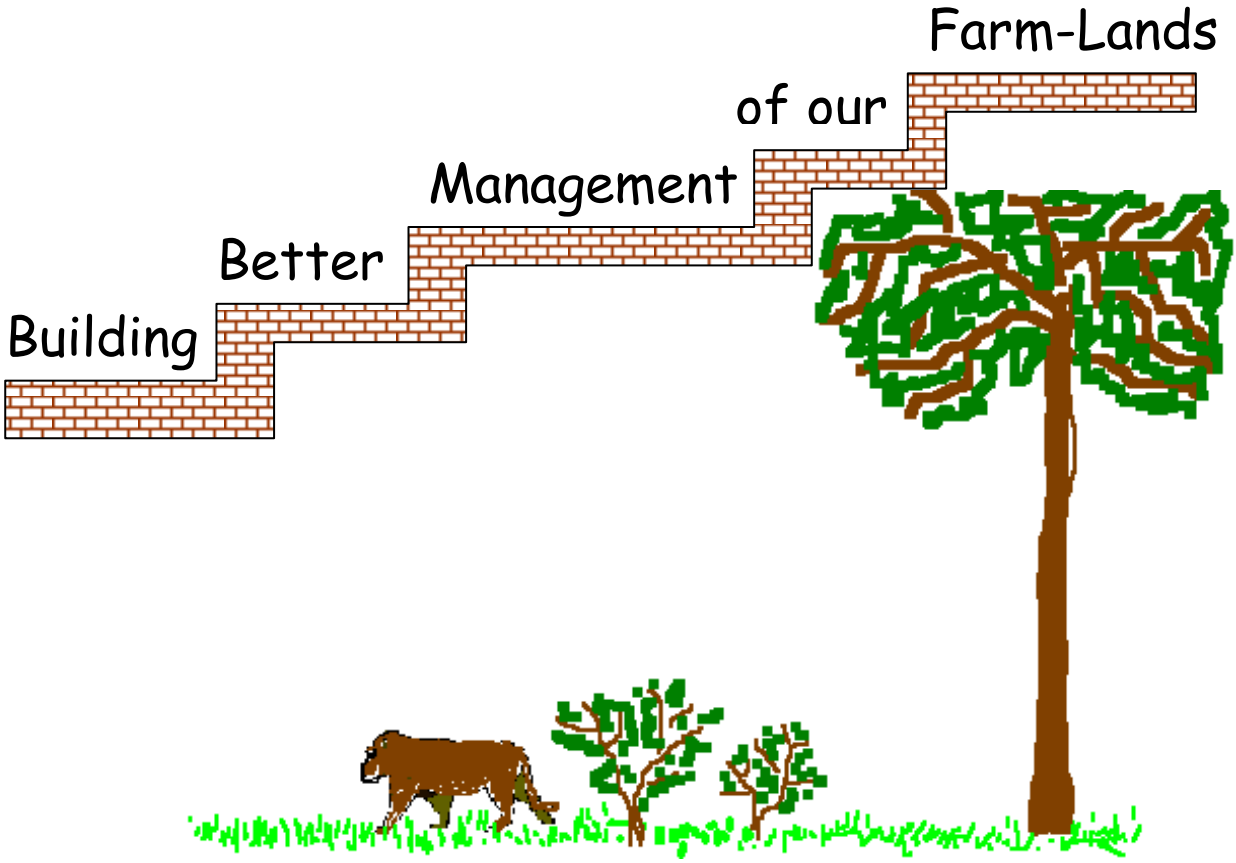
SUCCESSFUL AGRICULTURE



UNIT ONE

Course compiled by Nick Smith, Systems Agronomist,
for Liberty for the Nations Australia.

CROPS and PASTURES MANAGEMENT

Different crops, grasses and legumes require very different climatic conditions.
The hot, wet tropics (e.g. Pacific Islands) cannot grow wheat. Cool temperate regions (e.g. England) cannot grow rice.
Some farmers can adapt conditions (e.g. use irrigation, use "hot-houses") to grow crops which would otherwise not be suited.

Crops and pastures must be sown at the time of year when **soil moisture** levels and **soil temperatures** are best for plant growth, in an environment which offers optimum **light** levels and available **soils** and plant **nutrients**.

Plants particularly need soil moisture for:
- Seed germination – when seed opens and sends off its first roots
- Seedling establishment – when a few leaves grow, and the root system becomes established.
- Flowering – when the reproductive parts of the plant start to form e.g. more flowers = more fruits / grains / nuts
- Grain-formation – to continue the last stages of reproduction.

Plants need dry conditions at time of grain-setting, fruit-ripening (prior to harvest).

Most plants grow only within a narrow temperature-range:
Many plants cannot tolerate frosts (below 2°c.), or temperatures over 34°c., or day-night temperature ranges in excess of 10°c., or waterlogging, or drought, or winds which cause plants to blow over easily ("lodging").

Most plants have specific light requirements:
Many plants need specific, seasonal differences in daylight (day-lengthening or day-shortening) to grow, particularly at the reproductive stage, and specific amounts of light intensity / shade.

Most plants require specific soil types and levels of nutrients:
Most plants need very specific pH and salinity soil-levels, soil texture and soil structure, and available nutrients.
(see "Soil Management" section.)

<u>General Considerations of a healthy, productive field of pasture or crops:</u>

- **Avoid disturbance / cultivation of soil on "marginal land"**
  "Marginal land" is the agricultural term used for land which is unstable (steeply sloping land, or near water-courses, or risky due to climate).

- **Preparation of soil**
  "Minimum tillage" (using the least possible machinery) reduces the risk of damage to soil structure.
  Remove all weeds before sowing crop seeds.
  Reduce weeds before sowing pasture seeds, or planting grass runners (live, rooted lengths of grass).

