

# Animal Systems

## Fodder Plants for Livestock

In the perfect pasture livestock feeding system, annual pasture plants and perennial grasses, legumes, shrubs and trees would all be available to stock. Annual pastures are great for in-season forage production, complemented out of season by the perennials.

Legumes include pasture plants such as annual or perennial clovers, serradella, medics and vetches, as well as many fodder shrubs and trees such as tagasaste, acacias, albizias, pigeon pea, and casuarinas.

Because of their limited height and rooting depth, relying on pasture plants alone limits both the amount of sunlight harvested, and the depth to which soil nutrients and moisture is utilized. With their greater height and rooting depth, introducing fodder trees and shrubs overcomes these obstacles.

## Fodder Trees and Shrubs

- **Tagasaste or Tree Lucerne (*Chamaecytisus palmensis*)** - Tagasaste originates from the Canary Islands. It is a nitrogen fixing shrub that is drought tolerant and fire retardant. Tagasaste grows best in loamy or sandy soils with good drainage, and a rainfall of 350 mm or more a year.
- **Saltbush (*Atriplex spp.*)** - Saltbush is tolerant of salt, waterlogging and drought. Saltbush shrubs can be planted to make use of salty, seasonally waterlogged sites where productive pastures won't thrive. It can be grown in such areas with herbage such as tall wheatgrass, puccinella and saltwater couch. It has only moderate nutritional value, but is useful as a standing supplementary feed over summer and autumn. River Saltbush (*Atriplex amnicola*), Wavy Leaf Saltbush (*A. undulata*), and Old Man Saltbush (*A. nummularia*) are useful varieties in areas receiving less than 450 mm of annual rainfall.
- **Pigeon Pea (*Cajanus cajan*)** - A short lived shrub living up to 5 years, and normally grown as an annual. It grows best in subtropical situations with annual rainfalls exceeding 600 mm in a wide range of soils, but is sensitive to frost, waterlogging and salinity. In Asia the plant is grown for the peas that are used either green or dried in a variety of foods e.g. to make dahl. The same peas are very useful poultry food, hence the name. The leaves are high protein stock fodder but also high in roughage and low in carbohydrate, so should be fed with other species.
- **Wattles (*Acacia spp.*)** - Wattles are nitrogen fixing Australian natives. They have similar uses and growing requirements to Tagasaste. Useful varieties include *Acacia saligna*, *Acacia longifolia*, and *Acacia microbotrya*. These Acacias do well in sandy, coastal plains, but also in seasonally swampy sites and riverbanks to small, rocky hills. They recover well from hard grazing and can tolerate very dry soil conditions.
- **Carob (*Ceratonia siliqua*)** - This nitrogen fixing evergreen tree can grow to 15 metres and does best in full sun in light (sandy) to medium (loamy) well drained soils. It will even thrive in limy, gravelly or rocky soils. It is slow growing and frost sensitive when young, but drought hardy. Mature trees in a suitable environment can yield up to 400 kilos of seedpods in autumn. The pods are high in sugar (about 55%) and also contain useful amounts of protein (10%) and fat (6%).
- **Albizia** - *Albizia* species are nitrogen fixing trees that provide high protein (around 20%) fodder useful for raising small livestock and large. However, the foliage is also high in fibre and lignin, and so has low digestibility and should be fed in combination with other species. For dryland situations in Western Australia's south west, two species are suitable: *Albizia lebbek* and *Albizia lophantha* (now known as *Paraserianthes lophantha*).

*A. lebbek* is slower growing than *A. lophantha*, and unlike the latter is deciduous and grows into a larger tree to 30 m in height. *A. lebbek* handles rainfall down to 500 mm a year, and grows in a

wide range of soils, tolerating frost, salinity and seasonal drought and waterlogging. It has shallow roots and coppices well.

*A. lophantha* is a WA native evergreen that grows rapidly to from 2 to 15 m. It is suited temperate conditions and most well drained soils, and handles rainfall down to 600 mm a year. It is relatively short lived and may die off after 6 to 8 years when its timber can be used as firewood.

