Identifying, modifying & Creating Microclimates

www.underthechokotree.com
Sustainable Living in the Suburbs

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1.0 Introduction: The What and why

1.1 Context and disclaimer

While the concept of microclimates is applicable to all climates and species on earth, the purpose of this article is to consider microclimates in terms of the urban and (particularly) suburban environment and regarding the growing off productive species in those areas.
Disclaimer – I am old. I also tend to be pretty analogue in my thinking, so while I do suggest websites and aps which will help to make sense of your microclimates I also talk about stuff you can do from scratch without the need for extensive digital skills. You have been warned!

1.2 What is a microclimate?

Definitions

Below are a selection of definitions of the term 'microclimate' from various sources -

Wikipedia - A microclimate (or micro-climate) is a local set of atmospheric conditions that differ from those in the surrounding areas, often with a slight difference but sometimes with a substantial one. The term may refer to areas as small as a few square meters or square feet (for example a garden bed or a cave) or as large as many square kilometres or square miles.

Dictionary.Com - the climate of a small area, as of confined spaces such as caves or houses (cryptoclimate), of plant communities, wooded areas, etc. (phytoclimate), or of urban communities, which may be different from that in the general region.

Merriam-Webster - the essentially uniform local climate of a usually small site or habitat

Factors Affecting the Microclimate

So from the above definitions, it can be seen that a microclimate is a small area which has a different climate from the prevailing one in the area (macroclimate). For us that meant areas within our yard which were different from the cold and heat that is western Sydney. As usual with these things, the concept is simple but there are various factors which may play out separately, or together and can result in a variety of microclimates in any given area. These factors are -

Temperature – The temperature of a microclimate may be affected in many different ways, including warmer winter temperatures caused by the presence of thermal mass such as buildings of brick, clay or stone; large rocks and/or bodies of water such as pools, ponds or streams, or full water tanks. A glasshouse will also result in a warmer temperature inside the structure. Conversely, the temperature of an area may be reduced in summer by surrounding trees or bushes sheltering an area from the hot summer sun and wind or bodies of water.

The northern side of a shed can provide a warmer, protected microclimate for winter growing

Light – All plants need light but not all plants need full sun. The amount of light available in an area will be moderated by the presence of shade from buildings, sheds and fences (Full shade) and/or surrounding foliage from trees and bushes (which may be partial or dappled shade, depending on foliage density). Deciduous plants will provide foliage cover in the warmer parts of the year and then lose their leaves to allow extra light in during the winter. The amount of visible light from the sun is also tied to the amount of infrared light (heat) from the sun so increasing light levels will also have an impact on the temperature of a microclimate as well. The time of year will also have an impact on sun/shade due to the angle of the sun in the sky.

Air Circulation – in this case wind, which can be hot or cold, warm or cool. Cold winds can be very hard on temperate crops, and hot winds can dry out just about anything rapidly. This will be modified by surrounding foliage including trees and bushes, and structures like houses, sheds and fences.

Water – There are a number of ways in which water will impact the microclimate of an area. Soil moisture/drainage have considerable impact on what you can grow and how easily it can be grown. The books always tell you that the best soil is “moist but well drained” but I would bet that most of us a closer to one of the extremes than the ideal. A sandy soil will tend to be drier than a clay soil, which may contain moisture to the point of causing root rot in fruit trees.. Humidity due to bodies of water in the area can be good, reducing the amount of irrigation needed for your fruit and veg, but if coupled with low air circulation it can mean fungal problems may occur.

Also, water coming off unplumbed roofs such as sheds, garages, chicken coops or whatever on your land or that of your neighbour and impervious areas such as driveways, footpaths or other paved areas will result in localised areas staying damper for longer than the surrounding areas.

1.3 Why is it important to understand microclimates?

So, why is it important to understand microclimates in general and then be able to apply this knowledge to your own property? A knowledge and understanding of microclimate is key to successful growing of productive crops (food, fibre, biodiversity and/or amenity) in small suburban and urban areas, because –

1. It can enable you to pick which areas of your property will be unsuitable for a particular plant or class of plants. Moisture loving plants being put into a dry microclimate will not thrive and be productive.

Water runoff from sheds and tank outlets can result in a damp microclimate

2. Conversely. If the microclimates on a property are identified and made use of, they can ensure that plants are placed where they are most likely to survive and thrive, for example by planting a bog plant into that area of the yard that always seems damp.

3. Microclimates can be modified or created so Identification and study of existing microclimates will enable modification of them to better support the growing of desired productive plants or the creation of entirely new ones that better suit the types of productive plants to be grown.

2.0 Identifying your current microclimates –

2.1 But first: The macroclimate

To be able to identify the microclimates present on your small part of the world, you will need to have some understanding of the macroclimate which exists in your area because that is the context within which your microclimate(s) will exist. That is to say –

- What are your temperatures throughout summer and winter?
- When is the first and last frost? (If indeed you get frosts at all!)
- How much rainfall do you get what is its distribution throughout the year?
- How hard do the winds blow and from which direction?
- How many sunny/cloudy days do get over the course of a year?
- How does humidity vary throughout the year?
-

If you have lived in your area for any length of time you will have some idea of the answers to a few of these questions. We have been here a long time and I know that generally the cold winds come from the south, and hot winds come from the north and west.

There are a number of ways of finding this data out, but there are a couple of caveats –

1. The closer the measurements were taken to your part of the macroclimate the more likely they will be to reflect your experience of it and the more useful the data will be.

2. The term 'climate change' says it all. Things are changing so be circumspect when using old data or data that has been averaged over a long time period, it may not be as accurate for current conditions.

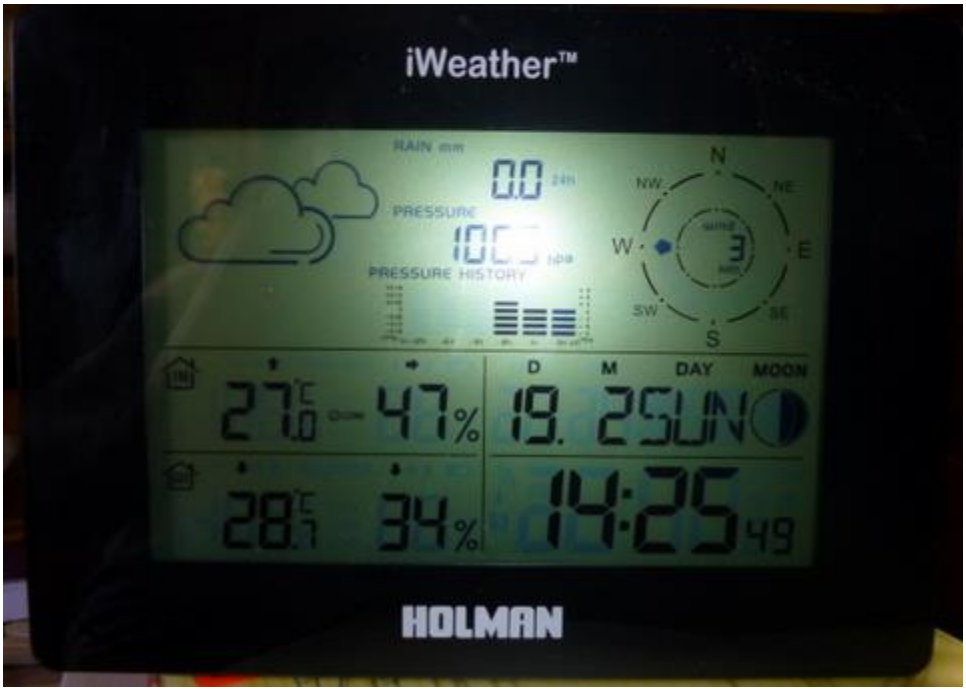
A good source of data in Australia is the Bureau of Meteorology (BoM). It is worth checking out how close a BoM monitoring station might be to your house. This link will take you to the BoM site where you can check out your place, and the closest meteorological site which can provide you data.

http://www.bom.gov.au/climate/data/index.shtml#mapoption
http://www.bom.gov.au/climate/data/stations/

There is also a website where people can share data from their own private weather station and that is accessible through the BoM here - **http://www.bom.gov.au/wow-support/**. Also, check with your neighbours to see if they are weather enthusiasts, or if they have friends that are. They might have an operational home weather station and record of weather data.

Of course, if you intend to get into this yourself, there are any number of companies who will be willing to sell you a home weather station of your own.

Our Weather station in place



What the monitor looks like

2.2 Identifying your microclimates

When we moved in, the microclimates available in our yards were few. Some areas close to the house affected by thermal mass, the southern side of the northern fence and the eastern side of the western fence and, of course, the house were providing some shade and that was about it. Where our house was built, and indeed the whole estate, was effectively clear felled so there was no existing vegetation to be worried about or of which we could take advantage. This would have been good, being able to start from scratch, but at that time I had no knowledge of gardening, let alone microclimates. So here, over forty years later, I have had lots of mistakes to learn from so you don't have to make them!