- **Control of weeds** – during crop and pasture growth,
  Remove (manually or by machinery) weeds before they compete with plants for light, water, nutrients. Do not let the weeds seed. (Safe herbicides can be carefully used.)

- **Ensure soil nutrient levels are O.K**.
  Provide organic or inorganic fertilisers as required *(see "Soil Management" section).*

- **Sowing density** – correct number of plants per square metre / per hectare.

- **Sowing depth** – correct depth of prepared soil.

- **Ensure seed is "viable"** (good, will germinate / grow).
  Seed must be stored where moisture (water or humidity), heat, and light cannot spoil it.
  Most seed purchased from good suppliers should be 85-95% viable.

- **Ensure losses of crops by animals and birds are minimised / reduced**.
  Animals must be fenced off. Animals and birds can spoil or eat the crops / pastures.
  e.g. cattle / goats eating plant leaves and grain, birds eating seed, grain, and fruit, pigs eating root crops, rats and bats eating peanuts & fruit)

Plant crops are used for humans and animals.
Humans eat fruits, vegetables and legumes. Animals normally eat grasses and legumes (some, like rats and bats eat fruits and nuts).

Grasses for food
Some grasses are "annuals" – it means they die off every year, and depend on seed for continuation of the pasture. Most grasses are "perennials**"** – they will live on for many years, but some natural re-seeding is advisable to replace those plants that naturally die off.

Inspect crops and pastures for problems.
E.g. diseases, pests and weeds, nutrient deficiency, animals. Correct as soon as possible.

Some grasses and legumes are more "persistent" than others.
"Persistent" growth means some plants tend to grow quicker and live longer than others. This is sometimes because of other plants that are growing around them.
Tall plants create shade which may stunt other plants. Some are more drought-resistant, and establish better in a dry season.
As a result of variations in persistency, the balance of plant types in a field's pasture is often changing: some plants may even die off completely, while others will increase in numbers.

It is important that the "best" plant-types persist:
Then, a desirable quality of food or grasses is maintained.

Native grasses and legumes (traditionally grown over hundreds of years, which have adapted well to their ecosystem,) are often not as nutritious as "introduced" species. But they are less risky, as they have been proven to survive / grow back in unfavourable (difficult) seasons / situations.

Growing a few different pasture-types in a field can help provide feed for animals (e.g. cows, chooks, pigs) as well as humans. Including legumes into pasture land helps the growth of grasses.

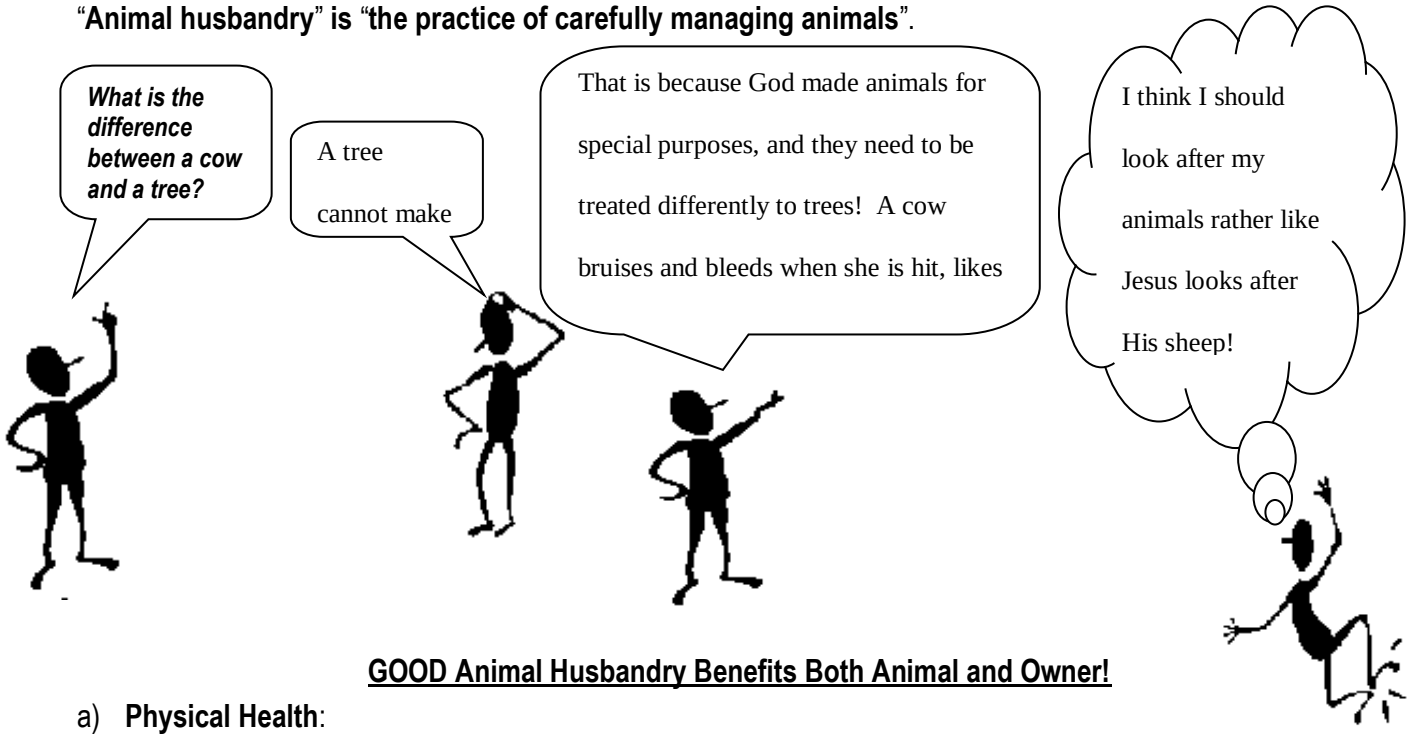
Efficient ways of utilising pasture growth, for feeding animals:
Generally, pasture grasses are most nutritious and efficiently grazed by cattle when about 8-10cm high.
Animals that are not easily able to graze very short grasses (e.g. cattle) should graze a field before animals such as sheep and goats that can graze the shorter pasture left over by the cattle.
Pasture rotation is when a herd is regularly, purposely moved from one field to another.
Pastor rotation:

- allows pasture to grow to an optimum height for grazing,
- ensures the pasture is evenly grazed, so that there aren't patches of old, "sour", unappetising pasture.
- allows natural seeding from the animals in fallow fields, if that is desired.