- **Honey Locust (*Gleditsia triacanthos*)** - Honey Locust is a legume but doesn't fix nitrogen. It is a deciduous tree with a wide canopy and grows at a medium pace to 20 m height. It is drought hardy once established, and can grow on any deep soil, even tolerating mild salinity. Trees can be male or female (i.e. it is dioecious), and coppice readily when cut. The leaves are an excellent source of high protein (20%) fodder and the flowers are a great source of nectar for bees. Female trees produce around 40 kg of pods a year in late autumn that are high in carbohydrates (85%) with a useful amount of protein (12-24%). The natural tree is quite thorny, but thornless varieties are available.
- **Australian Sheoak (*Casaurina* and *Allocasuarina* species)** - There is a range of Australian Sheoaks, with species to suit any temperate growing situation, from arid dry to seasonally swampy. This fast growing, medium sized tree is a dioecious, evergreen nitrogen fixer. Many varieties sucker. Cattle, goats and sheep enjoy the seedlings, suckers and high protein foliage, so weeping varieties are useful. The ground foliage has been used as an ingredient in chicken feed and also has value as a drought fodder.
- **Holly or Holm Oak – *Quercus ilex*** - The holm or holly oak is a large spreading (20 by 25 m) but slow-growing evergreen tree. It will grow in most soils other than those that are cold and poorly drained. Trees grown from fresh acorns planted directly in the ground often survive and establish without supplementary watering due to rapid development of deep roots. The acorns it produces are small, but unlike most oaks is very often free of bitter tannins and can be eaten raw or cooked like sweet chestnuts. The sub-species *Q. ilex ballota* is cultivated for its sweet-tasting edible seed in Portugal and Spain.
- **Mulberry (*Morus spp.*)** - The Mulberry is a deciduous tree that does well in Mediterranean climates with annual rainfalls from 1500 to 2500 mm or reticulation in drier climates. It will grow well on a wide range of soils if well drained and can tolerate some shading. Aside from the fruit, the leaves are also highly nutritious and a valuable fodder for poultry and livestock, especially sick or high production animals such as dairy cows.
- **Euphrates Poplar (*Populus euphratica*)** - A fast growing deciduous tree growing to 15m. All varieties of poplar grow foliage that furnishes good animal fodder. However, the Euphrates Poplar is one of the most hardy and thus suited to growing in a dryland situation in the south-west of Western Australia.

The Euphrates Poplar can tolerate a wide range of temperatures, from freezing to very hot, and very dry conditions. It is shallow rooted, the roots spreading widely, and can tolerate saline water and seasonal waterlogging. However, it does well in a range of well drained soils, and is particularly suited to rocky hillsides.



## Holistic Management & Cell Grazing

Badly-managed grazing animals can do immense damage to pastures, soils and land. However, well-managed grazing animals are useful in many ways; creating firebreaks, sealing dams via gleying<sup>1</sup>, and can actually reduce some greenhouse gasses, all in addition to restoring pastures and providing tasty, efficient protein. They can also be used to assist with the creation of and maintenance of productive ecosystems, increasing species diversity, soil life, and therefore topsoil. Any one piece of land is rested up to 90% of the year, yet the health of the animals and the land increases markedly.

Holistic Management was conceived in response to increasing desertification in Zimbabwe and is now established across the globe as a primary Regenerative Agricultural technique. HM includes effective farm design and cell grazing, but also a more broadly applicable holistic decision making approach.

### Cell Grazing

Time controlled grazing is the process of putting a lot of herbivores on a relatively small paddock of pasture for a relatively short period of time, and then moving them on to a fresh bit of ground. The idea is that you are mimicking the behaviour of a herding animal in the wild: a tightly packed herd (to protect themselves from predators) which moves across the landscape, not coming back to the ground they grazed and manured yesterday for a considerable period of time.

When left for the right amount of time between grazing, the pasture recovers, the seedbank within the soil is stimulated, and the biomass of the paddock, both above and below the surface, is drastically increased by this short sharp attack of grazing and the nutrient dump that comes with it.

A herd is moved across a landscape in a tight pack. The rate at which you move them depends on the weather, the time of year and the conditions of that paddock, all of which are variable. So this isn't a formulaic process. The rule of thumb is that by the time you move those herbivores on to the next patch you want one third of the grass in their stomachs, one third laid down on the ground, and one third still standing.

Milkwood Permaculture divided a 2 acre creekflat into 4 paddocks, fenced with temporary electric fencing<sup>2</sup>, for a mob of approximately 95 sheep. The sheep were moved every 24 hours. Milkwood used a mobile watering point, consisting of a watering trough on wheels with a float valve and gravity-powered refill hose, which could be moved to each new paddock cell with the animals



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<sup>1</sup> If you drain a leaky pond and fence a bunch of cattle or hogs inside, and spot feed and water them throughout the pond for a couple of weeks, and then slowly allow the pond to refill (remove livestock first!) it will often seal and hold water thereafter. It doesn't hurt to add expansive clay to the manure urine mix on the base of the pond or dam during the last couple of days and have that trampled in also.

