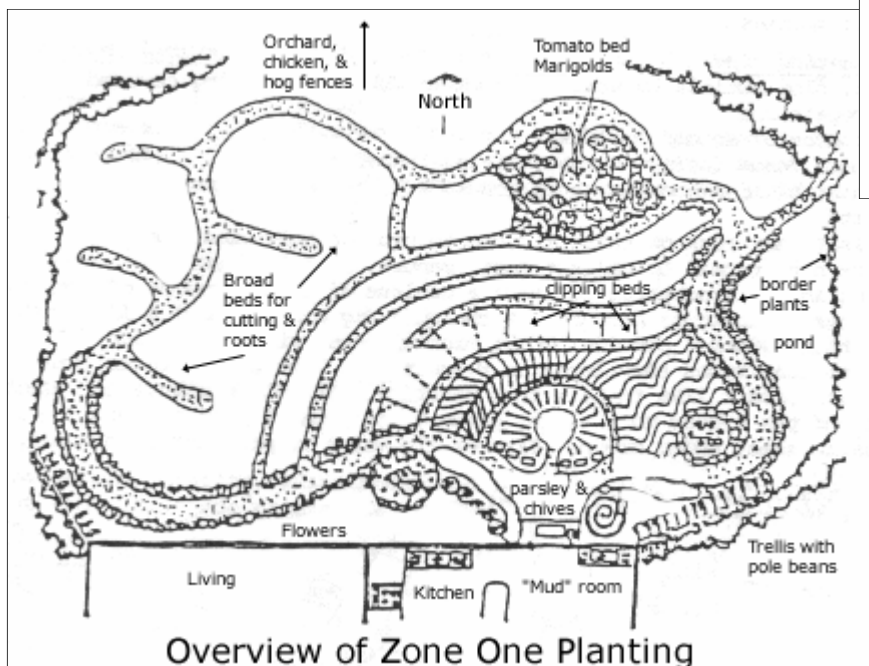
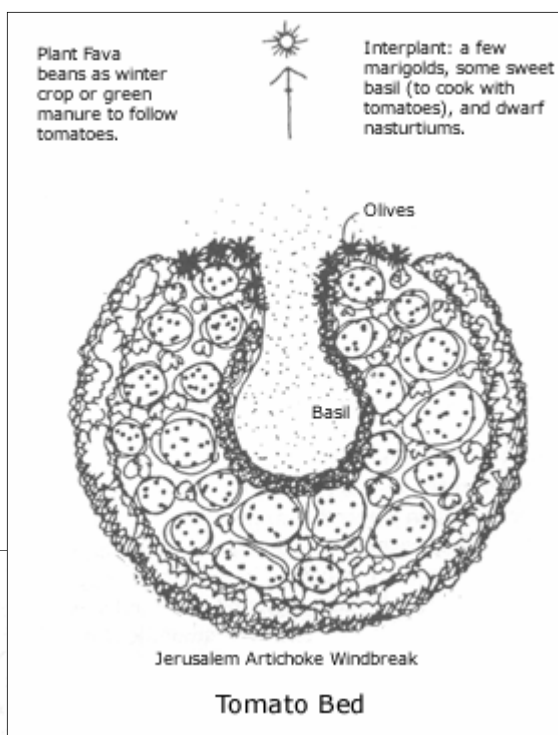
6) Broad Beds: here are planted the basic brassicas, lettuce, root crops that are closely spaced, self mulched, and are block planted to be cut over a period. E.g. beets, turnips, leeks, kohlrabi, onions, melons, parsnips, cabbage, cauliflower, Chinese cabbage, pumpkin, globe artichoke, potato.

7) Broadcast Sown Grain & Pulse Crop: here can be planted successions such as rape-sweet corn-buckwheat.

8) Vine and Trellis Crop: e.g. cucumber, pumpkin, passionfruit, jicama, beans, and peas.

Corridor and Semi-wild Planting (very important in deserts)

Hardy trees (palms, fruits, nuts) can be set out along river beds, dune bases, and in shaded valley niches. Figs, mulberries, olives, dates, mango, chestnut, etc. placed in highly selective niches will become perennial after 1-2 years of care and will yield for decades. Use every seepage, spring, and shaded deep soils. Develop useful local species, vines, and shrubs for corridors.



Human and Animal Nutrition

Vitamins and Minerals: Dangers include mineral deficiencies in irrigated areas, poisoning from bare water and rapidly grown, leafy plants. Very common diseases arise from:

- Gross lack of fresh food: leaves and fruit. Leads to lack of vitamin A & C
- Lack of meat protein (for iron uptake and B vitamins)
- Excessive nitrates & salts in water or leaf
- Low blood levels of iron lead to anemia

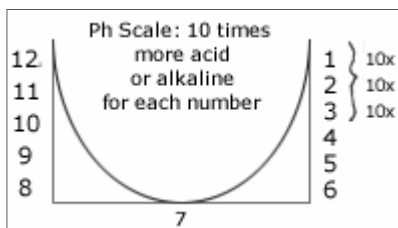
- and stunted growth
- Poisoning by fluorides, radioactives, water-borne nitrates & pathogens
- Processed food adds to health problems of dietary diabetes, high blood pressure, heart problems, liver failure from alcohol
- Animals on browse may be poisoned by oxalates, prussic acids, nitrates, sodium fluoro-acetate in fast growing vegetation. Toxemias common in pregnancy, breeding, young animals. Watch for lethal effects of Botulinus from blue-green algae in desert lakes, and for water-borne diseases.

Dust and Water:

- Dust carries several pathogens, cysts, spores, sometimes harmful minerals or radioactives, encephalitis, etc.
- Dryland borne waters can contain salt (sodium salts), radioactives, fluorides, nitrates, boron, and mineral salts
- Many desert diseases are water transmitted, showers are preferred to “swimming holes” especially when disease is endemic.

Section 7: Soils

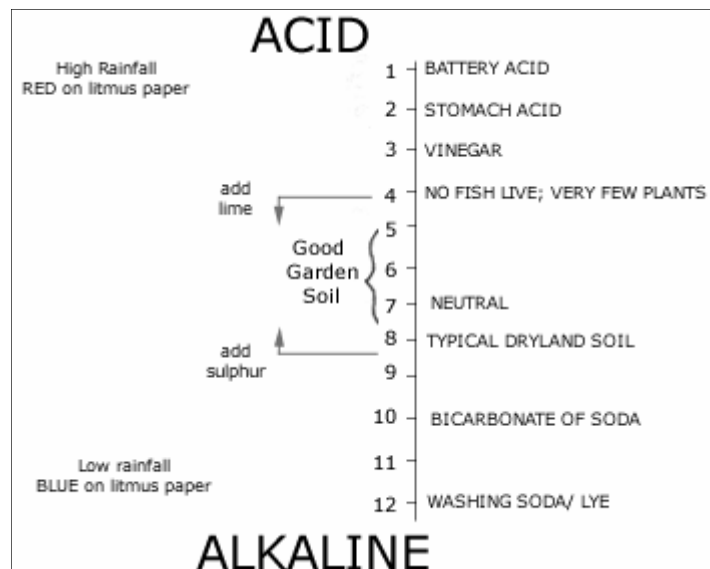
A. Soil analysis and interpretation – ph scale:



B. Creation of humus in soil

Can be done through addition of mulch, compost, vegetation, food scraps, manures, animal skins and bones, etc. May take 2-4 years to build up good garden soil. Humus solves the problems of **too acid** and **too alkaline**.

C. Difficult Soil



Alkaline areas expected in deserts, coasts, and alkaline rocks. Acid areas expected in wetlands, bogs, high rainfall, uplands, siliceous rocks. Species suited to alkaline areas are mesquites, locusts, carobs, some pines. Species suited to acid areas are oaks, pines, and blueberries.

Platin soil: islands, atolls and desert coasts. 18" deep a layer of calcium triphosphate, hard as concrete. Strategy: break up the platin layer, stuff with humus, and plant tree. Tree continues to break up platin and release phosphate nutrients.

Caliches: tropical equivalent of plantain. Hills. Ferric silicate composition lies 1-1.5 meters below soil, often in rainforest. Best to leave forest as is.

Non-wetting: dryland areas- water rolls off. Caused by algae-fungal association which produces wax. Strategy: can be mulched (for small areas); mixed with clay or a commercial gel.

Clay: drainage problem. Mix with gypsum to help seepage (2 meters penetration); can also use gels to hold water.

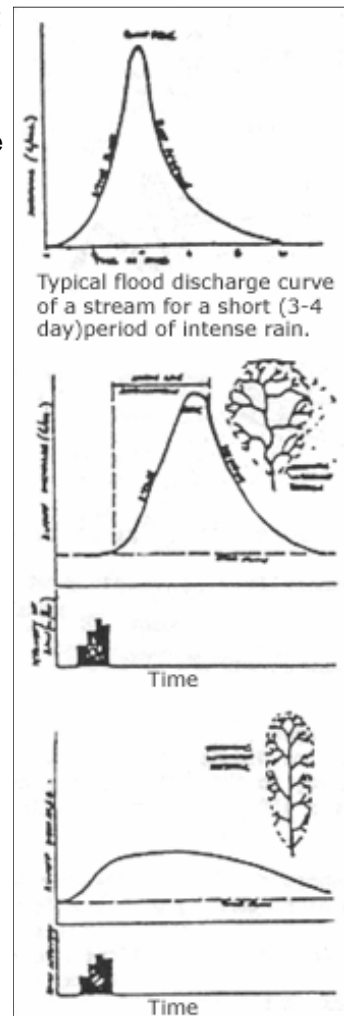
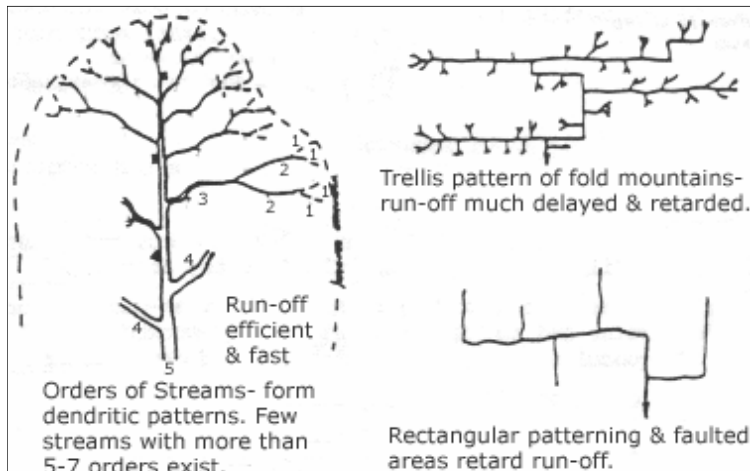
Section 8: Seeds and Nurseries

- Seed saving: collection and exchange (Kent Whealy system)
- Perennializing annuals: how to reduce the need for seeds
- Need for specialized permaculture nurseries for unusual plants, e.g. bamboo, palm, cacti, and for forage species: pampas grass, tagasaste, coprosma
- Seed companies (buy from small, non-hybridized stock)
- Seed legislation (P.V.R. in U.S.)

Section 9: Water Cycles and Management

Run-off Factors Depend On:

- Absolute catchment size: "small" catchments (stream orders 1-3) discharge a greater proportion of water and have greater flood flow than "large" catchment (stream orders 4-6). E.g. foothills will peak to flood more rapidly than plains, and may discharge 30-40% of rain. On plains only 8-20% may occur as discharge.
- Stream gradient: Also exacerbates rapid discharge.
- Absolute storm size: Large storms may wet all of a small catchment without causing much run-off in lower catchment.
- Retardation swamps and basins: Swales, dams, swamps, basins, water spreading generally delay or obviate flood and run-off. These are susceptible to our management. Sand beds and sand sheets have similar effects.
- Catchment form: Dendritic (tree form) catchment the most efficient. Thus fold "trellis" and fault catchments discharge less, more slowly.
- Drainage density: Dense streamlines remove water quickly; interfluvies retard flow, as do braided streams.
- Vegetation: Type and density affect run-off. Trees and tussocks retard; ephemerals and annuals or bare areas increase run-off, as does burning or cultivation.
- Sealed and rock areas: increase run-off. Also map soils and rock types, shattered "intake" areas, boulder fields, sand cover.
- Water viscosity: (temperature) has both diurnal and seasonal ef-



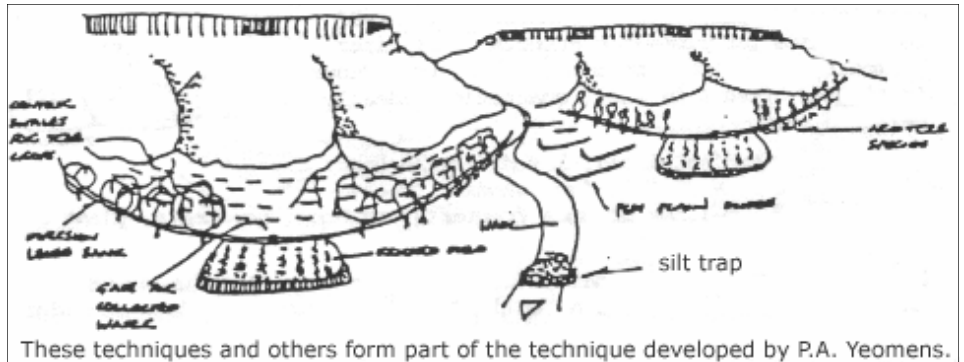
fects.

- Rain duration: a primary factor. Roughly a 4-5 year “wet” needed to flood basins, 2-3 years to recede.

Water Control: Managing Surface Run-off in Broad Landscape

General rules:

- Modest trials; extend on successes
- Do not **concentrate** flow across even low slopes or they will gully out
- Always **spread** and **absorb** flow in pits, swales, sands.
- Try to totally absorb run-off into **vegetated areas**
- Beware absorbing run-off into bare areas as this can raise the water table and cause salting
- Plant trees over shallow water tables
- (insert #9 from page 5, water flow-wadi)

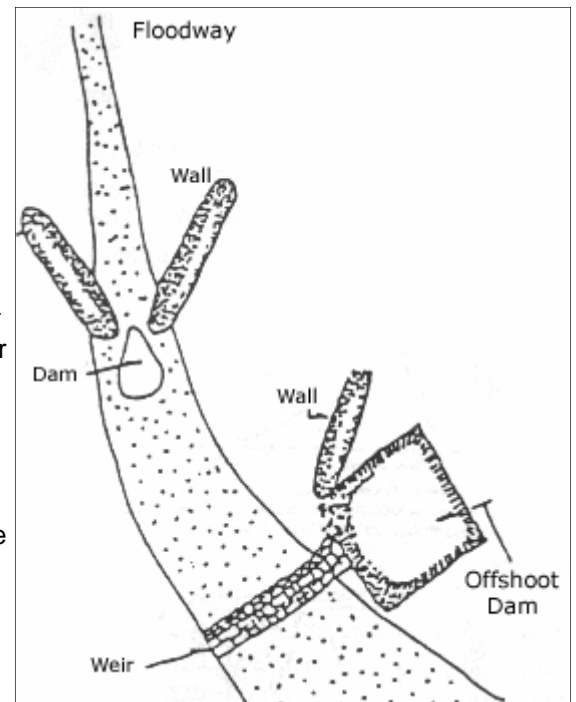


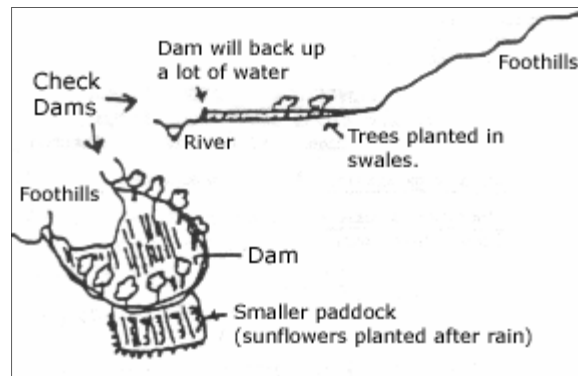
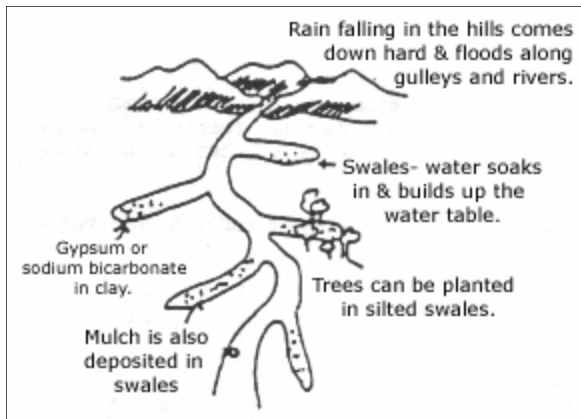
Arroyos:

- Rock-cut channels on scarp, back slope and in pediment rock will lead water to walled fields (walls 1.5m high). Water gates allow each field to be flooded or to spill to the next section for field crop.
- Small arroyos can be completely dammed across and sand absorption practiced.
- Large arroyos need central floodway left open to spill to large, low-walled fields in plains if excess water falls, these may fill every 6-10 years; not normally planted.
- Shallow flood streams in foothills can be “bled off” at bands to long swales 1-2m deep; overshadowed with trees. Swale base will carry crop seasonally.

Sandy Rivers:

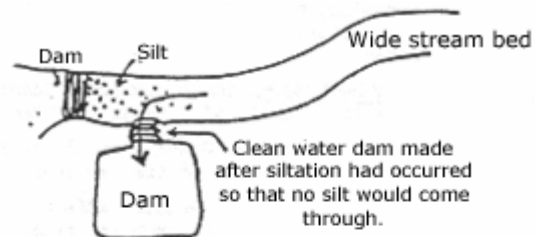
- Can be rock-dammed every 1-2km, at 1-2m deep, and sand allowed to fill dam area; spread floodwaters; absorb.
- Walls can “leak” to next dam; areas can be tree-planted or sub-surface drains led to pipes or a small open rockhole or clearwater dam for aquaculture (this dam: 1/25th of sand dam area or less)
- A notched concrete sill in sandy river beds will spread braided streams across entire flood plain; trees do well along braided channels. Absorption of water commonly 10-20m from streambeds in sands (this may be due to tree root reach).
- A 2-3m high bank towards a stream causes scour pool in the stream bed (1/100th of area of streambed will be permanent).
- Low permanent walls in flood plains retain silt and water for crop.





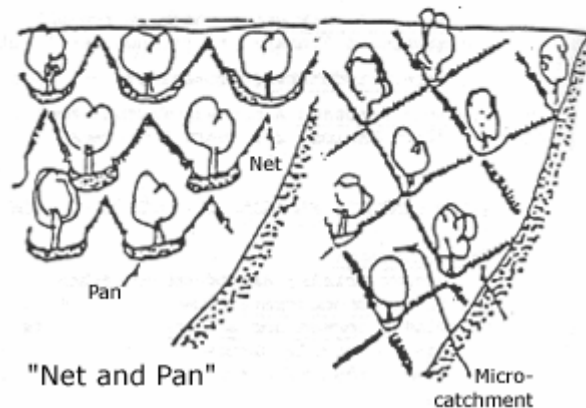
Slopes Generally:

- Swaled at 1-3m vertical intervals, swales of 2m deep, broad (3-5m); tree planted.
- Steeper slopes can be sculptured as "net and pan", "boomerang" banks.
- Low slopes (3°) set out as a series of large diamond-shaped basins of 0.5 hectare, each with a tree in the low corner, and a spillway to the next diamond; even light rain soaks into these. Try for 150-200m deep ponds in small areas.



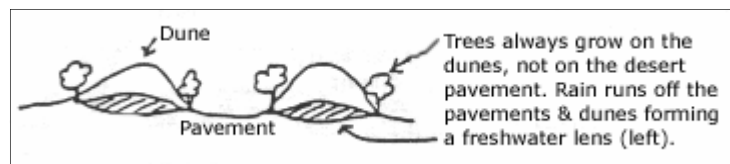
Plains:

- Dams between hills by a 4-cast bulldozer bank 1-5km long, banks 1-2m high, backing up water for 2-10km. This is then released over next 4-8 days into chiseled fields $1/20^{\text{th}}$ the size of the flooded area, and allowed to soak in by a succession of floodings. Crops are planted in both the dammed area and the fields. A bypass canal allows spillage of excess water.
- Patterned with great circles (30-50m across) cast out by blades, squares, etc. to totally prevent run-off, and pelleted seed sown to grow rangeland plants.



Dunes:

- Bases are good tree sites or whole dunes can be sown to oats in wet periods, with pelleted Acacia seed to stabilize for permanent effects. Fertilizer (ammonia, zinc, iron, trace elements, molybdenum) is applied often and in small quantities- ideally in pelleted seed.
- Between longitudinal dunes, low diversion banks will deflect run-off into dune sands and trees; repeat every .05-1.5km or more frequently on broad pavements; plant trees in sands. Try for ratio of 20:1 run-off: absorption.
- Fences 1m high, 7m apart, 40% penetrable stabilize dunes; need Acacia or other hardy trees to make this permanent. Trees need a "collar" and pit 15cm or more deep to reduce heat on roots.



Claypans:

- Spiral or ridge up to hold water, sow parallel seed, pit seed and spray on bituminous emulsion to

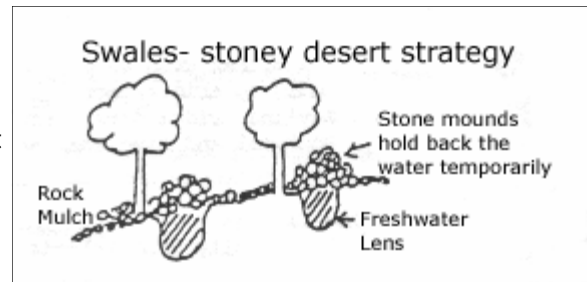
- prevent bird losses.
- Allow only very light browsing until shrubs establish. Banks will later “melt” but can be remade in 2-3 sequences until area is revegetated.

Extensive:

- “Pitting” for large, sandy areas. Series of pits or mini-swales 15-30cm deep- stagger across slopes.
- Seed and fertilize (pellet) area. Rains will soak into pits, establish plant cover and later shrubs.
- Totally prevents dust loss, dust storms from area. Important around towns, airports, downwind areas of desert. Permanent only if carefully stocked and if trees are later established from pelleted seed.

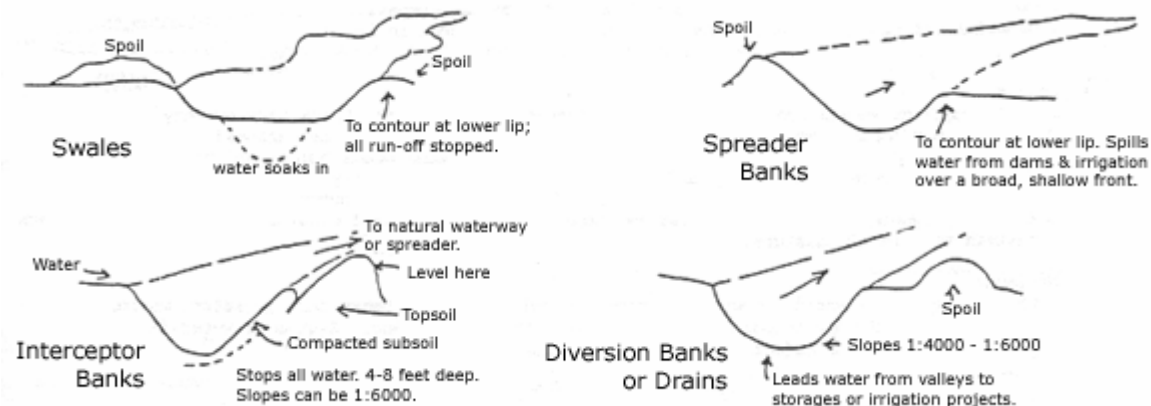
Gibber or reg:

- Sidecast pebbles to contoured swales to create tree sites in pebble lines. Test plantings before extensive swales are formed as area can blow to dust where pebbles are shifted. Pebble swales are good tree sites.



