One School One Planet is a three year project, that ran between 2016-2019. Its primary aim was to investigate the long term consequences of the Paris Agreement for education, economy and development in Powys, Wales. A global commitment to reach net zero emissions as fast as possible represents more than a tweaking of our economic models and erecting a few wind turbines, it requires a complete rethink of our priorities for education and development. What cost are we prepared to pay to continue living beyond our ecological means? Schools and communities have the potential to lead from the botom up and forge a path to a different future.

Human flourishing on Earth requires us to understand the ecological boundaries of our home and to learn how to live within them. ***Sector39*** is an independent enterprise based in Wales committed to exploring how permaculture design can be used as a tool to transform our society and economy to be fully sustainable. Permaculture embraces the concept of re-generative development, recognising the fact that we have damaged the global ecosystem to such an extent that we need to actively repair much of that damage for us to survive. To achieve that we need to learn to think differently, which is precisely what is offered by permaculture design!

BRACE (Building Resilience Against Climate Emergency) is a local action group that spontaneously formed in response to work by the *One School One Planet* team. We held a series of open 'community conversations' to share ideas about education, Climate Emergency and approaches to responding locally. The decision was to build a coalition of interested individuals and develop project ideas that can be easily implemented. In the process we hope to establish stronger relationships right across the community especially with the town council (Llanfyllin), the county council (Powys), the high school and those active local groups focusing on conservation, *Extinction Rebellion* etc.

Today's school age generation are being handed the biggest challenge of all, that of 'saving the planet.'

You could say that this is a gift from the generation who knew but failed to act meaningfully. Had we listened to the advice given at the Rio Earth Summit in 1992, the problem of climate change would most likely already have been solved. Yet here we are, in 2019, still contemplating the biggest shift in human society and behaviour since development began.

There is no magic bullet, no single solution. No government or corporation can solve this. It is going to take the collective action of all of us. The real leaders of the future will come from today's school age populations, what can we do to accelerate this process?

This essential book by the *One School One Planet* team maps out how we can collectively respond to the challenge of our life-time -- that of reforming our relationship with planet Earth.

arwain

Powys

Small and Slow Solutions

Permaculture in School and Community

Unleashing the Creativity of the Climate Change Generation

Steven Jones, Jack Hunter, Angharad Rees

We hope to inititate action is schools across Wales as well as across the world. Facing the climate and ecological challenge is the defining challenge of our generation. Sector39, here in Wales are keen to follow all of your actions and we encourage you to use social media to share any outcomes from your work.

Please feel free to contact the project team and to follow us on social media

steven.jones@sector39.co.uk
@misterjones2u
facebook.com/sector39

Office of the Future Generations Commissioner

"Climate change is one of the biggest challenges facing our current and future generations. According to IPCC, we have 11 years to do something or risk an environmental catastrophe. It is more important now than ever that our children are equipped with the right skills to understand and tackle climate change in their day-to-day lives.

There is a great appetite for change in children, as demonstrated by the global school strikes, and we should not only be encouraging this appetite but nurturing it and helping it grow. This was precisely the focus of the One School One Planet project, which aims to teach children practical skills that can help enhance biodiversity and the environment in their community. This textbook aims to spread this knowledge and skills to other children across Wales and the world and provides schools and teachers with practical steps towards sustainable development through permaculture.

One School One Planet, at its core, embraces and embeds the elements of the Well-being of Future Generations Act and, if implemented in other Welsh schools, can contribute to all of the national well-being goals of Wales. This project demonstrates how small and easy steps can build and have a big positive impact on our well-being.

I support the work of this project and would encourage schools and head-teachers across Wales to read this textbook and adopt some of the principles of the project, helping to address the climate emergency, one small step at a time."

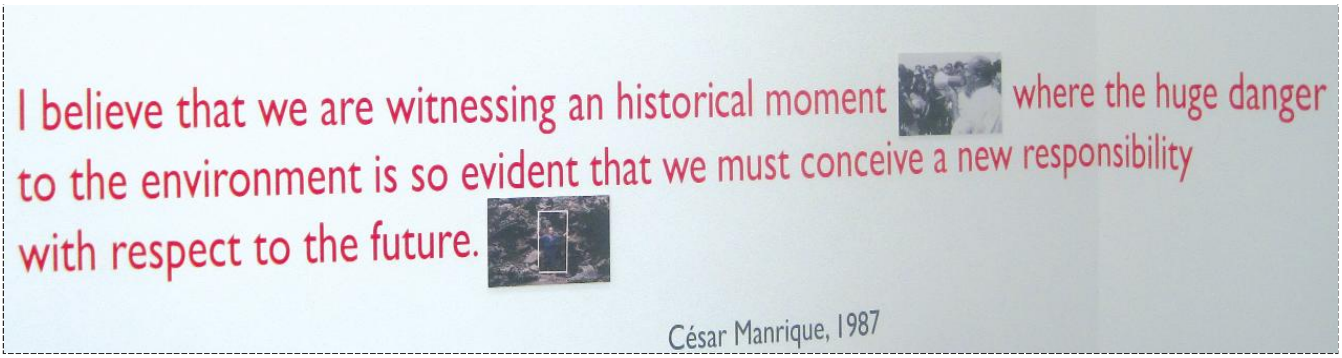
Endorsement

EXPLORE

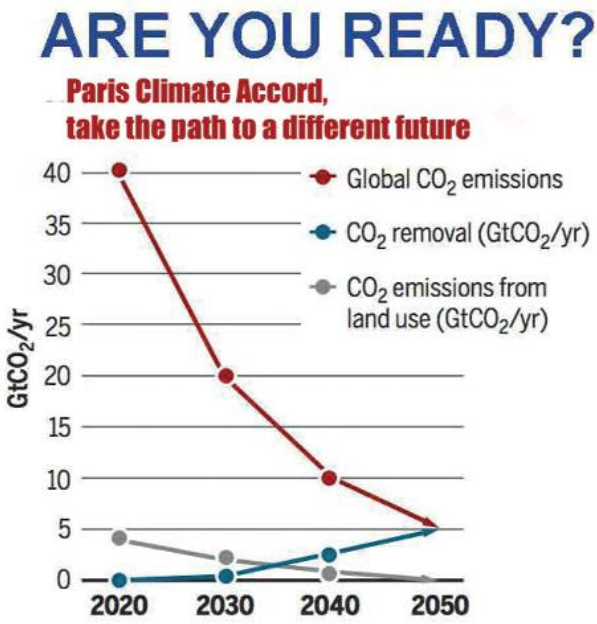
Contents

This book will take you on a journey

Contents



Introduction



The red line shows just how quickly we must reduce our greenhouse gas emissions.

The writing on the wall

One-hundred-and-ninety-five countries signed the Paris Climate Accord in December 2015. This science-based treaty sets out the optimum path for humanity to avoid disastrous runaway climate change. In fact, it doesn't go far enough. Adhering to its targets only gives us a 66% chance of avoiding catastrophe (Rockström et al., 2017). Nicaragua -- one of the two nations who refused to sign it -- withheld their support on the grounds that it lacks ambition and enforceable targets. Young people currently at school are growing into a world that will be dominated and defined by the content and implications of the Paris Climate Change agreement. It will colour their whole lives, and they must be prepared emotionally, intellectually and academically for what is coming. The agreement aims to: "[keep] global temperature rise this century well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius. Additionally, the agreement aims to strengthen the ability of countries to deal with the impacts of climate change"

(UNFCCC, 2018).

Education has a key role to play

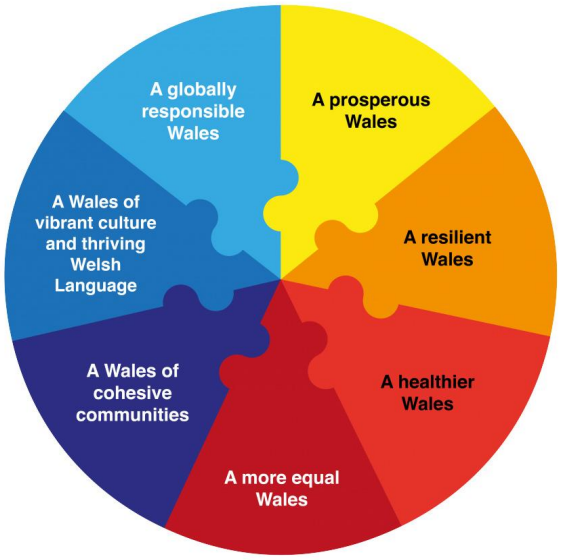
Political forces, performance targets, external assessments: there has never been more pressure on educators to conform to and perform to external agendas, mandates and dictates. The *One School One Planet* project fully recognises the current pressures on teaching staff and does not wish to add any extra burden to school time and curriculum. We are here to make your job easier! What we are proposing, rather, is that climate science, ecological literacy and practical permaculture principles should provide an underlying framework for the *whole curriculum*, through which all subject areas are revealed to be interconnected. Indeed, recent developments in the national curricula of Scotland, Wales and England are increasingly emphasising the importance of 'interconnected thinking' in education. The Welsh Government's recent consultation on education in Wales, for example, seeks to develop a new curriculum that is 'designed to support learners to "adapt to a changing world"' (Welsh Government, 2019). This is precisely what this book sets out to do – to facilitate educators (broadly defined) to adapt and respond meaningfully to the climate emergency we are now facing.

The Paris Accord sets the targets we have to beat

Future Generations

In 2015 the Welsh Government also introduced its Well-being and Future Generations Act. This pioneering piece of legislature is all about "improving the social, economic, environmental and cultural well-being of Wales." It has seven key well-being goals that can help guide individuals, organisations and institutions towards a positive future for Wales. The goals are for:

1. A prosperous Wales.
2. A resilient Wales.
3. A healthier Wales.
4. A more equal Wales.
5. A Wales of cohesive communities.
6. A Wales of vibrant culture & thriving Welsh language.
7. A globally responsible Wales.



Goals of the Well-being and Future Generations Act.

Education is going to play a major role in bringing about this vision of Wales' future, and this handbook seeks to facilitate schools (and other formal/informal educational settings) to adapt to the changes that are currently facing us. It is essential that we begin to incorporate these critical ideas about the ecological crisis and practical responses to it into the academic culture and into the education system.

Our project proposes cross-curricular themes, new content, facilitation and inter-school links to enable establishments – on a school by school basis – to respond to this huge challenge and to incorporate these ideas into their educational output and campus culture.

This project proposes that permaculture design needs to find a place at the heart of our educational values. We suggest that the permaculture approach can contribute meaning, rationale and action to the educational process. Moreover, it achieves this in a way that encompasses the huge and all-embracing challenge of climate change and the consequent re-evaluation of development objectives and outcomes this entails.

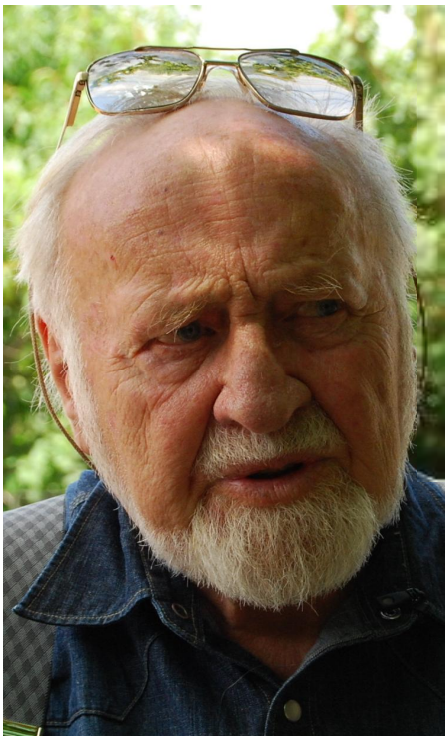
Dr. Jane Davidson was Environment minister in the first Welsh Assembly and also was the Minister who proposed what is now the Future Generations act. Here she is presenting at a Climate Emergency meeting at the Centre For Alternative Technology.

Wales is leading the way

What is permaculture?

Permaculture is a creative design process based on whole-systems thinking that uses ethics and design principles. It guides us to **mimic the patterns and relationships we can find in nature** and can be applied to all aspects of human habitation, from agriculture to ecological building, from appropriate technology to education and even economics.

What is Permaculture?



"There is one, and only one solution, and we have almost no time to try it. We must turn all our resources to repairing the natural world, and train all our young people to help. They want to; we need to give them this last chance to create forests, soils, clean waters, clean energies, secure communities, stable regions, and to know how to do it from hands-on experience."

~ Bill Mollison, Co-founder of Permaculture.

In essence, permaculture is a design system for sustainability and ecological regeneration. It was developed in Australia in the 1970s by forester turned ecologist Bill Mollison (1928-2016), and his student David Holmgren, and has been steadily growing as a loosely organised movement ever since. They checked the dictionary for a word that encapsulated their vision for a sustainable and regenerative agriculture, and tellingly there wasn't one, so they coined their own term. It is a combination of the words 'permanent' and 'culture,' or 'agriculture.'

Activity: What do you think this means? What would a 'permanent culture' look like, or a 'permanent agriculture'? How would it be different to our current system?

Permaculture is a process. It represents an evolution in thinking and a transition to a systems approach to problem solving. Permaculture offers the inclusion of the core concepts of ecology into design, planning and economic rationale. It uses observations of nature as models for how we might approach design in a form that embodies nature's resource-efficient, cyclical, dynamic and interconnected systems. Permaculture design steers us away from the often simplistic, linear and wasteful models that frequently typify human endeavours, towards sustainability and greater resilience. Permaculture views climate change, habitat destruction, top-soil loss and the increasing commodification of both the human and natural world as more than externalities of an otherwise healthy economy, but as inherent and potentially fatal flaws. Our society's ability to externalise the environment and see ourselves as separate from it has allowed us to view nature as a mere resource to be plundered, rather than a living interconnected life-support system that we are all a part of.

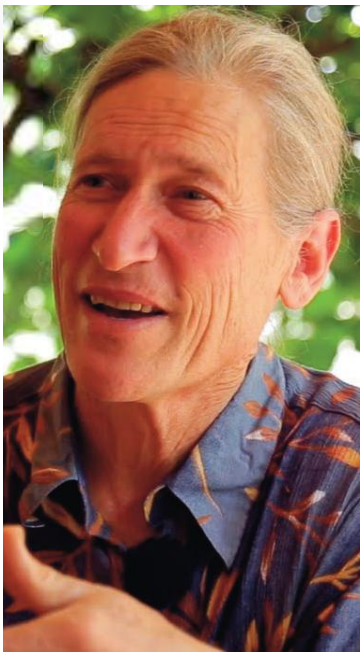
Activity: Can you think of ways that our dominant culture attempts to separate the human and natural worlds? Why does it do this? What effect does this way of thinking have?

Permaculture is a design approach

Permaculture Principles

"When we work with nature instead of trying to impose our will, the solution is often found within the problem."

~ David Holmgren, Co-founder of Permaculture.



Permaculture addresses this reality by presenting an holistic design system that allows us to build strategies that meet our individual resource needs in ways that are not at the expense of wider society, or the biosphere as a whole. Nature runs on dynamic relationships, it is never static. It is constantly changing, but it does so within observable patterns and cycles. The definition of permaculture reflects this, as every situation and individual is unique and every circumstance demands a unique approach framed within this wider understanding. The chapters that follow explore these principles and processes in more detail.

The Permaculture design process is encapsulated by twelve principles devised by David Holmgren, co-originator of the Permaculture concept. The first set of six are derived from observations of nature and the tenets of ecology; if we are to behave in a sustainable way, then ecology must guide and define our behaviours. The second six show us how to achieve these goals using design principles derived from natural observations. It is these principles that form the basis of our twelve-unit scheme of work. Making use of wide-ranging design tools, coupled with insights from the scientific method, permaculture challenges the student to action -- to turn aspirations into a strategy, and ambition into outcomes. The twelve principles, which form the backbone of this textbook are summarised as follows:

1. Observe and Interact.
2. Catch and Store Energy.
3. Obtain a Yield.
4. Apply Self-Regulation and Accept Feedback.
5. Use and Value Renewable Resources and Services.
6. Produce No Waste.
7. Design from Patterns to Details.
8. Integrate Rather than Segregate.
9. Use Small and Slow Solutions.
10. Use and Value Diversity.
11. Use Edges and Value the Marginal.
12. Creatively Use and Respond to Change.

Permaculture is learning from nature

Permaculture Ethics

Permaculture is also framed by a system of ethics. These three ethics have to do with setting limits to personal consumption and re-investing surpluses into society and the environment. Unfettered consumerism may be good for Gross Domestic Product (GDP), but it is not an end in itself and comes at a cost. This framework recognises that, as individuals, we do not exist outside of society, and that society and economy are in turn a subset of a healthy environment. Permaculture's principles and design tools equip us to achieve these longer term goals as expressed in its core ethics, which are also derived from observations of nature. Both principles and ethics empower and steer the designer to achieve more harmonious, sustainable and abundant outcomes. Let's break them down a little:

David Holmgren's three permaculture ethics.

1. Care for the Earth – Asset stripping and resource depletion in the name of economic growth are defficiencies of imagination on the behalf of humans.

2. Care for People – Meeting the needs of one social group by denying another's access to its own resources will always lead to conflict; there is an essential requirement to recognise the needs of all social groups.

3. Fair Share – We can only achieve the above by recognising the idea of 'enough.' Once we have met our own essential needs, the surplus must be reinvested to enable other societies, as well as the Earth's living systems, to meet their needs too.

Activity: How could you apply these ethics and principles to your own life?

Small and slow solutions

As much as we recognise the emergency we face, the response we propose is to unleash millions of small and slow solutions. Small scale mistakes are learning opportunities, a chance to adapt and modify ideas and for them to evolve; large scale responses run the huge risk of creating bigger problems. This typifies the permaculture approach.

In words and deeds, Greta Thunberg is the embodiment of philosopher Howard Zinn's admonition: "We don't have to engage in grand, heroic actions to participate in the process of change. Small acts, when multiplied by millions of people, can quietly become a power no government can suppress, a power that can transform the world."

Environmentalism Goes Mainstream

It used to be the job of fringe groups -- hippies and nay-sayers -- to communicate these messages, but those days are far behind us. The Intergovernmental Panel on Climate Change (IPCC) and the Conference of Partners (COP) couldn't be more mainstream, and the scientific weight behind their findings is immense.

The IPCC was set up in 1988 by the World Meteorological Organization (WMO) and United Nations Environment Programme (UNEP) to provide policymakers with regular assessments of the scientific basis of climate change, its impacts and future risks, and options for adaptation and mitigation. IPCC assessments provide a scientific basis for climate change policy. They hold regular meetings, known as the Conference of Partners (COP) and are the lead advisory body to world governments. The panel is the biggest collection of scientists the world has ever seen.

We simply cannot afford to ignore the messages coming from these climate scientists. Embracing this evolutionary leap forward represents the central arena for innovation and opportunity for the coming decades.

The 'first organic farmer in UK.' A tribute to Arthur Hollins

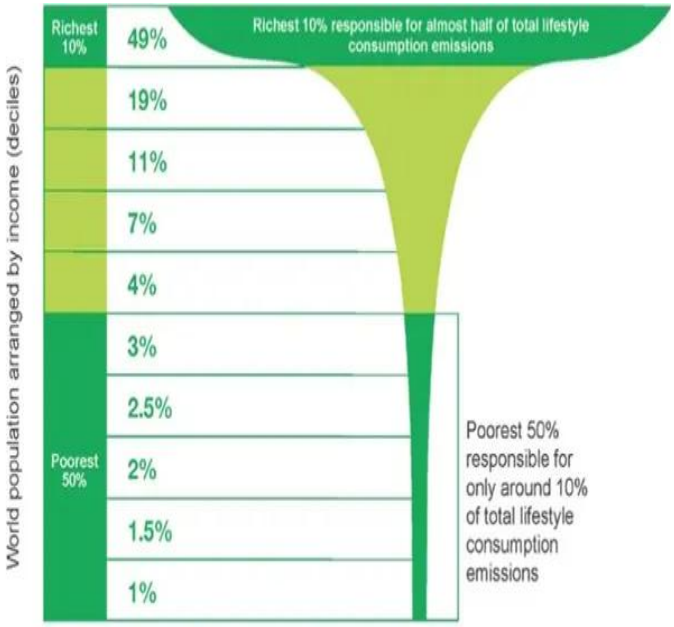
All farms were organic originally, before petro-chemicals arrived and gave us synthetic fertilisers, pesticides, diesel pumps for water and heavy machinery to work the land. Following the Second World War, however, there was huge pressure from the government to expand food production for a starving nation, and farmers were encouraged to embrace the miracles of modern technology, which they did, and yields rose rapidly.

Arthur was one of the first to notice -- and Arthur was a great observer -- that the new chemicals, although boosting yields, became less effective over time and began to interfere with the natural processes and biodiversity of the farm. Arthur had left school at 14 to support his father to run the farm, but even without a full education he could see with his own eyes the damage that was occurring to the fragile sandy soils on his farm from ploughing and chemicals. He devised his own farming system and created a successful business at Fordhall Farm in Shropshire. It flourishes today, now managed by his children. Arthur is considered one of the real pioneers of both organic farming and permaculture in the UK. His success is a real testament to the powers of observation. Arthur started a revolution in farming that has not stopped!

Even governments are taking a radical view on environment

Let's Talk About Population

For many people, when considering the environment and the possibility of a sustainable future, the 'elephant in the room' issue is population. More people = more environmental damage. From this perspective, strategies to limit numbers of people should be considered as part of the solution to the climate crisis. This view is not correct, however, and neither is it supported by evidence. Because it is such a common misconception, it is worth taking a moment to think about it so that we can understand it better.



Percentage of CO2 Emissions by World Population (Oxfam).

The current global human population has crossed 7.5 billion and is heading upward. The latest UN projections have it hitting 8.6 billion by 2030, 9.8 billion by 2050, and 11.2 billion by 2100. Average fertility rates are decreasing, but that effect will be overwhelmed by the sheer number of people. (There are many arguments out there that the UN is overestimating population growth, but let's stick with their numbers for the purposes of this argument).

The UN expects over half the growth up to 2100 to be concentrated in just nine countries, listed here in order of their expected contribution:

India, Nigeria, the Democratic Republic of the Congo, Pakistan, Ethiopia, the United Republic of Tanzania, the United States of America, Uganda, and Indonesia.

Most of those people will be fairly poor (by Western standards, though hopefully less than their forebears), which means their per-capita consumption of resources will be fairly low. Nonetheless, cumulatively, adding 2.3 billion people by 2050 amounts to enormous additional resource use and pollution (including greenhouse gas emissions).

That said, however, some members of the global community consume and emit a lot more than others. If your concern is the creation of new consumers and emitters, your gaze should be drawn to those who will consume and emit the most, i.e., the wealthy. The conclusion has to be *not* that there are too many people, but rather that as incomes rise and wealth accumulates people start to make increasingly bad choices about their resource use. It is how we use our natural resources that is important.

With modern design, technology and planning informed by permaculture principles, much of this waste and pollution could easily be avoided. If we can learn to act in the correct way then more people can become an

People have to be part of the solution

The Paris Agreement in More Detail

asset, not a problem. More people to plant trees, make compost and apply all of the other responses to the climate and ecological crisis explored in this book and elsewhere. What does seem certain is that the next generation will have to learn to live in a way that has a positive impact on this living planet of ours!

The Paris climate agreement in more detail

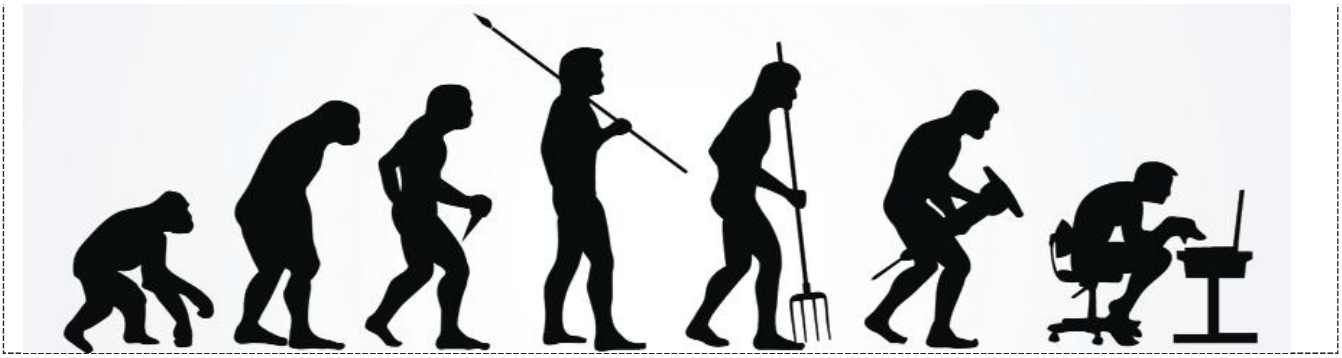
One hundred and ninety-five countries agreed to sign the Paris Agreement in December 2015, it was ratified the next year and comes fully into force in 2020. Nicaragua, one of the two countries that didn't sign, has since done so, in September 2017. This leaves only Syria, which has been consumed by civil war since 2011, and so has not been engaged in the discussions. Even they have since indicated they intend to work to its targets. Although Donald Trump has said he wants the US to withdraw from the agreement, this process could not begin until 2020 when his presidency will be nearly over. Individual US states, such as California and Hawaii, have already said they agree to abide by the agreement, even if their Federal government refuses to do so.

PARIS2015
UN CLIMATE CHANGE CONFERENCE
COP21·CMP11

It was at the COP21 meeting in Paris in 2015 that the terms of the Paris Agreement were agreed.

Perhaps the most important aspect of the agreement is not the targets it sets, but the fact that it is the first time the whole world has agreed to such a long term and all encompassing agreement. Of the world's climate scientists 98% support these targets and many warn that they are not ambitious enough. Hitting all of the targets in the agreement will only give us a 2/3 chance of avoiding a runaway climate disaster. There are no dissenting voices remaining in the scientific community. **Science is more certain about climate change than it is about gravity, or the fact that smoking causes cancers.** The only debate that remains on the subject is just how bad it really is and how urgent is the response we need to make! These targets represent the minimum we must do to avert disaster. We probably need to do much more.

If we are to be led by science and reason, then we are to be led by the Paris Accord. It is as simple as that. The terms of the Accord are based on the considered response of the greatest global coalition of scientists the world has yet seen - the Intergovernmental Panel on Climate Change (IPCC), and has been negotiating this treaty over a series of 22 international Conferences of Partners (COP).



Big Changes

What does the Paris Accord say? Here we break it down into three key ideas.

1. Beginning in 2020, in each of the following three decades **the world must halve its emissions of carbon dioxide**. Although for each successive decade the numbers become smaller the task will become harder as we will make the easy reductions first and leave the most difficult to last.

2. Over the course of those three decades the world must **invent and implement effective technologies and strategies for carbon capture and storage**. The treaty recognises that these technologies do not yet exist, but anticipates that over a three decade time span they will grow to contribute a five Gt per annum net sequestration.

3. Agriculture. How we produce our food and manage our landscapes has been singled out for a special role in this unfolding drama. Currently responsible for 5Gt per annum of emissions due to ploughing, land clearance and the widespread use of agro-chemicals, **farming is required to transition to carbon neutral by 2050**, and towards 5Gt per annum of carbon sequestration over the following decades.

Put simply, this represents the greatest challenge humanity has ever faced. It is equal to the changes made to the economy at the onset of World War Two, yet prolonged for three decades. Economy, education, design, planning, technology, farming, arts and culture all need to take note of where we are going!

Activity: Plot out the graph of the Paris targets using the figures below, and discuss what the implications may be of some of the huge changes we need to make. Emissions refers to global CO_2 emissions produced by human activity. Technology refers to a prediction of the contribution of technology to finding ways to extract and store carbon dioxide from the atmosphere (known as carbon sequestration), and Farming refers to CO2 emissions from agricultural activities. The X-axis charts the years from 2020–2050. The Y-axis measures emissions levels, and needs to run from 40,000 parts per million, to 0 parts per million in increments of 5,000.

	2020	2030	2040	2050
Emissions	40,000	20,000	10,000	5,000
Technology	0	1,000	3,000	5,000
Farming	5,000	3,000	1,000	0

Write down any questions or points you might like to discuss regarding the issues raised by this activity for discussion in class.

The Paris Targets are ambitious, but we need to go further

Youngsters sowing the seeds of farm's future acre of woodland

Permaculture in Schools

We believe that by working together with your school -- and all schools -- we can make a difference to the lives of the next generation - those who will make the decisions that shape our collective future. We can face our collective challenge with *One School One Planet*.

This project has developed a scheme of work based on Permaculture's twelve design principles. It is for students of. potentially all ages and can be easily adapted and differentiated for teaching at appropriate levels - for different age and ability groups. The intention is for this scheme of work to be delivered as a linked programme across several schools at once, whereby students are encouraged and supported to share work and collaborate with each other across different classes and schools in different locations. Through the programme, students are exposed to a series of twelve core ideas relating to change, sustainability, ecology, economics and the underlying processes that shape and change evolution. It examines the origins of the resources on which we depend, and questions the processes and outcomes we create with them.

School group at Cae Bodfach Community Orchard, Llanfyllin.

Principle	Objectives	Outputs
Creatively Use and Respond to Change	• To consider the concept of change. • Change can be positive or negative. • To introduce Climate Change. • The problem is the solution. • Processes over time.	• **Practical**: Start to produce 2020-2050 timeline. This could be an ongoing reflective timeline.
Observe and Interact	• In order to solve problems we need to observe and interact. • Biodiversity loss and climate change are two sides of the same problem. • Introduce natural principles.	• **Practical**: Set up High Fibre Composting (Cool Composting). • **Reflection**: Create a map of the school and identify edges.
Catch and Store Energy	• All life requires energy. • Plants capture and store energy through photosynthesis. • Co-operation, Not Competition. • Harvesting Water. • Building Soil.	• **Practical**: Explore opportunities for water capture and retention, e.g. water butts, rainwater gardens, etc. • **Reflection**: Catch and store the story/experience of beginning this process.