<sup>2</sup> They used 4-strand electric fencing from Thunderbird (<http://www.thunderbird.net.au/efencing.htm>), with a solar-powered SB40 energizer to power it. You can also use electronet fencing (<http://www.allsun.com.au/Electranets.html>).

## Pasture Cropping

Pasture cropping involves sowing crops directly into pasture, without first tilling the soil and turning it over, similar to the practices of Masanobu Fukuoka. It allows cereal crops to be sown directly into perennial native (or exotic, or mixed) pastures and have them grow in symbiosis with the pasture, for the benefit of both the pasture, and the crop.

This process has the effect of producing a very respectable yield from a field (as good, if not better, than conventional cropping, in terms of profit to the farmer), while retaining perennial. And, perhaps even more importantly, pasture cropping preserves the soil structure, builds biomass and results in no loss of topsoil.

Introduce some herbivores to that same paddock, after the crop has been harvested, and the nutrient cycle really starts to get interesting. By using Holistic Management techniques of herbivores like cattle or sheep, the biomass and available nutrients of that pasture builds even faster. Which means the topsoil, in turn, also builds at a rapid rate.

## Forest Systems

Forest gardening is a low-maintenance sustainable plant-based food production and agroforestry system based on woodland ecosystems. Natural forest systems include various animals to spread seeds and recycle nutrients. Constructed forest garden systems are enhanced by the inclusion of free ranged or cell grazed animals, just as pasture systems are.

## Which Animals to Use?

Any herbivores can be used to do the same basic job when it comes down to it: they eat the grass, process it into manure, deposit it back out and help accelerate the biology of that pasture by providing nutrient and stimulating the seedbank in the soil.

- **Cows** - Some would say Holistic Management pasture techniques work best with herbivores that have 4 stomachs, soft feet and nice big sloppy manure. Namely cows.

Cattle are not generally regarded as being suitable for forest systems, due to their size, compaction caused by the amount of pressure their feet exert on the ground, and their tendency to rub on and around trees. However, they can be kept in silvopasture<sup>3</sup> situations if spacings between trees are quite large.

- **Sheep & Goats** – Goats and sheep expels pellets which don't incorporate into the soil nearly as fast as a big sloppy cow-pat. Their hooves are also much harder on the soil than a cow's softer feet. Their gut biology is different from cows; the pasture and browse that sheep and goats eat is not as processed, digested and broken down as in a cow, which means it isn't as ready to incorporate into the soil. However, sheep and goats eat different plants to cows (and to each other) and contribute different biology to the soil and pasture. Their urine is also full of beneficial minerals and nutrients for the pasture.



<sup>3</sup> Forest pasture systems, which include a tree crop, a forage crop for livestock, and livestock.

Sheep need multiple strands of electric fence (i.e. 4 strands) to be effectively contained. Because of their insulating wool, they don't get the message sometimes when they press against the fence so you need multiple strands to make sure they get the idea if they touch the fence. With cows, you can use just one strand. As a rule of thumb, the fencing for goats should be good enough to keep in crossbred sheep.

Goats tend to go through or under fences rather than over them, so ringlock/hingejoint or electric fencing is recommended rather than plain wire. Existing plain wire fences may be protected by using a low electric outrigger or hot wire, run at approx. 45cm above ground level. Another outrigger at waist height prevents larger animals from standing up on the fence.

Sheep and goats are a bit more difficult to keep in a forest pasture situation since they like to eat twigs and thin-barked trees. With appropriate tree guards installed, sheep and goats can be grazed in orchards and forest gardens. There is also the possibility of grazing sheep and goats in areas with trees which don't mind being coppiced (willows, alders, hazels, and elders.) By rotating the sheep and goats through small pastures, with long recovery times between rotations, we could give the shrubs time to grow back rather than being decimated by gnawing teeth. Goats can also help prevent forest fires by eating the tinder-like grasses, bushes and small trees in the underbrush that allow flames to jump to the higher forest canopy and get further spread by the wind.

- **Alpacas & Llamas** – Llamas and alpacas exert very low hoof pressure (39 kPa as opposed to 82 kPa for sheep, and 49 for kangaroos), which helps avoid soil compaction. Their soft, padded feet are less damaging to the soil structure and groundcover than the hooves of cattle or sheep.

