

Permaculture in a Nutshell



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Preface by
Jonathon Porritt

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The author



Patrick Whitefield, is a permaculture teacher, designer and writer.

He grew up on a smallholding in rural Somerset and qualified in agriculture at Shuttleworth College, Bedfordshire. He then acquired farming experience in Britain, the Middle East and Africa.

He has expertise in many diverse areas. These include organic gardening, practical nature conservation and country crafts – thatching and tipi making. He was also involved in green politics for a number of years as a prominent member of the Ecology Party.

Patrick has found that his mixed experiences have led him to the logical conclusion of permaculture and are directly relevant to his present work. He is a permaculture teacher and writer who inspires respect, affection and a good measure of action wherever he imparts his considerable knowledge.

Patrick is also author of the acclaimed books, *The Earth Care Manual – A Permaculture Handbook For Britain & Other Temperate Climates* and *How To Make A Forest Garden* as well as other useful booklets such as *Practical Mulching*, *Woodland in Permaculture* and *Tipi Living*.

As well as being distributed in the USA, *Permaculture in a Nutshell* has also been translated into French, German, Czech, Danish and Russian.

Preface by Jonathon Porritt

These days, it seems that just about every politician on earth is having a bit of a problem with ‘the vision thing’. So few of the old ideas any longer seem capable of delivering the goods; so many of the ‘new’ ideas look remarkably like the old ones recycled!

And nowhere is this more true than in the area of agriculture and food. We produce it, distribute it and retail it all in the most hopelessly unsustainable manner – and now we are about to genetically engineer it in a similar fashion.

Permaculture stands four square against that collapse into the unsustainable. It talks about food production in a different language. Its dreams are issues in a different coinage. And for its practice, it goes back to the basics of natural systems and what it is that makes them work.

So alienated are we from these natural systems that many will undoubtedly resort to ridicule and denial as their automatic defence against such a radical alternative. Which for people like me only serves to underline the importance of its contribution to the current debate.

Putting into practice the design concepts that underpin permaculture is no mean challenge. But the new era requires hard-headed and creative thinking, and you’ll find plenty of that in these pages.



Jonathon Porritt
Environmental writer, campaigner
and chair of the Sustainable Development Commission

Introduction



Permaculture is an approach to sustainable living that has spread throughout the world, from Zimbabwe to Russia and Nepal to California. This book is an introduction to permaculture primarily for people living in Britain. It explains what permaculture is, and gives examples of how it can be applied in a variety of situations, in both town and country. It also tells you where to obtain more detailed information and how to contact people already practising permaculture.

Chapter 1

What is Permaculture?

There is a great awareness these days that we are reaching the physical limits of the Earth. We cannot go on creating pollution at the present rate, or filling our ever-growing appetite for energy and materials for ever. We are so profligate with oil and other fossil fuels that we have developed a way of producing food which consumes around ten calories of energy for every calorie contained in the food.

Changing to organic methods of food production could reduce this high input by a significant amount, as both chemical fertilisers and pesticides are energy intensive. But conventional organic farming still relies heavily on machinery and the transport infrastructure, so the whole process of putting food on our plates would still consume more energy than it produced. Simple peasant agriculture can reverse the situation and yield ten calories for every one expended. The energy here is almost entirely in the form of the farmers' own labour and that of their beasts, and herein lies the fear that our only choice is between a high-energy lifestyle and one of sheer drudgery.

But there is a third choice, called permaculture.



Permaculture includes many ideas and skills that are not unique to it; some are traditional farming practices, others involve modern science and technology. What does make it unique is that it is modelled very closely on ecosystems, which are natural communities of wild plants and animals, such as forests, meadows and marshes.

Imagine a natural forest. It has a high canopy of trees, lower layers of small trees, large shrubs, small shrubs, herb and ground layers, plus plants which are mainly below ground and climbers which occupy all levels. The production of plant material is mind-boggling compared, say, to a wheat field which is only a single layer about half a metre high.

If only the forest was made up entirely of food plants, how abundant it would be! How greatly would it out-yield the wheat field!

To achieve this great production of biomass, the forest needs no inputs but Sun, rain, and the rocks from which it makes its own soil. By comparison, the wheat field is a sorry state. It needs regular ploughing, cultivating, seeding, manuring, weeding and pest control. All of these take energy, human or fossil fuel. If we could create an ecosystem like the forest, but an edible one, we could do without all that oil.

That is the basic idea of permaculture: creating edible ecosystems.

How Does It Work?

What makes the forest so productive and so self-reliant is its diversity. It is not so much the number

species that is important, but the number of useful connections between them. We have all been brought up with phrases like ‘the law of the jungle’ and ‘the survival of the fittest’ ringing in our ears and to think of competition as the natural way that wild species interact. In fact, co-operation is just as important, especially when you look at the links between different species.

Different plants specialise in extracting different minerals from the soil and, when their leaves fall or the whole plant dies, these minerals become available to neighbouring plants. This does not happen directly, but through the work of fungi and bacteria which convert dead organic material into a form which can be absorbed by roots. Meanwhile the green plants provide the fungi and bacteria with the energy needs. Insects feed off flowers and in return pollinate the flowering plants. Many plants, such as the aromatic herbs, give off chemicals which are good for the health of their neighbours. The web of useful connections grows richer and richer as you look at it.

Some of the edible ecosystems of permaculture may actually look like a forest, for example a forest garden, in which fruit trees and bushes, herbs and vegetables are all grown together, one on top of the other. But in others the copy is not so direct, for example attaching a productive conservatory to the south side of a house. The conservatory helps to heat the house during the day and the house keeps the conservatory warm during the night, so tender food plants can be grown in winter. The building does not look like an ecosystem, but the design is based on the principle of making useful connections. This is what makes ecosystems work and it is also what makes permaculture systems work.