Types of Channels

- Swales
- Interceptor banks
- Spreader banks
- Diversion banks



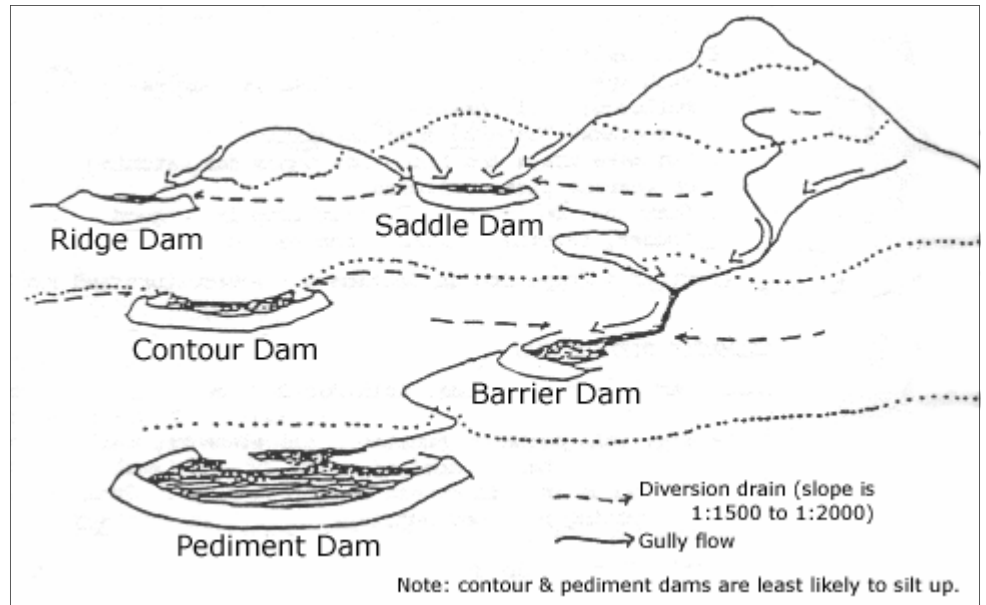
Water Storages (not in soil)

Types of Dams:

- Saddle dams: on skylines, in saddles
- Barrier dams: across valleys (only useful where silt is not a problem or if effective silt-traps installed)
- Contour dams: wall of dam follows contour
- Pediment dams: dam site on a flat at the foot of hill slope
- Ridge dams: dam is on a flat ridge area

Essentials of Dam Building:

- Backslope: 3:1 ratio, especially in sandy soils.
- Frontslope: 2-2.5:1 ratio
- Crest: 3m wide
- Freeboard: 1m
- Compaction: every 0.3m of soil rolled down by bulldozer
- Key: a clean cut at base for first layers
- Spillway: made along the contour and end well away from the dam wall. May lead to another dam.
- Surface, fibrous-rooting plants grown on frontslope (avoid tap-rooted trees)
- Silt traps may be needed in diversion drains leading to dams
- Plant windbreak surrounding dam to reduce wind evaporation loss
- Make dams deep. Try for shade. Taper sides to "V" or cone if practical



Strategies to Reduce Evaporation:

- Cover water surface with rounded, hexagonal "light concrete" blocks using polystyrene beads in aggregate. Paint upper surface white. Try for 0.8 specific gravity and make 1-2m across.
- Make a sequence of 3 dams, and empty from top dam to the lower dams as soon as these will hold the water. Each time you do this surface reduces by 30%. Several series of 3 is better than a chain of 6 or more dams long.

Section 10: Water in Landscape

Water as a rare mineral; it is the world's most critical resource. Fresh water is only 3% of all water (the rest is in oceans). Of the fresh water, 75% is ice and glaciers, 11% is available ground water* (less than 2500' deep), and 14% is deep groundwater and aquifers (2500' to 12,500')

*These are storages we can influence locally (as below)

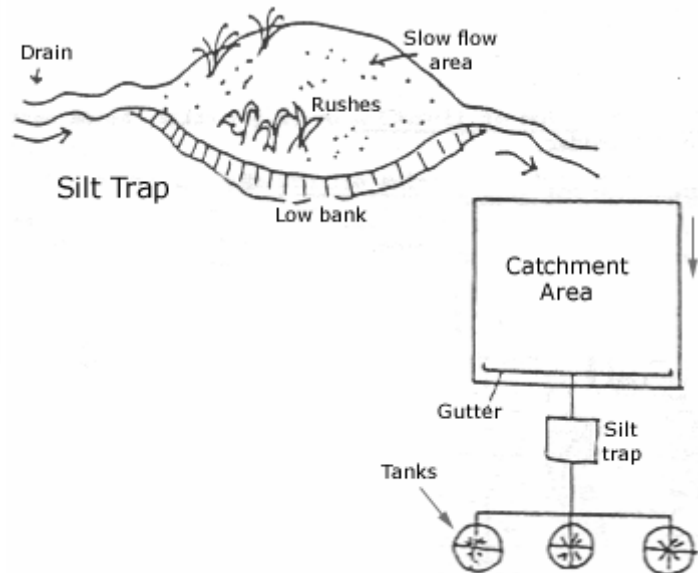
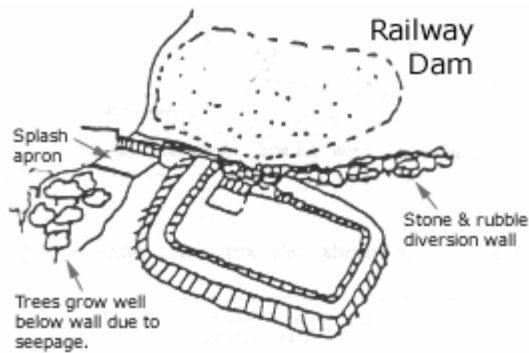
Lakes & ponds, surface*	0.3%
Soil Moisture, forests*	0.06%
Rivers	0.03%
Atmosphere	0.035%

Duties of Water: the idea is to use water as many times as possible before it passes through the system.

Duty #1: to procreate life (in growing organisms)

Duty #2: to develop productive water systems (aquaculture). Yield of system increases as life increases.

Duty #3: to develop hydraulic uses for energy production (pumping water, generating electricity and mechanical take-off).



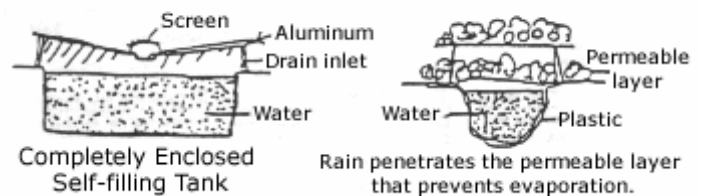
Small-scale Water Storages

- Tanks at home for freshwater supplies
- Stock ponds
- Small ponds in gardens (frogs)
- Use of larger catchment area to supply tanks; catchment can be of bituminous material, sealed clay, concrete, sheets of butyl rubber & polyethylene
- Roads, airstrips, firebreaks- all potential catchments if designed to concentrate water in storage structures such as roadside tanks.

Irrigation

- Drip or trickle, especially in drylands
- Flood irrigation (surface & sub-surface- wasteful and difficult to control)
- Sprinklers (not efficient, can build up salt in soil)
- Under canopy

Large Roof Tank: used in Australian deserts



Components of Irrigation System:

- Water source: dams, bores, soaks, run-off, swales, pipelines, creeks, tanks, lake
- Energy source: water at head, pressure with pump (electric, fuel, wind, hand, or animal)
- Distribution network: net and pan, pipes, channels, buckets
- Emitter: dripline, sprinkler, bucket

Methods & Advantages of Drip Irrigation

- Hole in a pipe
- Flagon or clay pots in ground with nail in cork
- Rocks in deep hole to lead roots down
- Relatively cheap
- Water the root zone directly
- Can use reasonably saline water
- Waters only the plant, not the weeds around it

Subsurface Irrigation

- Pitcher irrigation: 12" wide porous pitchers buried in ground 3' diameter, 2' deep, filled with matured soil.
- Tops of pitchers just above ground level, covered and kept topped up. Gourds, pumpkins, and melons cultivated. Can also be used for planting trees (narrow necked jars).

Irrigation Rules

- Irrigate under mulch (reduces salt problems & increases irrigation efficiency)
- Irrigate at dusk or night if possible (put on a timer)
- Give long watering every 3-5 days rather than a little bit every day (increases leaching effect, particularly for salt, and takes water down)
- Allow for leaching, put enough water on to leach salt
- Use sealed pipes to convey water; leaky drains may raise the saltwater table.
- Only use sprinklers under tree canopy. Never in the open by day.
- Do not over-water; use timers and pits to check on this; turn off drip in winter if enough winter rain.

Minor Water Landscapes

A) Volcanic Islands

- Rich soil- range of crops almost unlimited
- Types of Lava: 1) *pahoehoe*: rock lava- good only for run-off; 2) *u'u*: pumice-like with lots of holes. Can be planted in.

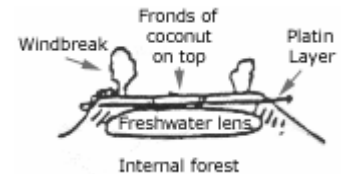


B) High Islands

- Are either granite or basalt
- Humid to arid aspects
- Keyline, ridge dams, terraces
- Rockwall and cave shelters
- Rich flora and fauna
- Importance of winds and rainfall
- Lagoon catchments and shorelines
- Special problems: cyclone and tsunami; earthquakes, mud flow, lava flow, cinder flow, volcanisms.

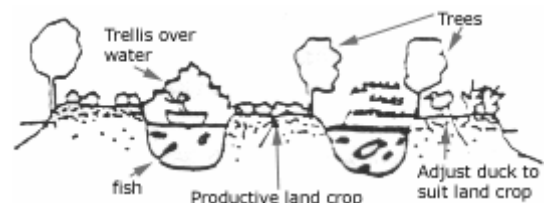
C) Low Islands

- Are usually arid islands
- Need essential foreshore plantings
- Need essential windbreaks
- Bi-modal and bi-directional winds
- Caliche or platin-removal techniques necessary (mulch pits)
- Gley (wet, sappy plant material) for tanks
- Atoll structures in lagoons



D) Coasts

- Need frontline vegetation so that beach is not undermined
- Salt-resistant frontline species. Eg. (casuarina, coprosma) have waxy or needle leaves
- Establishing plants in sand- sawdust and paper lowers ph and holds moisture. Chinese plant in woven basket to retain moisture.
- Sand blast resistant plants: thick bark or very fibrous barked trees (pines and palms; casuarinas)
- Alkaline sand needs humus. Soluble sulphates and oxides offset alkalinity.
- Deficiencies in zinc, copper, iron (non-soluble in alkaline)



E) Wetlands

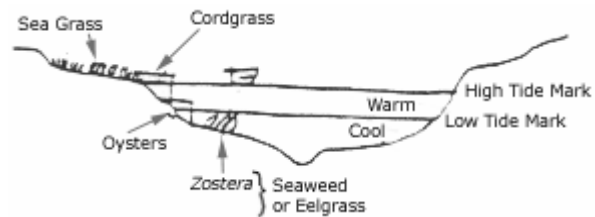
- Chinampa system- world's most productive agriculture,

using banks next to water, maximizes productive edge. Swampy or marshy land ideal for this development. System of water-land nutrient exchange in harmonic effect. (Mexico and Thailand)

- Ducks (main livestock) cycle nutrients, return potash to water and land.
- Fish are marginal feeders
- Azolla (a fern) contains Anabeana (nitrogen fixing bacteria). Can be scooped up and used as a mulch on land.
- Trellis crop over water saves space. Can be harvested by small boat.
- Occasionally streams are drained and nitrogen rich mud scooped onto banks.
- Marshes and wetlands support rich yields of wild rice (*zizania aquatica*), freshwater mussels, fish, and honey- producing species (marsh marigold)

F) Estuaries

- Rich species area (oysters, fish, sea grass, mollusks, fowl, geese)
- Sea grass (*zostera*) good insulation
- Can make traps and high tide ponds for catching or raising fish, mollusks.
- Spartina- mulch; catches silt from land, good fodder, returns nutrient from sea to land.



Climatic Differences

Three very basic divisions: cold/hot/dry or temperate/tropical/desert

Temperate: Soil contains nutrients and elements. Cultivation cautiously possible; natural mulch develops. Mulch (humus) either applied on top of soil (small areas) or cut/grazed in cycles for larger areas. Amount of humus in soil determines “fertility”. Smaller fields with deep rooted deciduous trees ensures nutrient cycling plus new nutrients, but best strategy for cropping is “no tillage” cultivation.

Tropical: Plants hold 80-90% of nutrients. Clean cultivation in the European mode is disaster. No mulch develops under forest. Biomass is critical. Bare soil leads to development of concrete-like layer below 3 meters of soil (caliche). Later comes erosion. Strategies: nitrogenous ground cover may be critical precursor to agriculture (*desmodium*, *sesbiana*, *dolichos*) e.g. barley/*dolichos* mixture is ideal; as is *desmodium* under a tree crop. Problems may be summer or winter dry and winter competition. This is solved by use of drip irrigation, selective grazing in advanced tree crops. 4-6 large trees/acre (*acacia albida*, *leucaena*) in crop as nutrient-recycling strategy. Essential to incorporate as much tree crop as possible, otherwise, waterculture- e.g. paddy rice, where nutrient is bound to algae and mud. Also essential to replace low nutrition plants (lettuce) with high nutrition tropical plants (kangkong, edible chrysanthemums, hibiscus spp. Etc.)

Desert: Nutrients plentiful but need humus and water for release. Must concentrate on soil cycle, plant cycle, and water cycle in arid environments. Desert strategies are basically water-connected; great attention must be paid to “waste water” use in mulch, floodflow and runoff techniques. Deep-rooted trees need mulch plus drip irrigation in establishment. Mulch can be planted in deserts as legumes, tamarisk, casuarinas.

Section 11: Aquaculture and Mariculture

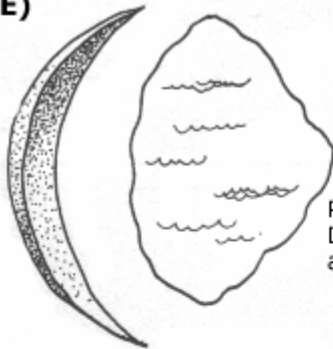
(see also “Useful Plants of Wetlands” by Bill Mollison, available from Permacultue Consultancy, Australia)

Aquaculture

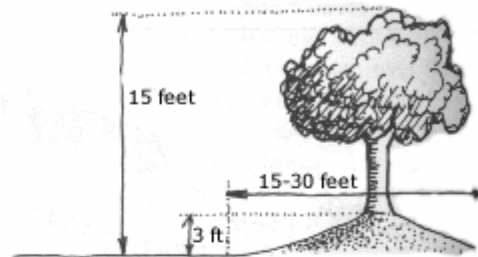
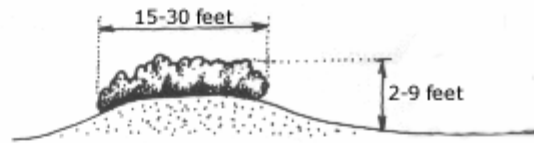
- Select species (plants and animals) for pond size
- Set up self-forage systems for fish

More Dunes

E)



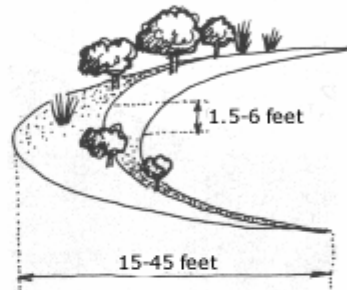
Parabolic Dune-
Dune rises from
a desert lake.



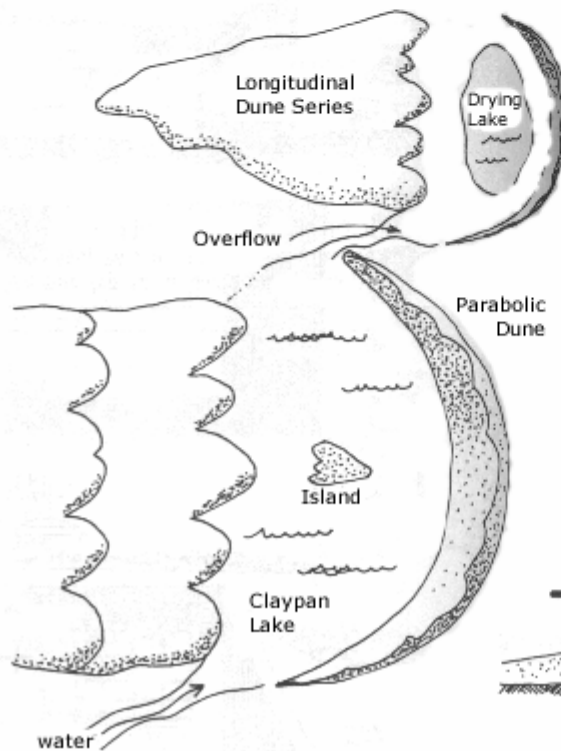
F)



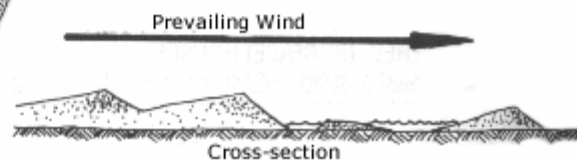
Ovoid Dune- light snow forms around
tussock grass.



G)



Hard
pavement
with thin
sand sheet



Pond Sizes:

- Mini-ponds in gardens: use for breeding frogs, water chestnut, watercress, taro, kangkong (water convolvulus)
- 300+ square meter ponds: fish, prawns, marron (need fence), eels, bait fish, Tilapia, freshwater mussels (must research habits of all- some will eat others if put in same pond)
- Plants: variety from edge (blueberry) to reeds (water chestnut), emergent (wild rice), marginal (glyceria), overhanging (mulberry, willow).

Self-forage Systems:

- Insectory plants at pond edges attract insects (many fall into the water)
- Plant heavily around edges to attract nesting and feeding birds. They'll deposit manures onto the water to supply detritus feeders. Ducks and fish are an excellent high yielding combination on ponds.
- Trellis crop and overhanging trees are important. E.g. silkworm on mulberry trees provide manure, their own bodies, and bits of leaf for fish below.
- Provide insect traps over water for fish feeding. E.g. a yellow balloon over water will attract grasshoppers; a baited fly trap will provide hundreds of flies; a black light with a fan will fan insects into the water.

Mariculture

Mangroves and Estuaries:

- Mangrove spp.: mulch effect will supply detritus feeders
- Plants: intertidal and sub-surface useful plants are Zostera & Spartina
- Mangroves hold sand and start off the food chain
- Estuarine ponds: controlled for oysters, mullet, flatfish
- Natural food trap systems (as above and use of sea organisms)

Tidal Areas:

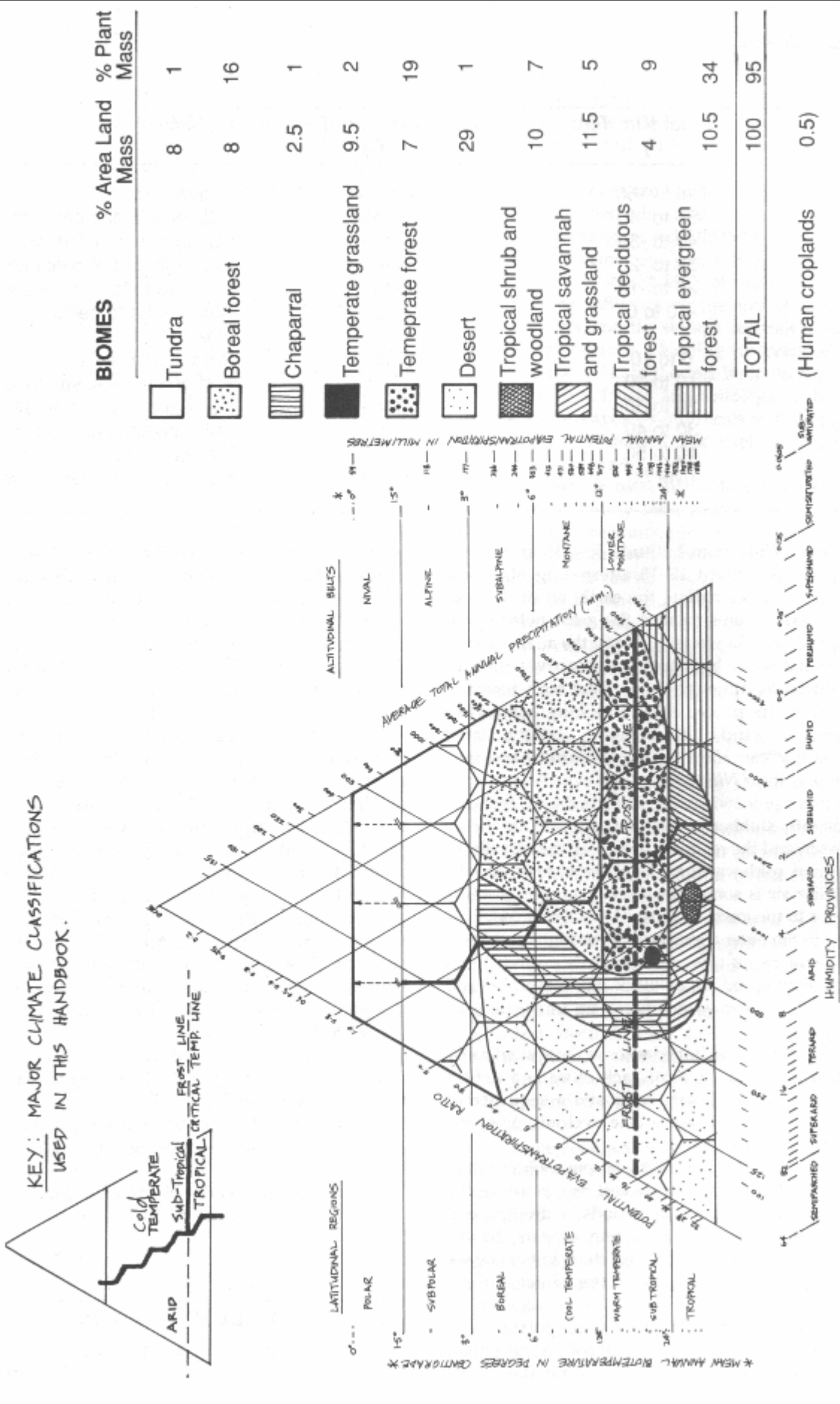
- Importance of fish traps
- Raft cultures: rig nets for fish; rope for mussels; plants and nesting sites.
- Phosphates: sea platforms, roosts, nests
- Rack and substrata cultures (mussels, oyster, algae, sponges, octopus)
- Reef cultures: tyres for fish; pipes for crayfish; pots for octopus

Fish convert algae and weeds into usable protein at high levels of efficiency relative to mammals. Molluscs, especially Unio, fix nutrients in mud for land cycle, dry crop cycle, and extract calcium.