Alpacas deposit urine and faeces in a common place in the paddock through a uniform pattern of pile allocation. Because urine and faeces are deposited in the same pile, the biochemical decomposition and incorporation to the soil of these organic materials is highly efficient; the microfauna activity around the dung piles is remarkable. Holistic management practices using high animal density and short occupation periods produced a full animal fertilisation of the paddocks after 7 to 10 rotations, since the animals moved the dung piles, within a specific pattern of allocation, in a regular manner within the paddocks.

Alpacas are generally safe to keep in a forest garden, although they may damage young trees during casually browsing.



- **Chickens & Turkeys** - Free-range chickens (or sometimes turkeys) are often used to follow cattle or other ruminants in cell grazing systems. They scratch up and turn over an area of ground, spreading the manure from the ruminants and eating the larvae and eggs of many pest organisms. They will also eat pasture seeds, meaning that while they are good for preparing the soil for planting, they may also deplete the existing seed bank.

Cell grazed pastured poultry systems consist of a mobile shed and happy, busy birds enclosed by portable, flexible electric netting fences. These keep the birds safe from predators while confining their foraging to a defined cell which is never allowed to be overgrazed. The sheds are built with mesh floors so that all the droppings from the roosting hens drop straight onto the pasture. The shed is moved daily so there is no build-up of manure and no labour requirement to move manure or litter build-up. Some pasture houses have a removable tray floor to comply with local shire

regulations. This removable tray collects the night droppings which can then be removed and spread on other pasture areas. With this type of set up the house is moved less frequently.

Free range turkeys and chickens are well suited to forest garden and food forest systems.



- **Ducks & Geese** – Geese and ducks, much more than chickens or turkeys, are grazing animals. The chicken tractor or the simple "turn the birds out on free range" method can be used to produce waterfowl. A system of rotational grazing should be practised to ensure birds have access to good pasture all the time. Where paddocks are fenced off and allowed to spell, the pasture will regrow quickly and the paddocks will be more hygienic.

Geese (and sometimes ducks) have historically been used to control weeds and grass in orchards, and may be used to graze in forest systems as well.



- **Pigs** - Pigs naturally root around in the soil, and dig up and turn over the ground, including the current ground cover. They aren't ideal for pasture management, but a pig tractor is a great way to prepare ground that needs a serious going-over (e.g. to prepare for planting a food forest), as the pigs literally turn the soil upside down, eating all the starchy roots of the grass as they go. They are also good for improving fertility and controlling pests in forest systems, although they can damage young trees.

Pigs do need a fairly serious electric fence to keep them contained; 7000 volts running through the electric fence is a goodly amount to 'train a pig'. They only need to get one or two shocks at that intensity to learn to stay clear of the fence.

Free range pigs are well suited to forest garden and food forest systems; many breeds of domestic pig were traditionally kept in woodland environments, where they ate roots and fallen fruit and nuts.



## Housing for Animals

- **Rabbits** - Housing for rabbits usually consists of cages or hutches that are up off the ground. The rabbits need protection from wind and rain and possibly predators. They will need adequate ventilation as well. Sheds or hutches should be insect-proofed to minimise infection with myxomatosis and rabbit calicivirus disease (RCD).

Each breeding doe is kept in a separate cage with her litter until weaning when the kittens are about 4 weeks of age. The growing young are then moved to another cage where they are kept until they reach approximately 12 weeks of age and are ready for slaughter. A target for doe productivity is seven litters per year with four to five rabbits produced per litter. About three cages are required per doe to cater for the doe and her kittens plus two groups of weaned kittens. Buck cages are required at a ratio of 1 buck for every 10 does.



- **Sheep** - Housing needs for sheep vary by climate, season(s) of lambing, and management preferences of the shepherd. If lambing will occur during periods of inclement weather, more elaborate housing is usually required. If lambing will occur on pasture during periods of mild weather, simple shelters may be all that is needed. Lambing percentages are usually higher when shed lambing is practiced. It is common to temporarily house sheep after shearing and/or during lambing. Adult sheep can handle cold and wet weather rather well, but newborn lambs cannot. The combination of cold and wet can kill even a two week old lamb, if there is not sufficient shelter. Emergency shelter is needed for bad storms.