This can only be achieved by means of careful design. Useful connections can only be made between things if they are put in the right place relative to each other. So permaculture is first and foremost a design system. The aim is to use the power of the human brain, applied to design, to replace human brawn or fossil fuel energy and the pollution that goes with it.

Permaculture design is very much about ‘wholes’. If someone tells you their farm or garden is basically conventional but there is a bit of permaculture on part of it, they are mistaken. That is not permaculture. Permaculture is a process of looking at the whole, seeing what the connections are between the different parts, and assessing how those connections can be changed so that the place can work more harmoniously. This may include introducing some new elements or methods, especially on an undeveloped site. But these changes are incidental to the process of looking at the landscape as a whole.

Although permaculture started out as **permanent agriculture**, the principles on which it is based can be applied to anything we do, and now it is thought of as **permanent culture**. It has grown to include building, town planning, water supply and purification, and even commercial and financial systems. It has been described as ‘designing sustainable human habitats’.

How It All Began

Permaculture is not a new idea. In many parts of the world there are people, such as the inhabitants of Kerala in southern India and the Chagga people of Tanzania, who keep gardens that are modelled very closely on the natural forest. Trees, vines, shrubs, herbs and vegetables grow together just as they do in the forest. This structure, called ‘stacking’ by permaculturists, enables the gardens to be far more productive than either orchards or annual vegetable gardens can be on their own, because several crops are being grown on the same spot at the same time. They provide the people with all their food, most of their medicines and fibres, some cash crop, and all on a very small area of land.

Permaculture has learnt much from traditional systems such as these, and it also incorporates many practices which have been developed in recent years. For example, organic gardening, especially the no-dig kind, and solar technology can both be important elements in permaculture design. It is important to recognise that permaculture has no copyright on many of the ideas it holds most dear and is indebted to many co-workers in the field of creating sustainable human habitats. The specific

contribution of permaculture is two-fold. Firstly, it provides the element of design, a way of putting components together for their maximum benefit. Secondly, it provides an overall framework which brings together many diverse 'green' ideas in a coherent pattern.

The word permaculture was coined by two Australians, Bill Mollison and David Holmgren, when, in 1978, they published a book called *Permaculture One*. It was an idea that had fascinated Bill for years. He had spent much of his life in the bush, both as a forestry worker and as a scientist, and the original inspiration came from the forests. He studied them, realised how they work, and said, "I could make one of these."

During the 1960s and '70s, Bill came to realise, as many of us did, that our present mainstream culture is heading down a blind alley, potentially a disastrous one. So he became involved in a lot of protesting, trying to persuade the people who are supposed to be running the world to put it to rights. After a while, he realised it was not getting him anywhere and he became convinced that real change takes place from the bottom up, not from the top down. So he gave up protesting, went home and gardened. And there permaculture was born.

Permaculture is very much about taking matters into our own hands and about making changes to our own lifestyles, rather than demanding that others do it for us. This does not mean that political action is a waste of time. There are many things which are decided at the political level and which probably continue to be so for the foreseeable future. It does mean, however, that our first reaction to any problem or challenge is not, "Something must be done!", but, "What can we do about it?"

A Sense of Ethics

At the heart of permaculture is a fundamental desire to do what we believe to be right and to be part of the solution, rather than part of the problem. In other words, a sense of ethics. The ethics of permaculture can be summed up as:

Earth care
People care
Fair shares

Earth care can be seen as enlightened self-interest: the notion that we humans must look after the Earth and all her living systems because we depend on them for survival. But on a deeper level it is the realisation that the Earth is a single living organism, and we humans are part of her, in just the same way that all the other plants and animals are. We have no more right to survive and flourish than any other species. Thus the protection of all remaining wilderness areas must be one of our highest priorities.

The human habitats created by permaculture are very much more Earth-friendly than those created by present agricultural and industrial technology. But permaculture is not about turning the whole world into a productive edible ecosystem. Far from it. By adopting permaculture, we can increase the productivity of our land to such a degree that we will need much less of it, leaving far more for wilderness.

We can help to save the dwindling remains of wilderness in the world both by campaigning and by being careful about what we consume – tropical hardwoods are an obvious example. But in Britain we no longer have any wilderness in a real sense. Every acre of the island has been profoundly affected by humans, or at least by our grazing animals. Here the richest areas for wild plants and animals are semi-natural habitats, in which humans have played an important role over many hundreds, even thousands, of years. Flower-rich meadows and coppice woodlands are examples. In these, continuing human activity, such as mowing or regularly cutting the trees, is often essential to the survival of

many species of wild plants and animals.

People care is just as important as Earth care. In the past, there have been societies which were completely sustainable, but at the cost of a life of drudgery for the majority of the people. We are not talking about going back to that kind of society. We are talking about replacing both drudgery and fossil fuels with the use of intelligent design.

In fact, it is becoming increasingly clear that the technical solutions to problems are very much easier to come by than the human ones. We largely know how we need to change our agriculture and industry in order to make them sustainable. How to deal with human emotions, such as fear and greed, is less simple however, and these are what really prevent us from making progress. Permaculturists are realising more and more that we must work on people care alongside Earth care if we are to have any success in establishing sustainable human habitats. This can mean anything from teaching ourselves communication and listening skills, to designing cities which cater for real human needs.

Fair shares is a matter of acknowledging that the Earth has limits. She is not of infinite size, so our appetites cannot be infinite either. However much we recycle or buy 'environmentally friendly' products, we can never consume our way out of trouble. There is no substitute for drastically reducing our consumption of non-renewable resources. Almost everything is produced from non-renewables in our present economy, such as most of our food for a start. Renewable resources which are used faster than they can be replaced are also effectively non-renewable, for example, timber and paper at present rates of consumption.

This does not mean we should all suffer in poverty. It means that the Earth can only survive in a healthy state if we match our consumption to need, not greed. This means leaving space for other species, enough food and other resources for the other peoples of the world, and a clean, well-stocked planet for future generations. In other words, taking our fair share.