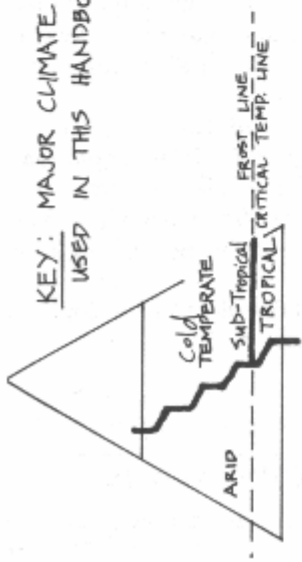
Section 12: Dryland Characteristics

Drylands:

- Represent 30% of occupied Earth and increasing
- Increasing at 6 million hectares a year, with 20 million hectares (size of Britain) reduced to zero economic activity per year (through overgrazing, overcropping, deforestation)
- From hyperarid to sub-humid area (cut-off is where precipitation equals or exceeds evaporation and transpiration). Rainwater never suffices for year-round cropping.
 - A) Hyperarid: (0-20mm average annual rainfall) e.g. Atacama & Namib deserts
 - B) Arid: (50-150mm) e.g. Sahara, Sonora, Mojave
 - C) Semi-arid: (150-250mm) e.g. Thar, Asian, Kalahari, Australian
 - D) Sub-humid (250-1000mm) All desert savannah borders. (Greatest loss of species occurs)



KEY: MAJOR CLIMATE CLASSIFICATIONS
USED IN THIS HANDBOOK.



BIOMES	% Area Land Mass	% Plant Mass
Tundra	8	1
Boreal forest	8	16
Chaparral	2.5	1
Temperate grassland	9.5	2
Temperate forest	7	19
Desert	29	1
Tropical shrub and woodland	10	7
Tropical savannah and grassland	11.5	5
Tropical deciduous forest	4	9
Tropical evergreen forest	10.5	34
TOTAL	100	95

(Human croplands 0.5)

HOLDRIDGE LIFE ZONE MATRIX

This analysis suits plant list classifications. The table gives the broad areas dealt with in this book.

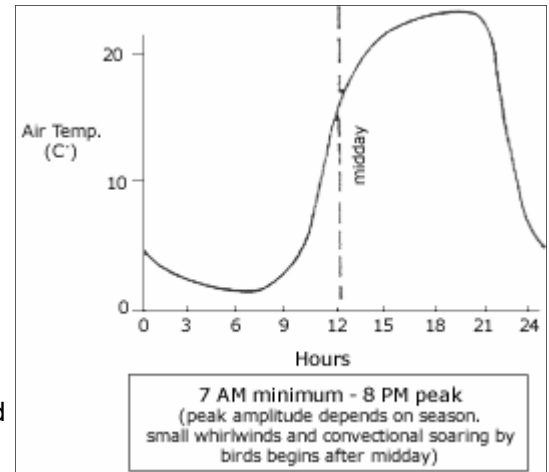
Many dry coasts and atolls have features in common with deserts.

Cold Deserts: (Latitudes 35-60°; altiplano areas of dry mountains). No dunes; snow melt; short seasons; aestivation **and** hibernation. Permafrost may occur. Great temperature ranges.

Hot Deserts: (Latitudes 10-30°) Excessive heat and light. Dunes a common feature. Pronounced dry wind effects, dust storms, high sub-tropical pressure areas.

Some Characteristics of Deserts:

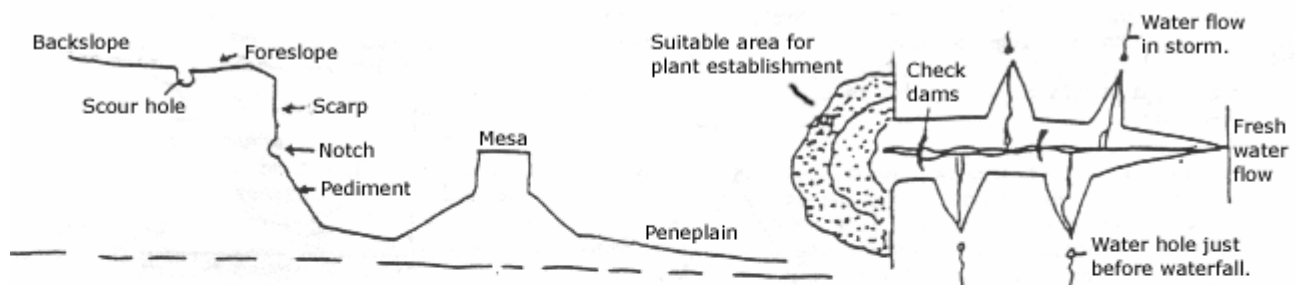
- Plant species mosaics: affected by topeodaphic features, fire, rainstorms, recruitment of species, land use patterns.
- Decomposers: termites, ants, macrofauna, fungi (compared with worms, arthropods)
- Drainage: often endochaic (pans); run-off **decreases** downstream.
- Erosion: episodic, greatly affected by wind, sudden floods.
- Animals: burrowing common, special metabolic and behavioral adaptation; fat storage organs. Animals avoid soil surface.
- Plants: special water storages, insulation, evasion via seed and root storages, salt excretion.
- Fragile soils: often held by "cryptogamic crusts", mineral crusts. Destroyed by hooves, cultivation.
- In general, a larger portion of biomass is underground. Extreme of heat and cold common.



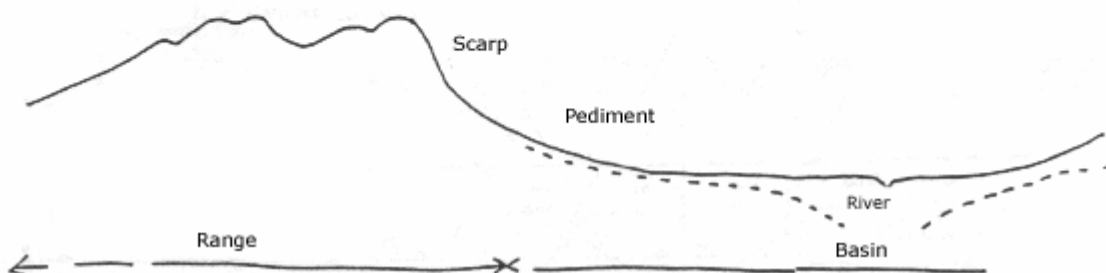
General Ethic of Dryland Use

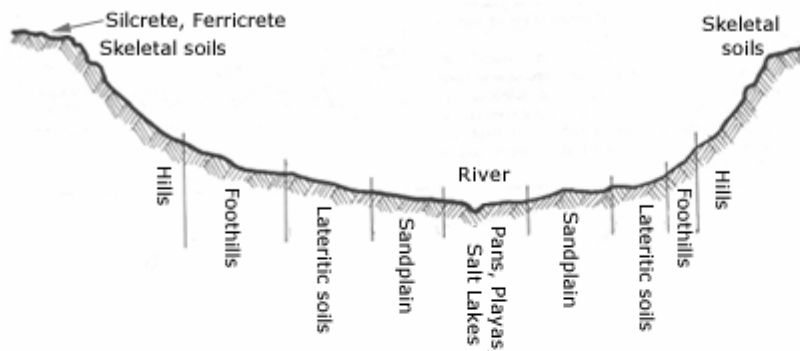
- Necessity to reduce human pressure on "extensive" areas
- Priority is to improve production on most favored soils and areas via skilled work, polyculture, selected species, intensive management.
- Species reserves and species trials are essential
- Careful assessment of natural yields and "conversions" to products is ideal
- Preservation of yield is more effective than increasing yield

A. Scarp and Wadi: abrupt angles, steep valleys, fault-line, & erosive effects.

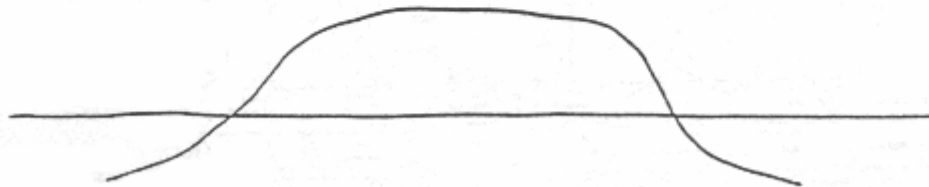


B. Basin & Range: tectonic basins by down-warping of crust; fold mountain series.





C. Residual: extruded or residual granite domes, old silicious folds.



D. Badlands: incised softer sediments subject to active complex erosion gullies.

Dominant Arid Landforms

Basements:

- A) Erg (sand seas)
- B) Reg (gravels & gibber plains)
- C) Hamada (stony pavements, concreted areas)
- D) Pans (salt, clay, marsh)
- E) Soils

Dunes: Major and Minor forms:

Order 1: Saltation: effective to 0.5-1.0 meters above surface. 50% of sand moves this way.

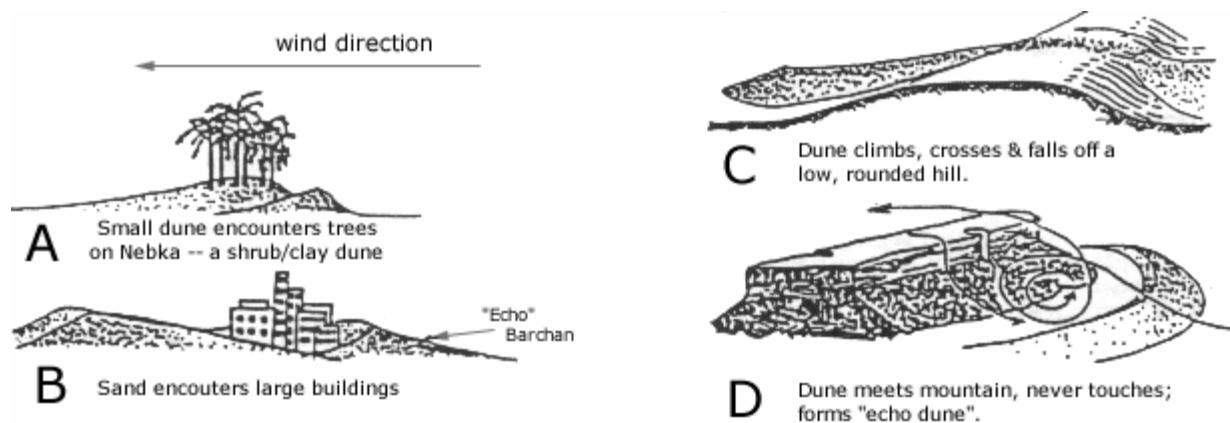
Order 2: Ripples: Move rapidly, several wavelengths per day.

Order 3: Barchans and longitudinal and transverse series: type depends on sand, basement, winds.

Order 4: Droughs: "Whalebacks" and star dunes. (Occur only where average sand depth exceeds 5-20m. May not move.

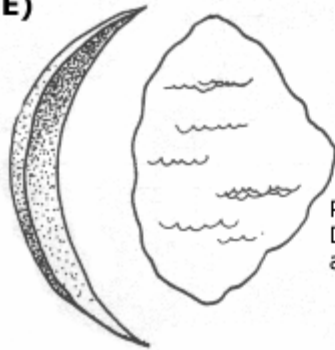
Order 5: Draas: Large fixed or permanent dunes.

Minor Forms: "Echo" and obstacle drifts, tail dunes, nebkas, lunettes.

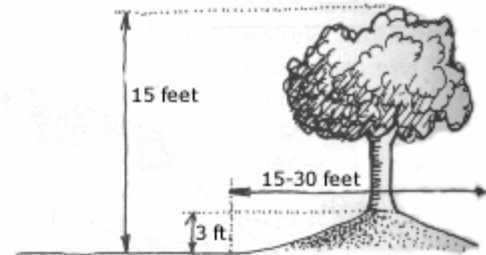
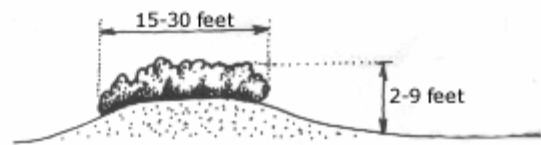


More Dunes

E)



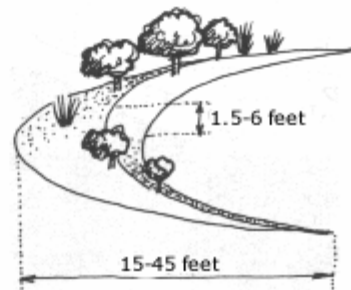
Parabolic Dune-
Dune rises from
a desert lake.



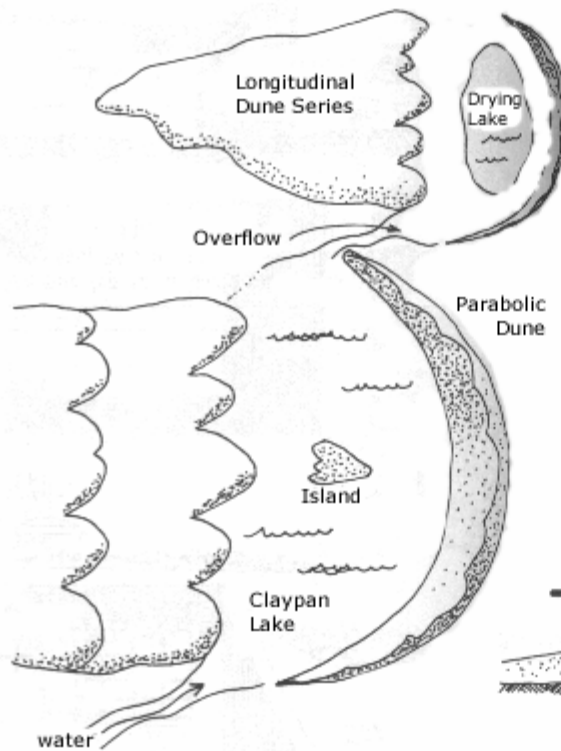
F)



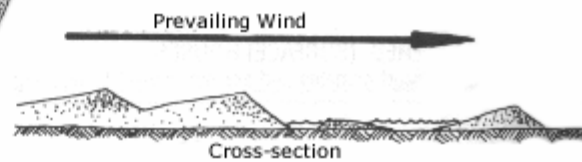
Ovoid Dune- light snow forms around
tussock grass.



G)



Hard
pavement
with thin
sand sheet

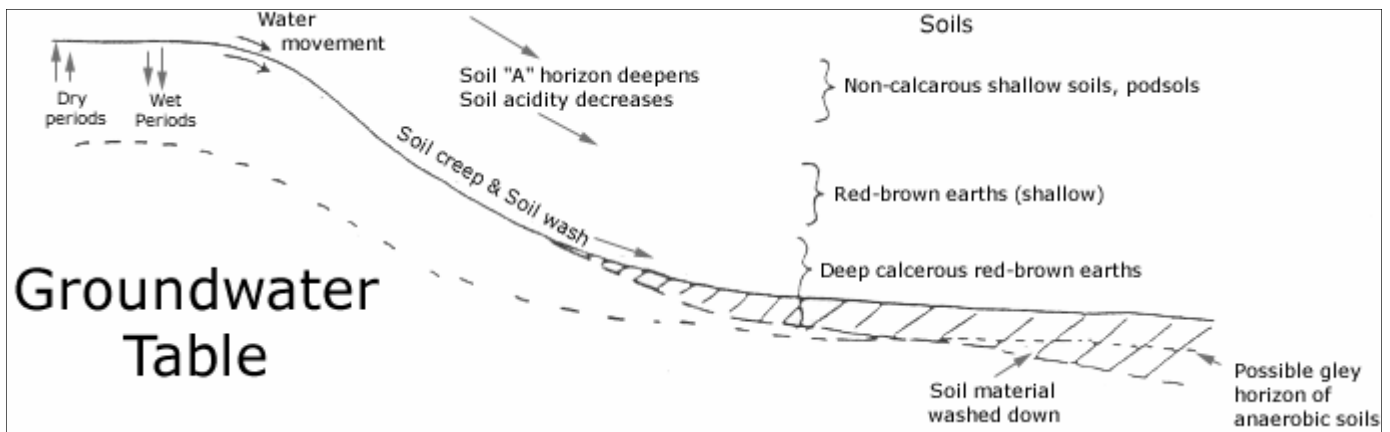


Stabilization of Dunes:

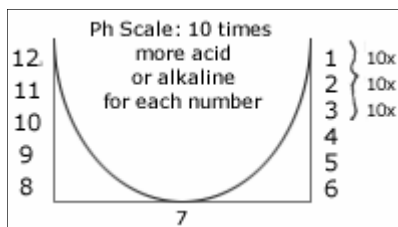
- Deflection of drift: using wind deflectors, correct slope of road surfaces, obstacles to break up and flow.
- Sand fences: 1 meter high, 7 meters apart, 40% permeable
- Pebble layers, pitting, "roughness" of surface
- Binding surface using emulsions, salts, water.
- Crop or selected plant species.

Specific Soils Types

Soil Catena: soil changes with slope (semi-arid area) 17" rainfall. Vegetation follows catena line. Factors affecting soil types in relation to slope:



Soil Analysis and Interpretation: pH Scale:



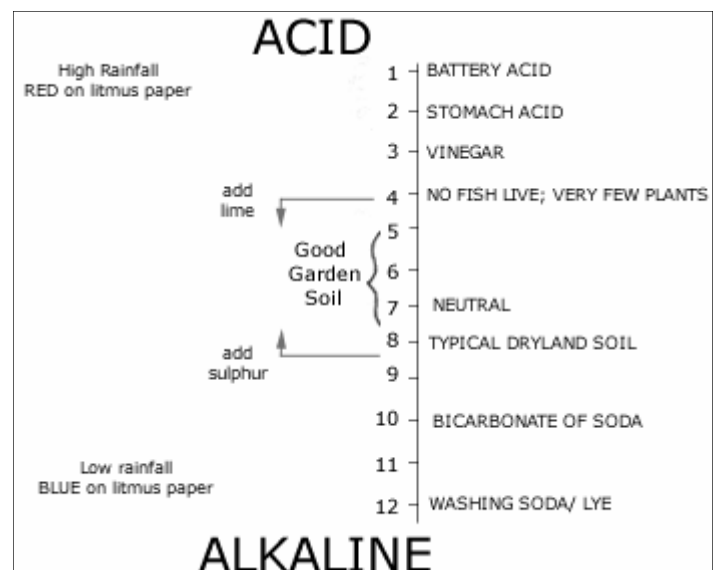
Concretions and Hardpans

Ferricretes: Iron-silica & duricrust caps, buried "buckshot" & iron concretions, ironpans.

Calcretes: Common on coasts, atolls, usually 0.5-1.0 meters deep if not exposed. Calcium carbonate, triphosphates. Must be broken up in order to plant trees.

Solcretes: salt-collapsed soils, "deflocculated", salt greater than 2 ppm of soil. Will not sustain trees. "Solonetic soils".

Pans: salt, clay, plough pans.



Soil Problems in Arid Regions:

- Low pH: very alkaline types in valleys, along watercourses, on hills, siliceous rocks (commonly pH 8.5 or higher). pH increases by evaporative effect on base minerals; affected by irrigation, cultivation.
- Soil drainage a key factor: waterlogging common if salts in water exceed 200 ppm.
- Common soil deficiencies: zinc, iron, manganese, molybdenum, sometimes silica (cement) in subtropics.

Trace element deficiencies need:

- Trace elements added to irrigation
- Humus content of soil increased
- Seed pelleting & soaking prior to planting
- Rhizobium inoculation of leguminous plants
- Foliar sprays
- Forestry in croplands
- Soil treatment with gypsum sometimes necessary for salts

Climatic CharacteristicsRainfall

- Occurs as sudden heavy downpours from convectional thunderstorms or a coalescence of storms on a broad front
- 50-70% of the total rain falls on only 13% or so of the rain days. The rest is as light rains over 80% of the days, and little but local run-off will occur on most rain days. Less than 7% of all days will be "rainy".

Strategies:

- Prepare over-sized systems of very gentle grade to divert, store, or control sudden heavy floods and run-off.
- Keep settlements and houses clear of flood plains, basins, the upstream areas of hill gaps, and clear wadi floors and spill-outs.
- Accept a general figure of 30% run-off to plan swales and storages, and prepare safe solid spillways, spreader banks, by-passes, and retardation basins to cope with the inevitable 7-22 year excess of water.
- Multiple small systems are needed close to headwater streams where water is still fresh; small storages of many types are appropriate.
- Never depend on being able to produce broadscale crop on a regular basis; aim for perennial, adapted, long term crop and careful rangeland management where stock capacity is below the "worst case" drought levels.
- Possible to run miles of cheap diversion drains to desert lakes and sand basins for later use.

Temperature

- Greatest variation in top 5-15cm of ground. Lethal temperature: 36° C for seedlings.
- Soil temperatures peak before air temperatures, radiate more rapidly and cool before dawn. Daily effect slight at 30cm deep, seasonal effect at 2 meters (hence efficiency of underground housing and animal burrows).

Thermal Cells (Air)

- Roughly hexagonal, 1-5km across; "walls" ascend or descend, causing thermals of ascending air from mid day on. These thermals may coalesce to form "fronts", dust storms (given a cold following airstream), and fierce downdraft in front of cloud systems. Often followed by rain, hence mud and silt flow.

- Diurnal temperature range of 10-30° C, 8-30° C annually. Peaks at 12 noon to 3pm.

Wind Effects and Strategies to Reduce Windblast

- Sandblast to 0.5 meters above surface, dust storms.
- Drying out of vegetation
- 200-300 meters width of windbreak needed; up to 5km width needed to prevent desertification on a national scale (e.g. Chinese strategy)
- Farming or forestry needs permanent windbreak around smaller (5 to 20 hectare) areas if cultivation is contemplated
- "Oasis effect" operates on even small (up to 40m) openings in crop and tree cover
- Leguminous trees (acacia and prosopis) in crop necessary on savannah edge. Root web to prevent nutrient loss, flooding, salt rising.