Barns should not be heated or closed up. Good ventilation is an absolute must. Respiratory problems (e.g. pneumonia and bronchitis) often result from poor ventilation. If ammonia can be smelled in the barn, ventilation is likely inadequate. Housed sheep have lower nutritional requirements, whereas sheep kept outside have fewer respiratory problems. Bedding (straw, wood shavings, shredded newspaper, or similar) provides warmth, insulation, and comfort to housed animals. Traditional barns, pole buildings, and metal buildings are usually the most expensive, but they provide the best protection for the shepherd, sheep, feed, and equipment. A lower-cost alternative to traditional housing is a greenhouse-type structure called a "hoop house." A hoop house has an arched metal frame that is covered with a heavy fabric. Fabrics last for approximately 15 years.

- **Goats** - Goats do not take kindly to rain and wind and are susceptible to respiratory diseases, this particularly applies to the dairy goat who does not have the protective coat of the fleece animal. Housing in tropical and semi-tropical regions should be kept to a minimum except for the more intensive systems of production. In the arid tropics no protection other than natural shade is required. In humid climates a simple thatched shelter will provide shade and protection from excessive rain. Sheep and goats do not tolerate mud well; therefore yards and shelters should be built only on well drained ground. In temperate climates and at high altitudes a more substantial structure may be needed. An open-front building facing north provides wind protection and a maximum of sunshine.

Dirt or gravel floors are best, although some people prefer wood. Dirt absorbs urine, and both gravel and dirt, when covered with straw, are warm. Avoid concrete because it's cold and hard on the goats' bodies, although it's easier to clean. Regardless of type of flooring, you need to use some sort of bedding for warmth and comfort. If you do have to use a concrete floor, make sure to put

down 3 to 4 inches of wood shavings or straw to insulate the goats. In areas of high rainfall it may be desirable to keep the animals off the ground. Stilted houses with a slatted floor which is raised 1 to 1.5m above the ground to facilitate cleaning and the collection of dung and urine have been used successfully.

Regardless of the breed, you will also need an area for doing routine care, such as hoof trimming or clipping. If you're raising dairy goats, you can use the same space for milking.

Goats will test fences, either intentionally or simply because they are handy to climb on. If any of the fencing can be spread, pushed over or down, or otherwise be overcome, the goats will escape. Goats are also very coordinated and can climb and hold their balance in the most precarious places, so remember to build your structure safe to climb on or tall enough your goat is unable to get onto it at all.



- **Alpacas & Llamas** - Alpacas need shelter from wind rain snow and hot sun. However they don't like small enclosures. If it looks like a cozy little warm place to you, it probably looks like a trap to your alpacas. Shelter can be anything from a straw bale structure with one side open to the elements, to a barn with heated floors and heated, automatic waterers. If you are designing a barn from scratch, consider having stalls that open out to a small paddock under an overhang, and then another gate out to a pasture. Access to shade at all times is essential and sprinklers may be provided on very hot days to allow the animals to cool down. Alpacas prefer shelters that allow them to see out.

Sheep fencing to a height of 1200 mm is adequate to keep alpacas penned. Do not use barbed wire. Alpacas rarely test fences but, if they are confined and stressed, they will jump easily over 1000 mm pens, particularly if they are confined without companions.

Apart from the boundary fences, the most important structure is a small yard or pen to catch the alpacas. Some alpacas will allow themselves to be caught in an open paddock, but even the friendliest ones tend to step just out of reach when you most need to catch them (eg. shearing time). The yard need not be elaborate, and often the easiest and cheapest one to construct is to place two 3 metre gates at right angles to each other inside the corner of the paddock. If the alpacas get used to being fed in this area it also makes it very easy to catch them.



- **Turkeys** - Housing turkeys is, in many ways, similar to other ways of containing fowls like chickens and ducks. Like all poultry, housing is essential at night to keep out poor weather and predators. A well ventilated shed will suffice. It is very important when you build houses for turkeys that you take into consideration the ventilation of the coops, as turkeys are very sensitive to air quality.

- **Chickens** - Chicken coops usually consist of an open bird-mesh front, a partially enclosed back and solid sides (sides may be more 'open', possibly with blinds, depending on climate and local siting). It should be well ventilated but not draughty, easily cleaned, and provide protection from extremes of temperature. A sloping roof which slopes to the rear with sufficient overhang at the front (600 mm) and back (300 mm), and a concrete floor with a rat wall are desirable. New bedding should be spread about 100 mm deep. Because there is plentiful feed, rats and mice may breed unless the shed is properly constructed and managed. The shed also needs bird-proofing (wild birds may introduce disease, eat feed and steal eggs) and to be predator-proof (to lock your birds in, especially at night - foxes do inhabit the suburbs).