If you ask most people what really makes life worth living they will say it is not material things at all, but non-material ones like love and friendship, and there is no need for a limit on these. Acknowledging the physical limits of the Earth can help to free us from the never-ending obsession for more material things, and give us more time and energy for the things that really matter.

We also need to limit our population. We in the industrialised North consume far more than the people in the poor South, in the order of 40 times as much per head by one United Nations estimate, and the amount of damage we do to the Earth is greater in proportion. So it is we in the North who most urgently need to control our population.

What causes population to grow is a very complex and controversial subject. But the changes which have taken place over the past few decades in Ladakh, in northern India, as recorded by Helena Norberg-Hodge (*Ancient Futures – Learning from Ladakh*; Helena Norberg-Hodge; Rider; 1991), are particularly revealing. When the people of this isolated Himalayan region depended for their livelihood entirely on the local ecosystem they kept their population steady, so as to be in balance with the ecosystem. Now that the Indian government has introduced a cash economy, many Ladakhis depend on resources brought from far off and their ability to obtain them depends only on their access to money. So there is no longer any immediate need to keep population within bounds, and it is rising.

All conventional 'development', in both North and South, is aimed at increasing people's involvement in the cash economy, replacing local production for local needs with long-distance trade. Here in the North it is called economic growth, and it increasingly separates us from the resources on which we depend for survival. Only by reconnecting ourselves with our local resources can we move towards a sustainable society.

Local Solutions to Global Problems

The Earth is enormously varied. Physical, biological and cultural conditions are never the same from one place to another. What is appropriate to one country is not necessarily appropriate to another. The principles of permaculture design are broad principles, not detailed prescriptions. They can only be used in combination with deep local knowledge, and the results will look very different from place to place.

By contrast, the conventional approach is to do away with traditional, local ways of doing things and replace them with a single, global culture. Applied to agriculture, this has been called the Green Revolution and in the short term it has greatly increased yields. But it is dependent on high fossil fuel inputs, causes pollution and is destructive of both the Earth's natural systems and human societies. It cannot be sustained.

The essence of permaculture is to work with what is already there: firstly to preserve what is best, secondly to enhance existing systems, and lastly to introduce new elements. This is a low-energy approach, making minimum changes for maximum effect, and has the least destructive impact on both natural and human communities. It applies on every scale. Not only will solutions be different from country to country, but from one locality to the next, even from one garden to the next. Subtle differences of microclimate, soil and vegetation are taken into account, and so are the differences between the needs, preferences and lifestyles of different gardeners and their families.



The best way to look at permaculture in practice is by taking an example, and there is no better example than the permacultural way of keeping chickens. A comparison with the battery method is particularly revealing, especially when you look at the two systems in terms of how they supply the chickens' needs and how they use their outputs.

Battery Chickens

The battery chickens' food is mainly grain, grown with the use of tractors and other machinery, artificial fertilisers and pesticides. All of these take a lot of energy both to produce and to use, plus a great deal of raw materials. A protein supplement is added to the grain which is often fishmeal or soya imported from poor countries where the people go short of protein. The soya beans may well be grown on land cleared from virgin forest. The feed is processed at a large centralised mill, requiring transport both from the grain farm and to the chicken farm. Water is pumped to the chicken unit via the main. The battery house takes a lot of energy both to build and to run, including the energy needed for forced ventilation to get rid of the stale air and accumulated body heat of all the birds.

Every material need is met by the use of a great deal of energy and the creation of much pollution. The chickens' welfare needs are not met at all.

As for the outputs, only the eggs are really thought of as an output. After a productive timespan, the chickens are killed and the carcasses may go for the lowest quality meat, but the manure is considered a nuisance to be got rid of, and the idea that chickens may have other things to offer us is not even considered.

Permaculture Chickens

Permaculture chickens have much of their food grown for them where they live. The chicken run is planted with trees and shrubs which produce seed or fruit which is edible to them. No transport is involved and the food simply falls down to them. We call this a chicken forage system. Supplementary feeding may be needed at some times of the year, but a well designed system will keep this to a minimum.

The chicken forage system illustrates two of the working principles of permaculture: it is a good **relative placement** to put the food plants and the consumers in the same place; and the greatest possible use is made of **perennial plants**, such as trees and shrubs. The great thing about perennial plants is that once they are established they need little or no maintenance, unlike annuals which need

big input of work every year. In this system you do not even need to harvest the food. The chickens do it for you.

If a wheat field, an orchard or a vegetable garden are placed near the chicken run, the chickens can make useful connections with them.

If they are let into the wheat field after harvest they will eat up the ears and grains that are missed in harvesting. We humans are not going to pick them up unless we go back to the drudgery of former years, when country people were so poor they were glad of the 'gleanings'. Here the chickens are making use of a resource that would otherwise go to waste.

In the orchard chickens will help to control pests such as codling moth and sawflies by eating the insects during that part of their life cycle they spend on the ground. This connection between chicken and orchard is useful to both parties, and that is the kind of connection we are always looking for in permaculture.

The same sort of connection can be made between the chickens and the vegetable garden. This is called a 'chicken tractor'. This is not a hundred or so chickens tied up to the front of a plough, it is using their natural inclination to peck and scratch to clear the ground of weeds and pests. They are confined on a relatively small area of ground for a short time, either by a fence or in a small, easily moved ark. In a few days they not only clear the ground and manure it, but find a part of their own food needs in the process.

The chickens' connections with the wheat field, orchard and vegetable garden illustrate two major principles of permaculture.