The climate generation are those currently in school today

Principle	Objectives	Outputs
Obtain a Yield	• Nature creates yields. • To understand the difference between industrial and organic agriculture. • Community food production.	• **Practical**: Germinate seeds and propagate plants. • **Reflection**: Collect interviews for a Vox Pop project addressing the following questions: 1. What does climate change mean to you? 2. What is the Paris Agreement? 3. If you were in charge what would you do about it?
Limits and Feeback	• Introduce Gaia Hypothesis. • Nature is in a state of dynamic equilibrium. • Natural systems are resilient but have their limits. • Introduce ecosystems and eco-system dynamics (Keystone Species, Trophic Cascades, Food Webs).	• **Practical**: Observe the compost heap. What can we learn from observations of this 'system'? • **Reflection**: How effectively are these ideas being communicated in the school? What is working? What is challenging? What do we need?
Use and Value Natural Resourcees	• Oil and Gas are finite resources. • Introduce the concept of Energy Return on Investment (EROI). • Renewable Energy.	• **Practical**: Identify the transport footprint of your school. • **Reflection**: How can we 'live within our means'?
Produce No Waste	• Natural systems are cyclical, there is no waste in nature.	• **Practical**: Return to compost heap to evaluate progress. • **Reflection**: Spot opportunities in the waste stream of school and community. How could you tap into them?
Design from Patterns to Details	• To understand that nature builds on its successes. What works in one place, often also works in another. • There is much to be learned from observing and mimicking nature.	• **Practical**: Map sites around your school and community. What patterns do you see? • **Reflection**: Design for community garden.
Integrate not Segregate	• Interconnected systems are more resilient.	• **Practical**: Design and plant a fruit tree guild. • **Reflection**: Research the history of co-operatives.
Small and Slow Solutions	• There is no single solution to the climate crisis. • Many small and slow solutions can make a big difference.	• **Practical**: Create biochar.
Use and Value Diversity	• Introduce the concept of succession. • Natural systems tend towards maximum biodiversity. • The greater the number of nodes in a network, the more resilient it is. • Introduce the concept of re-wilding.	• **Practical**: Install bug hotels. • Build habitat for wildlife to enhance biodiversity. • **Reflection**: Why is re-wilding so important?
Use Edges and Value the Marginal	• Change begins at the edges.	• **Practical**: Identify physical and social edges for opportunities.
Creatively Use and Respond to Change	• How can we apply what we have learned to the current climate crisis?	• **Practical**: Consider what we have learned throughout this process, and how we can apply it to our lives and communities.

Outputs

Materials and facilitation will be provided to help deliver sessions including talks, seminars and workshops. These will be used to stimulate and shape a dialogue around each theme in the scheme of work. Students are encouraged through discussion and debate to shape their own thoughts and to respond to the material presented to them, developing and expressing their ideas through their own work.

Academic work might include essays, coursework and multimedia output produced through individual, group and inter-school activities. This, in turn, will lead to student-led action and strategies dealing with areas of opportunity identified in and around the school community.

Initially, we imagine students working individually to consider each theme. They could read notes, watch video content and online resources (differentiated for age and ability level), produce artwork, creative writing, spoken word or multimedia content in response to their learning. Students might then group together to produce newspaper articles, blog posts, video clips, drama and spoken word, making collaborative use of all formats to represent the ideas of their group. This content can be shared via the internet with students and groups from other schools (e.g. using tags such as #smallandslowsolutions) -- and ideally in other countries and cultures -- to compare perspectives and to collaborate on producing output, which uses the best content from all contributors. These outputs will be utilised by the project as resources for further learning and dissemination to inform and stimulate future student groups.

In addition to theoretical and academic work, this project also places a central importance on practical, hands-on activities that make a very real positive impact. Simple practical activities, such as planting trees, creating habitat for wildlife, making compost, growing food and collecting water, for example, are all 'small and slow' responses to climate change and biodiversity loss that are easily achievable in school or at home.

Llanfyllin High School Eco-Team recording a podcast.

Planting a tree guild at Llanfyllin High School.

Unit 1:
Creatively Use and Respond to Change

The life cycle of the dragonfly is characterised by change. They go through three phases: larval, pupal and mature.

"Don't see things as they are, but as they will be."

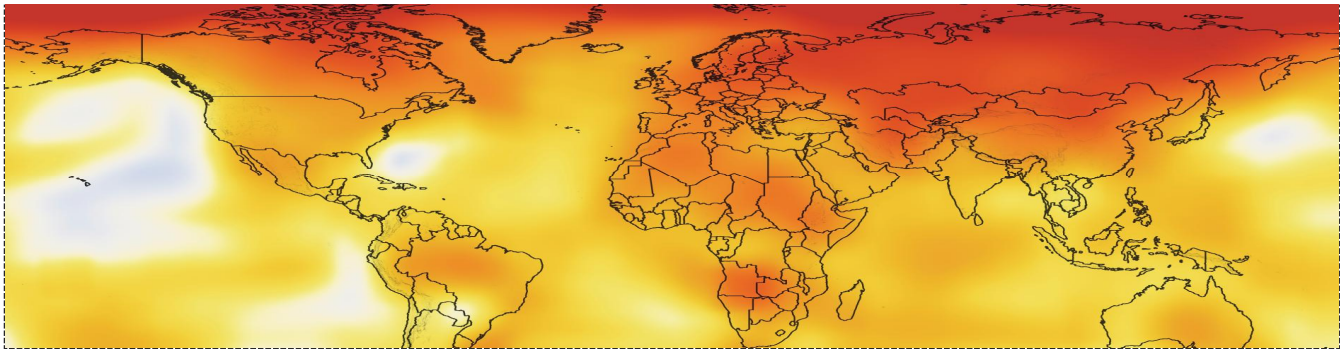
Each of the twelve principles covered by these units is symbolised by an iconic image. Typically the image used to represent a transformative change is the butterfly, as when it retreats into its chrysalis it doesn't just sprout wings, it totally reorders its cells into a whole new version of itself! We have chosen the image of a dragonfly to represent the same idea.

The one thing that life guarantees us is change. We are challenged to see this as a creative force to be embraced. We cannot control change, but we can embrace it and shape its forces to our advantage if we are both informed and willing to accept it as a positive creative force. What do you think this means? How could we go about doing this?

Activity: Making use of drawing, photography, or imaging software, create your own representative icon for transformational change. Think about the meaning of the words 'transformation' and 'change,' maybe look them up in the dictionary, or on the internet. How would you get these ideas across in a single vibrant image? What symbols or imagery would you use?

The climate is changing. This change is due in large part to the over-reliance of industrialised nations on fossil fuels, and their ongoing destruction of the natural world for financial profit. This environmental destruction stems from a particular economic ideology -- one that consumes environmental capital as if it were income, and externalises production and waste disposal costs onto the natural world. These activities are not without consequences. Another big change is needed!

Activity: Watch the twenty-minute animated film 'The Story of Stuff' on YouTube. The film explains the linear nature of the consumer economy and the need to move toward a more circular economic system. Make notes as you watch, then write a short article (100 words) for your local newspaper explaining the key themes raised by the film. Think about the simplest most straight-forward way to get these ideas across to your local community.



Climate Change

Scientists have anticipated climate problems from carbon fuel burning for well over a century. Indeed the 'greenhouse effect' was first observed as early as 1824 by the mathematician and physicist Jean Baptiste Joseph Fourier (1768-1830). The tendency, however, has been to put off worrying about this effect until some time in the future. That time is now here! The global community, after twenty years of discussion, has finally agreed on an outline plan of action. It commences in earnest in 2020, the beginning of a thirty-year period of concerted action to reduce the risk of this serious problem turning into a major catastrophe. Scientists across the planet have identified an alarming warming trend which will lead to devastating consequences if left unchecked.

This trend is referred to as Global Warming. This is because the rising proportion of carbon dioxide in the air traps heat in the atmosphere, which is increasing average surface temperatures at rates faster than observed in all geological history. This increased heat causes the global climate to change - more heat means more energy, so we can expect bigger storms and heavier rainfall, for example.

Activity: What is the difference between 'the weather' and 'the climate'?

Jean Baptiste Joseph Fourier (1768-1830).

Climate change refers to long-term changes in global and regional weather patterns. These changes in weather patterns cause other areas of the planet to experience drought, colder periods for some as well as much hotter ones for others. This process has already begun, and can be observed right across the globe, from disastrous flooding in parts of the UK to catastrophic droughts in East Africa.

"Major flooding in UK now likely every year, warns lead climate adviser."

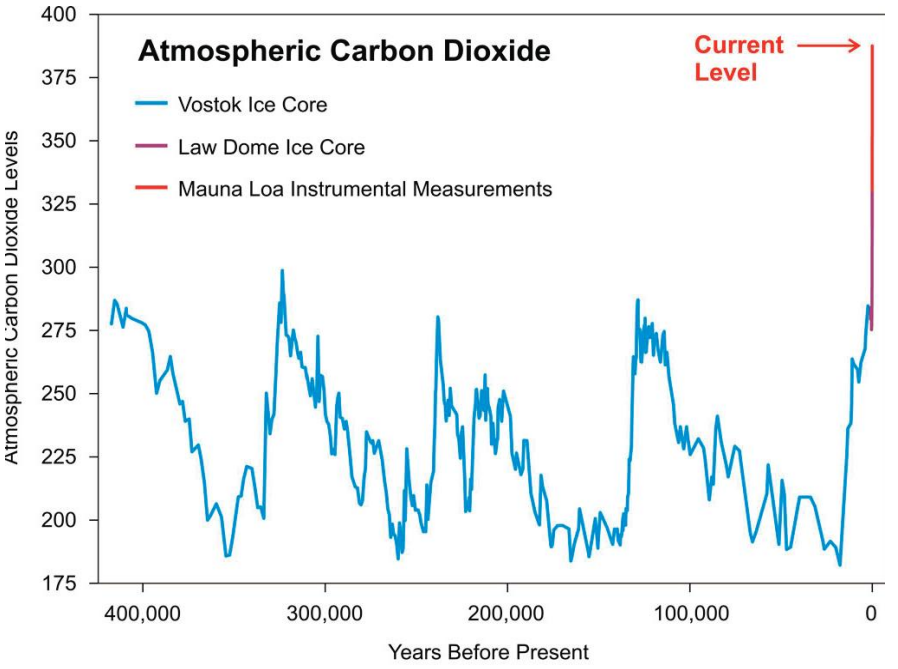
~ The Guardian, Monday 26th December 2016.

"Looming 'catastrophe' in East Africa proves why world must tackle climate change."

~ The Independent, Thursday 27th April 2017

Facing Up To The Challenge

All nations have observed these changes and scientists across the world have formed a panel to study them and make recommendations. The Intergovernmental Panel on Climate Change (IPCC) is the biggest union of scientists the world has ever seen.



This graph -- produced from geological data from cores of ancient Antarctic ice, as well as from atmospheric data from the Hawaiian islands in the Pacific -- shows that carbon dioxide levels in the atmosphere have always fluctuated because of a wide variety of natural geological factors. The problem is that CO_2 has never been anywhere near current atmospheric levels. Since humans began burning fossil fuels after the Industrial Revolution, the amounts of CO_2 in the atmosphere have literally gone off the graph. Left unchecked this will quickly become a very big problem, and we need to respond to it with urgency.

We have all been called to act on this! Facing up to this challenge will take the world thirty years of hard work, but it will also be a period of intense creativity. We are calling on thinkers, writers, artists, scientists, gardeners, farmers, teachers, builders, architects, designers -- literally all walks of life -- to embrace this change and use their personal creativity to help us all rise to the challenge. It is up to us to creatively transform the challenge of climate change to our global ecological advantage.

Activity: Find out more about the IPCC using the internet. What is it, and what does it do? How does it work? This project wants to create the biggest union of students to respond to challenge of climate change, like a student IPCC. In groups, come up with a plan for this student organisation. What would you call it? How would you organise it, and get people involved? What would your logo look like? What sort of media would you use to advertise your organisation? Once all groups have finished the plan for their student organisation, present your proposal to the rest of the class explaining all the reasons for the choices you have made. Students can then choose which name and logo they would like to use, and incorporate elements of each presentation into a final plan.

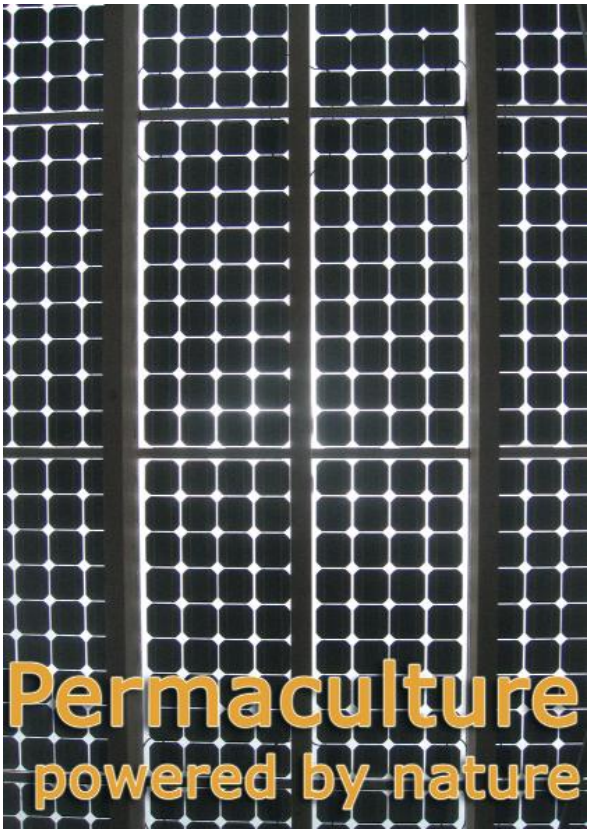
A failure of the world to act on this and to make the changes necessary will almost inevitably bring about unimaginable destruction. We simply won't be able to carry on living as we are used to. The biology of the planet -- which produces our clean air, water, food and habitats -- will simply break down into something unrecognisable.

The world is already feeling the effects of climate change, but these scary and very real threats will certainly become much worse if we collectively fail to act. That is why the world has come to together to work out courses of action that will avert the worst of this crisis and create new and better alternatives for us all. In fact, fixing this big climate problem will also help us fix thousands of other smaller social and economic problems at the same time – they are all connected! The decarbonisation process will create new jobs, livelihoods and real meaning and purpose for the next three generations, and that means you too!

You and your generation literally get to *save* the world!

Solving the climate crisis is also a social justice issue. By embracing the 17 U.N. Sustainable Development Goals we link environment, economy and society.

No Blame Game



Solar photovoltaic cells built into a roof at the Centre for Alternative Technology.

It is not helpful to seek people to blame for our current situation. In 1709, when Abraham Darby I (1678-1717) invented the first blast furnace in Telford, Shropshire, he had no idea about the impact burning coal and limestone to produce iron and steel would have on the world 250 years later. Steel making quickly moved from landlocked Shropshire to South Wales, to Cardiff and Swansea, which quickly became the most important industrial cities in the world at the time. In 1830 over 90% of all the iron and steel produced in the world had been made in South Wales, and enormous wealth and economic progress came as a result. Perhaps unsurprisingly this was perceived as change for the better.

Quite early on certain scientists had started to wonder what impact all of this coal burning might have on the planet. They realised that the fumes, smoke and smog would in some way change the atmosphere, but they didn't quite know how. In 1896, for example, the Swedish chemist Svante Arrhenius (1859-1927) suggested that man-made pollutants in the air would speed up the greenhouse effect. Mistakenly, however, he thought this warming would be beneficial for future generations! Additionally, the world seemed so big at the time, and industry so small, that all concerns were put aside and people generally assumed that in the future our science and technology would provide us with easy solutions, if such a problem did indeed exist. We also have to remember that scientists back then didn't have the necessary tools to measure such changes. There were no satellites, no internet, and very little funding. Besides, too much wealth was being created with these new technologies for anyone to really worry about the long-term effects.

Activity: On 1st May 2019 the UK Government declared a Climate Emergency. Why has it taken so long for us to heed warnings that were first expressed over 100 years ago?

There are no excuses anymore

We can be generous in forgiving our ancestors for not realising the impact of their work on the global climate. In many ways they created the tools and technologies we now enjoy in the modern age - our cars, computers,

Change is a Certainty

agricultural technologies, modern drugs and pharmaceuticals, all of which are made from and reliant upon the coal, gas and oil we started using at the dawn of the industrial age, and that are now fueling climate change.

We now have the resources and tools to measure the impacts we are making in great detail. We also have the technologies to enable to us to continue to live our modern technological lives without continuing to burn fossil fuels at the currently alarming rates that we do. As if the climate problem wasn't enough, these fossil fuels, which we mine and pump from deep below the Earth's crust, are becoming increasingly hard to find and so are also very costly to extract. This resource depletion is fuelling wars and conflicts around the globe as countries compete for access to the remaining economically recoverable reserves. Change is needed!

Working with nature creates exciting new possibilities for human environments.

Everybody knows we have to change, but somehow we are finding it hard to really commit to the changes we have to make. Sadly, every day we fail to make these changes we make life a little bit harder for the coming generations. The Paris Agreement is essentially our road map to the future. If we can follow what it asks of us then we have every chance of avoiding the worst consequences of global warming and the resulting climate change. The Paris Agreement gave us all just three years to make some plans, to think about where we are going to start, and to decide how we are going to face this challenge. By the time we get to 2020, however, we are all required to start putting these plans into action. We don't have much time to get prepared!

Governments and businesses, of course, will have to lead the way, but in reality they do not like facing up to change either. Furthermore, their ideas of how to solve these problems only go so far, and will often serve their own financial ends. It really is up to all of us to understand this challenge better and find way to respond in our own lives, in our schools, at work, in our communities and in virtually all aspects of our lives.

Activity: What changes could you make in your life, in your school and wider community, to help us to meet the requirements of the Paris Climate Agreement? How would things like travel, agriculture and shopping have to change to meet these requirements? It would be great to come up with a list of creative solutions that could be presented to the senior leadership of your school, or to community and town councils.

School takes lead in environment issues

Communicating Change

Greta Thunberg began her school strike for climate when still 15 and against the advice of her family and friends. She has refused to go to school every Friday since, holding a silent protest outside the Swedish parliamant instead. This was her Small & Slow solution. 'Fridays for Future has since become a global movement inspiring thousands of children around the world. Greta has met and challenged many of the world's leaders on issues of climate change.

"Some say I should be in school, but why should any young person be made to study for a future when no one is doing enough to save that future? What is the point of learning facts when the most important facts given by the finest scientists are ignored by our politicians?"

~ Greta Thunberg

To say that the advancement of climate science into the public arena has been controversial is an understatement. As the debate over global warming has grown, so too have the attempts of the oil industry and related businesses to confuse the agenda with 'bad science,' misinformation and outright lies. Even the current Trump-led USA administration claims not to believe in climate change. Science, however, is sceptical by nature. In order to meet modern scientific standards, new theories must be backed up with evidence, which must be checked and re-checked by other scientists in a process called peer-review. The climate change data has passed through this rigorous process. The scientific community is more certain about climate change than just about anything else. The body of evidence is overwhelming and still growing. The only debate that remains is just how bad it is and how urgent is the need for concerted action.

The climate science website www.skepticalscience.com is written by scientists using common every day language. Many common misconceptions about climate science are dismantled here with proper evidence based discussion. If you need to check any facts or arguments then this is the place to go.

Practical Activity: Begin producing your own 2050 timeline. Map out the next thirty years as we move towards a carbon-negative society. What changes will we have to make? When will we have to make them? This can be an on-going reflexive process. Your 2050 timeline might change as you learn more about what is possible.

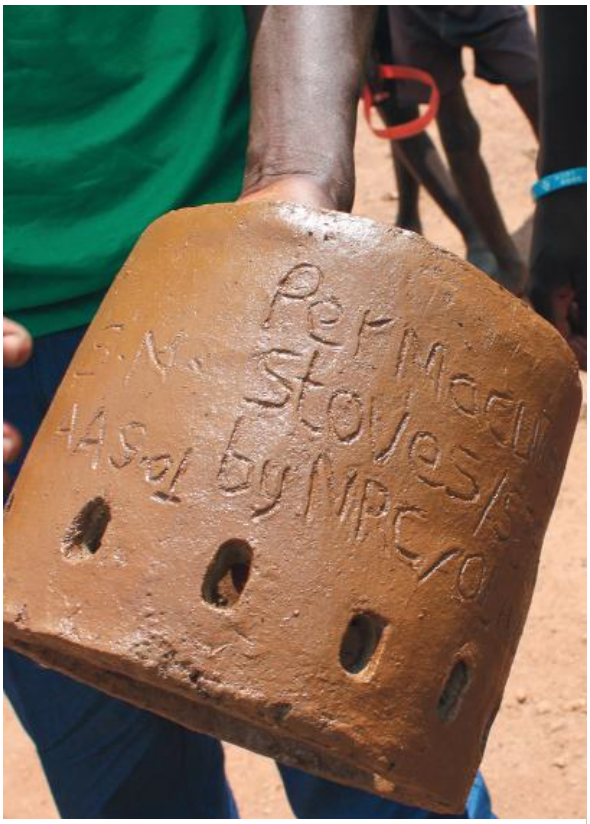
Unit 2:
Observe and Interact

"Beauty is in the eye of the beholder."

Following on from the idea of change as a constant force, we must ask ourselves a fundamental question: how do we deal with change? There are a great many looming problems in the world, and permaculture design puts forward the powerful idea that a problem and a solution are the inverse of each other. What do you think this means?

The way to resolve any problem is through protracted and thoughtful observation. Often when we might think we are tackling a problem we are in fact only dealing with a symptom of the problem, rather than the cause, and this can lead to much wasted energy.

Activity: Suggest some world problems that you are currently aware of. We have already talked about climate change as a global problem. Perhaps you can think of some other global problems? You could also include local problems, or even problems that directly affect you personally. How would you go about trying to solve these problems? What steps would you take?



Clay copy of a steel pyrolysis stove, created in Bidibidi refugee settlement, Uganda by permaculture trainee Oliver, and it worked!

Examples of global, local and personal problems:

Deforestation; top soil loss; rising food prices; world population; competition for resources; pollution; war; social deprivation; lack of jobs; discrimination against race; gender; religious or sexual orientation; litter; dog mess; lack of access to land; lack of economic opportunity; lack of money; fitness; health; exercise; good education etc...

Can you add anything more to the list?
Which of these worries you the most, and why?

Permaculture allows for more strategic, joined up thinking

Blue Planet

The relative amounts of water and air on the Earth.

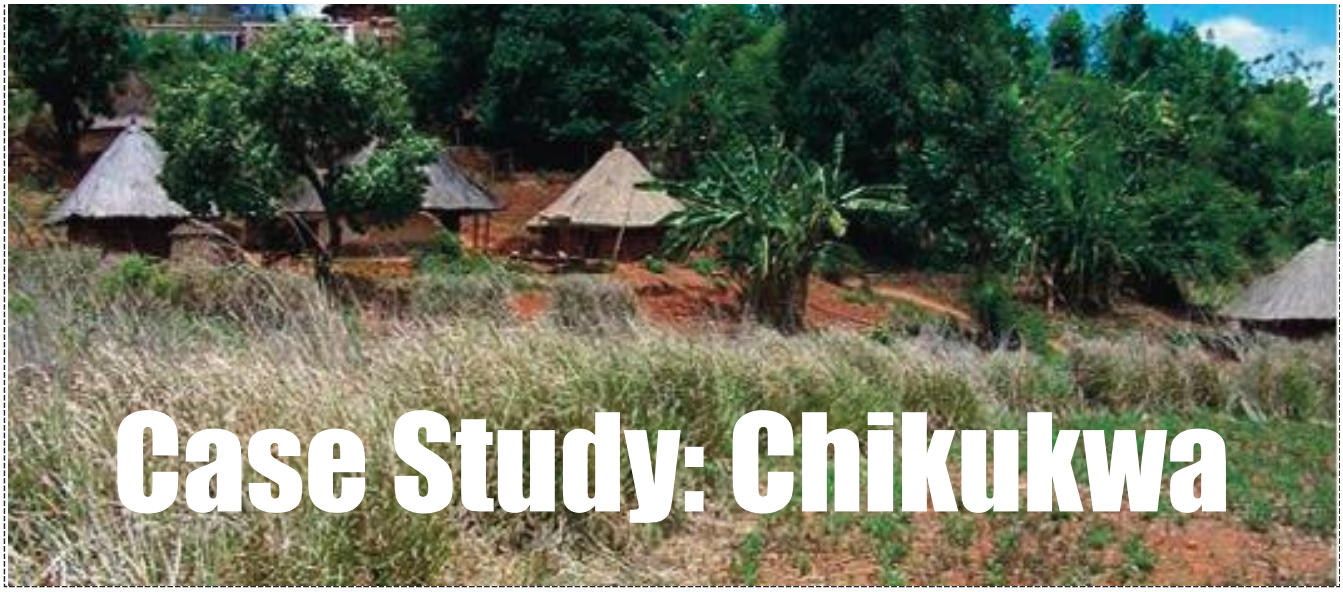
A frequently asked question is 'how can human activity affect the climate when the Earth is so big?' When humans first went into space, perhaps the most significant outcome was the photograph looking back at the Earth. To see our home planet hanging in space for the first time gave us a genuinely new and exciting perspective on our place in the cosmos.

However, with this view of the Earth also came the realisation that it is finite and very fragile.

When we see the blue globe of the Earth (13,000km in diameter), we tend to forget that the oceans are only 3-4km deep, at the deepest. The water and air surrounding the Earth is essentially a thin film. If you packed all the water on the Earth into a sphere, it is much smaller than you might expect. The same goes for the atmosphere too. Our new perspective on the Earth reveals just how fragile the system that sustains us really is. That fine blue line, the film of water and air on the outside of our spinning ball of rock is a mere 30km from the depths of the deepest ocean to the outer edge of the atmosphere.

Activity: We all share the same water and air. With this realisation comes a deeper understanding of the devastating effects of pollution in an interconnected world. Design an A4 poster that might help other people grasp this important idea.

Practical Activity:
If you cannot visualise how delicate the planet's atmosphere really is you can try this experiment. Take a basket ball, or one of a similar size, and a roll of cling film. If planet Earth was the size of a basketball it would look smooth like a billiard ball. Surround the ball with a layer of cling film, as best you can. The thickness of a single layer of film is about the width of the atmosphere in proportion to the size of the ball. Now the picture above will become much clearer to you.



Case Study: Chikukwa

Activity: Research the rainfall statistics for Zimbabwe and compare with the UK. How and why are they different?

One of the major inspirations for this project work was seeing the achievements of the Chikukwa project in Zimbabwe, having visited there in 1992, we have followed their progress ever since. Find out more about the project here: www.thechikukwaproject.com. Farming techniques used in this remote and traditional area of Zimbabwe had, over time, badly degraded the soils. There was a loss of fertility and even the wells and springs started to dry up. A small but determined group from the community started to research their options and to find ways to address the many problems they were facing. Happily, Permaculture is well established in Zimbabwe with a training centre in the capital city, Harare. Support and training allowed these people to see ways forward they themselves could use and adapt to suit their circumstances.

Pioneer groups of villagers decided to implement a system called swales. This involved mapping the terrain to find the contour lines and then digging ditches and banks along the level lines to stop rainwater from escaping and eroding the land during the rainy season. This was extremely hard work, and some villagers thought the people doing this work were mad as there was no immediately visible benefit.

Inspired by Chikukwa's example this permaculture design student presents ideas for a school forest garden at Busoga High, Uganda in 2017.

This work took many back breaking days, weeks and months, but gradually the land began to change. Slowly more people became interested in what the pioneers where doing and soon large groups of people heading up the hills each day to dig more swales. They sang songs as they worked and a strong feeling of camaraderie started to grow between them.

> *"Permaculture actually solves all the problems that we face in human life. So this is considered to be the right approach for us to live - if you want to save the earth."*
>
> ~ Julious Piti, a Chikukwa Project founder.

Compost is another key technology. One of the biggest changes for the villagers was to learn to value natural resources much more than they had previously. Having to repair the damaged landscape, being poor farmers on the verge of malnutrition, they learned to value what they had much more.