Nest boxes should be mounted on the cool side of the shed preferably 600 to 900 mm off the ground. Allow one 300 mm x 300 mm nest box for every four hens. The nest material can be shavings, straw or shell grit, to a depth of 75 mm, and should be kept clean and dry. Roosting perches made of 75 mm x 50 mm dressed timber placed 500 mm from the floor can be provided, but are not essential. If used, at least 150 mm of roost space per bird is required.

Councils may have by-laws regulating the size and location of a backyard poultry shed. Check with your local council before building.

Alternatively, a chicken tractor is a movable cage for chickens. It allows free range access to fresh forage and provides shade, shelter from rain, and protection from predators. Unlike fixed coops, chicken tractors do not have floors so there is no need to clean them out. Nest boxes and perches can be attached inside the tractor, as can a feeder and watering station.



- **Ducks** - Elaborate sheds are not necessary, but you should observe the general principles of poultry house design. The housing must be clean, dry, adequately ventilated and able to keep out beating rain. Allow each bird an area of at least 0.2 m<sup>2</sup> of floor space inside the shed (i.e. 5 birds/m<sup>2</sup>). Cover the shed floor with litter for the comfort of the birds, to absorb moisture and to prevent egg breakage — wood shavings are probably the most suitable, but any soft absorbent material to a depth of about 7–8 cm is satisfactory. Since ducks are very susceptible to excessive sun, provide adequate shade.

Nests should be clean, dry, comfortable and only large enough to be used by one duck at a time. Build them from timber and place them in rows along the walls. A suitable size is 30 cm by 30 cm by about 40 cm deep. Nesting material should be placed in the nest to a depth of about 7 cm. Use shavings, sawdust, sand or shell grit. Broody ducks will further line their nests with their own body feathers.



Swimming facilities are not essential. However, pools can be made available where outside runs are provided. Concrete ponds 1 m wide by 0.25 m deep are satisfactory. To keep litter in the shed dry,

place the ponds away from the house. Alternatively, saucer-shaped pools 0.25 m deep and 2 m wide may be used. In both cases, good drainage is essential. Although swimming water is not necessary, ducks do need plenty of clean drinking water. Birds should be able to immerse their heads completely and hence clean and prevent blockage of their nasal passages caused by food and dirt. Keep drinking containers shaded at all times. To prevent damp litter, place drinking vessels outside the shed or on a wire grid. Provide about 3 cm of drinking space for each adult bird.

- **Geese** - Geese do not require an elaborate shed. A moveable shed with a flat, sloping roof is a suitable shelter. The shed needs to be fully enclosed and locked at night for protection against foxes, dogs and feral cats.

A trio of geese will need a shed with a floor space of 1 m<sup>2</sup> per bird and a run. A 15 cm layer of wood shavings on the floor will help maintain dry conditions in the shed. Geese tend to foul their sleeping quarters so damp litter must be removed frequently. Each shed should have nest boxes, even though some geese may nest on the floor. Geese can be housed on slatted floors. The slats should be 2 cm wide at their top to ensure a comfortable standing surface and 1.5 cm wide at the bottom, while spacing between slats should be 1.5 cm to permit droppings to pass through. Droppings removal access from under the floor is essential.

Each goose should have at least 2 m<sup>2</sup> of ground space in the run or yard area. Yards should be as large as possible and preferably sown to suitable pastures such as millet, kikuyu, paspalum and Rhodes grass before geese are introduced. Each breeding flock need not be confined to a separate shed and yard.

The stocking rate for adequate grass control is 50 to 60 adult geese/ha. If only light grazing is required, this stocking rate could be reduced to 15 to 20 adult geese/ha. Excellent control of pasture may be obtained by moving the water trough to grassy sections of the orchard. One water trough is sufficient for 10 ha. A shallow ditch will serve for both drinking and swimming. Swimming provides beneficial exercise and helps prevent sore feet. Geese generally mate in water, which must be 2 geese deep for this purpose.

- **Pigs** - Pigs need a dry bed, and protection from extreme temperature and sunburn. Free range pork production consists of outdoor paddocks, which includes rooting areas, wallows and kennels/huts for shelter. The huts allow the animals to seek shelter from environmental extremes. They also provide additional protection for the piglets when very young.