No microclimates around here!

When you are carrying out your microclimate investigation, it is worth having a notebook to record your observations of any you discover and a digital camera is good to capture any interesting bits. A line drawing of the layout of your property, filled as you go or later based on the observations in the notebook is good to have so that you can put things all together and have a comprehensive map of what microclimates you have where, and how they might interact.

There are a few other bits of equipment which will help, too – one or two maximum/minimum thermometers, a sun sight, a soil moisture meter, and if you are up for it, a small hand held anemometer. Making and using a sin sight will be covered in an appendix at the end of this eBook.

sun sight

2.2.1 Temperature

The sun is the driver for both light and temperature, so will impact both these aspects of the microclimates present on the site.

A good way to start investigating for microclimates on your site is to just have a wander on hot days to detect cooler areas under trees or other foliage or otherwise shaded areas and take notes on what you find. Following up by placing a maximum/minimum thermometer in areas of interest, checking them daily and comparing the results with readings from the weather stations.

It is amazing the effects of trees on the air temperature. I was in a country town years ago and we were in the middle of a stand of trees in a park, I didn't have any temperature measurement devices on me but I would bet that it was 5^{o}C or cooler under the trees than out in the open. Also, while trees will have a cooling impact on microclimate by providing shade, the ground under the northern side of a tree will provide a sunny, sheltered microclimate and could be warmer than the surrounding area. So making notes about existing trees, their size, leaf cover and evergreen/deciduous status is worthwhile.

In colder weather, areas that are close to a thermal mass like a building or water tank and that are in a position where it is in the sun and/or sheltered from cold wind can result in warmer microclimates than the surrounding area. As well as providing slightly warmer temperatures due to the presence of a brick building, the northern eaves of a building can trap warm air and provide shelter from frost as well. Placing the max/min thermometers in these areas can provide confirmation and some idea of temperature differences.

The cardamom plant (Elettaria cardamomom) on the right (above) growing in the middle of the yard suffered leaf damage from a late winter cold snap, while the one on the left, close to the house and protected by banana plants growing nearby, suffered no damage at all. Photos taken at the same time.

Aspect or the direction the property faces has an impact on temperatures and light. It is probably the most critical non-alterable characteristic of the property as a whole. Here in the southern hemisphere a south facing yard may mean reduced direct sunlight and temperatures as a result which can limit options for growing food crops. Almost any aspect will allow some form of food production but the more favourable the aspect (ie closest to a north easterly aspect) the more productive the area can be.

To know how great the effect of aspect will have, it needs to be coupled with the slope of the land. A property with a southerly aspect but very little slope will generally be warmer than land sloping steeply to the south. Slope will also give an indication of drainage of water and cold air from high to low, and the steeper the slope the faster the drainage of both fluids. Thus microclimates at the bottom of the slope will tend to be damper in wet weather because that is where the rainfall will end up, and cooler in winter due to the accumulation of cold air/frost.

2.2.2 Light

To understand the effect of sunlight on your property (and this will also have an impact on temperature) it will require looking over your property with an eye to the type and amount of shade as well as the aspect and slope of your site (see 'temperature' above). Ponds can also have an impact, not only on temperature due to their thermal mass, but they can also reflect light, affecting light levels in a particular microclimate.

Of course, shade will vary throughout the year, being at its greatest area on the shortest day of the year and least on the longest day of the year, due to the variation of the angle of the sun. One way to go is to make a sketch of your property of the extent of the shade on the shortest and longest days, if you can wait long enough. There are aids which can help to work out how a given tree or object's shade will impact your property, one is by building the above mentioned 'Sun Sight' which measures the angle the shade of a particular object makes with the sun for a given day of the year, showing in real time where the shade from that object will land on your yard. It can be used to do this for the shortest day, longest day and everything in between. There are also phone aps like the 'Sunseeker' which will assist in a similar way, although I have no direct experience with them.

Even a single large deciduous tree can have considerable influence on the local microclimate

It is also worth recording the quality of the shaded areas in your yard, is it complete shade with only indirect or oblique sun available like from a northern fence, or a dappled or incomplete shade as provided by trees or bushes, or even summer shade and winter sun as provided by removable shades or deciduous trees.

2.2.3 Air Circulation

It is important to understand which direction the main winds come from in your area, however the direction and force of these winds and the turbulence associated with them will be modified by your local environment, especially the urban and suburban environment. Again, a wander about on a windy day will give an insight onto where the windiest and calmest parts of your site are. For comparison, it can be handy to have quantitative data as well as qualitative data so a hand held anemometer can be useful, but vary in cost from a few tens to several hundreds of dollars. I suppose it comes back to how much of an issue wind is for your site.

Air circulation can also be thought of in terms of air drainage, with hot air rising up and cool air moving down the slope of the land as discussed above. Air drainage through a site can be very important, particularly in damp times where a moist or humid microclimate is also a still microclimate, this can favour fungi and cause losses in food crops that are sensitive to fungal problems. It is worth taking note if there are any areas of the site where this may become a problem. Frost drainage in winter is also an important consideration, particularly if you want to grow plants that are marginal in your area in terms of frost.

2.2.4 Water

Again, for me, there is no better way of understanding how water acts on your site than taking a stroll around during a rainy day. That way it is possible to see where the water pools and where it drains well, where water flows enter your site from the neighbours and where water drains from structures. Even without a home weather station, cheap rain gauges are available and easy to install so that you will know exactly how much rain is falling on your property as a whole.

Follow the water!

Once the rain has stopped, a soil moisture gauge can be invaluable in identifying where water accumulates and hangs around, even if there is no surface water. Another indicator is the types of plants growing, and plants such as moss and sedges are a good sign that the soil is continually damp.

Sedge (left) is a good indicator of a damp microclimate

Moss (above) is also a good indicator of a damp microclimate

3.0 Modifying and Creating Microclimates

Once there is some understanding of the microclimates in the area for which we are responsible, it is then a case of working out the sorts of plants, both productive and (shudder) otherwise to be grown in that area. As Jamie Durie in his book 'Edible Garden Design' says – "To create a true microclimate, look at what makes your chosen edibles suffer or thrive. Then, all you need to do is provide protection from what makes the plant suffer, and serve up the elements that make it thrive."

The first thing is to match up any existing microclimates with the prospective plant list. It makes much more sense, when down the back of the yard there is a place that it always soggy, to seek out plants that will do well in that microclimate then spend time effort and money draining it to grow something else.

It now becomes a case of putting plans (plants?) in place to change or create microclimates that will 'provide protection……..and serve up elements that make them thrive'.

3.1 Temperature

Generally, setting up a temperature microclimate means that you want to keep the cold places warmer and/or the hot places cooler.

Three water filled baths (2 x constructed wetland and 1 x pond) increase winter temperatures in this microclimate. (left)

Cool places warmer – There are a number of ways of doing this, generally using a thermal mass of some description. Thermal mass is the property of a material to absorb energy from the sun in the form of heat and then re-radiate that energy, causing the area around the thermal mass to remain warmer than the larger surrounding area. One obvious source of thermal mass is a house, or to a lesser extend a shed, depending on its material of construction, but you will already be aware of those. So to increase thermal mass in an area where there isn't any one of the most useful materials is water.

Water has a number of advantages when in use as thermal mass. It has one of the highest specific heat capacities of common substances so it stores a large amount of heat per degree of temperature increase, it is easily stored and can be free, or at least available cheaply and the water can also be used for other things. To get water storage in the area where the microclimate is desired it can be either stored in drums, water tanks or other containers or it can be stored in the form of a pool or pond. The thermal storage impact on the microclimate will greater, the greater the volume of water is stored in the tank(s) or pond(s).

Plastic house (Pristine, when first constructed)

Another way of creating a warm microclimate in winter is the glass or plastic house, the larger sizes of which will be more effective and maintaining temperatures for longer overnight, regardless of which a glasshouse will provide frost protection for tender crops. The glasshouse may also be enhanced by including some thermal mass in the form of brick structures within it or, more easily, dark drums filled with water. It will allow the growing of out of season crops like tomatoes.

Water-filled black pickle drum inside plastic house to raise night-time temperatures in winter

The glasshouse can still be used in summer but it must be modified to reduce the heating effect of the sun (if we do not do this we regularly get temperatures of 60^{o}C or higher in summer). This can be done by painting the glass panes of a glasshouse white with limewash to reflect light and heat or covering either glass or plastic house with shade cloth, preferably 50% or 60% so enough light gets in for the plants to still grow.

Plastic house (not so pristine) with 50% shade cloth covering to reduce daytime temperatures in Summer.