A School Forest Garden

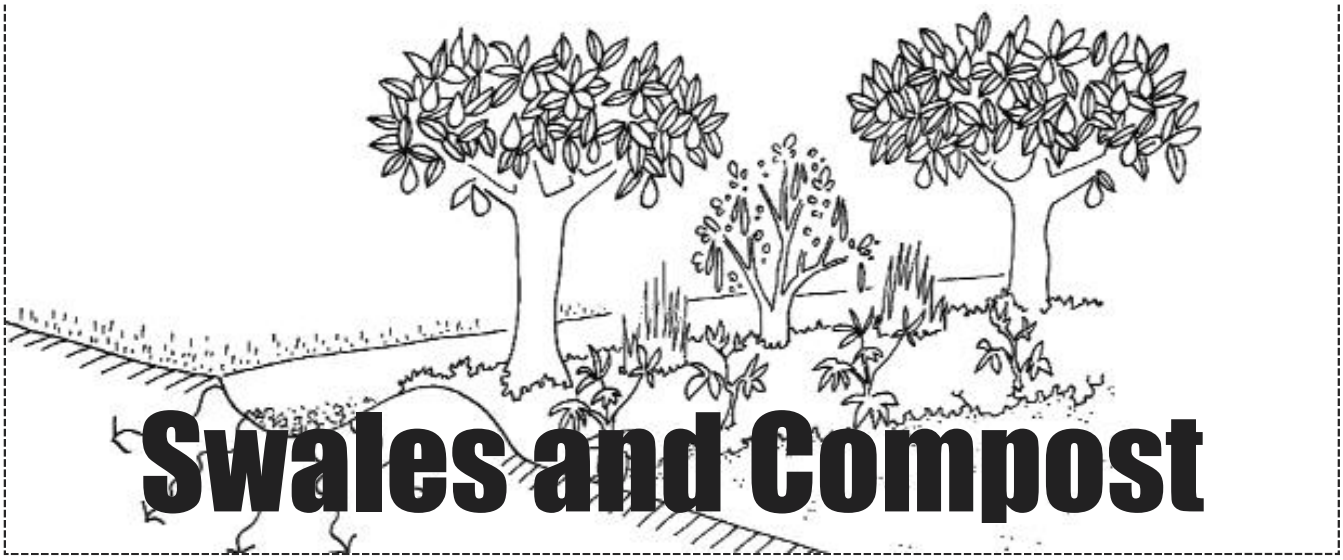
Busoga Uganda: Swale excavation in 2017, trapping surface flow from the heavy seasonal rains to feed the key trees and shrubs

They learned to combine animal manure, dead plant matter, food scraps and peelings together through composting to create stable and fertile soil additives, which in turn made it much easier to grow more plants to further stabilise the landscape, to cover and protect bare soils, to feed to grazing animals, and also to make more compost! Using a combination of techniques the swale is stabilised with vetiver grass, a fast-growing, deep rooted-fodder plant that secures the soil. It is cut regularly to feed cattle, taking some of the pressure off the grazing lands around the villages. The resulting animal manure is collected and composted together with food scraps, leaves and other plant matter to enrich his soils. The farmers have learned to always keep their soil covered and protected with either crops or green manure plants, grown for the benefit of the soil and soil life.

A combination of shrubs are also grown along contour lines to reduce erosion. These are nitrogen fixers, part of the legume family. The seeds can be fed to chickens and the leaves to carefully tethered goats, who produce manure to be collected for the compost heap. As well as growing traditional staple crops like maize, farmers diversified to produce tree crops, like avocados, guavas, oranges and papayas. These long term crops take a few years to develop but once established become a reliable addition to annual crops. The trees also provide shade and habitat for birds, which also helps to regulate pests. By 2014, 22 years later, the huge problems facing Chikukwa had been turned around. The upper slopes are now covered in forest and are out of bounds for grazing animals. Swales and contour plantings have stabilised the soils, and the leguminous shrubs, trees and compost use have boosted soil fertility. Tree crops add to the farmer's yields and provide shelter from the elements, as well as a diversity of other yields for the community. Many more families have joined the scheme now, and thousands of farmers are learning from the Chikukwa pioneers.

It is now regarded as one of the most successful projects in Africa and what is interesting to note is that it was not an aid, development or government project, but one that was initiated by the community itself using local resources and developing the skills they needed as they progressed. Key to this success were regular meetings and good communications. Not every idea they tried worked first time and some people were resistant to the many changes that were happening. As the work progressed many meetings were held

Uganda or Llanfyllin, the process is the same



Swales and Compost

to discuss plans. They talked about what had been learned, what was working well, what was most challenging, and what changes did they need to make to improve on the progress. They have demonstrated what can be achieved by problem solving using observation and working together.

Activity: Look up the work of CELLUCT ZImbabwe and explore how permaculture is transforming communities in East Zimbabwe. Also the work of the Wales for Africa program, investing in Wales/Africa partnership projects as part of the Future Generations goals. Good communication between countries is essential to finding responses to world problems.

Sector39 is a small Welsh enterprise with a focus on teaching permaculture courses and helping to develop projects from the momentum created by these courses. In 2017 the Wales for Africa fund provided seed funding to deliver two 12-day permaculture design courses in Uganda. This link came about through another partnership with a farmer's link charity local to our community in Wales, *Dolen Ffermio*. This group came from a partnership between a veterinary practice in Wales and Ugandan colleagues in the 1980s. Support from the Welsh Government gave us the chance to share the experience we had built up over 20+ years of working in the UK. Linking with pioneer permaculture organisations and teachers in Uganda created a unique learning environment and in just 24 months we trained a mix of well over 350 teachers, youth leaders, community elders, mothers, parents, citizens and refugees as permaculture teachers.

The Busoga High School forest garden in 2019.

> *"The permaculture concept has been well received at school. The students have been very active and have learned a lot. At the moment we are making an extension to the garden for especially the agriculture students to use as a demonstration."*
>
> ~ Connie Kauma, English literature teacher and permaculture design graduate, Busoga High, Kamuli, Uganda

In 2017 we teamed up with Busoga High School in Eastern Uganda, and held a two week course in the nearby town of Kamuli. This was attended by a wide range of Ugandan and Kenyan farmers, teachers and community leaders, along with a small group from Wales, including students from Llanfyllin High School. The course participants generated ideas for a school forest garden, based on and demonstrating many of the ideas that made the Chikukwa project in Zimbabwe so successful.

What can permaculture bring to your school or community?

Making It Work

Humanity is one species sharing a single eco-system. Solving the climate challenge will require us to work with this realisation.

As we have already seen, permaculture is a design process. It challenges the designer to make small but deliberate steps, all the time observing to understand how changes take effect, and considering their consequences.

If we really want to create sustainable systems then we have to realise that nature is our teacher. After 4.6 billion years evolution has created a dynamic, interconnected, ever changing -- yet remarkably stable -- system. So far, many of the developments of the last 200 years have involved seeing nature as a pile of resources we can gobble up, process and turn into commodities that we use then throw away.

This has worked well enough for so long, as nature is abundant and is also able to heal itself over time. However, as human populations have grown and our living standards have risen, the demands and expectations we are putting on the planet in a great many different ways are simply stretching it too far. The imperative is for humanity to transform our economic systems. Instead of running at odds with the natural world we must learn to harmonise with it.

The ideas, stories and examples contained in this book are all aimed at helping to build an empathy and understanding with nature and how it works. We literally have everything to gain from this process, and also everything to lose if we do not change or adapt. The only thing holding us back from making this change is the embedded momentum in old destructive system. What will it take to bring about the changes required? We can mobilise a whole new generation to see the possibilities of what we can achieve if we are only brave enough to leave behind what we know will not work in the future and concentrate on these new possibilities.

In a recent paper called 'Deep Adaptation,' Professor Jem Bendell suggested that we need to think about three key ideas: 1: Relinquish: stop investing in those things we know are counter productive, e.g. searching for more oil 2: Resilience: work to strengthen and extend those systems that we most rely and depend on. 3: Revive: look at our own traditional, pre-oil societies and through observation identify those practices we abandoned that might be essential in our low carbon future, and bring them back.

Observing Natural Systems

Permaculture design is informed by observations of natural systems and processes, creating more resilient human systems (sometimes referred to as biomimicry, see **Chapter 7**). The following are some of the key principles of ecology. We will be returning to explore these principles in more detail in later chapters:

"It's beautiful" said the tourist. "No, its a pest" said the farmer. "It's lunch" said the turkey!

Succession (no bare earth) The process by which bare rock or earth progresses towards a climactic ecosystem. Initial colonisation is followed by more varied species which trap nutrients (e.g. nitrogen fixing, leaf litter trapping), increasing fertility and supporting more and more diverse life. This is a natural strategy that reduces soil erosion and maximises productivity (see **Chapter 4**).

Key functions are supported by multiple elements Considering one function within an ecosystem, e.g. soil fertility, we can observe that many elements come together to support this function. In woodland, soil fertility is supported by decaying plants and animals, and by manure from animals (see **Chapter 11**).

Elements perform multiple functions If we look at one element within a system we can observe that it has many functions. For example, an oak tree provides habitat for insects and birds, creates shade, and provides leaf litter whilch builds soil and fodder from acorns.

Cycling (no waste) Describes the continued flow of energy within (and not out of) the system. Fallen branches slowly decay and perform different functions before they finally give energy, as nutrients, back to the system (see **Chapter 7**).

Local resources The ecosystem receives all that it needs from resources within the system (see **Chapters 5 and 6**).

Natural resources The ecosystem requires only natural resources to thrive and reach its climax state (see **Chapter 5 and 6**).

Natural Principles

The edge effect: unique conditions at the boundary between two environments.

Biodiversity In natural systems, many different elements survive and support each other, each within their own niche (see **Chapter 11**).

Micro-climate A rock, for example, may provide a heat store and perhaps a drier environment – thus providing a unique set of conditions that enable an element to survive.

Edge The edge is the interface between different states. Whether it be between shade and sun, or dry and wet, we can observe that an ecosystem is often most productive at its edge (see **Chapter 12**).

Stacking Natural systems have many different layers within them, maximising the productivity of the system. In woodland ecosystems we can see many layers occupied by mosses, lichens, fungi, grasses, herbs and ferns, shrubs and bushes, smaller and larger trees and climbers moving through the layers (see **Chapter 9**).

Symbiosis These are mutually beneficial relationships between elements in a system. Symbiotic relationships are two-way and reflect the interconnectedness of natural systems (see **Chapter 9**).

Activity: Go outside and observe your own local environment. What natural processes do you see? Look at areas that have not been managed, where random and unplanned processes are happening.

Practical activity: Set up high-fibre composting experiment

Compost is the process we use to return organic matter to the ground in a stable form. it feeds the microbes in the soil, and stimulates worms and other benefical organisms to work for us, opening up soils for air and water. All of these are essenial for the life below the soil. Compost is essentially a blend of carbon and nitrogen with air and water. If we get the balance right between these things then organic matter very quickly breaks down into a pleasant smelling, crumbly, moist material that is easy to work into the soil. Compost is nature's fertilizer and is the backbone of all organic growing approaches. The secret is to get the carbon (c) and nitrogen (n) balance right. The correct ratio is about 25:1, C:N. Too much nitrogen, e.g. manure, food waste, grass clippings, fresh weeds, etc. and the heap goes wet and smelly, loses oxygen and starts to pickle rather than break down. The best way to make compost is to start with materials that are mainly carbon, e.g. cardboard, shredded paper, straw, (not sticks or wood as they take too long). Add the nitrogen slowly and observe the changes each day. You will quickly get a feel for it. Follow the principle, observe and interact.

Unit 3: Catch And Store Energy

"Make hay while the sun shines."

Life and Energy

All life requires energy. The earliest forms of life on Earth were simple organisms made of one cell only. They used geothermal heat from the Earth's crust to perform very simple chemical reactions. Life at the dawn of Planet Earth was characterised by such simple organisms, but once established it evolved rapidly, giving rise to the huge variety of life forms we see today. The Earth became increasingly bio-diverse with time.

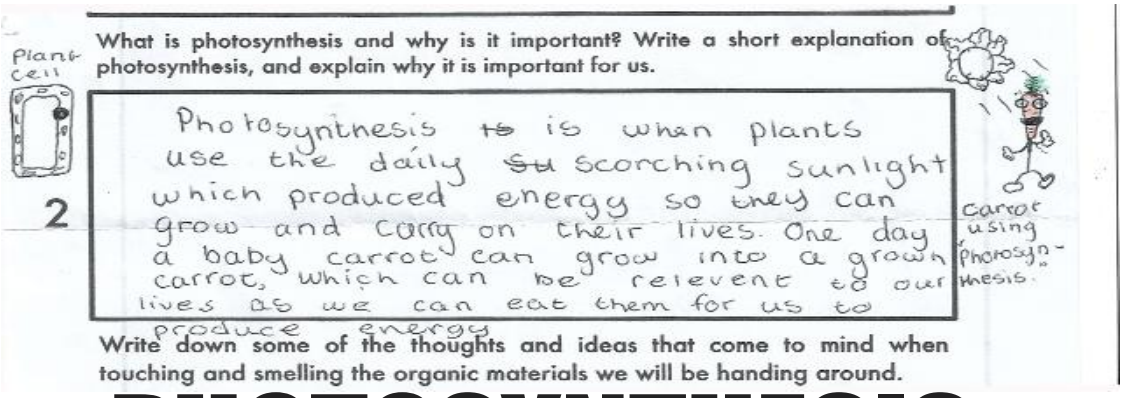
All life on Earth has a common origin, and many more species have evolved then have since gone extinct. A really important evolutionary step -- which occurred over two billion years ago -- was for organisms to learn how to catch energy from the sun and turn it into a stored form of energy: sugar. Plants are the masters of this and they have a strategy for catching the sun's energy that is so good that all other life forms have come to depend on plants, either directly or indirectly, for their energy.

Roof top beehives, Toxteth Liverpool. Bees thrive on the nectar from urban gardens

We humans are no different. All the energy we use today comes from plants, all our food is derived from plants - grasses, roots, tubers, seeds -- all stored forms of energy from plants, or it is animal in origin -- beef, lamb or chicken -- which in turn have derived their energy from eating plant material.

Plants have an amazing ability that sets them apart from all other life forms; they can photosynthesise. This means they have special cells in their leaves called chloroplasts, which contain a pigment called chlorophyll. Chlorophyll captures the energy of the sun and combines it with water and carbon molecules from the air to produce glucose (sugar), it is also what makes most plants green! It is worth noting that plants also give off six oxygen molecules and six water molecules as by-products of photosynthesis. This is very useful for us mammals, as we need oxygen and water to survive.

Activity: What is photosynthesis and why is it important? Write a short explanation of photosynthesis, and explain why it is important for us and the rest of the living things on Earth.



PHOTOSYNTHESIS

Douro Valley, Portugal, catching rainwater in the landscape with terraces and banks.

The sugar molecules combine together to create carbohydrates in the form of starch, and most plant energy stores are made up of this incredible compound. Potatoes, rice and wheat are good examples of plants high in carbohydrate stores. Chips and bread are full of carbohydrates, and this is what gives us the energy we need to live our lives. We all need energy to survive!

Activity: We can do a simple experiment to show the importance of sunlight for plants. Take a small houseplant or shrub and put it in a sunny position. Using aluminium foil and paper clips, cover one of the plant's leaves and leave for four to five days. Then, remove the foil and observe what has happened to the leaf. Compare it to leaves that were not covered. Why do you think this has happened? If you want to take the experiment a step further you can use an iodine solution to see whether starch has been produced in the leaves that were blocked from the sun.

Exchanging energy

Plants also make use of sugars -- this time in the form of nectar -- to entice other organisms to work for them, such as a hoverfly enjoying the sugary nectar from a flower. In return, the hoverfly will carry pollen grains to other plants enabling seeds to be produced. They also eat a great many aphids, regulating the potential pest population. It is a very clever and efficient exchange based on energy. When we study the natural world we slowly come to realise that all life is a complex web of interactions and exchanges between living things. No single organism can exist without the other, and most of these crucial interactions are based on energy exchange.

Practical Activity: Install water butts, or other forms of energy capture, around your school, community or home. Think sbout how to utilise the water and where will it overflow when full? Spot the leaks in your school or community - what else could you catch and store? Where else are unused energies or resources leaking out of your home or school?

Catching and Storing Energy is Our First Strategy for Survival!

'Co-operation, not competition, is the very basis of existing life systems and of future survival.'

Bill Mollison, the founder of Permaculture, observed this crucial web of interactions in his study of the world's ecosystems. In fact, 'ecology' as a branch of biology emerged towards the end of the nineteenth century specifically to explore the relationships and interactions between organisms and their environment. Before this time naturalists and biologists had tended to study individual organisms in isolation from other organisms and their natural habitats. By ignoring the wider context, early naturalists failed to grasp the key mechanisms that have allowed life on Earth to flourish and diversify.

Activity: The saying that goes with the Permaculture principle 'Catch and Store Energy' is 'Make hay while the sun shines.' It reminds us that catching and storing energy is a timely and strategic action. Can you think of forms of energy that we need to catch and store? Make a list of as many forms of energy as you can think of. Remember, energy can take many different forms!

Making salt from sea water and using the energy of the sun, Malta.

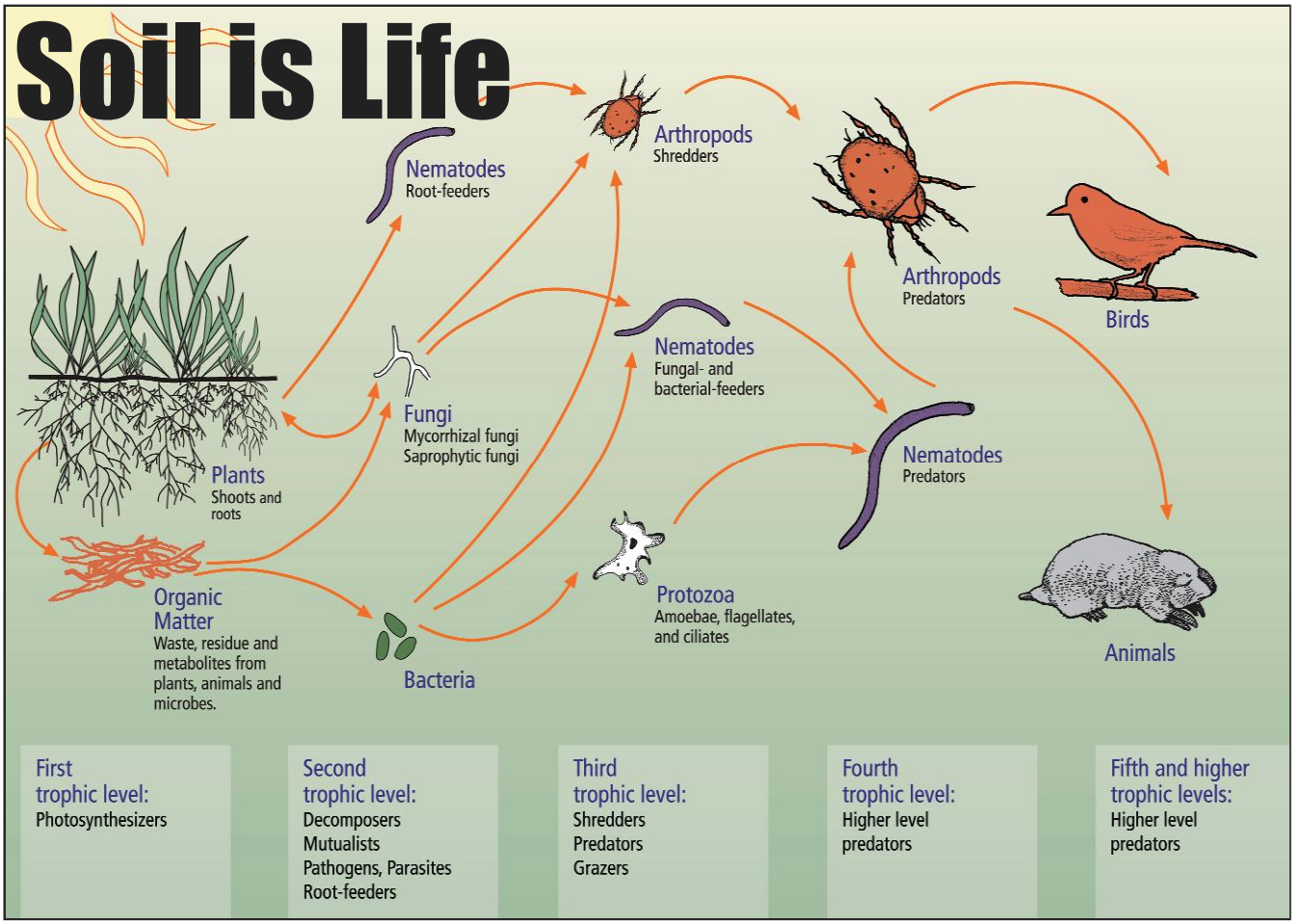
Water as energy

Water is constantly flowing through living systems. As soon as there is a drought, or some other kind of water shortage, we are instantly reminded of just how much life depends on water. We store water in dams and reservoirs, in tanks and bottles and in moist, fertile soils. All of these are strategies used to hold onto this vital resource.

In a world in which climates are rapidly changing we are reminded that we should expect periods of both shortage and deluge - in other words, droughts and floods. If we are wise we will have to prepare for this in

Practical Activity: Harvesting memories

Anyone old enough to remember the 1930s or 40s will also remember the world before we had abundant cheap energy. What questions would you ask about how life has changed most significantly in the time since then? Is there anything we used to do then that might be really useful to bring back now?



as many ways as we can. How many different methods of water capture and storage can you come up with? If we depend on plants for our energy then we also depend on soil. Without healthy topsoil there is no possibility for life on Earth. It is vitally important that we understand just how important soil is! Those fifteen inches or so of weathered rock and decomposing organic matter are what we, and every other living creature, depend on for our survival. It would be sensible for us to think about our soil, and to value it a whole lot more than we currently do.

Activity: It is probably not something you have thought about before, but what does soil mean to you? What does it make you think about? What impact does it have on your wellbeing? Write a paragraph explaining what soil means to you and why.

Soil is amazing, it is alive -- full of life in fact! There is more life -- more diversity and interactions of organisms under and within the soil than what we observe above ground. In the same way plants give off sugars in the form of nectar to entice pollinating insects, they also give off sugars through their roots to entice soil organisms to work with them. Fungi, bacteria and microscopic worms exchange minerals and other nutrients with plants through their roots in return for sugars, giving them the energy they need to continue working for the plants. The more scientists study soil the more complex its biology and chemistry are found to be.

Activity: Research the key ingredients in soil. What are they? Are all soils the same?

Soil is the ultimate store of energy and if we humans wish to carry on living on this planet then we will need to work with it much more carefully than we currently do. Our farming methods of ploughing -- which leave soils bare for months at a time -- and use of big heavy machinery -- which compacts and squeezes the air out of the soil harming soil life and causing erosion and flooding -- will have to stop. Soil is also the place where most of the world's carbon is stored. Too much carbon in the air in the form of carbon dioxide is what is driving climate change. More carbon in the soil makes it more fertile and better able to store water. What we need, then, are methods of capturing carbon and storing it in the soil where it belongs.

Observe natural processes going on around you

Composting and Mulching

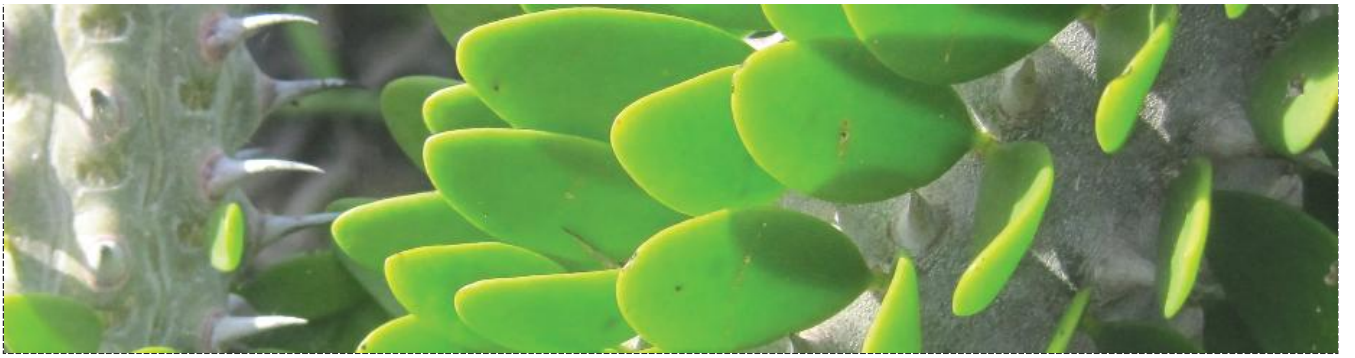
Activity: Now that we have talked more about soil, have your views about its importance and meaning for your wellbeing changed? If so, how?

One method of catching and storing carbon in soil is by making compost. Compost is a mixture of bio-degraded organic matter and living micro-organisms. When added to the soil, compost boosts fertility by adding nutrients and locking in carbon. It is very easy to make compost at home. Layering brown materials (rich in carbon) with green materials (rich in nitrogen) and keeping it moist and protected from the hot sun and daylight allows bacteria, fungi and insects to rapidly break down the organic matter into a stable compound know as humus that will boost fertility and soil life over time.

Another simple way of catching and storing energy in the soil (this time in the form of water, nutrients and carbon), is through mulching. In nature, soil is very rarely left bare and open to the elements -- it is usually covered with vegetation living or dead, which forms a blanket of protection for the soil below. Making use of this observation, we can copy nature and cover our soil to protect it too. Mulching involves covering the soil with organic matter to form a blanket, you could use leaves, wood-chip, straw or even cardboard to do this. The mulch protects the soil from the sun, preventing the evaporation of moisture. In heavy rain the mulch absorbs water and helps to prevent soil erosion. As it bio-degrades, carbon and nutrients are added back into the soil, making it more fertile.

Activity: We can do a simple experiment to see how important it is to keep soil covered. There is an excellent video in our resource sections showing this experiment in action. Can you replicate the experiment with soil gathered from your school? Are there any areas in your school that would benefit from being covered over with mulch?

Keeping soil covered with organic matter keeps it from drying out, feeds the soil microbes and builds fertility over time.



Unit 4: Obtain a Yield

Orchards high in the Atlas mountains in Morocco, working with nature to create yields.

"You can't work on an empty stomach."

Nature doesn't just catch and store energy in all its forms, it also creates yields. Every part of a system has to be fed for that system to continue. In the West we have become very detached from our food producing systems. Our food seems to 'miraculously' arrive in the shops, often processed to such an extent that we can no longer recognise where it has come from, or how it was made.

Activity: What is a yield? Write down some ideas.

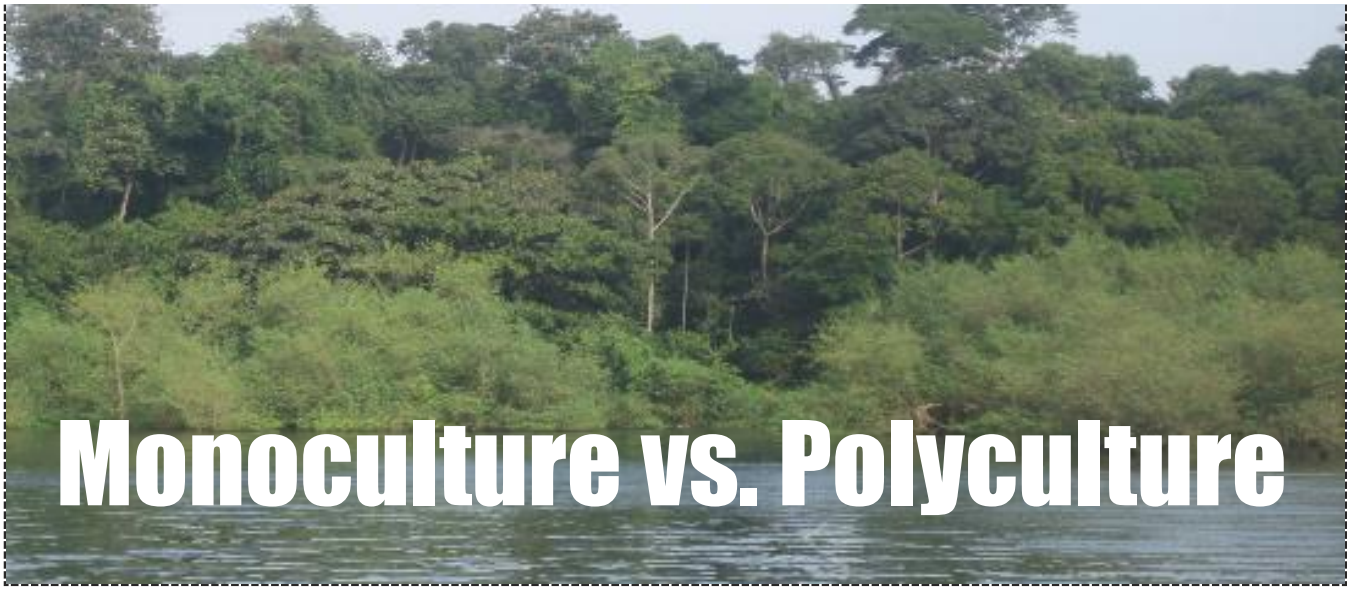
In the UK we are fed by the world through a complex delivery system that is wholly reliant on petroleum-fuelled transport and communications, and highly complex computerised payment systems. The hard fact that we have to face is this, the food on our plates, delivered by a globalised food system, consumes enormous amounts of energy in terms of the diesel, petroleum and petrochemical fertilisers and pesticides that went into producing it. Add to that the processing, storage, packaging and waste collection, it is easy to understand how it is possible for there to be 10 calories of oil energy for every calorie of food we eat. This is not sustainable!

What is a pest?

Large scale farming systems create the perfect conditions to create pests. Huge fields of a single crop create the conditions whereby insect populations can quickly multiply and decimate the crop. Contrast this to a mixed patchwork of small fields each growing a mix of different crops, which is a much more traditional way of producing food crops. This method makes it hard to harvest by machine but wide mixes of different plants, surrounded by trees, shrubs and more, create a range of conditions where not only potential pests are encouraged but so are their predators. In other words these kind of mixed systems make life much harder for what might be seen as a pest and tend to favour the birds, lizards, frogs and mammals that help regulate the populations of all the species in the system. There is much to learn from traditional systems and in our search to maximise production we have damaged the natural biodiversity and its ability to self regulate.

Activity: Take a look at the labels on food in the supermarket next time you are there. Make a note of where the ingredients in your food come from. What is the furthest distance your food has travelled?