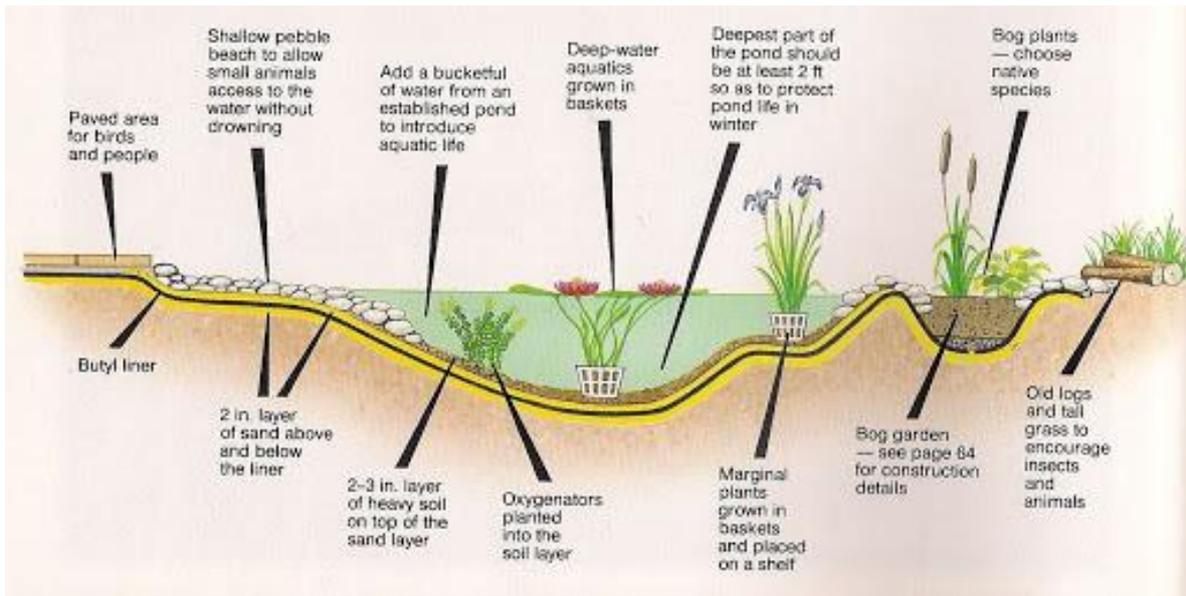
The temperature range required to achieve the best pig productivity is called the thermoneutral zone. Critical temperatures vary according to the pigs' total weight and specific conditions in the piggery. However, if pigs spend time huddling or shivering, and eat more than usual, they are usually cold. If they avoid body contact with pen mates, eat less, foul areas of their pens that they normally keep clean (possibly lying in this and other wet areas) and pant at more than 50 breaths per minute, they are too warm. Young pigs suffer most from the cold, while older and larger animals succumb first to rising temperatures.



*Movable, waterproof and cosy straw-filled pig house*



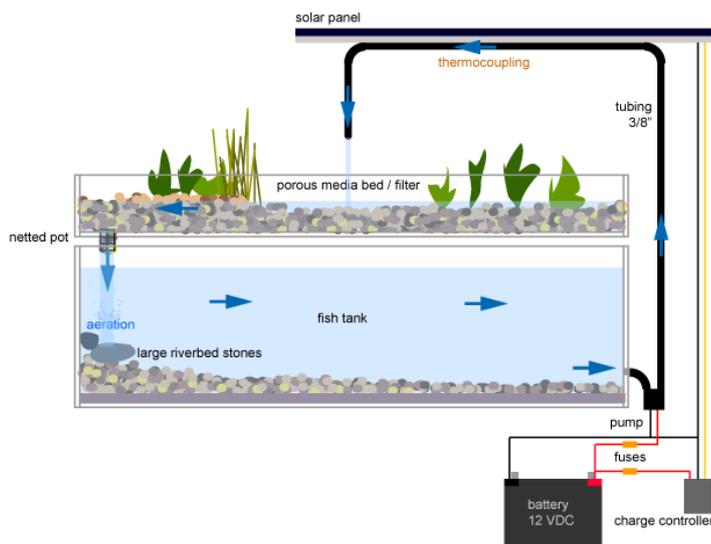
## Ponds



## Aquaponics

Aquaponics combines a traditional aquaculture (raising aquatic animals such as snails, fish, crayfish or prawns in tanks) with hydroponics (cultivating plants in water). Aquatic effluents, resulting from uneaten feed or excreta from aquatic animals, accumulate in water due to the closed-system recirculation of most aquaculture systems. The effluent-rich water becomes toxic to the aquatic animals in high concentrations but these effluents are nutrients essential for plant growth. These by-products from the aquaculture are filtered out by the plants in a hydroponic set-up as vital nutrients, after which the cleansed water is recirculated back to the animals. The term aquaponics is a portmanteau of the terms aquaculture and hydroponics.