Warm Places Cooler - Water can also cool the surrounding area in summer, particularly if it is couple with the shade effect of trees and open water (ponds as opposed to tanks) will also raise humidity around their microclimate, supporting plants that do well in a higher humidity environment.

Trees will also produce a cooling effect in summer due to both shade and transpiration on hot days, but the downside is, of course, that they will take a while to mature and provide the microclimate that is desired.

Over the years we have noticed the temperatures increasing as well as the intensity of sunlight increasing and have found the growing vegetable crops in high summer to be getting more and more difficult. To get around this we have modified the microclimate of the areas where we grow annual vegetables by setting up a framework and the covering the framework with 50% shade cloth. We generally put the shade cloth in place mid spring and remove it in mid-autumn as a rule but there may be some variation of the timing depending on the expected weather.

Seedling sun protection frame to reduce light/heat impact on seedlings

When we started growing on a year round rotation over 15 years ago I made some frames to go over seedling when they were planted out in summer, but this proved, after a while, to be not enough so we developed the shade cloth covers for most of the area. We do leave some areas uncovered because we have noticed that some plants, like corn, actually do better without the cooler microclimate of the shade cloth.

3.2 Light

Generally the problem with light tends to be not enough, rather than too much but even so a low light microclimate for plants adapted to that environment is not too difficult to come up with. One option is to plant trees which will provide dappled shade over the desired area, such as Tahitian lime, lemon myrtle, grevilleas and lemon scented gum which are fast all growing. Another option is to grow creepers over a frame covering the desired area such as passionfruit, grape or star jasmine, the downside being they will need to be managed by training and pruning to get the desired degree of shade.

Protection from strong light and heat of the western sun

Structures can also be put in place and then covered with shade cloth, as mentioned above, to reduce the amount of light and heat in high summer, creating a cooler and darker microclimate. Shade cloth comes in two different types: knitted or woven and is available in various colours.

Knitted shade cloth allows more airflow than woven so that it will not trap heat as much as woven shade cloth. Knitted shade cloth is also lighter and therefore easier to install and is also more resistant to fraying and wind damage than woven shade cloth. Also it is important to note that shade cloth is produced in a number of ‘densities’ expressed as a percentage of light that they block out, vegetables and fruit grow best under 30% to 50% shade cloth. Vegetables also do best under green or black coloured shade cloth whereas some fruits like apple, fig and guava trees do better when white shade cloth is used.

50% knitted shade cloth over the entire veggie patch means we get a harvest even in high summer

Where there is a lack of light in an area the options are somewhat reduced. One way is to just accept that you have a shady microclimate and go for plants that thrive, or at least survive in shade; another is to remove the object causing the shade. Where this is a house or shed or is a large tree that is on a neighbour's property or protected by a council tree preservation order, there may not be much option.

However, one option is to set up some sort of reflective surface which can reflect sunlight into the shaded area, providing a lighter microclimate than was available previously. Obviously the more light reflected from the surface, the more growing options will be possible and using mirrors can provide excellent light reflectance. The downside of using glass mirrors are that they can be expensive unless bought second hand, they are heavy and difficult to move around and are somewhat fragile. Another option is to construct a light frame out of wood and then affix mirror surface Mylar sheeting (think 'space blanket') using double sided tape. This is light and cheap to make but can also be somewhat fragile if exposed to high winds. A third option is thin sheets of mirror surface stainless steel which is not as heavy as glass and is very tough, but it is also very expensive. One of these options may be worth thinking about in a shady microclimate where a sunnier microclimate is desired.

3.3 Air Circulation

While a little air circulation is a good thing, particularly in avoiding fungal problems in a humid atmosphere, too much – as in strong winds – can cause problems as well. Part of the problem is that plants, even decent sized trees, can be damaged by strong winds, hot or cold winds can exacerbate thermal problems by drying out or freezing sensitive plants. An open area like a front yard will most likely have a high air circulation microclimate, even in a built up area, and require some work to ameliorate.

One of the issues with built up areas is that the buildings themselves and the fences dividing blocks will have an impact on wind speed and direction at ground level. To reduce the impact of strong winds a windbreak can be constructed. It is best if windbreaks are not impervious to the wind, but slow the air down as it moves through the windbreak. To this end they can be constructed from a trees and bushes, a wire screen and climbers or a longitudinal food forest.

This is a pic in the front yard looking south on a windy day, the effect of the wind was considerably reduced by the fruit tree circle down wind of it

Of course the other effect can also be true, if you have a dense planting of trees or shrubs the result can be reduced air movement and the consequent increase in fungal issues. Fortunately, this can be easy to treat just by pruning away some of the foliage of the plants to allow greater air movement though the plantings.

Thinning out thick foliage (like above) can increase air movement, reducing potential fungal problems

We get cold winds from the south at our place, and in the front yard the fruit tree circle has a noticeable effect on wind speeds north of it which impact on the nectarine tree and herb spiral. A strong breeze can become a light breeze in the shelter of the fruit tree circle. In a similar way, the bananas in the banana circle provide shelter from cold southerly winds to the chook retirement village and the worm shed. The sheds, bananas and the mandarine tree likewise provide some shelter to the back of the house for hot northerly winds and some shelter from hot westerly winds also.

The banana circle shelters part of the back of the house from hot westerlies and the chook retirement village from cold southerlies

It can take a while for a perennial windbreak based around trees to grow, so while that is being put in place, a windbreak can be constructed by building a wooden pailing fence, with every second pailing removed, upwind of the microclimate to be protected. Also, when planting a windbreak, plant vines, trees and shrubs at the same time. The vines will grow quickly, creating an initial windbreak and can be controlled by pruning, as the other trees and shrubs grow more slowly to form a permanent windbreak. Slope of the land can also have an impact so if you live below high ground, in cold weather cold air frost can move downhill towards your property. Low growing shrubs can be planted uphill to protect more delicate plants lower down, causing the frost to drain either side of the planted shrubs.

Hay bales can be used to create a calmer microclimate for low plants just starting out if placed upwind of the plants to be protected. Once the plants are established they will not need the protection and the hay bale can be allowed to rot down and provide organic matter.

3.4 Water

The thing to do in developing damper microclimates is to make absolutely the most out of every millilitre of rainwater falling on the property and ensure that it is either stored in tanks, ponds and/or the soil.

Tanks take rainwater off a building roof and store it for later use, reducing reliance in reticulated water supplies. They also have an impact on microclimates by storing energy from the sun as mentioned above under 'temperature'. Water from tanks can be used to top up ponds when rainfall is low, and to keep plants alive when the macroclimate wants to dry out our microclimates.

Our bath pond growing arrow and water chestnuts 2015

Same area 2023

Ponds can be set up to be filled directly by rainwater, either via runoff from the ground or by connection directly to a building downpipe. Ponds will also impact microclimates by storing heat and increasing the humidity in the surrounding area. A pond will increase opportunities for biodiversity by providing water for birds, insects and habitat for fishes and/or frogs. Bog plants like arrowleaf, water chestnut, water spinach and many others can be grown in the damper microclimate of a pond or pond edge, depending on how things are set up.

There are a number of ways of keeping rainfall on your land so that it sinks in rather than runs off, depending on the slope of the land. The greater the slope, the quicker and easier it will be for rainwater, particularly heavy falls, to exit your land before it can sink in. Generally speaking, storing water in the soil is the easiest and best option, hence the advice about moving water is to slow, spread and allow it to sink in.
Some ways of slowing, spreading and sinking rainwater runoff include –

Swales – a swale is a shallow trench dug across the contour, where the spoil from the trench is built into a mound on the downhill side of the trench. The trench may be left open or filled with material such as wood chip to reduce trip hazards. The idea is that water draining downhill on the land in question hits the swale and the water is directed into the soil rather than being allowed to run off. Where the land is steeper than 15^{o}, swales are not recommended due to the possibility of water saturation of the soil causing slides. The mound may also be planted out with beneficial species to take advantage of the damper microclimate created by the swale.

Fish Scale Swales – These are a small, curved swale, or series of curved swales, dug on the contour rather than one long swale. They are set up so that when one overflows the one each side of it farther down the slope will catch the overflow. They work very well to create a damp microclimate for a series of trees, with one tree being planted per fish-scale swale.

Fish scale swales put in as part of a school garden

Rain garden – This is a depression in the soil or basin filled with plants that can survive temporary flooding, usually built at the lowest point of a gentle slope. It may also be fed by a roof downpipe. It allows water to be slowed and spread so that it sinks in rather than running off.

Retention basin – This is sort of like a rain garden without the plants. It is designed to collect water that would otherwise be runoff and allow it time to infiltrate into the ground.