LIVESTOCK MANAGEMENT

Livestock includes all animals and birds that are farmed. Different types of livestock require different types of special management. This study provides a start for people interested in cattle, poultry (fowls), pigs, goats, and sheep. Further advice or knowledge may be required to successfully manage any one kind of animal

"**Animal husbandry**" **is** "**the practice of carefully managing animals**".



GOOD Animal Husbandry Benefits Both Animal and Owner!

a) **Physical Health**:

Nutrition – Ensure that plenty of good quality food and drinking water is available all the time.

Exercise – Avoid keeping livestock tied up, except perhaps at night-time.
Cattle-yards, sheep-yards, hen-sheds, pig-pens should always provide water, food, shelter from sun and rain, and enough room to move around.

Medical Attention – All sicknesses must be treated as quickly and as well as possible.
Animals with unusual symptoms should be isolated, in case the problem is infectious.
Keep animals in a stress-free environment.
If you have a problem with an animal that you cannot fix, call for help from a trained or person:
(e.g. Dept. of Agriculture, or experienced farmer).

b) Have the correct number of male breeders.

Too many bulls and cockerels will cause fights, and cause harm to the female animals / birds, and unnecessary costs for you / the owner.
Have enough cows to keep the male breeders "happy"! Approximately 1 bull / cockerel to 30 cows / hens.
Bulls not required for breeding may be **castrated / marked**, (between the age of 2-6 months is best).
Castration must be done in a clean environment by a trained person, and animals not stressed.
They are then called "**steers**", they are quiet / easy to manage on the farm, fatten much quicker, and the meat is better. Cockerels not required can be cooked for dinner!

c) Regularly inspect your male breeders.

Bulls must be "keen to mate," and can easily damage their reproductive organs∧ no calves = no money.

d) Good fences and "holding areas"

Fences, stock-yards, pig-pens, and hen-sheds need to be strong enough to keep your animals / birds inside, and to keep out unwanted animals e.g. neighbour's herd), and feral animals (rats, wild pigs, foxes)
Male breeders enjoy the company of female: so their fences need to be very strong.

e) Keep domestic animals away from your herd or flock, unless they are trained well.

Dogs and cats often frighten or harm animals, often causing injury, death, and increased costs for you!

f) A Breeding Plan

A POOR QUALITY ANIMAL COSTS AS MUCH TO FEED AS A GOOD QUALITY ANIMAL

Good quality male breeders: (e.g. bulls, cockerels) are <u>essential.</u>

Good quality female breeders (e.g. cows and hens) are desirable.

There are two types of cattle:

❶ Tropical breeds:

- *advantages:*

1) Generally they adapt best to tropical conditions. (high humidity and high rainfall, long "wet" or "dry" seasons, high temperatures.
2) More resistant to ticks and eye diseases caused by dust and flies.

- *disadvantages:*

1) Steers and heifers do not "finish" early (= their carcass (dead body) quality (for eating) is best when at least three years old).
2) Their temperament is generally less quiet (= less easy to manage)

❷ Temperate breeds:

- *advantages:*

1) Generally they adapt best to temperate conditions. (regions with four climatic seasons, (summer, autumn, winter, spring), where temperatures range from cold to warm.
2) Depending on the particular breed and its feeding programme, a steer can "finish" quickly (nine months to three years).

- *disadvantages:*

1) Their carcass weight is smaller than tropical breeds.
2) They do not like hot, dusty, flooded conditions.
3) They do not fatten well on poor pastures.

There are "meat" breeds and "milk" breeds for both tropical and temperate breed-types .

When farmers "cross" (mate between breeds) their cows, the calves have a combination of the qualities of both breeds.

Some special breeds of animals, called "multi-purpose," do not produce a great amount of any one product, but produce a good amount of two products. e.g. Sheep = meat + wool, or dairy (milking) cows = milk + meat.

Seek advice before deciding on the breeds for your bull and cows: some combinations are successful, some have problems. (e.g. big bull with small cows = calving difficulties)

"Artificial Insemination" (AI) is increasingly used as a cost-effective method of getting very good calves.

g) Treat your Animals with Care

A nervous, frightened animal /bird will not produce plenty of milk or eggs, and those animals take longer to fatten, and the animals will be difficult for you to handle.

h) Keep your herd / flock separate from other people's animals.

You do not want your animals to catch their diseases or bad habits, or unwanted mating activities.

i) Regularly clean "holding areas"

Manure must be cleaned out, (good for your garden compost).

Buildings, gates, and wire-netting inspected for good condition. Drinking-water containers cleaned.

j) Inspect your herd regularly.

Watch them regularly: often you will notice if there is something wrong.

Carefully moving your herd into another field or holding areas will help the animals get used to you and your voice, and will help you inspect them, e.g. near calving, underweight, eye problem, missing animal, limping.

k) When moving / transporting animals for sale / to market, use great care.