Species selection is important. Barramundi require water temperatures of 20-30°C, and will not breed in captivity without special hormone treatments. Murray Cod, eels, and Silver, Gold, and Jade Perch can easily be grown out, but will not breed in captivity without specialised conditions and hormone treatments (and in the case of eels, not even with these treatments). Tilapia will grow and breed in captivity, but cannot be legally kept in WA. Trout will similarly thrive and breed in captivity during winter, but Perth summer temperatures are too high<sup>4</sup>. Channel catfish will grow and breed in captivity, given enough space. Carp, including koi, will happily grow and breed in aquaponics systems, as will yabbies and marron.

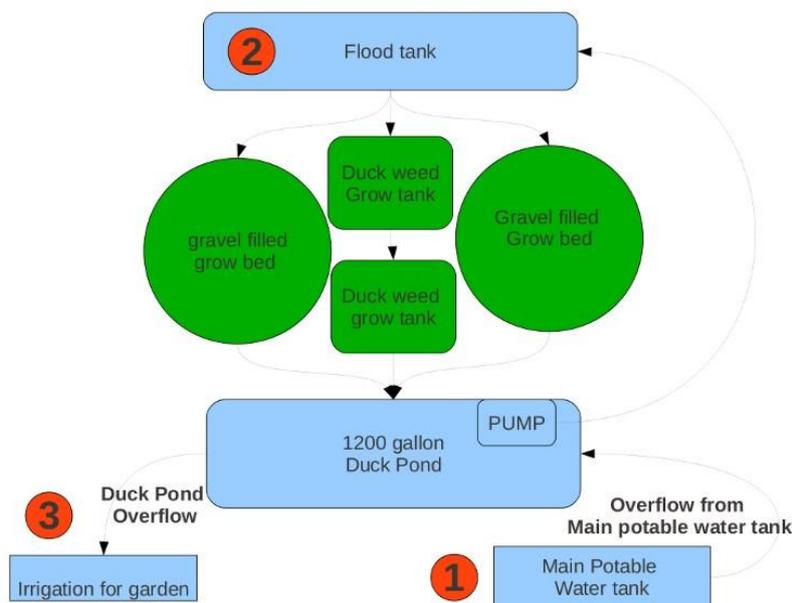


<sup>4</sup> Trout prefer water temperatures between 10°C and 20°C. Water temperatures above 23°C will kill them. A deep (1.5 to 3m) in-ground pond using the thermal stability of the earth - 1.5 to 3 m underground the ambient earth temperature is typically 10 to 23 °C all year round in temperate latitudes.

## Duckponics

Ducks eat many of the pests common to the garden, and their waste fertilizes the beds. However the water required to provide them with a clean place to swim is immense and a real waste. Reusing this water is the key to creating a more sustainable environment for your garden.

Integrating ducks into a simple aquaponics system is a relatively easy way of doing this. The idea is that the ducks would supplement or replace the fish in your aquaponics system. The more muck the ducks create in your pools the more nutrients that are provided for your plants. The water loss for this system would be more than that of a typical aquaponics system; however it would be SIGNIFICANTLY less than the water waste you would have if your duck ponds are not being actively cleaned by the plants.



## Animal Feed - Azolla

Azolla is a native water plant with some excellent attributes for anyone looking to develop closed-loop cycles for organic animal feed. It's high in protein and minerals, fixes nitrogen due to a symbiotic association with a blue green algae (*Anabaena azolla*), is palatable to chickens, pigs, goats, ducks and cows<sup>5</sup>, and can be grown on any closed body of water. It can double in volume every several days under optimal nutrient and water temperate conditions.

Azolla is an excellent aquatic green manure plant, and was until recently used extensively in Vietnam, China and other parts of Asia in rice paddies, where it would cover the surface of the water in the paddy and out-compete weeds while the rice grew, fixing nitrogen and contributing fertility as it went.

Growing Azolla is very easy: put some in a dam or pond, and watch it grow. It does deplete the nutrient content of the dam, so if you are trying to grow other things in the dam (lotus, water chestnuts etc.) you need a very high nutrient load.

<sup>5</sup> Azolla is 25-30% Protein, and low in lignin with makes it digestible to many animals, as well as nutritious.