Drain Chimney – This is a hole dug down into the earth where a downpipe drains, filled with a pit case with a drain matting sock attached and filled with gravel. It provides a way for rainwater to get into the soil without running off, thus creating a damper microclimate in that area. Also, when the drain chimney overflows, the energy gained as the water falls through the downpipe will be dissipated when it hits the drain chimney, meaning the water will have been slowed, giving it opportunity to spread and sink.

Drain chimney - constructed

In place

Operating

Terracing – this is where a flat area, or areas, are dug into sloping ground. While this requires earthworks and so is not a cheap solution, it only has to be done once. With reduced or removed slope to the ground any rain hitting the terrace will sink in than run off. The terrace also provides a great growing area for beneficial species.

Permeable paths – are paths made from wood chip, gravel or other loose aggregates which allow rainwater to percolate directly into the soil, as opposed to solid concrete or asphalt paths which result in runoff. A permeable path can be used around a building to conduct rainwater into the soil where no gutter is provided. The area where the rainwater falling from the roof meets the ground would rapidly become compacted or eroded and allowing the water run off the property rather than percolating onto the soil.

Our permeable path, taking water from the back deck

Other ways of keeping the water where you want it include –

Mulching - has a whole stack of beneficial actions for plant growth but also when it comes to creating a damper microclimate, generally by allowing less evaporation and more infiltration. Mulch provides a barrier between the hot sun and the soil surface, reducing water loss due to evaporation, a mulch can reduce evaporating losses from up to 80% to 10% or less. Also, ridiculous as it sounds, the cumulative impact of rain drops can cause a crust to form of the top of soil, resulting in rainfall running off instead of soaking in.

We use straw mulch on annuals, wood chip on perennials

Shade – The lee of a building or structure that provides shade, particularly from the harsh western sun, will allow the soil to stay damper for longer in that area from rain or due and maintain soil moisture. Planting in that area will take advantage of a damper microclimate. Obviously, shade is not an unmixed blessing and plants will need at least some direct sun to grow, fruiting plants will require more and leaf crops less.

Too much?

The thing with water is that while not having enough is a common problem, occasionally you can have too much. Clay soils in particular can puddle and become puggy, giving plants growing in that soil 'wet feet'. Some plants cope well with wet feet but others, like citrus can find wet feet difficult to survive (I learned this the hard way!). If you are looking to plant perennials or annuals which prefer a drier microclimate, then using raised beds and growing areas to get your plants above the water can be worthwhile.

Another option, particularly if your issue is a clay soil, addition of calcium salts such as calcium carbonate (which will also raise your pH) or calcium sulphate (which won't) can be spread on the soil at a rate of a handful per square metre, when you are cultivating the soil or on top, but before mulching, if you don't cultivate. It will take longer to be effective if spread on top of the soil rather than incorporated by digging it in, but it will still work.

4.0 Microclimates and the Soil

Dense, low albedo clay textured soil with blocky peds. Not much grows there!

While I did not think that soil was a major contributor to the microclimate, it turns out that it does have an important part to play and so should be taken into account when identifying, modifying and creating new microclimates. The impact of soil on the microclimate is due to its –

- Thermal conductivity
- Albedo (solar radiation reflectivity)
- Texture and structure
- Water content

Thermal conductivity

Impact - a dense soil (such as clay) will heat up more slowly, but retain solar heat for longer than a less dense sandy soil. The sandy soil will heat up more quickly, but also give up that solar heat more quickly when the sun goes down or is hidden by clouds or foliage. Soil thermal conductivity declines with increasing organic matter in the soil but increases with increasing soil density and soil moisture.

Modification – The thermal conductivity of soil can be modified by cultivating the soil (tillage) to introduce air and reduce bulk density in a heavy soil, although the downside of tilling the soil is the negative effect it will have on soil biota. Adding water to the soil (irrigation) will also improve the thermal conductivity of the soil and adding organic matter will reduce thermal conductivity.

Albedo

General – Albedo is the reflectivity of a surface (in this case soil) to solar radiation (light and heat). High reflectivity is referred to as high albedo and low reflectivity is (strangely enough) referred to as low albedo.

High albedo organic mulch

Impact – A light coloured soil (high albedo) will reflect more solar radiation and therefore heat up more slowly than a dark coloured soil (low albedo) which will absorb the solar radiation.

Modification - A soil rich in organic matter will, in general terms, be darker than one deficient in organic matter so adding organic matter to your soil will also increase its ability to absorb solar heat and reflect less light. Reflectivity can also be reduced by applying charcoal to the soil (like biochar), which will also aid in carbon capture as well. A low albedo is a great thing in spring when plants are starting to come on after winter, but can obviously be a problem in a hot summer. This is where mulch comes in, being raked back from plants in early spring to allow more heat to be absorbed by the soil, but re-applied to beds in late spring/early summer depending on the macroclimate in your area to reduce the heat input to the plant's root zone.

Also, in a hot area a light coloured rock mulch will reflect light and heat away from the soil, keeping it cooler, but allowing rain to percolate down to keep the soil moist.

Texture and Structure

Glass Jar Test

General - Soil texture is generally described in terms of the percentages of clay, silt and sand present in the soil and can be determined by a glass jar test to determine percentages and then referring to a phase diagram to identify your soil texture eg clay, clay loam, sandy loam etc. A soil composed of 20% clay, 40% silt and 40% sand is referred to as being 'loam', an ideal soil for growing vegetables. Soil structure is how the individual soil particles of clay, silt and sand group together to form aggravates (called peds). These aggregates will vary in size from very small crumbs to large blocks.

Impact – A clay soil will hold more water for longer than a sandy soil, which will be more free-draining. Clay soils will also swell when wet and crack when drying out, allowing water to penetrate when it rains. Plants which don't tolerate 'wet feet' such as citrus, will not be happy in a clay soil and thirsty plants like bananas will require extra watering if planted in a sandy soil.

Our soil has a high clay content, and it cracks pretty dramatically when drying out

Modification – in general terms if you want to improve water holding capacity of a sandy soil and improve drainage of a clayey soil, the fix in both cases is to add organic matter such as compost. The structure of a clay soil can also be improved (in sodium clays) by adding calcium salts, gypsum (calcium sulphate) if the pH is where you want it to be or agricultural lime (calcium carbonate) if the soil is too acid.
Soil moisture

Impact - Damper soil ie, higher soil moisture has a cooling effect on the soil surface and lower wind speed near the soil surface whereas dry soil tends to be warmer and have a higher soil surface wind speed. High levels of soil moisture also encourage growth of soil biota and the resultant benefits to plant growth and biodiversity.

Modification – soils, particularly sandy soils can become hydrophobic if they have been dry for some time, it is easy to check, just pour on some water and if it runs off or pools rather than sinking in, it may be hydrophobic. Wetting agents are a short term fix but a better, longer term fix is by adding organic matter to your soil and mulching.

Measuring soil moisture

In general terms, adding organic matter and using an organic mulch will improve the water holding capacity of just about any soil, as well as all the other advantages listed above.

Conclusion

The soil aspects that affect the microclimate do not have their impact in isolation. For example modifying the soil moisture content by irrigation will also impact its thermal conductivity and adding organic matter to a soil can impact its thermal conductivity, albedo and structure. It is therefore important to understand what changes to the soil that need to be made to achieve the desired microclimate and what side effects these changes may have in other ways. Needless to say the soil characteristics mentioned above (Thermal conductivity, albedo, texture and structure and water content) may also be impacted by changes made to other aspects of the microclimate.

5.0 The last word

If we are serious about our gardens, and for me that also means being serious about growing food, some understanding of what a microclimate is, how the concept applies to our own growing areas and indeed the particular microclimates that exist in our own yards is vital so we can take advantage of them. Also knowing that it is possible to modify and/or create microclimates means that in Jamie's words, we will be able to "…provide protection from what makes the plant suffer, and serve up the elements that make it thrive."

6.0 Resources

I have had a look around and there are not many books specifically about microclimates, especially about urban and suburban microclimates and what can be done to develop them. There are, however, books that mention microclimates as part of the topic about which the books were written, quite often with a permaculture cast. Some of these books, in my library, are mentioned below.

Designing and Maintaining Your Edible Landscape Naturally – Robert Kourik – Permanent Publications (UK) 1986 ISBN 1 85623 026 0 – Great section on gathering data about your microclimate (pp 23-28); choosing best microclimate for fruit trees in US (pp 141-144); impact of house on microclimates (pp 83-84).

Practical Permaculture – Jessi Bloom & Dave Boehnlein – Timber Press (US) 2015 ISBN 978 1 60469 443 7 – Discussion of the aspects of microclimates (pp 40-42); mention of microclimates within herb spiral (p 57); considering microclimates when siting permaculture design elements (p 99); windbreaks and microclimates (p 207).

