gaiaeducation

Design for Sustainability

ecological dimension

Module 1
Whole systems approach to ecological design

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English version

ecological dimension

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1. Introduction

The scale of global interconnectivity and interdependence has resulted in a step change in the complexity, uncertainty and speed of change in today's operating environment. Many of the concepts we used to rely on to make sense of our world no longer have traction. In many respects we are experiencing a 'conceptual emergency'. In response, organisations communities and governments are adopting familiar strategies: intensifying standard processes, strengthening the centre, sticking to core competencies, prioritising short-term results, promising only what can be delivered."

***International Futures Forum,** Powerful Times*

The aim of this first module is to sketch out a very large canvas of the 'big picture' of design for sustainability. You will be introduced to a series of whole systems approaches to ecological design all sharing a common thread, the agreement that we need to re-design the human presence on Earth if we want to get serious about co-creating regenerative and sustainable cultures everywhere, cultures contagious with creativity, meaning, and significance so they can spread across the globe, adapting to the bio-cultural uniqueness of place and manifesting a sustainable human civilisation in all its wonderful diversity, solidarity and communion with the wider community of life.

We will take a look at some of the major drivers of change that make such a transition to a sustainable human civilisation no longer a utopian dream, but an ecological imperative if we hope to see our species thrive into the 22nd or 23rd century. We will take a brief look at the dynamic Earth Systems that underpin the work of regenerative ecological design and our integral presence as a species within those dynamics. Briefly, we will review the most up-to-date information on the great challenges of our time - biodiversity loss, desertification and climate change — from a whole-systems approach that provides clarity for purposeful action. We will look at how concepts such as peak oil have been affected by the political decision to stay below 1.5 degrees average global warming in order to avoid catastrophic climate change and how the three UN Framework Conventions that emerged from the Rio Earth Summit in 1992 are finally coming together in the UN Decade of Ecosystem Restoration.

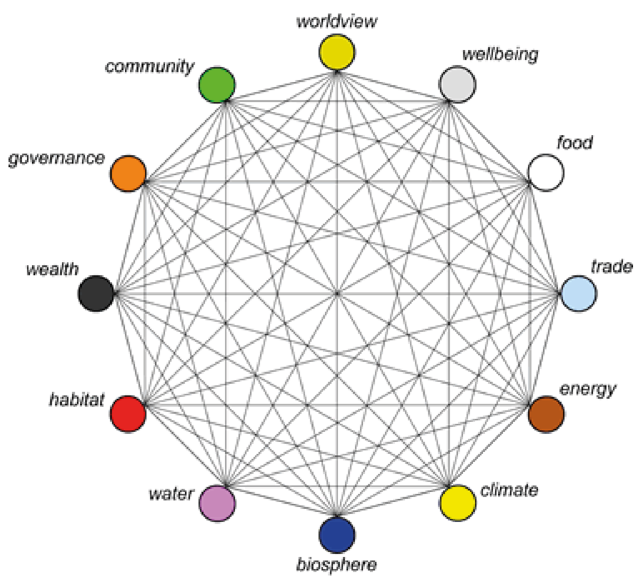
Before moving to specific applied and tested solutions in the areas of energy, food, water, and building, we will explore a whole systems framework for design that reminds us to link products to buildings to communities and industrial systems, to cities, bioregions and into national and global collaboration. Design for sustainability is about creating synergies between these different scales of design. Design for sustainability aims to optimise the health of the whole system for the long-term benefit of all participants in the systems, rather than maximising a particular aspect of the system to the short-term benefit of only a few. Building a globalised sustainable human presence on Earth is about decentralising and localising our intimate relationship with the uniqueness of place and the specific bio-cultural conditions of each bioregion and each ecosystem. This process will require global collaboration and knowledge exchange.

Starting from the concept of "Building Cultures of Sustainability", this section covers the "big picture". As opposed to detailed design concepts, we look at some broad philosophies and principles of ecological design. This involves looking at the whole system within which we carry out our lives and affect the world through the specific design decisions we take and implement.

The International Futures Forum has developed a "World Systems Model" (WSM) in response to our 'conceptual emergency', which looks at the linkages between key aspects of our world, within a whole system. The 12 nodes of the WSM connect twelve critical elements of a viable and thriving human system (Hodgson, 2012). The model can be used as a question generator and whole systems thinking framework. It has been designed so to be applied to the scale of communities, cities, bioregions, countries or for the planet as a whole. Healthy, regenerative and mutually supportive relationships between all the elements at any one scale affect the health and sustainability of the system at all other scales.

To give an example of how the model functions as a question generator that invites systemic thinking, imagine you are asked to design a water system using a whole systems approach. You can use the World Systems Model to explore the connections of your task with the other elements of a viable system and thereby find synergies which may also meet needs in other elements of the system. How does your water system affect and interact with the flow patterns of ecosystems and the biosphere? Are you creating a water solution with a positive impact on climate regulation and the health of the biosphere? Will your solution influence the need for inputs from afar and could it also be of use elsewhere (trade)? How does it help to increase the resilience and wellbeing of the local community? What are the energy demands of your solution and where does this energy come from? Is there an educational (worldview) component to the solution being more widely adopted or used appropriately? Can the water system be optimised in ways that support food production? How does our system relate to current policies, regulations and guidelines (governance)?

Applying the WSM as a tool for whole systems design can help us to create integrated regenerative design solutions, which take all elements of a viable human system into account. Each one of the 64 connecting lines invites us to explore the relationship between different elements and all of them together take us closer to making wise decisions as we are faced with complex challenges. The conceptual emergency humanity is facing invites all of us to learn the art of whole systems thinking and design.



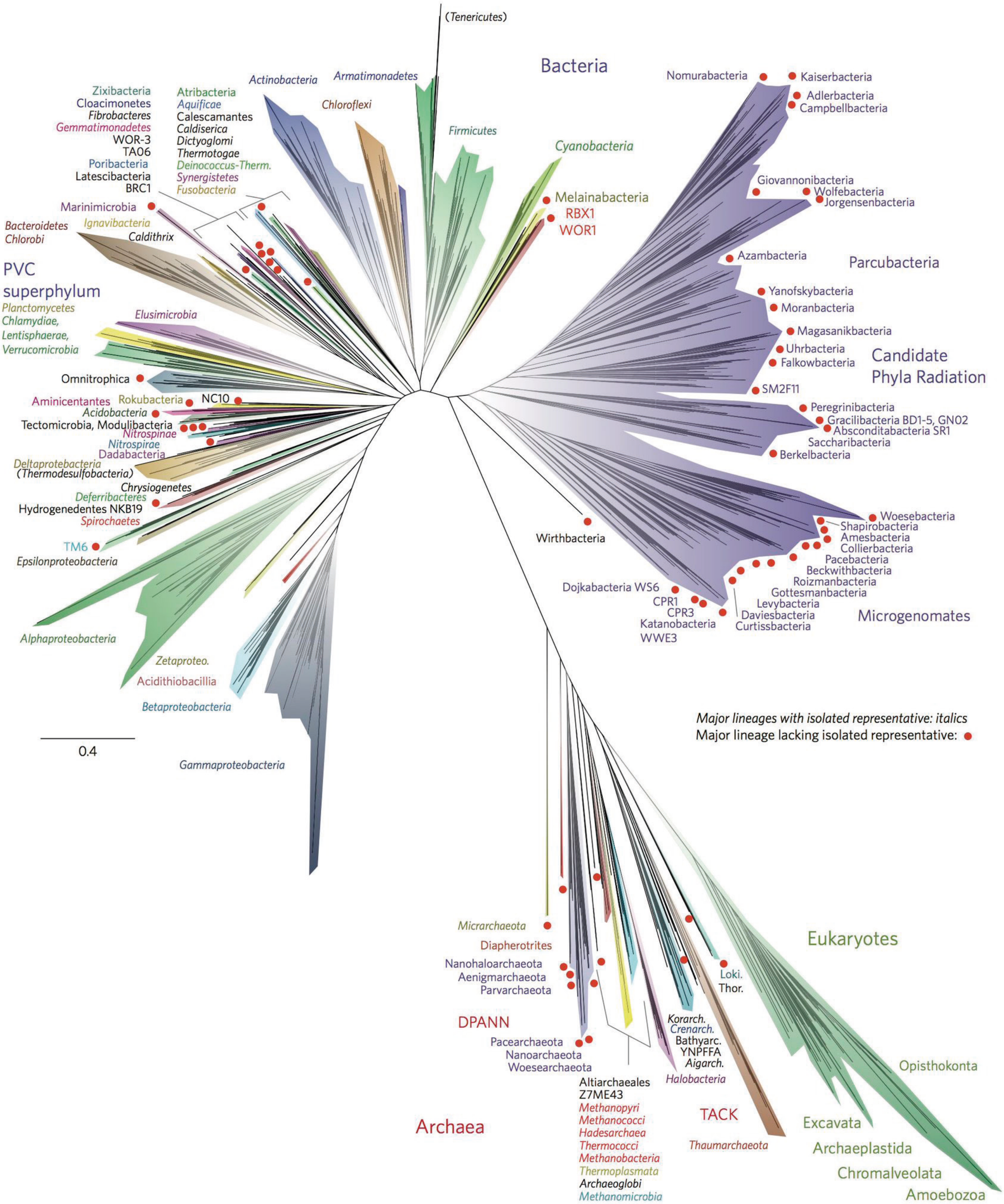
World model and image developed by International Futures Forum

2.

Ecology and the Whole-Systems Approach

In the world model from the previous page, the biosphere is just one of the points of reference, but in reality, the biosphere is everything. It is the total of the Earth-systems integrating all living organisms and their relationships in complex, functional and inter-connected cyclical patterns we refer to as the carbon, hydrogen and nutrient cycles. It is a roughly 25km space around the planet in which living organisms create the conditions that make life possible. Bio is the ancient Greek word for life, so the bio-sphere is itself a living, self-regulating organism, the life-support system for all life on Earth.

The Earth is 4.5 billion years old and has had a great deal of time for research and development. Life appeared on the planet early on, about 3.7 billion years ago. The time our own species has been around is just a blink of the eye in this context, and we can only understand a tiny fraction of Earth's evolutionary history through geology, fossil fuel records, ice cores and the technologies that advance scientific discoveries in the field of geophysics. As John Todd points out, we can never understand the full complexity of Nature, but interdisciplinary life sciences are making remarkable discoveries. Most recently, new gene-sequencing technologies have opened up the hitherto invisible world of micro-organisms and their interactions with other species to a new level of understanding. The Human Microbiome Project and the Earth Microbiome Project show that the influence of microscopic life on our health and well-being is vast and that they play a major role in the regulation of all the functional cycles of the biosphere. Likewise, massive fungal networks in the ground beneath our feet, the largest living organisms on Earth, connect trees to each other, pass nutrients and chemical messages and are essential for the health of the forests and for the soil. In the following modules we will see how these micro-organisms connect the hydrological, carbon, nitrogen and nutrient cycles, how they live in symbiotic relationships with all other living organisms and illustrate the extent to which collaboration between species is as important to planetary health as competition. With this understanding, we can design regenerative systems that supply our needs while regenerating the degraded biosphere.



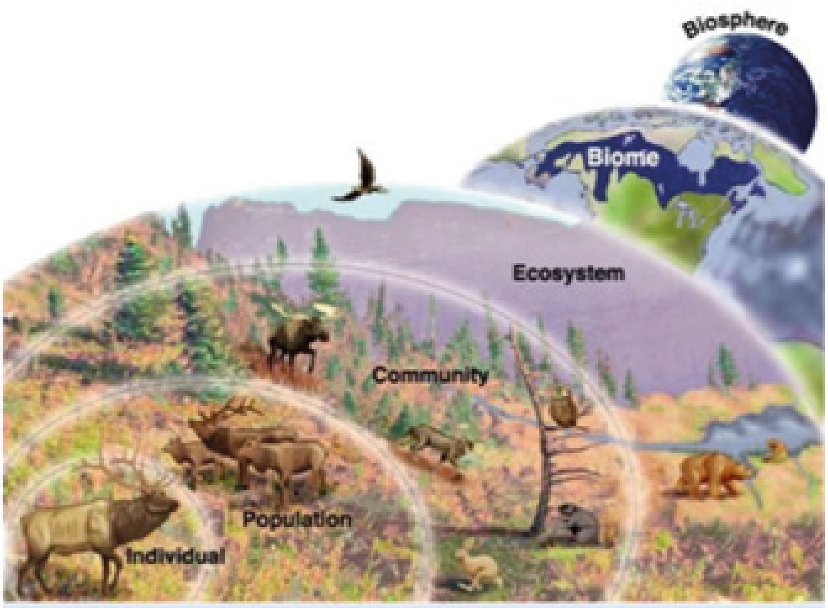
In this diagram, we can see the new Tree of Life drawn up by microbiologists to show the full range of species as yet discovered on Earth. This might come as quite a shock to those people accustomed to seeing a tree with humans at the top and all the animals and invertebrates below in a hierarchical order. In the new Tree of Life, the Kingdom to which we belong, together with all animals, plants and so forth, is to be found in the bottom right-hand corner, the branch of Eukaryotes. In terms of numbers alone, microbial life is vast and crucial to our life-support system. ***Image source:*** *Laura A. Hug et al, A New Tree of Life.*

Ecology, on which the work of ecological designers is based, is the study of the interrelationships between species. We can study individuals, populations of individuals within the same species and the various communities of different species that interact together in a habitat, an ecosystem. This includes organisms from across the kingdoms of life, from the tiniest micro-organism, fungi and vegetation, as well as animals right up to the top predators, all interacting as they breathe, feed and reproduce. But it is the interrelationships that matter, because through relationships they drive those functional cycles. Some species have found a niche and remain there interacting with other species within the ecosystem, others pass through as they migrate, seasonally or at stages of their life cycle, by land, water and air. As they migrate, they transport nutrients and seeds which promote the health and life-cycles of other species.

For example, watersheds (module 2) are dependent for the health of their ecosystems on the migratory fish that swim upstream from the ocean to spawn. When a whale excretes its faecal plumes, it fertilises entire oceans and feeds the phytoplankton which are essential to the marine food chain and produce 50% of the oxygen in the atmosphere. The phytoplankton feed the fish that feed the migratory sea birds that deposit nutrients from the oceans onto land to fertilise it, sometimes over long distances. They also underpin the food chain in which salmon and other migratory fish bring nutrients upstream to renew the riparian ecosystems that are the basis for a healthy watershed. Micro-organisms in the watershed propelled upwards in aerosols from trees seed clouds and cause rainfall to hydrate the land and swell the rivers that return water to the oceans, carrying migratory species with it. Everything is literally connected, and we break these connections at our peril.

The edifice of Nature is a cathedral of life and as a species we are part of it, just one strand woven into the fabric of life. Biodiversity is the key to maintaining healthy ecosystems; every microorganism, invertebrate, plant and mollusc matters as much as the iconic species we love to protect. As we have seen from the talk by Dr John Todd in the Introduction to the Ecological Dimension, as ecological designers and stewards of Nature, we can reduce our human footprint on the planet by 90% when we mimic nature and create complex ecologies in which symbiotic relationships between species function as natural cycles of the biosphere. Through science, ecology, microbiology, Earth systems sciences, we have been able to unravel some of the mysteries of life and the more we understand the better we get at forming those productive partnerships, the biomimicry, and the more humble we must feel at the great creative power of the biosphere and the individual species.

In Nature, there is no hierarchy of species. Plants determine the patterns of their own life-cycles according to sensory perception; they see colours in the spectrum with receptors on their leaves exactly the same as those in the human eye; they respond to wind and rain and heat, and make intelligent 'decisions' about when to grow, when to bloom, when to create fruits and seeds, when to return their nutrients to the soil. Plants respond to the frequencies in the buzz of pollinating insects and increase the sweetness of their nectar in response. They are masters of organic chemistry and produce complex molecule chains for nutrition, toxins, smells, to promote beneficial interactions with other species and to repel predators. They also manufacture chemical messages called pheromones. As ecological designers we are partners with these other species, interacting with them, and to do that effectively, we require ecological knowledge. At the beginning of each of the following modules we will look briefly at the functional cycles of the biosphere and the ecosystem interactions relevant to our design work. This is the essence of the whole-system approach in which ‘life creates the conditions conducive to life’ (Dr Janine Benyus, Biomimicry Institute).