Long term yields build over time



Monoculture vs. Polyculture

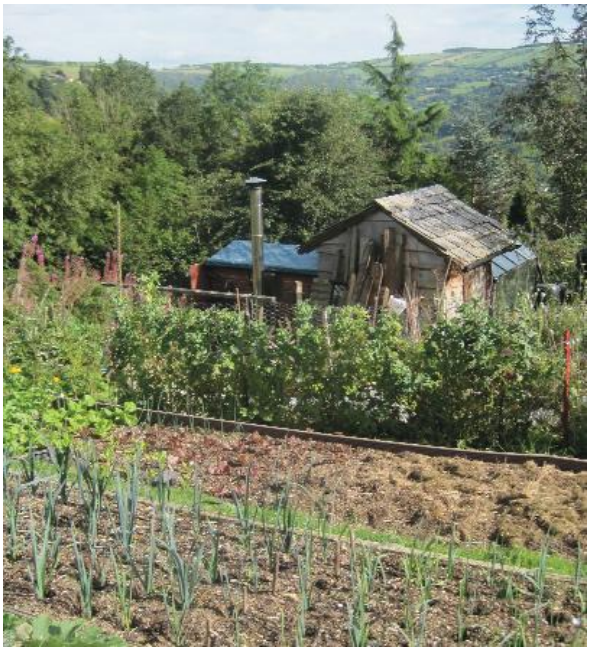
Most of the UK's vegetables currently come from green-houses in the South of Spain, an arid region and they are grown using ground-water pumped from many metres below the surface. Many of the workers are migrants from North Africa working for very low pay, and the produce is trucked or flown 2000 km to the UK in refrigerated units. The energy cost is high, and any disruptions in the supply chain would mean we would have almost immediate fresh food shortages in the UK.

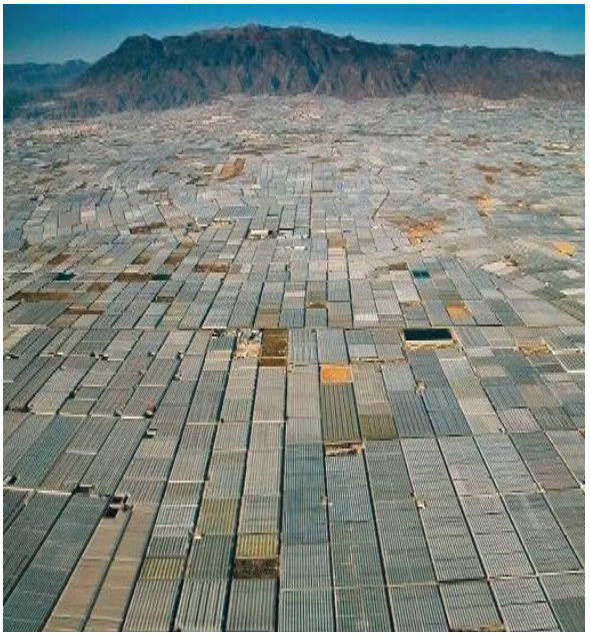
This is the Garth Organic garden in Glyn Ceiriog, Mid-Wales. It is run mainly by volunteers and is supported by very small amounts of funding. It produces fresh vegetables and fruits all year round for local consumption. All production is or-ganic, they grow green manures and make compost to keep the soil fertile. They also offer support and training for new growers keen to learn skills, and carefully monitor wildlife and biodiversity -- which continues to increase every year that they continue their work.

Across the world and UK included there is a resurgent inter-est in organic growing, small scale farming and community supported agriculture. There is a desire to blur the edges be-tween producers and consumers, for real food security it is suggested we should all be involved in producing at least some of our own food or participating more actively in things like community gardens, allotments and orchards.

The fact that we have all become so reliant on non-local food systems means we have lost touch with the soil and the nat-ural world and this lack of connection in some ways explains how this environmental crisis has come about.

Activity: Discuss and record your thoughts on the relative strengths and weaknesses of the two food production systems dis-cussed above. How might issues such as climate change and declining oil reserves affect the two systems in the future?





Contrast the diversity of the top image to the simplified farming system that has replaced it.

No Bare Soil

Wood Sorrel covering a forest floor, trapping moisture and protecting the fragile soil.

Farming is the source of 5 Gt of carbon dioxide. According to the Paris Climate agreement over the next 30 years it has to move from being one of the largest sources of carbon entering the atmosphere to being one of the main ways we remove excess carbon from the atmosphere. As we have already seen, by returning carbon to the soils it becomes and asset rather than a problem.

One of the main problems is ploughing. Large scale farmers regularly plough the soils to turn in weeds, bring up nutrients from deeper down in the soils, and to prepare the land for new crops. The problem is that in nature such a thing would never happen. Our rich soils formed under the cover of a permanent forest canopy, or beneath pasture. In nature soils are never exposed to the sun, wind and rain except on very rare and exceptional occasions.

Activity: When might you find bare, exposed soil like in a ploughed field in a nature? How many ideas can you come up with?

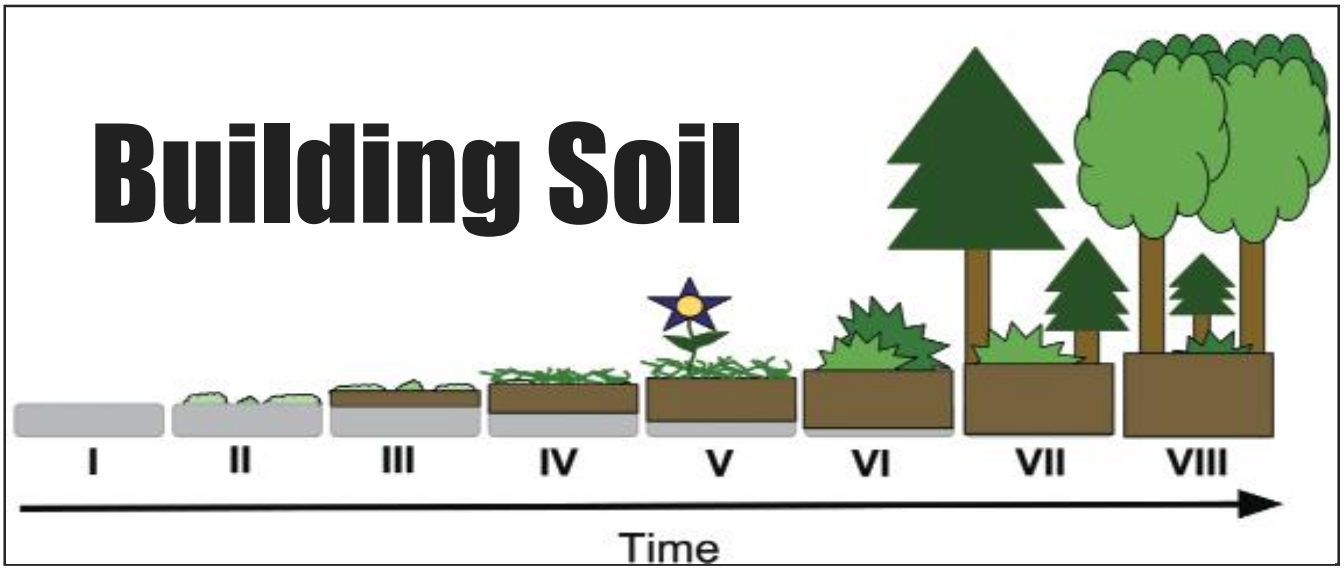
Natural causes for bare soil:

- Large tree falling
- Landslide
- Flood
- Fire
- Animal digging...

These are all things that would only ever happen very occasionally and the soil would be quickly covered by wild plants again to minimise damage. When precious soils are exposed to the sun the carbon - from dead plant matter, soil organisms, and so on - oxidises. That means it combines with the oxygen in the atmosphere to create carbon dioxide - the very thing that drives climate change.

The bigger the plough the more it can damage the soils. Industrial farming will have to tansform its practices if we are to curb the climate crisis.

The life in the soil is everything



Succession is the term used to refer to the way that ecosystems develop over time. Beginning with an area of land devoid of any plant species, specially adapted plants (known as pioneer species) colonise bare ground and start the process of transforming the environment to support other species. Each stage of succession is referred to as a sere. At successive seres the plant community tends to become more biodiverse, and so more complex. This culminates with a relatively stable plant community known as a climax. Succession works as plant species change the structure and nutrient content of soils.

Primary Succession refers to the changes in plant species and soil composition that take place in a habitat that has never been colonised before. Lichens, mosses and other pioneer plants grow on bare rock, and gradually build up the soil and its fertility, making it suitable for larger more complex plants to move in.

Secondary Succession refers to changes in plant species on land that has already been colonised, but has since been disturbed by human or natural activity. For example, after felling trees in a woodland, following land clearance, or in the event of fire. Gradually, again, the successive plant species transform the structure and nutrient content of soils, making it possible for the system to once again reach climax vegetation.

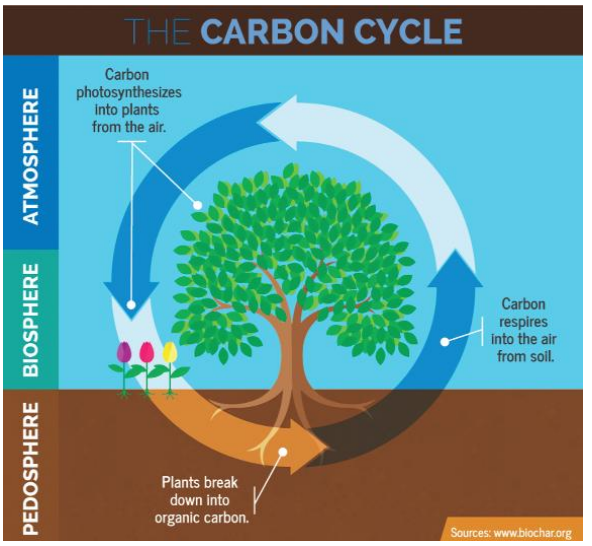
Forest systems like this roof garden at RISC centre in Reading constantly build their own soils.

The theory of plant succession was pioneered by biologist and botanist Frederic Clements (1874-1945) in 1928. He suggested that plant communities could be thought of as living organisms. Today succession is understood to be a much more complex process, but the general idea still has relevance. It helps us understand how plants cope with disturbance, and how they generate opportunities for more complex organisms to follow.

Activity: In what way do you think modern farming techniques prevent natural succession from taking place?

Practical Activity: Have a look around your home or school for areas that could be allowed to go wild. Make a record, using photography and video, to show what happens when succession is allowed to take place naturally. What sort of plants grow? What happens to the soil? What can we learn from this?

The Carbon Cycle



Organic growing systems are always centred around returning carbon back to the soil e.g. with manure, compost, green manures -- and are usually concerned with keeping the soil covered with crops, tree cover, and dead organic matter (mulch) to emulate the succession that we see in natural systems. In industrial agriculture this constant loss of carbon means that fertility and water retention are always decreasing; often compensated for by adding fertilisers (made from natural gas), and irrigation: pumping water using diesel powered pumps. Farming practices are going to have to change radically in the coming three decades! There is much scope for innovation and problem solving.

Activity: Research the carbon cycle. What is it? How does it relate to climate change?

The Biochar solution

We have been experimenting with the process of wood pyrolysis. This involves cooking wood to create wood gas, which burns cleanly while also leaving a pure carbon residue that can be used as an additive to soil and compost. Biochar can also be added to the feed of ruminant animals to reduce methane emissions by improving feed efficiency. Biochar is then transferred into the soil from dung through the action of beetles and other insects.

We conducted an experiment (see left), where we poured a glass of water into a glass of biochar. The biochar has such a large internal surface area that the water doesn't overflow. This proves that two into one can go! High carbon soils allow more rain-water to infiltrate and hold onto it for longer. The air and edges they create provide habitat for soil microbes, boosting fertility and productivity. This is an example of one of the many small and solutions that could be scaled up and utilised around the world, building soil, fertility and reducing flooding.

Food Production

"The greatest change we need to make is from consumption to production"

~ Bill Mollison.

Permaculture founder Bill Mollison made it very clear that our lives of consumption make us very vulnerable to changes in the climate (as well as in the economic system). An over-reliance on imported foods and petrochemical agriculture will leave us exposed to sudden changes. It also takes the pleasure of local food growing and the community connections that come from that work away from us.

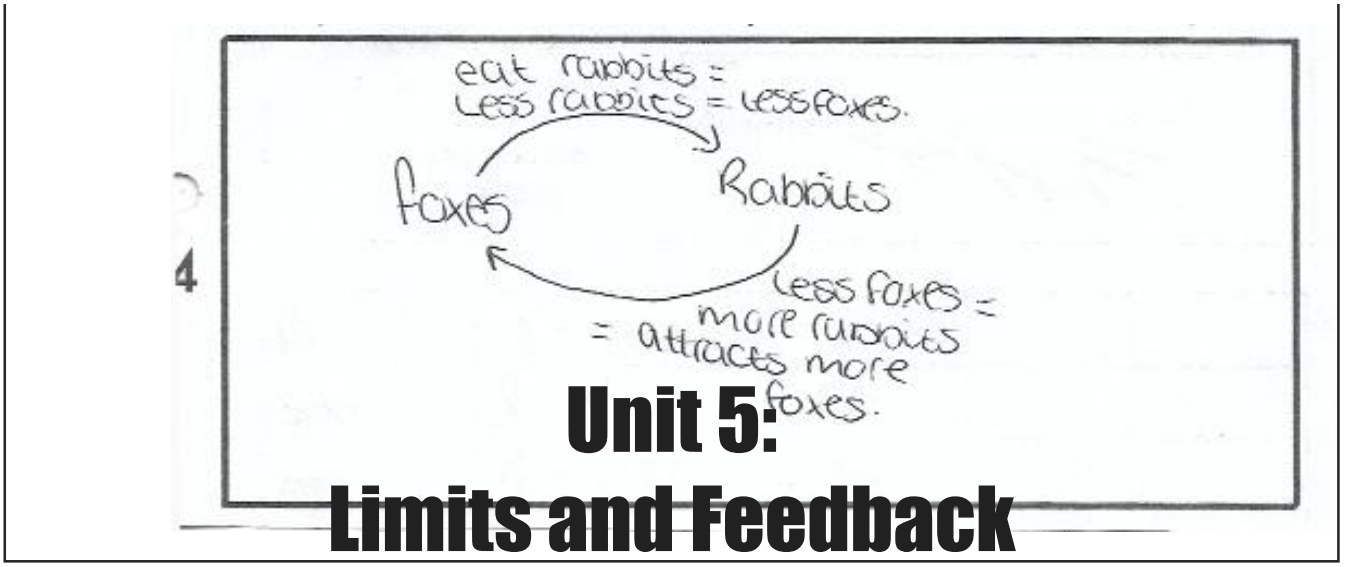
Organic growing on soil made from food waste at Newtown's urban farm: Cultivate.

Permaculture design suggests that a significant proportion of food production will have to be re-localised, and that families, schools and whole communities would be wise to begin to produce at least some of their fresh fruit and vegetables. By making simple changes, like keeping chickens for free range eggs, farming fresh water fish, and cultivating and growing mushrooms, we can create a more climate friendly -- and so also more climate resilient -- food system that can also help us reduce carbon emissions and help fight climate change.

Examples of community responses might include:

- More allotments and home and family gardens.
- Community supported agriculture schemes, where the public develop close relationships with local farmers to produce affordable and local organic foods.
- Community food growing spaces, where orchards and small scale field production happens in public and shared spaces, managed by professional growers but with most of the work carried out voluntarily in return for food.
- School gardens, where students work with teachers and professional growers to produce and process fresh produce for school and local consumption as part of enterprise and skills training schemes.
- Urban farms and gardens have a huge untapped potential.
- Protecting and enhancing edge spaces for wildlife and biodiversity.

Activity: What would you choose to grow at school if you had the opportunity? Think about what sort of plants would thrive in the grounds of your school, and about how useful they would be for the school community. What would be the benefits of having a school garden?



Unit 5: Limits and Feedback

Humanity is one species sharing a single eco-system. Solving the climate challenge will require us to work with this realisation.

"The sins of the fathers are visited unto the seventh generation."

Unit 5 is all about feedback. In the 1950s and 60s -- before we had even visited the moon -- there was an intense fascination (as indeed there still is), about life on other planets. A British scientist called James Lovelock, who was then working for the space agency NASA, was assigned the task of working out if there might be life on other planets.

Lovelock knew that by refracting the sunlight bouncing back to Earth from the planets he could determine the chemical composition of their atmospheres. As the light travels through the gasses of another planet's atmosphere it interferes with the structure of the light beam in distinctive ways. Armed with this knowledge he and his team started studying the atmosphere of nearby planets like Mars and Venus. He asked the key question: What would the chemical signature of life on another planet be? What do you think?

He realised that the answer is oxygen. Oxygen is the most reactive element and will react with whatever is around. It reacts with carbon to make CO_2, hydrogen to produce H_20, and iron forming Iron Oxide, FeO (better known as rust). For oxygen to be present it has to be continually produced by some means, otherwise it would all react away.

"Oxygen is too chemically-reactive to remain a free element in air without being continuously replenished by the photosynthetic action of living organisms". (Wikipedia)

Activity: Research the work of James Lovelock and write a short newspaper article (200-300 words) about 'Gaia Theory.' The article should include what 'Gaia Theory' is, how Lovelock came up with it, and how it helps us to understand our role in climate change and what we can do to face up to the challenge.

Nature is driven by feedback loops

Where Did Our Oxygen Come From?

Life creates the conditions for life. This was a startling realisation for scientist James Lovelock when he was asked by NASA to investigate life on other planets in the 1960's. He asked himself what would be the tell-tale signiture of life in an alien atmosphere? Oxygen, as it is so reactive, it would need to be consantly produced to be present in the atmosphere. Then he wondered where did our oxygen first come from and he looked into the gelogical record and discovered fossilized organisms know as stromatolites that were the very first organism to photosynthesise and start releasing oxygen, creating the condition for complex life in the future.

About 3.7 billion years ago when the planet was mainly shallow warm seas a new organism evolved called Stromatolites. They are still around today, but back then they were a new and relatively advanced life form. We have much to thank them for because without them we would not exist.

This fossil is in the Welsh national museum in Cardiff. It is 3.57 billion years old and shows the first living organism to create oxygen. It was the action of these stromatolites that made it possible for more complex life forms to come along later. All of our oxygen is produced by plants through the process of photosynthesis!

Stromatlites, these strange organisams have been around 3.6 billion years.

Deforestation rates are slowing down but much has been lost.
UK has the second lowest amount of forest cover for any country in Europe at about 12% What effect might this deforestation have on human society if it continues? Why?

Activity: 'Daisy World' is a video simulation created by James Lovelock and colleagues to show how the Earth functions as a self-regulating system. Watch the video and make notes before moving onto the next section of Unit 5, which focusses on the ways in which nature maintains balance:

www.sector39.co.uk/small&slow

Summary: In your own words, explain the Daisy World model. What is the key principle it illustrates? Have a go at drawing your own double feedback loop.

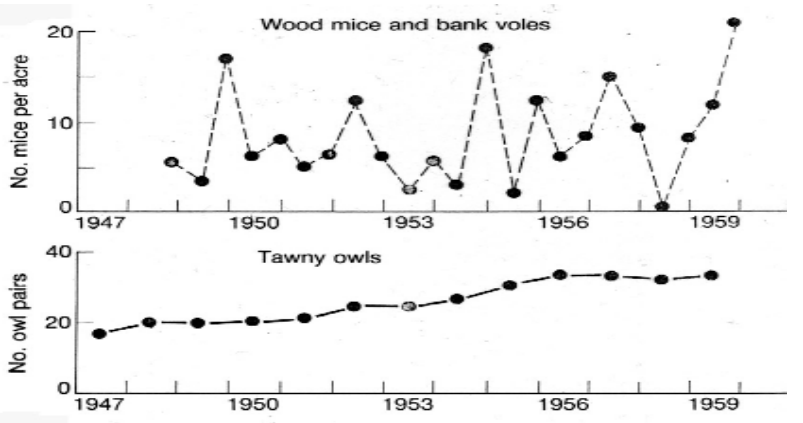
Dynamic Equilibrium

Nature runs on a dynamic equilibrium. It sounds technical, but really it's just like riding a bike. To keep upright the rider makes constant adjustments, wobbling left and right to compensate for uneven ground and the shift in weight as the rider pushes on the left pedal and then the right. This constant adjustment happens almost unconsciously, and together with the forward momentum means the bike never falls over. Nature works in the same way: many different species interact with each other, spotting opportunities as they arise and withdrawing into safety when the they end. Mice and owls are a good example of this natural balancing act in operation.

Small rodents become fertile at two weeks old and have a gestation period of two weeks (staggering if you think about it!). If good conditions exist and there is an abundant supply of food a population of mice can multiply from one breeding pair to thousands in a matter of months.

This is turn might trigger a rise in population of owls -- or any other predator -- who quickly seize on such an opportunity to focus their attention on this new abundant food supply so they can begin raising young of their own. This, in turn, will affect the population of mice, which will dip in number as the predators become more reliant on them to feed. A dropping number of mice might then lead to the owls moving further afield to look for food, slowing their own ability to successfully raise new chicks.

Populations self-regulate through dynamic, ever-changing relationships. This is a key idea in understanding the processes that allow natural systems to self-regulate. Can we use design to build feedback loops into human systems?



Nature's diversity creates a counter balance

Homeostasis

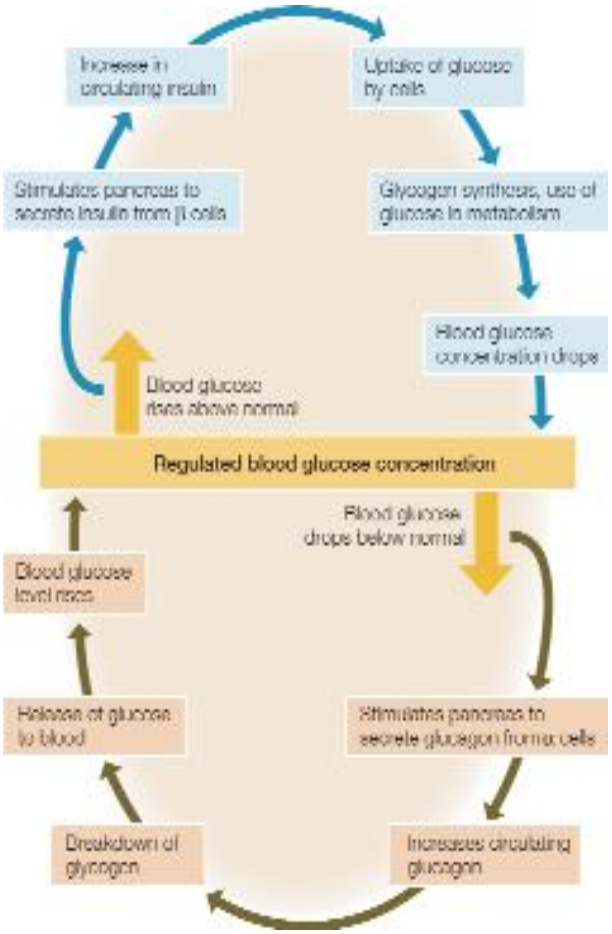
There is a similar kind of relationship going on in our bodies, helping regulate temperature, oxygen and sugar levels along with many other. This is known as homeostasis.

Definition of homeostasis:

"...a relatively stable state of equilibrium or a tendency toward such a state between the different but interdependent elements or groups of elements of an organism, population, or group..."

(Merriam Webster Dictionary).

A rise in the blood sugar, following a meal is detected by a special part of our brain, and this stimulates the pancreas, an organ in the digestive system that produces the hormone insulin. Insulin stimulates our bodies to break down sugars, and to either use the energy or store it for future use. As the body burns up the available sugars so the sugar level in the blood decrease, which in turn reduces the production of insulin. The drop in blood sugar also stimulates the hunger sensors in the brain, triggering behaviour to seek more food and thus raise the blood sugar level again. This is called a negative feedback loop -- where two variables are inversely linked. This is one of the absolute key ideas as to how nature works and as designers we are advised to bring this ability for systems to self-regulate into our plan-



The blood sugar-insulin feedback loop.

Practical Activity: IPM (Integrated Pest Management)

IPM is a key idea in organic farming and growing. Permaculture challenges the gardener to think outside the box with statements such as "there is no such thing as too many slugs, just a deficit of ducks, who love to eat slugs." Hoverflies and ladybirds love to eat greenfly. Slow worms also eat slugs and other potential pests. As we have seen, nature is built on dynamic relationships that self-regulate as they develop. Adding open water, even on a very small scale, is a really great way to diversify an ecosystem of any size. Why not construct a frog pond? You can observe the transformation as it comes alive. It could be as simple as sinking a container into the ground and filling it with rain water. Make sure any small creatures that might fall in can get out again using rocks and small stones. One side of the pond should be flanked by vegetation for shelter and habitat. It is season-dependent, but it does not take long before insects and other pond life simply turn up and begin colonising the space you have created for them. Make observations of the processes of succession that take place, and make a record of any other visitors to the pond.

Ecosystems

Tropical forest ecosystem, Mabira, Uganda.

ning.

Ecosystems are much more complex than the feedback systems discussed before, so it is worth taking so time to explore what they are and how they function.

Here are two standard definitions of the term 'ecosystem':

"An energy-driven complex of a community of organisms and its controlling environment" (Billings, 1978)

"An ecosystem is a community of living organisms together with the physical processes that occur within the environment" (Pullin, 2002, cited in Dickinson & Murphy, 2007, p. 2)

Activity: What are the key features of these two definitions? What do they emphasise as important aspects of ecosystems?

An ecosystem includes all of the living things (plants, animals and organisms) in a given area, interacting with each other as well as with their non-living environment (weather, earth, sun, soil, climate, atmosphere). Ecosystems are the foundations of the biosphere and they determine the health of the entire Earth system. The biosphere extends from about 0.5km below the floor of the ocean, up to about 6.5km above the Earth's surface (Dickinson & Murphy, 2007, p. 2). In an ecosystem, each organism has its own niche and role to play.

Permaculture design works to emulate the complexity of natural systems. Can we design not to just to feed ourselves but to feed nature and build soils, whilst also producing materials for building or to burn for energy? Permaculture seeks to generate a range of outputs from every system, choosing elements that offer many benefits, not just a single use. Permaculture likes to challenge the designer with the idea that there is potentially no upper limit to the number of species in an ecosystem, you can always add one more! This also introduces the idea of *stacking,* nature builds in 3D, not just covering the ground but growing in three dimensions. Tree roots build associations with fungi and microbes in the soil, they provide a structure that can harvest sunlight whilst providing providing nesting sites to birds, insects and even mammals.The droppings of these creatures feed the soil and boost its fertility, creating more opportunities for further life.

Many species working together create an ecosystem

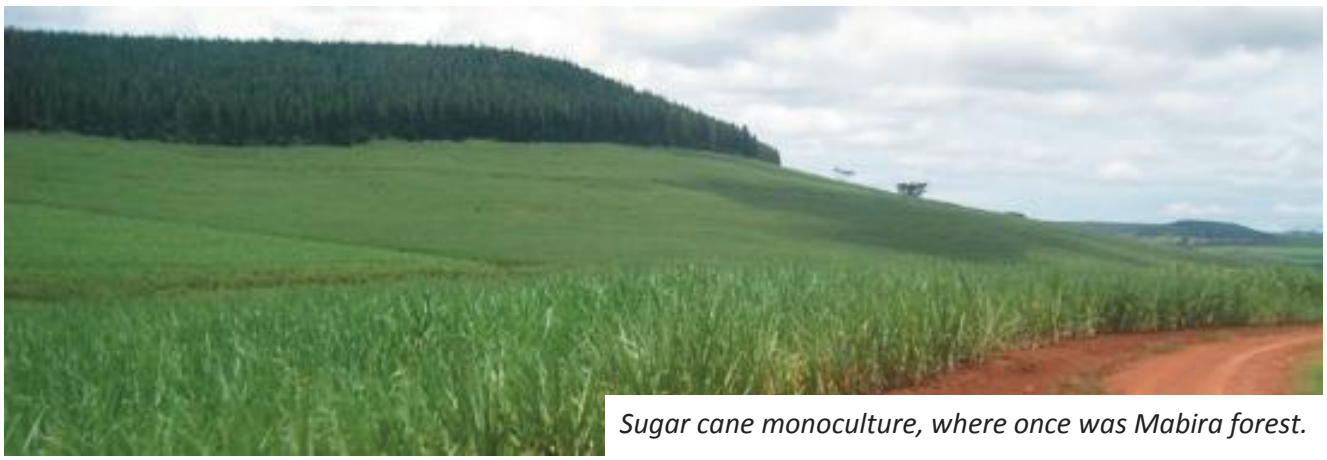
Keystone Species

A keystone species is a species that has a large effect on its natural environment even though there might not be many of them in the ecosystem. Just like the keystone in a bridge, if a keystone species is removed, the ecosystem will collapse. The concept of keystone species was developed by the biologist Robert T. Paine (1933-2016). The standard view in ecology had been that ecosystems are maintained from the bottom up – in other words, that ecosystems are built on a foundation of plants. Robert Paine's research on sea urchins, however, suggested that ecosystems are also maintained from the top-down, by predators. Predators feed on herbivores. What effect do you think predators have on plants lower down the food chain?

Predators reduce the abundance of herbivores, allowing plants to flourish. This observation came to be known as the green world hypothesis.

In 1979 Robert Paine and others put forward the idea of **trophic cascades**. This is the notion that species at, or near, the top of the food chain directly and indirectly regulate the species and population sizes in the rest of the community. This means that, counter to what we might at first expect, biodiversity depends on predators.

Whales are keystone species in ocean ecosystems.



Sugar cane monoculture, where once was Mabira forest.

Certain species punch above their weight

More Whales = More Fish?

Humpback whale breaching.

The largest mammals of all -- whales -- mainly eat large shoals of small fish, or krill -- a kind of shrimp. Fishing nations such as Japan have argued that their practice of whale hunting regulates the number of whales, which in turn makes more fish available for humans to catch. What the whales don't eat leaves more krill to feed the smaller fish and therefore more for us humans to catch, so their argument goes. It does seem to make sense, that is until you consider how marine ecosystems work.