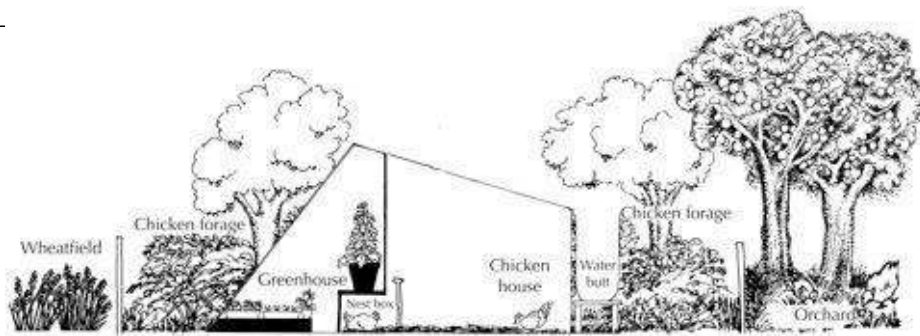
The first is that **every need should be met from many sources**. Just as the chickens get their food from many different sources, so should we. At present the world relies on just four plants for most of its food: rice, wheat, maize and potatoes. This makes us extremely vulnerable to crop failure if conditions should change, either due to global warming or for any other reason. We urgently need to diversify.



Chicken Ark

The second is that **every plant, animal or structure should have many functions**. Most plants and animals will yield us more than one useful output – if we have the imagination to see things like pecking and scratching as a useful output. But we can get even more variety of yields by choosing plants and animals wisely. For example, one of the shrubs we might choose as part of a chicken foraging system is gorse. Not only does it produce seed that the chickens can eat, but it adds to the fertility of the soil by 'fixing' nitrogen from the air and taking it into the soil. It can also provide fuel, winter feed for cattle and horses, and flowers which bloom in every month of the year, giving food for bees and pleasure to the human eye.

Another way of putting it is that we are looking for a **multiple yield**, not just a single one as in a battery farm. In this way permaculture systems can outyield conventional ones. Even if the yield of the main product is less, the total yield is more, because we are taking many different yields at the same time.



Chicken-Greenhouse

The Chicken-Greenhouse

The chicken house in a permaculture system will, as far as possible, be made out of locally produced materials. There will be a water butt to collect rainwater from the roof. This may not be enough to supply all the chickens' drinking water throughout the year, but it is a supply of water that can be had for very little outlay in energy – just a storage butt and a bit of guttering. What is more, once it is set up there is no continuing energy need for pumping. Where mains water is metered it will soon pay for itself in cash terms.

The thing that really makes the permaculture chicken house stand out is the fact that it has a greenhouse attached to the south side. The body heat of the chickens keeps the temperature up in the greenhouse at night, while the greenhouse helps to keep the chickens warm on a cold winter morning, and the carbon dioxide breathed out by the chickens may enhance plant growth in the greenhouse.

An overall pattern emerges from looking at these two ways of keeping chickens:

work = any need not met by the system

and

pollution = any output not used by the system

The battery system is dependent on a continuous input of energy to fulfil every need. This energy demand has been designed out of the permaculture system by making useful connections between its different parts. In the battery house the heat, carbon dioxide and manure produced by the birds are pollutants, while in the permaculture system they are useful outputs.

It is only possible to use these outputs because of the **diversity** of the system. An 'edible ecosystem', with chickens, greenhouse, vegetable garden, wheat field and orchard, can have many useful connections made between these components. A monoculture of battery hens cannot.

This kind of diversity is only possible on a **small scale**. If hundreds of thousands of birds are kept on a single farm there is no option but to feed them with bulk bought-in food, and there is no way they can be let out into the garden or the orchard to do useful work.

Using the roof to collect water is an example of another permaculture principle. Although a system may require some energy to set up, once it is running it should not need any regular energy input from outside the system. In fact, once it is established, it should **produce more energy than it consumes**. (Strictly speaking, it is impossible to produce energy. We can only change it from one form to another. But to all practical purposes the Sun's energy is unlimited and converting some of it to a usable form is a gain in real terms, whereas using up fossil fuels is a loss. Rainfall, wind and the energy in living things all come from the Sun.)

Using the body heat of the chickens, rather than paraffin or electricity to heat the greenhouse,

making use of a **biological resource**. A biological resource is a plant or animal that is used to fill a need that might otherwise be filled by fossil fuels or mined minerals. The great advantage of them is that they obtain all their energy from the Sun. We, and our descendants, can go on using them for ever, whatever happens to our stocks of oil, coal and raw materials.

Harmonious Landscapes

Permaculture is very much a matter of design. Putting things in the right places is essential if any of the useful connections we are talking about are to be made. If the chicken run is next to the wheat field or orchard, the connection can be made by simply opening a gate. Only when the chicken house and greenhouse are joined together can the exchange of heat and gases take place.

These days, landscape design is usually a matter of making things look pretty rather than making them really useful. A permaculture design is primarily concerned with making the landscape productive, self-reliant and sustainable. But this does not mean that it will not be beautiful. In fact, a landscape which is designed in this way will inevitably be beautiful, just as natural ecosystems are.

Compare the sight, sound and smell of a battery house with a chicken forage system. It is like comparing a factory with an ornamental garden. In fact, there is a great deal in common between the way in which a chicken forage and an ornamental garden are laid out. Both are designed so that each plant can thrive in harmonious relationship with its neighbours, receive enough light and moisture for successful flowering and fruiting, and make the best of the particular conditions of soil and climate. What is more, many of the plants will be the same. An example is the false acacia tree, which has long been planted as an ornamental and has given its name to many an Acacia Avenue, but which also bears a seed which is edible to chickens.

A permaculture landscape also tends to be an ethical one. Although it is possible to be cruel to animals in any kind of system, it is impossible not to be cruel in a battery system. On the other hand, it is very easy to be kind in a permaculture system, which is based on the idea of allowing the animals to do everything that comes naturally to them, and accepting this natural behaviour as a given. Permaculture has no monopoly on animal rights, but they are an essential part of the system.

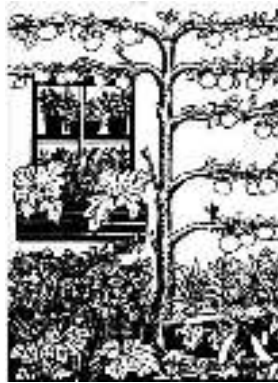


Productive Cities

Most of us in Britain live in towns or cities. We may think there is little scope for growing food in cities, but that is just what we need to do if any kind of city life is to continue beyond the present cheap energy boom. Enormous quantities of energy are used just to transport food into the cities, and it will not be available forever. We need to grow as much of our food as we can right where we live.

The potential of parks is obvious. Over a period of time the purely ornamental trees could be replaced with kinds which are also productive, such as fruit and nut trees, giving the parks the multiple output of food as well as recreation. Allotments and city farms also show how the city can be productive.

The rest of the city-scape looks less promising until we start looking at it in three dimensions. We can train fruit trees against the walls, grow productive climbers up them and make great use of both flat roofs and balconies. This is the principle of stacking applied to an urban situation.



South-facing walls are ideal spots for most fruit trees, especially the most tender ones such as peaches. It is even possible to grow fruit trees and shrubs in containers if the site has no soil. More tender cherries and some plums will grow against a north wall. These can be stacked with currant bushes and alpine strawberries to give high production in a shady spot. Another useful shade-tolerant perennial is the Jerusalem artichoke, and there are many others, both annual and perennial. Shady spots can also be made significantly lighter with white-painted walls, and even mirrors, to reflect light into them.

All our common vegetables and fruit can be grown in cities, and some of the less common ones we make use of the many sources of waste heat to be found there. What proportion of our total needs we can grow there remains to be seen, but it will certainly be far more than most of us would imagine.

People whose potential growing space is limited to a high-rise balcony, a series of window boxes or a small back yard can still grow a useful part of their food. Obviously this will not amount to much in terms of the family's bulk consumption, but it can be valuable both in terms of food value and money saving.

The difference in food value between green vegetables which are eaten within minutes of being picked, and shop-bought ones, which were picked days before, is enormous. So vegetables that are grown very close to where they are eaten have a nutritional value out of all proportion to their bulk. This is especially true of salad vegetables. A kind of lettuce which makes particularly good use of limited space is the 'Salad Bowl' type, which you pick individual leaves from rather than cutting the whole plant. If hearted lettuce is preferred, some of the miniature varieties of Cos lettuce will grow happily in a window box.

Many leafy salad vegetables can be grown on the cut-and-come-again method: seed is sown broadcast and when the seedlings come up they are clipped and allowed to sprout again. This can be repeated several times, and the repeated clippings add up to more yield than you could obtain off the same area by growing plants in rows and cutting them only once when they mature.

Seed-sprouting is a form of indoor gardening which is not to be despised. All kinds of beans, peas and lentils, seeds such as sunflower and alfalfa, and grains such as wheat, can be sprouted. As they develop from dry seeds into little plants, the food within them becomes more digestible (which effectively increases the quantity of food we can make use of), and they acquire the vitamins and essential vitality which makes fresh vegetables so much more nutritious than dried food.

Herbs have a high money value in relation to the space needed to grow them, as does garlic. So these are obvious first choices for the gardener with little space who wants a money saving from gardening. Sun loving herbs, such as thyme and rosemary, can be grown on the south side of buildings and shade tolerant ones, like the mints and lemon balm, on the north side. The taste and health-giving properties of herbs are also much greater when they are taken fresh than when they are dried.

In some urban areas food production is limited by air pollution. Although permaculture emphasizes the many things that we can do as individuals or in small groups, this is one area which can only be effectively dealt with on a political scale. In fact, lead pollution has fallen to safe levels in most areas since the introduction of unleaded petrol, a political decision.

A possible source of heavy metal pollution which remains is cadmium, which is in tyres and gets deposited on roads as the tyres wear. Runoff from busy roads should not be used to water food vegetables or fruit. Where there is any doubt about pollution levels both soil and leaf analysis can be done. The local environmental health office should be able to give information on this.

Fortunately, plants have some ability to restrict their uptake of heavy metals, so we are less likely to be affected by eating city-grown vegetables than we are by breathing city air. But these pollutants still do a lot of damage, including killing soil micro-organisms and hence interfering with the soil fertility cycle.

Living Houses

The house itself is an important energy system, and in permaculture we are interested in making more of a collector of the Sun's energy than a consumer of fossil fuels. The best way to do this is often by passive solar design. This means that the actual design of the building is such that it obtains most of its heating needs direct from the Sun, without the need for added gadgetry.

Building new houses of passive solar design is relatively easy. It costs about 5% more than conventional housing, but the extra cost is recouped in lower heating bills in around five years and after that it is pure profit for the lifetime of the building. Retrofitting an existing house is less straightforward, but there is much that can be done.

Draught-proofing, though unspectacular, gives the greatest saving in energy for the least input. Insulation comes next; a passive solar approach is to put the insulation on the outside of the walls, then the walls themselves become massive heat stores. This approach has been combined with heat recovery from the ventilation system to give a package which has reduced heating bills in high-rise flats by 90-95%.

Another good way to catch solar energy is to add a conservatory to the south side of the house. If that is not possible, it can be added to the side which catches the most sunlight, or even on the roof. Not only does this provide a highly productive growing area and extra space for the house, but the energy relationships are similar to those between the chicken house and its glasshouse. In winter, warm air from the conservatory can be vented into the main body of the house, and in summer the rising current of hot air in the conservatory can be used to draw cool air from the north side of the house and thus cool it down. Meanwhile, the conservatory converts some of the waste heat from the house into food.

Plants can be used to increase the energy efficiency of buildings. For instance, ivy grown up the north wall of a house can reduce winter heating needs. This is also beneficial to wildlife, and, if the brickwork is sound, will preserve it rather than cause deterioration. Using living plants as part of the actual structure of a building in this way is known as 'biotecture' and it is another way of using biological resources instead of non-renewables.

When using more conventional materials, it is necessary to be aware of where they come from and to choose materials that respect both Earth and people. This means avoiding such materials as aluminium, with its very high energy cost, some forms of mineral fibre insulation, which may cause cancer in the workers who make them, and paints containing titanium dioxide, which is harmless itself but very polluting in its manufacture. Alternatives to all these exist. For example, many natural insulating materials, such as wool or cork, can be preserved from rot, fire and rodents with a harmless dressing of borax.

Water supply and sewage disposal are under great strain both in cities and elsewhere, and much can be done to ease the problem by making better use of the available resources. At present, we fill the sewers with a mixture of rainwater off the roofs, 'grey' water from sinks and baths and 'black' water from toilets. The rainwater can be used for drinking, as it is probably purer than what comes out of the tap, while the grey water can be used for flushing the toilet and supplementary plant watering. By separating the three and using each quality for its highest use, mains water consumption in the city can be reduced by half for the cost of a little plumbing. In the country, rainwater could provide for all our domestic needs, as it does on many Australian farms, in a far drier climate than ours.

The real sewage can be purified by passing it through a series of carefully designed beds of reeds. Reeds and other water plants have the ability to remove organic matter, disease organisms and even chemical pollutants such as heavy metals. Reedbeds have been installed to cope with both domestic and industrial effluent. They take up less land than conventional systems, and can even be installed vertically in a series of plastic tanks.

Rather than seeing sewage as nothing but a problem we need to see it as a resource, full of valuable organic matter and plant nutrients. As long as we treat it as only something to be got rid of we will be dependent on a continuing input of fossil fuels to produce artificial fertiliser, and we will continue to pollute the seas with sewage sludge. Much work has already been done on developing safe and effective compost toilets, and these can be combined with reedbeds to make a comprehensive sewage treatment system.

Recycling of other materials, such as paper, glass, metals and so forth, can be easier in the city than elsewhere because people are concentrated into a small area, which reduces the energy required to collect the materials. But recycling should only be our third choice, after first reducing our

consumption and secondly reusing things. Returnable bottles, for example, are far more energy efficient than bottle banks and provide more employment.

This is another area where political action has a part to play. For example, in the state of Oregon in the USA, beverages can only be sold in a container which is returnable and has a deposit charged on it. We could have the same law here.

At least for the time being, a considerable proportion of the electricity supply to cities must continue to come from fossil fuels. But this can be made very much more efficient by using the heat produced by the process of generation as well as the electricity. This heat represents the majority of the energy in the original fossil fuel and it goes to waste in conventional power stations. Where small power stations are sited near where people live, the heat can be used for space and water heating. This is known as combined heat and power. It only works because of the relative placement of housing and power station.

By far the most cost-effective 'source' of electricity, however, is conservation. Reducing consumption by any means, including installing low energy light bulbs and other efficient appliances, always pays better and causes less pollution than generating more electricity.

Putting all the above ideas together would take us a long way towards creating a complete package for sustainable living. This is likely to be more than any one person or family can easily take on alone and the attitude of local councils and utility companies can range from indifferent to hostile. The answer is for local people to get together and form their own organisations for getting things done, and this is already happening in various parts of Europe, indeed all over the world.



Garden Design

Cities certainly present the greatest challenges to permaculture designers. As we move out to the suburbs and the country the potential is greater, as most things which can be done in the cities can be done there too, and there is the added potential of bigger gardens.

Perhaps the most valuable principle used in designing a permaculture garden is that of 'zoning'. It says that things which need the most attention should be placed nearest to the centre of human activity.

How often have you seen a garden where the flowerbeds are placed near the house and the vegetables tucked away behind a hedge as far from the house as possible? This is pretty typical. You know there is no truer saying than 'the best fertiliser is the gardener's shadow'. Vegetables grow better where you see them every day and give them the attention they need when they need it. Weeds are pulled before they start to seriously compete with the vegetables; watering gets done before the plants start to wilt.

Also, you eat more of what you grow when you can easily inspect what is ripe from day to day. It is a sad fact that every year masses of vegetables are grown and then left to rot in the garden simply because they were grown out of sight. Sometimes this is because no-one has visited the garden for a few days, so it is not known that such-and-such a vegetable is ready in quantity. At other times, you know what is there and want to cook it, but it is raining, the kids are yelling, you are behind with the cooking and the last thing you need is a trek to the bottom of the garden. A quick nip out of the back door would be quite another thing.

The most productive area of any back garden is that which can be seen from the kitchen window. The most effective way to boost the productivity of any garden is to move the vegetables into this area. You can get more food for the same work, or less work for the same food, just as you choose. Zoning can be that simple and that effective.

This need not mean losing the decorative value of the garden. Many vegetables are ornamental, such as runner beans, ruby chard, 'Salad Bowl' lettuce, ornamental kales, and most of the herbs; and many flowers, such as nasturtiums and marigolds, are edible. Also, flowers and vegetables benefit from being grown together. Not only is there a general advantage in creating maximum diversity, but there are some specific connections that are especially useful. For example, some kinds of marigold (*Tagetes*) help to control the eelworms that prey on tomatoes and can deter weeds such as bindweed and ground elder with the chemicals they release into the soil.

The layout is just as important to creating a beautiful food garden as the choice of plants. This is the

principle behind the French *potager* style of garden where vegetables are arranged in a design which is as pleasing to the eye as to the stomach. Indeed, a well-designed vegetable/flower bed can yield as much food as the same area down to pure vegetables and be as beautiful as a pure flower bed. By accepting more than one output from the land, we double the yield.

Along with the idea of zones goes that of 'sectors'. This is a matter of placing things in relation to influences coming from beyond the garden fence. Some of these are climatic factors, such as sunshine, winds and frost. Others are more human-oriented, such as a good view or the likes and dislikes of neighbours.

The climatic factors give rise to microclimates within the garden. These are areas which have their own distinctive conditions of temperature, moisture, wind and sunlight. The amount of light reaching different parts of the garden can be particularly important in determining which plant will grow best where. Temperature can also vary considerably from one part of the garden to another. Sunlight affects this, but so does the heat storage capacity of walls and other massive structures. A south-facing wall gives a choice microclimate for tender plants.

Wind can be important both in exposed gardens and in urban ones, where the wind builds up speed by funnelling through the gap between one house and the next. Careful siting of the appropriate plants and structures is needed, and a wind-break can have a multiple function if it is composed of fruiting species. Damsons, nuts and gooseberries are all fairly wind-hardy.

Before planting trees or doing any other work of a permanent nature, it is a really good idea to spend a year getting to know a garden, finding out exactly where the light and shade fall in different seasons, where the windy and sheltered spots are, and where the frost lingers in the spring. Trees last a lifetime and more. A year's careful observation and thought followed by harmonious planting is much better than a rush to get the plants into the ground followed by a lifetime's regrets.

Starting small is an excellent rule of thumb for new gardeners. There is nothing more dispiriting and frustrating than having just a little more land in cultivation than you can really manage. The garden becomes a burden and things are never quite as well done as you would like them to be. A smaller area which gets all the attention it needs can produce more than a larger area that does not.

Just how small will depend on a number of factors, including the amount of time available for gardening, the crops to be grown and so on, but an intensive vegetable bed of three by three metres could produce a very worthwhile contribution to the larder. The rest of the potential vegetable garden can be put down to a green manure crop, such as lucerne. This will provide mulch material for the vegetables at the same time as it improves the soil, and the garden can expand into this improved soil when the initial area is already running smoothly.

Low-work Gardening

There are many edible perennial plants which can be grown in the garden. As well as fruits and nuts there are perennial vegetables, some examples of which are listed in the table below. A lot of the plants we normally think of as herbs can be eaten as vegetables, especially in salads, and most of these are perennial. Lemon balm, fennel and mints can be used in this way.

Many of the perennial vegetables are native plants, such as salad burnet and sorrel. The great advantage of growing wild food plants in the garden is that they really want to grow there. They have been adapted over thousands of years of evolution to thrive under local conditions. Many of our cultivated food plants are introductions from other parts of the world, and they need a lot of support from us to survive and give a yield in an environment which is basically alien to them.

Some perennial and self-seeding vegetables

| Name | Perennial or Self Seeder | Size: | Main Use |
|--|-----------------------------|-------------|--------------|
| | | Low/Med/Tal | |
| Daubentons Kale (<i>Brassica oleracea</i>) | P | Mj | Greens |
| Nine-Star Broccoli (<i>Brassica oleracea</i>) | P | T | Curds |
| Sea Beet* (<i>Beta vulgaris ssp. maritima</i>) | P | M | Greens |
| Chard (<i>Beta vulgaris ssp. cicla</i>) | S | M | Greens |
| Fat Hen* (<i>Chenopodium album</i>) | S | M | Greens |
| Sea Kale (<i>Crambe maritima</i>) | P | M | Stems |
| Alexanders (<i>Smyrniium olustratum</i>) | S | T | Stems |
| Musk Mallow (<i>Malva moschata</i>) | P | M | Salad; mild |
| French Scorzonera (<i>Reichardia picroides</i>) | P | L | Salad; mild |
| Pink Purslane (<i>Montia sibirica</i>) | P&S | L | Salad; mild |
| Salad Burnet* (<i>Sanguisorba minor</i>) | P&S | L | Salad; mild |
| Chickweed* (<i>Stellaria media</i>) | S | L | Salad; mild |
| Lamb's Lettuce (<i>Valerianella locusta</i>) | S | L | Salad; mild |
| Winter Purslane (<i>Claytonia perfoliata</i>) | S | L | Salad; mild |
| Turkish Rocket (<i>Bunias orientalis</i>) | P | M | Salad; tasty |
| Chicory (<i>Cichorium intybus</i>) | P | Various | Salad; tasty |
| Herb Patience (<i>Rumex patiencia</i>) | P | T | Salad; tasty |
| Land Cress (<i>Barbarea verna</i>) | S | L/M | Salad; tasty |
| Rocket (<i>Eruca sativa</i>) | S | L/M | Salad; tasty |
| Herb patience (<i>Rumex patientia</i>) | P | T | Salad; tasty |
| Nasturtium (<i>Tropaeolum majus</i>) | S | L | Salad; tasty |
| Ramsons* (<i>Allium ursinum</i>) | P | L/M | Leaves |
| Welsh Onions (<i>Allium fistulosum</i>) | P | M | Leaves |
| Everlasting Onions (<i>Allium perutile</i>) | P | L | Leaves |
| Tree Onions (<i>Allium cepa proliferum</i>) | P | M | Leaves |
| Skirret (<i>Sium sisarum</i>) | P | M | Roots |
| Jerusalem Artichokes (<i>Helianthus tuberosus</i>) | P | T | Roots |

Notes:

Sizes are approximate only:

Low – less than 30cm; Medium – 30-60cm; Tall – over 60cm.

* Indicates a wild plant – seed available from wildflower specialists.

Many seed catalogues list perennial vegetables under 'Herbs'.

Details of many of the above plants are given in *How To Make A Forest Garden*.

Growing native plants is a way of working with nature rather than against, of accepting her gifts rather than imposing our demands. It is co-operation rather than confrontation. It both benefits the local ecology and makes life easier for us. Native plants tend to 'grow like a weed' with very little effort.

our part, and though they play host to many insects and disease organisms these rarely reach pest disease proportions as the plants have evolved to coexist with them.

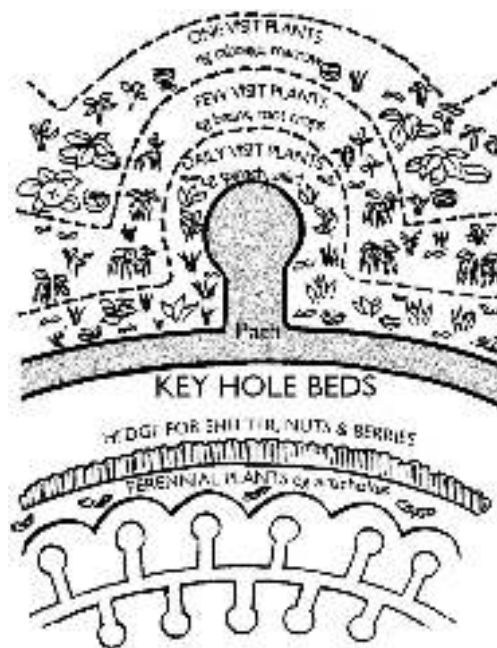
One of the great advantages of perennials is that they are ready early in the spring. They spend the winter as rootstocks or bulbs, and when spring comes they are ready to burst forth above ground with masses of leaves when annual vegetables are still only seeds in the packet, or at best seedlings in the tray. In the winter, when the perennials have mostly died down, there are annuals, such as brassica roots, land cress and lamb's lettuce that are yielding. So a combination of perennials and annuals is a good way to get an even supply of vegetables all year round.

Permaculture gardeners always prefer to grow annual vegetables on a no-dig system if possible. Growing vegetables without digging has been tried and tested over many years by the members of the Henry Doubleday Research Association in their gardens all over the British Isles. Results are similar to conventional growing, though they may be better in one year and worse in another. The amount of work involved is far less, and any soil compaction can be dealt with by simply loosening the soil with a fork without digging or turning it. Potatoes can be grown without digging by covering the seed with a layer of straw or other mulch.

Annual self-seeders, which can reproduce themselves without our help, are ideal for the no-dig garden. Common examples are spinach, chard and parsley, but native annuals which are edible obviously come under this heading. Fat hen, for example, makes a good spinach, and chickweed a good base for a salad.

It is important with no-dig gardening not to walk or stand on the soil where plants are growing so as to avoid compaction. Most no-dig gardens are laid out on a raised bed system, which has alternating beds and paths, with the topsoil of the paths removed and placed on the beds. The beds are sufficiently narrow for every part of them to be reached from the paths, so that no-one need ever step on a bed. This results in beds about 1.2 metres wide and paths of about half a metre. It is a highly productive system, but almost a third of the garden is taken up by paths.

This proportion can be improved by laying out the garden in keyhole beds (see illustration below). Little paths shaped like a keyhole branch off the main one, or radiate from a central spot.



Standing in the middle of a keyhole bed or on the main path, the gardener can reach much of the ground quite easily. This area is used for plants which need the most frequent attention, such as leafy greens which are picked over a long period. A little further away, but still within reach, are plants that

need less frequent attention, and further away again are plants that need little more than planting and harvesting, like garlic and onions. The last group may be out of reach without stepping onto the garden, but the odd footprint in dry weather does no harm, and stepping stones can give all-weather access.

As well as their purely practical advantages, keyhole beds are more attractive to the eye than straight beds, so they lend themselves to combined edible and ornamental plantings.

Mulch is any material laid on the surface of the soil in order to kill weeds, conserve moisture and protect the soil from rain or Sun. Many mulches also add fertility to the soil as they rot down. Mulching in all its forms is a great tool of permaculture gardening. It cuts out a lot of work, and leaves the soil undisturbed, just as it would be under natural conditions.

Mulch can be used to clear new ground without digging: it kills off the existing plant cover by excluding light. Black plastic sheeting does this well, though it should never be bought new for this purpose. There is plenty of it being thrown away all the time which gardeners can recycle. Old carpets and cardboard will do as well. It takes a whole summer growing season to kill off a heavy growth of really tough plants, but if you want to grow a crop right away, and the existing growth is not too rampant, it is possible to grow plants through the mulch.

The aim of mulching is not usually to kill all the weeds but to reduce them to the sort of level that is easy to live with. In fact, the presence of a few weeds increases the diversity of the garden ecosystem and is thus very good for the health of the garden. Deep rooted ones, like dock and dandelion, bring up minerals from the subsoil. It can be worthwhile simply to chop off the leaves of these plants and use them as a nutrient-rich mulch, leaving the roots intact as a nutrient pump, rather than digging the whole plant out. Other 'weeds', as we have seen, are edible.

Weeds that send out runners, such as couch and bindweed, may not be killed by the mulch. But they tend to grow more between the mulch and the soil than in the soil itself. So at the end of the growing season you can just pull back the mulch and scoop up the majority of the roots without any digging.

In an established garden any organic material, like grass mowings, leaves or shredded paper, can be used as mulch between the plants. It can virtually eliminate weeding and save as much as 40% of watering requirements by preventing evaporation from the soil.

Slugs can be a problem with mulch - as they can without it! So it may be necessary to withhold the mulch for a while in wet weather when the plants are still young. A way of controlling slugs is to dig a pond and stock it with frogs, or to keep a few ducks which can be let into the garden now and then, both of which love to eat slugs. (Chickens should only be let into the garden for tractoring, as they make a real mess of the mulch.) Perennial plants are hardly troubled by slugs, as they do not have to pass through the vulnerable seedling stage each year.

The Forest Garden

One of the best examples of a permaculture garden is the forest garden developed by the late Robert Hart of Shropshire. It has the layered structure of a natural forest: a canopy of fruit trees, a lower layer of dwarf fruit trees and nut bushes, a shrub layer of soft fruit, a layer of perennial herbs and vegetables at ground level, plus root vegetables and climbers.

The total production of this garden is greater than a monoculture of any one of its layers could be. This is partly because of the beneficial effect of such diversity on plant health and partly because the forest garden makes the maximum use of the resources available to it.

It makes the most of the sunlight available to it because the different layers come into leaf at different times of the year: the herb layer first, in the early spring, followed by the shrubs, and lastly the trees. Throughout the growing season there is something at the peak of its growth, making the most of the energy available from the Sun. This is something that does not happen in a single layer.

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