Section 13: Desertification

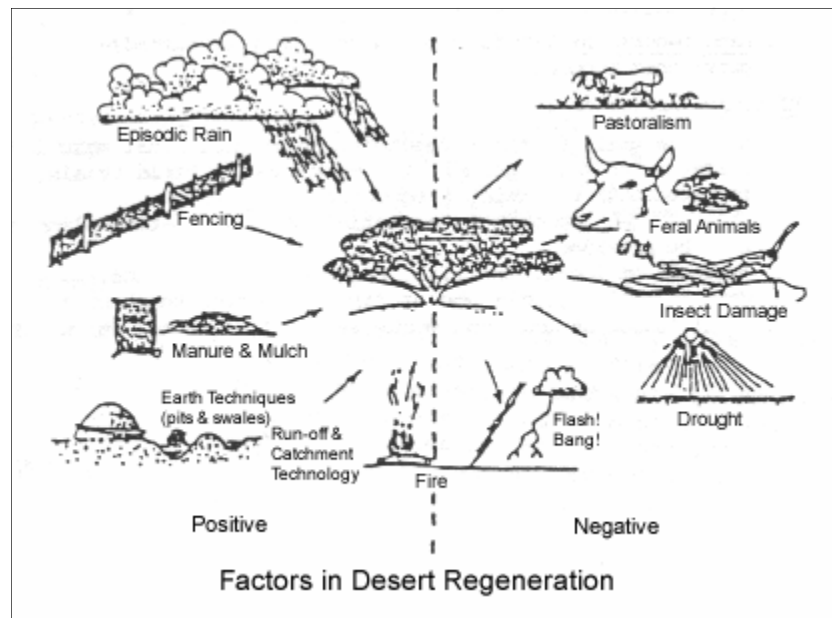
Desertification is the creation of collapsed, compacted, eroded, and salted soils. It is primarily a socio-political problem. Causes are:

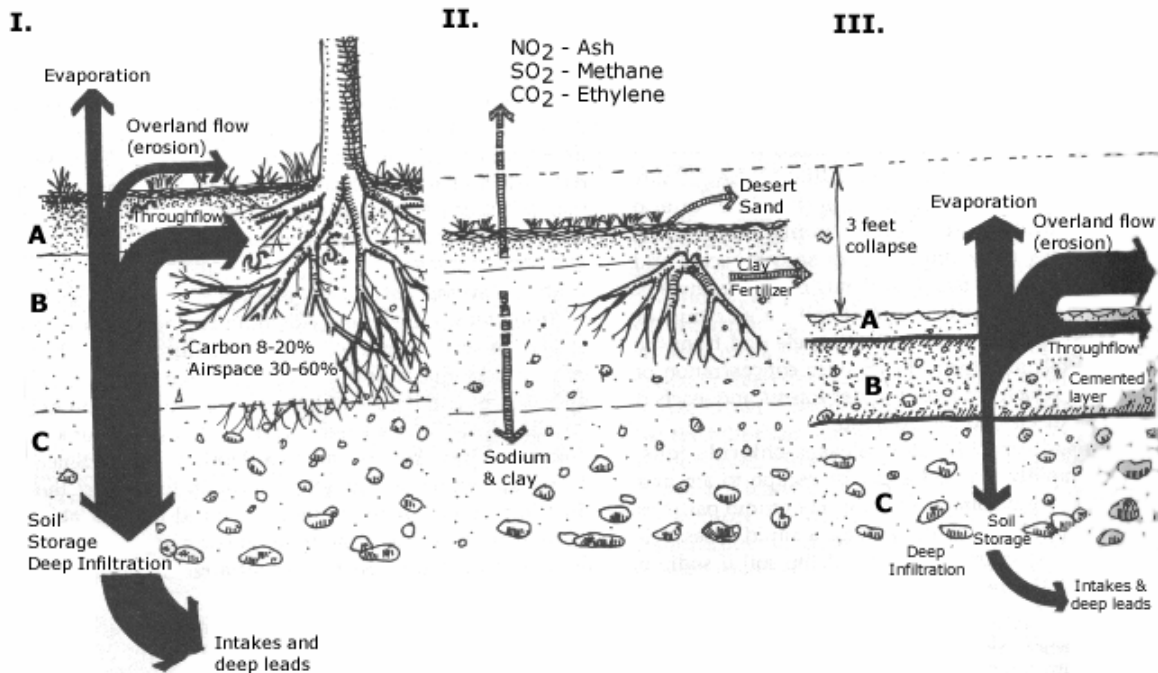
- Headwater and Local Deforestation: allows increased wind effects, rain splash, erosion, fast overland flow, more infiltration to salty layers, groundwater rise, release of soil salts.
- Cultivation: breaks down topsoil structure, compacts subsoil layers.
- Overgrazing: combines above effects
- Burning: combines above effects; may bake topsoil, removes soil humus & nutrients (usually it takes 20-30 years to replace nutrient loss from rain, trees)
- Local concentration of livestock: well access leads nomads to settle in one place- causes over demand for firewood and fodder
- Increased hot wind evaporative effects as trees are cut down.
- Salting of drylands leads to soil collapse by deflocculation, concretions, salt ponds off streams, permanent deforestation, swamping of collapsed soils in rain.

Deserts can be reclaimed.

Some cures:

- Reforestation of intake areas on rocky hills, ridges, headwaters.
- Interceptor banks to prevent overland flow and to lead salty water to streams
- Swales plus trees to permit "sweet" groundwater recharge.
- Gypsum to restore soil structure, allow salt to wash out in rains.
- Change of land use to forestry, mulch, green crop, sparse livestock systems, reduction of cultivated areas.
- Supplanting fire regime by slashing or strategic grazing, reduction of litter to mulch by any means but fire (rollers, slashers, chippers, livestock).



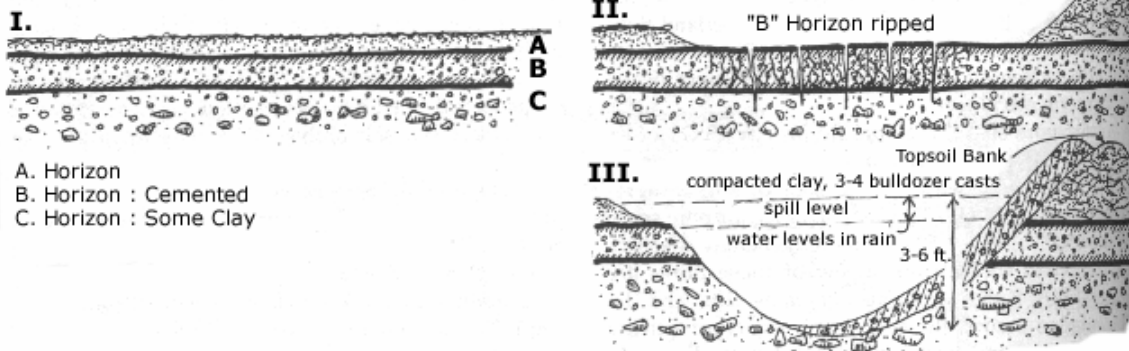


I. Unconsolidated Forest Soil Profile: composed of humus, water, clay, sand, air with crumb structure. 30% or so water space; overland flow a minor element. Deep water/soil field capacity.

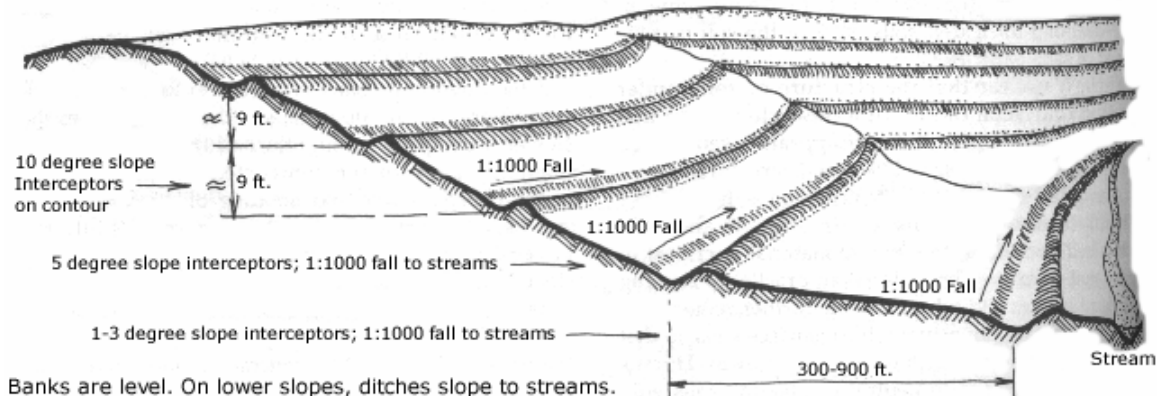
II. Process of Misuse: Clearing, overgrazing, fire, hooves, ploughs, machinery (compaction), and rain & wind leads to nutrient movement & compaction. (Sodium flocculates clay which fills air spaces and leads to III.

III. Collapsed Soil Profile: "Massive soil". Horizon (see "B") now hydrophobic, salts concentrated. 5% or less water space. Greatly increased overland flow (erosion) and evaporation. Soil collapsed about 1 meter. Only thin surface soils get wet.

3 Steps in Interceptor Bank Construction



Vertical and Horizontal Spacing of Interceptors on Steep Slopes



Human and Socio-political Factors of Desertification

Great changes may be resisted on the basis of:

- Risk: traditional methods work well and are “safe”.
- Land ownership: benefits may accrue only to already privileged people
- Increased work & expense for families and farmers
- Culture prevents the use of some foods and strategies

Effective approaches:

- Multiple small trials and feedback. Meaningful local solutions and work. Must be moderated by a land ethic.
- Education of large groups- tie education to field trials, create field days, have effective non-institutional extension and education
- Whole system approach is essential, as is long term planning for new evolutions. Interdependent services must be provided.
- Emphasis on local, familial, regional self-reliance.
- Work only with people who at first volunteer to change; others will watch and assess
- Local “associations” and work-nets (not networks) raise morale.

Section 14: Domestic Animals and Wildlife Management

Small Livestock for Zone II

- Bees
- Poultry
- Ducks
- Geese
- Pigs
- Pigeons
- Rabbits

Bees

- Careful placement to avoid stings, windblast
- Pollen and nectar sources

Poultry

- Choice of breed for situation
- Seed specifics
- Cover from predators (thorn & shelter)
- Pod species
- Placement of poultry house & range for best advantage
- Greens
- Grit and dust
- Vines and fruits
- Termite breeder

Pigs

- Forage
- Kitchen and market scraps
- Pods

Livestock Management

- Best yield strategy is a polyculture of adapted species. Native, especially “soft footed” animals

are best to use

- Make a polycultural range of ephemerals, shrubs, trees, perennials
- Rest animals after rains
- Feed them mature (not young) foliage of several species of plants
- Rangelands need regular resting, low stocking rates, rotation of grazing lots ("block grazing")

Wildlife Management

- Heavy harvest only after rains, and refuge areas provided for drought periods
- Native species (e.g. reptiles, large grubs from *Acacia* spp., frogs, and insect larvae) form large part of the diet of native people
- Mound builders (megapods) may perform a critical function, as do termite mounds, ant nests, prairie dog towns, and burrowers in general.
- Special forages, shelter, water points (underground ramp tanks) greatly increase wildlife numbers.
- Mosaic burning in cool periods may assist grazers
- Large species, e.g. in savannah, use very different habitats, food, and follow browsing sequences. Observation and assessment is essential.

Section 15: Wildlife Management and Biological Pest Control

Wildlife Management

Encouragement:

- Species to encourage: insectivorous birds, ground birds
- Forage: extension of Zone II hardy forage systems and pioneer species, especially tagasaste, oaks, pines, and locusts (honey & black)
- Provide water
- Provides shelter: hedgerow, escarpment into dams, rockpiles, logs and litter, rough places
- Mowing: strip mowing for stability, mulch, seed crop. Permanent "un-mown" strips needed
- Corridor into Zone I

Discouragement:

- Trap and cull systems for targeted noxious species
- Increase bias towards chosen species
- Provide no escape routes, shelter, food, or water

Pest Control

Integrated Pest Management:

- Use of animals in pest control, e.g. frogs (pear slug, caterpillars), guinea fowl (grasshoppers and insects), ducks (snails and some slugs); lizards (slugs and caterpillars); dragonflies & dragonfly larvae (flies & mosquitoes); predatory wasps (smaller insects, egg parasitism of some species); bantam chickens (cutworms & slugs)
- Mixed planting in orchards and gardens to encourage predator species (birds, wasps, beneficial insects)
- Sound management and husbandry practiced to discourage soil and leaf pests
- Use of plant-derived insect sprays, e.g. pyrethrum, extract from the neem tree (*Azadirachta indica*)
- Use plant competition to control land and aquatic weeds
- Release of biological fungus and bacteria to control pest populations, e.g. *Bacillus thuringiensis*
- Use of insect traps and behavioral chemicals
- Artificial feeding and attractants to induce predator species to orchard or garden site
- Mechanical management and barriers: handpicking off insects and snails; sticky goo around trunks of fruit saplings to discourage climbing insects; diatomaceous earth around garden beds to discourage slugs and snails

Section 16: Buildings and Structures

A) The temperate to sub-tropical house (latitudes 30°-60°) Essential elements:

- Orientation of axis to sun
- Insulation and draft proofing
- High thermal mass
- Ventilation
- Insulated ground under house
- Heat banks
- Cold banks and well shading
- Attached greenhouse/shadehouse/water tanks
- Function & aspect of rooms (bedrooms on shade side, living and functional rooms on sun side)

B) The tropical house (latitudes 0°-30°) Essential elements:

- Orientation to winds
- Shade on walls, valley shade, tree shade
- Reduction of mass
- Venting and air flow ducts
- Trellis and shadehouse
- Air scoops
- Tanks and cisterns
- Insect screening
- Guttering and rain catchment

C) The desert house:

- Underground
- Patio structure
- Shadehouse
- Insulation
- Trellis
- Windbreaks
- Underground water tanks

D) Special houses:

- Houseboat
- Bio-shelter (plant house)
- Earth houses
- Cave house
- Pond housing, reflective systems
- Flat land, earth-bermed house

E) Planting around houses:

- Suntrap
- Windbreak
- Wall trellis
- Shade/heat: summer-winter use of deciduous & evergreen plants
- Roof trellis

F) Fencing types and locations:

- Walls – stone and earth
- Hedges – alive
- Combination ditch/hedge
- Trellis types (linear, radial, catenary)
- Electric
- Woven
- Railed

G) Integration of function in homes:

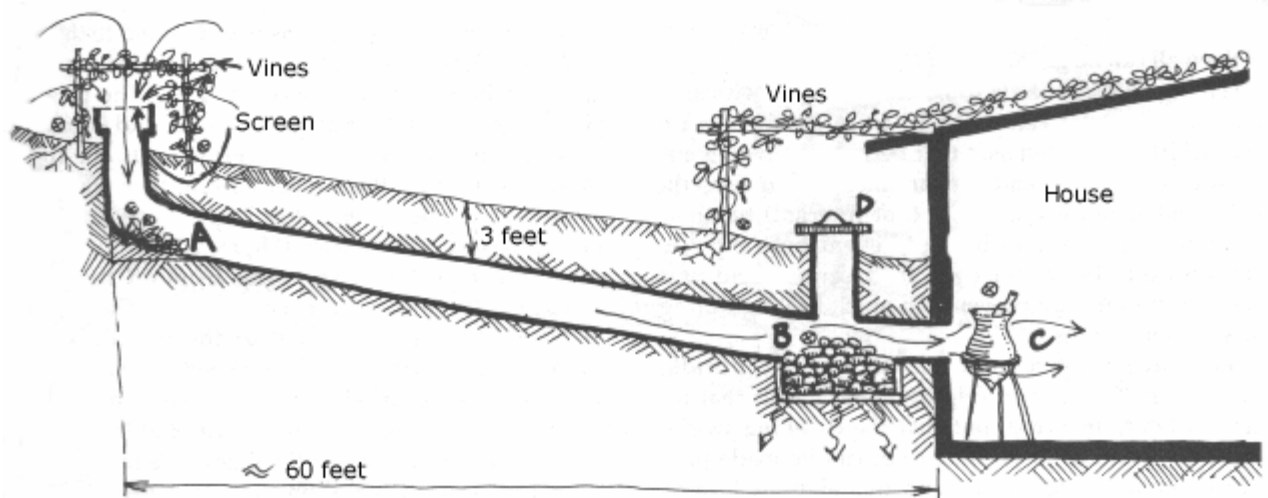
- Mud room and processing center (saves money for individual and community)
- Commerce and light industry in home (alleviates social deprivation for many women with young children, saves money on gas, good working conditions)

Section 17: Desert Housing

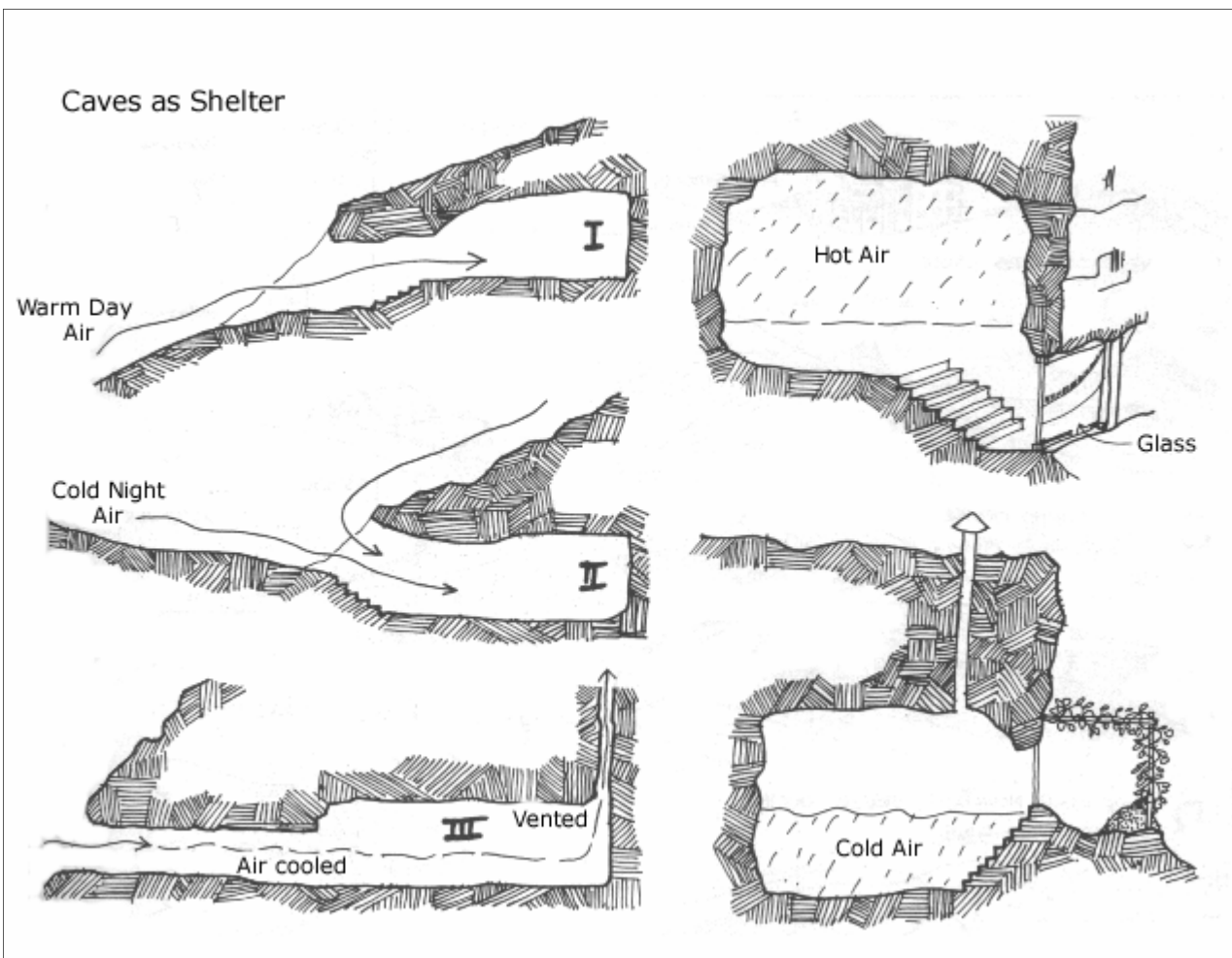
~~Underground, Dug-outs, Earth Bermed.~~

- Houses can be cheaply excavated in soft rock or where calcrete “roof” is available (use large drills, mining equipment)
- Cost is less than 50% of surface housing
- Check for radon & radiation emissions of clays and soils, especially in volcanic or granitic areas.
- Temperature varies about 5°C annually; ventilation is essential.
- Houses are comfortable, quiet, cool, dust-free.
- Caves “upslope” trap hot air; caves dipping down trap cold air.
- Examples: Coober Pedy, South Australia; Forestiers in Fresno, CA; Canary Islanders.

Courtyard House Type:



Cool Air Tunnel- provides cool, humid air to dry desert houses, food storages, hospitals, etc. Slopes down to house, has shaded intake, moist cinder bed, & unglazed pot of water at outlet.



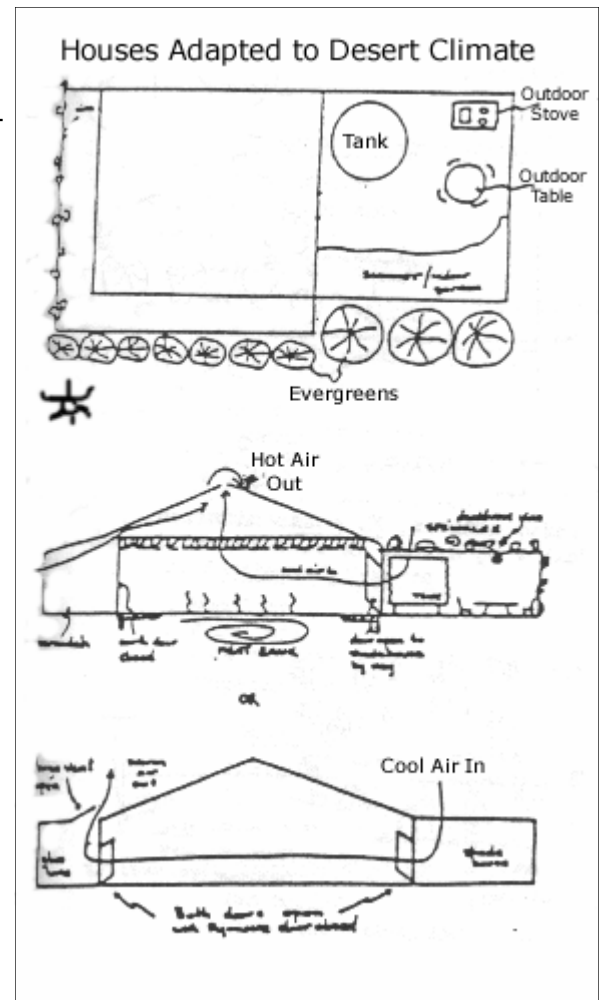
- Old & successful type used in Mediterranean countries
- All rooms face onto trellised, shaded, and watered courtyard. Can have solar chimneys to vent air.
- Flat parapet roofing is practical & allows a lot of uses (washing & drying clothes, location of tanks, pigeon loft, grain drying area, water collection/drainage to tank, entertainment area).
- Houses can have thick walls, often painted white on sun side. Often placed next to one another in settlements to reduce west wall heating.

Bungalow (Pavilion) Type:

- House should be two times longer than wide with long side facing the sun.
- Most glass on the sun side; small windows on shade side.
- No west windows; west wall painted white & fully shaded; vine-screened, evergreen trees to the west.
- Insulated ground under house
- Cold air tunnel or cold air source as a fully-enclosed, bark-mulch shadehouse
- Positive hot air exhaust as a solar chimney or small attached glass house to the sun side.
- Unimpeded through-ventilation for cool air.
- Either very thick, white, fully-shaded walls (cool deserts & cool nights) or very light, screened or matted walls (hot days & nights)
- Evaporative cooling surfaces in a through-draft; as unglazed pottery, coke mounds, ferns in bark, thick vines, or wet burlap screens.
- Cool cellars for storages or deep cool internal courtyards with vines & ferns
- Ceilings insulated, thick vine mass over roof area
- Water tank placement under shade

Placement of Vegetation Around Houses:

- Deciduous trellis on sun side. Shade in summer, open in winter.
- Permanent trellis to shade west side of house
- Trellis shadehouse or verandah on shade side
- Tall trees (e.g. palms) to the sun side (no short evergreen trees to obscure sun in winter). Trees can be tall, feathery deciduous.
- Fast-growing, drought-tolerant windbreak trees to the shade side to stop cold winds.
- Shrubs to west side to act as windbreak against hot, dry winds.