Whales actually play a very important role in marine ecosystems. Blue whales, for example, can consume vast quantities of krill, up to 40 million per day, which would quickly overpopulate an ecosystem if left unchecked. Whales also play a vital role in marine nutrient cycles, moving nutrients up and down between the surface and the sea bed. Whale's are also helpful in the amount of carbon they help to sequester. Sperm whale poo, for example, contains vital nutrients necessary for phytoplankton to thrive, which draw down carbon from the air in vast quantities through photosynthesis. Phytoplankton are also an essential source of food for fish, so the more phytoplankton in the ocean, the more fish!

The complex interactions between living things and their environment is the foundation of energy, carbon and nitrogen cycles, and consequently they have a major impact on the global climate. In the supporting video, George Monbiot explains how whales and their role in ocean ecosystems have an influence on climate change. This is an excellent introduction to systems thinking and natural feedback cycles.

Supporting Resources Online

There are a great many relevant videos and sources of information available on the *Sector39* website. They are arranged according to the chapter headings in this book and there is a list of resources for each chapter. You will find a short description of the suggested video, running time and key points. You may also view the videos from within the resource page.

www.sector39.co.uk/small&slow

How Wolves Change Rivers

In the 1920s, government policy in the US allowed for the extermination of the Grey Wolf in what is now the Yellowstone National Park. The Grey Wolf was the apex predator in the Yellowstone ecosystem -- a keystone species. With the removal of the apex predator, the Yellowstone ecosystem began to break down.

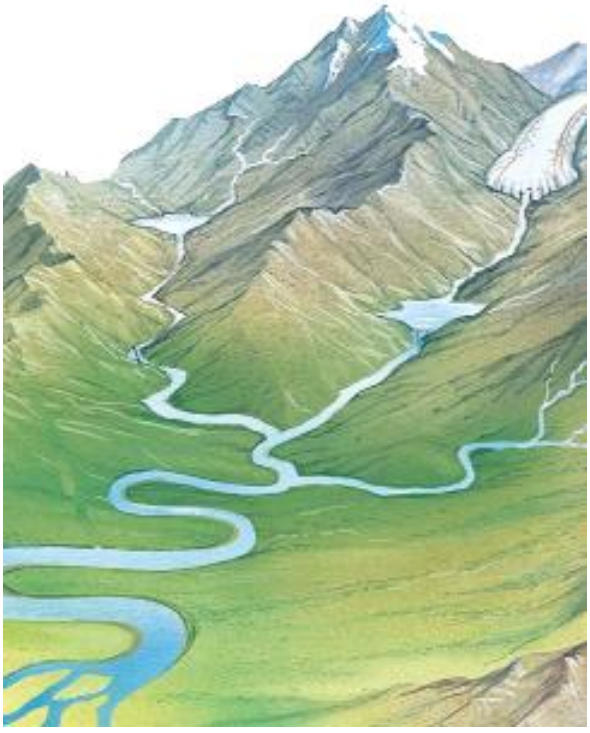
In the 1940s a growing movement of conservationists, environmentalists, biologists, and park officials supported reintroduction of the wolves to Yellowstone. In 1995 the authorities moved forward with a plan to reintroduce wolves to the park. In the twenty years since the reintroduction of the wolves, scientists have noticed many positive changes to the park ecosystem.

Activity: Watch the short video 'How Wolves Change Rivers,' then answer the following questions:

What happened to the Yellowstone ecosystem in the absence of wolves?

Create a food chain of three organisms involved in a trophic cascade in Yellowstone National Park.

In your own words explain how the re-introduction of wolves in Yellowstone National Park impacted the shape and flow of rivers.



Complex river systems are shaped by the biology around them.

More Whales = More fish. See the excellent short video exploring the relatiohsips between key elements in the ocean aquatic system. Whales drive a huge and complex nutrient cycle in the oceans that in a round about way improves fertility and keeps valuable nutrients within the photic zone, or sunlit layer of the oceans. The video is narrated by zoologist, naturalist and author Geoge Monbiot.

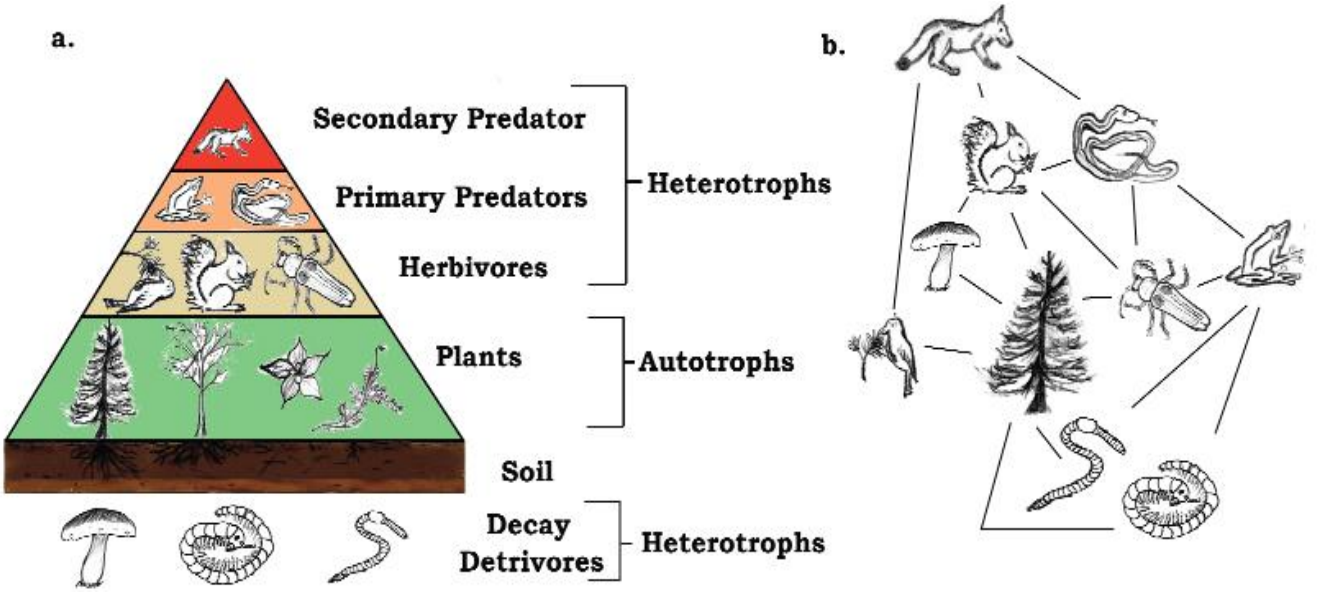
How Wolves change Rivers. Another excellent short video, and a fascinating accout of the impact of predators on a large natural system. Grazing herbivores, wary of wolf attack avoid certain parts of the valley, allowing a different vegetation pattern to emerge -- one that supports many more ecological niches and opportunites for diversity. This is a wonderful illustration of the 'everything is connected' view of natural systems.

Food Webs

Permaculture trainees in central Africa using permaculture to design farming systems based on natural principles.

The simple food chain model has more recently been replaced by the idea of a food web. Food webs are much more complex, they consist of more than one food chain linked together. The notion of the food web helps us to understand that consumers can obtain food from populations at different trophic levels, and that the elements within natural systems are connected to one another by more than one link.

Activity: It is possible to map out the connections in an ecosystem with a ball of string! Choose an element in an ecosystem, e.g. a fish in pond, a squirrel in a forest, plankton in the ocean, etc. Think of the inputs, outputs and functions offered by your element to the ecosystem. Sit in a circle and use the ball of string to trace the relationships between the elements of your chosen ecosystem. What do you notice about the pattern that emerges? Is it a simple pattern?



Everything is connected to everything else

Unit 6:
Use And Value Natural Resources

This unit is about using and valuing natural resources and services. It may sound like an innocuous idea, but in many ways modern agricultural and technological developments have caused us to forget this rule. We take so much for granted! Horse vs. Tractor? No contest! It is interesting to contrast the horse and tractor and to consider what that might mean in terms of how much our ideas of development have changed in less that one hundred years.

Powered by diesel, tractors can generate 700 horse power. With that phenomenal force there is very little they cannot do. Tractors can plough, dig and reshape the land, pull huge loads, and can be driven by a single person who can learn the skills to use it after just a few weeks of practice and training. Having such machines has allowed farmers and builders to change and dominate landscapes to fit human needs. For many farmers and engineers it is almost impossible to consider using anything else.

Activity: Draw up a table with two columns, one for strengths and one for limitations. Think about the tractor above and see how many strengths and limitations you can come up with.

A willow sculpture, 'dancing with nature' at Cae Bodfach community orchard, Llanfyllin.

Some of the problems with the tractor include: diesel is a finite resource, it causes pollution and has to be imported and refined in far-away places. Tractors need maintenance and spare parts, which are often expensive to import. As powerful as they are, they make the farmer reliant on money and technologies that cannot be supplied locally. Undeniably, tractors are great tools for setting up new systems, ploughing a new field, establishing new farms, building dams, roads and so on, but when they become the main tool for maintaining a system we end up becoming overly-reliant on non-local inputs that are expensive and hard to replace.

Now consider horses. Horses can run on local resources, grass, hay, oats wheat, they don't complete with humans for feed and they produce manure which can be made into valuable compost from which we can grow more food. If the driver of the tractor falls asleep at the wheel he will most likely end up in the hedge, whereas the horse knows the way home! What other differences can you think of? Admittedly, you can't hitch 700 horses to a single plough, even if you had that number of animals, but farmers who use draught animals tend to farm on a much smaller scale. They often work very locally and are particularly sensitive to the land

End of the Oil Age?

Extinction Rebellion. The young generation are demanding rapid change.

on which they work and depend. Rather than changing it, or trying to dominate it, they are required to work with it. Small scale farmers may produce smaller yields, but they tend to produce much more per acre and cause less damage to the land.

Oil and gas are finite resources

We have already talked about climate change and the role fossil fuels have played in causing significant changes to the Earth's atmosphere. We know that we have to move away from them for this reason, but there is another reason too - if that wasn't reason enough. As we dig deeper into the ground to extract oil and gas the amount of energy taken by drilling goes up so that the energy value of the resource goes down. This is called the law of diminishing returns in economics.

Oil companies have, naturally enough, extracted the easier-to-reach, cheap oil first. The oil pumped first was on land, near the surface, under pressure, light and 'sweet' (meaning low sulphur content), and therefore easy to refine. The remaining oil is more likely to be off-shore, far from markets, in smaller fields and of lesser quality. It therefore takes increasing amounts of money and energy to extract, refine and transport.

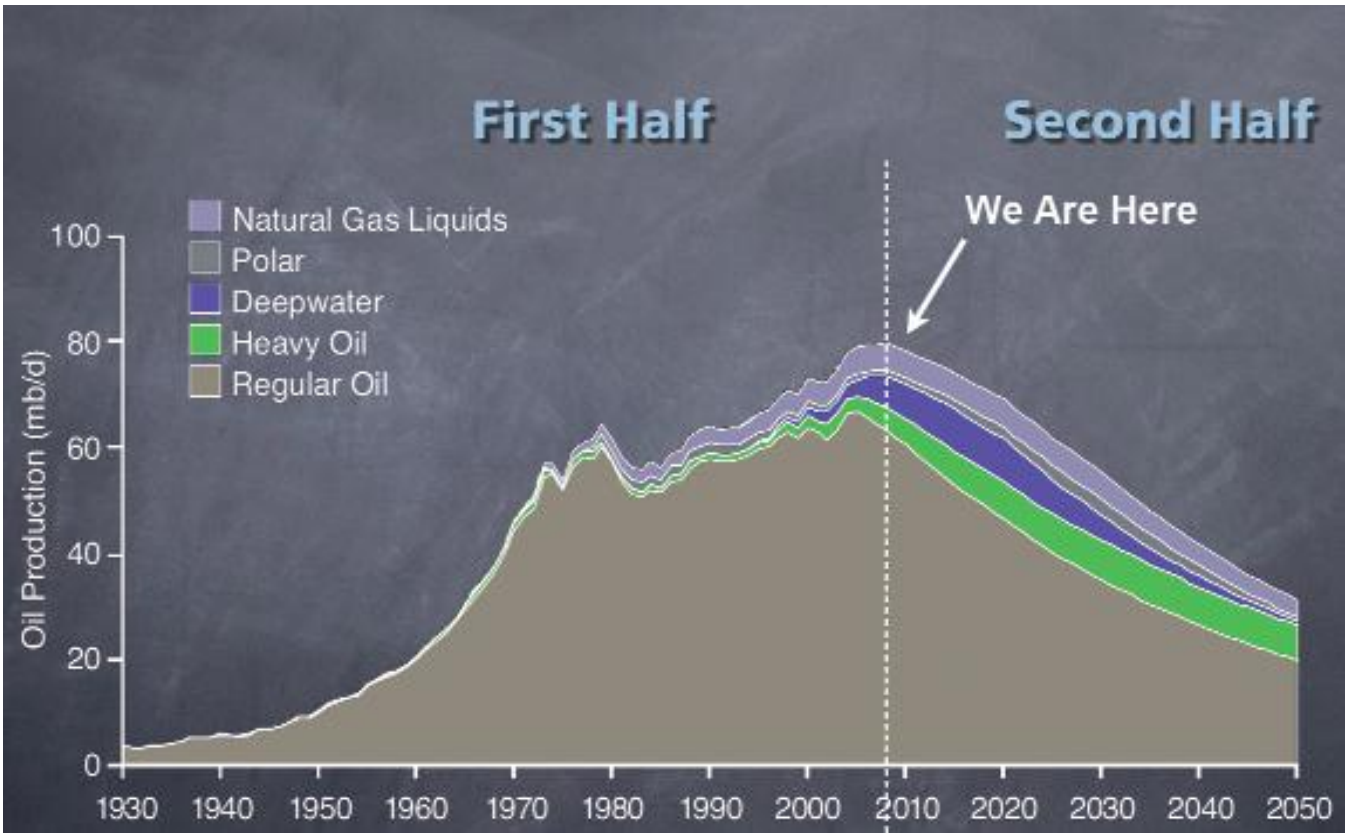
Under these conditions, the rate of production inevitably drops. Furthermore, all oil fields eventually reach a point where they cease to be economically, and energetically-viable. If it takes the energy of one barrel of oil to extract another barrel of oil, then further extraction is pointless, no matter what the price of oil.

So, oil may never run out, but extracting and refining it will cost more and more per barrel. There is a very real problem developing and it is that oil companies need the price of oil to be about US$75 dollar a barrel to make a decent profit but at that price the consumers and the economy can't afford it and they tend to go into debt. So neither position is sustainable in the long run. We are rapidly running out of cheap and easy ways of extracting oil, much faster than we will run out of oil in the ground.

Fossil fuels have powered human growth and ingenuity for centuries. Now that we're reaching the end of cheap and abundant oil and coal supplies, we're in for an exciting ride. While there is a real risk that we will

HALF OF ALL OIL HAS BEEN USED IN A GENERATION

Have We Been Greedy?

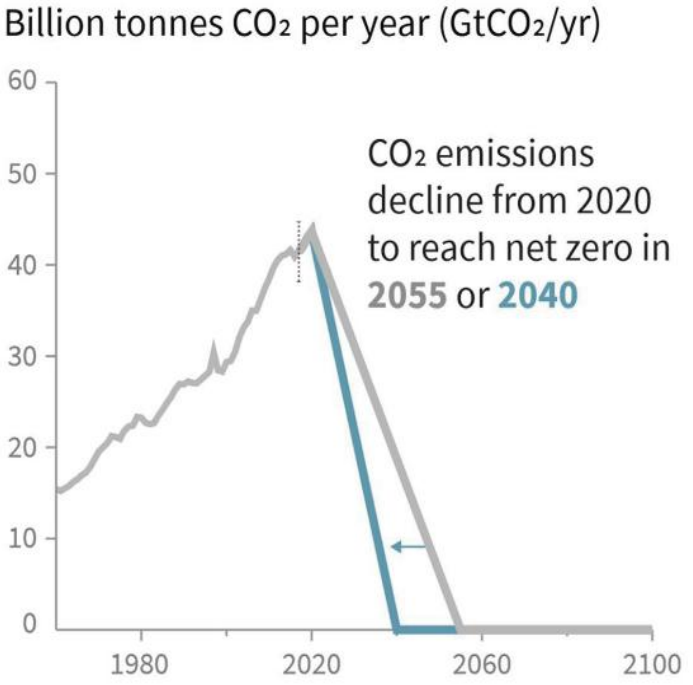


The world has already used half the oil, the easiest to extract and the nearest to market.

fall off a cliff, there's still time to control our transition to a post-carbon future. Watch the five minute video '300 years of Fossil Fuels in 300 Seconds,' created by the Post Carbon Institute, for a lightning quick overview of 300 years of Fossil Fuel consumption.

Activity: Oil is slowing becoming increasingly scarce and ever more expensive to extract. We will never run out as such, but the energy return on extraction is in a downward spiral. The World has never faced a downward sloping energy supply curve before, we really are entering a new era. As has been said before, "the stone-age didn't end because they ran out of stones, but because they came up with a better technology". Consider some of the options for our low carbon future, where will be most affected, where do the best opportunites lie for ways forward. One thing is for sure, we are going to have to learn to live with a lot less!

Energy



The world will have to transform its energy systems in a single generation. This is a huge challenge.

A brief history of energy in the UK

At the height of empire Britain was mainly powered by wind as a sailing nation. The shift to coal marked the industrial revolution which peaked in 1907, just before the First World War. At this time Winston Churchill, who was then head of the Navy, decided to commission the next generation of war ships, these would be powered by oil. This amazing new fuel - that was in liquid form and energy dense - was much better than coal. The problem was, however, that the UK did not have any oil of its own. From this point onwards, foreign policy switched to an emphasis on controlling the shipping routes to Saudi Arabia and the rest of the Middle East, which is where most of the world's oil is found. These decisions still have big repercussions today, and are behind many of the conflicts now arising in the region as different nations jostle for access to these remaining resources.

North Sea oil

When oil was discovered in the North Sea, Britain had the opportunity to join the powerful oil exporting nations for about twenty years, but that supply has been depleted and is tailing off rapidly. The North Sea oil companies are now receiving grants and tax relief from the government to keep them profitable as supplies diminish.

EROI is the measure for energy

Energy is a big subject and can be quite difficult to understand. In fact, most people - even politicians! - don't fully understand the problem. But there is a simple way to understand it and to make comparisons. It is a simple calculation called Energy Return on Investment (EROI). People ask the question how much energy is there, will it ever run out, and the answer is there is loads of energy and it will never run out! But that is actually the WRONG question to ask. Why?

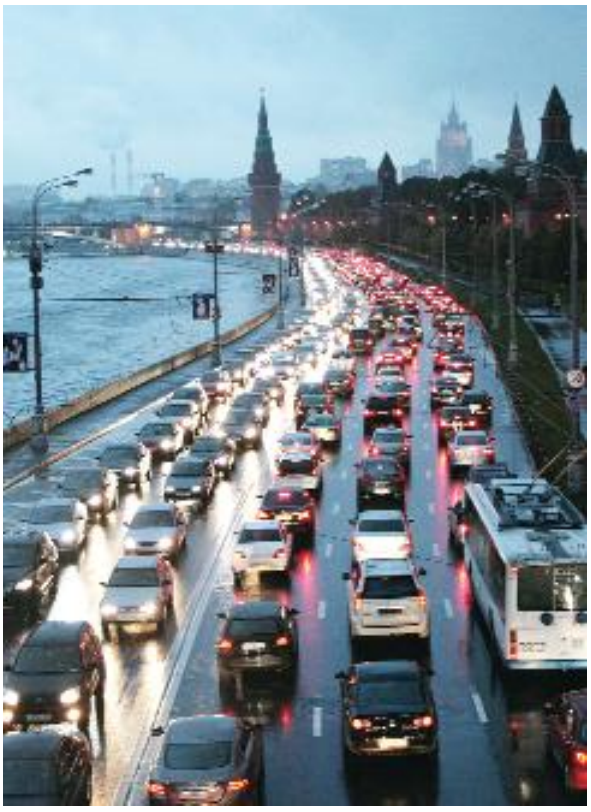
Transport

There is no such thing as free energy

Consider a solar panel up on your roof humming away on a sunny day creating electricity. Is this free energy? The answer is: No, because it takes energy to make a solar panel and to put it up on the roof. Then, over time, the panels become less efficient and things wear out so that eventually it has to be replaced. So it is not free energy, but overall the energy it produced in its life time is much more than it took to make it.

Energy from renewables like wind and solar are the best bet for meeting our future energy needs. Nevertheless, they also present us with a problem -- they only provide electricity. Electricity is very useful in the home, but most of our agricultural and transportation infrastructure runs on diesel -- tractors, pumped water for irrigation, freight shipping and more are all powered by oil derivatives. The fertilisers and pesticides used in industrial agriculture are also made from oil derivatives.

The reality is that future farming will have to move to an almost entirely organic system, using a combination of techniques that are also good for nature and help sequestrate carbon back into the ground.



Going nowhere. Cars in big cities makes little sense. It is time for a re-think?

No more cars after 2040?

The UK government has already announced that by 2040 we will be phasing out the internal combustion engine, but in reality it will have to disappear much sooner than that. Sharing cars and coming up with much more flexible transport options and more localised ways of doing things will be a big part of the solution, but we will have to begin to think and plan very differently than we do today.

Driverless cars, electric car sharing and electric taxis will become the cheapest forms of transport in cities, even cheaper than using your own car, but in a rural area like Powys the challenges will be harder as we are a very dispersed population. Oxford city has set a target of no cars within the city centre for 2030.

Natural Resources

Horse power, slow and steady, reliable and low carbon but much less power than what we have become used to.

Activity: Changes like these are going to affect every level of our infrastructure, right from the way that farmers produce crops, through to the way we travel around the country and even how we get in to school. Be as creative as possible and try to come up with a solution for getting students into school in a world with no petrol cars, vans or buses. What would you do?

This graph compares different kinds of freight transport in terms of how much carbon dioxide they emit per tonne of goods moved a kilometre. What does it tell us about the future of freight transport?

It tells us that the future for transport is big and slow. Fast forms of transport like jet planes are very useful, but in terms of moving freight around the world they are likely to become prohibitively expensive very soon.

This will have a big impact on how we import and export goods. The reality is that we will only be able to transport goods that have a high value and that don't go off very quickly -- goods that have a long shelf life. So, yes to importing coffee and no to importing water melons.

Summary: Our over-reliance on fossil fuels for everyday activities -- such as traveling to and from school, popping into town for shopping, going abroad for holidays -- is going to have to come to an end. It doesn't mean that we have to turn back the clock and live like our ancestors, but it does mean we will have to develop a new respect for the resources we have at our disposal, and reassess the importance of the many things we take for granted! Think about your school. How will it be different in a carbon-free world?

Energy is like an ATM

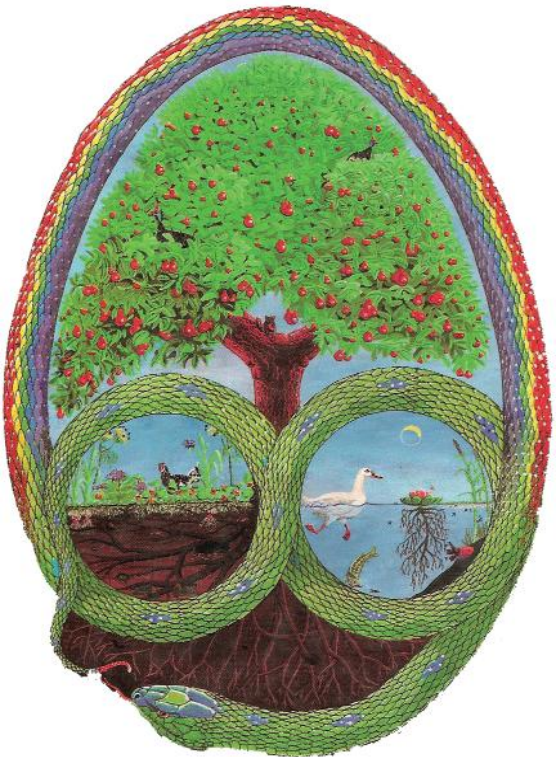
The analogy is this: We are billionaires. We will never run out of energy. It is inexhaustable, but the lesson we have to learn is that we can only withdraw a certain amount on any single day. Once we let go of the fossil fuel economy we will quickly realise that energy is limitless, but we can only access so much at any time. In other words, imagine if you were a millionaire but you can only access your wealth through an ATM that lets you withdraw £250 a day. If you can live on £245 a day and invest the rest, life only gets better, but if you live on £260 a day and your debts will only get bigger.

Unit 7:
Produce No Waste

This image is symbolic of permaculture. It was developed by Bill Mollison, the founder of permaculture design, who wrote:

"The great oval of the design represents the egg of life; that quantity of life which cannot be created or destroyed, but from within which all things that live are expressed. Within the egg is coiled the rainbow snake, the Earth-shaper of Australian and American aboriginal peoples...Within the body of the Rainbow Serpent is contained the Tree of Life, which itself expresses the general pattern of life forms...Its roots are in earth, and its crown in rain, sunlight and wind. Elemental forces and flows shown external to the oval represent the physical environment, the sun and the matter from which life on earth is formed. The whole cycle and form is dedicated...to the complexity of life on Earth."

~ Bill Mollison



The Rainbow Serpent cover design of Bill Mollison's Permaculture Designers Manual. It incorporates the symbol for infinity.

Activity: What is Bill Mollison trying to express in his use of the Rainbow Serpent symbol? Do you think it is a good way of expressing these ideas? What symbol would you use?

Also encapsulated in this image of the Rainbow Serpent is the idea of natural cycles. When we observe natural systems in the real world (a garden pond, a woodland, a desert) we see that energy and nutrients move through systems in cycles, and are never wasted. The tree at the centre of Bill Mollison's symbol is the perfect example. As we saw in Unit 3, energy from the sun is captured and stored in the leaves of trees through photosynthesis. Nutrients from the soil are absorbed through the tree's roots. Fruits form, which are eaten by animals, who extract the energy and nutrients they need from them, before excreting the leftovers back into the ground to be reabsorbed and re-cycled. In the autumn, when the leaves drop, energy and nutrients are returned to the soil through decomposition. There is no waste and the cycle continues indefinitely! Nature has a lot to teach us about how to be sustainable.

No waste in nature, can we learn this lesson?

Hedge Your Bets

Woodlice. These important creatures break down dead wood and help make new soil.

Dead hedges are a clever way to use excess materials found on or near woodlands, gardens or allotments to create simple, low tech, low cost, ecological structures that have some serious multi-functional purpose power! In permaculture we say 'every element must perform at least three functions.' Here are at least three functions of the dead hedge, can you think of any more?

Structures. Firstly they can be used as useful structures; as a boundary, to separate or create space, protect a water way such as a pond, to guide people through a space, and so on. We used ours to define the space that is the herb garden.

Habitat and mini ecosystems. Secondly dead hedges create micro-climates and provide valuable habitat for a variety of wildlife. From birds to insects, all the way down the food web, past the primary decomposers such as beetles and fungi, all the way to specialist microorganisms like protozoa and beyond. Dead hedges provide shelter, food and homes for entire mini ecosystems!

Builds healthy soil. As the dead material slowly rots it releases nutrients and, with help from our decomposer and microorganism friends, it slowly builds soil helping to increase the fertility and water retention of the surrounding soil.

Closed cycles. By not burning the excess material, and storing it in the form of a dead hedge, we are also storing carbon that would otherwise have been released into the atmosphere. As the matter breaks down carbon is released back into the soil to create a healthy, closed carbon cycle.

Principle: The output of one system becomes the input for the next system.

Applying What We Have Learned So Far

Now that we have covered the first half of the units we have arrived at a perfect point to review the programme so far. In the second half of this book we will be starting to think much more about the practical implementation of some of the ideas we have discussed so far.

Over the course of the first six units we have seen how **change is an inevitable part of life** that we must creatively respond to. That **solving problems requires observation** of the world around us. That the natural world functions through **catching and storing energy** to produce an abundance of **yields**. That **the Earth is a self regulating system** (of which we are a part) that operates through **feedback** loops and is subject to **limitations**, and that if we want to reverse the negative impact of human activity on the global ecosystem we will have to **change the way we use and think about natural resources**.

We have covered a lot of theoretical ground here (and there is still more to come), but the units in the second half increasingly emphasise the practical application of these key ideas through design, innovation and community action. Above all, the units that follow encourage a different way of thinking about our role in the Earth's dynamic system, and demonstrate how we can practically incorporate this new way of thinking into our daily lives and communities.

Graphic produced by students after a visit to the Cultivate garden in Newtown.

Infinity Is A Long Time

This large flightless bird was native to Mauritius. It was very popular with sailors as food, until it became extinct. The Dodo has become a symbol for extinction.

When we think about sustainability we still tend to think in short timeframes. Humans have been farming in Wales for a few thousand years and in that time we have lost nearly all of our woodland, most of our topsoil, and have built on much of the really fertile land, rendering it inaccessible. Nature on the other hand has been evolving here for 4.6 billion years, which really is a long time! In recent years we have developed recycling schemes where single use items like bottles and plastic containers can be used again, or reformed to re-use the materials within them. This is undoubtedly an improvement, but it pales in comparison to nature, which can re-use resources endlessly through natural processes.

Natural recycling

Nature does not produce waste. Everything serves a purpose in an ecosystem. Plants, animals and other living organisms require nutrients to form and develop. These nutrients are extracted from the soil and air through various biological processes (see discussions of photosynthesis in part 1, for example). These nutrients are returned to the earth and air when organisms die. Nutrients are released from dead organic material by microorganisms and fungi, ready to begin the cycle again.

The core idea is that nature has already solved many of the problems we are grappling with. Animals, plants, and microbes are the consummate engineers. After billions of years of research and development, failures are fossils, and what surrounds us is the secret to survival.

Activity: Think about the following questions: What can we learn from the observation that there is never any waste in natural systems? How can we apply these observations and insights to our everyday lives? Are our man-made systems as efficient as those we observe in nature?