Bruised animals lower "carcass" (dead animal) quality. (Meat is easily bruised).

l) Keep accurate herd / flock records.

e.g. mating dates: animal birth dates: parent' details: medical records: birth-weights: castration dates: sales dates, prices, and purchaser's details: costs of livestock purchases: bird hatchlings: egg:

Bull / s = a male cow, kept usually only for breeding. Bulls are not kept from the calves. New bloodlines are essential.

Cow = a female cow, kept usually only for breeding, or for its milk.

Calf / calves = young cow or bull.

Steer / s = bull calves that are castrated (either for fattening by farmer and later sold for meat, or sold when young to another farmer who fattens them). The only purpose for all steers is to be fattened for meat.

Heifer = a young cow who has not yet given birth to a calf. Best heifers are kept for farmer's own breeders. Worst heifers are sold for meat or to another farmer for fattening or breeding.

Weaner = a steer should be separated from his mother (**weaned**) before the time when the cow needs to put on good condition to help the growth of her next unborn calf: (usually about six months).

Cows and bulls are sold from the herd if they are disruptive (cause trouble), or regularly suffer injuries.
The cows with the lowest calving records or lowest quality calves are usually the first to be sold, if pasture feed is low or there is any need for quick income.

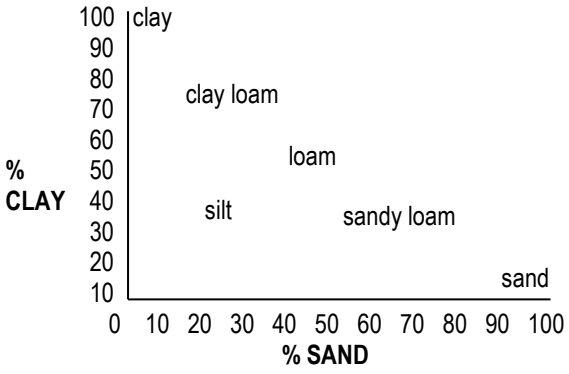
A farmer who keeps cattle is helped by having a calendar plan of operations, knowing his busy months and his quiet months. For example, he needs know when he might need extra labour, fencing maintenance, pasture establishment, transport, equipment, or medicines.

If the farmer has other operations, he will need to plan every operation in the knowledge of what else is happening at that same time.

A farmer's Calendar of Operations is influenced by climatic conditions. Heavy rainfall, or very low or high temperatures, makes many farming operations very difficult, or inefficient, or harmful.
So, some important monthly climate information is often shown on the same Calendar of Operations.

SOIL MANAGEMENT

Soil is made up of mineral particles, which vary in size, shape, and chemical composition.



Soil Types:		Soil Texture
sand	-	does not stick together coarse and gritty
sandy loam	-	sticks together, slightly gritty friable (easily crumbled)
loam	-	sticks together, not gritty friable
clay loam	-	sticks together, slightly friable but plastic
clay	-	sticks together, not friable, plastic, and sticky

Characteristics	*Sandy soils*	*Clay soils*
Particle (bits) size ΞΞΞ	large	small
Pore (spaces) size ΞΞΞ	large	small
-able to hold water	poor	good ΞΞ
infiltration (absorb water) rate	fast	slow Ξ
-able to hold nutrients	poor	good
-able to be cultivated	easier	harder
-called …	"light soils"	"heavy soils"

ΞΞΞ **good "Soil Structure" is very important**

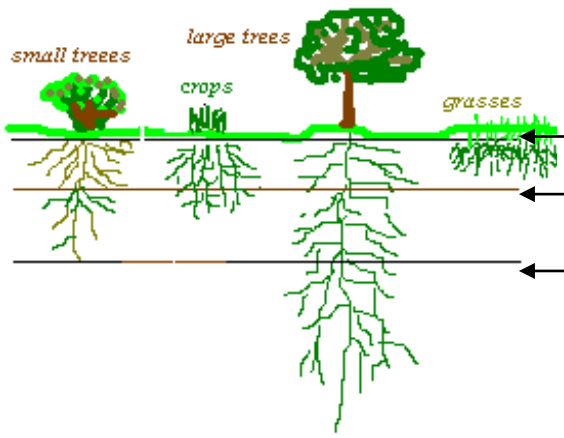
ΞΞ saturated clay soils often get stinky

Ξ clay soils have naturally poor drainage

Note: Loam soils are usually the best soils, as they combine the best characteristics of sand, silt, and clay (not extremes).

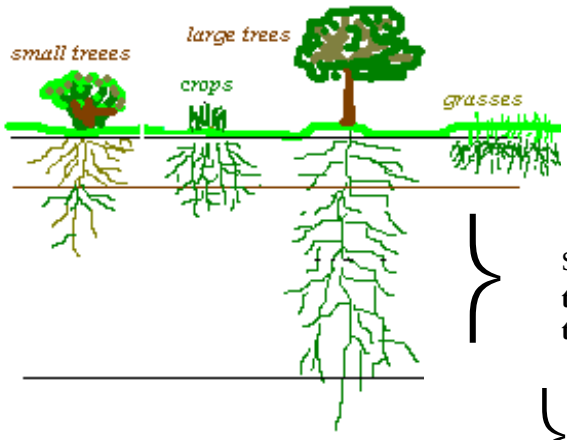
DRAINAGE

Too much water is harmful. The pore spaces become **full of water**, and there is **no room for air**
full of water = colder soil = decrease root respiration ("breathing" / growth) = decrease of plant growth.
no room for air = restricts both bacteria and soil organisms (living tiny creatures) working to improve soil structure



"saturation" – when all the pores in a soil are filled with water. After two days, water drains from the large pores, and the soil is at
"field capacity" – the maximum amount of water a soil can hold against the forces of gravity. When plants cannot remove any more water from the soil, the field has reached
"wilting point" – now plants will be stressed, wilt, and need a new supply of water to maintain maximum growth.