Home Energy Conservation

Water conservation:

- Water tank off roof, ideally located uphill from house
- Hand basin water flows into toilet
- Compost toilets
- Dual-flush toilets

Cooking and cookstoves:

- Wood fueled (with hot water supply)

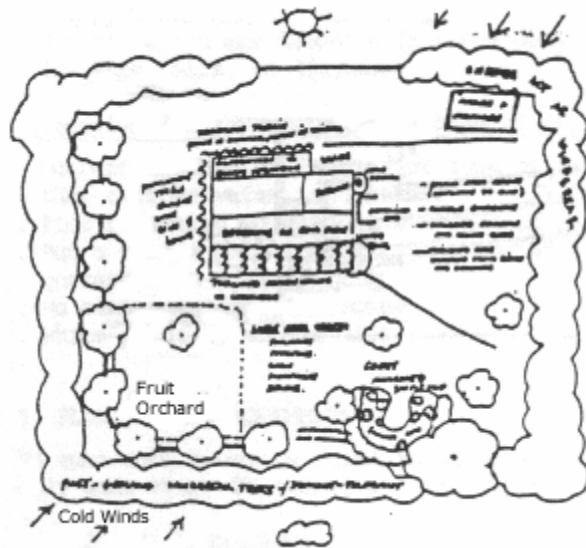
- Bottle gas, kerosene
- Solar cooking
- Haybox cooking (insulated container)

Hot water supplies:

- Hose on roof
- Solid collectors
- Flat-plate collectors
- Solar ponds
- Bread box collector

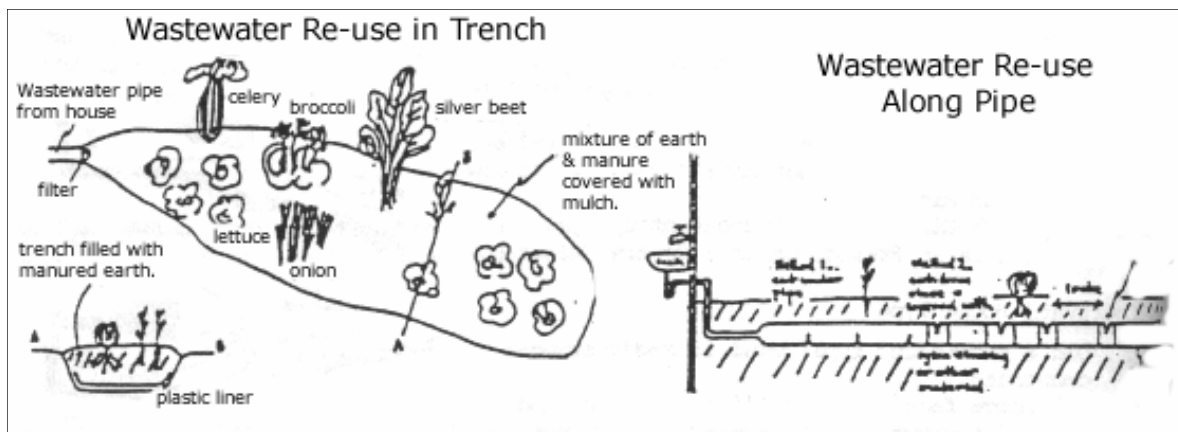
Electricity and lighting:

- Photovoltaics
- Energy conserving lights
- Gas & kerosene
- Wind power



Waste Water Re-use from House

Greywater re-uses:



Should be discharged **underground**.

- Wastewater reuse in trench
- Wastewater reuse along a pipe
- "Arbor" system for wastewater (can be sewage)

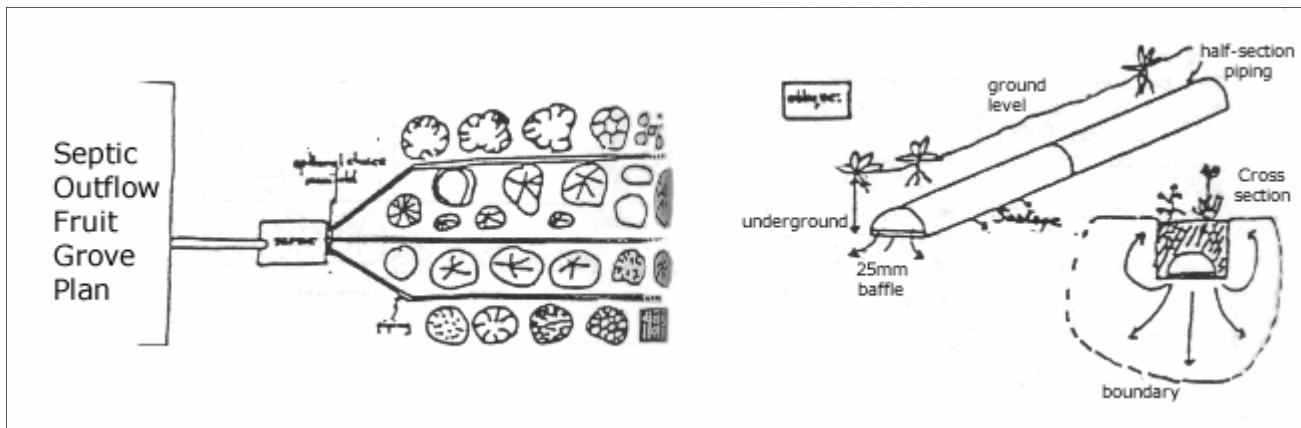
Disposal of septic tank effluent:

- via outflow to fruit grove
- via pre-planted grow holes
- discharged to non-food forests or nut crop, essential oils, & bamboos

Clearing Polluted Water (source: Max Plancke Institute, "Contributions to Revitalization of Waters" by Seidel, Happel, Graus; Am Waldwinkal 70, D 4150 Krafald-Hulserberg, W. Germany)

Water may contain acids, heavy metals, chlorinated hydrocarbons, radioactives, E. coli, nitrates, salts, silt and soap which render it unfit for human consumption. The following system is recommended for

cleaning polluted water:



Section 18: Appropriate Energy Conserving Technology

(For further information, see "Energy Paper #1" and "Energy Paper #2" by Bill Mollison, available from the Permaculture Institute, Australia)

Domestic

Conservation of domestic energy may be achieved by a set of strategies applied in combination and suited to specific sites and climates. Strategy sets are:

- Behavioral: active time of day, best use of natural daylight, and choice of clothing for climate
- House Design: house must be designed for climate, utilizing energy-conserving siting, use of plants, and use of structures such as greenhouse, shadehouse, ponds, etc.
- Technological: energy generation and choice of appliances.

Categories for technological strategies are:

- Climate control: space heating
- Cooking and cook stoves
- Hot water supplies
- Electricity and lighting
- Washing and drying clothes
- Refrigeration and cooling
- Water conservation

A) Climate control: space heating and cooling:

- Radiant heat (heats solid objects: massive stoves- slow to heat and cool; burn fuel at high temperatures; use small sticks & short burning time.
- Convective heat (cast-iron stoves)
- Greenhouse: shadehouse
- Trellis; air vents
- Conducted heat (usually large, under-floor systems using water pipes or electrical wires connected to waste heat)

B) Cooking and cookstoves

- Wood fueled (with hot water supply)
- Bottled gas, kerosene
- Solar cooking
- Haybox cooking (insulated container)

C) Hot water supplies:

- Hose on roof
- Solid collectors
- Solar ponds
- Flat-plate collectors
- Bread-box collector
- Cylindrical collectors
- Trough collectors

D) Electricity and lighting:

- Photovoltaics
- Wind power
- Energy-conserving lights
- Hydro-electric power
- Gas and kerosene lighting

E) Washing and drying clothes:

- Hand-operated pressure washers
- Coin-operated washing machines shared by community
- Drying: airy & roofed (preferably fiberglass) area
- Drying in insulated cupboard surrounding uninsulated hot water cylinder

F) Refrigeration and cooling, food drying

- Photovoltaics
- Gas and kerosene
- Sun chimneys
- Fans

G) Water conservation

- Water tank off roof, ideally located uphill from house
- Hand basin water to toilet
- Compost toilets
- Dual flush toilets
- Hydro-pneumatics (air compression)
- Harnessing tide or stream flow

Hydraulic Systems

- Pumps and water lifts
- Hydraulic rams and pumps
- Water wheels

Water turbines

Biothermal Systems

- Woodlots
- Pyrolysis
- Compost heat (the Jean Pain system)
- Gasification
- Biogas
- Metabolic heat

Solar Powered Devices

- Photovoltaic cells
- Solar ponds

- Swimming pools
- Solar chimneys

Wind Powered Devices

- Fan mills
- Blade and propeller mills
- Wind kettles
- Savonius rotors

Section 19: Waste Disposal and Recycling

Water and plants as cleansers of systemic pollution:

- Fix excess nutrients: watercress, rushes (e.g. *Scirpus validus*), water hyacinth
- Algae, e.g. *Spirulina*: desalinating, cleanses, removes radioactives, builds protein from nitrates and nitrites, has a high BTU value, is 68% digestible protein, and is low in cellulose.

Uses of waste water:

Sewage lagoons: treated through aeration, weeds, and waterfowl, then goes to fish and finally discharged to non-food forests, nut crop, essential oil crop, and bamboos. (see Section 10 for more information.)

Section 20: Design for Catastrophe

Best strategy for design is to learn climatic and landform history of area and site. Use common sense in siting houses & gardens to avoid major catastrophe, and design buildings to withstand such external energies.

Fire

Criteria for fire control:

- | | |
|--|--|
| <ul style="list-style-type: none"> • Plant firebreaks of fire resistant plant species • Use plant species with little or no litter drop • Damp mulched gardens • Mulch pit and swales system | <ul style="list-style-type: none"> • Ponds • Use succulent ground covers (e.g. ice plant) • Use foraging animals to clean or rake up litter (e.g. "raked" soil of chickens) • Paving of stone or tile; driveways |
|--|--|

Strategies for saving house in case of fire:

Criteria for plant species to assist fire control:

- | | |
|---|---|
| <ul style="list-style-type: none"> • Species having a high ash content (least combustible material) • Species which develop least dry litter as fuel • Species which burn slowly and which are self-extinguishing • Along roads and around houses are low carpeting species • Species which will extinguish (by competition) | <p>annual grasses that flash in fire</p> <ul style="list-style-type: none"> • Species that are easy to propagate by cuttings, divisions, runners, or offsets so that carpeting species and hedges are easy to develop • Species which are not summer deciduous • Species which are heavy with large water storage, low fats, oils, or turpenes |
|---|---|
-
- Gutters cleaned of leaves or type of gutter that catches water, not leaves
 - Fine screening on windows (in case of sparks)

- Put a tennis ball into the downpipe and fill gutters with water
- No bushes against the house
- White paint on wooden houses is best
- Have a tank or pond at house (all water pipes break during a fire)
- Rake up all leaves 100 feet around the house
- Fire comes uphill with greatest force so don't locate house on the ridge (have two fronts to fight)
- Keep larger, burnable trees upslope behind house

Flood, Earth Movements

No cure once house is sited in wrong spot. Must make sure not to site on flood plain (even if floods occur only once every 50 years) and don't put houses below deforested slopes (mud slides).

Cyclone, Hurricane

- Site in sheltered place, even underground
- Use bamboo as a shelter. It bends in the wind, not breaks
- House design very important. High pitched roof, 45° angles, cut stud into brace
- Have a back-up "famine garden" in very sheltered area

Tsunami

Site main house and garden far enough away from tsunami area (which occurs as frequently as every 15 years), but can have "temporary" shack or smaller house near beach.

Section 21: Settlement Design

Location:

- At abundant, low salt groundwater (which may run out); oases; reliable exotic streams, permanent pools
- At the foothills of runoff uplands (about 5% of total drylands)
- At valley or wadi sites, at time under the shelter of cliffs and scarps

Dwelling Layout:

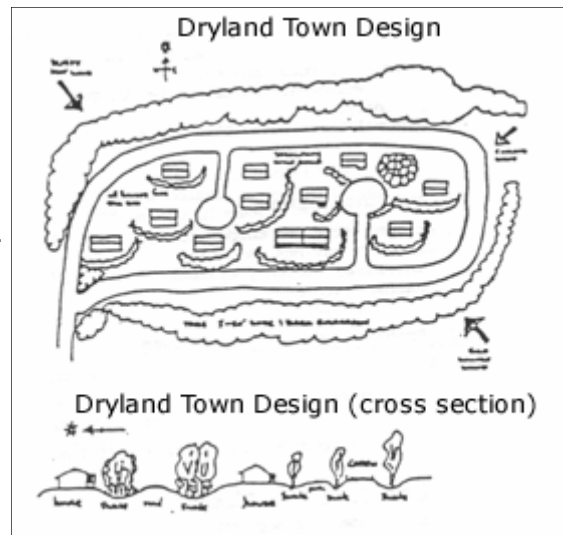
- Dense housing placed side by side along east-west alignment
- Single story housing with dense vegetation
- Multiple story housing appropriate in restricted sites (e.g. wadi banks, niches at base of cliffs, small valleys)

Reduction of Heat Sources:

- Narrow, tree-lined streets to keep sun off bituminous areas
- Paint houses and roof areas white to reflect sun
- Covered markets, usually with white canvas or cotton

Protection from Wind:

- Pitted or planted area 50-500 square kilometers around town to reduce dust storms. Ungrazed or lightly grazed in 9-18 year shifts, 4-9 year rotation.
- Road alignment of main access roads a flat "S" shape so that dust and winds cannot blow into settled area.
- Windbreak trees around settlements and at individual home sites.



Water Conservation and Reuse:

- Individual tanks and cisterns for homes; public sealed and roofed reservoirs or cisterns from run-off from public buildings, paved areas, and roads.
- Swaling to recharge groundwater supplies and to accommodate drainage needs.
- Effluent to sewage lagoons: used to grow fuel wood and/or orchard trees

Vegetation:

- Broad tree belts surround and go into town
- Species selection for fire protection, drought-resistance, fruit and nut provision, occasional fodder provision, etc.
- Lawns are of Lippia or other carpeting and drought resistant plants; not grass.
- Tree parks in town for recreation, mulch provision
- Fuel wood plantation from sewage or swaling

Livestock:

- Best as small livestock on roof, in courtyard, around house. Use pigeon, chicken, rabbit, bees, ducks.
- No livestock allowed in town- will damage trees.
- Locate livestock yards, milk sheds, shearing, and shoeing outside of town.

Section 22: The Invisible Structures of Settlements

Recycling in the Community

(for further information see "Bioregional Organization" by B. Mollison, and "The Fiscal Economy of Village Community" by B. Mollison and Reny Slay. Both available from Permaculture Institute, Australia)

A worthwhile goal of any community is to keep the money saved and earned in the community cycling within itself. The only way to do this is to establish financial and economic systems in the community, such as a credit union, revolving loan fund, or local currency.

Community economics falls into two broad categories:

- The informal economy (e.g. barter)
- The formal economy (subject to accounting procedures)

The Informal Economy

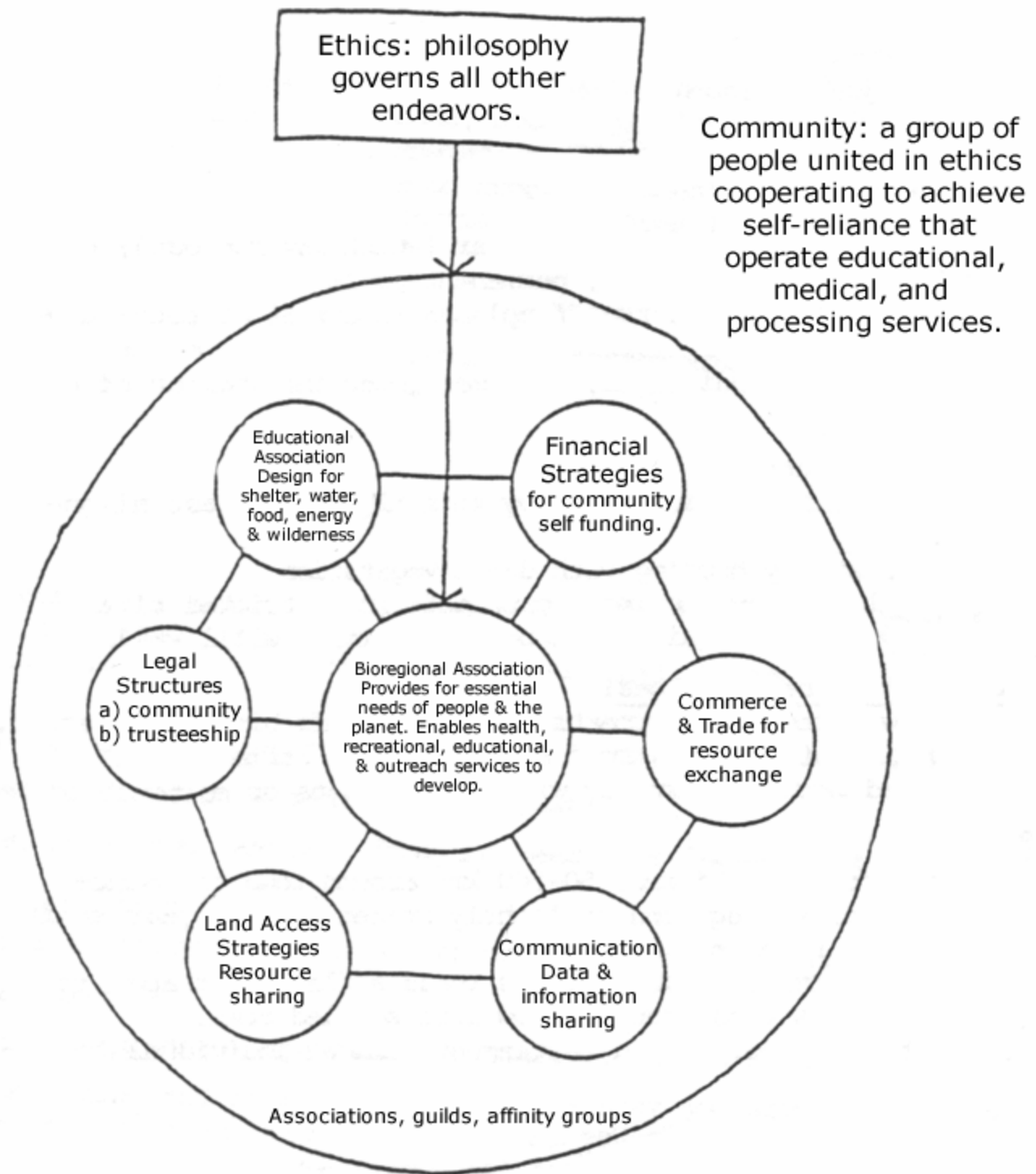
- Work groups cooperating to accomplish projects
- Community barter clubs operating on a system of "debits and credits" for the exchange of goods and services
- Purely volunteer labor to the group or community
- Informal bartering within the community

The Formal Economy

- Consumer-producer cooperatives
- Community savings and loans
- Bioregional currency systems
- Leasing systems
- Earthbank

Producer-consumer Cooperatives

A cooperative is a group of people acting together for the benefit of members. Principles are:



- Open membership
- Cooperation
- Strictly limited interest on share capital
- Surplus/savings belongs to the members
- Education
- Democratic organization

A producer-consumer cooperative both buys from and sells to the community. Money is circulated within.

Community Savings and Loan:

Revolving loan funds provide capital to community based groups as well as technical assistance. They also develop networks of lenders and borrowers. Some examples:

A) S.H.A.R.E. Program (Self Help Association for a Regional Economy, Great Barrington, MA)

Non-profit organization formed to encourage small businesses that are producing necessary goods and services for the community. Works in conjunction with local bank. Members open a SHARE account (6% interest); loans are 10% interest. Borrower must show that proposed business will be a success by 1) references of past experience & character, and 2) getting support from the community.

B) C.E.L.T. Program (Community Enterprise Loans Trust, New Zealand)

Charitable trust which promotes and supports cooperatives: provides advice, runs training sessions, and acts as a savings and loan organization. The borrowing criteria is 1) must be a cooperative group, and 2) the cooperative must be willing to work closely and regularly with CELT during the loan so that it has the greatest chance to succeed.

C) Credit Union

Credit unions must have a unifying common bond that links the membership together. They have a purposeful, non-profit structure and are owned by the depositors who are shareholders and are organized for the benefit of the members, providing both the normal banking services as well as financial counseling and guidance for members.

Credit unions are harder to start, and must comply with governmental regulations by having a common bond (occupational, associational, and community) and by demonstrating the need for starting a new credit union and the support to sustain one.

Local Currencies:

Already there are many "currencies" in the form of vouchers, coupons, and tickets. These can be traded for goods and services. On a community level, these vouchers or currency can be based on a real asset of the community (e.g. wood or clean water); a community services council could print, back up, and handle the currency which can be exchanged for most goods and services in the area. The community can then start community projects with the money. Businesses starting up can "pre-sell" their services in order to get start-up capital.

Earthbank:

The Earthbank Society in Australia and Earthbank Association in the U.S. exist to gather data on current alternative economic and financial strategies, and to assist in setting up ethical financial systems in the

region. Local earthbank societies must be started in every bioregion. For lists of revolving loans, funds, ethical investment banks and associations, and examples of community self-help systems subscribe to Permaculture Journal, Australia (for Earthbank News) and "Earthbank News", USA (addresses in resource section)

Leasing Systems:

Any community, group, or individual can run a leasing service for others. A group may get together to purchase an item (i.e. vehicle, photocopier, mulch chipper) for lease to the general community (i.e. by the kilometer, piece, or hour). The charge applied must pay for purchase, maintenance, and replacement costs within a period of 2-5 years depending on the item purchased.

Land Access and Urban Systems

- Oxfam (land lease) system
- City farms
- City as farm; and gleaning
- Land trusts and trusteeship
- Farm and garden clubs
- Farm-link system
- Commonworks

Oxfam (land lease) system:

A regional office is needed to link landless people in the city with those (usually pensioners) who have a large lot or backyard that needs tending. Regional offices prepare a standard lease specifying rental (if any), goods exchange, length and type of lease, and access. The office should make a small service charge for this and many other urban services (the function of a bioregional office is to serve the community).

City farms:

Very popular in the U.K. Associations lease or are given land and a management group is appointed. On this land the following activities are promoted:

- Demonstration gardens/allotment gardens
- Domestic animals kept; used as demonstration and breeding stock
- Recycling center for equipment and building materials
- Family and community meetings and picnics
- Tool rental and access
- Gleaning operations (see below)
- Plant nursery
- Seeds, books, plants, and general retail sales
- Seminars, demonstration, training programs, and educational outreach

City as Farm: Gleaning:

Surplus city product is collected, sorted, packaged (if necessary), and retailed. Example is of a man in Melbourne who makes a living collecting and selling chestnuts from backyards. Gleaning operations can even take place in country areas near the city for distribution to community groups, the poor, the general public, etc. Another strategy is to provide a service (mowing, pest control, manuring, fire control) by ranging sheep, duck, or geese flocks in city backyards or lots.

Farm Link:

Appropriate to high-rise or rental families in an urban area. Fifteen to twenty families link to one farm in

the nearby country thus providing a farmer with income and themselves with fresh, inexpensive fruits and vegetables, wheat and meats depending upon the arrangements made with the farmer. The families should meet quarterly (or have a representative do so) with the farmer to make seasonal choices. As the “link” grows, the system can also accommodate holidays on the farm, city (family) help on the farm at busy periods, and educational workshops.

Farm and Garden Clubs:

These suit families with some capital to invest as shares with annual membership dues. A farm is purchased by the club or association, and a manager (if necessary) is appointed. Depending on the aims of the association, farms can be used for a variety of purposes: food growing, holiday retreat, woodlot and forest establishment, fishing, etc.

Commonworks:

A farm held by a land trust near the city arranges a series of special leases for a variety of purposes and businesses (forestry, livestock, teaching, crafts, dairy, brickworks, and other complex enterprises). Some of these are land (area) leases and others are activity leases. 10% net profit is returned to the Commonwork Fund for land to be developed for other leases. One such farm in Kent, UK demonstrates the best model of such farm use at the highest level (send \$2 for information from: Commonwork, Bora Place, Chiddingstone, Edenbridge, Kent TN8 7AR, UK)

Trusteeships and Land Trusts:

In order to acquire land (without purchasing it) for community or public purposes, must set up a public charitable or non-profit trust (more information follows in other sections). Once the trust is formed, it is in a position to advertise for and receive gifts of land and funds.

Legal Forms

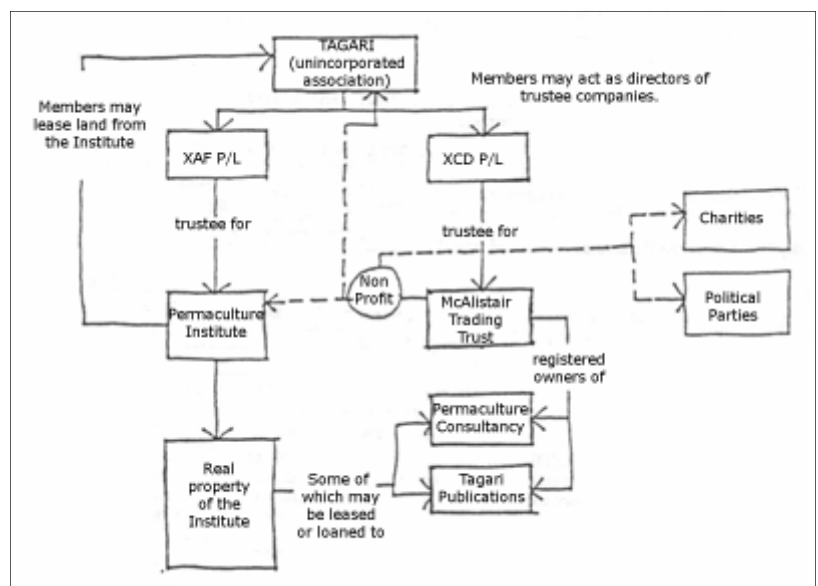
- Discretionary trusts
- Subscription trusts (investment trust)
- Charitable trusts

Discretionary Trust

Conducts affairs as any normal business. The difference is that it does not keep any profit but rather distributes it to beneficiaries. The company does not pay tax if it distributes its income, but the beneficiaries are liable for personal tax. Trust has a trust deed (statement of purpose), board of directors, secretary, annual general meeting, and can own business names. (In the case of McAlister Trading Trust, for example, it owns the business names “Permaculture Consultancy” and “Tagari Publications” — see right for schematic drawing).

Non-profit, Education, Charitable Trusts

Set up for the public good. May accept gifts and donations (lands and goods)



from the public and other trusts (e.g. the discretionary trust described above). Directs the money towards its stated aims as described in its trust deed. Also has a board of directors and must follow the legal rules. It is immune from taxation and may apply also for tax deductible status (for people gifting goods and property).

Investment Trust

Groups get together to advertise for investment funds (or even donations) from the public in order to invest in ethical propositions, particularly the purchase and renovation of degraded land, village developments, bioregional development, and purchase of forested areas. The emphasis would be on rehabilitation- both social and environmental.

Village Development

(For further information see "Outline for Permaculture Village Development" by B. Mollison, available from Permaculture Institute, Australia)

- Forming the management group
- Location of site or formation of group
- Arranging site option or purchase terms
- Obtaining agreement from local government (may require extensive planning and environmental reports)
- Obtain sealed permission for subdivision, cluster title, strata title from local authority
- Do careful budgets for roads, land purchase, sewage, water, electricity supply, etc.
- Prepare a detailed and careful site plan and proposal for the village
- Sell to clients by advertisement (if group not formed previously)

Village Infrastructure:

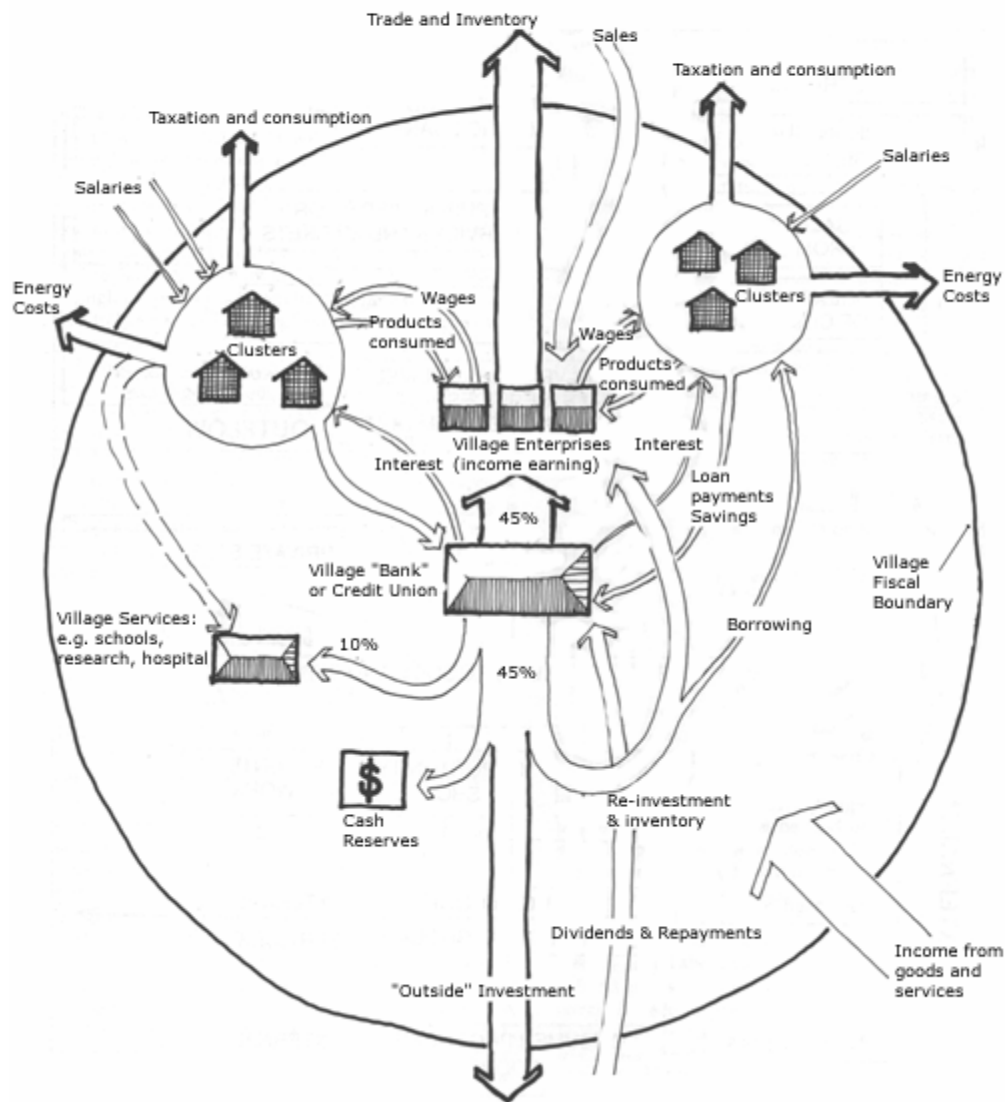
- Private housing
- School, seminar and workshop rooms; craft and community area
- Food processing center, café, commercial or surplus market (open air Sunday market)
- Retail shops and "tourist" facilities
- Dairy processing center
- Domestic livestock housing (chickens, goats, pigs, sheep)
- Common areas for recreation, woodlot, building materials (poles)
- Domestic and commercial crop areas
- Water storage and reserves
- Wildlife and forested conservation areas
- Village revolving loans fund

Potential Enterprises and Occupations:

- Food provision
- Energy provision
- Vehicle and tools
- Financial
- Medical
- Building
- Services (accounting, typing, computer)
- Repair
- Craft
- Trade (retail)

Schematic of Capital Flow Within and Without a Village

The aim is to keep as much money as can be usefully and productively used within the system. This reduces taxation, consumption of outside resources, energy costs, and outside investment and returns resources to income and consumer products within the village. Consumption is reduced by lifestyle change, vehicle sharing, etc. Taxation is reduced by legal strategies. Energy is saved by technological strategies and conservation. Outside trade is reduced by developing local resources. Little of this is possible unless investment via the village bank is controlled by the village.



Village Homes, Davis, California:

- Stores all surplus storm water into swales for groundwater recharge
- All buildings face the sun and contain solar devices
- Streets narrow with few parking spaces (but enough) to cut down on heat build-up from pavement
- Many bicycle paths throughout the community
- Common spaces for recreation; lots smaller than usual
- Privacy on street side (usually fenced) with share “public” backyards that usually contain gardens and fruit trees
- Common food growing areas, particularly grapes, fruit trees, jujubes.
- Ten percent of houses allocated for low income families (who apparently do most of the planting and even have an on-site tortilla business).

Commerce

- Cooperatives
- Strategies applicable to small businesses
- What makes a small business successful?

Cooperatives:

Cooperatives are formed to help in community revitalization and worker productivity and contentment. Decentralized, worker owned, and (usually) socially conscious, co-ops are a useful alternative to single ownership businesses. A famous example is the Mondragon Cooperatives in the Basque region of Spain where 10% of profits are returned to the community for public services; a cooperatively run bank oversees businesses and gets them started; and there are no redundancies- workers are retrained and new jobs found in other expanding cooperative endeavors.

Small Business Strategies (including for co-ops):

- A) Presales and pledges: can get a business started. Books are often “pre-sold” in order to pay for printing costs. One example of a restaurant (“Zoo-Zoos”) printing food vouchers redeemable up to a year (discount on a meal) to buy out the original owner. Individuals contemplating a small business should ask the people in the community whether they would buy his/her goods or services.
- B) Cooperative catalog: individuals and businesses can get together to put out a catalogue of all their goods and services. This has been done in the US in “The Catalogue of Wonderful Things” (crafts) with each product and address given individually. Can also try the idea of a cooperative “label” and the filling of orders through a co-op business set up for such a purpose.
- C) Loans: should receive loans from a local SHARE or CELT group. There are even government agencies that make low interest loans to cooperatives (which must demonstrate viability).

The Successful Small Business:

- Start small and learn how to run a business
- Start a business in an area in which you are interested (not which you think will make \$\$)
- Gain a good reputation for service and durability
- Action: once decision is made, effort is made quickly to adopt it
- Belief in a set of values for the company that are often restated.
- Respect and encouragement of co-owners or staff
- Use a simple organizational structure with “management” in close contact with staff and customers
- Look ahead

Section 23: How Permaculture Trainees Operate

What Next?:

Graduates of a permaculture design course are designated as “trainee permaculture designers” and must complete at least two years work in any permaculture field (as designated below). Evidence of work must accompany written submission. Usually this is an accompanying letter signed by 1) your initial permaculture design course teacher(s), 2) a permaculture designer who has received a diploma from the PC Institute, or 3) a reputable, independent person known by both the designer and the Institute.

A Diploma of Permaculture Design shall be issued in the following fields (check Permaculture Journal #19, page 13 for full description):

- Site design
- Media and communications
- Site development
- Education
- Administration
- Trusteeship
- System establishment and implementation
- Manufacturing
- Community development
- Finance
- Research

Diplomas are issued by the continental Permaculture Institutes (see references). Higher degrees may be obtained: contact Bill Mollison at Permaculture Institute, Australia. All design course graduates should maintain a subscription to the Permaculture Journal to keep abreast of news and changes.

Report Writing and Client Needs:

- Clear addresses: client home & business addresses, your own address, client’s property location
- Client needs and resources: lifestyle, future development, number of people and form of involvement, expenditure, other resources, skills, interests.
- General property description: size, titles, sub-divisions, aspects, orientations, slopes, present vegetation, soils, water, access, areas defined (planning units). Attached maps, aerial photographs if necessary (caution: do not over-do general property description as client generally already knows it)
- Detail of areas: e.g. Zone 1: house & yard design, intensive culture; Zone 2: cultivation, animals; Zone 3: forest; Zone 4: shaded slopes, water, etc.
- General themes affecting the site, e.g. fire, marketing possibilities, mosquito control, aquaculture, and so on.
- Include useful references: resource people, other clients, books & publications, government assistance, financial help, organizations.
- Documentation: e.g. plant lists, details of retrofits, layouts of areas (designer may need illustration assistance)

Common Errors:

- Assumption of client knowledge of all facets of report
- Lack of detail sketches
- Depersonalized approach
- Recommendation of difficult technologies
- Resources not noted or explained
- Generalities (e.g. “suitable plants”)
- Poor patterning
- No management data
- Priorities not stressed
- Recommending illegal or “impossible to get” species

For methodologies of design see Section 2.

Creating Work:

- Find a niche and fill it
- Start to teach and design even if its free at first. Paid work will eventually come.
- Research and assemble data for other designers
- Cooperate with co-designers to form team
- Start a permaculture association or consulting agency in your area (combine it with earthbank or bio-regional services)
- Offer services and help set up community social services (e.g. city farms, food co-ops, teaching and demonstration areas for permaculture, etc.

Ending:

Half a day of assessment. Class to indicate future work and ideas, volunteer for responsibilities, etc. Complete curriculum vitae for the continental permaculture institutes. Provide:

- Name and home address (please notify if address changes)
- Qualifications (Education)
- Skills
- Affiliations
- Ability to lecture
- Phone numbers
- Job experience
- Interests
- Ability to travel

Section 24: Resources

Permaculture Literature:

Permaculture Journal, P.O. Box 367, Maryborough, Victoria 3465. A must for all permaculture design course graduates. Contains news, information, informative articles, and the world wide permaculture directory. \$13/yr/Australia; \$15/yr overseas. Editor: Terry White (also contains Earthbank News)

The International Permaculture Seed Yearbook (TIPSY), P.O. Box 202, Orange, MA 01230, USA Excellent yearly publication on many aspects of permaculture including bio-regionalism. Encompasses urban and cold weather permaculture, useful plants and techniques. 1983 & 1984 TIPSY: \$7.50 US/ \$10 overseas; 1985 TIPSY: \$10 US/\$12.50 overseas. Editors: Dan Hemenway and Thelma Snell.

Permaculture Design Course Pamphlet Series, Yankee Permaculture, P.O. Box 202, Orange, MA 01230. 1981 edited transcript of Bill Mollison's PC Design Course. Write for complete list and prices.

Permaculture Tapes, Treespeak Studios, P.O. Box 10, Nannup, West Australia 6275. Recorded at 1983 PC Design Course taught by Bill Mollison. Kit of twenty-nine 90 minute tapes with supporting index and diagrams available for \$300. Sample Tape 1 available separately for \$12. Editor: Jeff Nugent.

The Permaculture Designer's Newsletter, Brian Davey, Helenvale via Cooktown, Queensland 4871. Monthly consultant's news and contacts, things that don't get into the PC Journal, a chance to know what everybody is involved in. B. Davey also collects consultants' site designs.

Permaculture Communications, Guy Baldwin, P.O. Box 101, Davis, CA 95617 USA. Offers a mailing list service and the "1984 Permaculture Designers Directory" (US only)- a listing of all people who attended permaculture design courses in the US. \$5/US/ \$6.50 overseas.

Global Consultancy Service, organized by Lea Harrison, Stoddarts Rd., Tyalgum, New South Wales 2484. For design consultants who wish to become involved in overseas development work. For those who feel they are competent for such work, please send for a questionnaire.

Perma- What? The Best of Permaculture, coverage of the best articles found in the permaculture journals and newsletters around the world (updated where possible). Concentrates on work that is timeless and practical. \$12.50 plus postage. Checks payable to: Nascimanera, c/ 56 Isabella Ave., Nambour, Queensland 4560.

Permaculture Consultancy, check address in PC Journal. Has many reports and publications for sale, most written by Bill Mollison and not available elsewhere. Plant Series, Outline for Permaculture Village Development, Energy Papers on Domestic and Village Energy, Permaculture Trust Documents, etc. Send SASE for brochure (Australia only please; overseas: please add \$1.)

Permaculture Resource List

International Permaculture Seed Yearbook
PO Box 202
Orange, MA 01230

Permaculture International Global Directory
P.O. Box 6039, South Lismore, NSW 2480 AUS
Fax: Int. (61)(0) 66-22-0579
(list of Permaculture connections worldwide)

Permaculture Institute
P.O. Box 1, Tyalgum
NSW 2484 AUS
Tel: 011 61 66 793 442
Fax: 001 61 66 793 567

Permaculture Institute (USA)
Scott Pittman, PO Box 3702
Pojaque, NM 87501
505-455-0270, Fax: 505-455-0514

Permaculture Activist
PO Box 1209
Black Mountain, NC 28711
704-298-2812, Fax: 704-298-6441

Permaculture International Journal
Available from the Activist (above)

Permaculture Drylands Journal
PO Box 27371
Tuscon, AZ 85762-7371

Ag Access, 603 4th Street
Davis, CA 95616
916-756-7177 (booklist 800-239-7177)

Oasis Bio-Compatible Products
1020 Veronica Springs Road
Santa Barbara, CA 93105
805-682-3449

Bio-Integral Resource Center
PO Box 7414
Berkeley, CA 94707

Institute for Sustainable Forestry
PO Box 1580
Redway, CA 93560
707-923-4719

Ecology Action
5798 Ridgewood Road
Willits, CA 95490

Permaculture Institute of Northern California
PO Box 341
Point Reyes Station, CA 94956
415-663-9090

Permaculture Institute of Southern California
1027 Summit Way, Laguna Beach, CA 94657
714-494-1443

Sonoma Permaculture
3696 Burnside Rd., Sebastopol, CA 95472
707-329-5524

ATTRA: Appropriate Technology Transfer for
Rural Areas
PO Box 3657
Fayetteville, AR 72702
800-346-9140
Sustainable farming info center

Permaculture Journal
PO Box 367
Maryborough, Victoria 3465 AUS

Permaculture Design Course Pamphlet Series
(same address as above)

Permaculture Communications
Guy Baldwin
PO Box 101
Davis, CA 95617
Mailing List Service

Bay Area Permaculture Guild
PO Box 9606
San Rafael, CA 94912
415-761-8220 email: bapo@slip.net
www.nbn.com/people/bapo

Landlink Center For Rural Affairs
PO Box 405
Wathill, NH 68067-0405
402-846-5428
NAFEX-North American Fruit Explorers
100 South 055 Madison St.
Hinsdale, IL 60521

Permaculture News & Gossip
Michael Lockman
PO Box 45472
Seattle WA 98145
360-376-2071

Friends of the Trees Society
Traveler's Earth Repair Network (TERN)
Third World Resource Guide
Michael Pilarsky
PO Box 4469
Bellingham, WA 98227
360-738-4972 fax 360-671-9668

California Oak Foundation
1212 Broadway, Ste 180
Oakland CA 94612
510-834-3741

Northwest Intentional Communities Assoc.
Membership Information Exchange
Finney Farm
4004 South Skagit Hwy
Sedrow Wooley, WA 98284
360-826-4004

Intentional Communities Directory
C/O Alpha Farm
Deadwood, OR 97430
Flowforms, Inc.
Jennifer Green
Rt. 177 Box 930

Bluehill, ME 04614
207-374-2384

Integral Energy Systems
800-735-6790

ITDG of America
Bootstrap Press
777 United Nations Plaza
New York, NY 10017
212-053-6920 or 914-271-2039

Ecology Center Terrain Newsletter
Berkeley, CA 94705
510-548-3403

Network to Reduce Overconsumption
Directory of Organizations and Leaders
PO Box 15981
Seattle, WA 98115 (\$10)

International Center for Ecology and Culture
PO Box 9475
Berkeley, CA 94705
510-527-3873

Bamboo

The Bamboo Garden
Ned Jaquith
1507 SE Alder
Portland, OR 97214
503-231-7322

Bamboo People
322 N 82nd St.
Seattle, WA 98103
www.highway99.com/bamboo
Daphne Lewis 206-761-1437
Simon Henderson 360-629-6160; simonh@sos.net
Stuart Bruno 206-788-5292
Farmers, designers, consultants, and researchers
for bamboo shoot and pole cultivation, production,
and marketing.

Clinton, Inc.
12260 1st Ave
South Seattle, WA 98168
Field grown phyllostachys. By appointment.

Colvos Creek Nursery
John Rogers
Box 1512
Vashon Island, WA 98070
3 owners, many varieties, wholesale

Elysian Gardens- Elizabeth Boyd
26400 NW Lobo Lane
Hillsboro, OR 97124
503-647-0100; Fax: 503-647-2836
Field grown bamboos, by appointment

Bamboo Gardener: Jeannine Florance
196th Ave and SR 202
Redmond, WA 206-782-3490

Beauty and Bamboo
Stan Andreasen
306 NW 84th St
Seattle, WA 98117-3117
206-781-9790

Blue Heron Farm
A. Schwartz and Michael Brondi
1219 East Saulk Rd
Concrete, WA 98337
Plants, poles, free bamboo removal, by app't

Bob Boatman
12121 38th NE
Seattle, WA 98135
206-363-2951 Retail/Wholesale
40 species of Bamboo

Tom Copeland- by app't
3817 Mount Baker Hwy
Everson, WA 98274
Rare trees, shrubs. 5 acres of bamboo.

Jim Engan
20914 135th Place
Kent, WA 98024
206-631-9702

Recommended Reading

Permaculture

- *Permaculture: A Designer's Manual*, Bill Mollison, Tagari
- *Introduction to Permaculture*, Bill Mollison and Reny Mia Slay
- *Ferment and Human Nutrition*, Bill Mollison
- *Travels in Dreams*, Bill Mollison
- *Permaculture Garden*, Graham Bell
- *The Final Empire*, William Kotke, available from Arrow Point Press 605 SE 15th Ave., Portland, OR 97204
- *From Eco-Cities to Living Machines*, Nancy Jack Todd and John Todd
- *Soft Energy Paths*, James Lovelock
- *Patterns in Nature*, Peter Stevens
- *Ecological Design*, Sym Van der Ryn and Stuart Cowan
- *Sustainable Settlements: Restoring the Common Habitat*, v. 19 #4, Newman Press 1961, Australia Conservation Foundation
- *Permaculture in a Nutshell*, Patrick Whitefield
- *Earth User's Guide to Permaculture*, Rosemary Morrow
- *The Best of Permaculture*, Max O. Lindergerger and Rosemary Tap
- *Living Communities: a Permaculture Case Study at Sol y Sombre*, Ben Haggard

Economics

- *The Ecology of Commerce*, Paul Hawken, Harper
- *Beyond Counterculture*, Jentril Anders
- *Rebuilding Community in America*, Ken Noward and Kathleen Smith
- *Community Land Trust Handbook*, Institute of Community Economics
- *Intentional Communities Handbook*
- *Bioregions and Biotechnologies: a New Planning Tool for Stable State Economic Development*
- *Paradigms in Progress: Life Beyond Economics*, Hazel Henderson
- *The Ladakh Project: Ecological Steps Toward a Sustainable Future*, Helena Norberg Hodge
- *Ancient Futures*, Helena Norberg Hodge
- *Industrial Ecology*, Hardin Tibbs
- *Start Your Non-Profit Corporation*, Nolo Press, Berkeley

Energy

- *Hydraulic Ram Pumps*, T.D. Jeffrey, *Intermediate Tech Publications*, 1992
- *Wind Power*, Donald Marier, *Rodale Press*, 1981
- *Passive Solar Energy Book*, Edward Mazria, *Rodale Press*, 1979
- *Solar Living Sourcebook*, *Real Goods*, 800-762-7325
- *Energy Basis For Man in Nature*, H.T. and E.C. Odum, *McGraw Hill*, 1961
- *Environment, Power and Society*, Howard Odum
- *Renewable Energy: Sources for Fuel and Electricity*, Thomas B. Johansson
- *Ecological Literacy: Education and the Transition to a Post-Modern World*, David Orr

Water/ Greywater/ Ponds, etc.