These are some of the questions that Permaculture design work seeks to address - how best to use design ideas inspired by natural systems to live sustainably as part of the global ecosystem.

Biomimicry

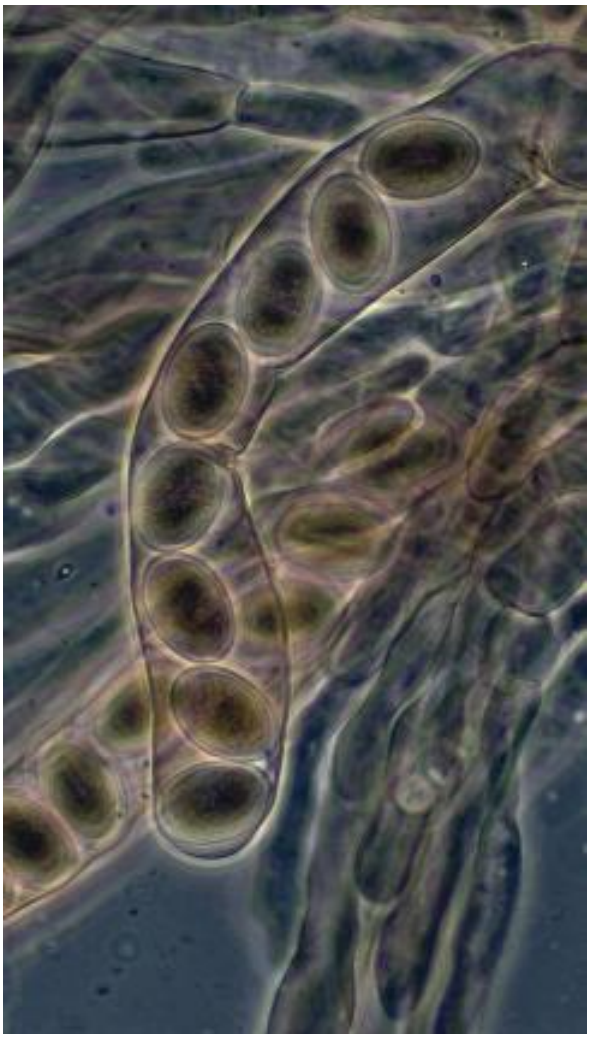
Good design links each output in such a way that it becomes an input. For example:

willow > coppice > dead hedge > habitat > healthy soil > willow

By connecting inputs and outputs we can create positive closed cycles where there is zero waste. The Biospheric Project was an experiment initiated by ecologist Vincent Walsh in 2010. His idea was that urban areas (towns and cities) could be transformed into sustainable and productive ecosystems through mimicking natural systems and processes. The Manchester Festival of Ideas writes that:

"The Biospheric Project aimed at a total change in the way we think about food, farming and the environment. When the site threw open its doors to the public, more than 2,000 people visited this inspiring agricultural laboratory, and saw plants, fish, chicken and worms take their place in a carefully constructed ecosystem within an old mill on the banks of the River Irwell in Salford."

Walsh designed an integrated ecological system inside an old warehouse. He used aquaponics systems for growing fruit and vegetables, which were connected to fish tanks that provided nutrients and fertiliser through fish waste. A vegetable stall selling fresh produce from the project was set up outside to encourage community participation. Every aspect of the system was carefully considered to make sure that nothing went to waste. Although the project is no longer running, the ideas it encapsulated remain relevant. It illustrates how sustainability can be achieved through innovation, creative thinking and bio-mimicry.



Nature's patterns have much to teach us.

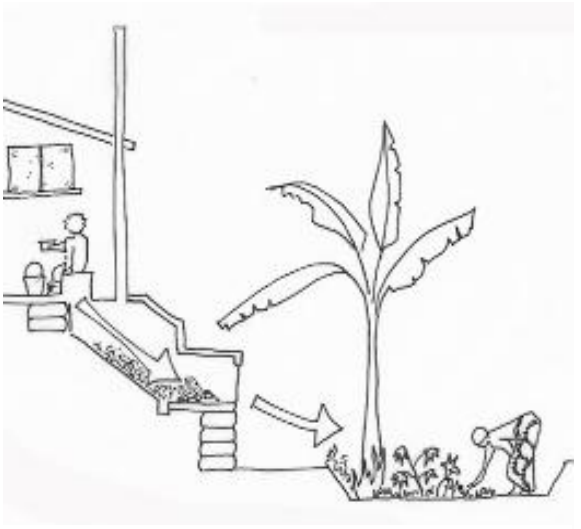
Activity: If you were going to design an integrated systems house, how would you do it? What would you include to make sure that nothing is ever wasted? How would you ensure that the house is always productive? Draw out your design showing the inputs and outputs of the system, and how they can be put to use. Remember to think about how natural systems work, and take inspiration from your observations of the world around you.

Opportunities In The Waste Stream

Recycling is something that we are all familiar with by now. We all have recycling bins for plastics, glass, food waste, newspaper and cardboard, and we have become used to the idea of separating these materials to be put to use again. But we can also recycle a much wider variety of waste products. Recycling can take place in a whole range of different ways, and doesn't necessarily have to be centrally organised like our bin collections. Toilets, and what we do with our sewage waste, are a good example.

Whatever did we do before the toilet?

It was only in the 1850s with the rapid onset of urbanisation that the flushing toilet became popular. Overcrowded urban areas had meant that there was an abundance of human waste to deal with, and once the link between Cholera and sewage was established, sewage systems were constructed to get rid of it. It was at this time that Thomas Twyford developed the first single piece ceramic toilet bowl. By the 1890s these had become common in most households in the UK. But what did we do before toilets, and where did our waste go? Flushable toilets distanced us from our own waste -- literally flushing it away -- but are there ways this most unsightly of by-products can be put to good use? What happens to faeces in natural systems, is there something we can learn from observing nature? When mixed with a carbon-rich soak material smells are trapped within and biology does the rest. A succession of microbes break down and eat everything, several times over, potential pathogens and parasites are consumed and nutralised, leaving only compost.



Composting toilets return nutrients to the soil and help drive the nutrient cycle.

Compost toilets

Human waste is a resource too, though we are often very squeamish in thinking and talking about it. It has been used as a natural fertiliser for many centuries all around the world. Composting toilets provide an ideal opportunity to put this much maligned natural resource to good use. Some people call this resource Humanure:

"Faeces and urine are examples of natural, beneficial, organic materials excreted by the bodies of animals after completing their digestive processes. They are only "waste" when we discard them. When recycled, they are resources, and are often referred to as manures, but never as waste, by the people who do the recycling."

~ The Humanure Handbook

Activity: Look at your own life, your home and school, what opportunities do you see in your waste stream? What could you do to tap into this resource?

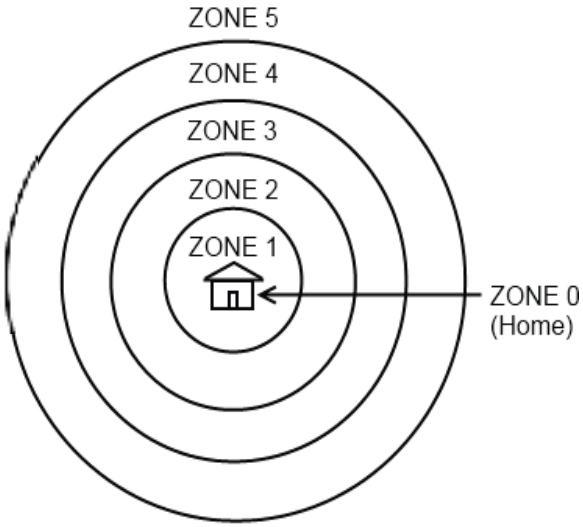
Unit 8:
Patterns To Details

"The holistic and practical permaculture garden is the best classroom for studying biology, chemistry, physics, poetry, economics, every subject. Permaculture is one of the most beautiful, inspiring, resilient, sustainable, ecological, and joyful pathways of living."

~ Satish Kumar, Peace Activist.

Zones

An important part of permaculture's design process is to identify the zones and sectors that define a plot of land. Permaculture design highlights five key zones of activity. The closer to home the easier things are to manage and the more we receive feedback. Those zones that are further away require less input and management, so that by the time we reach Zone 5 we are in unmanaged wilderness.



Permaculture Zones 0-5.

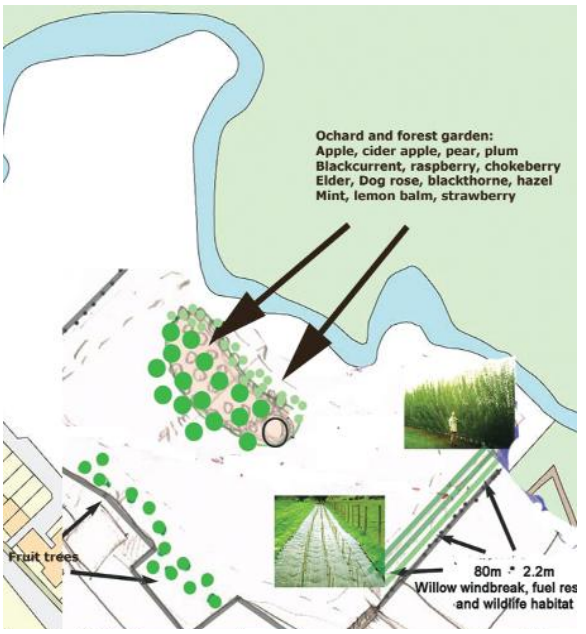
Zones and Sectors remind us that there is always a windy side and a sheltered side, there are always wetter area and drier areas, and so on. Wildlife is as much a flow across the landscape as water or traffic. All of these can be designed for and made the best from. Limitations can be minimised through correct placement and careful planning.

Zone 0 - The Centre: You, your inner sanctum or base-camp.
Zone 1 - Home zone. High maintenance activities supporting Zone 0 functions.
Zone 2 - Community. Garden, vegetables and soft fruit, recreation spaces, family.
Zone 3 - Work. Farmland, main crops, colleagues and co-workers.
Zone 4 - Edges. Woodland for collecting firewood, foraging, hedges, acquaintances, tribe.
Zone 5 - Wilderness & wildlife. Uncultivatated, public. Zone 5 can be brought into all zones.

Practical Activity: Conduct a zone analysis of your own home, school or community as part of a broader design. Start from your back door. Make space for nature and arrange elements strategically according to their function and relationship to other elements.

See the patterns

Creating a Community Garden



Initial plans for the Cae Bodfach community garden in Llanfyllin, identifying the most suitable area for planting a perennial food forest in an old pasture field.

Living willow dome

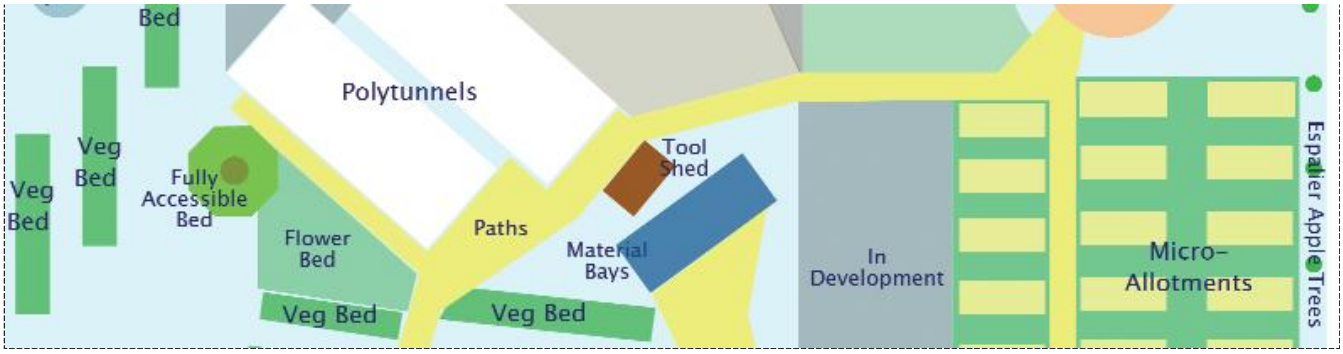
The Cae Bodfach community garden is a living example of the approaches we have taken to encourage engagement with the garden as a community and educational resource that simultaneously enhances biodiversity and captures and stores carbon. These diary entries also go some way towards demonstrating how we have sought to make connections between our various projects and activity sessions with students from Llanfyllin High School, and could be taken as inspiration for how to structure your own projects.

Patterns to details (Jan 2018)

We were down at Cae Bodfach Community Orchard this morning thinking about the next stage of its development. Steve and Jack were joined by Dewi Morris, from the Severn Rivers Trust, John Waddington, a recent Sector39 graduate, and Grace Maycock, who has been awarded funding to add a medicinal herb garden to the orchard. We hope to get members of the community and pupils from the school involved with the planting of the herb garden, which we are calling 'Cae Ysbyty' ('Hospital Field'). Using maps and designs drawn up by participants on a Permaculture Design Course held in Llanrhaeadr in the Summer of 2017, we worked out where the best place to plant the herb garden would be. Then we went down to the site to map out the location using pieces of willow and some string. It is going to be a wonderful addition to the food forest.

Building a living willow dome (March 2018)

On Friday 9th March we were down at Cae Bodfach Community Garden building a living willow dome with assistance from The Willow Bank, living willow specialists since 1985. The Dome is adjacent to what will soon become the medicinal herb garden, which we started mapping out on the site a couple of months ago. Activities such as these really get to



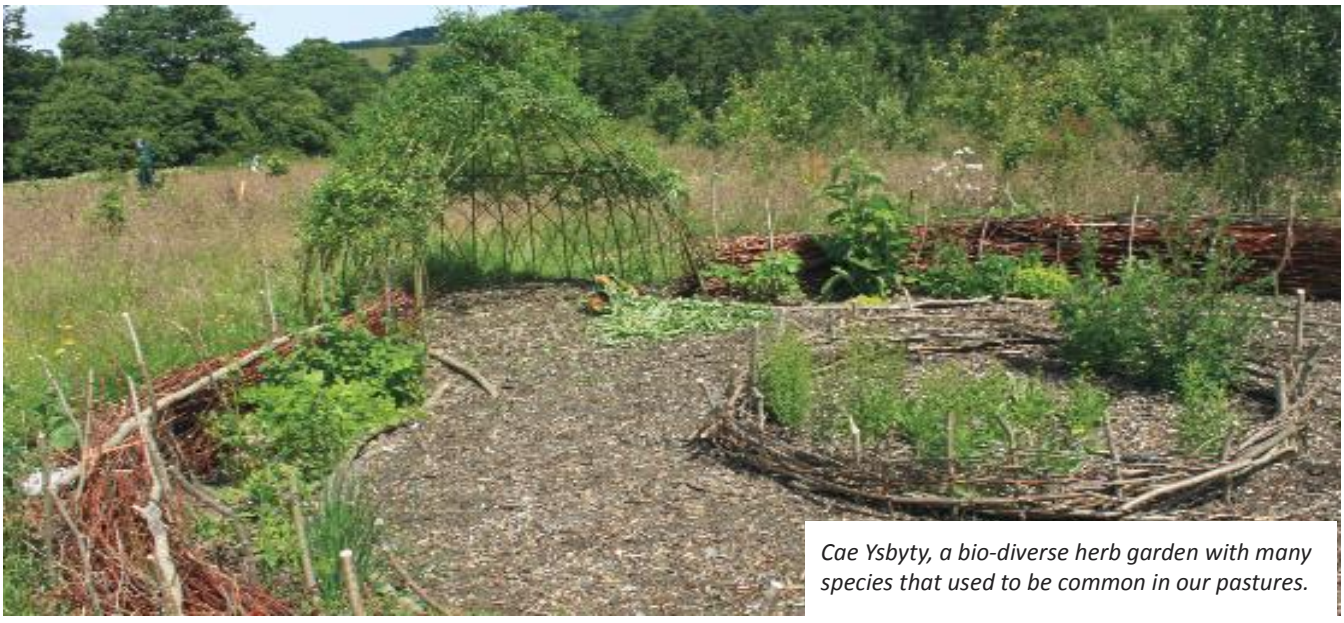
Creating a Community Garden

the heart of what permaculture is about – bringing communities together, while also enhancing biodiversity, building community spaces, sequestrating carbon, learning new skills, developing community resources, and so on.

Building a dead hedge enclosure (March 2018)

We had a great day today down at Cae Bodfach working with Year 10 Land Based Studies students from Llanfyllin High School. We were also joined by Dewi Morris of the Severn Rivers Trust and Tom the Apple Man for a day of planting trees, orchard tending, willow harvesting and hedge building. We planted several varieties of apple tree to expand the orchard, and added a couple of black elder trees and a juniper bush. Students harvested lots of willow from the site to use in the construction of a dead hedge around the medicinal herb garden. The hedge will create a wonderful habitat for all manner of creatures, enhancing biodiversity while also providing much needed shelter for the medicinal herbs that will soon be growing inside it.

Constructing the dead hedge at Cae Bodfach with students from Llanfyllin High School.



Cae Ysbyty, a bio-diverse herb garden with many species that used to be common in our pastures.

Dead hedge enclosure

Creating a Community Garden

Land Based Studies students preparing a mulch mat ready to plant a new willow coppice.

Welsh Baccalaureate students creating interpretive signs for Cae Bodfach Garden.

Mulching, planting herbs and apple trees (April 2018)

The next phase of activities at Cae Bodfach included mulching around the herb garden and living willow dome with woodchip donated by a local tree surgeon. This really brought the garden together. We then filled the herb garden with a wide variety of native medicinal and dye plants. The idea for the garden is that it can serve as a nursery for practical plants that were once common in our fields and meadows. These will then overspill into the surrounding landscape. While all of this was going on, Year 10 students from Llanfyllin High School were working alongside Tom Adams, a local orchard specialist, and Dewi Morris to extend the food forest with new trees. An excellent opportunity to learn new skills and contribute to the community garden.

Creating signage (July 2018)

Following a brief hiatus on activity, owing to the school's busy exam season, we returned to Cae Bodfach in July, just before the summer holidays, with a select group of the Welsh Baccalaureate students we had worked with in 2017. We undertook two key activities. The first was to design and produce signage for the community garden, to explain it to the public, and the second activity was to plant a fruit tree guild right in the middle of Llanfyllin High School campus, as a direct link between the school and the community garden.

We revived a dry old raised flower bed in a courtyard at the school and mulched it over with rotted down wood bark from the woodlands surrounding the school. We managed to find a variety of apple called 'Draig Goch' (Red Dragon), which was particularly well suited to the task, as the Red Dragon is the emblem of the High School. This was underplanted with gooseberry, solomon's seal, welsh onions and comfrey, as a model of community co-operation through

Creating a Community Garden

guilds of plants. It also serves to remind the students at the school that they are connected through natural systems and processes (as well as the work they have put in) to the community garden at Cae Bodfach, just down the road from the school (which itself is connected to the global system).

Foraged foods (September 2018)

This week at the community garden there has been much discussion in the volunteer group about how our parents and grandparents commonly used foraged foods for culinary purposes, such as the mustardy flavours of jack of the hedge in salads and a variety of hedgerow wines and meads, like damson wine. An interesting point brought up was how foraged foods in the past were used as an important part of a daily diet. It is important that this valuable plant knowledge continues to be passed down through the generations. Foraging is a fun way to get outside and enjoy the local landscape and many still collect wild plants to use in their everyday lives.

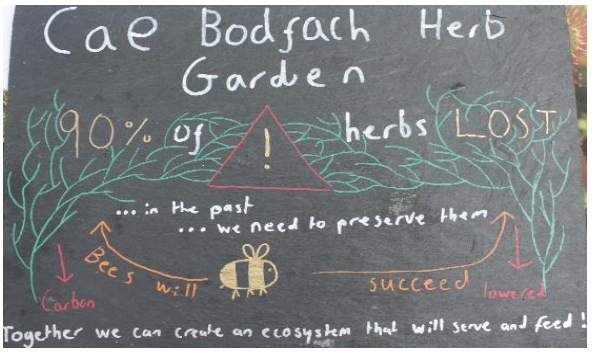
A blackcurrant cutting takes root.

Creating connections (September 2018)

Today we created mown pathways to provide clear access into and around the orchard, these connect with existing paths to create a more cohesive park space and allow for a meandering walk through the orchard. This helps visitors to fully engage with and enjoy the seasonal colours the orchard has to offer during the autumn. It was great to see volunteers from Mencap enjoying the warm sunshine and eagerly chipping in with the mulching of the fruit trees and hammering in the stakes for the signs, created by students from Llanfyllin High School. We used wood-chip donated by a local tree surgeon to mulch around the fruit trees to help suppress the grasses. Over the years we have mulched with cardboard boxes from local shops, grass cuttings, tree prunings and anything else to hand that is high in carbon.

Forest garden team celebrating at Stockbridge Village, Liverpool, linking community gardens.

Creating a Community Garden



Signage created by Welsh Baccalaureate students as part of their coursework.

Community particpation in the design process is essential for building relationships.

As the mulch gets broken down by soil micro-organisms it slowly changes the soil composition from a grassland soil, which is dominated by bacteria to one dominated by fungi, which is what a woodland ecosystem prefers. The fungi (known as Mycelium) create a strong interconnected network underground and form mutually beneficial relationships with the trees and plants in the woodland system. Mycelium networks connect to the plant roots and increase the root length and surface area making otherwise unobtainable water and nutrients available to the plant, while the plants convert sunlight into sugars (photosynthesise) and make these sugars available to the mycelium, which cannot photosynthesise. This exchange is known as a symbiotic relationship. This special relationship helps strengthen and create a more resilient ecosystem.

Natural Play: Observe and Interact (October 2018)

In Permaculture we say 'Nature is our teacher.' We can learn a lot from simply observing how the world around us works, and what better way to discover that than through play? Studying nature's patterns in a snail shell or a spiderweb, experiencing the natural cycles of the seasons, seeing how a caterpillar metamorphoses into a butterfly, or simply feeling the wind on your face, or smelling the deep earthy scent of the woodland floor. Engaging in the natural environment improves a whole range of skills and is invaluable for physical, mental, personal and social development. Watching a friend's young one run around the herb garden, and in and out of the dome, really reminds me that natural play can also inspire a strong sense of guardianship, and a genuine and long lasting love for the world around us.

Obtain a yield (October 2018)

In permaculture we like to say "every element in a design

Remember the importance of natural play

Creating a Community Garden

must perform at least 3 functions." To this end, everything we do at the Community Garden should have multiple functions. We have already had multi-functional yields from the willow hedge that was planted in Cae Bodfach only three years ago, here are just a few of the yields:

• The hedge marks a boundary and defines space (visually and physically) between Cae Bodfach and the wetland.
• It serves as a wildlife corridor connecting the field to the river.
• It provides valuable wildlife habitat and an essential early source of nectar for emerging native pollinators and insects, such as our honey bee.
• As a British native shrub, willow creates a sense of place and provides seasonal interest.
• It can be coppiced and used for firewood, or to build structures, such as the willow dome and herb garden earlier in the year!

Cultivate Newtown. A source of inspiration.

Willow coppicing (November 2018)

Willow should be coppiced in November. When the leaves drop from the stem you know it's time to cut, as the sap will have stopped rising. Volunteers Ruth and Alex, along with Llanfyllin High School students and members of the local Mencap group, have all helped to coppice the willow this year. Alex graded the best of the willow by height, width and variety. This willow can be used for willow craft and to create willow structures, such as the willow archway demonstration we have planned for the orchard in the next couple of weeks. We also worked with year 9 and 10 students from Llanfyllin High School to coppice the willow. We used some of the willow to make brash bundles called 'fascines,' which will be used by the Sixth Form students on a project with Dewi Morris, of the Severn Rivers Trust, to restore the degraded areas of the Cain river bank.

Willow rods for basketry, wildlife and biomass.

Creating a Community Garden

Cain river group working on revetments to protect the exposed river banks.

Everything is connected (November 2018)

We had a very interesting day at the river with Dewi Morris, Emyr Jones and the Llanfyllin High School Sixth Form today. We learned how to make 'soft river revetments' using bundles of brash, galvanised wire and sweet chestnut stakes. This low-tech, low-cost solution to improving degraded and eroding river banks has multiple benefits including enhancing habitat for biodiversity. The bundles of brash are laid along the eroding river bank and secured into position using sweet chestnut stakes. Galvanised wire is then tied from stake to stake over the brash, this allows the brash to move a little with the flow of the water, because if they were rigid they would simply be washed away.

Nettles growing up from previous years' brash demonstrates the success of the soft revetment on the river bank. The strong roots of the alder trees planted above the bank help stabilise the soil. The force of the water is dispersed by the woven structure of the brash, all the little holes slow the water down as it passes through, therefore reducing the force of the flow against the vulnerable river bank. These holes are also perfect habitat for river wildlife such as insects, their larvae, and small fry (baby fish).

Sediment carries in the water drops and is caught in the holes in the brash, and this starts to rebuild the soil. Seeds of riparian plants then sow themselves in the captured soil and, as they grow, their roots help to further stabilise the river bank. Natural Resources Wales have reported that Nant Alan is a prime salmon and trout breeding river, therefore, using biodiversity-friendly and enhancing techniques such as these ensure the health of the river and the wildlife within it. As salmon are a keystone species, they play a critical role in maintaining the heath and structure of the river ecosystem by supporting the life of many other living things. The effect the salmon run has on the ecosystem is enormous as they have a positive impact for plants, animals and humans in both coastal and freshwater habitats.

Working with the river and its inhabitants reminds us that small events can have large, widespread consequences, both positive or negative. This work strongly reminds us of how important it is to remember that 'everything is connected' and to consider what our impact will be on the local and global community.

Unit 9: Integrate

"Many hands make light work"

Mycorrhizal fungi

Mycorrhizal fungi are amongst the best illustrators of the concept of integration and symbiotic relationships in the natural world. Myccorhizae are very fine filamentous strands of fungus that attach to the root tips of trees and other plants. In exchange for sugars produced by plants (as fungi cannot photosynthesise), mycorrhizal fungi vastly extend the reach of the root system, giving the trees greater access to nutrients and water. This is a mutually beneficial relationship where trees and fungi support one another through the provision of reciprocal services. This model of nature seems to provide an alternative to the view of nature as a competition. Co-operation seems to play just as much of an important role!

Fine threads of fungal mycelium forming complex networks for energy and nutrient exchange.

Practical session in Cae Bodfach: seeding mushrooms

Ploughing the soil and using fertilisers and herbicides disrupt the fungi from functioning, so we decided to seed the Cae Bodfach orchard and meadow with field mushrooms to remedy this and kick-start a more connected ecosystem. We also aim to gain another yield from the system, in terms of edible mushrooms (reinforcing food security), and to help restore a much higher level of fungal activity in the soils. This will have a broader beneficial impact on the whole of food forest system we have been developing at the site. We ordered white cap field mushroom spawn from King's Seeds and it came in a form of wheat grains -- fuzzy and white with mushroom spawn. These can be seeded just beneath the turf in the field. We added some well-rotted manure to some of the holes to help their growth. We are looking forward to seeing the fruits of our labours in the autumn.

GCSE Land Based student seeding the ground with mushroom spawn.

The more connections the stronger the system

Co-operative Evolution

Giraffe grazing on its favourite Acacia thorn tree in Uganda, a relationship that is managed by a termite!

These galls on the Acacia thorn tree are home to a termite that rushes out to defend the tree when the giraffe first takes a bite. This prevents the giraffe from taking too much while creating home for the termite.

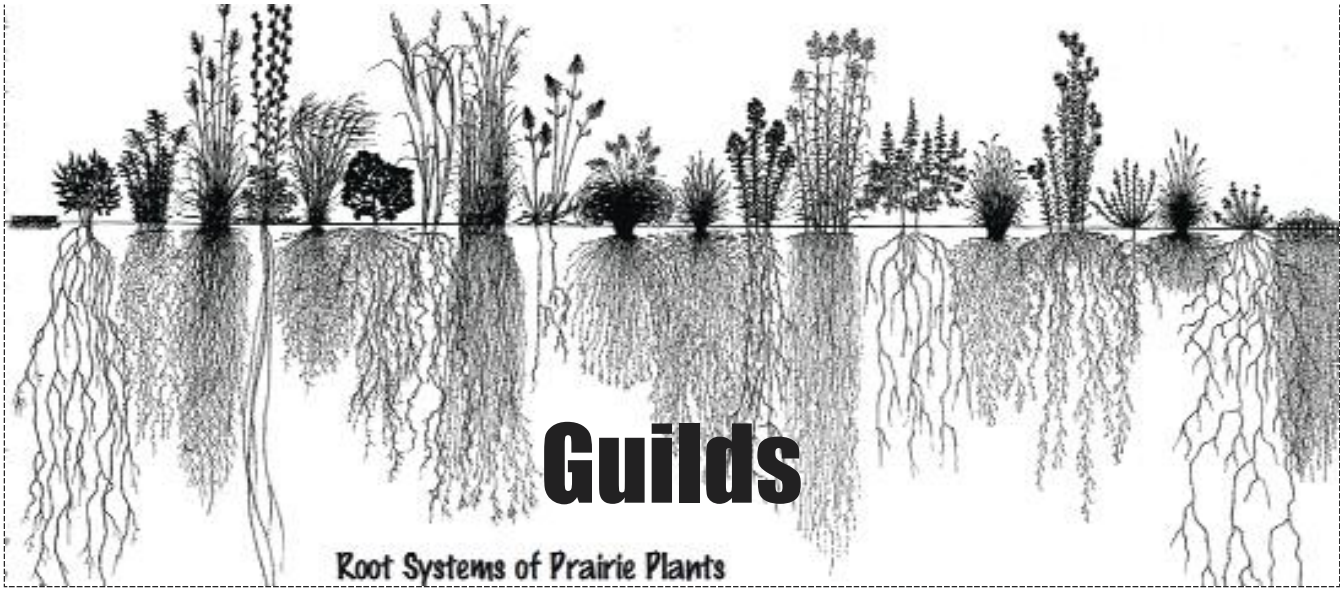
Nothing in nature exists in isolation, everything is part of a dynamic relationship in which one species complements and regulates another. Ecosystems become stronger as more connections are developed between each of the components in the system. Some of the relationships are obscure and hard to understand, such as the example of the giraffe and the termite. We might see the termite galls on the acacia tree as a problem for the tree but I am guessing the small amount of sugar the tree gives up to the occupying termites is well worth the protection from giraffes they gain in return. A mutually benefical or *symbiotic* relationship.