*Ecology is the scientific study of the interrelationships between living organisms and the environments in which they live. Ecosystems are embedded in the geological and climatic conditions of biomes and together then form the biosphere. **Source:** Biomes By: Paul Nolasco & Lorraine Manalese*

While science is making great inroads into the functioning of life on Earth, we mustn’t underestimate the traditional ecological knowledge of indigenous peoples and the worldview that underpins it. Often, science is confirming what indigenous peoples have always known and understood. Reports drawn up for the UN and its affiliated programmes have shown that indigenous people manage their lands much better than we do and we can learn a great deal from them. As we leave the UN Decade on Biodiversity and enter the UN Decade of Ecosystem Restoration, we need this ecological knowledge to steer our way through the crisis to regeneration.

Humans constitute just a tiny fraction of the total biomass on Earth however according to a recent study human-made objects may now outweigh all of the living beings on Earth. Of the total 550 Gt C, humans make up just 0.06 Gt C. The vast majority of life on Earth is composed of plants, fungi and microbes.

Pause and Bring it to Life

Why are our current approaches reductionist? Could you give an example of this?

Name some areas of your life and community where you see these approaches and what have been the unintended consequences?

How are they affecting ecosystems and the species and cycles in them?

How are they affecting people’s lives? How are they affecting you?

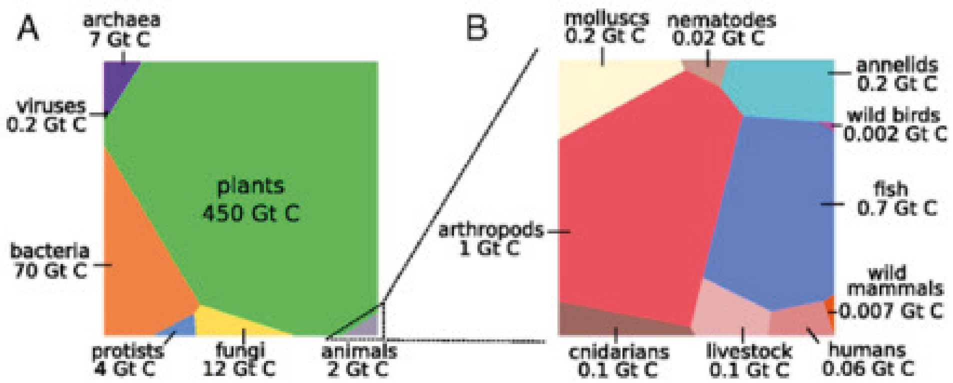


Image source: Yinon M. Bar-On et al. “The Biomass Distribution on Earth”.

3.

Different Streams of Ecological Design

The application of ecological design principles and technologies to the built environment has become a major imperative with increasing understanding of global environmental problems. These problems have been largely created by the building and energy practices that characterise the 'developed world' with its linear – extract, use, and dispose – economies and wasteful systems of production and consumption.

The new ecological agenda for sustainable building design is one that insists on the incorporation of not just energy efficiency in all aspects of the built environment but to do so in a regenerative way based on renewable energy and materials, while caring for the health of communities, ecosystems and watersheds within an integrated socio-ecological framework.
To start with, we will take a closer look at seven complementary and related ecological design approaches and methodologies which have been successfully applied to the creation of solutions with improved sustainability and often also to regenerate degraded systems and improve systemic health:

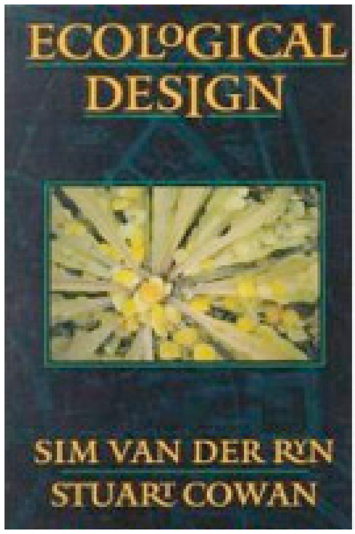
1. **Permaculture –** design inspired by ecology;
2. **Ecological Economics** – balancing the four capitals;
3. **Restorative Environmental Design** – importance of place and biophilia;
4. **Ecological Engineering** – nature is the toolbox;
5. **Industrial Ecology** – cyclical vs. linear processes.
6. **Cradle to Cradle Design** – up-cycling and the circular economy; and
7. **Regenerative Design**

Subsequently, we will explore Master Planning as a design process and how to develop and apply design protocols and sustainability indicators as tools for project implementation. We will look at the integration of utilities, the importance of the different scales of design as well as appropriate scale and scale-linking design, before we end by investigating the relevance of re-localisation versus centralisation in urban design approaches.

John & Nancy Todd, two pioneers of ecological design who started the New Alchemy Institute in 1969, proposed a set of general precepts that should guide all approaches to ecological design practice. In their book From Eco-Cities to Living Machines Principles of Ecological Design, they invite us all to become conscious and responsible co-designers of the world we inhabit:

- **That the living world** be the matrix for all design;
- **That design follow**, not oppose, the laws of life;
- **That biological equity** determines design;
- **That design reflects** bio-regionality;
- **That projects be based** on renewable energy sources;
- **That design be sustainable** through integration of living systems;
- **That design be co-evolutionary** with the natural world;
- **That building and design** help in healing the planet;
- **That design follows** a "sacred ecology".

Jack-Todd & Todd, 1993



"Ecological Design" is one of the early books in the field, written by two industry pioneers - Sim Van der Ryn and Stuart Cowan

3.1. Permaculture: An Ecologically Regenerative Energy-Descent Design Concept

"Permaculture (permanent agriculture) is the conscious design and maintenance of agriculturally productive ecosystems which have the diversity, stability, and resilience of natural ecosystems. It is the harmonious integration of landscape and people providing their food, energy, shelter, and other material and non-material needs in a sustainable way. Without permanent agriculture there is no possibility of a stable social order. Permaculture design is a system of assembling conceptual, material, and strategic components in a pattern which functions to benefit life in all its forms. The philosophy behind permaculture is one of working with, rather than against, nature; of protracted and thoughtful observation rather than protracted and thoughtless action; of looking at systems in all their functions rather than asking only one yield of them; and of allowing systems to demonstrate their own evolutions."

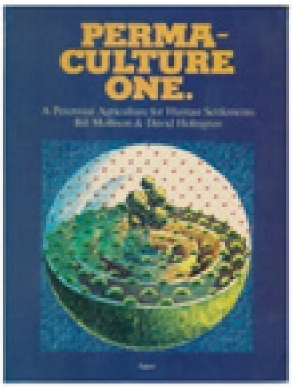
***Bill Mollison**, Permaculture: A Designer's Manual, 1988*

What is Energy Descent?

Two events that took place in the early 1970s challenged the assumptions about progress current since the onset of the Industrial Revolution. The Oil Crisis (1973) drastically and suddenly reduced the availability of crude oil and raised questions about the long-term viability of our dependence on fossil fuels, while the publication of a report from the Massachusetts Institute of Technology entitled The Limits to Growth (1972) predicted that our growth-oriented industrial societies would collapse due to depletion of resources if we continued to over-exploit them. Among the many people discussing the socio-economic and environmental implications for the future were Bill Mollison, a lecturer at the University of Tasmania, and David Holmgren, the environmental design student he was mentoring.

The scenarios that emerged from a range of scientists, economists and engineers in response to the Oil Crisis and the Limits to Growth report varied considerably. At one end of the spectrum were those who envisaged transcending the limits through technological innovation, nuclear and renewable energies, automation, robotics and exploitation of other planets. On the other end were those proclaiming the inevitability of a 'Mad Max' scenario of famines, disease and wars over resources. Mollison and Holmgren were among the few who actually sat back and calmly asked what a planned and measured 'energy descent', one that embraced a whole-systems approach to resources, would look like. The result of their collaboration was Holmgren's dissertation, published as Permaculture One in 1978.

The structure of any society, be it hunter-gatherer, agrarian or industrial is largely determined by the quality and availability of the energy sources that sustain it. The intense energy generated by burning fossil fuels has enabled our industrial society, and a transition away from fossil fuels to any other form of energy, including 'renewables' such as wind and solar photovoltaic, will inevitably be a step down in energy intensity. Moreover, fossil fuels are a stock of energy, laid down in the ground over hundreds of millions of years, once we have burned through this stock, we will be obliged to return to 'flow' models of energy provision.

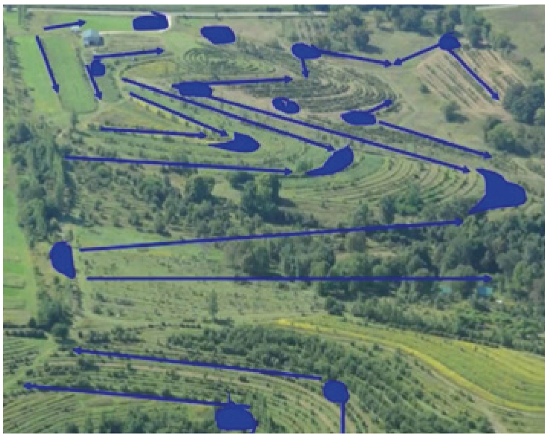


Permaculture One: A Perennial Agriculture for Human Settlements

For this reason, Permaculture One focused on land-based design solutions to powering down and providing our essentials without the need for fossil fuel inputs.

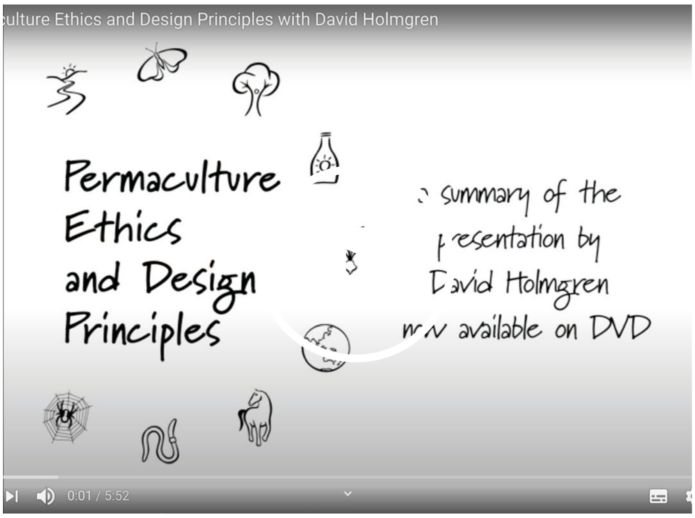
Permanent Agriculture

Mollison had spent many years working on the land as well as in some of Australia's last-remaining intact rainforests and one question dominated their thoughts. Nature is dominated by perennials, so why is our agriculture dominated by annuals? Nature exhibits remarkable abundance as well as resilience in the face of shocks such as droughts and storms without any human intervention, so why is our agriculture based predominantly on scarcity, for 90% on annual crops that erode soil, degrade ecosystems and deplete groundwater resources through irrigation? This was at the crux of any energy-descent scenario - modern agriculture is highly fossil-fuel dependent and requires massive and steadily increasing inputs of artificial fertilisers, chemical pesticides and heavy machinery. A transition to any lifestyle that could limit our dependence on oil and provide for our basic human needs — food, fuel, fiber and shelter - would require a system that mimicked nature's resilience - permanent agriculture - an edible ecosystem perfectly adapted to the local biome. The title was shortened to permaculture, recognizing that in order to facilitate an orderly descent from the energy-intense industrial societies that fossil fuel stocks have permitted, there would need to be changes to the culture too. Mollison and Holmgren subsequently went in different directions. Mollison set up Zaytuna Farm, the Permaculture Research Institute and the curriculum for the basic courses in permaculture design still taught today - the Permaculture Design Certificate - and toured the world teaching thousands of people and producing a second generation of permaculture teachers across the globe. In 1988, he produced The Permaculture Designers' Manual. When he retired due to ill health, he named Geoff Lawton as his successor. Lawton continues the teaching in land-based design and has expanded into ecosystem restoration projects. Many of Lawton's videos can be found online (see the appendix for more details). Mollison died in 2016 leaving behind him a global movement.

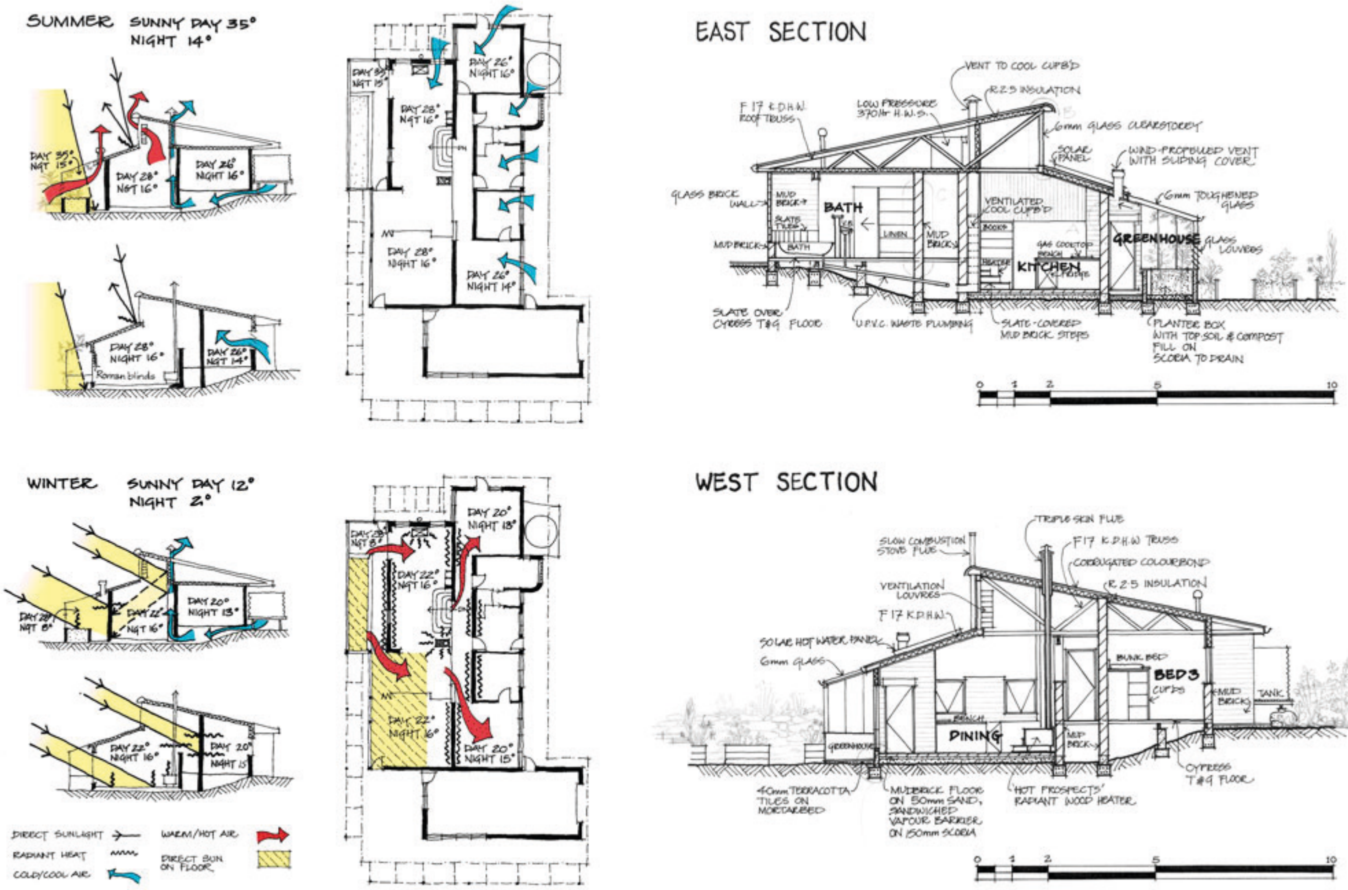


Mimicking nature: *Mark Shepard's permaculture project, New Forest Farm, transformed land degraded by annual cropping through a process of restoration. Permaculture focuses on creating water-retention landscapes following application of Yeoman's 'keyline' structures on landscape contours. More of these in modules 2 and 3. Source of image*

Mollison had spent Holmgren always regarded permaculture as more of a philosophical mindset for a way of life rather than just gardening and agriculture. He continued to work on models of energy descent geared to creating small communities in the margins of small towns and transforming the suburbs of major cities. His model homestead, Melliodora, includes all aspects of an energy-descent plan, the bioclimatic buildings, water management, passive and renewable energy as well as small-scale, ecologically designed food and fuel provision. It is situated on the outskirts of a small town to facilitate community-building through exchange of goods and services and in the expectation that more people will follow by example.