SOIL HORIZONS



TOP-SOIL – **the main feeding-zone of the plants. The depth of this darker soil, called the "A horizon", is richer in organic material**

SUB-SOIL – **water and essential elements pass ("**leach**") down through the top soil. This "B horizon" acts as a reservoir of water and food for the plant's roots.**

This "C horizon" is underlying rock material. It is of little use to plant roots.

Soil depths for top-soil and sub-soil vary greatly. e.g. top-soil can be 5 centimetres or 50 metres even within the same region.

- River flood plains usually have deep top-soil, (because of alluvial silt built up from material washed down and deposited over thousands of years.
- Hill slopes usually have shallow top-soil, (because of geological movements, soil run-off, and exposure to winds)

ORGANIC MATTER / MATERIAL:

Soil is enriched by plant material and the waste and decayed bodies of animals.
This organic material is continually being broken down by micro-organisms, and by soil animals (insects). e.g. insects such as ants and worms help by mixing the soil, aerating the soil, and worms also help to change vegetation into relatively stable "**humus**".

- **Humus** is the dark-brown organic material, which remains unbroken.

It improves the friable soil-texture, assists good soil structure, -therefore improving moisture and nutrient retention.

Plants get food from water in which food elements are dissolved, (not from solid particles.)
As plants take these nutrients out of the soil solution, many are replaced by the continual release of minerals in the soil. The rate at which they dissolve into the water helps determine the fertility of the soil.

Examples of organic matter:
animal manure • **leaf mould** (from trees) • **foods** • **dead animals, birds, insects, fish, seaweed** • **fruit and vegetables waste** • **husks and nut-shells** • **green manure crops** (leafy and /or bulky crops grown only to plough / turn back into the soil. **Legumes** are very good, due to their nitrogen-fixing root nodules, e.g. glycine, peas.) • **compost** (long-standing waste vegetation / plant matter, piled up and allowed to rot / decay) • **roots** • **stubble** (the stems and unused crop material which remains in the field after the crop has been harvested)

SOIL COMPOSITION:

Nature (by the weathering of rock through climate, and by the decomposition of organic material,) can take hundreds of years to make 1cm. of top-soil.

- The greater the weathering process, the finer the particles of soil that result.
- Most tropical and sub-tropical soils are acidic, because mineral salts are leached from the weathered rock particles while being broken down (by wind, temperature variations, rainfall) to make soil.

Land surfaces affect soil development.

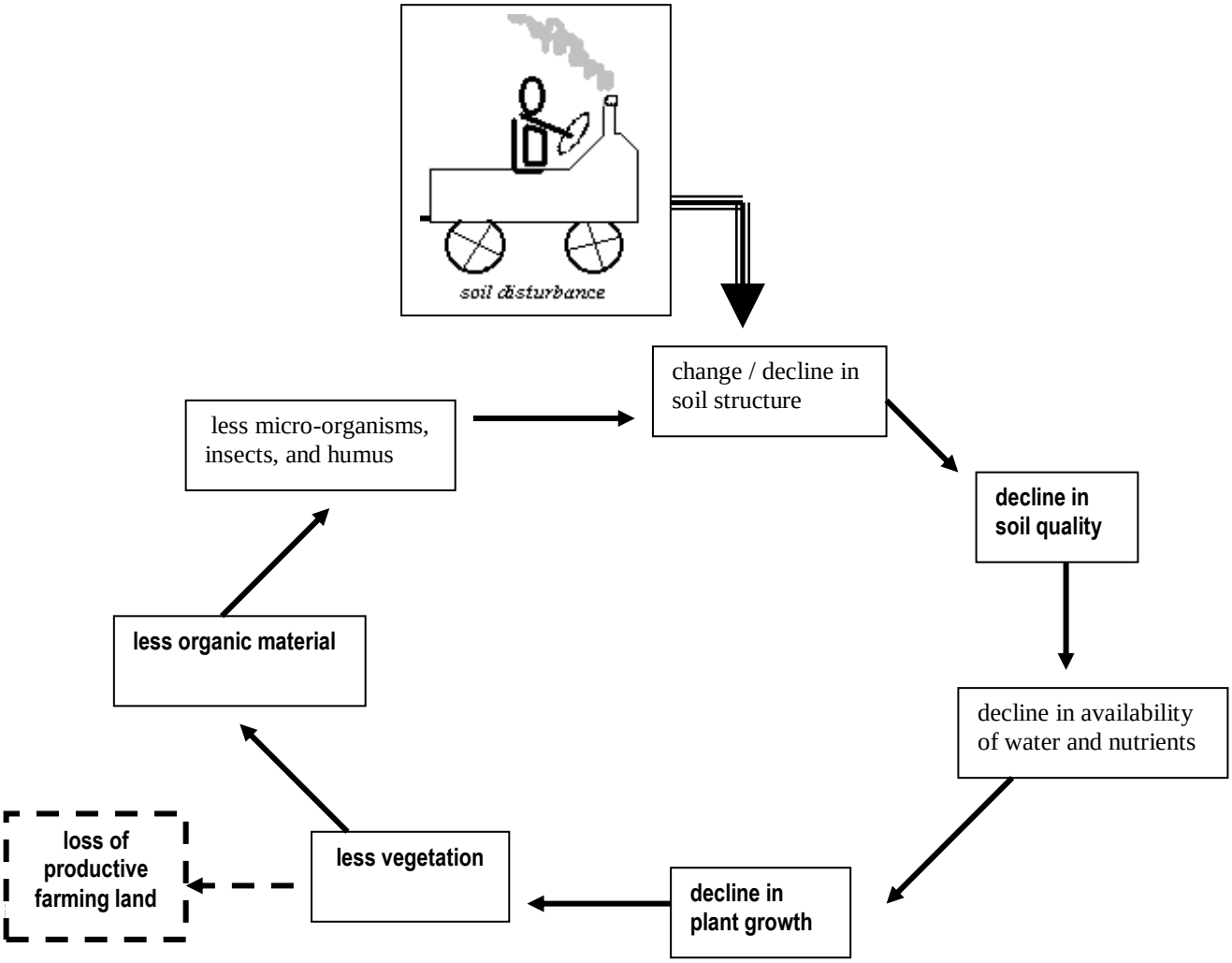
- Slopes increase water movement, leading to soil movement.
- Low land (depressions / swamps) result in poor drainage = lack of soil oxygen = slows plant growth.