Permaculture encourges us to design in ways that create as many beneficial relationship as possible, while also allowing the formation of new connections to form over time that we had not anticipated.

When designing community activities like public gardens it is important to include strategies that help connect the community to the landscape. In permaculture we are taught to consider the role of every element in a system, and to understand that each element can play a very important role, even if they are not part of the final yield.

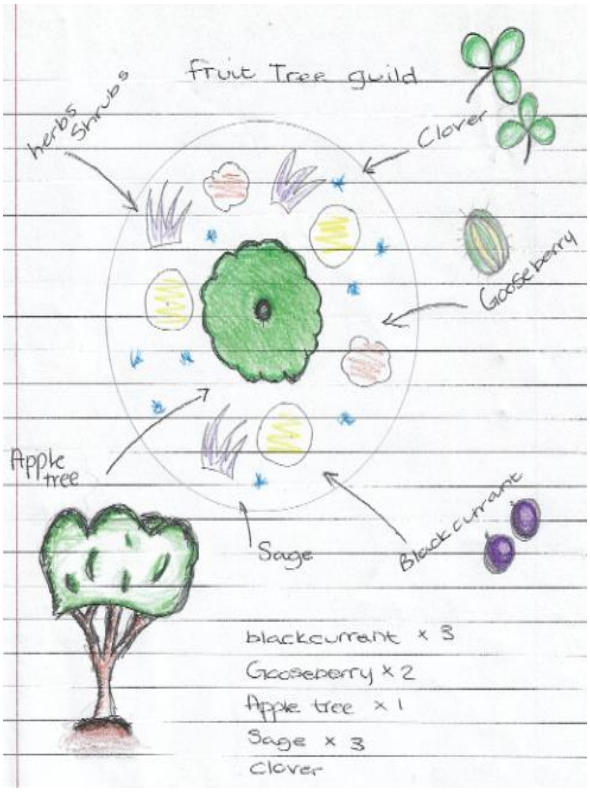
What can be said about plants is also true for people. Building mutally beneficial relationships and embracing the diversity of our community greatly broadens the scope and inclusivity of any project. It is important to develop strong connections that allow each segment of your community to potentially find a way to be involved in any project initiative.

Co-operatives are also a type of enterprise that exists and trades for the benefit of its users and stakeholders, rather than the owners or investors. This is the economic equivalent of a mutually benficial community, or mutual company. The very first co-operative was created by a Welshman, Robert Owen, a retail co-op for the workers at New Lanark Mill in Scotland. This action started a global movement.



It is not correct to think of plants as individuals. In fact, they tend to grow in teams, supporting each other and complimenting each other in different ways. As soon as you create a monoculture -- a vast field of only one plant species -- those plants are forced to compete with each other for survival. Each is growing in the same way, seeking the same moisture and nutrients with roots of a similar depth.

When left to its own devices, however, nature tends to mix things up. Benefical associations develop in these circumstances. Deep rooted plants can access water and nutrients way beyond the reach of the shallower rooted plants that protect the delicate surface of the soil and keep it covered with vegetation. Consider the wild prairie grasses in the top picture. Different root shapes and depths interact with different soil horizons, and in the process help to circulate nutrients that keep the soil alive and vibrant for a longer period, to a greater depth, and in many different ways than a field of a single species.



A fruit tree guild design by a Llanfyllin High School pupil.

We explored this idea in several different ways in the establishment of the orchard at Cae Bodfach. Trees and grasses compete. Trees like a soil dominated by fungi, while grasses tend to build soils dominated by bacteria. Trees, shrubs, herbaceous plants and herbs tend to like similar conditions. In order to push the grasses away from the young trees we mulched the ground heavily with rotten woodchip. This serves to promote the growth of mycelium in the soil and suppresses the grasses. We then sowed yellow-rattle seeds amongst the grasses. Yellow-rattle is a parasite that weakens grasses by stealing water from their roots. This favours hardier plants and wildflowers enabling them to enter into the otherwise closed pasture. Comfrey is a deep rooted plant that accumulates vital plant nutrients, this also helps push back the grasses and provides an easy feed for the trees right next door to where they are growing. To help protect the young fruit trees we also planted a thick hedge of hawthorn, rosehip, blackthorn and hazel. This serves to keep off cold winds, errant sheep and whatever else might come along, while also providing lots of fruits and berries for birds that will help regulate insect populations, while their droppings help to cycle phosphates through the system, a vital nutrient for plant root development.

You can think of a guild like a football team. There are many different roles to play - not everyone can be the centre forward or the goal keeper! Specialists work together to create a greater whole. This is a forest garden!

A guild is like a family or team

Unit 10:
Use Small and Slow Solutions

A 30cm green willow stick, with 20cm below ground, sprouts new growth.

Case study from Cae Bodfach: The Willow Project

The principle aim of the willow project is to generate an annual income for Cae Bodfach. However, willow is a highly multi-functional plant, with many other benefits that stack on top of this initial aim. As well as generating an annual revenue for the field the willow will also:

- Stabilise the soil and the riverbanks
- Rejuvenate the soil
- Provide food and shelter for wildlife
- Increase habitat connectivity
- Sequester carbon
- Provide material to use for propagation
- Surplus used to make biochar to remediate the soil

Habitat and Soil Conservation

Willow provides habitat in the form of food and shelter for wildlife as one of the first species to flower in early spring/late winter, and this is crucial for our early pollinators as they wake after a long winter. The stools of willow coppice provide safe habitat for overwintering invertebrates.

Willow is a wetland plant, so planting it in the flood plain at Cae Bodfach makes a lot of sense. It is in its natural habitat (right plant, right place), and being a wetland plant it will be able to cope with flooding, as it has very deep and strong roots which help stabilise and rejuvenate soils and river banks.

Practical Activity: What is your small and slow solution?

Every one of us has our own perspective on what can be done to build resilence against the climate crisis. What can you see from your life that could be changed in a way that can contribute to the bigger whole? Use this book as a jumping off point to form your own ideas. We would love to hear from you, post any suggestions at **www.facebook.com/sector39/**

> When people talk about traveling to the past, they worry about radically changing the present by doing something small, but barely anyone in the present really thinks that they can radically change the future by doing something small.

Start small

Muliple Yields

Sustainable and regenerative management

Willow coppice is a sustainable management technique where the shoots are cut down to 30cm above the soil level with the main stem being left in place. The cutting (known as coppicing) encourages fresh growth the following year. Coppiced plants are known to live many times longer than non-coppiced plants.

The straight young stems (known as rods) can be graded and sold for biomass or traditional willow crafts such as basket making or willow structures. Coppiced rods are also used to grow new plants, so once you have a particular variety it will be possible to use it to propagate more plants. Any surplus could also be made into biochar for use in soil amelioration, or for the construction of dead hedges. Keeping these management practices and crafts alive helps to maintain a strong link to British cultural history while also looking forward to a regenerative future.

Harvesting willow rods by hand at Cae Bodfach.

Obtain a yield

The idea behind this project was to generate an annual income for the Cae Bodfach Community Garden. Working alongside a willow professional – Steve Pickup of www.thewillowbank.com – we have specifically chosen to plant this species of willow due to its rapid growth rate – it can grown up to 5m a year! Cae Bodfach has the space to grow 100msq of willow. While the willow is growing it will provide all of the services listed above, then in a couple of years, Steve will buy the willow back from the field for a sum of money which will go into the Cae Bodfach community fund. Win Win Win.

Why use mypex? Permaculture mimics natural systems...

We are mimicking natural systems by planting our willow into mypex. As willow is a pioneering plant, it has a small lightweight seed which will be blown by the wind onto bare soils and there it will quickly colonise and begin to stabilise and rejuvenate the soils. That's one of the ecological functions of willow.

Permaculture is About Experimenting

As a primary coloniser, willow likes to grow in bare ground without competition.

Yes, but isn't that plastic?

Questions are often raised about using mypex, which is fair as it is a plastic. However, mypex is a polypropylene. Unlike other plastic (used for carrier or animal food bags, for example) polypropylene does not degrade and break down in the same way as other plastics would. It is made for purpose, and when used correctly does its job well. It is specially woven for maximum permeability to allow water and air to get to the soil. It completely excludes light, therefore suppressing the grasses beneath it, which eventually die and are incorporated into the soil by soil microorganisms to become nutrients for the willow plant above. Importantly, once the plant is growing sufficiently to hold its own against the grasses, the mypex can then be carefully removed and even reused in other projects. If the willow is spaced correctly you can then use a lawnmower to keep the grasses down.

A fair test

Dewi Morris from Montgomeryshire Wildlife Trust planted a willow experiment at Cae Bodfach which demonstrates very well the difference between planting with mypex and without mypex. The willow with the mypex has grown substantially better than the one without.

Activity: Why not do your own experiments with growing, to find out what works best for you?

Small and slow solutions

Permaculture principle 9 is 'Use slow and small solutions.' This principle reminds us that systems should be designed to function at the smallest scale that is practical and energy efficient. So in a similar way to Dewi Morris' mypex willow experiment, we have planted one corner edge as a test site to showcase the idea, and see if it works for the field. By coming in from the edges, next to a degrading section of riverbank, not taking up too much space, and only planting a small crop, we are able to try out ideas before committing too heavily, while still obtaining multiple yields from it.

Wonderful Willow

This versatile, fast growing plant loves wet conditions, full sunlight and fertile soil. It is tough and can survive in thinner soils and drier places, but it really thrives along riverbanks and is specially adapted to such environments. Although very supple and bendy willow can also be quite brittle, so in a flood branches break off sparing the tree itself and quickly regrow. Also, any part -- especially the younger parts -- of the tree will sprout new roots if it comes into contact with the ground. Broken branches can lodge themselves into the ground, potentially miles downstream from where they snapped off, and re-grow, propagating the plant and helping stabilise riverbanks while creating significant amounts of wildlife habitat.

A pollard is created by coppicing at head height, rather than at ground level.

Previously, we prepared the ground by covering it in mypex, a non-biodegradable fabric we can remove in two or three years' time when the plants are established. As willow is a coloniser, it thrives on bare ground or disturbed soil, it doesn't like to compete with the grasses, so this favours the willow. The willow came by post from our friends at TheWillowBank.com, specialists in habitat restoration,willow coppice and living structures. The freshly cut rods are slightly thicker than a pencil, are 30cm long and we will plant them 2/3 in the ground, using a bar to make hole, so the plants are not damaged.

We expect these to be able to grow up to 5m a year once established and it will create a local supply of these super-fast-growing willow variety, salix viminalis. Demand for this material is high and we can generate revenue for the garden by selling cuttings to our own customers or back to the Willowbank who supplied them.

This is permaculture thinking, relationships and multi functionality. We are generating income to sustain the garden whilst adding to the wildlife and biodiversity of the garden. Students are learning skills whilst building a personal connection the garden themselves whilst having a healthy active experience. The willow itself will produce pollen and seed that will feed insects and birds, make the river bank more tsable, reduce flooding and erosion. Dog walkers, parents and children are using the space more and more and enjoying seeing it develop.

Unit 11:
Use And Value Diversity

School garden project in Kenya, led by a Sector39 graduate from 2016.

We are currently experiencing the Sixth Mass Extinction. It is different from previous extinction events that have occurred in the past because it is anthropogenic. This means that the current extinction event has been caused by human activity. Previous extinction events have been due to natural factors, such as volcanic eruptions, asteroid strikes and changes in sea level.

The WWF (World Wildlife Fund) reports that between 1970 and 2010, the planet has lost 52% of its biodiversity. In the same 40-year period, the human population has nearly doubled! In this time we have lost 76% of freshwater wildlife, 39% of terrestrial wildlife and 39% of marine wildlife.

Given these shocking facts, it is vitally important that we take responsibility for our actions and do all that we can to protect and restore biodiversity. Biodiversity matters because it supports the vital benefits we get from the natural environment. It contributes to our economy, our health and well-being and it enriches our lives.

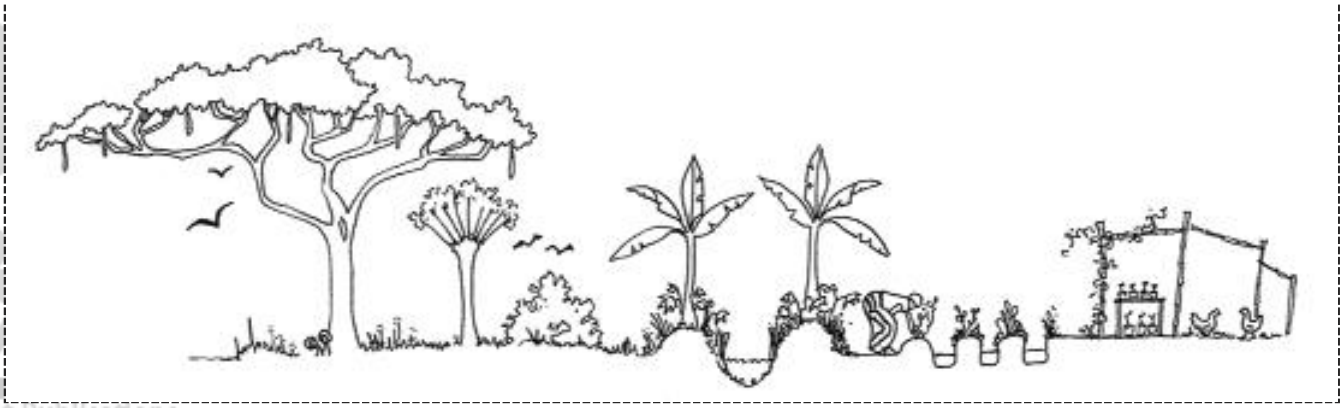
Re-wilding: letting nature take its course

When we look at the fields and hills around us we are essentially looking at a man-made desert dominated by grasses, created for agricultural purposes. This basically brings a halt to the process of succession. The landscape we see around us is far from wilderness, in fact it is referred to as a plagioclimax. Our farmed landscape is frozen in time, field boundaries are often hundreds of years old. A natural landscape would change and fluctuate, from forest to clearings, from scrub to thicket, creating an ever shifting patchwork of ecosystems allowing for a far greater diversity and complexity of species.

Activity: Use e.g. Wikipedia to research the term 'plagioclimax' what does it mean, and what does it tell you about the impact of our landscape management methods on biodiversity?

If succession is naturally allowed to continue without disruption it will eventually culminate with climax vegetation. Depending on the climatic conditions in which succession takes place, different plant, tree and animal species will make up the climax community. If the UK's natural environments were left to their own devices,

In nature stability comes from diversity



Nature Invests in Diversity

and were allowed to continue with the process of succession without human interference or disruption, the climax community would be an ecosystem dominated by Atlantic Mixed Forest.

Activity: How does re-wilding help to tackle the negative effects of climate change? Do some research.

Fruit tree treasure map

Our community orchard contains 100 different fruit tree varieties. Much fun and laughter was had at Cae Bodfach when we used maps drawn up by Llanfyllin High School students the previous autumn to locate and label all the different fruit trees in the orchard.

It was good going to navigate the map and locate every single piece of fruit tree treasure in the orchard! Almost every fruit tree is a different variety. They are mostly apples, but, there are also medlar, cherry and pear tree treasures to be found too!

There are hundreds of different varieties of apple, the fruit originated in Kazakhstan.

Re-purposed 'waste' and low-tech solutions

We re-purposed aluminium drinks cans by cutting them up to make labels and used a hole punch so we could thread flexi-tie through them and attach them to the trees. We then imprinted the names of the varieties onto the aluminium using a biro style pen. Simple activities such as this are a great way of encouraging appreciation of the importance of biodiversity.

Practical Activity: We can all do our bit to help promote biodiversity in our homes, schools and places of work. There are simple things that are easy to do that make a big difference. You could:
+ Scatter wildflower seed on unused areas to introduce diverse native species, create habitat, attract bees and add colour to your surroundings.
+ Leave space for wildlife to flourish. Untended corners of the garden are great for providing food, shelter and habitat for many different species.
+ Create a small pond. A new pond will very quickly attract different species into your garden, school or place of work. They are hubs for biodiversity!

Unit 12:
Use Edges And Value The Marginal

A wildlife garden on the edge of a street, feeding insects and birds while taking up very little space.

Llanfyllin public institute has odd-shaped unused bit of ground behind it. This edge space has recently become a base for local community prmaculture work

Edges

The frontier between two types of environment or system often presents a unique set of conditions. For example the seashore -- it is neither land nor sea, but a mixture of both. This key area is the most productive of all. Think about where the sea birds go at low tide, and why?

In the picture (left), the wall and road edge creates a special set of conditions, where the cars don't drive and where particles of soil and seeds blown by the wind tend to lodge, triggering the process of succession. In this instance we exaggerated the process by adding some stones, which further trap moisture and allow soil and habitat to form.

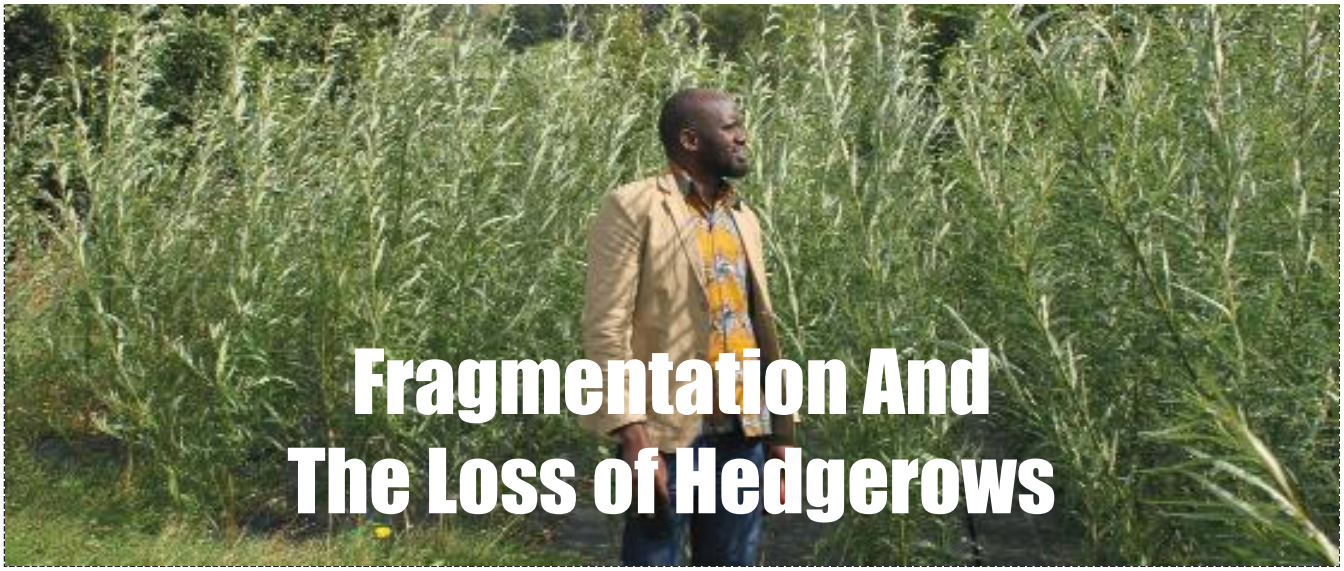
It is not uncommon to see succession, new species, or even new ideas, enter a system from the edge. Permaculture designers recognise this and use it to great effect, seeking to find the smallest input which can create the maximum effect. These opportunities to work with natural and social forces often occur on the edge.

The importance of hedgerows

The humble hedgerow is an important feature of the British landscape. They offer so many benefits – historically, culturally and ecologically. Hedgerows are multifunctional structures that:

- Create a 'sense of place' and regional and cultural variation
- Create links to our historic past
- Act as effective livestock barriers
- Sequester carbon, reduce soil erosion and prevent flooding
- Provide valuable food and shelter for wildlife and stock animals
- Offer vital wildlife corridors connecting 'islands' of habitat.

Start from the edges



Fragmentation And The Loss of Hedgerows

Nature's highways

Nature's highways come in many forms including; waterways, long grassy verges, green roofs and of course hedgerows! Hedgerows create an important refuge for wild plant and animal species, and in an increasingly disconnected landscape they act as vital wildlife corridors which help creatures move safely from one habitat area to another, providing much needed landscape-scale connectivity.

Agriculturally improved pasture has very low habitat value for wildlife, and often acts a as a barrier to movement from one habitat to another, leaving wildlife isolated and vulnerable. Habitat loss and fragmentation are considered to be the leading drivers of biodiversity loss. Pressures from agricultural intensification, poor management and replacement with galvanised steel fencing have resulted in the decline of hedgerows in Britain.

Wales and other countries are exploring how to team up with keystone species to rewild the landscape, beavers are a great starting point!

Wildlife depends on these crucial highways. The link between the removal and degradation of wild-life corridors and the decline in wildlife is very real. The Woodland Trust states that; "During the 20th century an estimated half of all hedgerows were lost from the countryside, the majority due to agricultural intensification between the 1940s and 1970s." If wildlife species lose their means of travel from region to region because hedgerows are damaged or removed completely, they become isolated and vulnerable to the 'island effect.'

The island effect

The 'island effect' occurs when a habitat becomes isolated from its surroundings by an expanse of unsuitable land, such as agriculturally improved pasture. Without the freedom of movement, genetic pools and resources become dangerously low until, eventually, the habitat is unable to support or rejuvenate itself and it dies out. It is vitally important to actively increase and safeguard connectivity to the waterways and other habitat patches to prevent habitat isolation and fragmentation. Enter: Hedgerows! Linking wilder, more bio-diverse areas together using natural or man made pathways such as hedges, rivers, canals and railway lines can greatly improve the value of those habitats and allow the free movement of the species between habitats.

The Art of Hedge Laying

Laying a hedge to create a field boundary, a wildlife habitat and resources for use on farm.

Diverse edges at a town garden in Machynlleth.

Good management and beneficial relationships

Good management of hedgerows is key to the obtaining the benefits of these valuable resources. Neglect and poor management leads to hedges becoming overgrown with tall trees and undesirable gaps appearing. When managed correctly, by hedge laying or coppicing, hedgerows can be supportive for both humans and wildlife. The natural world has long been intertwined with human activity: it is our choice to make it a positive or negative relationship. The traditional skill of hedge laying is a regenerative practice that ensures the health of the hedgerow and its functional and ecological value. Just as with the art of stone walling, over the years many regional variations in hedge laying style and technique have developed resulting in an authentic regional character, and with it a meaningful sense of place and culture.

With proper management it is possible to coexist harmoniously, to work with nature and build supportive and regenerative relationships with the natural world.

In the winter of 2018-19 we planted over 400 native trees and shrubs at Cae Bodfach with local volunteers, MENCAP and Llanfyllin High School students. This planting took the form of shelter belts, to protect less hardy species, and hedgerows. A mixed variety of native trees and shrubs, including Hazel, Dog Rose, Blackthorn and Elder, were planted to fill in the gaps along the Bodfach and Cae Bodfach field boundary. The trees came as part of a free pack supplied by the Woodland Trust in November. Native trees are better able to withstand climatic conditions and provide early sources of nectar for pollinators. We also purposely chose fruiting and nut trees to maximise the yields from our tree planting efforts!

Unit 13: Creatively Use And Respond To Change

The rise and fall of the River Cain

Table top garden, creative play in Machynlleth's community gardens

Due to the riverside location of the Cae Bodfach community garden, we have had to make detailed observations of the river itself. The rise and fall of the River Cain is constantly changing the landscape, in many ways and on many levels. Sometimes when we visit the river, parts of it are completely unreachable and at other times new places become open to us to explore and discover. Gravel shores provide safe access for people and animals. Shallow waters that gradually deepen are great for play and are perfect for young fish fry! The Cain, Tanat and Vyrnwy rivers drain into the Severn River and represents a major conduit for wildlife, espcially fish.

Change is the one constant we can rely on

When visiting the river – no two days will ever be the same. This constant flux is the beauty and opportunity that comes with living along a river and its floodplain landscape. The rise and fall of the water in the river Cain reminds us of permaculture principle 12: 'Creatively use and respond to change.' Change, in whatever form it comes, is inevitable. It can be frightening and challenging. Permaculture challenges the designer to see 'The problem as the solution.' A problem is the inverse of its own solution. Principle 12 invites us to embrace and accept change and to see the opportunities it brings. It encourages us to envisage new possibilities and to act in a effective way. A simple example of this from Cae Bodfach is how and where we decided to plant the orchard due to the existing conditions and potential flooding of the river Cain. We understood that the field was a boggy flood plain (which is not ideal ground for fruit trees), but we worked with the challenges we had and found the opportunities that were open to us.

Firstly, we surveyed the field. Through this survey, we identified the highest ground – this is where we would plant our orchard to give it the best chance of survival. We then arranged the orchard to capture enough warmth and light to help the trees grow most efficiently. We reinforced this by planting cheaper support trees (in the form of a sacrificial shelter belt) to create a microclimate and protect the fruiting trees from the cold weather that blows in from the north. Having anticipated how the water would flow across the land when the river inevitably flooded, the sacrificial shelter belt would also diffuse the flow of the water and any debris it was carrying, with the hope of protecting the heritage orchard trees. Understanding our environment and knowing that things will change helps us to plan ahead, it also enables us to use change in creative and beneficial ways, to learn to be flexible and to creatively respond to outcomes we had not anticipated.

Turning Problems Into Solutions

"My Granfather rode a camel, my father drove a car, I fly in a plane, my children will ride a camel."

~ Saudia Arabian saying

The oil age is a one time only economic boom, we must recognise it is coming to an end and that it needs to

The End of the world?

Scaring the living daylights out of people telling them the world is going to end is irresponsible. But this is an emergency and we must treat it as such. In permaculture design we are interested in small and slow solutions. Things that use natural materials and energy, can grow of their own accord and are easily replicated. A good idea can travel far and fast. The central idea to building resilience to external shocks and changes is to build lots of connections, to make things stronger. Community, the more we know each other and build community links through working towards longer term goals then the stronger the community. Southern Africa has just been hit by the strongest southern hemisphere storm ever. It is your neighbour who will rescue you when disaster strikes.

We do need to recognise the reality of the times we live in. We are at the end of an era, an era of cheap energy and business has had a free hand to 'externalise' many of the costs of production by exporting pollution to developing countries, exploiting slack environemtal controls and labour laws to flood the world with cheap goods. Technology has moved so fast the goods have become obscelecent very quickly and their cheapness and short shelf life have meant they are not worth fixing ro recycling. It is utterly absurd that we have developed a throw away culture of technology like mobile phones and computers, they contain rare earth minerals which will run out as well as representing complex technologies that few years ago didn't exist but to keep up with the market they don't last more than a few short years. None of this will make sense to a future world where these resources will be scare, expensive and will most likel be shared across large groups of people.

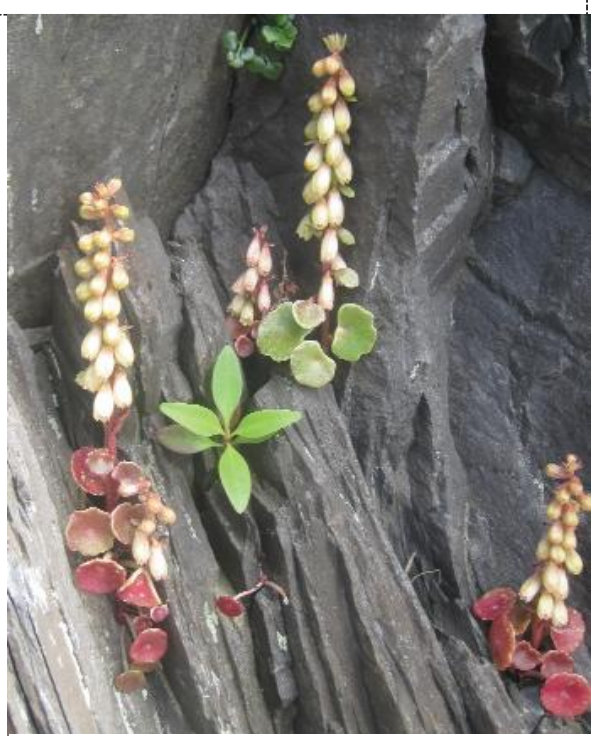
Spending time living and working in Africa is like a glimpse into the resource scarce future. You rarely see a car or minibus travel with empty seats, they wait on corners and junctions to pick up passengerrs, vehicles leave when they are full, not at an allotted time. The average car in the UK might have 5 seats and 1.5 passengers. Just filling the car reduces your energy by 75% potentially, a huge saving. We need to learn to think like we will be required to in the very near future to better prepare ourselves for what is coming.

Next Steps

"Vision is not seeing things as they are but as they will be."

None of us will be immune to climate change, it is going to get bumpy. We will need each other to ride out the waves that are coming our way. Climate change is obviously driven by fossil fuel consumption, but the resilience of nature to withstand this rapid change is vested in its biodiversity. Forest and soils are essential and act as a store for much of the carbon. However our industrial scale monoculture farming methods have eroded heavily into them with a devastating effect.

Wales for example has lost 90% of its herb rich meadows in the last few decades. Hear local lad and famous naturalist Iolo Williams speaking at the Senedd on the state of nature in 2013, his ire is palpable. This is already six years ago. www.sector39.co.uk/smalll&slow Ch. 13



Sedums growing on slate rock, these are one of the specialist plants that start off natural succession

Climate change to-do list

We need to:

- Mentally prepare for a more local and less resource based lifestyle.
- Build much stronger, more interconnected local communities.
- Protect and enhance local biodiversity, as a priority not an afterthought.
- Grow, compost and consume much more of your food locally.
- Develop a local carbon based economy, centred on food.
- Develop teams of people who can lead on habitat repair and restoration.
- Support these efforts with the outputs of the local food economy.
- Create local specialism to facilitate these activities.