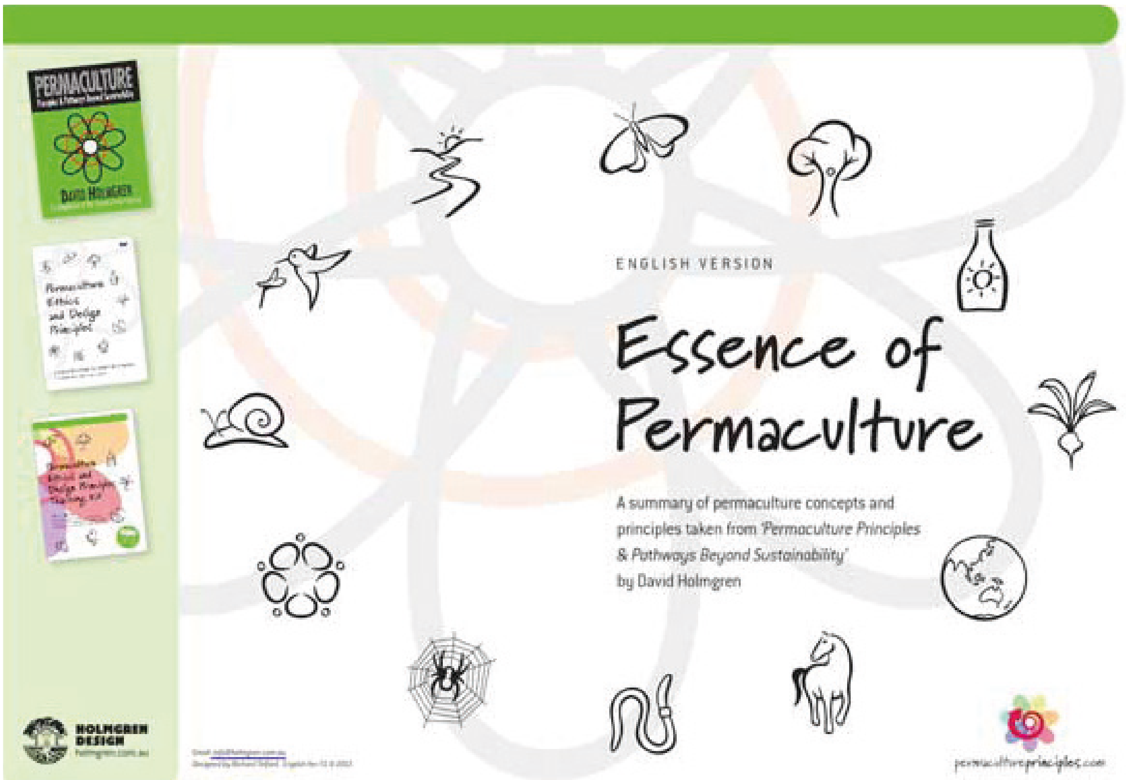


Permaculture Ethics and Design Principles with David Holmgren [short vídeo](5min) of David Holmgren introducing the permaculture design principles and their relationship to the foundational ethics of permaculture: Earth Care, People Care and Fair Shares.

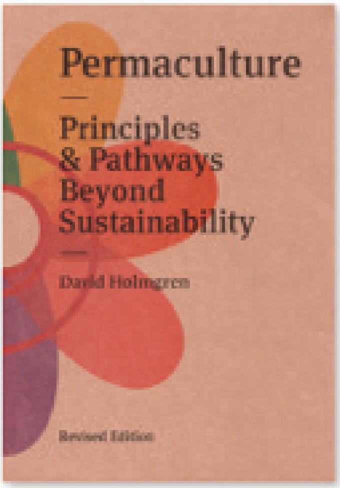


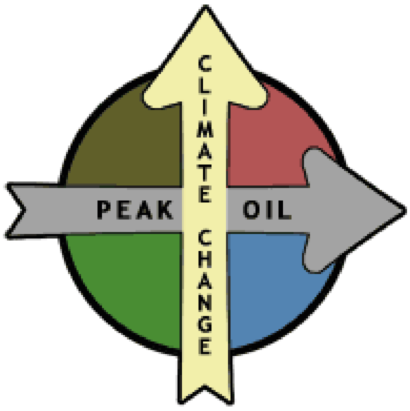
Bioclimatic design for the house. David Holmgren, Melliodora. The project designs can be seen in enlarged format at https://store.holmgren.com.au/product/melliodora/ Bioclimatic design will be discussed in module 5.

Holmgren also embraced the work of Howard T. Odum (Ecological Engineering) in search of a deeper understanding of energy flow through (living) systems (we will introduce Odum later). He simplified Mollison's 18 principles and reduced them to 12 clearly defined approaches to the design process and to ongoing change. They focus on the importance of observation, integration, conservation and renewal of resources, on systems, rhythms, patterns and process. More information can be found, including a downloadable booklet, from the permaculture principles website.



You can also download a short summary entitled The Essence of Permaculture in various languages here.

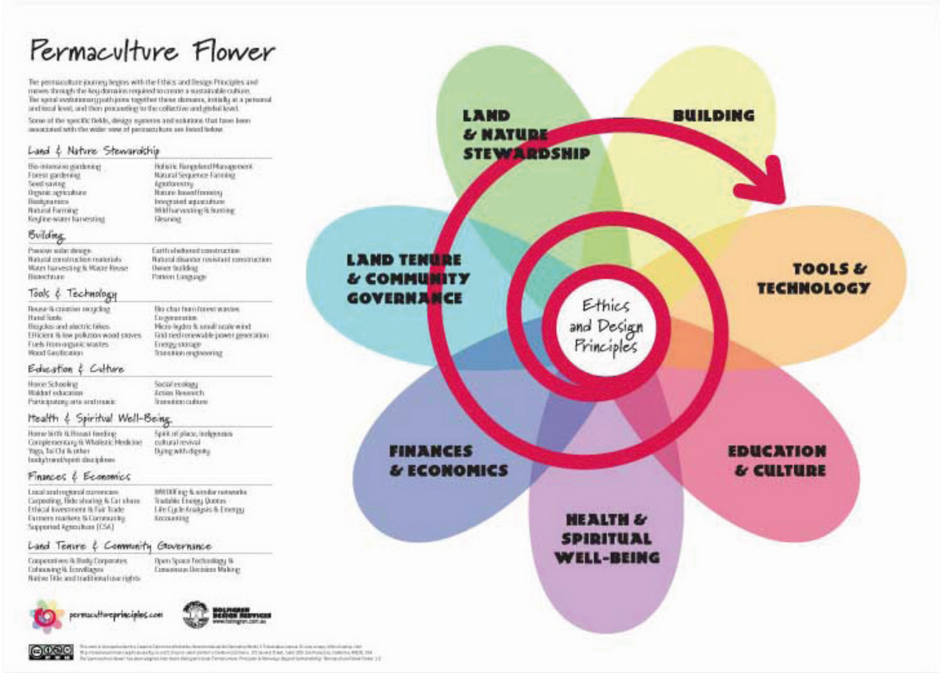




Source of image

It was followed in 2009 by Future Scenarios: How communities can adapt to peak oil and climate change in which he envisaged four global climate change and energy-descent scenarios. These formed the basis for ongoing discussions about the impact on resources and potential choices we would make within each of the scenarios bearing in mind that even the 'techno explosion' scenario run on renewable energies would still be a step down from the energy intensity of fossil fuels.

Holmgren's vision of permaculture has evolved but remains true to the initial conception of human lifestyles and settlements determined by the need to adapt to dwindling resources and an ecological, climate change crisis. In his work, permaculture is both a design concept based on a long-term vision as well as a culture of ongoing change. For Holmgren, energy descent is not a problem, it is an opportunity to build resilient, regenerative cultures, as long as we fully comprehend the energetic and biological basis of life.



For an enlarged version, [click on the link below](https://permacultureprinciples.com/resources/free-downloads/#lightbox/1/). You can also listen to David Holmgren's explanation on the same website.

https://permacultureprinciples.com/resources/free-downloads/#lightbox/1/

As a logical development of Holmgren's trajectory, the most recent project is RetroSuburbia. It highlights the vast potential for 'retrofitting' suburban houses and gardens and transforming neighbourhoods into resilient communities, on a street-by-street basis, for an energy-descent future. The book also contains designs for heating and cooling, growing and storing food, DIY building tips and community-building exercises as well as 8 case studies. On the website there are 3 short videos and further links to information and examples about simple ways to retrofit your home and build community. Since the covid-19 pandemic, in the true spirit of applying the third permaculture ethic, it is now also possible to read the book for free, online. https://retrosuburbia.com

Permaculture embraces every module in this dimension as part of a comprehensive whole-systems approach. It is now a global movement growing daily in response to climate change and the degradation inherent in an extractivist model of industrial society. It is a diverse movement, one that has inspired homesteading and backyard self-sufficiency, ecovillages, urban community and rooftop gardening as well as ecosystem restoration and sustainable business models. It is taught in almost every country across the globe by second and third-generation teachers and has entered schools and universities and influenced design across disciplines.

The Permaculture Flower shows the seven domains of permaculture design. While all energetic and biological processes relate

The US permaculture film INHABIT is available on Vimeo. The filmmakers visit projects from the smallest backyard through to Mark Shepard's 105-acre farm passing through businesses, prisons and urban projects on the way. Watch the trailer [by clicking on this link](#)

to land use, so that tenure, community governance and stewardship of land are primary concerns, the sphere of activities expands outwards through buildings, tools and technology, education, spiritual well-being, culture and finance/economics. The ethics embrace all aspects of human organisation.

Permaculture is not a 'toolbox' of techniques, it is whole-systems thinking in practice. Some more recent developments in permaculture design include:

Marine Permaculture

Marine Permaculture aims to combat the loss of ocean biodiversity naturally through the use of kelp platforms and as the kelp photosynthesizes CO_2 is drawn out of the atmosphere and returned to the carbon cycle. It is an excellent example of a whole-systems approach.

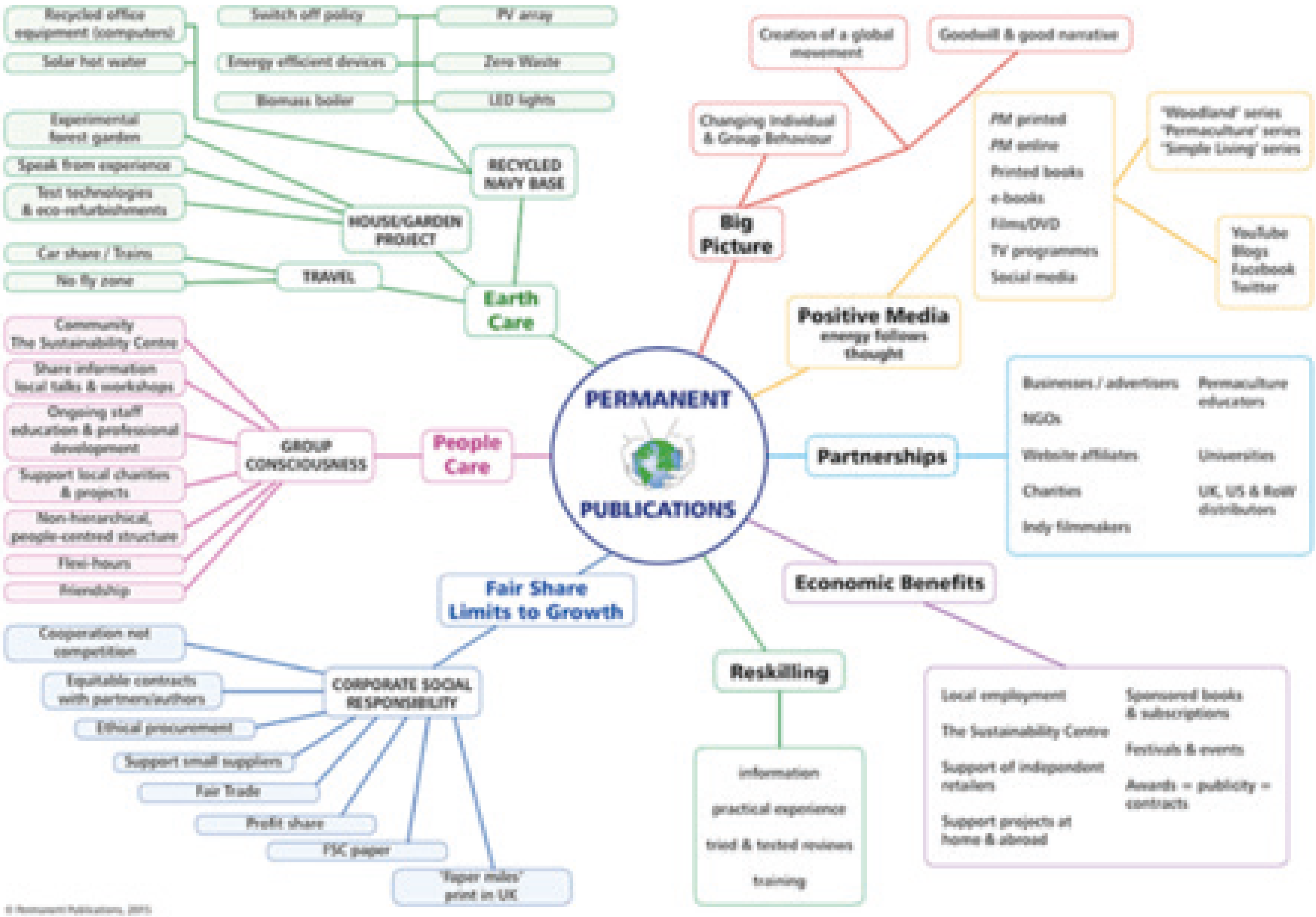
A Permaculture Design for Business

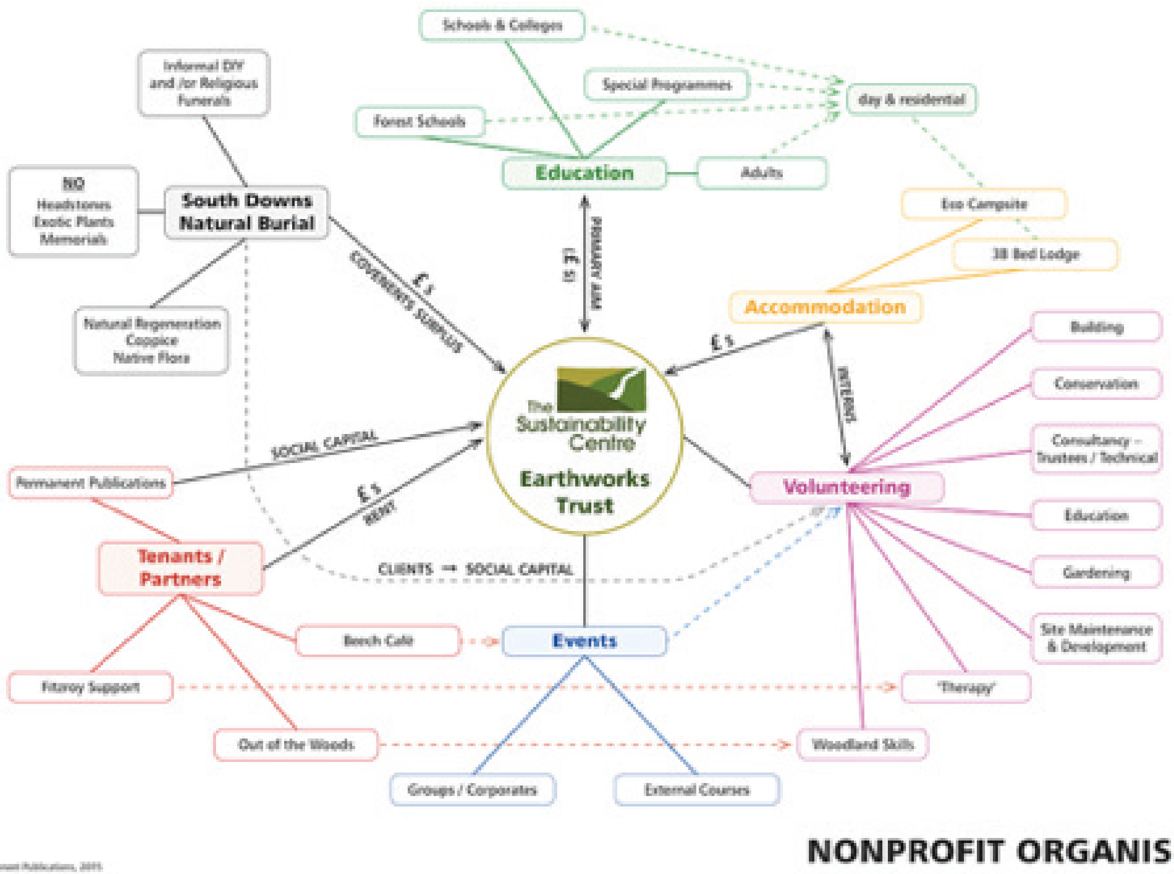
The whole-systems design concept offers a great deal of potential for networks of local businesses sharing and recycling resources. A good example would be the former navy terrain in southern England where a small group of sustainable businesses co-habit in symbiosis. It is an excellent example of how a site can be regenerated by designing businesses around ecosystem restoration. The Sustainability Centre, which runs courses, and a sustainable camping site, shares the terrain with Permanent Publications (Permaculture Magazine), the Beech Café, the Green Beans (children) Group, Convex Environmental Media, Fitzroy, Support-Rural Skills Centre Project, Hampshire Beekeeping, Memorial Benches, Nifty Bins and South Downs Natural Burials.

The design concept can be seen from the mind maps. The first shows the relationships with the Sustainability Centre. The second, the design for Permanent Publications is based on the permaculture ethics: Earth Care, People Care and Fair Shares. Maddy Harland (Permanent Publications) has given an inspiring talk about permaculture designs for business as part of Gaia Education's webinar series. While this is not part of the Ecological Dimension course work, a link can be found in the appendix for those who are interested.

Permaculture has also played a major role in the evolution of the school garden movement, ecosystem restoration camps and many other regenerative projects.

Watch this short (3min) video here.



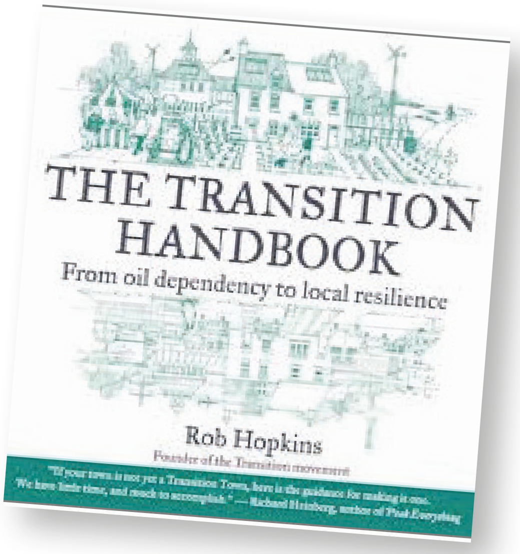


NONPROFIT ORGANISM

3.2. The Transition Town Network

In 2005, an energy-descent plan drawn up by students for permaculture teacher Rob Hopkins led to the first Transition Town in Totnes, England. The movement is now global.

You can watch a documentary that shows, among many interesting initiatives, a bit of this movement story, named "Demain" (tomorrow) here.



3.3. Greening the Desert

Geoff Lawton's permaculture project in Jordan has regenerated 5 hectares of semi-arid land badly degraded through over-grazing. It receives only 2 or 3 light rainfalls a year and the fine-grained silt is salty; wells in the area are too saline for irrigation. Using water-retention-landscape techniques to capture rainfall and run-off from the road in tanks with fish to purify and fertilise the water for drip-node irrigation, they planted trees in heavily mulched, moist trenches: olive, fig, guava, date palm, pomegranate, grape, citrus, carob, mulberry, cactus and a wide range of vegetables. Barley and alfalfa were planted as legumes and forages for farm animals (chickens, pigeons, turkey, geese, ducks, rabbits, sheep, and a dairy cow) that also provide fertilisation. Watch this short (8mins) video celebrating 10 years of the project in 2018.

We can see from this video that not only has this permaculture, whole-systems approach regenerated land desertified by inappropriate agricultural practices, but it is also a whole-systems approach on a broader level including food sovereignty, education for adults and children, community building, alleviation of poverty and empowerment for women. It contributes to achieving many of the Sustainable Development Goals and can be implemented anywhere in the world.

3. Different Streams of Ecological Design

3.4. Ecological Economics

While it rightly belongs in the Economic Dimension, Ecological Economics is mentioned here because it is underpinned by ecological design principles. The whole systems framework of ecological economics distinguishes four fundamental capitals or resources. In the past, "built" capital was increased at the expense of "natural" resources and often our "social" capital, through political activities. From a balanced, whole-systems perspective we have to optimise the health of the whole system including the four types of capital. The intention now is to create sustainable human settlements and wellbeing by increasing or at least not diminishing any of the capitals, while building others. Ecological design at its best is regenerative, not just sustainable. It aims to regenerate all vital resources in ways that ideally leave the system as a whole richer, healthier and more abundant. In the design of sustainable communities, it is particularly important to pay attention to

Sustainable Human Wellbeing is created by optimising the contribution of four basic types of capital. ***Source:*** *Gund Institute for Ecological Economics* how proposed designs beneficially affect all four types of capital.

Four types of capital:

- **Built** (infrastructure and buildings)
- **Natural** (environmental)
- **Social** (quality of interactions)
- **Human** (skills - education)

“So, if we want to assess the “real” economy – all the things which contribute to real, sustainable, human welfare – as opposed to only the “market” economy, we have to measure the non-marketed contributions to human well-being from nature, from family, friends and other social relationships at many scales, and from health and education. One convenient way to summarize these contributions is to group them into four basic types of capital that are necessary to support the real, human-welfare-producing economy: built capital, human capital, social capital, and natural capital.
The market economy covers mainly built capital (factories, offices, and other built infrastructure and their products) and part of human capital (spending on labor), with some limited spillover into the other two. Human capital includes the health, knowledge, and all the other attributes of individual humans that allow them to function in a complex society. Social capital includes all the formal and informal networks among people: family, friends, and neighbors, as well as social institutions at all levels, like churches, social clubs, local, state, and national governments, NGO’s, and international organizations. Natural capital includes the world’s ecosystems and all the services they provide. Ecosystem services occur at many scales, from climate regulation at the global scale, to flood protection, soil formation, nutrient cycling, recreation, and aesthetic services at the local and regional scales.”

Robert Constanza, *2006*

“Ecological economics is a transdisciplinary field of study that broadly examines the relationships between ecological and economic systems. Ecological economists understand that the economy is a subsystem of a larger ecological life support system, and they strive for an ecologically sustainable, socially equitable, and economically efficient future.”

Gund Institute, *2015*

Sound ecological design meets human needs in ways that do not degenerate and ideally regenerate the healthy functions of ecosystems and in a global world we impact on ecosystems across the planet for the materials and other inputs we require for the built environment. If we take Ecological Economics as a model for evaluation across the four capitals globally, and from an energy-descent perspective, we can ask the right questions about our building projects; where we can afford further urbanisation, or whether green retrofitting is more appropriate. We will deal with this in module 5.

As you set out to design any specific project, ask yourself the question how your design might serve to optimise the impact on all four types of capital, no matter which capital the original design brief might be focused on. We will revisit this topic in the Economic Design dimension of this course.

Watch this short video of Robert Constanza explaining how human beings can flourish on Earth if we apply the lessons of ecological economics to the way we design new ways of meeting human needs within planetary boundaries and opportunities. He highlights the importance of a clearly defined vision of a sustainable and regenerative human future in the process of creating a strategy to implement such a vision.

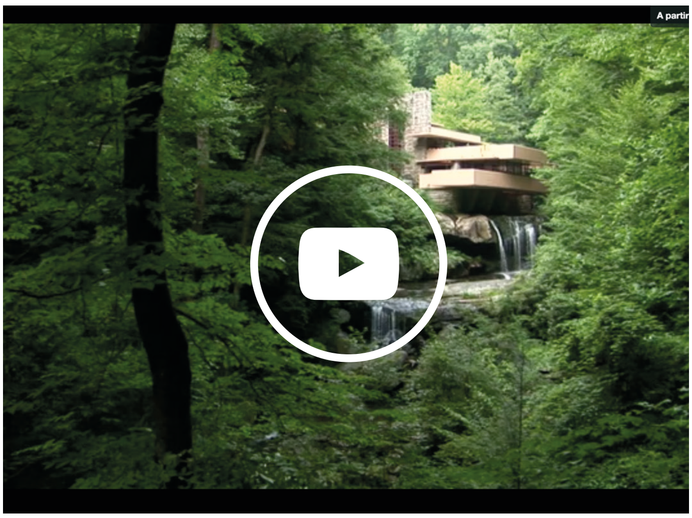
ISEE is a not-for-profit, member-governed organisation dedicated to advancing understanding of the relationships among ecological, social, and economic systems for the mutual well-being of nature and people.

3.5. Restorative Environmental Design

Another important contribution to ecological whole-systems design was developed by Professor Stephen Kellert of Yale University. Human and natural systems are connected, linking 'quality of life' and integrity of natural systems. Ecological and human values are mediated through landscape, providing economic, social and psychological as well as environmental advantages. The built environment and its operation uses large amounts of resources and so Restorative Environmental Design emphasises that wise design decisions have to take into account: i) how to minimise their impact on ecosystems and in doing so minimise their ecological and carbon footprints; ii) how design can be an expression of our interconnection with and innate love for nature (biophilia); and how local traditions, indigenous wisdom, and vernacular architecture are all valuable expressions of the 'spirit of place' in a given location and can inform restorative design.

Kellert has come to call this approach Biophilic Design – literally design that expresses and engenders our innate human love for life and all living beings. Here is a short introduction (3min) to the documentary Biophilic Design – The Architecture of Life.

Ecosystem services	Low impact design = Small ecological footprint
Biophilia	Organic design using natural materials and ecological engineering.
Spirit of place	Vernacular design with a strong relationship to place.



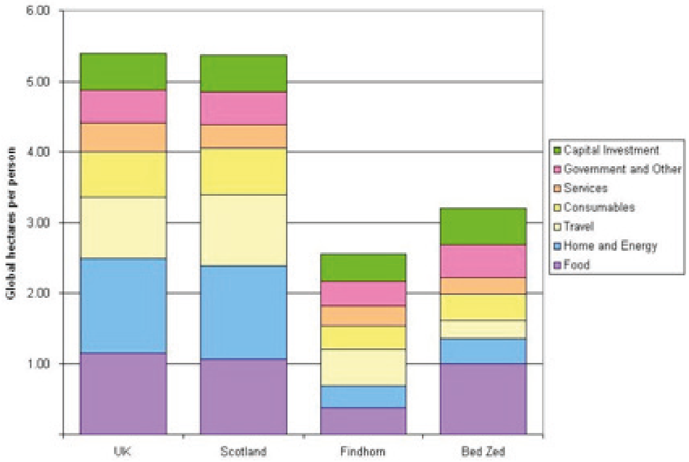
Kellert has come to call this approach Biophilic Design – literally design that expresses and engenders our innate human love for life and all living beings. Here is a short introduction (3min) to the documentary Biophilic Design – The Architecture of Life.

4.

The Ecological Footprint

The greater the ecological footprint of a community or population, the greater will be the impact on the ability of ecosystems to provide the means to support life.

The Ecological Footprint compares human demand with Earth's ecological capacity to regenerate from the impacts of natural resource use and waste generation. It represents the amount of biologically productive land area (measured in global hectares or gha) needed to regenerate the resources a human population consumes and to absorb and render harmless the corresponding waste. Using this assessment and comparing it to the (theoretical) fair share each human being (all 7.5 billion of us) has of the world's bioproductive surface area, it is possible to estimate how much of the Earth (or how many planet Earths) it would take to support humanity if everybody lived a given lifestyle. For example, if all human beings consumed resources and generated waste at the rate the average US American does today, we would need 5 planets the size of Earth to sustain such patterns of production and consumption. Clearly, we only have one planet, and such patterns are deeply unsustainable. We will revisit ecological footprinting in some more detail in the economics dimension of the curriculum.



Comparison of Ecological Footprints for UK, Scotland, Findhorn Foundation and Community and Bed Zed.

In 2001-2002 researchers at the University of Kassel in Germany compared CO2 emissions from Sieben Linden; another German ecovillage, Kommune Niederkaufungen; and the average German household. The study showed that both communities use far less water, electricity, heating fuel, fossil fuel for heating, and fossil fuel for growing and transporting food, than the average German household.

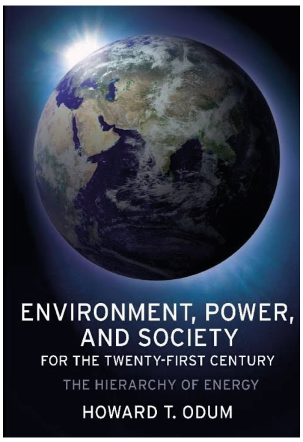
A number of ecovillages, in particular Findhorn in Scotland and Sieben Linden in Germany, have been able to demonstrate that through whole systems design and the associated changes in lifestyle it is possible to reduce a communities ecological footprint to a fraction of the national average in their location.

5. Ecological Engineering

The basic principles in the field of ecological engineering were first put forward by Howard T. Odum in his book Environment, Power and Society over thirty-five years ago. The fundamental idea is that, in addition to modelling human designed systems on Nature, we can use complete ecologies to carry out useful tasks.

Living technologies are different from dead technologies in that the main working parts are alive. This means they are not really "parts" at all, but participants in a continuously transforming web of living relationships and processes. Such living systems self-replicate, auto-regulate and form adaptive networks within networks at different scales. We can work with these complex adaptive systems to support them in their regenerative functions. Different ecologies can be linked to handle many inputs, self-manage a multitude of internal, closed-loop functions and provide a variety of outputs. Howard Odum stated:

"The inventory of species of the earth is really an immense bin of parts available to the ecological engineer. A species evolved to play one role may be used for a different purpose in a different kind of network as long as its maintenance flows are satisfied."



Howard T. Odum is known for his pioneering work on Ecosystem Ecology.

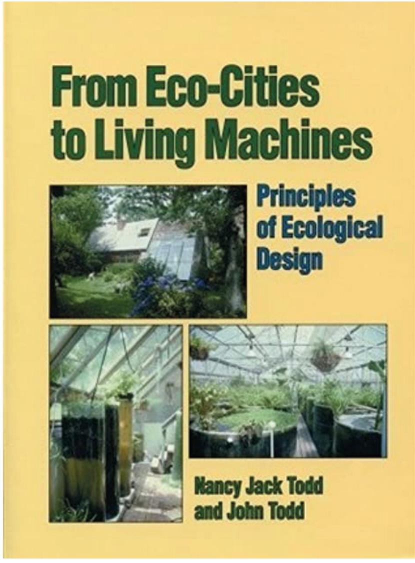
While the language is still mechanistic, what Odum was referring to here is that if we design with nature we can restore and regenerate ecosystems services. John Todd describes ecological design as the science of following nature's operating instructions and the art of creating elegant solutions adapted to the uniqueness of place. As we have seen, David Holmgren has integrated much of Odum's work, especially on energy flows through a system, into Permaculture.

Within the last few decades practitioners in ecology, design and the fields of complexity and chaos dynamics have begun to communicate to their shared benefit. This exchange is beginning to influence ecological engineering. Stuart Kauffman (1993) has studied how self-organisation, ranging in scale from the molecular level to large ecosystems, is generated in Nature. He has proposed an explanation of why self-organisation and self-design occur in the natural world and why it is possible to use these attributes in technological settings.

Rather than manipulating parts of the system in a mechanistic way, we pay attention to interactions and relationships, as well as information, material and energy flows, and as co-participants in these systems aim to create design solutions that facilitate the emergence of desired systems properties and behaviours. Rather than pretending that this is an exact and predictable science, we simply have to stay humble and keep learning how to dance creatively with life's systemic dynamics.

5.1. The Bioshelter

One example that demonstrates the whole-systems approach of ecological design is the 'bioshelter', a multi-purpose greenhouse which is particularly relevant to ecovillage design. Ecologically engineered systems are used to treat wastes, grow multiple food products, heat and cool the structures, and generate energy. We have seen this already in the work of John and Nancy Jack Todd. Their



Dr. Todd is one of the pioneers in the emerging field of ecological design and engineering.

book, From Eco Cities to Living Machines gives many examples. One of the early experiments with bioshelter design was done at the New Alchemy Institute and called the Cape Cod Ark.

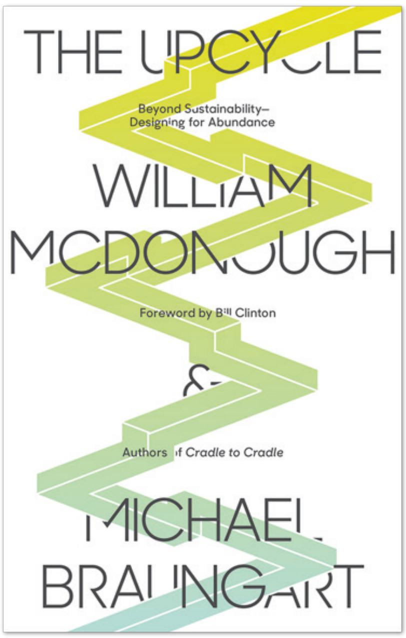
The excellent article to the construction and maintenance of the Ark shows the overlap with Permaculture Design, particularly in the bioclimatic elements of construction.

5.2. Cradle to Cradle (C2C)

““Using the Cradle to Cradle framework, we can upcycle to talk about designing not just for health but for abundance, proliferation, delight. We can upcycle to talk about not how human industry can be just 'less bad,' but how it can be more good, an extraordinary positive in the world.” ”

***William McDonough & Michael Braungart** (2013)*

One successful way of taking the concepts of ecological design and industrial ecology into the heart of many industries has been the Cradle to Cradle (C2C) framework of improvement promoted by William McDonough and Michael Braungart. They contributed a very useful distinction between technical and biological metabolism. All material flows should remain within one of these two cycles. That is the basis for creating

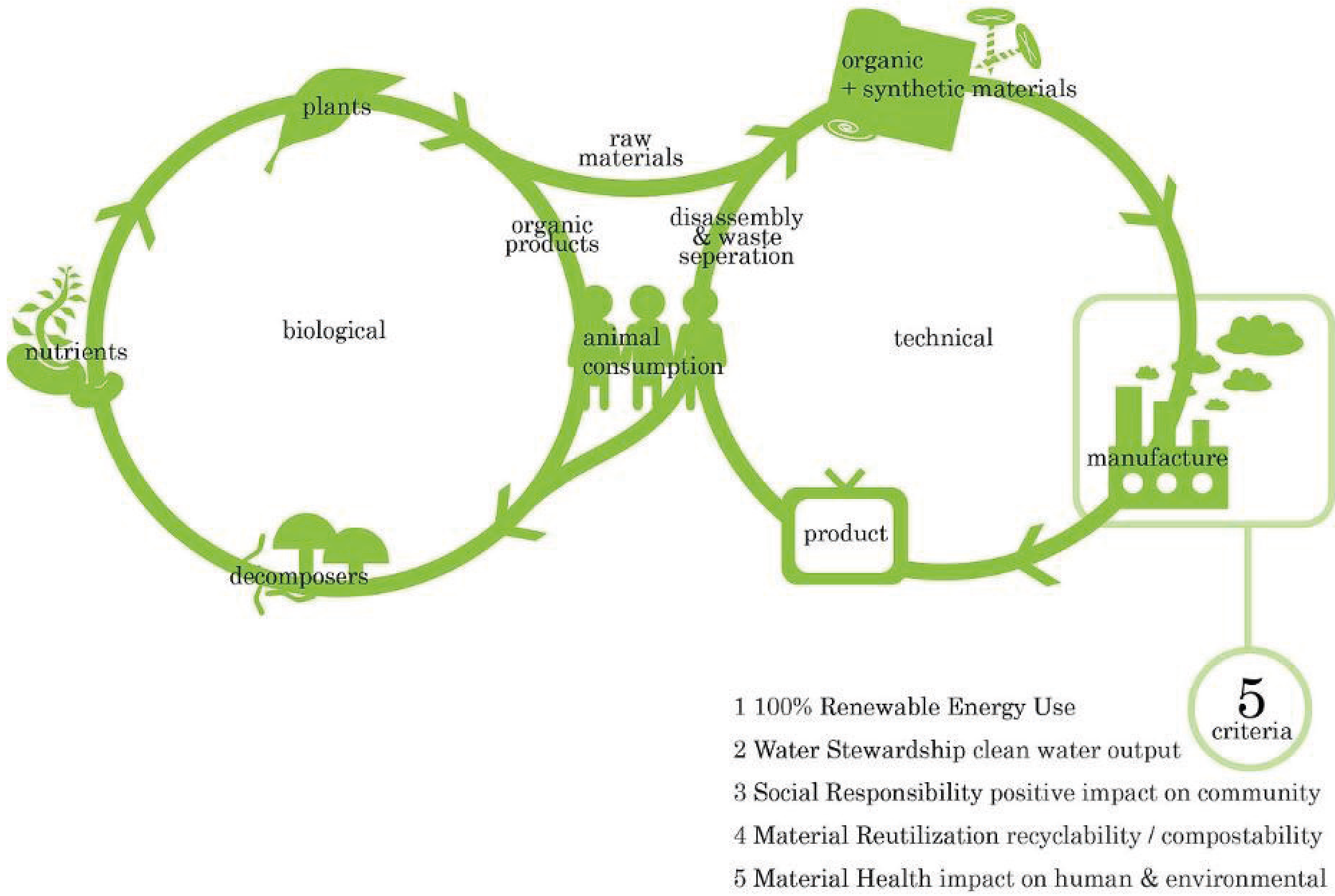


circular economies.

To achieve this shift towards integrated, cyclical whole-systems design we need to transform products, and how we design and produce them, in ways that allow disused products at the end of their useful life to be disassembled into fully recyclable or up-cyclable industrial feedstock or organic feedstock.

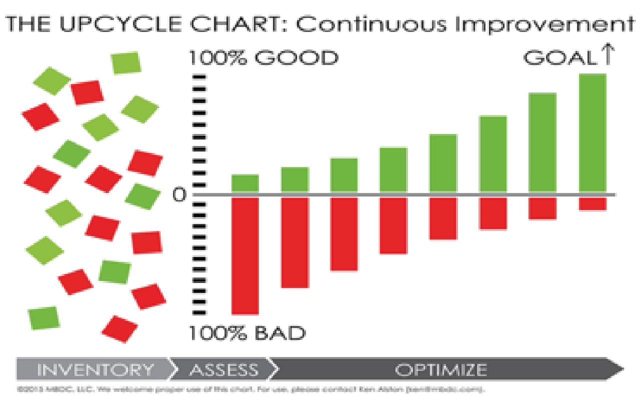
In McDonough and Braungart's

CradletoCradle



book [The Upcycle](), they ask: "How can humans – the people of this generation – upcycle for future generations? ... How can people love all of the children, of all species, for all time?" (2013: 49).

The graphic bellow illustrates the 'Cradle to Cradle Continuous Improvement Strategy' they propose in order to implement a transformation of our industrial systems. Rather than stopping at 'sustainable' (0% bad) the Cradle to Cradle approach is also regenerative, aiming for 100% good.



Watch William McDonough's [TED-talk]() (21mins) on Cradle to Cradle.

5.3. Regenerative Design

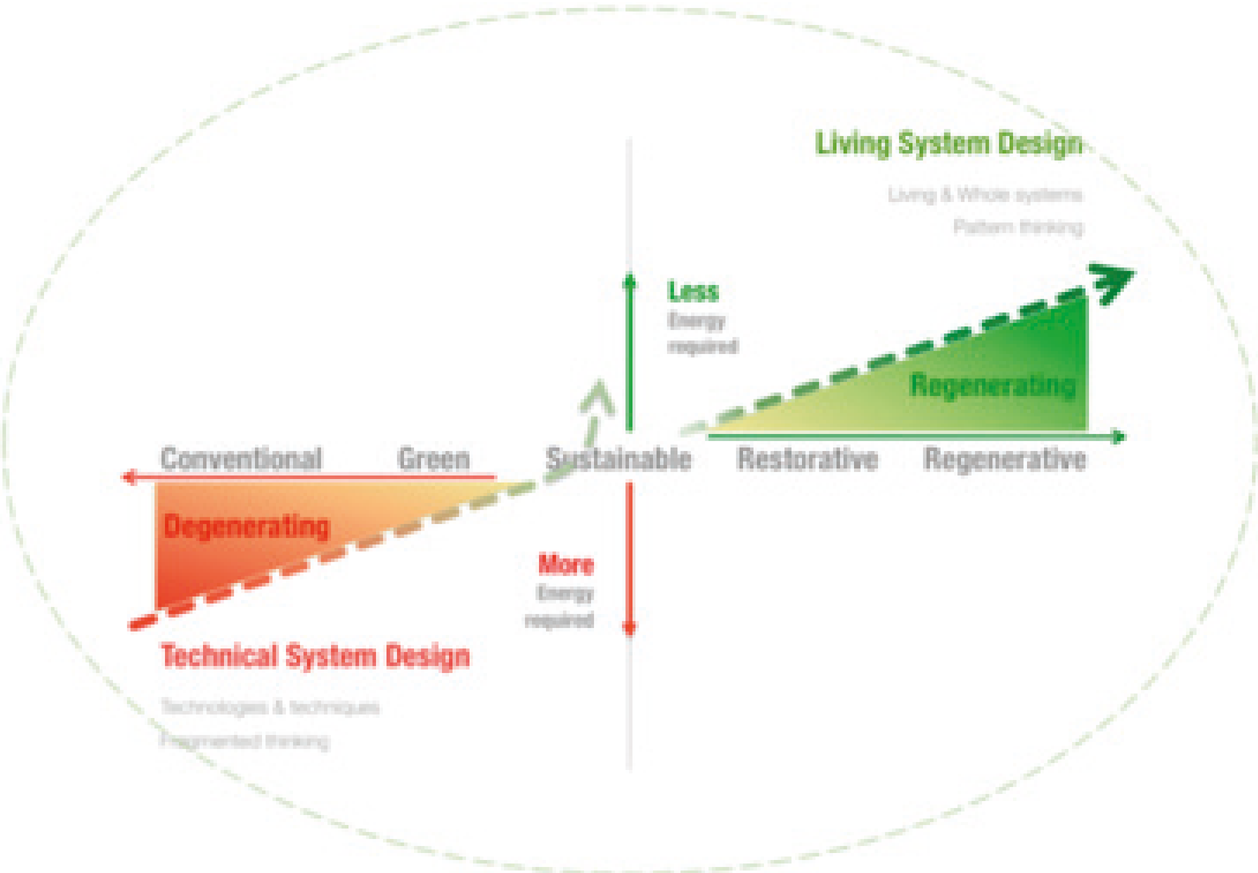
Bill Reed has mapped out some of the essential shifts that will be needed to create truly regenerative cultures. In 'Shifting our Mental Models' he laid out a framework that puts different approaches to ecological design into a relationship with regard to the extent that they aim for truly regenerative solutions. Reed argues:

"Instead of doing less damage to the environment, it is necessary to learn how we can participate with the environment – using the health of ecological systems as a basis for design. [...] The shift from a fragmented worldview to a whole systems mental model is the significant leap our culture must make – framing and understanding living system interrelationships in an integrated way.

A place-based approach is one way to achieve this understanding. [...] Our role, as designers and stakeholders is to shift our relationship to one that creates a whole system of mutually beneficial relationships."

Bill Reed *(2007: 674)*

The figure on this page shows the different shifts in perspective as we move from 'business as usual' to creating a regenerative culture. The aim to create regenerative cultures transcends and includes sustainability. Restorative design aims to restore healthy self-regulation to local ecosystems. In the early versions of this figure Bill Reed included reconciliatory design before regenerative to highlight humanity's participatory involvement in life's process and the unity of nature and culture. Regenerative design aims to create regenerative (socio-ecological) systems capable of continuous learning and transformation in response to, and anticipation of, inevitable change.



The graph bellow puts different whole systems approaches to ecological or regenerative design into context and shows that they relate in a 'transcend and include' way to each other, meaning that we should not think of them as an either/or approach but employ them as complementary approaches that can help us move the cultural transition along towards a redesign of the human presence on earth and the co-creation of diversely adapted regenerative cultures everywhere (more).

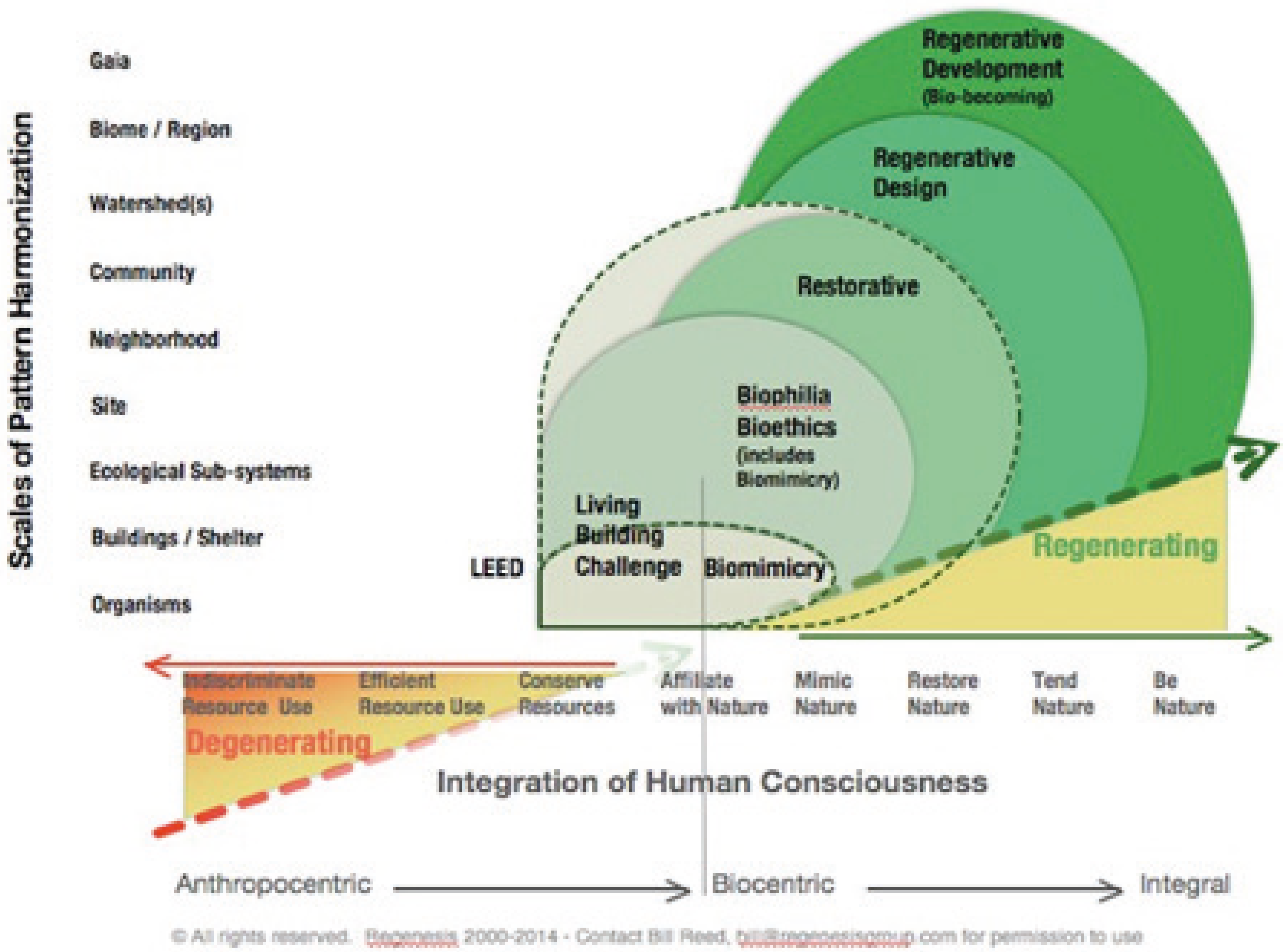


Image Source

6.