Earth User's Guide to Permaculture – Rosemary Morrow – Kangaroo Press (AUS) 2006 ISBN 978 0 7318 1271 4 – Chapter 5, In depth discussion of microclimate and climate including microclimate characteristics and impact of topography, soils, water bodies. Vegetation and structures on microclimates (pp 48-57).

The Permaculture Handbook – Peter Bane – New Society Publishers (CAN) 2012 ISBN 978 0 86571 666 7 – definition of microclimate (p145); analysing microclimates (pp 136 – 138); microclimates and edge effects (pp 145 – 146); impact of bodies of water on microclimate (p146).

You can have your Permaculture and Eat It too – Robin Clayfield (self-published in AUS) 2013 ISBN 978 0 99230 181 1 – Herb Spiral and microclimates (p19); solar arcs, swales. Terracing, net and pan, small ponds and paddies (pp 52-53); definition (p252).

Permaculture One – Bill Mollison & David Holmgren – Corgi Books (UK) 1978 ISBN 978 0 55298 0 609 – Microclimate as part of site planning including topography, soils, vegetation, water masses and manmade structures (pp 37-49); Planning with microclimates (pp 49 - 52).

Permaculture Two – Bill Mollison – Tagari Publications (AUS) 1979 ISBN 978 0 908228 003 – creation of small climates (p89).

Introduction to Permaculture – Bill Mollison with Reny Mia Slay – Tagari Publications (AUS) 1991 ISBN 978 0 908228 08 09 – Broadscale site design: climate and microclimate including topography, water masses, structures, soils and vegetation (pp 36-50).

Smart Permaculture Design – Jenny Allen – New Holland Publishers (AUS) 2002 ISBN 978 1 74110 305 3 – Frost and the microclimate (p83); Creating beneficial microclimates including maximising winter sun, minimising summer sun, designing effective windbreaks (pp 94-99).

The Vegetable Gardener's Guide to Permaculture – Christopher Shein with Julie Thompson – Timber Press (US) 2013 ISBN 978 1 60469 270 9 – Permaculture in hot climates and permaculture in cold winter climates (pp58 – 61).

Edible Garden Design – Jamie Durie – Penguin Group (AUS) 2013 ISBN 978 1 92138 308 3 – Microclimate in the backyard (p20); light and the microclimate (p34).

Weather-wise Gardening – Leavitt Dudley – Ortho Books (US) 1974 (no ISBN) – Identifying and modifying your climate/microclimate (pp 31-40); assessing your microclimate (p41); harnessing the wind (pp 42-44); frost (p 45); Water in the garden (pp 46, 47); indoor growing microclimate (pp53-62); microclimates and multiple housing (pp 62&63); confined microclimates – cold & hot frames, greenhouses (pp 65-71).

The Permaculture City – Toby Hemenway – Chelsea Green Publishing (US) 2015 ISBN 978 1 60358 527 9 – microclimate as small garden design quality (p 54); Managing your microclimates (pp 65-67); creating and enhancing your yards' microclimates (pp 68-71); How to enhance indoor climate via outdoor microclimate management (p168); a review of energy strategies - create microclimates (p175).

Gaia's Garden (2nd Ed.) – Toby Hemenway – Chelsea Green Publishing (US) 2009 ISBN 978 1 60358 029 8 – The herb spiral and microclimates (p44); Suntrap and microclimate (p137); Microclimates for the garden (pp143-146); saving time with microclimates, creating cool and warm microclimates (pp 246-249); siting initial gardens using microclimates (p269).

Food Not Lawns – H. C. Flores – Chelsea Green Publishing (US) 2006 ISBN – Make microclimates work for you (pp37 & 38); water and microclimates (p63).

RetroSuburbia – David Holmgren – Melliodora (AUS) 2018 ISBN 978 0 9943928 7 9 - Sun movements and microclimates (p75); mushrooms and microclimate (p289); microclimate and bio-intensive market gardens (p337).

Sepp Holzer's Permaculture – Sepp Holzer - Chelsea Green Publishing (US) 2004 ISBN 978 1 60358 370 1 – aspect and climate/microclimate (pp11 & 12); microclimates and Permaculture (pp21-24); microclimates and ponds (pp 46 & 47); microclimates in town gardens (pp 189 – 192, 196).

Waterwise House and Garden – Alan Windust – Landlinks Press (AUS) 2003 ISBN 0 643 06800 7 – Site assessment, identifying microclimates (pp 85-89).

Costa's World- Costa Georgiadis – ABC Books (AUS) 2021 ISBN 978 0 7333 3999 8 – Climate and microclimate, identifying microclimates (pp 30-33).

Four Season Harvest – Eliot Coleman – Chelsea Green Publishing (US) 1992 ISBN 978 0 930031 57 1 – and cold frames (pp 66, 99); garden microclimates (pp34, 35); of a root cellar (p110).

7.0 Appendices

Appendix 1 - Making and using a sun sight

One of the fun things with designing your own, or somebody else's, permaculture garden (particularly if you haven't been there very long) is knowing where the shade from existing structures and plants (such as trees) will fall throughout the year. There is nothing like going to a lot of trouble putting in a planting in mid-summer sun to find it is actually in shade most of the rest of the year. Well, worry no more! Following is how to make and use a valuable tool with which you can work out where shade will fall anywhere at any time of year.

Making the Sun Sight

The sun sight itself can be easily and cheaply put together with a drinking straw, protractor, length of string and a small weight but it can be put together more durably the way I did it. My way will cost a bit more, depending on what bits and pieces you have hanging around, but the end product will give you years of service. To use the sun sight to identify shady areas you will also need a compass and a **sun position map** for your latitude, but more on that later.

The Finished Sun Sight

The idea is simple enough, first get hold of a protractor, the bigger the better but whatever you have will do. If you are going by the cheapie method, tape a drinking straw along the flat side of the protractor, then insert some string or cotton through the hole in the centre of the long side of the protractor and tie it off. Then to the other end of the string tie a small weight such as a nut (nut-and-bolt type nut) or fishing sinker etc. You are now ready to go!

But before we get too far into the mechanics of using the tool, here is how to make the sturdier model like I did.

The protractor I Bought

Get hold of the largest protractor you can, in most of the school type of geometry sets the protractor is only 10cm long on the flat side, but I was able to get hold of a larger one that was 15cm long and that became the base for my sun sight. Rather than use a somewhat fragile drinking straw I had some 10mm diameter aluminium tube from a previous project and cut a length of 17cm long so that the tube would overhang 1cm each end of the protractor (no real reason for the overhang, I just liked the look of it!)

The brackets used to hold the sighting tube onto the protractor

I bought a couple of P type cable clips from the local hardware to attach the tube to the protractor. While the protractor was a decent size it was still only made of thin plastic so to reinforce it I made a tracing of it on some 6mm three-ply plywood board and then cut it out with my small band saw, or you could use a fret saw. To hold it all together I drilled a 3/16” hole towards each end of the flat side of the protractor through both the protractor and the backing board, while holding the P clips in place around the tube and against the backing board. Sounds exhausting doesn’t it?

The aluminium tube I used to the sighting tube

It is a bit easier to do than it sounds but the whole idea is to make sure that when the whole thing is bolted together, the tube is exactly parallel to the straight side of the protractor. With the holes drilled through the protractor and the backing board I used two 3/16 x 10mm (!!!) mushroom head bolts to put the thing together.

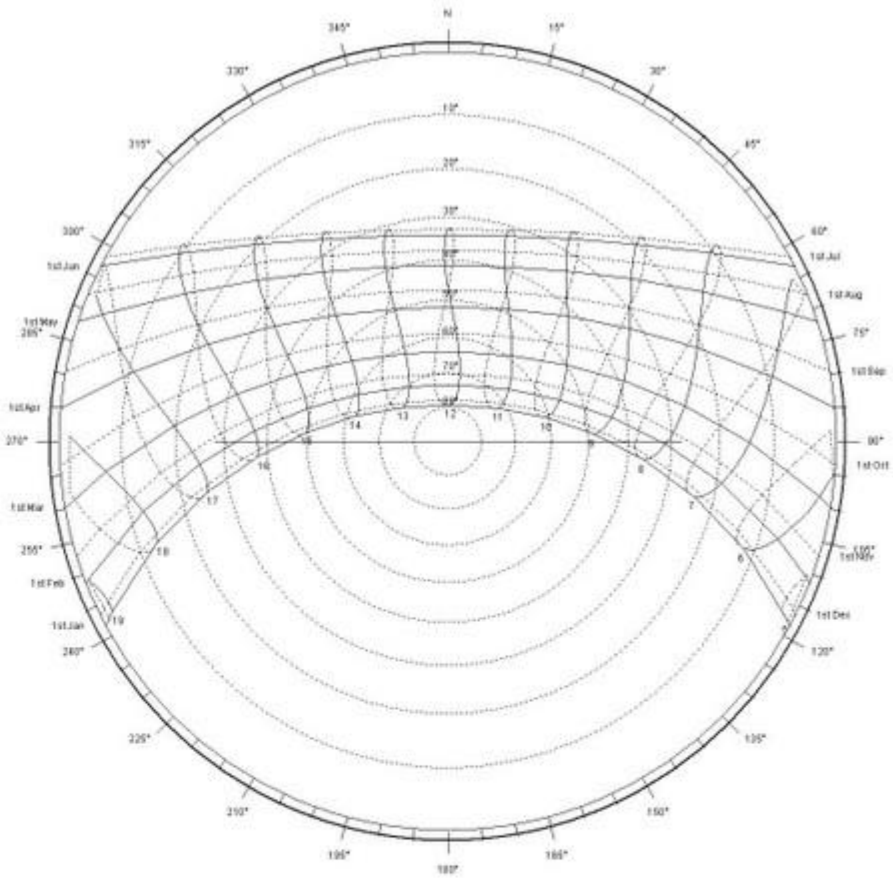
There is a small hole in the dead centre of the long side of the protractor, I used this hole and drilled through the backing board as well I then I threaded some string through the hole from the protractor site and tied it off on the backing board side with a large knot to prevent it pulling back through. I looked around for a weight to tie onto the other end of the string, to keep it vertical and while I couldn’t find any sinkers I did find a small bearing that has been hanging around for a long time, so it got the job.