Suzuki and Thunberg

Severn Suzuki "We can build a society where our actions align with our values"

In the spring of 2019 we went into Llanfyllin to visit the High School and to interview the school's 'eco-group' members. These are conscious kids who are leading on recycling and waste reduction initiatives around the school. We wanted to ask them what they thought of climate change and Greta Thunberg's school strike. They reminded us that had we listened to the Rio Earth summit conclusions of 1992 and acted on them, by now we would already have made the Paris Agreement style transition to the post carbon world. The fact that we are now staring Armageddon in the face is down to the fact that the world did not wake up and did not act.

So the buck has been passed to the next generation. It is they who will have to grow up in a climate changed world not knowing whether it is left too late respond at all. Kids are grappling with this, and these are still early days of the full realisation of the challenge we face. It is revealing to go back and hear some of those voices that have been sounding the alarm call down the years. We need to listen to current voices much more carefully. All this is happening before our eyes, yet we act as if we have all the time we want and all of the solutions. We don't.

"I am only a child yet I know that we are all part of a family of five billion strong, in fact 30 million species strong, borders and governments can't change that. I am only a child yet I know we are all in this together and we should work as one single world, towards one single goal."

~ Severn Suzuki in 1992.

In her passionate call to action, 16-year-old climate activist Greta Thunberg explains why, in August 2018, she walked out of school and organised a strike to raise awareness of global warming, protesting outside the Swedish parliament and grabbing the world's attention.

"The climate crisis has already been solved. We already have all the facts and solutions. All we have to do is to wake up and change."

~ Greta Thunberg in 2018.

Small and Slow Solutions

What if everybody could unleash their own small and slow solution?

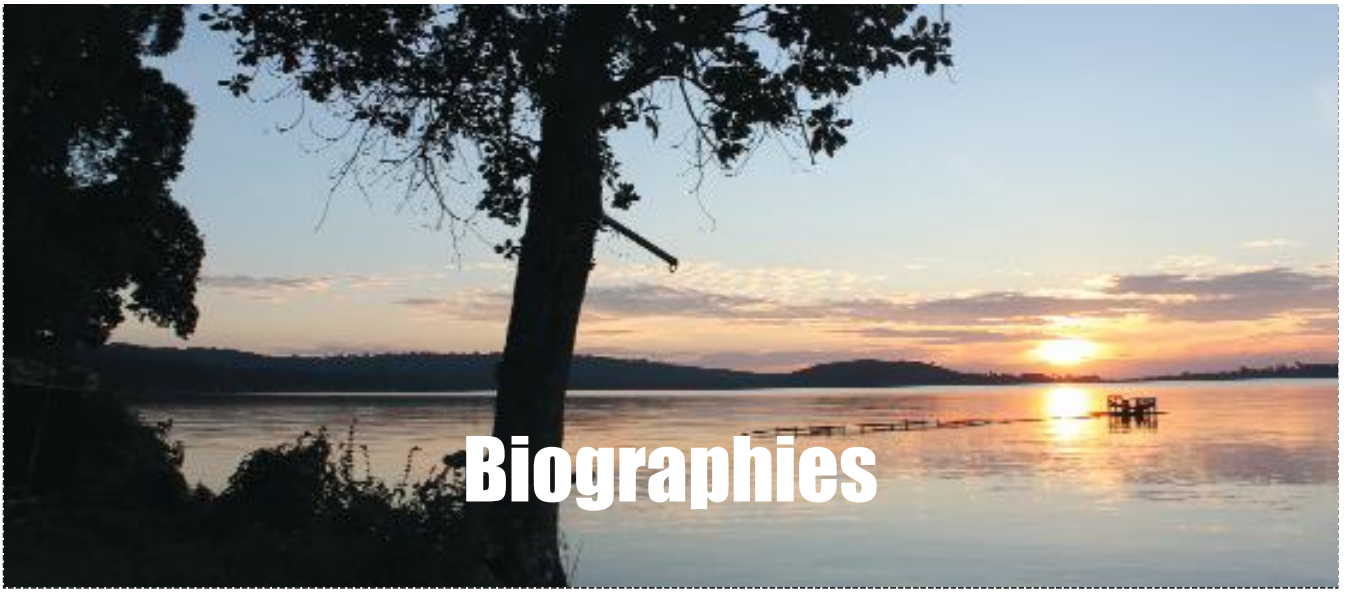
When a huge and imminent problem is rushing over the horizon, what is the correct way to respond? Surely a big problem needs a big solution? Permaculture advises us to take the opposite path. A single big response, like geo-engineering, might not work, or it could have drastic unintended consequences -- in fact it almost certainly would. Such consequences would be impossible to predict and to prepare for large-scale action may be as dangerous as the problem itself.

For the reason that there is no single answer to this challenge and no single new technology to resolve the climate problem or its consequences on the planet's ecology, we need to try out as many things as we possibly can.

Seeing the potential in old buildings and under-used landscapes to create opportunites

The reason that 'Small Is Beautiful' is that at small scales we can observe, make adjustments and return any surplus back into whatever processes we have started. In other words, small scale solutions present learning and fine tuning opportunities, rather than potentially catastrophic failure. Small solutions that work well and meet real needs will grow quite quickly, and as they do they will inspire other people to take on similar ideas, perhaps adapting them to their specific circumstances to replicate it. A great many small initiatives would create an atmosphere of inventiveness. It would stimulate and challenge everybody to become more involved. One of the key themes we have explored in this book is the need for us to move away from being passive consumers in the global marketplace and learn to produce at least some of what we need. Growing in the region of 10-20% of your own food greatly insulates you from market fluctuations and sensitises you to the living world to a greater extent than buying everything from supermarkets. Growing gets much easier as your skills develop and you gain experience, and as your garden develops you will also be contrubuting to the growth of healthy organic soil, bursting with life and fertility.

Good ideas grow of their own accord. People copy things that work and replicate them. The atmosphere of creativity could quickly accelerate. Our experience working in refugee settlements in 2018 was that trainees initiated projects like these almost immediately. They chose ideas that made sense to them and then innovated, using locally available materials and skills familar to themselves. Within months some of the trainees successfully transformed their situations, using fuel efficent stoves, growing their own produce and much, much more. Let's take some inspiration from this and see what small and slow solutions we can implement in our own lives!



Biographies

Steven Jones, here at Lalibella in Ethiopia, is a passionate permaculture teacher and wildlife enthusiast who also has a fascination with history and economics. As well as working in permaculture education, project development and promotion Steve is immersed in housing co-operatives and sees the co-operative model as one of the great innovations of the modern era. Steve grew up on a farm in Shropshire before spending time in Canada, India and Zimbabwe, finally settling in Wales in 1994. Since then he has established a series of housing co-operatives using permaculture as a model as well a starting *Sector39* in 2005 as a means to share much of what has been learned along the way. He lives at Dragons co-operative in Llanrhaeadr ym Mochnant, Powys.

Having completed a Permaculture Design Course with Steve Jones in 2009, Angharad has worked as part of the Sector 39 team facilitating on three PDCs in Uganda in 2016 and 2018. Most recently she has taken the role of education officer and enjoys finding creative ways to engage, inspire and teach others about the environment. Whilst working for eight years as a gardener, Angharad pursued her interests in the environment through horticulture and garden design which lead to a Diploma in Landscape Garden and Design at Harper Adams University, followed two years later by a BSc in Landscape Architecture with Ecology at Sheffield University in 2015. With a healthy thirst for knowledge Angharad has most recently undertaken a course to become a Level 3 Forest School Practitioner.

Dr. Jack Hunter is an anthropologist exploring the borderlands of consciousness, religion, ecology and the paranormal. He lives in the hills of Mid-Wales with his family. He is currently a Visiting Lecturer in the Department of Theology and Religious Studies at the University of Chester, and an Access to Higher Education lecturer in the Humanities and Social Sciences at Newtown College. He completed a Permaculture Design Course at Chester Cathedral in 2017. He is the author of *Engaging the Anomalous* (2018), and editor of *Strange Dimensions* (2015), *Damned Facts* (2016), *Greening the Paranormal* (2019), and is co-editor with Dr. David Luke of *Talking With the Spirits: Ethnographies from Between the Worlds* (2014). Find out more about his work at www.jack-hunter.webstarts.com

Busoga Link

Think global act local

Change is accelerating around the world as more and more countries feel the effects of climate change and resolve to respond to it. Llanfyllin has a long-standing link with Eastern Uganda through Dolen Ffermio, a Wales/Uganda farmers' support charity. There have been a series of visits in both directions for pupils from Llanfyllin High School, local farmers and teachers over many years. Through this interaction strong friendships have evolved.

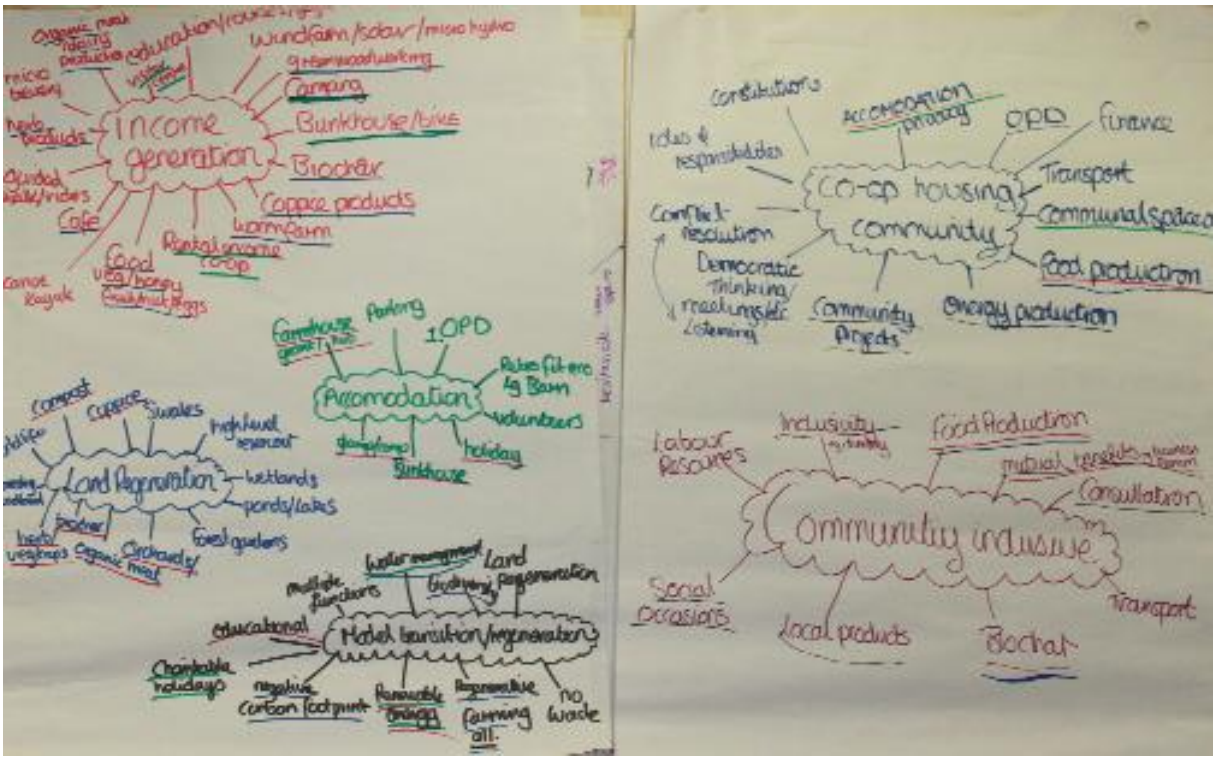
When we had the opportunity to teach our permaculture course in Africa it made every sense to run our first ones in the town of Kamuli, where Busoga High School is situated. This is the school that Dolen Ffermio had originally worked with, linking Llanfyllin High to its African sister years before.

Once Sector39 had begun working in Uganda it became clear almost immediately that we had started something that could really take off. Permaculture's peer-to-peer learning model makes it relatively easy to propagate and spread across a community, especially where people have access to land and basic resources, and where there is a clear need to develop food and livelihood security.

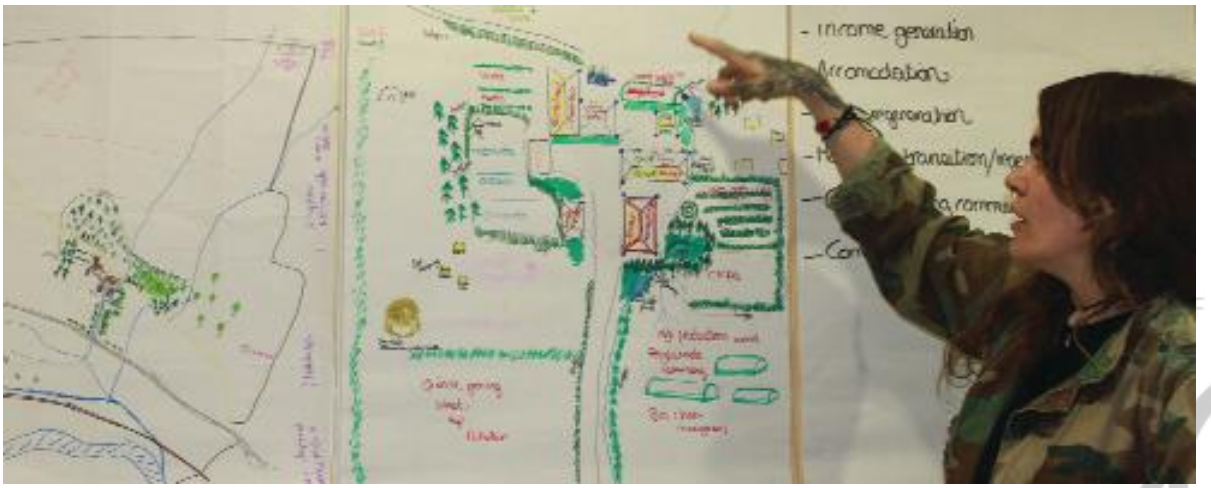
Permaculture study group in the field, Kamuli Uganda. Paul Ogola, (centre) has since gone on to set up his own successful training centre in his home town of Homa Bay, Kenya.

It has been an absolute pleasure to work with the Busoga team, both as a learning opportunity and because we made so many new friends. It has been wonderful to have the chance to build on these relationships. We delivered two PDCs in this community, helping shape a demonstration farm and the school's own forest garden, which is now a significant feature and teaching resource at the school.

The communities we have worked with in Uganda in particular are easy to work with as they speak great English and are really keen to reach out and make international friends and partners and to link schools and communities. Everybody needs to feel connected, to feel part of a bigger whole, especially when we are engaged in innovative change like this. We have much to talk about and share. If you or your school or community want to find partners in East Africa then we really urge you to do so. This is not about charity, it is about connections -- sharing and realising that we are all living on this big ball of rock and that collectively we are managing the ecosystem that we are all part of. Let's work together!



Design from the big picture first, working towards the details



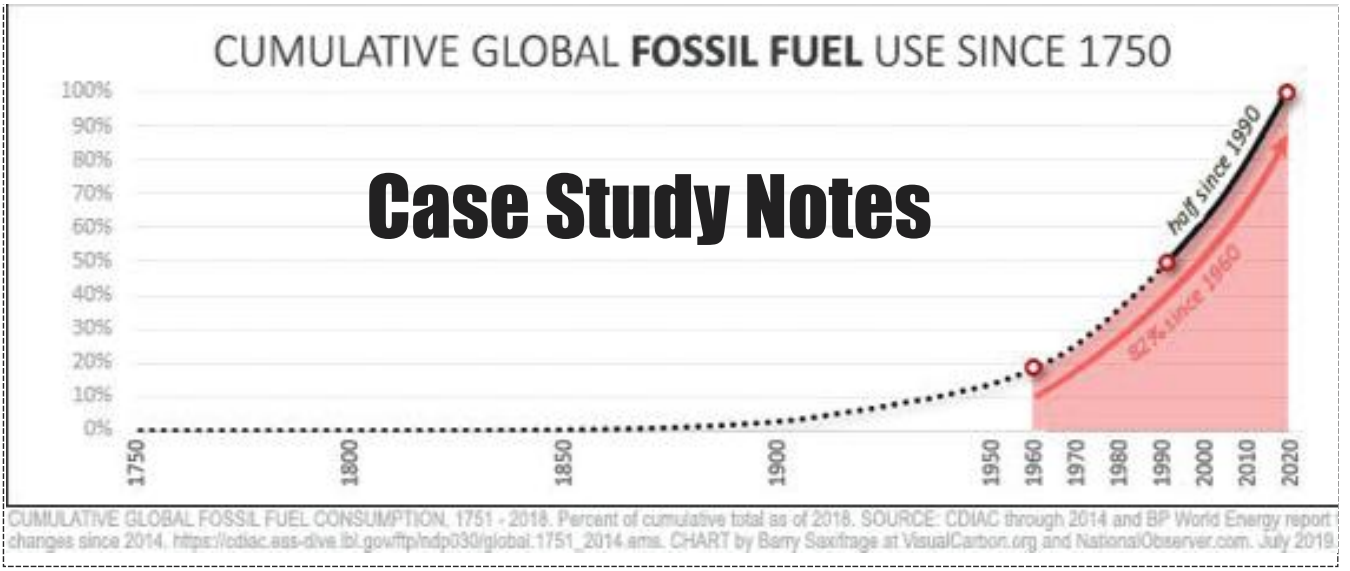
Permaculture as a design tool

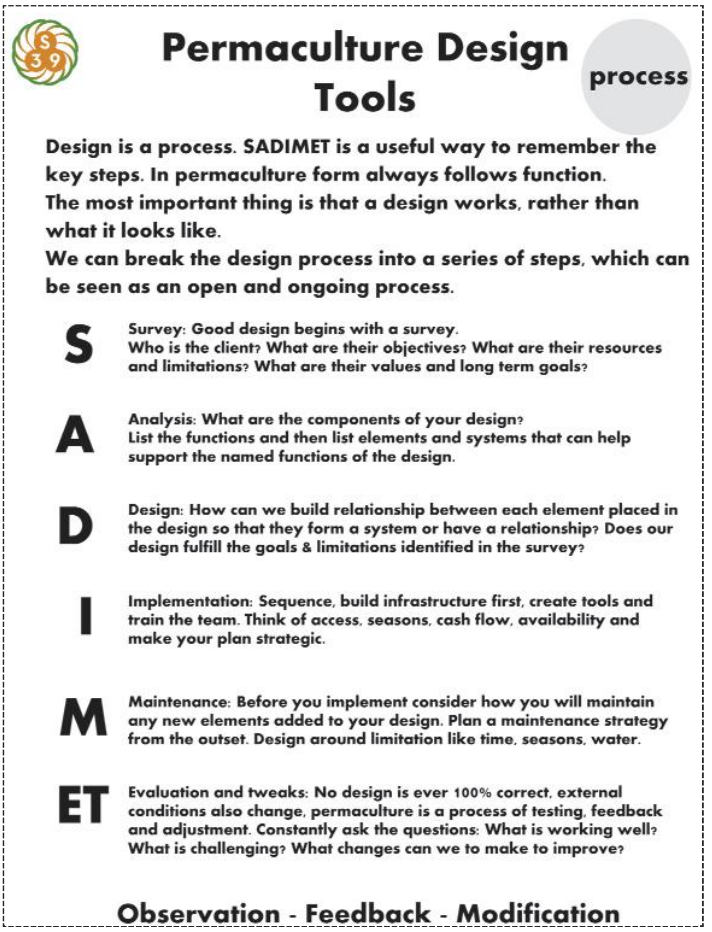
PDC19 graduates at Tan y Fron co-operative, Meifod. They created designs for an upland farm and a community garden for our community, helping to visualise the possibilities of embracing permaculture.

Basemap, concept map then design. Taking in feedback from the client community at each step.

We challenged the S39 Winter/Spring PDC19 course to come up with designs for two potential land-based projects. Upland farming in Wales is in an economic crisis yet strategic land management changes could be a key part of making our landscapes much more resilient to change, create new opportunities for the next generation and take a leading role in habitat restoration and carbon sequestration.

Case Study Notes





SADIMET design model, helps a design team think through a design process, generating ideas that meet specific design outcomes and functions

We evaluated a local farm that was for sale at the time and created a business plan to bring it into co-operative ownership as an example that other farms could follow. We wanted to create the kind of farm that Welsh naturalist Iolo Williams would approve of!

The second group was tasked with envisioning a small-scale, intensive community garden utilising an unused and unvalued strip of land on the edge of our community orchard. It turns out that a strip garden, or Selion, is part of a long standing tradition here in Wales. Another interesting example of the power of edges.

The two designs together explore some important themes for possible next steps for the project. Since then we have been offered a plot in the local town of Llanfyllin from which we could start a community horticulture project. This is an idea we will base on the experience of Cultivate in Newtown, the organic horticulture training centre established in 2014.

These kinds of case studies, examples and community-led projects allow people to see potentials and, more importantly, to be involved in the design and planning process. Permaculture runs on feedback, remember, and the thoughts and inputs of the community surrounding any project are essential if it is to meet the needs of, and be understood by, that community. Throughout the three years of this project we have been regularly working at the Cae Bodfach orchard with a diverse range of groups, including several different classes from the High School, the Primary School, town councillors and the general public, as well as groups like MENCAP, permaculture study groups and other interested individuals who want to be able to learn from and adapt these ideas to fit their own communities. Seeing us working in the field with these groups has helped our community to see the value of the work being done.

Permaculture design helps visualise change

Sector39

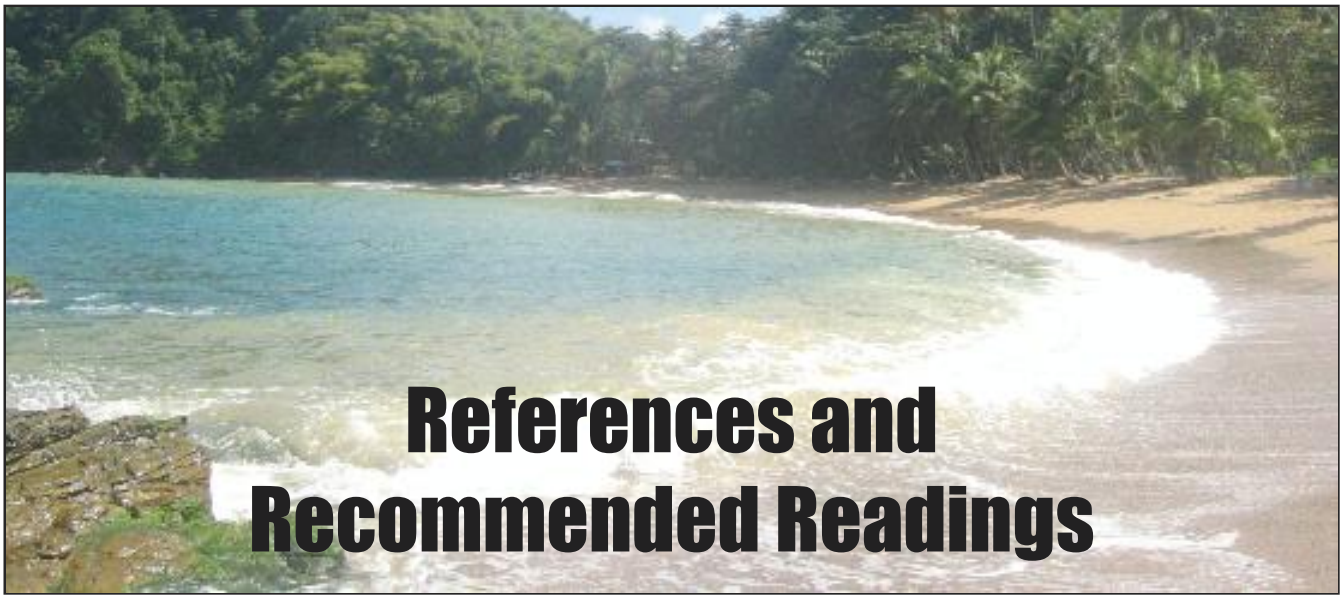
Llanfyllin High school alumni Nina Duckers and Grace Maycock with the rest of the gardening team who set up the site for the 2018 PDC and conference at Ssanje Uganda. They created demonstration gardens, built composting toilets and hand wash stations. They built a team of helpers and delivered practical sessions on the two-week intensive course that followed. Everyone makes a difference. Working with international partners can be a life changing experience.

Sector39 began in 2005 as an enterprise aiming to bring permaculture teachers, practitioners and artisans together so we could deliver courses, develop projects and take pemaculture design ideas into new areas of society and the economy. What started on the roof-top forest garden of Reading International Solidarity Centre (RISC, at 39 London Street Reading) has since reached environmental activists, professionals from across the board, the general public on many occasions, television series, teachers, schools and the church.

In 2014 we started working in East Africa where we have linked up with grassroots permaculture leaders in Uganda, Kenya and Rwanda, delivering a series of courses there to a broad range of farmers, teachers and environmental workers. In 2018 we won a seven month contract to train 200 refugees from South Sudan as permaculture teachers and community leaders to help build food security and sustainable incomes in some of the biggest refugee settlements in the world. We expect there is much more to come as permaculture is such a powerful tool for fighting climate change and building community resilience.

Permaculture brings people ogether

READING LIST



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The roundhouse at the Cultivate community horticulture centre in Newtown. The perfect place to read, share and discuss exciting new ideas, taking learning out of the classroom and into the field!

INDEX

INDEX

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Images

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P3 Writing on the Wall by Cesar Manrique
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P 18 UN goals. United Nations
P19 Ironbridge, creative commons
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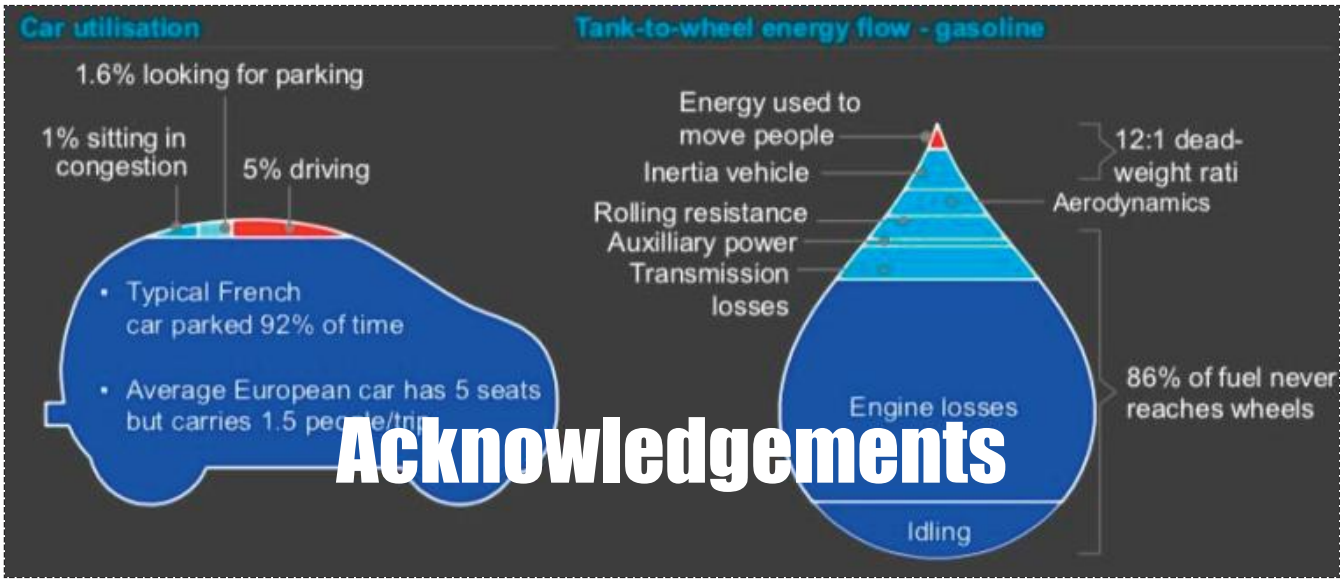
P21 Greta thunberg, creative commons
P23 Blue Planet, both images creative commons
P24 Chikukwa village, creative commons
P26 Busoga Garden by Connie Kauma
P27 Blue Marble, NASA creative commons
P28 Mural at Cultivate Newtown
P31 School Work from Llanfyllin high school
P33 Soil Life, creative commons
P34 Soil Experiment, creative commons
P36 Glass houses Spain, creative commons
P37 No Bare Soil and Ox Plough, creative commons
P38 Building Soil, creative commons
P39 Carbon Cycle, creative commons
P41 School work, Llanfyllin
P42 Stromatalites, creative commons
P43 Equlibrium, all pics creative commons
P44 Homeostasis, creative commons
P46 Whale and Beaver, creative commons
P47 Humpback whale, creative commons
P48 Wolf and Rivers, creative commons
P49 Images by course particpants S39
Food webs, creative commons
P51 Fracking sites Texas, creative commons
'Golden boy' by Tom_Dorrington
P52 Ice melt and Peak Oil graph, creative commons
(Peak Oil is a complex subject, worthy of further research)
P54 Transport pics, creative commons
P55 Tractor and Horse, creative commons
P59 Dodo, creative commons
P60 Nature's Patterns, creative commons
P64 Garden Design by Ian Watt
P67 Sign by Llanfyllin High School Students
P72 School work Llanfyllin High School
P77 Kids Planting by Paul Ogola
P80 Beaver, creative commons
P81 Hedge Layer, original print by Bob Guy
P83 Future scenarios, creative commons
P85 Suzuki & Thunberg, creative commons
P98 Car Graphic, creative commons



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