A Systemic Biosphere Crisis

Now that we have reviewed a number of related and mutually supportive whole-systems approaches to ecological design, let's take a brief look at the systemic context that is driving us towards having to redesign the human presence on Earth. Three related issues are at the forefront of this need for a re-design:

i) we are facing dangerous run-away climate change if we do not change our ways;
ii) the age of fossil fuel has to come to an end and we need to find ways to meet our energy, transport and other material needs without burning fossil fuels;

iii) human activities over millennia have badly degraded the biosphere, in particular since the discovery of fossil fuel energy and the Industrial Revolution.

The end of the age of fossil fuels, therefore, is an opportunity for us to meet our needs through regenerative practices that restore degraded land and combat biodiversity loss.

The calls for a rapid, radical and sustained response to climate change are getting louder and louder. The scientific community has been in consensus for many years. Reports on biodiversity loss and desertification have called for a whole-systems approach support. Ecologists, hydrologists and soil microbiologists are calling for ecosystem restoration. The Indigenous Peoples of the world are leading the way in defending the Earth and promoting restoration. People on the streets are calling for drastic action, Pope Francis has compared humanity's inaction with being on the verge of suicide, and even political and business leaders are beginning to call for wise and long-term decisions to protect the planetary climate regulation system upon which all our future depends.

6.1. Biodiversity Loss, Desertification and Climate Change

Three UN Framework Conventions emerged from the Rio Earth Summit in 1992. The Framework Convention on Biological Diversity (UNFCDB), the Framework Convention on Desertification (UNFCCD) and the Framework Convention on Climate Change (UNFCCC). While two of the Conventions have been overshadowed by the Convention on Climate Change, together the three represent the essential aspects of the systemic biosphere crisis and they should be tackled through a whole-systems approach.

The UN Convention on Biological Diversity aims to study the increasingly alarming loss of species' populations and communities that threaten ecosystem functioning and even collapse. 196 Parties (nation states, plus the EU) have signed the Convention, including the Strategic Plan and the Aichi Targets for the UN Decade of Biodiversity (2011-2020). The objectives were to provide education and funding to ensure a resilient biodiversity of species by 2020.

Nonetheless, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) produced an 8,000-page Global Assessment Report in May 2019 showing conclusively that 1 million species are threatened with extinction and that ecosystem collapse due to biodiversity loss will impact severely on human survival too. The main drivers of terrestrial biodiversity loss were (specialised industrial) agriculture, urbanisation and other land-system change.

We can tackle these aspects of the problem through regenerative ecological design. Climate change came in fourth place, though undoubtedly, the impact of global warming will be felt more keenly as the temperature continues to rise. Degradation of ocean ecosystems is more directly attributable to global warming and ocean acidification as the oceans absorb CO2, but over-exploitation of species through industrial-scale fisheries, pollution and dead zones from agricultural fertilisers are major culprits too.

The link below is for reference only and you are not required to read the report.

https://www.ipbes.net/global-assessment-report-biodiversity-ecosystem-services

The UN Convention to Combat Desertification was included in 1994. Desertification is the degradation of land in arid, semi-arid and dry sub-humid areas. It is caused primarily by human activities and climatic variations. Desertification does not refer to the expansion of existing deserts. It occurs because dryland ecosystems, which cover over one third of the world 's land area, are extremely vulnerable to overexploitation and inappropriate land use. Poverty, political instability and armed aggression, deforestation, overgrazing and inappropriate irrigation practices can all undermine the productivity of the land. The livelihoods of more than 1 billion people in some 100 countries are threatened by desertification and they are the poorest and most marginalized people. One in three people inhabit drylands.

We can also combat desertification through regenerative ecological design. Restoring land combats desertification and this requires methods of reforestation, ecosystem restoration and changes to agriculture that are appropriate for the local biome. Maximising the soil organic carbon facilitates rainwater retention and restores the natural carbon, hydrological and nutrient cycles (see module 3). Restoring land through community action is the most effective and can also add to achieving a number of Sustainable Development Goals.

In the video below, we see an example of Farmer Led Natural Management (FLNM) in a region badly desertified by deforestation and inappropriate agriculture. When reforestation projects failed for a number of years with 80% of planted saplings dying, they adopted a different, whole-systems approach, adapted to their local biome, rehydrating the land and improving the lives of small-scale farmers, many of whom are women. It embraces several of the Sustainable Development Goals and is a fine exampleof a whole-systems approach to combating desertification and climate change while restoring ecosystems.

Watch this vídeo "Land for Life Award" - Farmer Led Natural Management FLNM

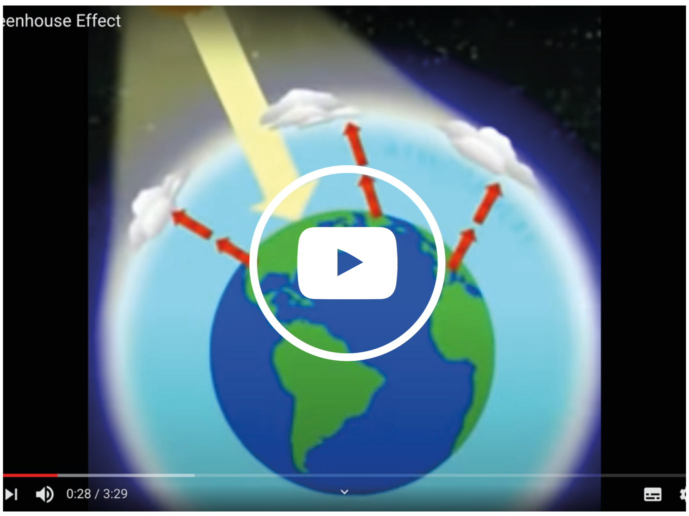
Source UN Convention on Combating Desertification

The UN Framework Convention on Climate Change is the best-known of the three and most of us have seen media reports about the urgency of tackling fossil fuel emissions and the consequences for further delay.

Since the advent of agriculture, humanity has interfered with the natural cycle of carbon. This has become more pronounced since the Industrial Revolution, after which the normal dynamic equilibrium, which involves carbon cycling between the atmosphere, the oceans and the land (forests, soil and vegetation) and some carbon being sequestered into the Earth's crust by geo-physical processes, has been seriously disrupted.

This cycle has been disrupted by emissions of greenhouse gases – mainly carbon dioxide – from the burning of fossil fuels, but also large amounts of CO_2 emissions from degraded land and agriculture. In many ways, what we are burning as fossil fuel is ancient sunlight that was stored in the Earth after a geo-chemical transformation of ancient plant and animal matter that had absorbed this ancient sunlight. And by degrading land we are disrupting the carbon and hydrological cycles.

By digging up this ancient carbon that had been safely stored away in the Earth's crust and burning it at ever faster rates since the start of the industrial revolution we have altered the chemical composition of the Earth's atmosphere and oceans. The increase of CO_2 in the atmosphere resulting from the burning of fossil fuels creates a planetary greenhouse effect.

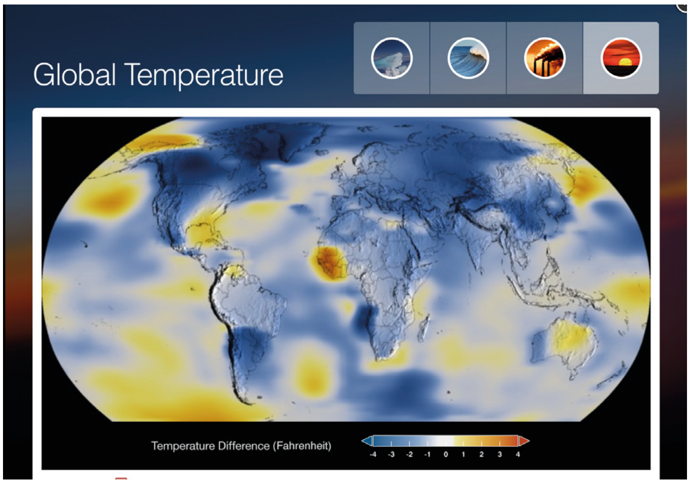


Watch this 3 min. vídeo by NASA's Earth Observatory that explains the basic principle of the 'greenhouse effect'.

The parties to the Framework Convention on Climate Change meet annually at the COPs (Conference of Parties) to discuss reports drawn up by the IPCC (Inter-governmental Panel on Climate Change). At the COP21 in Paris in 2015, the parties succeeded in signing up to the Paris Agreement to limit global warming to 2 degrees C and 1.5 C if possible. The decision was based on the science presented in the IPCC report in 2014.

Video (15min) summarising the 2014 synthesis report on climate change. The report mentions solutions for mitigation, some of them heavily critiqued in subsequent years, such as BECCS (Bio-energy with Carbon Capture and Storage) and other 'Negative Emissions Technologies'. We will look at these in module 4 on energy and technology.

According to the Paris Agreement, each country submits a National Determined Contribution, proposals delineating the mitigation measures they will take in accordance with the pathways laid out by the IPCC on limiting temperature rise. 'Climate neutrality' (net zero emissions) should be achieved by 2050 and meanwhile adaptation measures should reduce risks of loss and damage, particularly to sustainable development goals, and in support of developing countries, by conserving sinks such as forests and wetlands, but also financial and technological assistance. The poorest parts of the planet, and those people who have contributed the least to global warming, are the first to feel the consequences.



On NASA's climate website you can find a Climate Time Machine that illustrates the changes in temperature, emissions, glaciers and sea-level rise over time.
If you want to you can click on the link below to see the changes over time. The website also contains more details and updates on extreme weather events such as hurricanes and flooding.

In 2018 and 2019, the Panel published two reports, one on the differences between 1.5 and 2 degrees C and the other on climate change and land. In the former, it is clear that differences are substantial. For example, at 2 degrees C the coral reefs disappear completely, at 1.5 degrees C only 70% will disappear. However, according to the UN Environment Programme's "Emissions Gap Report", released in November 2018, current unconditional NDCs will see global average temperature rise by 2.9 to 3.4°C above pre-industrial levels by the end of this century. BAU (Business As Usual) scenarios with no emissions reductions see us on a path to between 5.9 and 8.4 degrees of warming by 2100.

According to the Climate Transparency Report 2020, G20 countries are not on track to meet emissions-reduction pledges, the majority are not on a path that will lead them to meeting their targets for 2030. Moreover, to restrict warming to 2°C above pre-industrial levels, the world needs to triple its current emission reduction pledges. To restrict global warming to 1.5°C, global ambition needs to increase fivefold and the IPCC has determined that to have a 66% chance of halting warming at 1.5 degrees, we will need to reduce emissions by 45% by 2030. The Climate Transparency Report (which we recommend you to download and read) highly recommends investing in adaptation.

The links below are for reference only and you are not required to read the reports.

The links below are for reference only and you are not required to read the reports.

http://wedocs.unep.org/bitstream/handle/20.500.11822/26896/EGR-KEYMESSAGES_2018.pdf?sequence=1&isAllowed=y

https://www.ipcc.ch/sr15/chapter/spm/

The report Climate Change and Land: An IPCC Special Report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems published in 2019 is a very welcome addition to previous reports. It follows the UN's FAO'(Food and Agriculture Organisation) conference on climate change in Paris in 2017 which drew together scientists from agriculture-related disciplines. The report explores the role natural systems play in the carbon cycle and the vast potential to draw down CO_2 through reforestation and agricultural methods that store carbon in the soil. Whole systems approaches to agriculture, such as holistic planned management for grazing, permaculture, agroforestry and agroecology, can draw down atmospheric CO_2 and at the same time combat desertification and biodiversity loss. As we saw in the video above about Farmer Led Natural Management, this pathway can also help achieve many of the Sustainable Development Goals. The UNs Food and Agriculture Organisation has called for more support for small holders practicing agroecology and in 2014 this was the pathway proposed by Prof. Olivier de Schutter, the UN Special Rapporteur on the Right to Food, in his report. He also advocates for a move away from the global trade in foodstuffs to food sovereignty. We will be looking at relocalisation of food provision and a wide range of agro-ecological practices for carbon sequestration in soil in module 3.

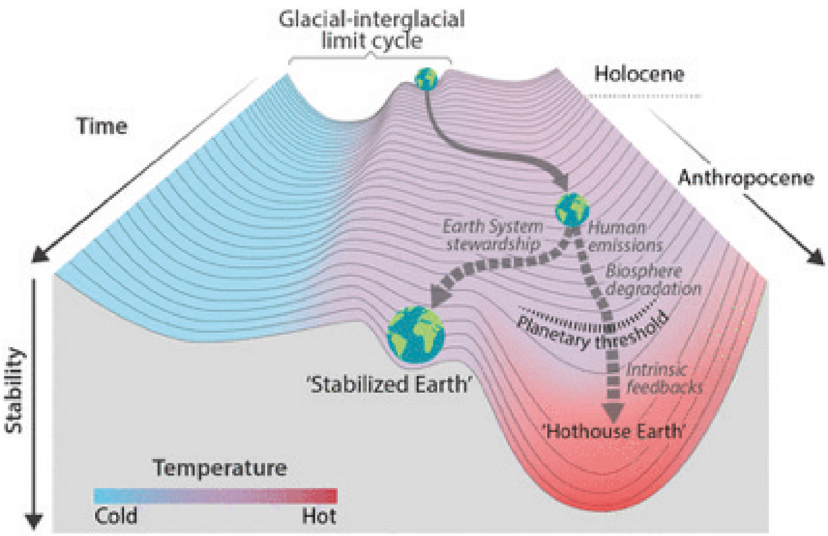
"Sustainable Development Goal 2 presents a vision for integrated approaches to eradicate hunger and malnutrition under climate change through sustainable agriculture. Hunger, poverty and climate change can be tackled together through approaches that recognize the critical linkages between rural poverty, sustainable agriculture and strategies that promote resource-use efficiency, conserve and restore biodiversity and natural resources, and combat the impacts of climate change."

***FAO's Work on Climate Change**, 2017*

We have the solutions and now we need to start implementing them through a whole-systems approach and through a change in attitude to our place in the biosphere, in the fabric of life. This is urgent, because we must avoid the point of no return, the tipping points that could tumble us into a 'Hothouse Earth' scenario.