SOIL EROSION CONTROL:

Soil disturbance can be caused by climate (wind and / or rain), people (farming, building, digging, clearing, etc.) animals (over-grazing, walking paths, destruction of vegetation).

Soil compaction is a major cause of decline in soil structure. <u>All</u> objects which push down on the soil compact / crush the soil, which leads to decline in soil structure.
e.g. wheels (tractors, cars, bikes, etc), people and animals (walking paths).

Generally, sub-soil clays erode even easier than top-soils, as they cannot absorb water so quickly.



Minimizing Soil Disturbance and Loss:

Great care must be particularly taken in windy areas, heavy rainfall areas, sloping land, and gullies.

- **Don't plough / work the soil in strong winds**, particularly when the soil is very dry.
- **Don't burn plant residue (plant waste) after harvest**. Leave it on the surface until the next sowing.
- **Don't plough / work the soil when it is saturated**, as damage to soil structure / compaction is increased
- **Don't remove native vegetation on steep, sloping land**, e.g. trees, bushes, grasses. Never grow crops on steep slopes.
- **Terrace-cultivation** and **contour-farming** may be carefully designed (as practiced in many Asian countries)
- If improved pastures are needed, then **minimum cultivation** (e.g. sod-seeding) is best.
- On steep slopes where trees have been removed, **plant trees**, particularly in gullies and natural run-off areas.
- **Multi-storey gardens** are much safer / sustainable / stable / productive than only one level of plants.
- **Use only appropriate technology.** Tractors and trucks are often not suitable for the Asia / Pacific region. Man-power and bullock / oxen carts are less damaging on soil structure.
- **Use groundcover-crops**, particularly legumes, to ensure that the soil is not bare or weedy between the main crop.
- **Don't overstock the land with grazing animals,** or the soil will be bared. **Grazing rotation plans** will reduce risk of overgrazing.
- **Ensure that stock / herd drinking water is available in "safe" areas,** where erosion is least likely to be caused by the regular walking and gathering together of many animals to drink and rest, usually under shade-trees.
- **Never farm in, or very near, a water-course.** Keep away from sides of creeks, rivers, and flood plains.

Surface run-off water, (containing soils, chemicals, and nutrients) causes problems in the fresh water-supplies, (e.g. rivers and creeks).

- fish die
- people's drinking water is contaminated
- water weeds quickly increase.
- most aquatic life is seriously affected.
- Rivers and harbours silt up, restricting the movement of shipping.

SOIL NUTRIENTS

Soil Nutrients are made up of **Essential Elements**

major elements	**Nitrogen (N) Phosphorus (P) Potassium (K)**
secondary elements	**Calcium (Ca) Magnesium (Mg) Sulphur (S)**
minor / trace elements	**Iron (Fe) Manganese (Mn) Copper (Cu) Zinc (Zn) Boron (B) Sodium (Na) Molybdenum (Mo)**

and **Non-Essential Elements**, (which include Aluminium, Arsenic, Fluorine Iodine, Mercury, Silicon)

Different plants use (by absorbing through their roots) different amounts of these elements at different stages of their plant growth.
When a plant grows poorly because it cannot get enough of an essential element, it is said to be **deficient** in that element.

Here are some of the complex, (and often confusing) reasons, related to nutrients, for the plant's poor growth:

- the soil having too little (being deficient) of an element.
- or by the apparently ample supplies in the soil of that element being unavailable to the plant, due to the chemical composition of that element making it not possible for the roots to absorb it.
- or the oversupply of one element has the effect of decreasing the available supply of another element.
- or one element being deficient has the effect of "locking up" another element from being available to roots.

Leaf Symptoms may be due to:
• nutrient deficiencies • toxicities (too much) • viruses • fungi • insects • climate • salt • poor soil structure • pesticides • shade • water •

A quick guide to work out the nutrient deficiency problem:

Symptoms appear first in the OLDEST leaves

Nitrogen	general yellowing: stunting: premature maturity
Phosphorus	yellowing: erect habit: lack-lustre look: blue-green, purplish colours
Potassium	scorched margins: spots surrounded by pale zones
Magnesium	patchy yellowing brilliant colours especially around edge
Molybdenum	mottling over whole leaf but little pigmentation: cupping of leaves and distortion of stems
Cobalt	legumes only, as for nitrogen
Excess salt	marginal scorching: generally no spotting

Symptoms appear first in either the OLDEST or YOUNGEST leaves

Manganese	interveinal yellowing: veins pale green, diffuse: water-soaked spots: worst in dull weather

Symptoms appear first in the YOUNGEST leaves

Calcium	tiphooking: blackening and death
Sulphur	yellowing: smallness: rolled down: some pigmentation
Iron	interveinal yellowing: veins sharply green: youngest leaves almost white (if severe)
Copper	dark blue –green: curling: twisting: death of tips
Boron	yellowing margins: crumpling: blackening: distortion

Often a plant is deficient in two or more elements at once. Different combinations of deficiencies produce many confusing symptoms, that are further confused by different climatic conditions.