- *Getting Food from Water*, Gene Logsdon, *Rodale Press* 1978
- *Water for Every Farm*, P.A. Yeoman
- *Water: Element of Life*, Theodore Schwenk
- *Sensitive Chaos*, Theodore Schwenk
- *Handbook of Gravity Flow Water Systems*, Thomas Jordan, *Intermediate Tech Dev. Group*
- *The Toilet Papers*, Sim Van der Ryn, *Wild Woman Press*, New York
- *Constructed Wetlands for Wastewater Treatment, Municipal, Industrial and Agricultural*, Donald Hammer, 1989
- *Dynamic Aquaria: Building Living Ecosystems*, *Academic Press*

- *Freshwater Crayfish Aquaculture*, J.V. Hunter, Food Products Press
- *Freshwater Aquaculture Book*, William McClarney
- *Water Encyclopedia*, Van der Leeden
- *Practical Handbook of Groundwater Monitoring*, David Nielsen, 1991
- *Ecological Engineering: an Introduction to Ecotechnology*, Mitch & Jorgenson, 1989
- *Ecological Engineering for Wastewater Treatment*, C. Etneir and B. Gullerslam
- *Aquatic Plants for Water Treatment and Resource Recovery*, Reddy and Smith, 1987
- *Residential Wastewater Systems*, NAHB Staff, 1980
- *We all Live Downstream: A Guide to Waste Treatment that Stops Water Pollution*, Costner
- *Groundwater Quality Protection*, Larry W. Xanter, 1987
- *Limnology*, Goldman and Horne
- *Watershed Hydrology*, Peter Black, 1991
- *Groundwater Hydrology*, David K. Todd
- *Aquifer Restoration*, R.C. Knox
- *Home Water Supply: How to Find, Filter, Store and Conserve it*, Stu Campbell, 1983
- *Principles of Aquaculture*, Robert R. Stickney

Gardening/ Farming/ Soil/ Biodiversity

- *The Organic Method Primer*, Bargyla and Gylver Rateaver
- *Seeds of Change*, Kenny Ausubel, Harper, 1994
- *Soil Conservation Handbook*, from Kenya
- *Pay Dirt*, (on CSA's) Mimi Luberman
- *Dirt, the Ecstatic Skin of the Earth*, William B. Logan, Riverhead Books, 1995
- *Common Sense Pest Control*, Oikowski
- *Landscape Ecology*, R.T. Foreman
- *Nature and Property of Soil*, Grady
- *Start with the Soil*, Grace Gerchuny
- *Factors of Soil Formation*, Hans Jenny
- *Seed to Seed*, Suzanne Ashworth
- *One Straw Revolution*, Masinoba Fukuoka
- *A Natural Way of Gardening*, Masinoba Fukuoka
- *New Roots for Agriculture*, Wes Jackson
- *USDA Yearbook*, 1950
- *The Ruth Stout No Work Garden*, Ruth Stout
- *Soil Types*, Miles C. Brady
- *Secrets of the Soil*, Peter Tompkins and Christopher Bird, Harper
- *The Secret Life of Plants*, Peter Tompkins & Christopher Bird, Harper, 1973
- *Encyclopedia of Organic Farming and Gardening*, Rodale Press
- *Monocultures of the Mind*, Vandana Shiva, Zed Books, 1993
- *Biotechnological Slope Protection and Erosion Control*, Gray/Donald
- *Sunset Western Garden Book*, 1994 and later editions for high altitude zones
- *Seeds of Peace*, Sulak Sivaraksa
- *The Rodale Guide to Composting*, Jerry Minnich & Marjorie Hunt
- *Companion Planting*, Richard Bird, Quarto Publishing, 1990
- *The Vegetable Garden*, M.M. Vilmorin-Andrieux, Ten Speed Press
- *Gardening with Nature*, Leonard Wickenden
- *Plowman's Folly*
- *Grass Productivity*, Andre Voisin
- *Bugs, Slugs, and Other Thugs*, Rhonda Massingham Hart, Storey Publishing (800) 441-5700
- *Deer Proofing Your Yard and Garden*, Rhonda Massingham Hart, Storey Publishing
- *Rocky Mountain Horticulture*, George Kelley's Garden Book, Pruett Press

Agroforestry

- *A Forestry Journey*, Robert Hart and A.J. Douglas
- *Forest*, Robert Hart and A.J. Douglas
- *Tools and Devices for Coppice Crafts*, F. Lambert
- *The Scientific Basis of Alternative Agriculture*, Miguel Altieri
- *Petersen's Guide to Forests*
- *Green Woodwork*, Mike Abbott
- *Traditional Woodland Crafts*, Tabor
- *The Joy of Wood*
- *How to Make a Forest Garden*, Patrick Whitefield
- *Restoration Forestry: A Guide to Sustainable Forestry Practices Worldwide*, Michael Pilarsky

Architecture and Design

- *A Pattern Language*, Christopher Alexander
- *Design with Nature*, Ian McCarg
- *The Passive Solar Energy Book*, Edward Mazria
- *Buildings as Organisms*, Day Chahroudi
- *Places of the Soul*, Christopher Day
- *Architecture for the Poor: an Experiment in Rural Egypt*, U of Chicago Press
- *The Straw Bale House Book*, David Bainbridge; Athena and Bill Steen, Real Goods
- *The Rammed Earth House*, David Easton, Real Goods
- *Cob Building Book*, Ianto Evans
- *Architecture Without Architects*, Bernard Rudofsky
- *The Re-Envisioning Manual*, Kevin Wolf
- *Sacred Geometry*, Robert Lawler
- *On Growth and Form*, D'Arcy Thompson
- *Design and Construction of Small Earth Dams*, K.D. Nelaon, Inkala Press, 1985
- *The Climate Near the Ground*, Rudolf Geiger, Harvard University Press, 1950
- *Boundary Layer Climates*, T.R. Oke, Routledge, 1978
- *Earth Sheltered Homes*, Marty Davis
- *Earth Ships*, Michael Reynolds
- *The Small House Book*, Richard Metz
- *Shelter Book*, Lloyd Khan

Language

- *Song Lines*, Bruce Chadwick
- *Language, Thought, and Reality*, Benjamin Warf
- *ABC*, Ivan Illyich
- *Sense and Sanity*, Korzypsky
- *Angles Fear*, Gregory Bateson and Mary Katherine Bateson
- *The Ohlone Way*, Malcolm Margolin

Miscellaneous

- *Women's Work: the First 20,000 Years*, Elizabeth Wayland Barber
- *The Guru Papers*
- *Holistic Range Management*, Allan Savory
- *Abehsera Biotransmutation*
- *I Won't Learn from You*, Herbert Cole
- *The Archetypes Within You*
- *Beyond Majority Rule*, Sheenan
- *The 5th Sacred Thing*, Starhawk, Harper
- *How to Lie with Maps*

- *Map Resource Book*
- *Map Reading*, available from the Boy Scouts of America
- *The ABC & XYZ of Beekeeping*, Ormand Harry Aebi
- *The White Goddess*, Robert Graves
- *Taliesin*, John Matthews
- *California's Changing Landscapes*, Michael Garbour Davis
- *An Island Called California*, Elna Bakker
- *Natural History of California*, Allen Sheener
- *Clean and Green*, Debra Dadd Redalia
- *The Way Things Are*, Malcolm Margolin
- *The Material World*, Peter Menzel, Sierra Club
- *The Spell of the Sensuous*, David Abram
- *State of the World*
- *Diet for a New America*, John Robbins
- *Empty Harvest*
- *Red Earth, White Lies*, Vine Deloria
- *The Survival of Civilization*, John Hamaker & John Hammond
- *Sacred Land, Sacred Sex*, Delores LaChappell

Kids

- *My Side of the Mountain*
- *Journey to the Mushroom Planet*, Eleanor Cameron
- *The Education of Little Tree*

Bibliography: Plants for Permaculture

- *A New Tree Biology*, Alex Shigo, 1986. Shigo and Trees Associates, 4 Denbow Road, Durham, NH 03824. An extremely important and educational book on how trees actually are "constructed", grow, and die that debunks the myths which keep us damaging trees by our ignorance. Expensive, but worth it.
- *Nut Tree Culture in North America*, Richard A. Jaynes, editor, 1979. Northern Nut Growers Association, Broken Arrow Road, Hamden, CT 06518. **The Book** on nut trees.
- *Organic Orcharding: A Grove of Trees to Live In*, Gene Logsden, 1981. Rodale Press, Emmaus, PA. Both Philosophical and practical. Covers a fair number of less well known fruits and nuts as well as planning, maintenance, and harvesting of orchards.
- *Ecological Fruit Production in the North*, Bart Hall-Beyer and Jean Richard, 1983. Distributed by Bart Hall-Beyer, RR #3, Scotstown, QUE JOB 3JO, Canada. More detailed than Organic Orcharding and more specific to our climate.
- *The Handbook for Fruit Explorers*, Ram Fishman, North American Fruit Explorers (NAFEX), 1986, NAFEX, Chapin, IL. Tells what NAFEX is and how it works, but most importantly describes skills for being a true "fruit explorer" : grafting, budding, rootstock selection, etc.
- *Fruit, Berry, and Nut Inventory*, Kent Whealy, editor, 1989. Seed Saver Publications, RR 3, Box 239, Decorah, IA 52101. An inventory of nursery catalogs listing all fruit, nut, and berry varieties available by mail order in the US. Extremely helpful if one is looking for rare species or varieties like most permaculturists.
- *Roots: An Underground Botany and Foragers Guide*, Douglas Elliott, 1976, Chatham Press, Old Greenwich, CT. Outrageous illustrations of a number of useful wild roots, tubers, corms, and rhizomes of North America with some info on their uses and dangers. Excellent.
- *Woodland Ecology: Environmental Forestry for the Small Owner*, Leon Minckler, 1975. Syracuse University Press, Syracuse, NY. Good guide to small scale forestry for multiple purposes, but still fairly conventional by permaculture standards.
- *Landscaping for Wildlife*, Carrol Henderson, Minnesota Department of Natural Resources, 1987.

Minn. Dept. Nat. Res., 500 Lafayette Road, Box 7, St. Paul, MN 55155-4007. Most useful for the charts of plants and how they are used for attracting wildlife

- *Woodworking for Wildlife*, Carrol Henderson, see above address. Companion to *Landscaping for Wildlife*. This book has plans for bird and bat nest boxes and platforms for various habitats.

A Partial Listing Of Plants By Use Hardy to USDA Zone 4±

Courtesy R. Kalin, C. Evans

Please note: There may be some spelling errors in this listing.

Legumes and Nitrogen Fixers

Caragana aborens - Siberian Peashrub
Cladrastis lutes - American Yellowwood
Comptonia peregrina - Sweetfern
Gymnocladus dioica - Kentucky Coffeetree
Medicago sativa - Alfalfa
Robinia pseudoacacia - Black Locust
Sophora japonica - Japanese Pagoda Tree
Vicia villosa - Hairy Vetch

Useful Vines

Akebia quinata - Five-leaf Akebia
Lonicera japonica - Honeysuckle, Bee Forage
Vinca minor - Periwinkle, Myrtle
Vitis vulpina, V. cinerea - Grape bearing fruit

Bare Soil/ Erosion Control

Vicia villosa - Hairy Vetch

Stream Bank Control

Alder incana - Speckled Alder (nitrogen fixer)
Clethra alnifolia - Sweet Pepperbush
Nasturtium officinale - Watercress
Cornus canadensis - Bunchberry
Populus spp. - Poplar
Salix alba, nigra - Willow

Wetland Tolerant

Acorus calamus - Sweet Flag
Alnus incana - Speckled Alder
Asarum canadense - British Columbia Wild Ginger
Asperula odorata - Sweet Woodruff
Clethra alnifolia - Sweet Pepperbush
Cornus canadensis - Bunchberry
Cornus stolonifera - Red-osier Dogwood
Hemerocallis fulva - Tawney Daylily
Mentha piperita - Peppermint
Nasturtium officinale - Watercress
Populus spp. - Poplar
Salix alba, nigra - Willow

Bearing Fruits

Amygdalus persica- Reliance Peach
Amygdalus persica- Mericrest Nectarine
Arctostaphylos uva-ursi- Bearberry
Cornus canadensis- Bunchberry
Cornus stolonifera- Red-osier Dogwood
Crataegus spp.- Hawthorn
Diospyros virginiana- Common Persimmon
Fragaria vesca americana- American Strawberry
Maclura pomifera- Osage Orange
Morus alba, rubra- White, Red Mulberry
Podophyllum peltatum- May Apple
Prunus armeniaca- Sungold, Moongold, Manchurian Apricot
Prunus avium- Ranier, Venus, Sweet Cherry
Prunus cerasus- Montmorency Cherry
Prunus domesticus- Redheart, Premier, Siberian Plum
Prunus tormentosa- Nanking Cherry
Pyrus communis- Moonglow, Delicious Pear
Pyrus malus- Prima, Priscilla, Sir Prize Apples
Rhamnus spp.- Buckthorn
Rhus aromatica- Fragrant Sumac
Rubus spp.- Raspberry, Blackberry, Wineberry, Dewberry
Sambucus spp.- Elderberry
Vaccinium angustifolium laevifolium- Lowbush Blueberry
Vaccinium corymbosum- Highbush Blueberry
Vaccinium macrocarpon- American Cranberry
Viburnum trilobum- American Cranberry Bush
Vitis spp.- Grape

Seeds and Pods in Summer

Caragana arborescens- Siberian Peashrub

Nuts

Castanea mollissima- Chinese Chestnut
Corylus spp.- Filbert, Hazelnut
Juglans nigra- Black Walnut
Juglans regia "carpathian"- Persian Walnut

Roots, Shoots, and Tubers

Acorus calamus- Sweetflag
Apios americana- Groundnut
Asarum caudatum- Wild Ginger
Asparagus officinalis- Asparagus
Helianthus tuberosum- Jerusalem Artichoke
Hemerocallis spp.- Daylily
Rheum raphonticum- Rhubarb
Sassafras varifolium- Sassafras

Bee Forage

Aster spp.- Aster
Borago officinalis- Borage
Fagopyrum esculentum- Buckwheat
Medicago sativa- Alfalfa (nitrogen fixer)
Monarda fistulosa- Wild Beebalm

Nyssa sylvatica- Black Tupelo
Phellodendrum amurense- Amur Corktree
Robinia psuedoacacia- Black Locust
Rubus spp.- Raspberry
Salvia officinalis- Sage
Symphytum officinalis- Comfrey
Tilia americana- American Linden, Basswood

Bird Attraction

Nyssa sylvatica- Sourgum
Prunus virginiana – Choke Cherry
Sambucus canadensis – Sweet Elder
Viburnum lentago – Nannyberry

Ground Covers

Achillea millefolium – Yarrow
Ageopodium podagraria – Bishop's Weed or Goutweed
Akebia quinata – Five Leaf Akebia
Arctostaphylos uva-ursi – Bear Berry
Asarum caudatum – British Columbia Wild Ginger
Comptonia peregrina – Sweet Fern
Cornus canadensis – Bunchberry
Cornus stolonifera – Red-osier Dogwood
Dianthus deltoideus – Maiden Pink
Epimedium grandiflorum – Longspur Epimedium
Fragaria vesca americana – Strawberry
Lamium maculatum – Spotted Dead Nettle
Mentha piperita- Peppermint
Nepeta mussini- Persian Ground Ivy
Thymus lanuginosus- Wolly Mother-of-Thyme
Thymus vulgaris- Common Thyme
Vaccinium angustifolium laevifolium- Lowbush Blueberry
Veronica officinalis- Drug Speedwell
Vinca minor- Periwinkle, Myrtle
Viola spp.- Violets

Also Useful

Achillea millefolium- Yarrow
Allium schoenoprasum- Chives
Amorpha fruticosa- Indigobush Amorpha
Calendula officinalis- Marigold
Equisetum arvense- Horsetail
Eucommia ulmoides- Hardy Rubber Tree
Hamamelis virginiana- Common Witchhazel
Linum Perenne- Linen Flax
Matricaria recutita- Chamomile
Salvia officinalis- Sage
Saponica officinalis- Soapwort, Bouncing-bet
Sassafras albidum- Common Sassafras
Tilia americana- American Linden, Basswood
Urtica dioica- Stinging Nettle
Valeriana officinalis- Valerian, Heliotrope

NATIVE PLANTS FOR MOIST COOL SHADED PINE FOREST ECOTYPE

Aquilegia caerulea (ROCKY MOUNTAIN COLUMBINE) perennial 1.5'-3' tall / blue and white flowers June-July / part shade, rich soil, moist / MEDICINAL / (seeds:) WN / (plants:) SI, LV

Arctoataphyloa uva—urai (KINNIKINNICK, CORALILLO) evergreen mat forming shrub 3"-1' tall and 4'-15' wide / waxy pinkish white flowers, May / sun to part shade, drought tolerant but likes moist well drained soil / edible fruit / VERY MEDICINAL / controls erosion / good bee forage / natural dyes / cleaning lotion / tans leather / herbal smoke (as in peace pipes) / floral arrangements / LV, GA / --

Aster laevis (SMOOTH ASTER) perennial 1'-3.5' tall / medium blue to pale purple flowers with golden eyes August-October / part shade / beneficial insect habitat / WN / GA cu,-r ~

coannelina dianthifolia (DAY FLOWER) perennial 6"-1.5' tall / blue flowers with yellow stamens, summer / part shade / edible young leaves and stems as salad or cooked veggie / bee forage / AF / ---

Diaporum trachycarpum (FAIRYBELLS) perennial 1'-1.5' tall / small whitish flowers, April—June / part shade, rich soil, moist / showy red to orange velvet fruit is sweet and edible / NP / --

Dodecatheon pulchellum (SHOOTING STARS) perennial 6"-1.5" tall / rose purple flowers, April—July / leaves in salads or as cooked greens / part shade, rich soil, moist / NP / ---

Fragaria americana (WILD STRAWBERRY) perennial about 4" tall and spreading / white flowers, May-August / part shade, rich soil, moist / edible fruit, tea from leaves / MEDICINAL / LV, GA / --

Geranium caespitosum atropurpureum. (PURPLE GERANIUM, GERANXO) perennial 2' tall / purple to rose purple flowers, May—September / sun to part shade, moist to semi-drought tolerant / MEDICINAL / WN / --

Geranium viscoaiasimum (PINK CRANESBILL, GERANIO) perennial 1'-3' tall / pink flowers with purplish veins, May-July / sun to part shade, moist to semi-drought tolerant / MEDICINAL / more typically with aspens, not pines / NP, SI, LV

Hera cium aphondylium asp montanum syn *H. ianatum* (COW PARSNIP, YERBA DEL OSO) perennial 3'—8' tall / white flowers in large clusters, June / sun to part shade, rich soil, moist / young stems are sweet and edible when peeled, this is a succulent treat but the skin must be peeled, for prolonged contact with its hairs or juice can cause blisters / MEDICINAL / WN / GA

Ligusticum port en (LOVE ROOT, OSHA, CHUCHUPATE) perennial to 3' tall / white flower clusters, June—August / sun to part shade, rich, moist / seeds and leaves can be dried for a spice / VERY MEDICINAL / warning: poison hemlock can be mistaken for this plant. Osha's seeds do not have thin little bracts that reflex down, poison and water hemlock do. Osha root is larger as a rule than hemlocks and is highly aromatic where hemlock roots have little smell. osha roots are hairy, hemlock roots are not. Hemlock plants however smell a little like something dead, osha smells much better (when bruised). Poison hemlock has purple splotches on its stems, osha does not. The foliage of water hemlock is coarse compared to osha's fine fernlike foliage. Water hemlock always grows in or next to water / osha harbors beneficial insects /

SI / --- *Mimulus lewisii* (RED MONKEY PLOWER) perennial 1'-4' tall / showy rose pink to purplish flowers, June-August / part shade, moist / NP, WN / GA

Oamorrhiza occidentalia (SWEETROOT, SWEET ANISE) perennial to 4' tall / variable flower color whitish to yellowish usually, in clusters, May—June / part to full shade, rich soil, moist / the sweet highly aromatic roots are dried and used as a substitute for anise or licorice, the anise flavored seeds also can be used / MEDICINAL / beneficial insect habitat / warning: oops this one also resembles those cruel killers the hemlocks. Sweetroot however is pleasantly aromatic unlike the hemlocks. The leaves are coarser than poison hemlock and sweetroot lacks its purplish markings on the stems. The seeds of sweetroot are elongated and taper at the ends, quite different from the round or egg shaped seeds of the hemlocks. The leaves of sweetroot and water hemlock are similar, sweetroots are broader and slightly hairy, water hemlocks' leaves are more narrow and hairless **I SI** / —*Pot entilla anserina* (SILVER CINQUEFOIL) perennial about 4' tall and spreading by

runners **I** bright yellow flowers, May—August / sun to part shade, moist / thick roots are edible fresh or cooked and are quite tasty / MEDICINAL / AF **I** — *Sidalcea neomexicana* (CHECKER MALLOW) perennial 2'-3' tall / showy pinkish or rose purple flowers, June—September / sun to part shade, rich soil, moist / edible foliage as cooked greens / WN / ..

Smilacina stellata (STAR FLOWER, SOLOMON'S PLUME) perennial 1'-2' tall / small white flowers, May-July / very ornamental foliage / part shade, moist **I** edible but bittersweet fruit is usually cooked, the fruit is dark red to purple black, round and about 1/4" in diameter. The new shoots are tender and are cooked for greens. The root is edible and starchy but tastes pretty bad, however pickles made from the roots are said to be tasty / MEDICINAL / NP / ..

NATIVE PLANTS FOR GRASSLANDS/PINE FOREST ECOTYPES

species found in both ecosystems I

- Achillea lanulosa* (WILD YARROW, PLUMAJILLO) perennial 3'-3.5' tall and spreading / creamy white flower clusters, May-September / sun to part shade, drought tolerant but likes moderate moisture / edible foliage as tea or dried spice / VERY MEDICINAL / harbors beneficial insects / mineral accumulator / increases volatile oil content of plant associates that are aromatic / controls erosion / VERY FIRE RESISTANT / WN / GA
- Agaatathe urticaefolia* (GIANT HYSSOP, HORSEMINT) perennial 3'-7' tall / showy rose to violet flowers, June—August / sun to part shade, moist to semi—drought tolerant / edible nutty flavored seeds / excellent bee forage / NP / -
- Antennaria nacrophylla* syn *A. roaea* (LIFE EVERLASTING, ROSY PUSSY TOES, LADIES TOBACCO) perennial 4"—10" mat, spreads by runners / attractive clusters of bright pink to rose floral bracts with pearly white centers, occasionally the whole head is white, July—August / leaves and stems woolly silvery gray—green / sun, part shade, withstands drought and moist soils / the stems yield a gum once popular for chewing among native people / MEDICINAL / floral arrangements / beneficial insect habitat / NP / -
- Balaaniorhiza sagittata* (ARROWLEAF BALSAMROOT) perennial 8"—2' tall / large golden yellow flowers, May-June / handsome arrowhead shaped foliage / sun to light shade, drought tolerant / edible seeds, roots and leaves said to be quite nutritious / MEDICINAL / controls erosion / bee forage / harbors beneficial insects / NP, SI, WN / AF
- Epilobium angustifolia* (RED FIREWEED) perennial 2'-7' tall / showy pinkish purple flowers, June—September / sun to part shade, semi—drought tolerant, loves moisture / CAN PRESENT SUBSTANTIAL FUEL WHEN DRY, grow in swales to keep it green, let goats munch them down after flowering / leaves and new shoots are edible fresh, boiled, or steamed, also dried for tea / MEDICINAL / bee forage / WN, NP / LV, GA
- Linum lewisli* syn. *L. perenne a~p. lewisiai* (BLUE FLAX, LINASA) perennial 6"—2' tall / attractive blue flowers, May—September / sun to part shade, drought tolerant / edible seeds when prepared properly, raw seeds contain cyanide which is rendered harmless when seeds are dried, then cook and eat, or roast or bake and grind for meal. seeds are high in oil, contain ALA (similar to GLA) and omega 3 in significant amounts / VERY MEDICINAL / a good fiber plant / WN, SI, NP / LV, GA
- Nimulus guttatus* (YELLOW MONKEYFLOWER) perennial, 6"—2' tall, spreads by creeping roots / bright yellowish flowers with purple lips, March-August / sun to part shade, moist / leaves and young shoots fresh in salads / — / LV, GA
- Nonardella fistulosa* syn *N. menthaefolia*, *N. fistulosa* var *menthaefolia* (BERGAMOT, OREGANO DE LA SIERRA, LEMON MINT) perennial 1'-3' tall / showy rose purple FRAGRANT flowers, July-August / sun to part shade, semi—drought tolerant, likes moist conditions and rich soil / all the above ground parts of this plant are edible for use as cooked greens, as a tea, or dried for a somewhat hot and spicy seasoning / MEDICINAL / contains an ample supply of the antiseptic thymol / insect repellent / bee forage / WN / LV, GA
- Nonardella odoratissima* (COYOTE MINT, POLIO CHINO) perennial 6"—2' tall, spreading to form clumps / showy pale purple to light reddish purple flowers, June-September / sun to part shade, semi-drought tolerant / highly aromatic plant, good for tea, or dried for a spice / MEDICINAL / insect repellent / — / AF, GA
- Penstemon strictus* (ROCKY MOUNTAIN PENSTEMON) perennial 1'-3' tall, semi-evergreen / showy deep bluish purple flowers, June-July / sun to part shade, drought tolerant / VERY FIRE RESISTANT / WN, SI, NP / LV, GA, AF

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Penstemon virgatus aubsp. *aua*—*grayii* (WANDBLOOK PEESTENOI) perennial 1'-1.5' tall / showy light bluish purple to pale violet flowers with dark purple veins, June-August / sun to part shade, drought tolerant / WN /

Ratibida columnifera (CONEFLOWER, YERBA DI LA TUBA) perennial 1'-2.5' tall / handsome bright yellow or reddish purple flowers (sometimes both colors present) with a protruding center resembling a green or brown corn cob, July—September / sun to light shade, drought tolerant but also common in moist soil / native tribes used the leaves and flower cob for tea (reported to be pleasant) / MEDICINAL / SI, WE / LV, GA

Vicia americana (PURPLE VETCH) perennial 6"-30" tall, trails along ground or climbs over rocks and shrubs / flowers reddish purple to bluish purple, May—August / sun to part shade, drought tolerant but also fond of moisture / edible starchy seeds (similar to peas) and young tender stems can be steamed or boiled, southwestern tribes also ate the pods whole and the leaves, warning: some other toxic legumes like the locoweeds are similar, make a positive ID before eating / NITROGEN FIXER / bee forage / one tribe used the roots for a hair wash / WN

wyethia aizplexicaulia (MULE EARS, P1—1K) perennial 1'-2' tall, form colonies / large showy bright yellow flowers, May-July / handsome glossy leaves shaped like the ears of a mule / sun to part shade, moist soil, dislikes steep slopes / edible seeds typically dried and ground for a meal, young shoots cooked as a veggie, tribal peoples also ate the large roots which they sweetened by long slow cooking / MEDICINAL / this plant is uncommon in Colorado's front range, occurring principally in North Park up against the eastern flanks of the continental Divide. It has been the unfortunate recipient of large eradication programs dating back to the early 20th century / WN, NP /

NATIVE GRASS FOR FOREST AND GRASSLAND ECOTYPES

These grass species grow both in grassland and ponderosa forests of Boulder's mountain and foothill region.