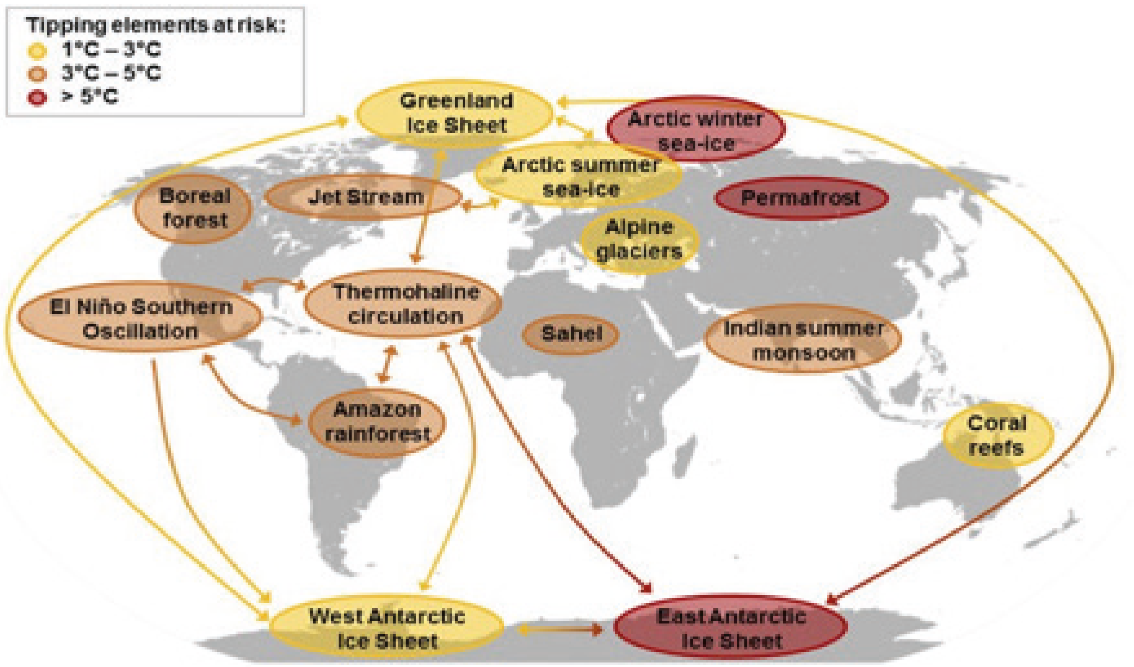
6.2. Tipping Points and Earth Stewardship

In 2018, a number of Earth Systems' scientists published a warning that feedback loops in the climate system would, at some point, most likely send us into 'runaway climate change'. They call for a major change in attitude to stewardship of the biosphere. The diagram below shows the potential trajectories set in motion by feedback loops as well as our potential arrival at a stable Earth system within the Anthropocene.



As we can see from the diagram, we have moved out of the Glacial-interglacial limit cycle and beyond the relative climatic stability of the Holocene that allowed civilizations to flourish, firstly as settled agrarian societies and towns until the fossil fuel age allowed for rapid development of cities in industrial societies. We are at the dawn of the Anthropocene, where human emissions and biosphere degradation are carrying us towards the planetary threshold after which intrinsic and positive biogeophysical feedback loops kick in and the internal Earth Systems Dynamics are unstoppable no matter what we do. These biogeophysical feedbacks are a normal part of the Earth Systems Dynamics, they maintain the system in a stable state (negative feedbacks).

However, feedbacks that amplify a perturbation (positive feedbacks) can change the state of the System. It is a fork in the road. The diagram below shows the potential tipping cascades.



6.3. Human Feedbacks in the Earth System

““In the dominant climate change narrative, humans are an external force driving climate change to the Earth System in a largely linear, deterministic way; the higher the forcing in terms of anthropogenic greenhouse gas emissions, the higher the global average temperature. However, our analysis argues that human societies and our activities need to be recast as an integral, interacting component of a complex, adaptive Earth System. This framing puts the focus not only on human system dynamics that reduce greenhouse gas emissions but also on those that create or enhance negative feedbacks that reduce the risk that the Earth System will cross a planetary threshold and lock into a Hothouse Earth pathway”.

Will Steffen, Timothy M. Lenton et al,
Trajectories of the Earth System in the Anthropocene, PNAS, 2018

We are not separate from the biosphere, like all life on Earth we are part of the Earth Systems Dynamics. Through a whole-systems approach, through regenerative ecological design, we can return the planetary cycles we have disrupted to full functioning again. The stewardship the authors call for is within our grasp.

6.4. Human Feedbacks in the Earth System

As we have already seen, the Transition Town movement emerged from permaculture in 2005 as the result of an energy-descent plan drawn up by students on a course given by permaculture teacher Rob Hopkins. During its expansion to many countries through new transition initiatives and the ‘transition training’, the twin-issue of climate change and peak oil have been presented as the major drivers of the need for ‘transition’.

Peak oil is the point in time when conventional oil production reaches the maximum rate of extraction and thereafter production gradually begins to decline. It is not the point where we are running out of oil or fossil fuels, but rather the point where the energy and money that have to be invested into extracting these good quality fuels rises sharply as more expensive drilling or extraction techniques (e.g. fracking, and tar-sand extraction) have to make up for the decline in conventional (sweet crude) oil sources. The quality of the oil declines too in terms of EROEI (Energy Return on Energy Invested). So, whereas the high-quality, conventional oil might give a return of 100 barrels for 1 barrel of oil used in extraction, decline in quality might reduce the EROEI to 10 to 1 or even less.

The rising global demand for fossil fuels, not only for transportation and the generation of electrical energy, but also as a key resource for our entire material culture, including industrial agriculture, further drives us towards a peak in many fossil fuels. Conventional sources peaked in 2005. Over the last decade, a large amount of new fossil fuel reserves has been discovered (albeit reserves that would be very costly to exploit). The point is no longer 'peak oil' or 'peak fossil fuel', much rather we have to ask the question: Can we afford – both financially and with regard to climate change – to burn and exploit the remaining fossil fuel reserves? The short answer is no we cannot (more in chapter on peak oil and unburnable carbon below).

Einstein famously said: "The stone age did not come to an end because we ran out of stones." Nor will the fossil fuel age end because we are running out of fossil fuels. We simply cannot afford to burn the reserves we have left, if we hope to stabilise global climate patterns and avoid overstepping the climate tipping points that would lead to even more catastrophic climate change.

However, the pathways presented by the IPCC and adopted by the Paris Agreement call for 'Net Zero Emissions' by 2050 and this does not mean burning fossil fuels will stop. 'Net Zero Emissions' calls for a balance between emissions produced and emissions drawn down and sequestered either in natural carbon sinks such as forests and soil, or stored underground in reservoirs through Carbon Capture and Storage. These 'Negative Emissions Technologies' and their feasibility will be discussed in module 4.

The Post Carbon Institute has produced a large number of studies and books on peak oil and energy-descent to help prepare people and their communities for a post-carbon future.

https://www.postcarbon.org

Image Source: Think Resilience - Post Carbon Institute

7. Our Carbon Footprint

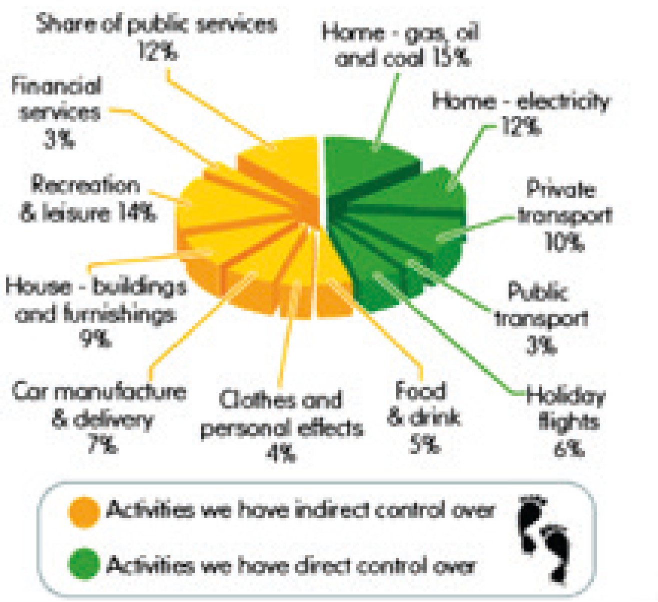
A carbon footprint is one way of measuring an important aspect of the impact our activities have on the environment - in particular how our behaviour impacts climate change directly. It relates to the amount of greenhouse gases produced in our day-to-day lives through burning fossil fuels for electricity, heating and transportation, etc. Our carbon footprint is a measurement of all greenhouse gas emissions our individual behaviour results in. It is typically measured in units of tons of carbon dioxide equivalent per annum (tCO2pa).

A carbon footprint is made up of the sum of two parts.

- **Our individual share of carbon emissions** related to the household we live in and our own transport, holiday, and consumption habits is referred to as the primary footprint (shown by the green slices of the pie chart). We have direct control of our primary footprint.

- **The share we have in maintaining public** infrastructures, key industries that we buy or rent products from, the entire life-cycle of the products we use, the financial service industry we use as participants in the economy, and the emissions resulting from public services, etc., are all referred to as being part of the secondary footprint (shown as the yellow slices).

Click on the link to watch a video explaining the basic concept of a carbon footprint.



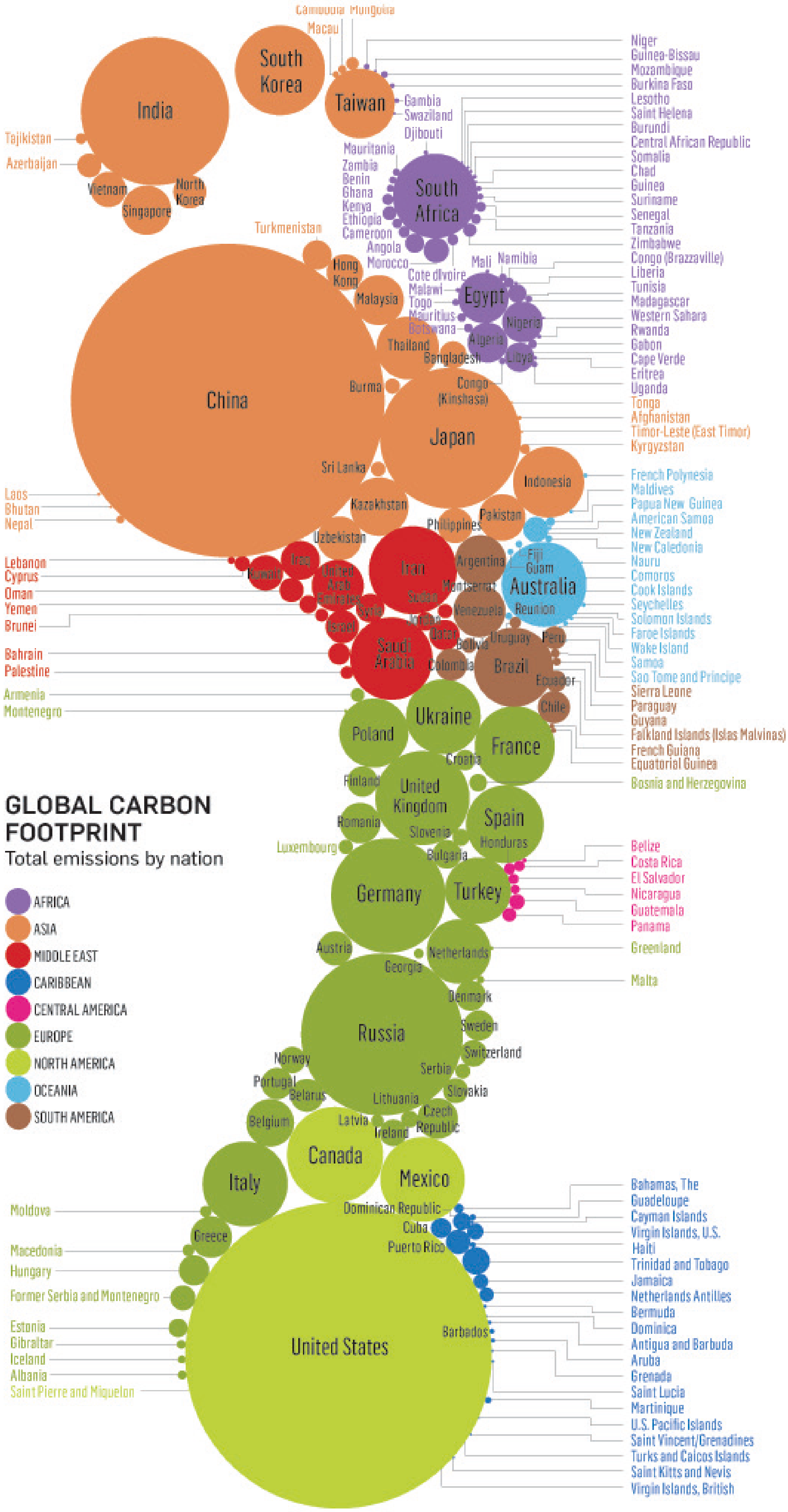
The pie chart below shows the main elements, which make up the total of a typical person's carbon footprint in the developed world.

https://www.youtube.com/watch?time_continue=1&v=8q7_aV8eLUE&feature=emb_title

A Few Facts:

- **At the start of the Industrial Revolution** the CO2 concentration in the atmosphere was 280 ppm (ppm = parts per million)
- **By the late 1950s the CO2** concentration had risen to 315 ppm
- **In November 2020, CO2** concentrations in the atmosphere reached 412.89 ppm
- **And it is rising by approximately 2 ppm** annually

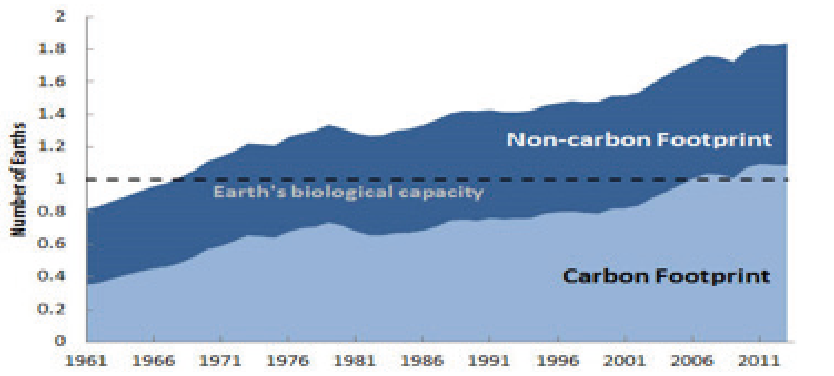
In the Economics Dimension of the GEDS course we will revisit the issue of climate change and address a number of global emissions reduction strategies in more detail, among them 'contraction & convergence', 'cap & trade', and 'cap & share'.



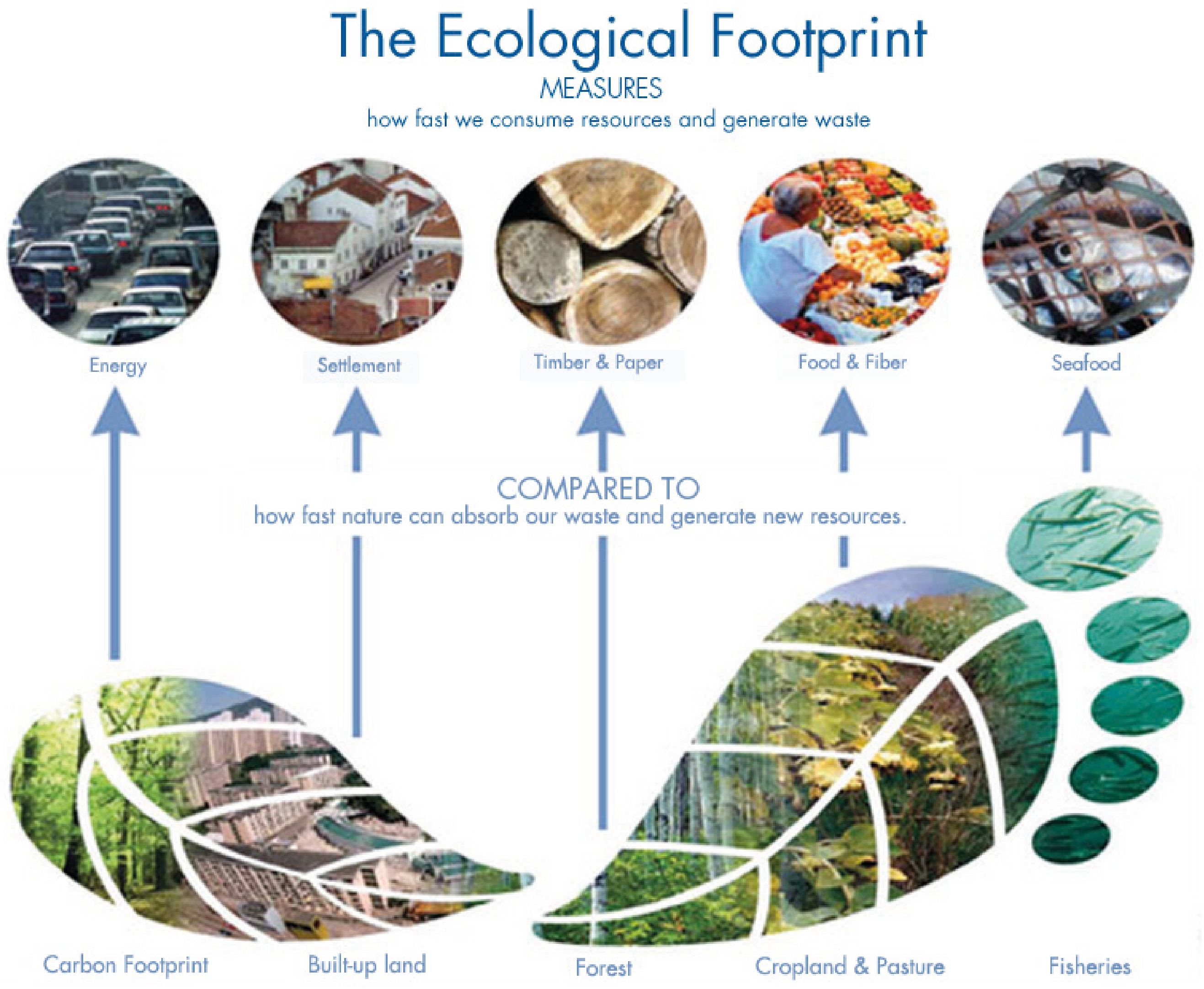
On the infographic below, you can look at your country's carbon footprint (Source)

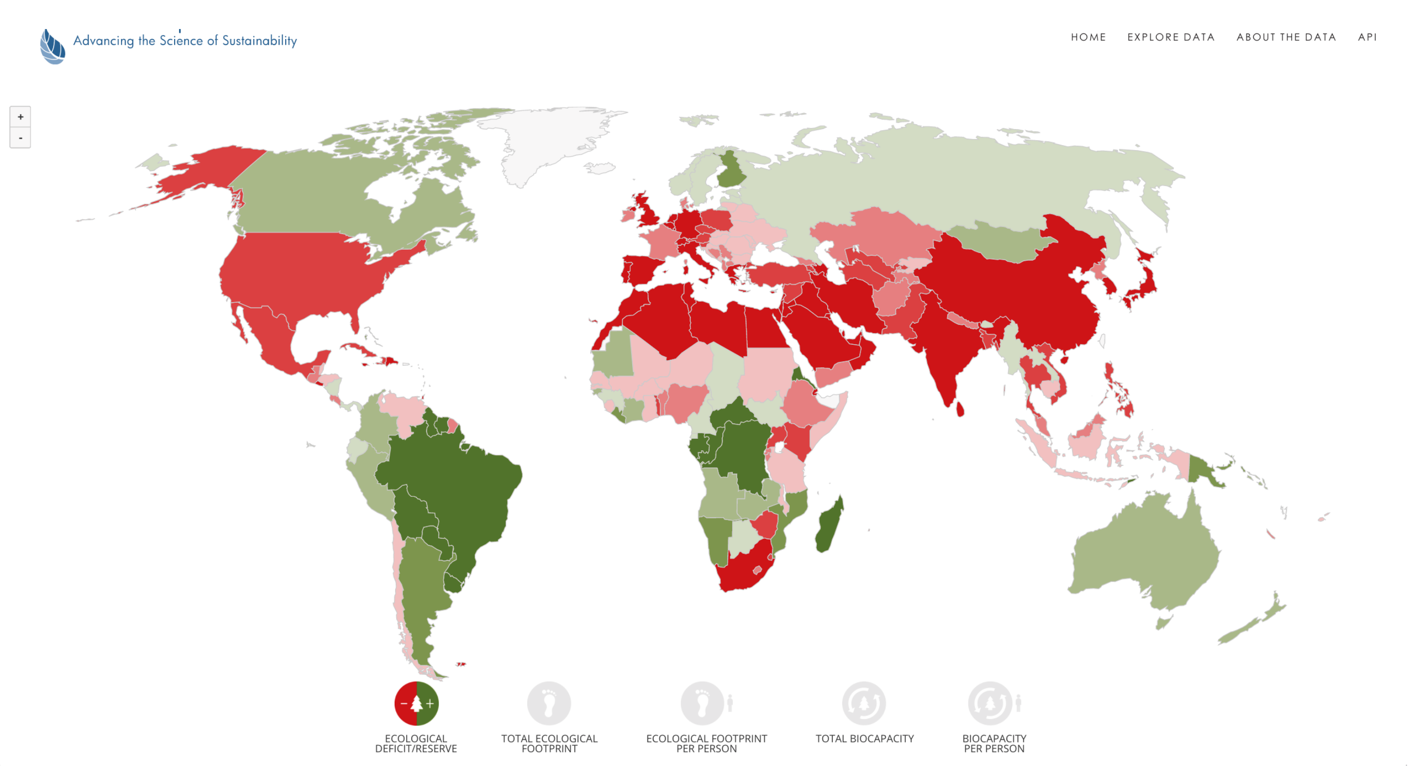
7.1. Ecological Footprint, Earth Overshoot Day and the Happy Planet Index

Our carbon footprint is a significant part of our more general Ecological Footprint. We have already mentioned this measure before. Our ecological footprint can be defined as "the impact of human activities measured in terms of the area of biologically productive land and water required to produce the goods consumed and to assimilate the wastes generated" (WWF, 2015). The graphs below show how much of the increase in



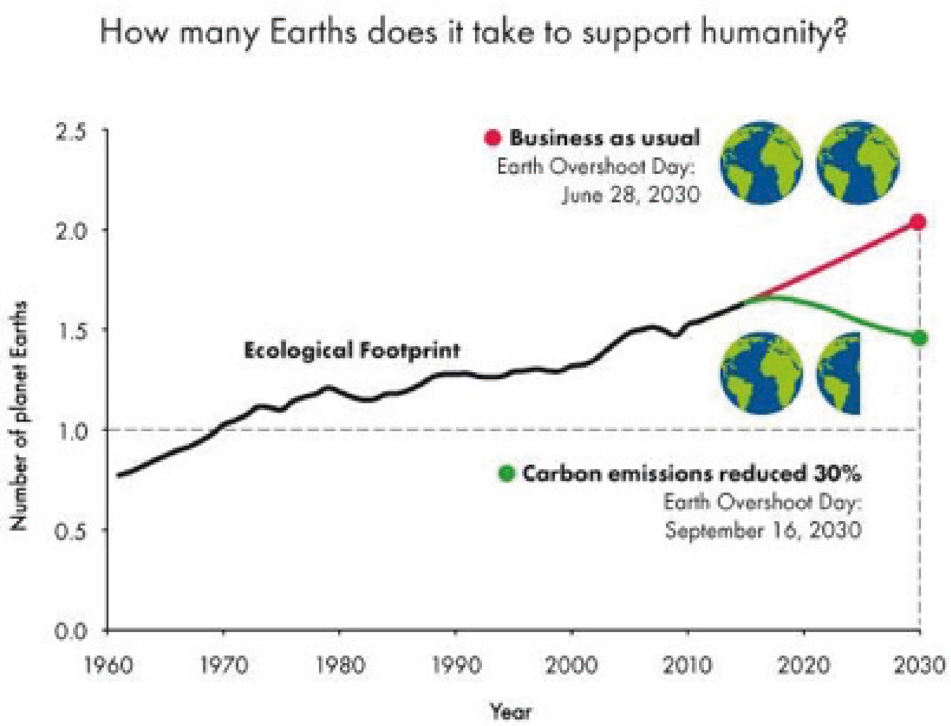
Source: Carbon Footprint





Ecological Wealth of Nations interactive map here

humanity's ecological footprint is due to an increase in our carbon footprint since the 1960s; the second graph also illustrates the other contributions to our ecological footprint besides carbon. For more information on ecological footprinting and comparisons of different ecological footprints by country please take a closer look at the website of the Footprint Network. Some countries exceed their biocapacity constraints, which means they are borrowing resources from future generations within their own country and also importing resources from other countries. There are very few countries in the world that live within their biocapacity, and these are primarily those countries with vast open spaces with substantial biomass, such as, Canada and Brazil (see map below). On a planetary scale humanity went into overshoot in the late 1960s. Overshoot in this context means that we started living off the capital rather than the interest of what the bioproductivity of the



[Watch the video](#) explaining the concepts of ecological footprint and earth overshoot day.

If you want to calculate your own footprint, please follow this link. We will revisit the issue of our ecological footprint in the Economics Dimension.

Does our ecological footprint correlate with human well-being? Are we happier when we have more stuff or more development?

planet provides to regeneration each year. [Earth Overshoot Day](#) 2020 landed on 22th August. It is the day when, as a planet, we collectively reach the limit of resources we can use this year without jeopardising the planet's ability to replenish those resources for the future.

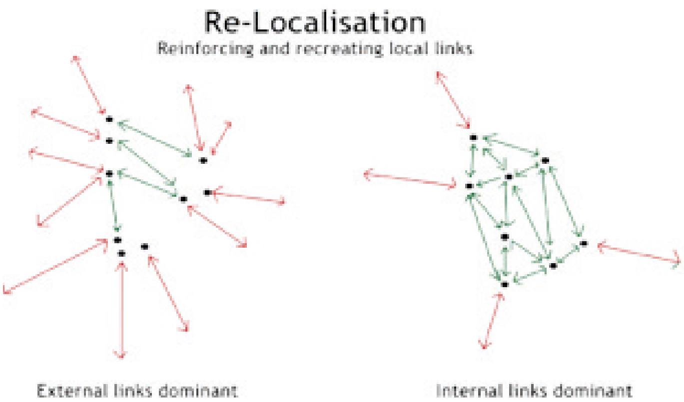
[Watch the video](#) explaining the Happy Planet Index. More of this alternative to GDP (measuring well-being in terms of Gross Domestic Product) in the Economics Dimension.

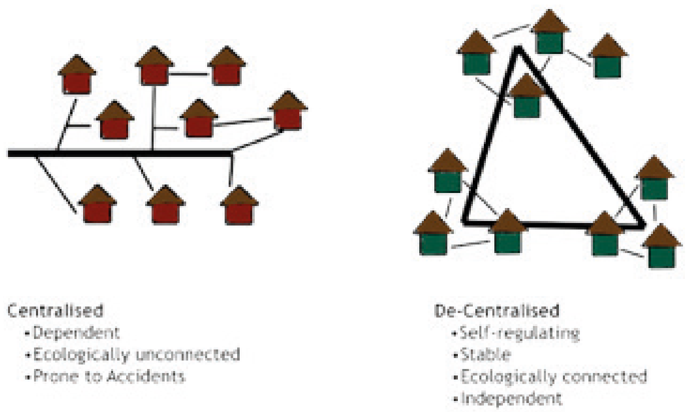
8.

Scale-linking designs for communities, cities and bioregions

So far this module on Whole Systems Approach to Ecological Design has introduced us to a number of different ecological approaches that are based on a living systems perspective. We also took a closer look at the challenge of avoiding catastrophic climate change and further ecological degeneration of the Earth's life support systems through our excessive impact. We can pay attention to appropriate scales, decentralisation and re-localisation and ways we can apply master planning to processes in ecological design too. While this will be discussed in full in module 5, we briefly introduce the concepts here.

In nature local, regional and global are interlinked in nested living networks and dynamic fast- and slow-moving processes. These processes maintain the health and resilience of these





living networks at and across the different scales. Ecological whole-systems design tries to emulate and integrate these patterns of organisation and continuous transformation and adaptation.

To do so we have to mimic Nature's scale-linking patterns and the way nature creates multiple redundancies at and across scales in order to keep disruption and breakdown localised. Following a strategy of decentralising vital functions and re-localising the way we meet our basic needs for water, food, shelter, energy and transport, as well as our patterns of production and consumption, will definitely be part of the transition towards a more sustainable human presence on Earth. To do so successfully we will need regional and global collaboration, knowledge and technology exchange at a so far unprecedented scale.

9. Conclusion

What has become clear throughout module one is that a whole systems approach to ecological design cannot be one singular approach, but has to be expressed through a diversity of related and mutually supportive design-based frameworks and practices that function a little bit like a diversely equipped toolbox which offers different approaches or tools for different problems.

We need to see the diversity of permaculture, cradle to cradle, industrial ecology, restorative design, bio-inspired design, regenerative design approaches as a strength of the overall impulse to create a systemic response to multiple converging crises and find a path towards a more sustainable and regenerative human presence on Earth.

One of the reasons why the Gaia Education 'Design for Sustainability" course is primarily focussed on the scale of 'ecovillages' and 'sustainable communities' is that at the scale of face-to-face human interactions on a daily basis – at the scale of human-scale community – the theory of sustainability will turn into the lived practice of sustainability. It is in our communities, villages, neighbourhoods, and towns where diverse cultures of sustainability and regeneration will emerge, yet we need to collaborate not just at the local and regional scale to make this happen, we will need widespread global solidarity and exchange.

The remaining four modules of this dimension will take a closer look at what options and design possibilities we already have identified as useful ingredients in our tool-box for a sustainable culture. We will have a closer look at a diversity of solutions in the areas of food systems, energy systems, water systems and building systems.

Before we move on to look at ecological design in other modules, let's watch the Brazilian climatologist and Earth systems scientist Antonio Nobre make a passionate plea for saving the Amazon rainforest and the crucial role forests play in regulating the climate.

https://www.youtube.com/watch?v=CIesJyZUWTY&feature=emb_title

Pause and Bring it to Life

Think of your life as an integration of various dynamic systems.

You can write, draw or mindmap on a paper, or a digital map the different systems you are part of for your subsistence and living, you may choose one system or decide to map them all (we recommend you do this even beyond the time and scope of this course and that you revisit this "mapping" every year to reflect changes):

1. **Water system:** where is the water coming from? What do you do with that water and where does it go after it is used?

2. **Food system:** map one regular meal, such as breakfast or lunch and think about the usual components of this meal for you or your family: what are these? Where are they produced? Who produces them? What happens with ecosystems and humans in the place they are produced? What happens after you have consumed these foods? What happens with the parts you don't consume?

3. **Energy:** where is the energy you use for daily life coming from? (think about the power that feeds your heating or cooling systems; the one that feeds your computer or phone, the lights you use at night, etc.

4. **Building and structures:** where do you live? What type of structure and materials have been used? Is your house energy, water and waste efficient? How is the space in relation to the people and other beings who may inhabit it? How does it heat? Cool? Who built it? What is made of? Are the materials appropriate to the local ecosystems, climate and needs?

5. **Waste:** what is your current waste system for: unused food, human waste (humanure), pet waste, garden waste, disposal of things you no longer use or need, etc.? Is any of these systems in place benefiting other organisms or ecosystems or is it contaminating and polluting? Is the system energy efficient?

You can continue with other systems: disaster and recovery, transportation, communication, etc.