Nutrient	Soil Type and Condition where deficiency is most likely	Crops most susceptible
Nitrogen	sands, leached soils, wet conditions, absence of legumes, little organic matter	all non-legumes, especially leafy vegetables
Phosphorus	almost all Australian soils	all vegetables
Potassium	sandy soils in high rainfall areas, soils which have been cropped for long periods	most vegetables
Calcium	acid soils, high applications of nitrogen and potassium (not where superphosphate, lime, and gypsum have been added)	most vegetables
Magnesium	acid soils, heavy application of potassium	cabbage, spinach, carrots, cucumbers, melons, beans, tree fruits, onions, potatoes, tomatoes
Sulphur	sandy soils, especially in high rainfall areas, little organic matter	citrus, legumes, most vegetables
Molybdenum	acid soils, leached soils	citrus, all legumes
Cobalt	coarse sandy soils in high rainfall areas, soils with high manganese levels	legumes only
Manganese	sandy, peaty soils, alkaline soils, and when too much lime applied	leafy vegetables, beans, tree fruits
Iron	alkaline soils, wet soils, and when too much phosphorus applied	beans, peas, tree fruits, citrus, grassses
Copper	sandy soils, peaty soils, and when too much lime applied, high levels of iron and manganese	vegetables, fruit trees
Zinc	alkaline soils, leached soils, coarse sandy soils, peats, dry conditions, and when too much lime applied	apples, beets, citrus, cabbage, spinach, celery, tomatoes, tree fruits
Boron	acid, leached soils, coarse sandy soils, peats, dry conditions, and when too much lime applied.	

Soil pH

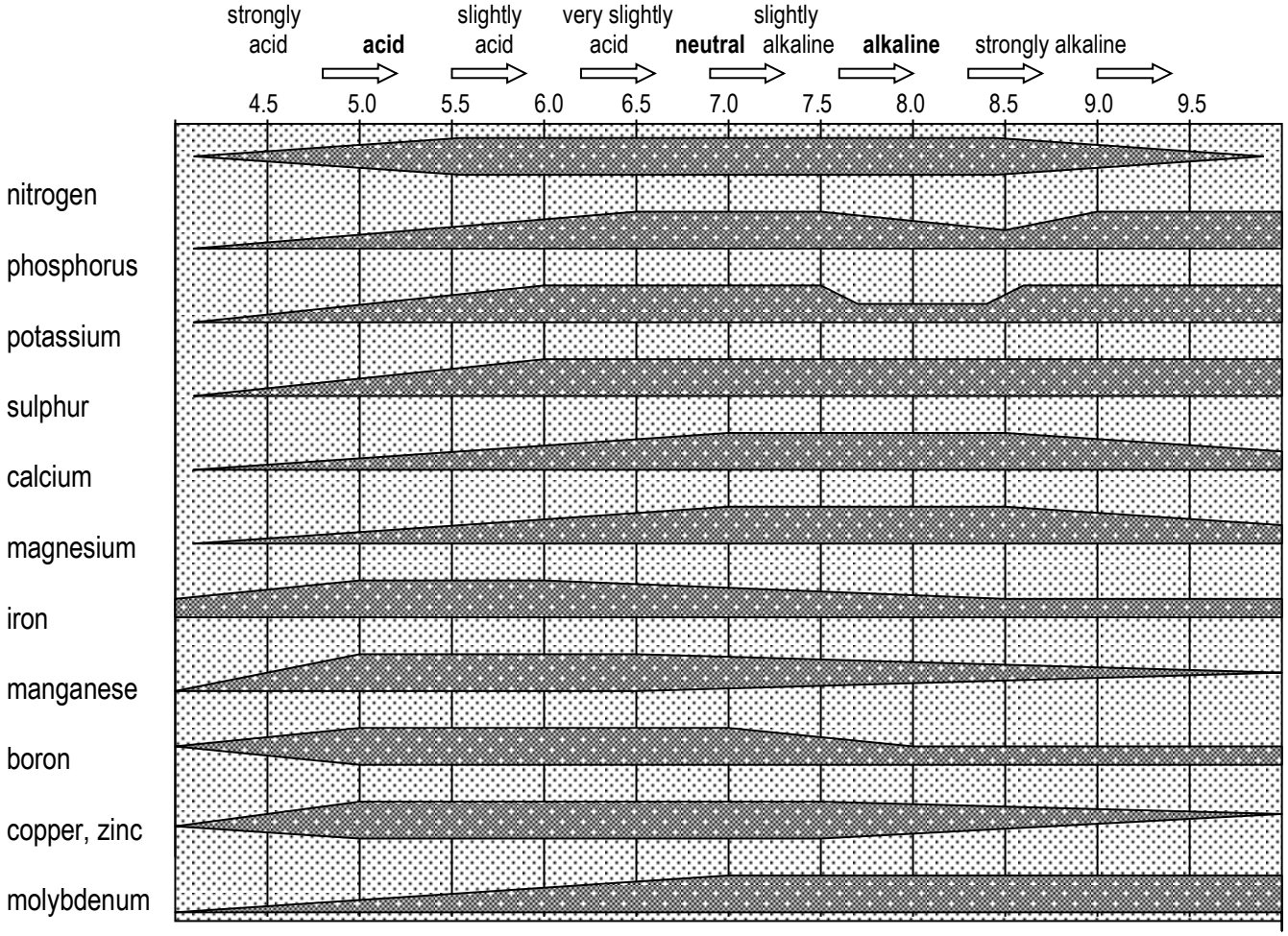
Soil pH is a measurement scale that indicates whether soils are more **acid** or more **alkaline**.
In agriculture, soil pH is measured by numbers ranging from pH 4 (very acid) to pH 10 (very alkaline).

pH 7 level is called 'neutral' (neither acid nor alkaline).
Farmers can usually measure their soil pH by obtaining a simple kit from the Dept. of Agriculture.