Agropyron amithii (WESTERN WHEATGRASS) perennial 1'-3' tall / sod / drought tolerant but prefers moisture, plant in swales, check dams, etc. / edible grain (barley family) / controls erosion / MW, CC, SB, G, SI / -

Agropyron trachycaulum (SLENDER WHEATGRASS) perennial 1'-4' tall / drought tolerant, prefers moisture / very ornamental / edible grain (barley family) / controls erosion / stays green until late fall / AKV, CC, SB, G, SI / -

Bouteloua gracilis (BLUE GRAMA) perennial 6"-30" tall / bunch grass but forms sod under heavy grazing / very drought tolerant, fast growing / ornamental / should be planted as the dominant grass for the grassland zones, plays a minor role in ponderosa forests / AKV, CC, G, SB, SI / —*Festuca idahoensis* (IDAKO FESCUE) perennial 1'-3' tall / may produce some fuel / SB /

Festuca rubra "CREEPING" (RED FESCUE) perennial 1'-3.5' tall / fairly drought tolerant / ornamental / FIRE RESISTANT, should be planted in the ponderosa pine zone as the dominant grass / shade tolerant / controls erosion / although the species is native most seed companies sell varieties whose parentage may come from across the big water (Europe) / commonly available

Koeleria cristata (MOUNTAIN JUNEGRASS, PRAIRIE JUNEGRASS) perennial 1'-2.5' tall / bunchgrass / drought tolerant / seeds are reported to have been harvested by the people of Isleta Pueblo and ground for meal / G, SB,

SI / —

Nuhlenbergia montana (**MOUNTAIN** BUNCHGRASS, MOUNTAIN MURLY, **PINE** BUNCHGRASS) perennial
1'—2' *I* dense growing bunchgrass *I* drought tolerant *I* erosion control *I* CC / —

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Sitanion hyatrix (BOTTLEBRUSH SQUIRRELTAIL) short-lived perennial 4"-20" tall *I* bunchgrass *I* very
drought tolerant / seeds reported edible as a grain *I* MW,
CC, G, SI

Stipa comata (SILKGRASS, NEEDLE AND THREAD, PORCUPINE GRASS) perennial 1'-4' tall *I* bunchgrass /
very drought tolerant, reproduces better on moist sites *I* —MW, G,
SB, SI

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LANDSCAPE PLANT LORE (STAR HOUSE AND MORNING STARI

(These are useful plants not profiled elsewhere.)

NATIVE WOODY PLANTS

Acer glabrum (ROCKY MOUNTAIN MAPLE), N, The seeds of this and all other maples apparently have been eaten. However, they are reported TOXIC (Dr. John Churchill) and in any event they taste bad / MEDICINAL / It's been reported that the young shoots of this species were eaten by Rocky Mountain tribes.

Acer grandidentatum (BIGTOOTH MAPLE) N, This tree is believed to be a subspecies of the eastern sugar maple. it does produce excellent maple syrup but the tree is too small and uncommon today (once a popular fuel*) to make the effort worthwhile / MEDICINAL

Prunus americana (WILD PLUM), N, edible fruit makes an excellent jelly / some tribes used various parts as a MEDICINE, but it's seldom used today / purple brown dye one tribe planted their corn, beans and squash as soon as it bloomed

Prunus virginiana melanocarpa (CHOCKECHERRY), N, edible fruit may be astringent and bitter fresh though some trees are OK fresh when fully ripe, fruit is excellent dried or for syrup, pies, jelly, in muffins, etc. even wine; leaves and pits are TOXIC / an important MEDICINE plant to some tribes / erosion control

Ptelea trifoliata (WAFFER ASH, COLA DE ZORRILLO), native to southern Colorado front range / quite MEDICINAL / bitter fruits are used as a substitute for hops when brewing beer or malt liquor

Cowania mexicana stanaburiana (CLIFF ROSE, QUININE BUSH), native of S.W. Colorado / foliage makes a mint—like tea, honey fragrance of the flowers can be added to herb teas, remove the bitter calyx and use sparingly or tea becomes bitter, scraped bark has been used to flavor other herb teas / MEDICINAL / lovely red dye from bark and roots / fiber for clothes, sandals, mats and rope made from the bark / erosion control

Atriplex canescens (FOUR-WING-SALTBUSH), N, see *A. gardneri* for lore which is the same

Chrysothamnus nauseosus (CHAMISA, RABBITBRUSH), N, contains a high grade vulcanizing rubber known as chrysil, but is considered impractical economically due to its low content / Hopi use its flexible branches for wicker after stripping the bark / yellow orange dye from boiled flowers, green dye from inner bark

Rosa voodaii (WOODS ROSE), N, edible fruits are high in vitamins A and C; one cup of rose hips may contain as much vitamin C as 10—12 dozen oranges / eaten fresh or dried / fruits are used for tea, in soup, as a syrup and a jelly. The flower petals can be used in salads, dried for tea, candied and as a liqueur. The whitish base of each petal is bitter and should be snipped off. Leaves are also used for tea / rose water can be made for use in cosmetics, perfume, hand lotions, cold creams and for mouthwash; rose water is also used as a food flavoring / very MEDICINAL / excellent bee forage

Amphora nana (FRAGRANT FALSE INDIGO), N, NITROGEN FIXER

EXOTIC WOODY PLANTS

C. laurastis lutea (YELLOW WOOD), excellent bee forage / NITROGEN FIXER / golden yellow dye

Robinia x pseudoacacia (PURPLE ROBE LOCUST) see *R. neomexicana*⁴ur native for the lore which is very similar to this

Rosa rugosa var. (BLANC DOUBLE DE COURBERT ROSE) see *R. woodsii* our native for the lore which is the same as this. The fruit of *R. rugosa* is usually much larger than *R. woodsii* and possibly more nutritious.

Syringa vulgaris (LILAC) MEDICINAL

Rhus aromatica **var.** *grolova* (DWARF FRAGRANT SUMAC) see *R. glabra* *cia-montana* our native for lore which is quite similar. This sumac is also very fire resistant

Ceanothus integerrimus (DEERBRUSH, BLUEBRUSH) native of Arizona and Nevada / see our native *C. fendleri* for lore which is very similar

NATIVE PERENNIALS

Geranium richardsonii (WILD GERANIUM) N, see the other native geraniums which are used interchangeably

Berlandiera lyrata (CHOCOLATE FLOWER) native of S. E. Colorado I the flower heads which have the aroma of chocolate were used as a seasoning by some tribes

Agastache cana (DOUBLE BUBBLE MINT, HYSSOP), an endangered species, native to New Mexico I aromatic foliage for tea / MEDICINAL

Athyrium filix-femina (LADY FERN) N, the rhizomes were roasted and eaten by some tribes I MEDICINAL

Helianthus scaberrimus (MAXIMILIAN SUNFLOWER) native to N.E. Colorado I edible tubers much like Jerusalem artichokes to which it is closely related, seeds too are edible and have been roasted for a coffee substitute I MEDICINAL / seed oil for hair tonic, soap making and candle making I herbicidal roots / yellow dye from flowers, purple or black dye from the seeds I excellent bee forage I textile fiber from stalks

Stanleya pinnata (PRINCES PLUME, DESERT PLUME) N, a selenium accumulator and TOXIC where selenium is highly concentrated in the soil I otherwise the cabbage flavored young leaves and stems can be boiled in a few changes of water (bitter otherwise), seeds can be eaten parched or roasted

Solidago nemoralis (DWARF GOLDENROD) N, tea from dried fully opened flowers or dried leaves; one report suggests at least one species is TOXIC I MEDICINAL I yellow— tan or gold dye / some species have a high rubber-latex content with commercial potential

Yucca baccata (BANANA YUCCA, DATIL), native of S. Colorado I large edible fruit (second largest edible fruit native to the continental U.S.) fresh, dried or cooked, removal of the tough skin and rind as well as the seeds reduce the bulk considerably, but the fruity flavor is excellent. An alcoholic beverage made from them is rated as a powerful stimulant. The mild licorice flavored seeds are also edible and make nice bracelets and necklaces

Yucca glauca (SOAPWEED YUCCA) N, like banana yucca the fruits of the soapweed are also edible but the similarity ends there. These fruits are smaller and dry, after much boiling or baking they taste somewhat like squash with a bit of a bitter aftertaste. On the other hand, the immature flower stalks, unopened flower buds and the flower petals are all tasty, even delicious

yucca's in general share the following virtues:

They are very MEDICINAL I they have been an essential fiber for pre-Colombian peoples, producing clothing, blankets, sandals, hats, bags, brushes, brooms, fishing nets, belts, baskets, chair caning, string and rope; they even come with (the leaf fiber) their own sewing needle attached. In the 20th century during W.W.I and W.W.II the U.S. government used yucca fiber extensively for heavy paper, burlap, twine and rope. In W.W.I alone 80 million pounds of yucca fiber were utilized / yucca saponins produce a superior natural soap called amole which is good for bath soap, for washing dishes and clothes, excellent for wool leaving it fluffier than the dry cleaners (which contribute to greenhouse gases). Today commercial yucca plantations are a source of a popular sudsing agent used principally for shampoo products which impart to hair body and lustre / yucca is

a beneficial companion plant to other members of the ecosystem in the highest meaning of the term. For example, it was discovered that its steroid saponins (in its organic matter) are naturally deposited in the soil of a large area around each yucca (wind borne), once the yucca's organic debris settles into the soil it begins to act as an anti-stress factor and in addition a wetting agent for 'neighboring plants. This provides those other plant species the ability to utilize available moisture much more efficiently. This knowledge led to the development of a process of extracting the yuccas' steroid saponins for use in commercial agriculture for arid and semi arid lands. Crops like strawberries, cotton, onions, potatoes, alfalfa, tomatoes, broccoli and orchard crops like citrus, in these climates, have shown through studies to yield 15% to 25% higher during periods of stress when yucca saponin extracts were applied. When environmental conditions are sufficient no affects are registered good or bad, but under stress, such as drought, plants are more adept at consuming moisture and soil nutrients than untreated controls / Yucca saponins are also used today in sewage disposal plants in the U.S. and Canada. The yucca extract greatly stimulates microbial communities, which then accelerate the breakdown of organic wastes quite significantly, enough in fact to make it an important agent 'of municipal sewage disposal / This extract has also proved successful at cleansing and clarifying water polluted by salt and minerals / Yucca is very fire resistant

EXOTIC PERENNIALS

Glechoma hederacea (GROUND IVY) foliage has been used for tea and as a flavoring particularly for beer which it also acts to clear / MEDICINAL

Hemaerocallis (DAYLILY) as food and MEDICINE all or nearly all species are valued. Native to central Europe through to China and Japan where numerous species are used more or less interchangeably for these purposes. The flowers, flower buds and new shoots are used raw or dried in soups and salads, or are sauteed, boiled or pickled. The tubers are very tasty, although for some individuals they are **laxative. They are eaten raw, fried, boiled, baked, creamed or mashed.** The whole plant is reputedly high in vitamins A and C / very MEDICINAL, in use here and China (where daylily has long been prescribed for cancer) / makes great cut flowers

Hesperis matronalis (DAMES ROCKET, SWEET ROCKET) The flowers, are all edible with a mustardy flavor (it's a member of leaves and stems have a slightly acrid taste and should flowering / MEDICINAL leaves, stems and seeds the mustard family). The be gathered before

Matteucia struthiopteris (OSTRICH FERN) rhizomes are reported edible when peeled then boiled or roasted

Platycodon grandiflorus (BLUE BALLOON FLOWER) the young leaves can be used in salad / CHINESE MEDICINE / good cut flower

Ranunculus repens (BUTTERCUP) Some species in the ranunculus genus are TOXIC. This species is however said to be non toxic. In any event the toxic qualities are unstable and are rendered harmless by drying or cooking. Foliage and roots are eaten after boiling, flowers are pickled, seeds are parched and ground for flour or meal, typically used for bread / yellow dye

Teuchrium chamaedrys (WALL GERMAMDER) MEDICINAL / mute fire resistant

Thymus minus (DWARF CREEPING THYME) can be used as a seasoning / MEDICINAL / the essential oil contains the antiseptic thymol and is also used in perfumes and soaps

Viola odorata (SWEET VIOLETS) edible leaves are high in vitamin A and iron and very high in vitamin C; used fresh in salads or steamed with vegetables, fresh or dried for tea. Flowers are candied or added to syrups and the like for flavoring, the roots and seeds are considered TOXIC / MEDICINAL

NATIVE SHRUBS AND SNAIL TREES FOR ECOLOGICAL REHABILITATION

PONDEROSA ECOTYPES

These are shrubs which should be grown in the ponderosa forest. Although they are tolerant of part shade, they should not be sited in deep shade. Because they have a high moisture requirement they should only be planted out in water catchment schemes.

Holodiscus dumosus (MOUNTAIN SPRAY, ROCK SPIREA) 3' to 6' tall by 4' to 6' wide *I* showy cream white flowers, June—August *I* pink seed heads age to rust color *I* fall color bronzy red *I* part shade in ponderosa forest, need some moisture plant in swales etc. *I* the small dry seeds were eaten by tribes throughout the west / -/ LV, GA

Pot entilla fruticosa syn. *Pent aphyllodes floribunda* (SHRUB CINQUEFOIL, CINCO ENRAMA) 2'-4' tall by 2'-3' wide *I* showy yellow flowers, June-August / gray—green leaves turn yellowish in fall / sun to part shade, best in moist spots among the ponderosa *I* the leaves can be brewed for tea / MEDICINAL *I* bee forage *I* controls erosion *I* used for making brooms *I* -/ LV, GA

PONDEROSA AND GRASSLAND ECOTYPES

These species are found in the wild in ponderosa forests and grasslands alike. Many of them are most fond of the edge between the two systems. When planting these species in among the ponderosa, care must be taken to site them according to their tolerance of shade. If in the species profile no mention is made of their degree of shade tolerance, then it should be assumed they appreciate it little. Such plants should go only in the sunniest openings in the forest or on sunny edges.

Amelanchier alnifolia (SABKATOON) Shrub or small tree 4' to 40' tall, typically a large shrub 6' to 15' tall and spreading wider *I* attractive flower display of pure white FRAGRANT star flowers, May-June / excellent fall colors, reds and yellows *I* sun to part shade, drought tolerant, but enjoys moisture *I* excellent edible fruit / MEDICINAL! bee forage *I* control erosion *I* violet and black dye / a highly recommended fruit tree for ethanol production on marginal land. Saskatoon feels most at home at the edge where the ponderosa forest meets the grassland. On this site it's the uplands *I* -/ LV, GA

Ceanothus fendleri (MOUNTAIN BALM, DEERBRUSH, WILD LILAC) 2'-3' tall, 3'-5' wide / an abundant display of FRAGRANT white flowers, June-July / thick gray-green leaves *I* spiny/ drought tolerant, favors some moisture *I* the seeds and the leaves are edible and high in protein, phosphorous and calcium / MEDICINAL / flowers are a great soap substitute, fragrant and sudsy / NITROGEN FIXER / bee forage *I* habitat for beneficial insects *I* basket coppice / a plant for the pine forest and it's edges / -/ LV

Cercocarpus montanus (MOUNTAIN MAHOGANY, PALO DURO) 4'-6' tall and spreading wider *I* attractive silver seed plumes, resemble feathers, hang on a long time *I* drought tolerant / bark for tea or flavoring *I* MEDICINAL / bee forage *I* insecticidal / NITROGEN FIXER *I* controls erosion *I* red to purple dye from bark and roots *I* -/ LV, GA

Philadelphus mcrophyllus (WILD MOCK ORANGE, JERINGUILLA) 4'-6' tall *I* abundant display of VERY FRAGRANT showy white flowers, June-August *I* sun to part shade, fairly drought tolerant, prefers some moisture *I* the small seeds were eaten by western tribes / -/ LV, GA

~urshia tridentata (ANTELOPE BRUSH, BLACK-SAGE) semi-evergreen 2'-10' tall by 2'-6' wide / attractive, VERY FRAGRANT pale to creamy yellow flowers, April—August *I* silver gray foliage *I* very drought tolerant *I* MEDICINAL *I* NITROGEN FIXER *I* controls erosion *I* bee forage / violet dye *I* -/ LV, GA

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Ribea aureum (GOLDEN CURRANT) 3'-6' tall by 2'-S' wide / showy FRAGRANT yellow flowers, April—June / scarlet red fall color / sun to part shade, drought tolerant but much better with some moisture, golden currant is indigenous to ponderosa forests and grasslands / the dark red fruit is considered the best of the western wild currants, sweet and spicy, the flowers and leaves are also edible / —/ LV, GA

Robinia neomexicana (ROSE LOCUST, HOJALITO) 10'-25' tall by 15'-20' wide, can form broad thickets fast / attractive pinkish purple flower clusters, May-August / thorny / sun to part shade, drought tolerant but enjoys moisture, native ponderosa forest openings or on the edge where ponderosa and grasslands overlap, commonly inhabits northern slopes and ridges / the flowers are definitely edible and good, the pods are reported to be edible, but the seeds are toxic (as are the bark and roots) perhaps cooking renders the seeds in the pods harmless, not enough is known / MEDICINAL / NITROGEN FIXER / controls erosion / dye / firewood or fence post coppice / —/ LV, GA

Rhus glabra *cia—montana* (ROCKY MOUNTAIN SUMAC, LEMITA) 3'-6' tall by 3'-6' wide, forms colonies / creamy yellow flowers, June / yellow to scarlet fall color / sun to part shade, drought tolerant but prefers some moisture, native of both ponderosa forest and grasslands / fruit is used to make a lemonade—like beverage (add sweetener), young shoots can be added to salads / MEDICINAL / bee forage / controls erosion / ink making / leather tanning / —/ LV, GA

GRASSLAND ECOTYPES

This is the sun worshipping plant group. All are indigenous to the grasslands. Some of these can also be found in nature among ponderosa on sunny open sites. However, here it's recommended they be planted well away from the pines for reasons of wildfire safety.

Artemisia filifolia *ayn Oligosporua Lilifoliua* (SAND-SAGEBRUSH, ROMERILLO) evergreen 1'—5' tall by 3' wide / a SWEETLY AROMATIC silver bluish grapy shrub with a lovely delicate feathery texture / silver seed heads persist through winter / sun to part shade, drought tolerant / a sweet but strong seasoning can be had from the dried leaves / MEDICINAL controls erosion / an excellent aromatic for the sweat lodge / floral arrangements / —/ LV, GA

Artemisia tridentata *syn Seriphidllu. tridentatum* (BIG-SAGEBRUSH, ESTAFIATE)

nearly evergreen 3'—7' tall, sometimes to 15', up to 6' or more wide / handsome aromatic silver green foliage / very drought tolerant but likes moisture / edible seeds are dried or parched and ground into meal for mush or pinole (uncooked) This was an important food to some tribes / MEDICINAL, antimicrobial / leaves can be used as a food preservative / an aromatic volatile oil can be extracted from the leaves / NITROGEN FIXER / insect repellant / bee forage / hair tonic from a leaf tea / green and yellow dyes / bark used in basketry / used to make ceremonial brooms / **makes an aromatic** firewood, plant it sparingly and in the open because it is QUITE FLAMMABLE / good aromatic for the sweat lodge / —/ LV, GA

Atriplex gardneri (GORDON SALT BUSH, CHAMISO) evergreen subshrub 1.5'-3.5' tall / foliage and young stems are a whitish gray green / drought tolerant / the seeds are edible and starchy, very mineral rich, they may be ground to meal for pinole or to mix with water for a beverage. The meal is sometimes mixed with flour for baking. The leaves and new shoots can be steamed or boiled for greens, saltbush accumulates mineral salts and often tastes salty, add to other foods for flavoring. Warning: as a dynamic mineral accumulator saltbush will absorb toxic amounts of selenium if it's abundantly present in the soil, otherwise it's quite nutritious / VERY FIRE RESISTANT, plant it liberally / controls erosion / bright yellow dye / beneficial insect habitat / —/ GA

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Prunus besseyi ayn. *Ceraaus pumila subsp. besseyi* (SAND CHERRY, BUSH CHERRY) 3'-

6' tall, 4'-6' wide / profuse pure white flower display, May / red fall color

/ drought tolerant / edible but puckery (astringent) fruit, great for pies,
jam, sauce, etc., the flowers can also be eaten in salads or as a garnish /

- / LV, GA

Quercus gambelii (GAMBEL OAK, ENCIRA) typically seen as a slow growing shrub, one old timer discovered in the mountains of **SW New Mexico measured 47' tall with an 85' wide crown span**, circumference of the trunk 18' / drought tolerant prefer some moisture / the acorns are sweet and edible. several of the sweet edible American oaks have been tested for their nutritional value. Protein ranged from 3.9% to 8%, carbohydrates from 54.6% to 69%, fiber from 9.5% to 12.7%, ample amounts of phosphorus, potassium, calcium, magnesium and sulphur were also present. Many edible oaks may possess bitterness due to tannins but the gambel is considered edible, good and lacking bitterness right off the tree. They can be eaten fresh after removing their cap and outer coat (collect them in autumn as they fall from their mother). They can be stored in a cool dry place, or dry them in the sun or oven and cut them into bits for chopped nuts or grind coarsely, dry again and then grind them finer, use **this flour for bread, gravies, soups, etc** / MEDICINAL / tan dye / - / LV, GA