Protractor, backing board with sighting tube attached

Tying off the bearing to the free end of the string completed the sun sight.

Using the Sun Sight

Head outside with your sun sight, compass and sun path map (I laminated mine to make it more durable) and find an area you want to check for shading. If you are checking veggie patches and the like you might need to get down low to be absolutely sure. With your compass, find magnetic north then find solar north by adding or subtracting the magnetic variation for your area, then face solar north. This **website** will help you there.



Sun Path Map for Sydney

Get hold of your sun position map and locate the sun arc line for the date you are interested in, let's say it is first of July, it is nice and close to the shortest day when the sun will be at its lowest angle and shadows will be at their longest. According to my sun path map at midday on July first the sun will be around 33^{o} above the horizon here in Sydney. Hold the sun sight up with the tube facing solar north and with the string hanging down from the protractor, tilt the protractor up at an angle of 33^{o} from the horizontal, which will read as 57^{o} on the protractor (90^{o} - 33^{o} = 57^{o}).

Now, look through the tube. Any object blocking your view (house, shed, tree, etc) will be shading the area where you are standing on the first of June. If tree branches are the cause of the shade they may be able to be removed. Repeat this process for several angles east and west of solar north so that you will have a good idea if there are any objects which may shade the area where you are standing over the sun's arc.

This process can be used to identify shade sources in any area for any time of year, and if the shade is a problem that can't be moved (due to existing buildings etc.) you can locate your growing or solar charging areas in a more sun-soaked area.

Appendix 2 - Making Veggie patch sun covers

Finished Product

The summers here in western Sydney seem to be getting hotter, and the numbers (number of hot days, length of hot spells, highest temperatures) definitely back that impression up. It can be hard to keep the garden going, let alone producing, in the hot dry conditions we have experienced lately. The ollas have helped to keep the water were it needs to be, in the beds that have them but the long, strong afternoon sun takes a heavy toll on the plants. Seeing as it was a bad year this year and all the gurus say that global warming will only make things worse I decided to do something about it. I obviously needed to put some protection between the fierce afternoon sun and the veggies, but the question was… how? It took some time to get the design right, because my original design followed the one my father put in place many years ago. He used to grow orchids and had built a huge shade house that took up half of our fairly generous back yard. He built most of the structure out of 25mm (or 1" as it would have been then) galvanised water pipe. It was strong and durable and comparatively cheap and easy to build. Perfect!

We it was perfect until I tried to get hold of some 25mm water pipe! If I wanted it in one metre lengths I could walk right into Bunnings and get as much as I wanted, but I wanted four to six metre lengths, plus fittings. To get hold of that stuff was almost impossible second hand (there was some 50mm stuff available but very heavy and very pricey) and the stuff was expensive with a capital "E"! So after some months of trying to work out a design I decided it didn't need it to survive a nuclear blast and I would have to use something lighter (and cheaper!).

The new design was based around poly pipe, star posts and some timber.

Components

When we had a dog, and before the chook tractor, I used lots of star posts to make fences around the veggie patches and the chook area to separate the livestock from the crops. When the fences came down I kept the star posts in the shed, some were 1350mm and others were 1800mm so at least I didn't need to buy any. In any case they are easily available and sometimes you can pick them up second hand.

To make the overhead bows that would support the shade cloth I am using 50mm (nominal) green stripe polypipe. To work out how much I needed, I measured the distance I needed to cover (in this case almost 4 metres) which gave me the diameter of a theoretical circle. By multiplying the diameter by π and then halving it I could calculate an arc that would do the trick, it came out to roughly 6 metres, so that is what I went with.


The roll of polypipe

Unfortunately many suppliers want you to buy a whole 100m roll and are unwilling to cut lengths off for you, particularly hardware and produce merchants in my experience. I wanted 6 x 6 metre lengths to make 6 bows but I was eventually able to buy a cut 36 metre length from a rural irrigation supplier. This stuff is big and I had to hire a ute to bring it home in but that worked out much cheaper than home delivery and there was NO WAY is would have fitted into my little Suzuki Alto!

The battens to hold the hoops together and support the shade cloth and allow it to be attached to the structure are 20mm x 42mm treated pine. For the back veggie patch I needed timber about 4.5 metres long to go the distance in one go and the stuff came in 4.8 metre lengths which worked out pretty well. Transport was a bit problematic so I used the same ute which we hired to pick up the poly pipe.

Shade cloth effectiveness is measure by how much light the shade cloth blocks out, hence 90% shade cloth only lets through 10% of the light. While I wanted to break the strong sunlight down a bit I didn't want to block out the light almost completely and get leggy plants that were not productive. To that end I got hold of a roll of 50% shade cloth and it seems to work pretty well, allowing the plants to keep growing in the hot weather without stopping them from developing normally.

Putting it all together

Measuring the polypipe out is a bit of fun, the stuff can be fairly stiff so a warm sunny day helps to soften the plastic. It is also handy to have another person to stretch out the pipe straight and hold the end of the tape measure while you measure out the right length. Once you have the pipe stretched straight out and measured it is easy to cut to length with a hand saw.

Putting in the star pickets can be easy or difficult. I have tried hammering them in with a club hammer, a sledge hammer and a claw hammer and they all fit into the category of "difficult". I recently got hold of a tool specifically designed to install star pickets, a post driver. It is basically a galvanised pipe with handles (see photo) and you lift it over the post and ram it down to drive it into the ground. It works very, very well, but is somewhat noisy if you are going to do more than a few at any one time I would recommend hearing protection of some sort.

Post Driver

In designing the cover I had to take into account the chook tractor and ensure that the distance between the star pickets would be enough to allow the chook tractor to be manoeuvred between them. The chook tractor is about 2 metres long so I allowed about 2.5 metres between the star pickets for the back veggie patch where I would have to take it through sideways. In building the front one, I have access to the front end of the patch so I can take the chook tractor in end-on so in this case the distance between was not critical and I opted for 1.5 metres (one at each end of the patch and one in the middle.

Most of the star pickets I had were of the 1350 mm long variety so I basically pounded them in until the post driver hit the ground, leaving about 770mm out of the ground which meant that there was over half a metre of star post in the ground. That seems to have worked pretty well.

It is possible to fit the hoops over the star by yourself but having another person helps! Once the hoops are over, pull them down until they have gone as far down the star pot as they will, for me that turned out to be when the end was still 450-500mm off the ground. That coupled with the bow of the 6 metre poly pipe meant the height under the middle of the bow is a bit over 2 metres.

The Hoops in Place

At this point I needed to affix the battens to the polypipe. To be absolutely sure I got the length right I measured it at the bottom of the star pickets rather than the bows, which are flexible and will move around a bit. With the two outside battens cut to size I fitted them by drill a hole and countersinking it, then drilling in one screw into each batten. I left the top two full length to form a bit of an overhang for the shadecloth. I also had to make sure that the battens were high enough for the chook tractor to fit under them. Another factor was that the shade cloth was 3600mm wide, so the outer battens on each side could not be further apart than that or I wouldn't be able to attach one side.

Holding the battens in place prior to fixing

With the battens in place I pulled the shade cloth up and over the top of the structure so that the south end was level with the last bow and the north end hung down by about 1500mm to give extra cover against the hot northerly midday sun. To affix the shade cloth to the battens I used "Cooleroo" Timber fasteners. Just pull the shade cloth down over the end batten on each side and hammer a timber fastener (a metal rectangle painted green with 8 projections that stick into the wood) in every 200mm. This secured the shade cloth cheaply and effectively.

How Does it Work?

It made an immediate difference to the feel of the veggie patch, it was much more pleasant to walk around underneath. I have had problems with poor growth of some veggies (brassicas, celery) which were planted during the hotter times or were in full sun for most of the day. I think next year will be better even if it is as hot as this year has been.

One interesting side effect has been that I have not needed to water quite as much in the plots where I don't have ollas. On the down side, we have had some rain lately and when it is only light rain there is a tendency for some of it to collect and run off the sloping side panels of shade cloth, reducing the amount of rainwater getting to the veggies. Fortunately we have just had a day of heavy rain and everything is well and truly rehydrated.

In half a day I was able to put up a cover over a veggie patch 4500mm x 4000mm almost by myself and it is guaranteed to increase production next year so it is a worthwhile project for anybody to have a go at.

Appendix 3 - The Bathtub Pond

We like Asian food in our house and consequently when I am cooking I tend to cook it quite a bit, so growing the ingredients makes sense for us. I became interested in water chestnuts a few years ago, after being given some tubers by a friend I decided to try and grow them. My first effort was in a concrete pot out the front of our house and for whatever reason, that year I got about three water chestnuts per pot, and pretty small and disappointing they were too. So the project went on hold.

I saw them for sale by mail order a few years later and thought I would try a different tack by growing them in a recycled bath tub in the back yard. They were also advertising a different water chestnut-like plant called Arrowhead (Sagittaria Latifolia) or Duck Potato, a North American edible tuber, so I got some of them too. The rush-like leaves of the water chestnuts, while interesting, are not particularly decorative but the arrow shaped leaves and white flowers of the Arrowhead are very decorative. The mature Arrowhead bulbs when harvested can also look a bit like an eyeball – very entertaining for visitors!

Edible tubers - Arrow (L) Water Chestnut (R)

Our neighbours were remodelling their bathroom and getting rid of their enamelled steel bath, so after asking, I nipped it out of their skip bin and spirited it home to the back yard. My lovely partner is sustainable living knows my habit of putting things off so declared the next weekend that it had to go in the ground, NOW! So off I went shovel in hand and conned my son-in-law into helping me. We dug the appropriate sized hole and lowered the bath into it. We sited the bath in between the lemonade tree, the lemon tree and the mandarine tree with a northerly aspect so that it gets sun for most of the day but is shaded from the harsh afternoon summer sun.

The Water Garden Bath - Early Spring

I plugged the drain hole with a standard drain plug and then put a layer of 12mm gravel over the bottom slope of the bath to give a firm base to place the pots on. I was able to fill it with rainwater from one of the tanks on the back of the garage, so that it was then ready for habitation.

To plant the water chestnuts and arrowhead was the next task, so I got hold of six 200mm black plastic pots and to make sure of good water flow through them, punched a stack of holes in the sides of the pot using a 6mm hole punch and hammer. I then filled the pots with a conventional potting mix to about 10-15mm from the up of the put, placing a water chestnut or arrow tuber or two in each pot, about half way down. Each pot was then topped off with a layer of small round gravel to retain everything in the pot as I put it in the water.

Punching Holes in the Plastic Pot

I placed all of the pots into the water garden slowly to allow the water to filter in and this worked pretty well, each pot wound up about 25mm below the surface of the water. Since the weather was warming up I soon noticed mosquito wrigglers making an appearance so the addition of half a dozen goldfish meant no more wrigglers, lots of entertainment and fertilizer for the plants.

Both types of plants have grown well in the water garden over the last few years and maintenance has been minimal, mostly consisting of replacing the water lost by evaporation and transpiration form the water plants every week of two in summer. As the days get cool the plants die down and it is time to harvest although in later summer and autumn you can get decent size tubers by just feeling around the bottom of the pond.

The Water Garden Bath - Late Summer

Harvesting consists of removing the pots from the water garden and tipping them out and sorting through the cold, wet and slightly smelly potting mix (this is one of my favourite jobs!) to remove the tubers and gravel for use next year. Last year i pulled out 5 kilograms worth of tubers so I must be doing something right! Due to the nature of how they grow, you will also find escapee tubers in the gravel in the bottom of the water garden, so don't forget to look there too.

Close up of Arrowhead Leaf

I keep a dozen or so of the best and biggest tubers for replanting and the rest get washed off and placed in clean water in the fridge, change the water every few days and use them up as you can. They don't look all white and naked like they do when you get them out of the can; you have to peel them with a potato peeler, we generally slice them and put them in stir fries or put them in dishes such as san choi bow for their crisp and crunchy texture.

To replant for next year, just replace the potting mix and place a tuber or two in each pot, re-apply the gravel and sink the pots back in the water garden. In spring, when the weather starts to warm up, they will sprout again from the pots and start a new year's supply for you.

The lowest point of the bath is the south western corner and the bath is designed to drain to that point, the idea being that there are times when the bath needs a bit of a flush out such as after a couple of lemons or mandarins have fallen into it. You tend to get a (citrus) oily film on top and I am not sure what the fish think of it so once the fruit is removed, a bit of a flush out goes a long way.

Anyway, because all the water (and of course some of the nutrients) drain to this corner I thought it would be worthwhile planting something that could convert these nutrients into food. When I was doing my Permaculture Design course last year we went to a property that allowed me to get hold of a piece of arrowroot from one of their plants and arrowroot loves waterlogged, boggy soils. I scratched away at the ground and then planted my bit of arrowroot, unsure of how it would do.

At the end of last winter it shot up a couple of canes over two metres high, so it seems reasonable happy, but even so I was not sure how the frost would affect it. We have now come out of its second winter here and while some of the leaves got scorched, even under the canopy of the lemon and lemonade trees, it is proceeding to send out lots of new spikes heralding a great growing year.

I can recommend including arrowroot in your plantings around your productive water garden, they add even more visual interest and another great food for you to experiment with, assuming you haven't tried it already.

Appendix 4 - Fish Scale swales

I developed a Permaculture design for one of our local schools and as part of that they had a sloping area of ground where they wanted to put fruit trees, so to maximise the water retention for the trees the designed a series of interlocking swales called fish scale swales to plant them in. Of course for that sentence to make sense it pre-supposes that you understand what a swale is, but just in case you don't, a swale is a long excavation forming a ditch and mound along the contour of the land which allows rainwater travelling downhill to be absorbed into your land and stay within the property rather than being lost as runoff.

Setting out

Swales are quite often used on extensive properties and can run for metres or hundreds of metres depending on the need but they don't usually find much application in urban or suburban settings, however the smaller fish scale variety can work very well into a small to medium back or front yard. Rather than form a number of lines extending along the contour in series down the slope they are made by digging a number of smaller (2-3 metres) interlocking curved swales along the contour. So that no water is lost each swale is designed to accept overflow water from any uphill swales and to overflow into down slope swales if they can't hold the water flow.

Making the Swales

It helps with planning if you make a scale sketch of the area and draw in the swales to see how they fit, but if you are not that organised you can just go with the flow and see how it turns out. I also found it useful to have a spray can of water based making paint to mark out all of the swales first, because this makes it easier to get the location and orientation of each swale right in comparison to the others, before you start to dig. My original plan was for the swales to be in straight lines but in practice they were better being at an angle, so long as they were across the slope of the land, the slope of the land turned out to be more complex than I thought.

Digging the swales

Once you have marked out your swales, dig down 20cm to 30cm, if you can avoid digging into the subsoil that is best, but if your topsoil layer is thin you might not be able to avoid digging into the subsoil a bit. The digging is best accomplished by pushing in a spade around the line of the swale and about 30cm uphill from where you expect the downhill face of the swale to be, start to dig and place the spoil downhill so that the mound of the swale is formed in front of (or on the downhill side of) the ditch. If you intend to plant into the swale then put most of the spoil towards the centre of the swale, thinning out towards each end, forming a crescent.

The Swales Dug Out

When the ditch is dug and a nice swale formed, to prevent the ditch filling up with crap or becoming a trip hazard, it should be filled almost to the top with coarse river sand, this will provide bulk in the ditch but still allow water to infiltrate into the ground. The sand can be washed out or crust over so to make sure that the surface remains open to water put down a 25 to 50mm layer of medium gravel (say 20mm) on top. The gravel will also form a good surface to walk on and even if it is eventually covered by grass it will be able to maintain an open structure so that the rainwater will be absorbed into the swale rather than running off.

Filled With Sand

Putting in the gravel

Planting the fruit trees

The fruit trees are planted into the front, raised part of the swale rather than in the ditch so that even though the roots will find their way down into the swale and the rich water supply, the main part of the tree will be above the soil level and the tree won't suffer from "wet feet" in times of high rainfall.

The centre of the swale should be thickest and that is where you need to plant the fruit tree. Dig down until you have a hole big enough to easily accept the root ball of your tree, place the tree in back fill then firm the soil down around the roots with your foot, mulch well, making sure the mulch does not contact the trunk of the tree and cause collar rot.

Add Fruit Trees!

That's about it! The swales will add interest to your property as well as maximising use of rainfall almost guaranteeing a great fruit crop.

Finished Construction - View Down-slope

Appendix 5 – Constructing and Installing a Drain Chimney

Many, many years ago when we put the first tanks on the back of the garage, the council inspector had said that I needed to put in a rubble drain to take the stormwater from the roof of the garage. This would have taken out most of my veggie patch at the time and fortunately he said putting in a couple of tanks instead was fine. However once the tanks were full, I still needed a place for the overflow to go. If I just let it go onto the ground the water would flow into the next door neighbours place, this crapped them off and meant the water was lost to our property.

The Tanks

This was a problem I have wrestled with for some years and had not found a suitable answer. I had considered putting in a dry well, which I had read about in some of the American books on sustainable living. It is basically a hole lined with bricks and filled with rocks, which allows rainwater to filter back into your soil. It does, however, require a fair bit of digging, and I am not getting any younger! So when I came across the concept of a drainage chimney, I knew I had the answer, and this is how I built it.

Construction

The key to building a drainage chimney is having access to a post-hole digger, one of those hand turned earth augurs that allows you to dig straight down into the earth without killing yourself. In the area where I needed to make the chimney it was quite shaded and still fairly moist after some recent rains, so it was easy to bore the hole. If this is not the case for you, start the hole off and get down about 20 or 30cm if you can, otherwise as deep as you can do it easily. Fill the resultant hole with water, let it drain, then fill with water again and leave overnight for the soil to soften. Next morning the digging will be much easier.

I wanted to dig my chimney down a metre (a nice round number!), but in the event I was only able to get down to 800mm before the handles started to run into obstructions and I had to call a halt. The digging was comparatively easy once I made it through a band of gravel some 50mm – 80mm thick just below the soil surface. The spoil went into a couple of old chook feed bags and the stuff from below the gravel layer wound up being incorporated into a garden bed which we were expanding.

Once rainwater started going into the hole the sides would collapse and it would eventually fill with dirt if that was all there was to the design, so I planned to fill the chimney with pebbles. I had access to some 30mm – 40mm rounded pebbles from my daughters place which would hold up the sides but still contain enough voids between the pebbles to hold a substantial amount of water as it moved into the soil. Even with the pebbles though, the spaces in between them was likely to fill up with soil eventually. The answer was to make a "sock" out of drain matting which would hold the pebbles together and keep out small soil particles but still allow water to infiltrate through the sides.

The Whole Hole!

It was my intention to make a sock deep enough to go from the top of the chimney to the bottom, then work out some kind of covering for the top which would let in the rainwater. I found the EASYdrain rainwater pit case in the local hardware, which is a box 260mm square and 280mm deep, which can have a drainage grate fitted into the top. As it was, there were no holes in it to let the water out so I needed to provide a drainage hole. With the pit case going down 280mm into the drain chimney, the sock did not need to be so long, which in the end turned out well.

The Sock

The drain matting I buy is 600mm wide, by 6m long and to make a sock 250mm in diameter I needed the fabric to be roughly 750mm wide. By cutting 750mm from the long side it gave me a sock 600mm deep, which was a bit short for the 800mm deep hole I needed, but with the 280mm contributed by the pit case it gave me 80mm overlap between the top of the sock and the bottom of the pit case.

Storm water Pit Case

To fit the 260mm square pit case into a 250mm diameter round drainage chimney hole I had to dig away the sides of the hole a bit, and remove enough soil to make corners to fit the square profile of the pit case. This was basically trial and error – dig out the soil, fit the pit case and see how far down it would fit, remove and repeat – until it fitted all the way into the drainage chimney.

To make the hole in the bottom of the pit case to allow the water to drain through was a simple matter of applying a 75mm hole saw to the centre of the bottom of it and to attach the drain matting sock I used that marvel of modern engineering – duct tape. This proved to be as easy as fitting the open end of the sock over the bottom of the pit case, allowing a 50mm – 80mm overlap, and then securing the sock with a 150mm of tape up each side of the pit case. A final run of tape around the top edge of the sock and it was bound to the pit case (I hope) permanently.

To allow me to fit the sock/pit case into the hole I dropped a few pebbles through the hole and into the sock, keeping the sock vertical and stopping the side of it fouling on the sides of the hole. With the drain case and sock in place it was a simple matter to fill the sock the rest of the way to the top with pebbles through the central hole in the bottom of the pit case. I figured the pit case would stop the hole collapsing at the top level so I did not will it with pebbles, thus leaving more volume for rainwater to fill during a deluge. With the fitting of the removable grate in the top of the pit case, that part of the project was completed.

Directing the outflow

The outflow from the tanks goes into a black 200litre plastic drum and from there just overflows onto the ground, so I had to fabricate a 50mm overflow pipe from the side of the drum into the drainage chimney. This was accomplished with some 50mm pipe, a 90° elbow, a 50mm floor flange my perennial friend, silicon sealant. I just drilled a 75mm hole in the side of the 200 litre drum, inserted the floor flange, sealed with silicon sealant and screwue4d into place, then fitted the horizontal pipe section and also screwed it into place, sealed with silicon. The 90° elbow was then placed on the end of the pipe and then downpipe inserted into the other opening of the elbow. Done!

We have had one downpour since and the system seemed to work pretty well, we'll see how it goes in the future.

Appendix 6 - Installing a Permeable path

When we built the back deck we did not include a gutter on the end of the roofing, so the water just drips off onto the lawn, or the dirt as the case may be. This has proved to be unsatisfactory because the drips are wearing a ditch into that part of the yard and it is contributing to flooding parts of the backyard during heavy rain. Some of this water can flow into the neighbours, which although it doesn't upset them, it does mean rainwater lost to our system.

The Finished Product

To get around this I proposed to Linda about digging down a bit and putting some gravel in so that the water would not overflow, but soak in and not be lost. With typical common sense she suggested extending the soak area at each end and widening it so we could also use it as a path from the back step to the door of the garage. So it became a multipurpose path, which works for me!
To install the path/drain I did the following –

- First I marked out the extent of the area to be dug. Fortunately we have had a bit of rain and it is winter, so our essentially clay soil is still fairly soft and diggable. I marked out the extent of the path by using the spade to cut down a few centimetres forming a line which I could follow.
- After marking the area out, I went through with my mattock quite shallowly and removed the surface grass in the area to be dug and carted it away to be composted.
- Then the main dig commenced! To be able to hold the volume of rainwater required, I wanted to dig down to around 15cm, again for the most part this was

easy because of the state of the ground, but closer to the deck had been sheltered from the rain and was quite hard and dry in places.

- Then came the surprise. Running along the area close to the deck and at a slight angle to it, I encountered and obstruction. As little as 5cm below the soil surface, unknown by me, was the terracotta pipe sewage line! Fortunately I was using the spade ant not the mattock – otherwise, mass unpleasantness! Once I knew it was there is was relatively easy to uncover it without damage, but it just goes to show, you never know!
- To dig out all of the spoil took me almost a week, working on and off and fairly early on I ran out of places to dump it in our yard. I noticed that one of the neighbours had some holes in their yard and a bit of a retaining wall and when I approached them they were happy to take the barrowloads clay and soil I was digging up.
- With the soil dug out, I got hold of some timber and used it to line the outside of the trench, keeping them in place with 450mm star pickets, making sure not to hit the sewer line while driving them in. I then lined the bottom of the trench with drain matting to reduce the chance of the gravel mixing with the soil beneath the trench.
- To fill the trench I used 10mm blue metal gravel. My preferred material would have been crushed, recycled terracotta tiles and bricks, but when I made enquiries I was told the place that made it had gone bust so gravel it was!
- I measured up the trench and calculated I needed 0.8m3, but had to order 1m3 (or 1.5Tonnes). The calculation was pretty rough but in the end must have been close as I still had some gravel over when the trench was filled. Starting at one end and filling it in meant I needed to put some particle board down or the wheelbarrow, which was quite heavy with gravel, would dig in too much.
- Once the gravel as in it was just a case of using a rake to smooth off and flatten the surface.

So we now have a dual purpose path/drainage trench and from the rain we have had it seems to work well, but I waiting for a big rain to see how it performs then!

The Area Prior to Commencement of Work

Grass cover removed

Dug out, with timber edging installed

Drain matting in place

Complete!

Over the years we have had a number of fairly severe rain events and the permeable path has performed remarkably well, accepting all run off from the back deck without overflow. The photo below was taken towards the end of the latest downpour. The water at the top end of the photo has run back from the drain point of the tanks.