Even if all essential elements are present in the soil, it cannot be assumed that they are all available to the plants.
Testing the soil in slightly different areas of the farm will help the farmer decide

- what crops and pastures will grow well
- what fertilisers will provide both the needed nutrients and adjust his soil pH to his crop's and pasture's needs

The availability to plants of nutrients elements varies with soil pH as shown below:



Maximum availability is indicated by the widest part of the dark bar

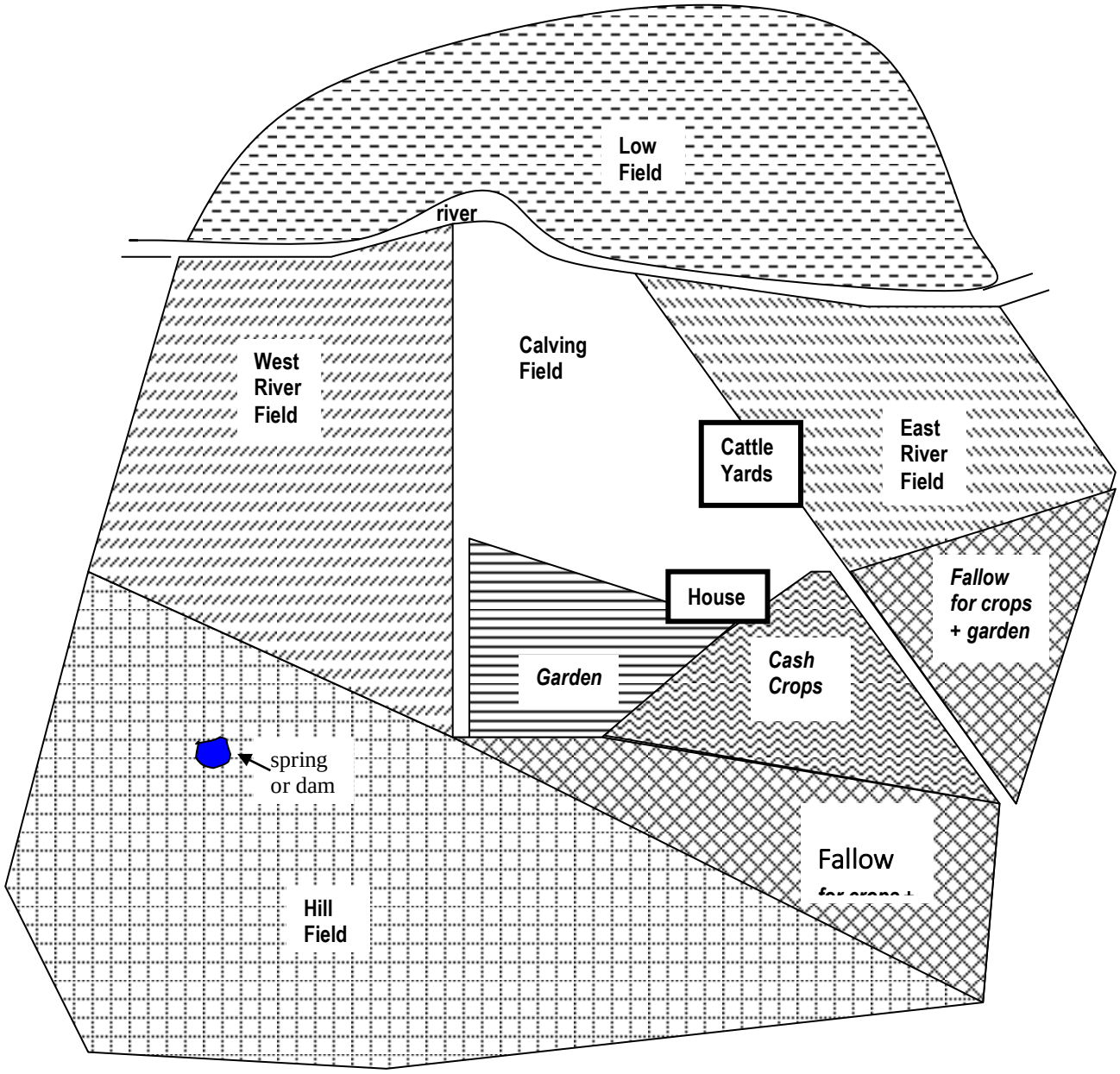
pH levels are important because different plants need different pH levels.
e.g. sweet potato likes pH 5.5, and spinach pH 6.0, and legumes pH 7.0
By adding chemical fertilisers to the soil, pH levels can be changed.

to raise pH levels – (to make soil more alkaline) use chemicals calcium and sodium nitrates	**to lower pH levels –** (to make soil more acid) use chemicals sulphur-based

Check quantities required with supplier: best to add minimum recommended quantity, then test soil again.

WHOLE FARM PLAN

Example Whole Farm Plan for a Farmer in Vanuatu - of 100 ha.



ℵ When people live centrally on their land, they can observe herds and crops easier.
ℑ All fields need access to permanent water and shade.
ℜ Fields that can flood should only be grazed in drier weather.
℘ Cattle yards, house, and cash crops need good road access.

⊗ Unimproved hill country is best used for mating and early pregnancy, when very good nutrition is less important.
⊕ Improved pastures are needed when cows are “lactating" (making most milk) for their calves, and for more quickening animals ready for market, and for heifers to be kept for breeders.

∅ Naming fields helps farmers to plan, to communicate their plans, and to keep accurate records.

Example Field Grazing Rotation: *(see Calendar of Operations on page 33)*

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec