open permaculture school
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Regenerative Permaculture Design

a beginner's guide to designing a truly liveable world

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Chapter 1

Introduction to permaculture

Permaculture has been for me and for many others a life-changing experience. When I took my PDC, a whole new world opened up for me, and once you learn to see the world in a new whole way, there is no going back.

The outpouring of creativity and ingenuity that this design system inspires constantly amazes me: It is a very empowering tool.

Permaculture also gives me hope. It has taught me that it is entirely possible for us to repair the damage we have done to the Earth and improve both the quality of our lives and those of future generations.

The content of this course is based on the book Permaculture: A Designer's Manual by Bill Mollison, which is an extraordinary resource for skills and information to help us survive the challenges we face and renew the world we live in.

Most of what you will learn in this course concerns how to design sustainable and regenerative gardening systems according to the principles of permaculture. These principles are based on designing the way nature does. Nature has been creating complex, resilient, regenerative, multi-functional, adaptive ecosystems for

millions of years. If we pay attention, we might learn a thing or two.

However, while permaculture is a brilliantly effective design strategy, it is much more than that. This first section will cover the ethics and philosophy behind permaculture: What it is, why it is important, and how it offers a different way of seeing and relating to the world.

The heart of permaculture is its values and ethics, which involve taking a personal responsibility for caring for the Earth.

It invites us to a radical re-thinking of our relationship to nature and our part in it.

Above all, permaculture is a call to action!

Underlying philosophy of permaculture

> The sad reality is that we are in danger of perishing from our own stupidity and lack of personal responsibility to life. If we become extinct because of factors beyond our control, then we can at least die with pride in ourselves, but to create a mess in which we perish by our own inaction makes nonsense of our claims to consciousness and morality..
>
> **– Bill Mollison**

We have been taught to think that we, humans, are the exception to the laws of nature; that we are somehow exempt from the consequences of our failure to understand and cooperate with nature. But nature doesn't operate that way. She doesn't play favorites – if we do not

work with her we will not survive, while if humans all disappeared, the Earth would eventually restore itself to balance. It would not miss us.

Our economy, based as it is on unlimited growth, ever-growing consumption, competition and waste, is unnatural. Natural resources are converted to material goods and then to waste seemingly as quickly as possible, so that more goods can be created and sold. Many of these resources, such as petroleum and minerals, are irreplaceable.

The 'economy' is a concept humans made up, and it values things of no practical worth (for instance, dollars) over things of real benefit to our existence (such as clean air, fresh water and healthy soil) in a way that endangers not only our own future survival but also deprives future generations of the means to survive.

In modern human societies we have become isolated from this natural way of being, and also isolated from each other. The economy of competition and consumption has placed us in artificial environments that don't require us to adapt to real world changes. Thus we impede our own evolution. The experience of the natural world and its laws has been abandoned for closed, artificial and meaningless lives. We have lost our connection to nature, to each other and to the complex web of life on Earth. No wonder we are depressed, anxious and prone to shooting each other. People at every level of the social and economic hierarchy are deprived of the ease and aliveness that is possible in a cooperative society. Both 'guards' and

'prisoners' are equally captive in this system of society.

In the economy we have constructed, more importance is placed on the invented world of products and currency than on the real, natural world. In this system our value as humans is determined by how much stuff we have. But no natural systems function this way. Natural systems do create greater abundance as they develop, but they do not hoard it; rather they use it to sustain more life. Nature wastes nothing, and neither should we.

Principle of cooperation

> "Cooperation, not competition is the very basis of existing life systems and of future survival.
>
> **– Bill Mollison**

Life should be cooperative, not competitive. The commonly used phrase "survival of the fittest" is actually a mis-quote of Charles Darwin made by a military general, implying that the last species standing 'wins' somehow. What

Darwin actually said was, "survival of the fit". He meant that those organisms best adapted to their environment are the ones that survive over the long haul, and adaptation is achieved far more often by cooperation than competition. More often than not competition wastes energy to no useful end while cooperation harnesses the energy of many individuals for the benefit of the group as a whole. One way people cooperate is by adhering to a shared set of ethical principles. Ethical systems evolve in societies out of experience in what supports survival of the group.

Ethical principles of permaculture

There are three basic principles that underpin all permaculture:

- Care of the Earth: Provision for all life systems to continue and multiply
- Care of people: Provision for people to access those resources necessary to their existence
- Fair share, or share the surplus: By managing our own needs and designing for abundance, there will be enough for all people and species on the Earth.

Following these principles represents some profound shifts from the way much of the modern world works. It requires a change so that we work with, rather than against, nature, so we see nature as something we are a part of, not something that is there for us to exploit.

It means we recognize that we are just one element in an interdependent web of life.

Caring for the Earth means considering all the yields and functions of natural systems rather than asking only one yield of them, and taking into account all the living things that are part of the system. Sharing the surplus produce from our labors with our local communities is one aspect of caring for people. Permaculture

seeks to help people cooperate, to level hierarchical structures and seek more sustainable, self-reliant ways of organizing communities.

We need to ask the right questions. Instead of asking: "What can I get from this land or person?" ask "What does this person or land have to give if I cooperate with them?" And what can I give in return?"

The difference in these approaches – modern competitive society and permaculture – is profound: the first leads to war and waste, the other to peace and abundance.

Preserving what we have

Rule of Necessitous Use: Leave any natural system alone until we are forced to use it out of necessity.

Rule of Conservative Use: When it becomes necessary to use a natural resource, every attempt is made to:

1. Reduce waste and pollution
2. Thoroughly replace depleted minerals
3. Do a careful and honest accounting of energy required
4. Assess the long-term negative effects on society and attempt to avoid or ameliorate these.

– **Bill Mollison**

When taking account of our actions we need to consider all the fiscal, social, environmental, aesthetic and energy impacts we have (our current ways of accounting considers few, if any, of these).

A clear accounting would go a long way to helping us recognize our effect on and interconnectedness with nature. Given that we depend on the health of natural systems for our survival, it is beholden to us to fully understand the effect of our actions upon them.

Observation of nature reveals that cooperative species and associations of self-supporting species (e.g. mycorrhiza on tree roots) create healthy and resilient communities.

When we expand this idea of cooperation to the natural systems of the Earth as a whole, we understand that all life has common needs and so is interdependent. Understanding that we are all family and we need each other leads us to evolve ethics of sustainable and sensible behavior.

Sustainability and peace

The common characteristic of all permaculture systems is that all the energy needed by the system is provided by the system: It is self-sufficient.

Our current industrial agricultural model is, by contrast, completely dependent on external energy sources, specifically oil and gas, guaranteeing that it will not only pollute the Earth but also be short-lived. This method of producing food has only been around for 50–60 years and it is already failing, causing terrible damage to the environment and putting greater pressure on communities, by focusing on profit rather than people.

Moving away from commercial agriculture, where land is a commodity and high-energy inputs are required, is necessary not only to protect the Earth but also to have a stable social order. Shifting to productive permanent systems, where we provide for our food and energy needs in our communities, is essential if we want peace in the world.

Consider that we in America are currently maintaining our rate of consumption by exploiting the resources of the Middle East, South America, and many other countries. This prevents them from having the resources they need to build a sustainable life in their own communities and leads to understandable resentment and, sometimes, retaliation, thereby requiring that we use an extraordinary amount of the resources to protect our interests. This is an excellent recipe for conflict and exactly the situation we find ourselves in. And as resources get scarcer, it is only likely to get worse unless we change the way we live.

Preservation and restoration

The basis of permaculture is beneficial design, whereby actions are taken that benefit the system as a whole. Therefore, the concepts of permaculture can be applied to almost any human activity or system.

But our approach cannot just center on humans. Designed ecosystems that focus on the needs of humans and their livestock, are very valid, but we need to remember that humans are only a small part of the whole of nature. Our survival depends not only on creating more sustainable communities for us to live in, but on making room for natural ecosystems to thrive as well.

We should concentrate on rehabilitating and redesigning already settled areas and agricultural lands. This can allow the remaining ecosystems to be restored to balance. By integrating food supply and settlement, harvesting rainwater, and establishing a fuel forest that receives waste and supplies energy, we free most of the globe for the rehabilitation of natural systems that are left to recover their natural balance rather than being exploited by us for resources.

We also need a nature-centered ethic for wilderness conservation. This can't happen until we reign in our greed and create sustainable human settlements that allow natural systems to recover and flourish.

If we leave ecosystems alone, they will recover over time. If we intervene in the right ways, they will recover much more quickly.

So permaculture focuses on providing for our needs in the least amount of space possible with the minimum impact on land outside our settlements. Therefore, a long with making human settlements self-sustaining, we also

have to control our population. Unchecked, exponential growth of human numbers will ultimately defeat any of our efforts to be self-sustaining.

As a human society, some of the key actions we need to take immediately to restore the planet to health are:

- Implacable and uncompromising opposition to further disturbance of any remaining natural ecosystems (forests, coral reefs, etc.) where most species are still in balance
- Vigorous rehabilitation of degraded and damaged natural systems
- Establishment of plant systems for our own needs on the least amount of land possible
- Establishment of plant and animal refuges for threatened species.

Fundamentally, we rely on an interconnected web of species – of which we are a part – for our own survival. For example, we rely on large forest systems to clean our air and stabilize our weather, to purify our water and stabilize pollutants. We can see how important even a single species is when we consider that bees pollinate 60 percent of the plants we eat. But rather than working to protect these animals, the agricultural chemicals and genetically-modified crops we cultivate are leading to their precipitous decline.

Permaculture is a call to action. So what stops us from acting?

> The most common way people give up their power is by thinking they don't have any.
>
> **– Alice Walker**

There are many reasons why we might not implement permaculture ideas. For instance, modern life can be overwhelming and it is sometimes a struggle just to keep up with the demands of our complicated lives. We may fear that restoring a natural balance to the world will mean we have to give up what we value and the things that make our lives easy (a few people think sustainable living means everyone has to live in a mud hut). And change in itself can be scary – it can be easier to stick with the present way of things if you aren't sure what the future will hold if you do change.

But change is what must happen, given what we are doing to the planet.

We have nothing to lose by changing and everything to lose if we don't. (And even if you believe climate change is a big hoax and the planet has unlimited resources to exploit – both of which science has

proved to be wrong, by the way – we would surely benefit from changes that bring more resilience, more freedom and independence, more time, community and meaning to our lives.

Ultimately, choosing whether we change the way we live and how we treat the Earth is an ethical decision, and all ethics come down to the choices we make.

We can choose the values we care about. We can choose to reuse, recycle and reduce waste, to grow our own food and support local growers. We can choose to live simpler, more connected, more meaningful lives, and in doing so restore the planet to a thriving, vibrant place.

We also have the opportunity to vote, every day with every dollar we spend, for the kind of world we want.

What we have done, we can undo. We don't need new technology. We have all the means to correct the problems and heal our world and ourselves right now. We already know how to build, maintain and inhabit sustainable systems. Every essential problem has been solved . . . what remains is for us to change our attitudes and act on what we know.

The crucial thing we have to change is our understanding.

Chapter 2

Permaculture principles

Austrian farmer Sepp Holzer is credited with developing the first practical permaculture system on his farm in the early 1960s. Australians Bill Mollison and David Holmgren, and their associates, developed the theory of permaculture during the 1970s. As we saw in the previous chapter, they crystallized what permaculture is and the ethical principles that underpin it.

> "The world teeters on the threshold of revolution. If it is a bloody revolution it is all over. The alternative is a design science revolution . . . Design science produces so much performance per unit of resource invested as to take care of all human needs..
>
> **– Buckminster Fuller**

They defined permaculture as an approach to designing human settlements and perennial agricultural systems that mimic the relationships found in natural ecologies. The three principles underpinning this approach are: care for the Earth, care for people, and fair share.

David Holmgren, however, went on to define a more detailed list of principles that gave a broader and more comprehensive account of what permaculture is, how it is implemented, and what it seeks to achieve.

12 Principles of permaculture as described by

1 Observe and interact – "Beauty is in the mind of the beholder"

By taking the time to engage with nature and observe how it functions best, we can design solutions that suit our particular situation, and avoid wasting time, labor and resources.

By working with nature rather than against it we can find solutions that benefit us, and the natural ecosystems we rely on. Nature has been developing and refining complex, regenerative systems for 4.5 billion years, so we are not going to come up with better solutions than she has. We need to watch what nature does and learn from it. Aiding natural cycles results in higher yields and less work. A little support for nature from us goes a long way, and is much more beneficial for both parties than trying to outdo nature. For instance, if we use pesticides to kill insects, nature will evolve more resistant species. We cannot outsmart nature.

Stress and harmony

Stress is defined as either the prevention of natural functions or forcing functions. Harmony is the integration of chosen and natural functions to supply essential needs.

Placed correctly, any element in a system will perform its natural functions while benefiting other parts of the system. Stress occurs when you force an element to do more functions that it can sustain or force an element to perform just a single function when it would naturally perform more. Think about a chicken in a battery cage; its only function in that system is to lay eggs. Its other natural functions – such as scratching and turning the soil, eating pest insects, providing the soil with nutrients through its droppings – are denied.

It is deprived of many parts of its nature and is overloaded with demand for a single function. (the same could be said for a human sitting at a computer in an office cubicle all day.)

Order and disorder

Order and harmony produce energy for other uses. Disorder consumes energy to no useful end.

By order we mean things working beneficially together, not the unnatural forced appearance of order in tidiness, straightness and neatness.

True order may look like confusion to the uneducated eye. The true test of whether a system is ordered is yield. If a system consumes more than it yields, it is in disorder. If it yields more than it consumes, it is in order. Therefore, the mowed lawn and trimmed hedge – even though they may look neat and tidy – represent an energy intensive-low yield system, as do rows of mechanically cultivated crops.

2 Catch and store energy – "Make hay while the sun shines"

Energies that enter a system either remain or escape. As permaculture designers, we seek to prevent energy from leaving the system before the basic needs of the whole system are satisfied. And by developing systems that collect resources when they are abundant, we can use them in times of need. We try to maximize energy storage in any system by identifying the available resources on site as well as the ones entering the system (streams, wind, rain, sunlight, etc.) and storing them as much as possible. Doing so will allow the living components in the system to grow, reproduce, and maintain themselves, and ultimately to increase yield. Therefore, we design in order to catch and store as much energy as possible, and to slow the rate at which energy leaves the system, making as much use of it as possible. So, for instance, we seek to prevent rainwater running off the site so that it can soak into the soil and be used by plants and organisms. Some designers have used techniques to make the entire site energy balanced. One permaculture farmer used the energy of a waterfall to compress gas for the canisters he used to power the vehicle in which he took the produce from his plot to market.

There is one caveat; we must not store more energy than we can use in the system. This is a form a waste. For

instance, in the fall, there are often more leaves than can be effectively composted to add to the soil. These should be bagged and given to others who can utilize their energy within them.

3 Obtain a yield – "You can't work on an empty stomach"

Ensure that you are getting truly useful rewards as part of the work you are doing. The aim of functional design is to obtain yields. Yield is defined as the surplus over and above the needs of the system. In industrial agricultural systems yield is typically a single product grown at maximum volume for maximum profit. Not only does this ignore the interdependence of ecosystems, it wastes all other possible yields from the land. There are different types of yield:

- **Product Yield:** The surplus in any part of a system.
- **System Yield:** The sum total of surplus energy produced, conserved, stored, reused, or converted by the system beyond its needs for growth, reproduction and maintenance.
- **Impalpable yields:** These include such things as health, nutrition, security, satisfying social context and lifestyle, freedom and ease. These less tangible notions can often get overlooked in designs, but they are vital to human wellbeing. (Consider how typical subdivisions of housing, made simply to maximize profit by squeezing as many properties into a location as possible, make the quality of life much worse than if human needs for space, privacy and so on were taken into account in the design stage.)

A true accounting of yield takes into consideration all these types of yield. It looks at both upstream costs (energy) and downstream costs (health).This will then result in designs that are efficient and meet the needs of all the elements within them, without the overuse of resources.

The yield of a system is theoretically unlimited. The only limit on the number of uses of a resource within a system is the limit of the designer's imagination. There is always a niche for something new.

Good site design and development has a much greater impact on yield than, say, the type of seed planted (which is not what Monsanto, Syngenta and other seed patent holders would have you believe).

Good design disperses food yield over time, diversifies yield and recognizes all the yields of a system. Using a diversity of crops and livestock, extending yields over time, and producing the maximum yield with the minimum amount of energy

are the most productive and sustainable strategies. Forcing product yields creates unique and inflexible health problems in plants, soils and animals. These yields are economically and ecologically unsustainable – typically concentrating yield into a short period and so creating a 'feast and famine' cycle – and a danger to public health (for instance, reports suggest as many as 93 percent of chickens in battery cages develop cancers).

Sustainable strategies are far more productive but are not perceived to be in the best interests of commercial product producers. Our political structures tend to support these interests over common sense design strategy.

What contributes to the unlimited potential of yield in a permaculture system is that there is always an opportunity – a niche – in space or time to increase turnover.

There are three types of niche:

- **A niche in space**: A place to be, to fit in and find food, shelter and room to operate.
- **A niche in time**: Cycles of recurring opportunity (seasonal, annual, diurnal, etc.)
- **A niche in space-time**: A schedule.

4 Apply self-regulation and accept feedback – "The sins of the fathers are visited on the children of the seventh generation"

We need to discourage inappropriate activity to ensure that systems can continue to function well. Humans have a large complex brain, and we need to use it to consider the effect our actions will have on future generations, and to consider the consequences our actions now will have on the planet in the future. Current political and economic systems rarely encourage us to look beyond the next set of financial figures: Short-termism almost seems hard-wired into our society. They are failing to take significant action on climate change, and pedal the lie that consumption can continue to increase indefinitely. For instance, oil consumption is still at levels that reflect an 'oil boom' when in fact oil reserves are shrinking dramatically.

(See *Scatter, Adapt and Remember, How Humans Will Survive a Mass Extinction by* Annalee Newitz for an interesting analysis of how humans have trouble comprehending change over a long time scale.)

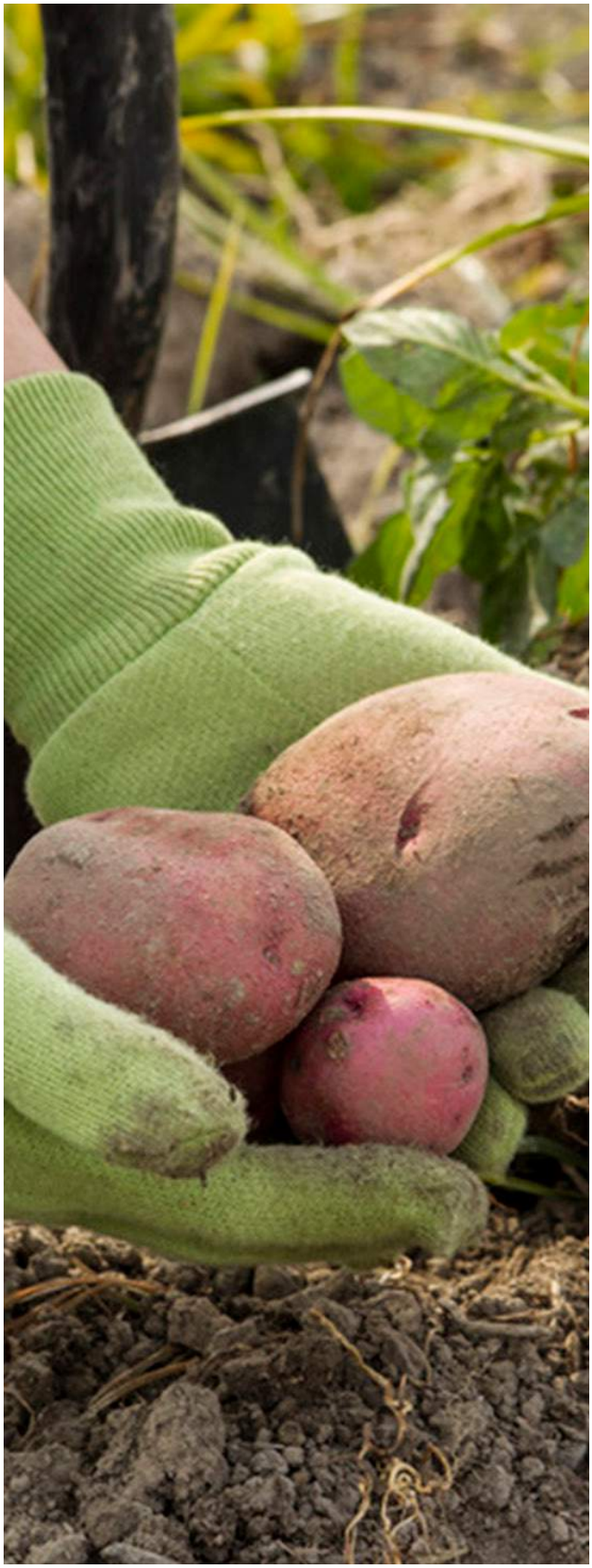
A responsible society would ban the use of elements that permanently reduce

yields of sustainable resources, e.g. pollutants, persistent poisons, radioactive materials, large areas of concrete and highways, sewers that spew waste into the sea, irrigation methods that deplete aquifers, fracking that poisons groundwater.

Failure to do so will eventually cause society itself to fail.

We are not learning and adapting. This does not bode well for the survival of our species.

Just as permaculture design seeks to create stable, self-managed ecosystems, so social and political systems can be redesigned to embody the same principles. We should not be seeking some climax or end point, an ever-growing orgy of consumption; we need to provide ourselves with enough, that's all. A stable system does not foster competition or use resources in a profligate manner. We need to create systems where people take responsibility.



5 Use and value renewable resources and services – "Let nature take its course"

We must seek to make the best use of nature's abundance in order to reduce our consumption and dependence on non-renewable resources. Natural ecosystems, unlike non-renewable

resources, become more complex and efficient over time. Surely it makes sense to design systems such as those we rely upon for food in a similar way so that they can support us over the long term. And given that such systems remain productive even without human intervention, why do we not seek to minimize the work we need to do?

Current agricultural practices, designed seemingly without an understanding of natural systems, require a great deal of energy and maintenance input from us to prevent them falling apart. A natural integrated system contains, captures and produces all the energy it needs. We can get potentially unlimited yields from any system by filling every niche within it with an element that works in harmony with those around it, and simply let nature do the work. This means we will also use fewer finite resources to maintain the system.

The key to wise resource use is to abide by the principle of 'enough'. In permaculture, we seek to produce enough to satisfy our needs, not to produce excess just for the sake of it. This is a very different notion than that proffered by our consumption driven economic system with its demands for continual growth.

In permaculture we subscribe to the Law of Return: Whatever we take from nature we must return in kind. We must think of the things that nature gives us as gifts that are given reciprocally. Every object must provide for its replacement; society must, as a condition of use, replace an equal or greater amount of the resource than has been used.

This is why we must look to renewable energies, vote with our dollars for food produced in a sustainable, ethical way, and take responsibility for reducing our own consumption and waste.

6 Produce no waste – "Waste not, want not" or "A stitch in time saves nine"

By valuing and making use of all the resources that are available to us, nothing is wasted. In nature there is no such thing as waste. Natural ecosystems establish a balance of energies. All living organisms maintain their complex forms and functions through continuous exchange of energy with their environment. Any system or organism can accept only the amount of a resource that can be used productively. Any input beyond that point throws the system or organism into disorder. The same is true if there is an undersupply of a resource – the system becomes unbalanced.

As permaculture designers we must seek to balance the inputs of resources with the demands of the system. Doing so will create a zero waste strategy, whereby every input into the system is used by it.

7 Design from patterns to details – "Can't see the forest for the trees"

By stepping back, we can observe patterns in nature and society. These can form the backbone of our designs, with the details filled in as we go.

Pattern is the language of nature, so understanding patterns and their meaning is a very effective way to design because it gives us a broader perspective on the interactions between elements of a system.

Understanding pattern can also have a transformative impact on our vision and experience of the world. It helps us to see things as whole interactive systems, rather than a collection of independent elements.

We will explore pattern in more detail in Chapter 4.

8 Integrate rather than segregate – "Many hands make light work"

By putting the right things in the right place, relationships develop between those things and they work together to support each other. The beneficial relationships between elements in a system are what makes it function at its most efficient.

Food webs are very complex systems based on the interdependence and connections between many different organisms (plants, insects, animals, bacteria, etc.) all cycling nutrients among themselves.

In permaculture design we seek to replicate this so that the system becomes as self-supporting as possible. Therefore, we seek to find multiple functions for

each element in a system, and locate them in the best position for them to perform all those functions. For instance, a tree can provide shelter for birds, a fruit crop, act as a windbreak, bring water up from the soil profile for other plants to access, etc.

As such, we need to view components in the system in relation to all the others, not in isolation, and to balance the various elements so that one doesn't overpower the others. By analysis, we determine how much of an element needs to be produced in order to fulfill the needs of the whole system, as adding too much of one or too many elements can lead to a more disordered system (think about how inefficient human systems that involve a lot of bureaucracy can be).

9 Use small and slow solutions – "Slow and steady wins the race" or "The bigger they are, the harder they fall"

Small and slow systems are easier to maintain than big ones. They also make better use of resources and produce more sustainable outcomes. When you first begin with permaculture it is best to start small and create a system that is manageable and produces high yield.

When you start small your 'learning curve' (during which you will undoubtedly make mistakes) has less impact on the environment.

An ecosystem will also have an ideal size, depending on the inputs of energy into it. Systems that are too large tend to be less efficient as the elements suffer from a lack of energy. As such, permaculture designers always look to preserve as much energy as possible. The least energy expended tends to result in the best possible effect. Consider building a dam. A permaculture designer would look to locate the dam where you can get the most water for the least amount of earth moved, and where that earth can be utilized in close proximity to the dam. You are then expending less energy building the dam than if, say, you had to shift the earth to the other side of your site, and you are still getting all the effects you want.

10 Use and value diversity – "Don't put all your eggs in one basket"

Diversity reduces the vulnerability of an ecosystem to a variety of threats, and takes advantage of the unique nature of the environment in which it resides.

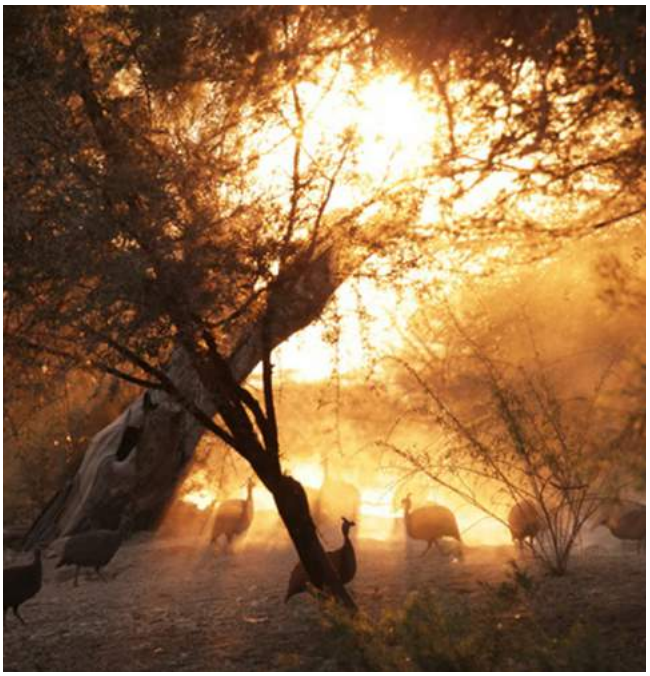
As sustainable systems mature, they become increasingly diverse, and so able to support more species. However, the number of elements in an ecosystem is not as important as the relationships between them.

Adding diversity for the sake of diversity may create chaos or confusion, whereas elements with multiple functions bring order and develop resources. A happy medium is to bring as much diversity into a cultivated ecosystem as it can maintain itself and let it simplify or become more complex as it sees fit. For instance, planting a particular species in a certain location may or may not be beneficial. If the system can support it there, the species might grow and expand. Alternatively, it might disappear quickly or even migrate to a more suitable location.

The best balance for an ecosystem, however, is a mix of young and old elements. If everything in a system is very mature, energy use is less efficient, as the large, mature plants store more energy to maintain their size. This leaves less energy for turning into crops and so lowers yield. Completely old and completely young systems are also more vulnerable to disease and pests. Having a mixed system protects against the entire system succumbing to a destructive element (this is one reason why monoculture farming system require so many chemical pesticides and herbicides; they are vulnerable to devastation).

11 Use edges and value the marginal – "Don't think you are on the right track just because it's a well-beaten path"

The interface between things is where the most interesting events take place. These edges are often the most valuable, diverse and productive elements in a system. In permaculture, we seek to maximize and optimize the edge effect – the places where two different environments meet and interact (often called an 'ecotone'). These locations benefit from the input of both ecosystems, and are typically the most diverse and fertile areas in a design. Such locations are already in nature (such as the border between mountains and plains, and riparian zones where land and water meet) and we can design to deliberately create more places where different environments intersect.



12 Creatively use and respond to change – "Vision is not seeing things as they are but as they will be"

> "Hit a nail on the head, or cause a machine to do so, and get a fairly predictable result. Hit a dog on the head, and it will dodge, bite back or die, but it will never again react in the same way. We can predict only those things we set up to be predictable, not what we encounter in the real world of living and reactive processes.
>
> **– Bill Mollison**

Change is constant. In life and in design immutable rules will not work. For any design to be able to adapt and be resilient we need to allow ourselves to be guided on a continuing exploration by nature's flexible principles and directives. All permaculture designers should be aware of the fundamental principles that govern natural systems. These are not inflexible rules but guidelines that can be used as a set of directives, taking each case as unique.

The answer to every question in permaculture is, at least at first, "It depends". Understanding what it depends on is the rest of the answer.

The problem is the solution

In permaculture the focus is on turning constraints into resources. We create 'problems' when we try to impose something on a system that doesn't work there.

Everything is a positive resource if we learn to conceive of things outside of current constrictive paradigms. For instance, things that are normally considered to be 'waste' – from bathwater to fallen branches – can have many uses on a permaculture plot.

The problem is really our attitude and lack of creative imagination in using these resources. Fortunately, while we may well be the problem, we are also the solution.

David holmgren's general guidelines for effective design

- The systems we construct should last as long as possible and require the least maintenance
- These systems should provide for their own needs and the needs of the people creating or controlling them; they should sustain themselves and those who construct them
- The systems should store or conserve more energy than is needed to construct or maintain them.
- Nothing in nature remains forever, not soil or hills or forests but for our foreseeable future we can have dynamic life support systems that can provide thousands of years of constructive regulation.

(This is demonstrated by the fact that tribal peoples have lived on and cultivated the same lands for thousands of years.)

Chapter 3

Methods of design

Definition of permaculture design

Permaculture is a design system that attempts to integrate fabricated, natural, temporal, social and ethical components into a pattern which functions to benefit life in all its forms. It concentrates on the relationships between components and how they function to assist each other, rather than on the components themselves in isolation.

It seeks to provide a sustainable and secure place for all living things on this earth.

Components of design

- Techniques: How we do something
- Strategies: Using techniques to achieve a goal; because they involve future goals they are value oriented
- Materials: Physical components, such as wood, glass, metal, mud
- Assemblies: Arrangements of technologies, buildings, plants and animals.

General considerations

- Begin with a clear idea of your objectives and of the yields you want from the system you are designing – this will drive many of your choices
- A good design is flexible and can be adapted and modified based on learning and experience
- Design is a place to begin, it is not an end result but a continuous process that evolves as observations, understanding, skills and creativity grow
- All designs involving life forms undergo a long-term process of change – you are seeking to create stability and self-regulation that allows this change to happen.

Design methods

There are several different methods that are used in conjunction to create a permaculture design.

- **Analysis:** Design by listing characteristics of components
- **Observation:** Design by expanding on direct observations of a site
- **Deduction from nature:** Design by learning lessons from nature
- **Options and decisions:** Design by selecting options based on decisions
- **Data overlay:** Design by map overlays
- **Random assembly:** Design by assessing the results of random assemblies
- **Flow diagrams:** Design for work places
- **Zone and sector analysis:** Design by applying a master pattern.

1 Analysis, or need, function, product analysis

List all the characteristics of each component – both inputs and outputs. This comprehensive assessment helps you make decisions about the placement of different components in a system so that the needs of each are met by other elements in the system.

The objective is to create a self-regulating design by placing elements so that the byproducts or yields of one element supply the needs of another. If any needs are not supplied by another part of the system, it will require external energy or extra work on the gardener's part to meet them. If all the elements cooperate, energy is used efficiently, while if they are in competition, energy is wasted.

Let's take chickens as an example, and analyze their inputs and outputs.

Inputs/Needs

- Shelter
- Grit
- Dust
- Water
- Air
- Food
- Other chickens

Outputs/Functions/Products

- Meat
- Eggs
- Feathers
- Manure
- Methane
- CO2
- Scratching
- Foraging
- Flying
- Fighting
- Sound
- Heat
- More chickens

We can classify these outputs in different ways:

Primary products

Eggs, manure, heat, etc.

Derived products

Things we can make from the primary products e.g. feather dusters, compost from manure, feather pillows, heat for a greenhouse, etc.

Behaviors

Scratching, flying, mating, hatching eggs, etc..

Intrinsic characteristics

Breed characteristics such as color, form, weight, temperature tolerance, and egg production (these factors influence the chickens' needs and behavior, with some breeds needing more space, taller fences, warmer conditions, and so on, than others: your local conditions will influence your choice of breed).

Some helpful questions in determining placement

Having conducted a thorough analysis of each component in a system, it is then time to look at how components may interact.

- What products of this component supply the needs of the other components?
- What needs of this component are supplied by other components?
- Where is this component incompatible with other components?
- Where does this component benefit other parts of the system?

Putting it all together

You may use a diagram like the one below to draw connections between compatible elements. The needs of the element are above the line, the products below.

Orchard	Chicken	Greenhouse	People
Weeding	Shelter	CO2 for plants	Food
Pest control	Grit	Methane for germination	Bedding
Manure	Dust	Manure	Fuel
Pruning	Water	Heat	Lights
----------	Food	Water	Water
Food	----------	----------	----------
Insects	Eggs		Food Scraps
	Meat	Shelter	
	Feathers	Food	
	Manure		
	Methane		
	CO2		
	Scratching		
	Foraging		
	Flying		
	Heat		

By looking at how the elements interact we can design to support those connections, making the system more efficient and saving us time, energy and labor.

This is very different from how most commercial farmers think of things, which tends to be considering things as isolated units. This is why farms are usually places of long hours, physical labor and hard work; the components are not arranged to supply each other's needs.

2 Observation: design by expanding on direct observations of a site

There really is no substitute for field observation of your site for dependability and relevance. By looking at your site, over a long period of time, you will gain an understanding of how and why things occur that are unique to the conditions on your site, and enable you to design in response. For instance, observing processes and events such as heavy rain and subsequent run-off allow you to devise strategies that involve the least amount of change to harness the energy of that water, so saving you energy and time.

While mapping and data certainly have a place, living processes and events are only going to be revealed by regular observation. This is in part because observation involves you in the environment. What we observe changes as a result of our observation, and the only way to discover how it changes as a result of our involvement is to be a part of the process. After all, you are an integral part of your permaculture plot as much as the plants, animals and soil.

When you observe your site, use all your senses, and approach it with an open mind. You can take notes, photographs or video for later reference, but spend some time simply being in the landscape and noticing.

Approaches to observation

There are lots of different ways to approach your observation.

- Non-selective, child-like approach: This involves coming to the site without preconceived notions, deliberately having an open mind and sense of wonder
- Focus on a theme: Look at a particular aspect of the site, such as water, energy sources, wildlife, etc.
- Instrumental approach: Measure quantifiable data, such as temperature ranges, wind, rainfall and other variables
- Experiential approach: Use all your senses to get a feel for the site: Notice details, sensations and how you feel being in the site (our intuition often involves lots of unconscious processing we are not aware of, and is often right).

Working with your observations

Having made lots of observations about your site, you can start devising your design with those in mind. For instance, if you start with a value-free statement about what you've observed, you can begin to consider what it could mean, what patterns it suggests, and how the information could improve your design.

Here's an example. Your value-free statement is '

Moles have thrown up earth mounds on the field.' You could then make various hypotheses, reasons and results about what is going on, such as:

- Moles are everywhere but their activity is only visible in the field
- Moles are only in the field
- Fields are their preferred territory
- They are damaging the plants in the field
- They are improving the soil

You might then consider what you wish to do with the information you have gathered.

How is this information useful? How can it improve or influence our design? If the moles are beneficial to your ecosystem, you would simply leave them alone, but if they are detrimental you would start to think about ways to deter them, perhaps with certain plants that repel them.

3 Deduction from nature: design by learning lessons from nature

In permaculture, we take our cues from nature. By observing nature we can learn how to harness natural systems in our own designs.

One of the key figures in the history of permaculture, Masanobu Fukuoka (whose book 'The One Straw Revolution' is an inspiring text concerning farming with natural methods) followed this path after noticing how rice grew naturally along the side of the road, while on his rice farm he was working very hard to get any yield. By observing and analyzing what was going on in nature and applying the same principles to his farm he was able to increase yield without intervening with machinery, fertilizers or pesticides.

When observing nature there are several aspects to consider, and which will feed into your designs.

Structure: After studying the natural occurrence of plants and animals, their locations, activities and functions, we can imitate these in our designed systems or improve on them by finding species that do the job more effectively or provide more functional benefits to us. Questions you may ask during your observations could include, which plants grow in the soggy areas, what groundcover appears in open areas, and which plants do local fauna and insects frequent.

Process: What processes are at work in the environment? You will look at how water drains from a landscape, how animals migrate across a site, which plants are growing where (and trying to work out why), how plants and animals interact in terms of food and propagation, and how different species of plant interact.

Landscape: Every unique landscape offers a variety of opportunities and niches for development. We can observe how in nature there are places in which plants and animals thrive, how food is provided and how water moves through a system. We create opportunities in the permaculture landscape by the plants and structures we choose to include, by adding earthworks, and by creating edge and microclimates. Doing this well will increase diversity and yield on the site,

Philosophy: It is not only practical techniques we can learn; we enrich ourselves by learning the lessons nature can teach.

We gain wisdom that we can pass on to future generations, and heal the parts of ourselves that suffer from our loss of connection to nature and community. Spending time in nature helps heal us from the stress of living unnatural lives and, more often than not, not having the time to be still, create and enjoy our lives.

4 Options and decisions: design by selecting options based on decisions

Any design has many potential outcomes. The goals, desired lifestyle and resources available will all play a part in dictating which options we choose to use in our design.

The starting point is the goals you have for your design, which are informed by both practical and ethical considerations. Subsequently, the choice of options may be influenced by aspects about the site, such as how much area is available for cultivation, what water harvesting potential there is, and so on.

This leads to the next set of considerations, which include things such as finances, skills, resources, available energy, etc.

The process of considering all the options available to you can be made easier by plotting a decision tree that shows practical pathways to defining your design.

5 Data overlay: design by map overlays

A good site map can be very helpful in landscape design. Starting with a sketch of the basic layout of a site (you could also use standard topographical maps or tools like Google Earth), overlays (on tracing paper, for example) show the placement of elements and earthworks in relationship to the terrain of the site. They can be a useful way of seeing how elements could interact, and can reveal possibilities not seen during observation on the ground.

There are some things map overlays can't detail, such as ethical, legal and financial constraints, and they do not show how conditions change over time, but used in conjunction with other techniques, such as analysis, they are very useful.

6 Random assembly: design by assessing the results of random assemblies

This is essentially a brainstorming technique. It is a way of letting your imagination off the leash, and can reveal some creative possibilities for innovative designs. It can help liberate your brain and reveal previously unconsidered connections between elements. One strategy is to list a set of design components and then link each to all the others and try to think of a connecting strategy between them.

Some ideas might be absurd, but some might be uniquely brilliant. Without a brainstorming session would anyone have come up with the idea of placing a pond in a cave to reduce evaporation, or putting a compost pile underneath an animal shelter in order to heat it?

7 Flow diagrams: design for work places

Flow diagrams detail the movements of people performing activities in a space, and the tools and areas they use for production. They can be useful for designing energy efficient spaces and making locations such as kitchens, workshops and settlements easy for people to use. Talk to those who regularly use a space to determine their needs and how they feel things could be improved, but also observe how resources are used in a space, how tools are used and stored, and how outputs could potentially be used more efficiently within the space.

8 Zone and sector analysis: design by the application of a master pattern

Zones address the placement on on-site resources (including people, access, fuel, waste, etc.) and are comprised of concentric circles, starting with the area we visit most frequently and manage most intensively, and radiating out to the areas of less intensive management.

Sectors address energy flowing through the site, including elements such as wind, water, sunlight, wildlife, and so on.

By conducting zone and sector analysis, we can determine the most energy-efficient placement patterns for the whole site.

There are six potential zones that can be part of a permaculture site (the size of your plot will determine how many you can institute).

- **Zone 0** (person, house, village) the epicenter of your design
- **Zone1** (garden, animals, herbs, nursery) those elements needing frequent visits, continual observation and the most management
- **Zone 2** (orchards, ranging animals, ponds, main crop beds) areas that are less intensively managed than those in zone 1
- **Zone 3** (Broad-scale farming, large water storage, trees that don't need pruning)
- **Zone 4** (bordering on forest or wilderness used for wild foraging, pasture or range, forest for fuel needs)
- **Zone 5** (left natural or unmanaged, wildlife corridors).

You will normally start your permaculture plot by focusing on zones 0 and 1, then expanding outwards as they become established. For each component in your design, think about how often you would need to visit it, for harvesting, maintaining or servicing, to get an idea of which zone it belongs in – the fewer times you attend it, the further out it will typically go. And by placing components in relation to other components or functions that require similar attention, you maximize energy saving and make the most efficient use of your space.

It is worth pointing out that you do not try to arrange your site in concentric circles; that is just the archetype. In reality, your zone configuration will conform to the landscape of your site.

For example, you may end up having a wedge of zone 5 extending to the house, or zone 1 may be a path or circuit for efficient transfer of materials.

Your zones may even be side-by-side depending on the unique characteristics of your site. The important thing to remember is that you can define as many zones as your site will allow and their sizes will vary.

Zones and ethics

In zone 1 we are developers, cultivating the land, but beyond that we should think of ourselves more as students of nature.

We must seek to limit our impact and imposition as much as possible, putting in place only those things that help meet the needs of the elements in the system, and allowing the system, in all its complexity, to evolve naturally. We must remember that everything in a natural system is of use to something else in that system – just because humans may not be able to use it, does not make it worthless. Rather, we must see ourselves as just one small part in the larger natural system. By doing so, we increase our appreciation of nature and our opportunities for learning from it.

Sectors

Sectors are defined by the energies or other flows that move into and out of them. They are more site-specific than zones; their placement will depend upon the unique forces and inputs acting on your permaculture plot. In our designs we seek to use positive energies to the best advantage and minimize the impact of damaging ones, and there are different strategies for doing so, for example:

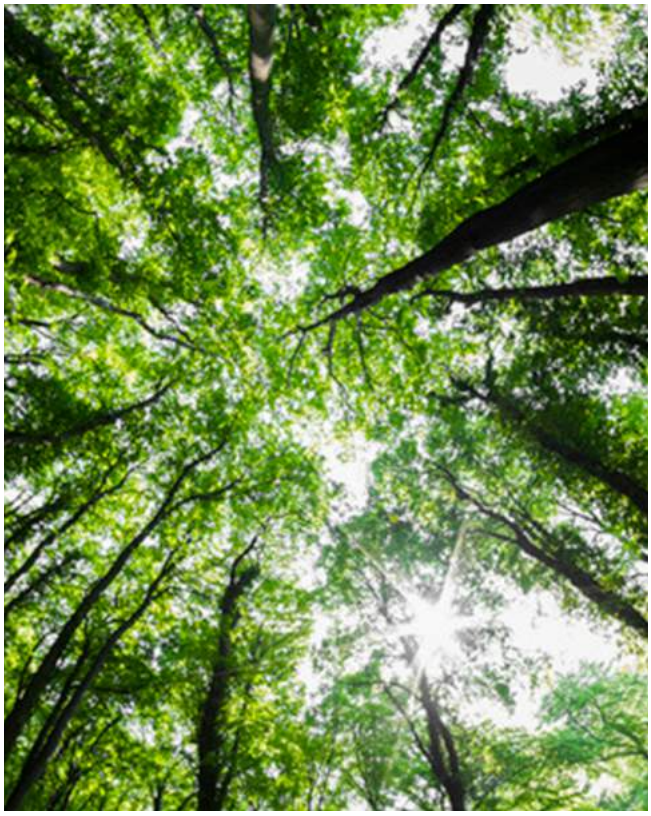
- **Block:** Using walls, roads, windbreaks, embankments and ponds to block, prevent or divert fire, strong winds, bad views, and floods
- **Deflect:** Using planting and habitat provision to deter or attract wildlife

- **Channel:** Directing wind to a windmill, or water to a swale or pond
- **Collect:** Capturing energy, such as harvesting rainwater or using solar panels.

Here are some of the site-specific considerations that will affect your sector design:

- **Sun angle:** The arc of the sun during the summer and winter months will determine determines the size of eves, the placement of windows, greenhouses, and thermal mass structures, as well as where certain plants go
- **Aspect:** The orientation of a slope to the sun: A north-facing slope has very different conditions than a southern-facing one
- **Elevation:** Impacts upon the steepness of the terrain, the snowline, the types of soils, and the species that inhabit the area
- **Slope:** Provides many opportunities and advantages, especially for water catchment, diversion and storage.

Place every element in your design with consideration of its zone and sector needs. But don't stress too much about getting zones and sectors perfect. Start small and manageable then build from there, and you will get a feel for where elements belong.



They will, as they develop, teach you about their ideal placement as well. And besides, you can't do worse than the design of a typical suburban sub-division.

9 Incremental design

In engineering, design is often based on small adaptations to existing designs until some ultimate limit in efficiency and performance is reached. Permaculture site design can also be done by incremental changes of existing designs. After all, those designs have worked in the past. Of course, as with all design features, you need to consider the individual variables of your particular site, but by doing so you may be able to

fine-tune an existing strategy to suit your own climate, landscape or goals.

Of course, some strategies are inappropriate if transferred to a different climate, culture or purpose, so use common sense. However, generally, structural designs and other technologies that have evolved to reliable working standards (e.g. overshot waterwheel, ram pump) can be incrementally adapted for any site over time. If you take into account the principles of energy conservation and selective placement for maximum efficiency, you may find that existing designs give at least a good starting point for your own design.

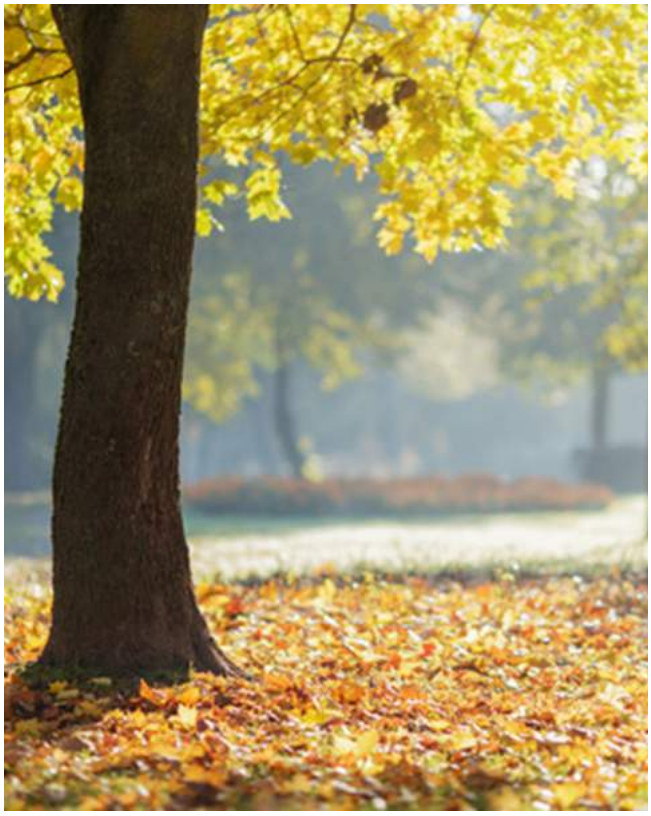
Guilds

A guild is a harmonious assembly of species, typically around a central element (a plant or an animal) with each providing a yield that benefits other members of the guild.

In the natural world, different species cluster together for their mutual benefit, be they plants that seed near each other to benefit from nutrient provision or insect protection, or animals that have symbiotic relationships (think of a cleaner fish picking off parasites from a turtle). We can replicate the idea of guilds in our designs, placing plant species next to others so that all benefit from the relationship. For instance, a guild can

reduce root competition for nutrients (e.g. fruit trees prefer ground covers that outcompete grasses) or assist with pest control by producing chemical deterrents, killing root parasites or predators, or hosting predators that prey on damaging insects. There are other benefits that can be derived from a guild, such as using plants like comfrey to improve soil conditions for other species, using legumes to fix nitrogen in the soil, and planting various species to provide protection from the sun, wind or frost. And given that often plants that grow well together taste good together, a guild can make harvesting easier, e.g. tomatoes, parsley and dill.

Animals are integral parts of many guilds. For instance, ground foraging livestock like pigs and chickens help improve soil conditions and clear rotting fruit in orchards that harbor pests, while insectivorous birds can control pest populations. Even your pet dog can be useful in your permaculture plot, driving off deer, rabbits and other pests, while fake animals like plastic owls can deter troublesome wildlife.



Possible interactions between species

We can classify the interactions between species using a system of symbols

++	Win-win, symbiosis between species
--	Lose-lose (e.g. plants competing for nutrients or space)
oo	Neutral, no harm or benefit to each other
-o	The actor is hurt, not the acted on (e.g. a wasp trapped in amber on a tree)
o-	The actor is unaffected, but the other is harmed
+o	The actor benefits, the other is unaffected
o+	The actor is unaffected, the other benefits (e.g. charity)
+-	The actor benefits, the other loses (e.g. parasitism)
-+	The actor loses, the other benefits (e.g. self-sacrifice)

The above table details simple pairings of species, but in design we are most often working with multiple species or elements. Again, observation is often the key to working out what's going on. For instance, the negative effects of one species on another can be countered by another species. If an apple and walnut tree are together the relationship is –o, if an apple and a mulberry tree are in proximity the relationship is +o, so by combining all three into a guild we get +oo.

Remember that the space between plantings affects their interactions, and both spacing and interaction change as the plants grow. Many animals, meanwhile, have territories that affect their interactions.

Succession: evolution of a system

Succession planting can be the most efficient way to institute a guild. It involves planting to provide short, medium and long-term yields. Sometimes this involves species following one after another. For instance, if an area has damaged soil, pioneer species (typically weeds) will congregate first, stabilizing erosion and water flow, and adding nutrients. Over time, other species will move in and crowd out the weeds, and so on.

In cultivated systems, we can plant for succession in a single, initial planting if properly planned. By planting a mixed system of trees, shrubs, and vegetable crops, alongside groundcovers, under-story species, legumes, herbs, mulch crops and windbreak species, we create a system that is self-sustaining, and which grows and evolves over time. As the system grows, some plants will be shaded out and others will expand into those vacated niches, while livestock and wildlife will have various interactions with the guild as well, with relationships changing over time.

Practical procedures in property design

First, design the site thoroughly on paper and/or using a CAD program. As mentioned previously, try to design so you are using as compact a space as possible to meet your needs.

Set your priorities based not only on site conditions but also less visible factors such as economics.

Minimize costs by maximizing the use of resources already on the site (and if you need to bring them in from an external source, doing so as locally as possible).

Start small, concentrating on zone 1 and expanding from there once those systems are fully established. Concentrate on taking one step at a time and you are more likely to be successful.

Evolve the system based on your observations, trials and experience over time. There is always something to learn. As you come to know your site and your systems better you will be able to use the species, materials and technologies that are most suited to it.

Some general priorities to consider when designing you property

- Earthworks: Roads, paths, swales, dams
- Housing and buildings
- Water: Supply, purification, irrigation, and storage
- Energy systems
- Forest, crop and animal placement
- Slope, existing landforms and soil suitability
- Legal constraints: Easements, permits, water and sewer requirements
- Financial resources
- Relationships with neighbors
- The people who live on the property: You need to take into account the needs, habits and patterns of all the people, from the youngest to the oldest, in designing your system. They are the factor most likely to make or break the system.

Chapter 4

Understanding patterns

Pattern is the language nature speaks.

Eons of evolution, adaptation and experimentation have resulted in certain forms and patterns emerging as the most efficient for certain purposes. These patterns appear at every scale, from the microscopic to the galactic. They are found in all dimensions, including time, and can combine with other patterns to create even more complex structures. You could spend a lifetime studying patterns. It is a subject with a lot of depth.

Once you know what to look for you will see patterns everywhere in nature, and understanding why patterns form and how they function helps you understand how natural systems work. We can then take inspiration from these patterns and apply them to our permaculture designs in order to create effective systems.

In this chapter we will cover three main topics:

1. General pattern understanding: Identifying some of the most common patterns in nature and their functions
2. Applying pattern to design across different disciplines
3. Applying pattern to achieve goals in design and to shape our thinking.

> “Patterning is the way we frame our designs, the template into which we fit the information, entities and objects assembled from observation, map overlays, the analytic divination of connections, and the selection of specific materials and technologies. It is this patterning that permits our elements to flow and function in beneficial relationships. The pattern is design and design is the subject of permaculture.
>
> **– Bill Mollison**

Some patterns in nature

Symmetry

Symmetry means an object has two halves that are a reflection of one another with a correspondence of form on opposite sides of a dividing line or plane, or around a center point or axis.

There are two types of symmetry. One demonstrates an exactness that can be analyzed with the rules of geometry and physics, while the other is less precise, reflecting a general sense of harmony and balance between the two halves, rather than an exact match.

Symmetry is widespread in living things. Most animals that move, including species as diverse as butterflies, horses, centipedes and humans, exhibit bilateral, or plane, symmetry. Plants, on the other hand often have radial symmetry, with several similar parts arranged round a central point. Animals that are primarily static also have this kind of symmetry, such as the five-fold symmetry found in starfish, sea urchins and sea lilies

Perhaps the most pristine example of symmetry in nature is the snowflake. Each snowflake has six-fold symmetry with each of its six arms an exact replica of the others. And even more remarkably each snowflake is utterly unique in design.

Symmetry is also an important part of

human society. Things humans create are often done so symmetrically, in things as diverse as architecture, algebraic equations and music. There is also a sense of symmetry, or at least reciprocity, in many social constructs, such as the notion of justice, dialog and apology.

When we have a relationship with peers, as equals, the relationship is symmetrical in that both parties are equal within it. Power relationships do not have this characteristic and are therefore inherently imbalanced.

Spirals

Spirals consist of a curve that starts at a central point and gets progressively farther away as it revolves around the point. A 3D spiral that turns around an axis at a constant or continuously varying distance while moving parallel to the axis

forms a helix or vortex. Spirals are found everywhere in nature, from the circulation of global air currents to seashells, whirlpools and fingerprints, and even the structure of DNA. Astrophysicists believe our entire galaxy to be a spiral.

Spiraling inward concentrates energy and material, while spiraling outward disperses energy and material. Thus, a spiral is a balanced, efficient form of energy transfer, and so they are often found in nature where anchoring, transportation or harmonic flows are needed.

There is actually a mathematical sequence that descries spirals. It is called the Fibonacci Series, and involves each number being the sum of the two preceding it (e.g. 1+1=2, 2+1=3, 3+2=5, 5+3=8, and so on. The increasing ratios describe spirals that get further away from the center point as they revolve, such as Nautilus shells.

Branches

Branches are one of the most common patterns in nature. They concentrate energy and then disperse it, so are useful when there is a need to disperse, collect or distribute materials. Think of the tributaries of a river collecting water and distributing it to the main channel, or the human circulatory system, dispersing blood to all parts of the body.

The size of the branch has a significant effect on its ability to move material. Smaller branches have high pressure and slower flow; which is the opposite for larger conduits. Smaller branches have their advantages though, as they allow the branch to change direction more

easily, without causing turbulence or interrupting flow, while they can provide easier penetration into other media to allow for the exchange of material (e.g. the small capillaries in our kidneys that make the inflow and outflow of blood efficient).

Orders of magnitude in branches

Branches rarely exist in isolation. They exist in interrelated systems, with some branches larger than others. Branches can also join up to form larger ones. The order of magnitude in branches means that a branch is of the next highest order when it is three times the thickness of the branch below it, while in terms of length, a branch that is double the length of another is considered of another order.

Many different systems show these levels of order, from social hierarchies, food pyramids and the size of animals in allied zoological families. Physical entities from protons to universes display the same order.

This order of magnitude typically only extends to seven orders; beyond that the diffusion of energy across the branch makes the transfer of energy very difficult. Species of marine animal have adapted to the different flow rates at the different levels of branching. Streamlined species tend to inhabit the faster flows, oxygen-loving species live in the turbulent flows, while weaker swimmers, the less

streamlined and less oxygen-loving species inhabit the smaller branches and slower flows.

When networks of branches form, their shape is determined by the substrate (the surface on or through which it flows) and the media (what the substrate is made of). So, for instance, the flow of a stream will be determined by the landscape contours and how much the water can erode the surface it passes over. Thus streams can tell us a lot about the underlying geology of an area.

Cracking patterns and nets

These form as a result of the expansion or contraction of elements. For instance, cracks in drying mud are due to contraction. Such patterns are in fact at the very core of how the Earth is arranged, as the tectonic plates that comprise the planet's surface expand and contract to reshape the globe.

Cracking patterns and nets often form in materials to relieve stress, and the resultant cracks can help determine properties about the material. For instance, in elastic materials the joints of the cracks are 120 degrees, while those in inelastic materials are typically only 90 degrees.

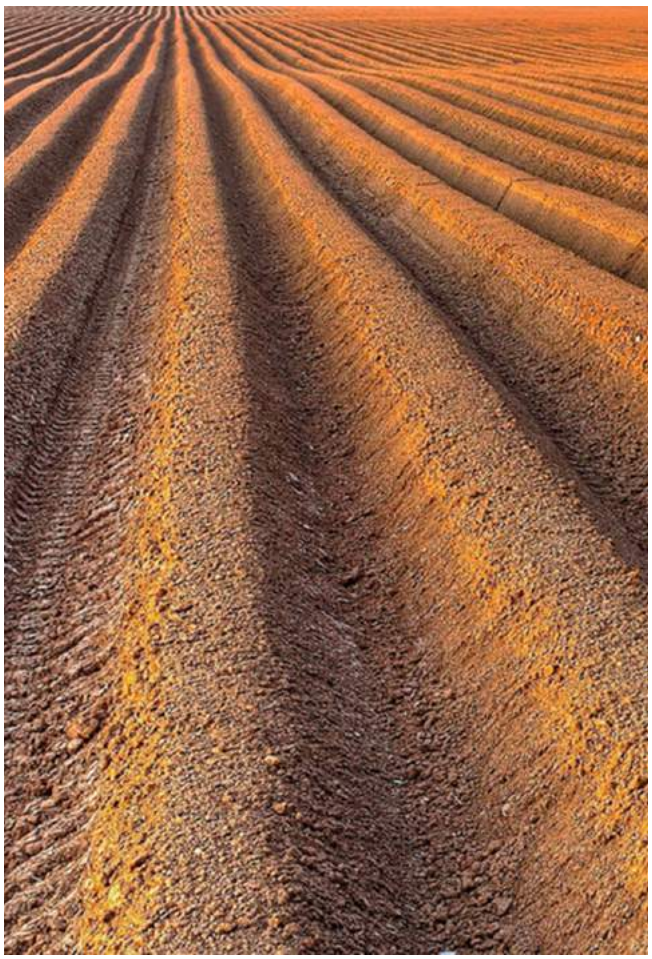
Cracking patterns are widespread in nature, for example in rocks, mud, tree bark and deserts. In each instance, the cracks increase the edge in the material, and increase its porosity.

Some net patterns are not the result of cracking, but rather are patterns that retain their structure while allowing material to flow through them, such as the membranes surrounding cells, or the framework of a geodesic dome.

Waves

Waves are disturbances that carry energy as they move. Wave motion transfers energy from one point to another. There are two main kinds of wave:

- Mechanical waves move through a medium, such as air or water, and cause it to oscillate as they do so, e.g. sine waves
- Wind waves are surface waves that create patterns of ripples as they pass over water or sand. Waves on the ocean and on sand dunes are examples.



Lobes

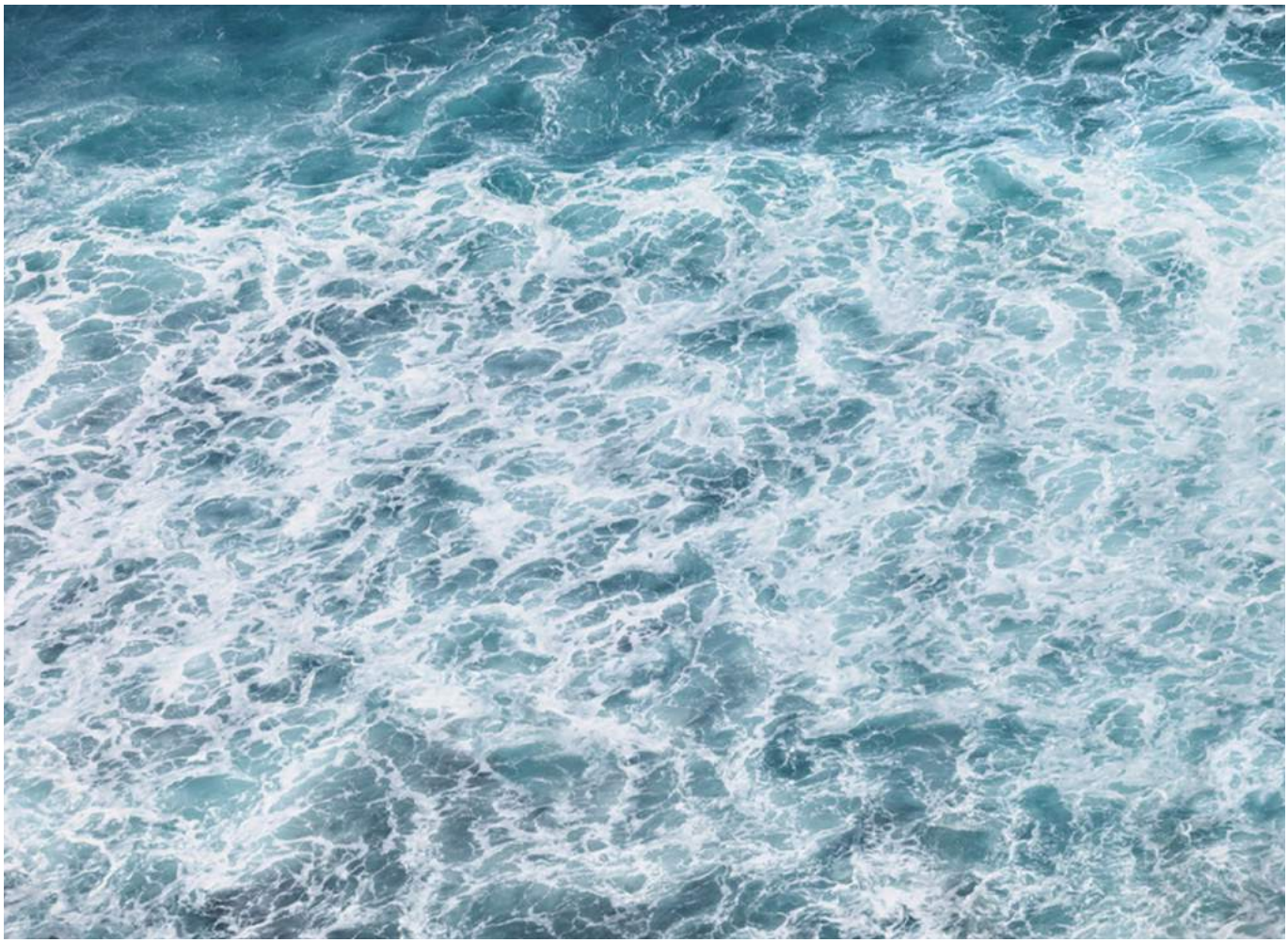
A lobe is a roundish, flattish part of something, an extension of an element that typically protrudes, hangs or projects from the edge of the element. A lobe can be two- or three-dimensional, and may be segmented or fissured. Examples in nature include the edges of saltpans, the leading edge of cooling magma from a volcano, and the parts of a human brain.

Torus

A torus is a closed, three-dimensional vortex. Their function is the accretion and expulsion of material or energy., usually at the poles. Perhaps the best example is that of a black hole in space. The torus is the ring of material around the hole, being drawn into the vortex, while material is ejected at the poles. The Earth's magnetic field acts in a similar, if less destructive, way.

Meanders

A meander is a bend in a sinuous watercourse or river. Meanders are what give a river its 'snaking' pattern. Often, the position of the meanders can seem random, but they relate to underlying geological features and how these affect the flow (just as the movement of snakes is an adaptation to the terrain they live in). This is why no two rivers have the same pattern of meanders – as in much of nature, the pattern is determined by local conditions, rather than universal laws.



Foams

Foams are formed by pockets (or bubbles) of gas becoming trapped in a liquid or solid. Foam and bubble patterns occur widely in nature, for example in radiolarians, spicules in sponges, the skeletons of sea urchins, and the foam produced by spittlebugs. There are two main types.

In closed-cell foam, the gas forms discrete pockets, with each completely surrounded by the solid material, while in open-cell foam, the gas pockets connect with one another.

Stripes and spots

These are patterns that often serve to camouflage – think of tigers, leopards and zebras.

The biological mechanisms that create spots and stripes on the skin of mammals and the plumage of birds were discovered by famous scientists Alan Turing and James Murray. They identified a system that involves two counter-acting chemical mechanisms, one that activates and one that inhibits pigment development. Both are active in striped and spotted animals.

Streamlines

Streamlines indicate a flow of air or water. A streamlined form is one that offers the least resistance to fluid flow, and is designed to minimize friction and loss of energy. This is why fish aren't square and why birds' wings are the shape they are.

Fractals

Fractals are mathematical patterns that are scale invariant. This means that the shape of the pattern is the same no matter how closely you look at it – each part, magnified, looks like the whole.

Benoit Mandelbrot founded the mathematics of fractals, which evolved to make sense of seemingly irregular phenomenon. Fractal theory shows that underneath seemingly chaotic forms there can be some order, and like the mathematical rules for symmetry, waves and meanders, it can be demonstrated visually.

Some examples of natural fractals include ferns, Queen Anne's lace, a pineapple, forked lightening, neuron nets, snowflakes, tree roots and crystalline forms.

Scatters

Scatters are apparently random placements. For instance, algae, clumps of trees and islands appear not to have any regular or ordered patterning. However sometimes these scatters can be explained by fractal patterns, as on the distribution of lichen on a rock.

Flow over landscape and object

There are three main forms of flow:

- **Overbeck Jet or Mushroom form:** A characteristic flow form caused by liquid or gas streaming past and around a fixed object e.g. islands in tides, a post in a stream or a tree in the wind
- **Von Karman trails:** A series of 4 or 5 vortices, rotating in different directions on either side of a fixed object in a flow. These occur when flow rates are moderate; very high flow rates results in turbulence, while at slower rates, the flow simply streams around the object without creating vortices.
- **Ekman spirals:** A form created when a flow meets a horizontal boundary, for instance, wind flowing over an island or windbreak, or waves breaking on a beach.

In addition, all flows pulse, e.g. blood, wind, water, traffic, lava. The sun pulses every 11 years or so affecting our climate, ozone and rainfall. The elements that regulate these pulses (e.g. traffic lights, the cells that create our heart beat) are called 'pulsers'. Different pulses can also interact. For instance, diurnal cycles control the production of the hormone melatonin in birds, changing levels of which trigger annual cycles of nest building and breeding.

How patterns interrelate

There are several different ways in which patterns – either repetitions of the same pattern or completely different ones – can interact.

- **Tessellation**: The intersection of tiles in a matrix. The patterns intersect and interlock as though on a grid – there is no overlapping or any gaps between them. The drawings of MC Escher often depict tessellations.
- **Nesting**: Parts that are the same shape but different sizes fit inside each other. Nesting is an efficient use of space. Examples include Russian dolls, stacked bowls in the kitchen, and the rings on a tree trunk.
- **Superimposition**: This involves the placing of instances of the same pattern or different patterns over one other An example would be the placement of one spiral over another going in the opposite direction, as seen in the petals of some flowers and the whorls of leaves in many types of plants.

Tessellation, Nesting and superimposition are all strategies for developing complex and compact designs and can be used for analyzing complex landscapes (e.g. seeing how ridges and valleys tessellate).

Dimensions and generators

Patterns may exist in two or three dimensions. For instance, tessellation is 2D but a tree or glacier is 3D. Pattern is also influenced by generators – forces of energy that impact upon a pattern's shape. Indeed, the shape of a pattern in nature is often the best clue in determining the force that created it. For instance, wind typically creates wave patterns, be it on sand dunes or the ocean, while freezing and thawing cycles will create cracking patterns.

Classification of events

There are several different ways to classify patterns of events:

Nature

- Explosion, disintegration, erosion, impact
- Growth, integration, construction, translation
- Concept, idea, insight

Stage

- Potential (e.g. un-germinated seeds)
- Evolving – in process
- Completed – growth and expansion have ceased
- Decaying – disintegrating, being replaced or invaded by new events

Dimension

- Linear phenomenon (e.g. curves)
- Surface phenomena (e.g. dendrites)
- Solid phenomena (e.g. trees)
- Moving phenomena – both in space and time
- Conceptual (e.g. models of particles or forces, and states of energy)

Location

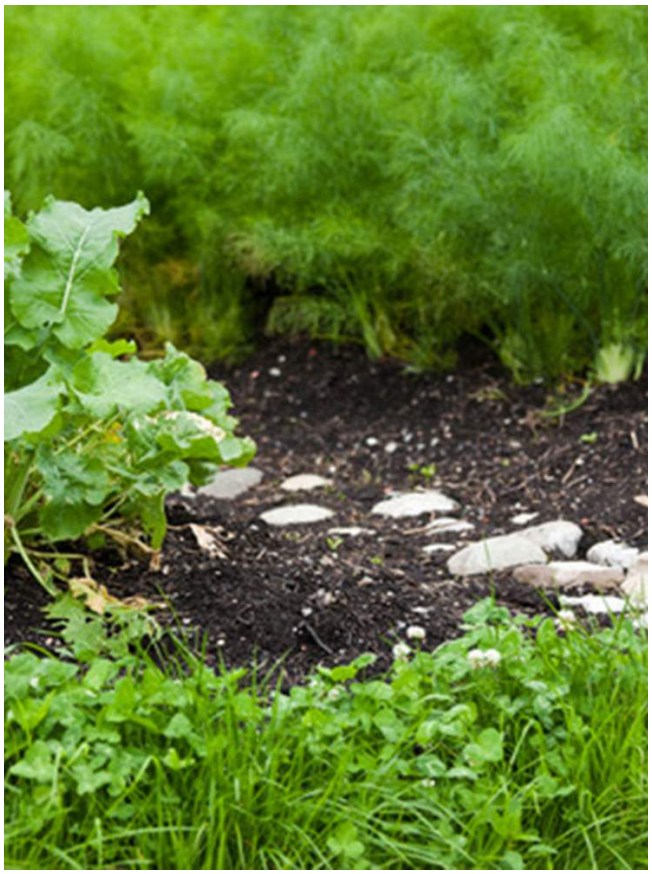
- Generating across surfaces (e.g. storms at sea)
- Within media (e.g. weather frontal systems)
- Englobements (e.g. some explosions and marine organisms)

Boundary conditions

Wherever different environments interface a boundary condition is created. These boundaries are a place for things to happen or for events to locate. In permaculture we often refer to them as 'edges'. Think about a pond and all the possible interfaces between different elements:

Air/water, fresh/brackish, warm/cool, flowing/still, grass/water, stream/bank, water/mud, soil/subsoil, catchment/storage, and so on.

Parts of the systems that move across boundaries are sometimes called



'translating elements'. These can store resources in one part and pass on resources to be used by the adjoining system. Plants, people and pipes are some different types of translating elements. We can also divert or modify flows across boundaries, by the use of obstacles. Just as stanchions control the flow of people in a line at the theatre, so rocks and logs can divert the flow of water in a stream, interacting at the boundaries between fresh and brackish water, the stream and the bank, and the flowing and still parts of the system.

Where different media come together there is also the potential for stress conditions to occur. For instance, friction, shear or turbulence, violent chemical reactions, powerful diffusion forces or social disruption are all examples of stress at a boundary. In fact it is rare that there is no stress at a boundary; though it can be quiet as rust or as lethal as war.

In response, boundaries are often adapted to mitigate or take advantage of these stresses. Cell membranes allow certain parts of a flow of energy to cross them while keeping others out, while boundaries in nature often evolve to resist invaders.

Design strategies

The creation of complex boundary, or edge, conditions is a basic design strategy for creating spatial and temporal niches. Again, this mimics what is observed in nature – organisms often inhabit boundary zones because resources accumulate there (e.g. debris along a fence line), the resources of two or more media systems are available and often form a third media by their combination (e.g. turbulence creating an emulsion of oil and water), or the boundary is itself a unique and rich niche (e.g. tidal pools). It is no coincidence that estuaries and coral reefs are the most productive parts of the ocean, primarily due to the complex interaction between land and water.

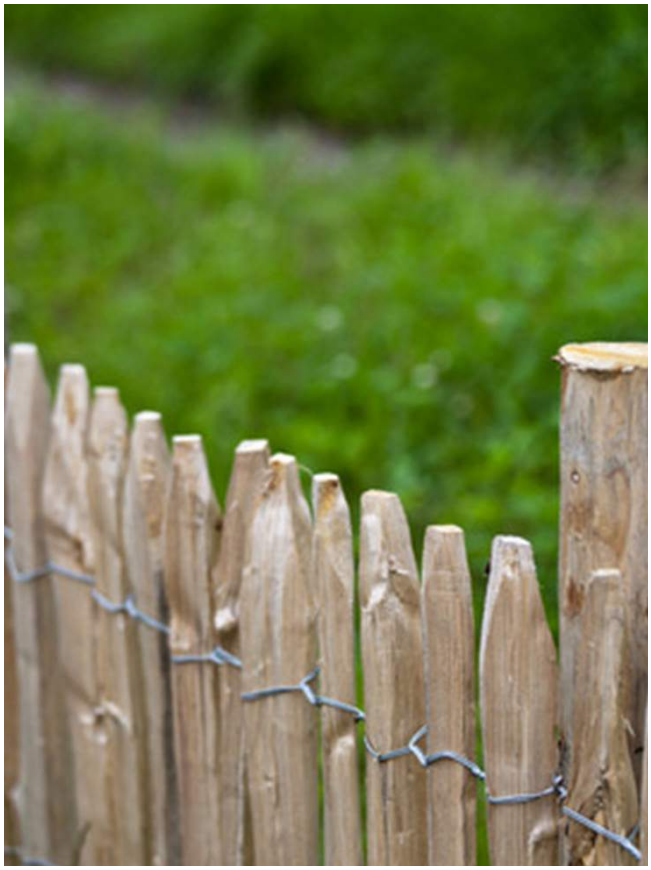
Aspects of edges to consider in design

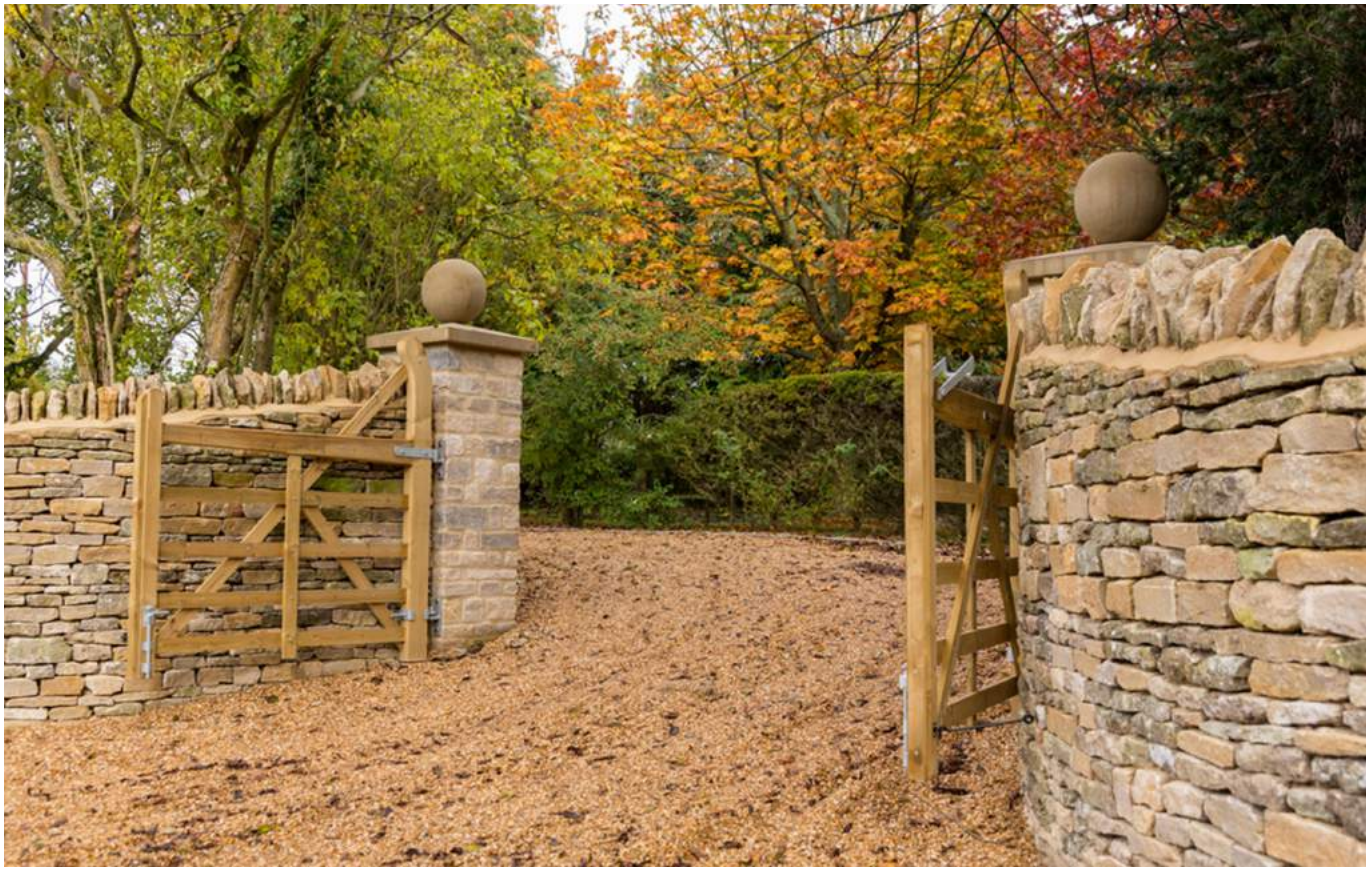
- The geometry or harmony of a particular edge
- Diffusion of media across boundaries, which are always in flux, often seasonal or sporadic.(e.g.
- water is the 'universal solvent', diffusing through the soil, plants and atmosphere
- What conveys material to or across boundaries, typically organisms or flows (e.g. bees or streams)
- The compatibility of species or elements brought into proximity by edge design
- Boundaries are accumulators that can collect mulch or nutrients.

Ways to work with boundaries

- Increase the amount of edge (e.g. make ponds irregular in shape rather than circular, make planting rows wavy rather than straight to fit more plants in)
- Increase the available growing surface by reducing path size (e.g. a keyhole garden bed design provides 20 percent more growing space than a series of raised beds with paths between them)
- Smooth or interrupt the flow of air or water to create desired conditions (e.g. add a weir to a stream to help salmon migrate, or institute a windbreak to protect fragile plants)
- Make surfaces that are pitted, ridged, spiraled or mounded in order to create water and/or mulch catchment areas or to increase planting space. (e.g. a herb spiral)
- Arrange edges to net, stop or sieve animals or plants (this idea could also be used on human notions like money and influence).

While interactions at boundaries can have positive or negative effects, in general plants and organisms at boundaries have mutually beneficial interactions. For instance, it generally doesn't pay to attack others unless you are trying to eat them; you waste energy without useful gain and suffer





accumulated injuries (this is a lesson humans are still trying to learn). But it is worth considering edge harmonics and species compatibility when planning your boundaries to get an efficient system.

Differences create trade and interaction. The objective is not to eliminate differences but to use them creatively. Design to allow the differences to produce mutually beneficial outcomes. For instance, intercropping of different species of plants helps all the species thrive and increase the productive edge – indeed, doing so creates nothing but productive edge!

Most boundaries benefit from media moving across them, which is why impermeable boundaries create stress in a system. It is important to design boundaries with relief valves or translators in them to ease pent-up energy. For instance, a mesh fence will allow mice to traverse the edge, but will keep predators from doing so.

Pattern and human culture

Human societies have long used pattern in their organization. Cities have often been designed to certain patterns to make the populations easier to control (this originated with the Romans who

realized that arranging cities in certain regular shapes meant they could be guarded by fewer soldiers).

Such patterned organization may make social control easier, but it also prohibits functional and aesthetic design considerations. The 'one size fits all' attitude that is a handover from these ancient cities continues today in building codes, making patterns that are dysfunctional because they do not integrate all the needs of the site and the people living within it.

Permaculture suggests that rather than designing human settlements that provide for social constructs (such as control), it make more sense to design them in accordance with natural features we need to interact with, such as bioregions or watersheds.

Doing so makes people far more aware of their local resources and of their relationship with them, making them motivated to protect and preserve them.

When the World Bank (a non-elected body, remember) has the authority to override local laws if they interfere with international commerce, we can see how hard it is to break the stranglehold on our societies that the global, competitive economy has. But we need to move forward with new ways of thinking about how we organize human settlements, or we risk destroying not only the natural world we rely on, but also human societies themselves.

The tribal use of patterning

Patterns have long been a part of human culture. Ancient and tribal peoples made practical use of pattern to encode important information.

For instance, they tracked seasonal, navigational, and long-term cycles as well as genealogical and societal history with patterns.

They used songs and chants to chart distances and currents in the ocean for travel, while evidence from petroglyphs shows that they accurately tracked solar and lunar cycles over decades, identifying planting times and drought and rain cycles. Indeed, early Polynesians, despite being ignorant of the concept of scale, of trigonomic measures and cartographic convention were able to find and navigate between almost 2,000 tiny islands in the vastness of the Pacific Ocean, all through the use of pattern maps.

Patterning is also seen in tribal art, typically as a conveyor of history and meaning. Dancing in formation with repeated movements, or the pattern of drumming can convey information about the tribe, its history, structure and beliefs. We often consider a society primitive when we don't understand the depth and breadth of knowledge conveyed in their art, music and symbols, but tribal art, song, dance, sculpture and design are often full of meaning we can't initially detect. (Compare this with most modern art, which is individualistic and all surface, with no educational or sacred function.)

In the modern world, the use of pattern as a means of learning and conveying meaning has given way to the use of numeric and alphabetical symbols. While undoubtedly a major element in the ability to communicate, these methods lack the instinctive sense of underlying principles

that pattern learning can provide and aid with remembering information. (They can also lead to increased division – for example, the 'lingo' of different professions or social groups serves to separate them from the rest of society.) It is no coincidence that the majority of methods used to improve memory and information recall relies on patterns and repetition to get us to remember things.

Patterns of sounds, images and story are threads that can be found woven through many different cultures, pointing to their similar origins or beliefs. Many world beliefs share an essential core but we have drifted from these nature-based and essentially universal systems toward more personalized dogma, which serves to divide instead of uniting us in shared meaning and understanding of life.

Focusing on these shared patterns allows us to transcend the emphasis our culture places on the individual and the division of life into disciplines and categories that separates groups or individuals from one another.

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