Global Climate Change: Ecosystem Decline and their Rescue through Establishment of Sustainable Biodiverse Ecosystems

A Proposal by Earth- & Eco-Systems Expertise for Environmental Modelling and Restoration

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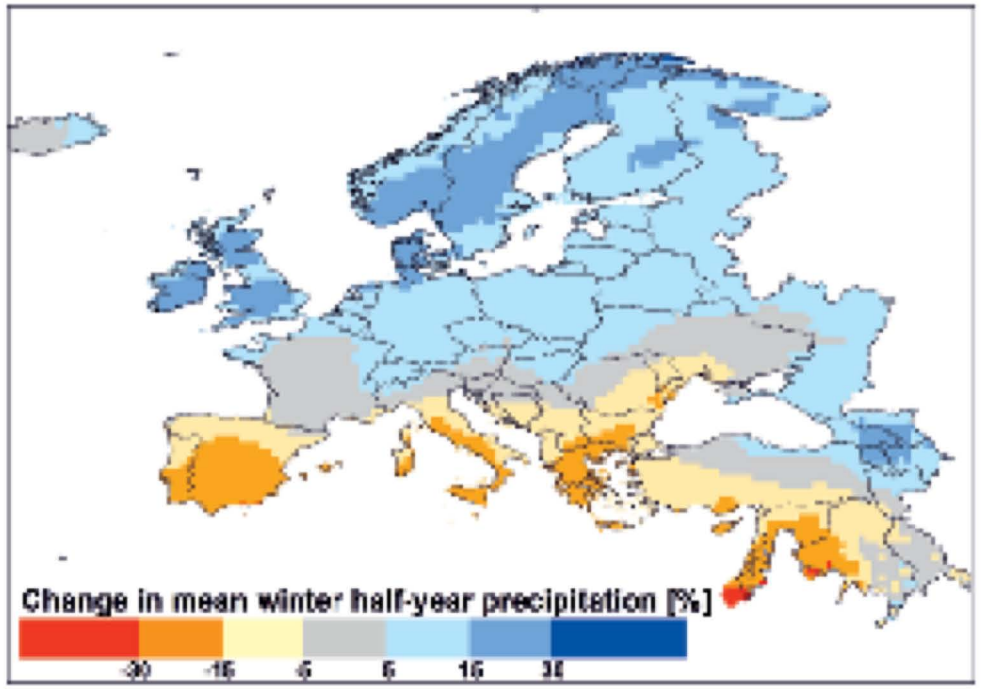
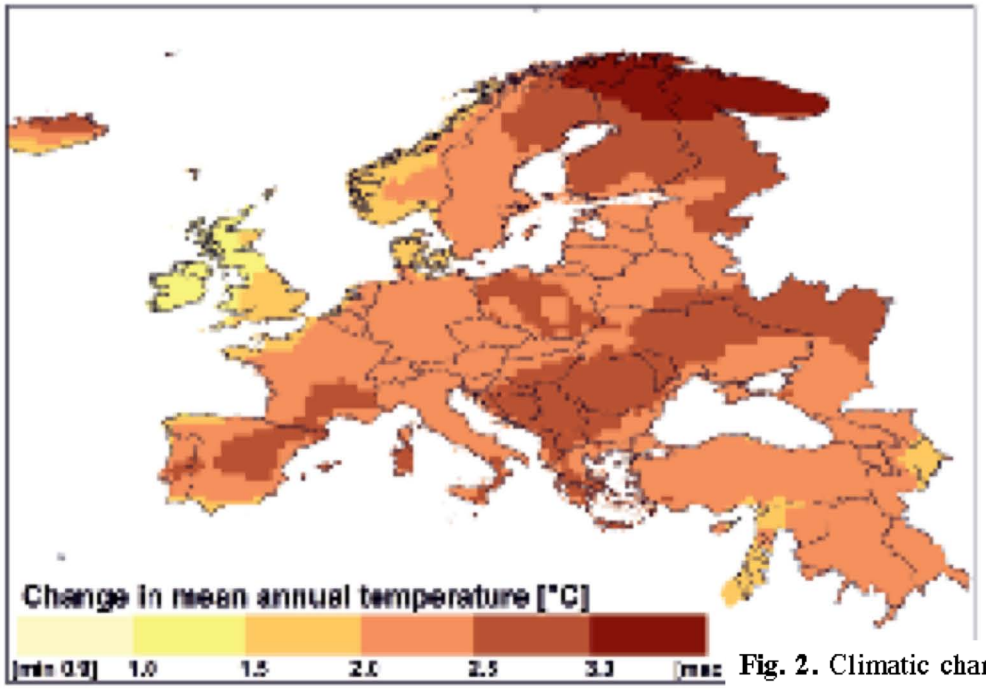
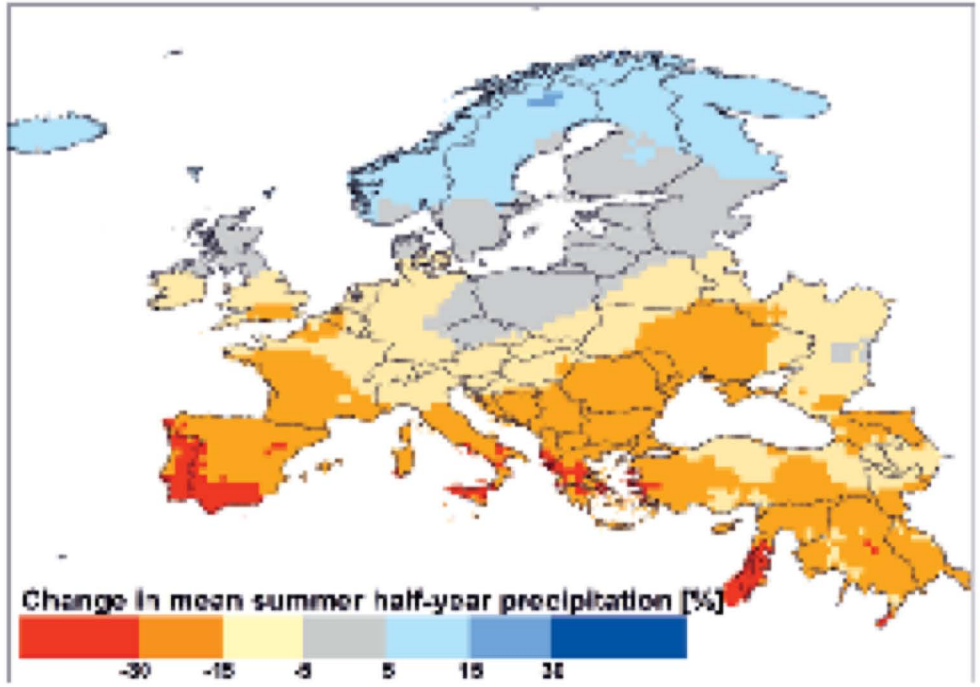
Climate Change:
Effects that have already occurred in Ireland

- **Temperatures have risen by 0.7°C between 1890-2008 and most significantly by 0.4°C between 1980-2008.**
- **This has changed the growing season affecting farming and has increased the number of animals suited to warmer temperatures**
- **An increase in the frequency and impact of storms has also been recorded in the last few decades.**
- **If the rate of global warming continues to increases and the climate continues there will be severe adverse effects on Ireland. As an island nation Ireland is particularly vulnerable to increasing sea levels with coastal regions facing issues of flooding.**
- **More erratic weather conditions will lead to both increased rainfall and storms as well as water shortages in summer.**
- **Increased rainfall will lead to flooding and in turn this would have adverse effects on water quality**
- **Because decreased rainfall will reduce vegetation cover and increase fire frequency, the landscape will be exposed to increased erosion**
- **Changing weather could also have devastating effects on the kinds of plants and wildlife that can favourably be supported in Ireland**

European Change in Precipitation and Temperature by the 2050s







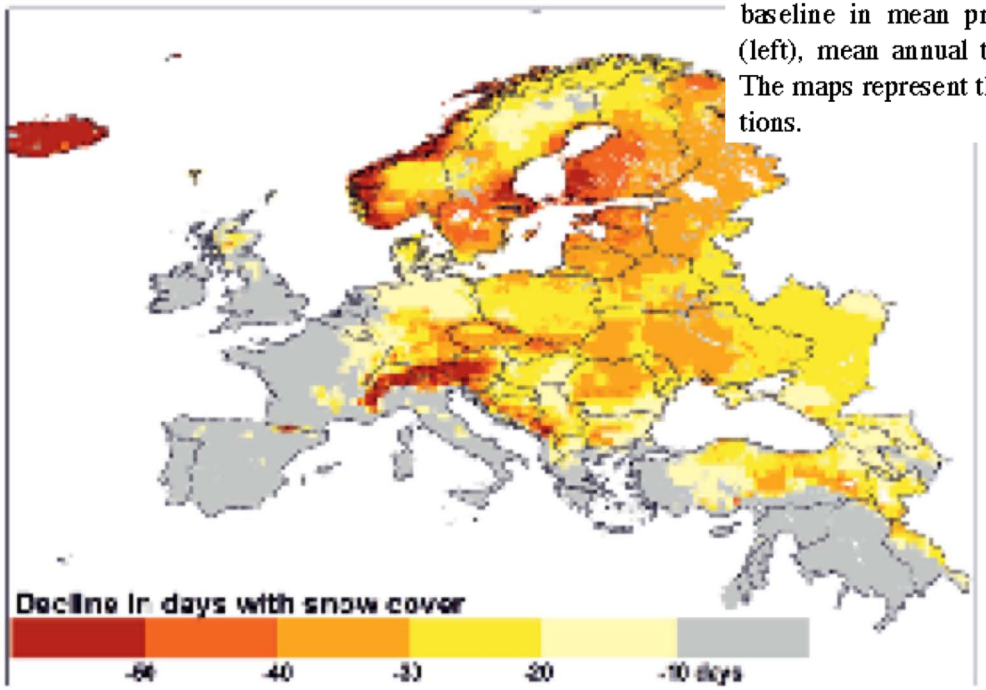


Fig. 2. Climatic changes in the 2050s featuring changes from the baseline in mean precipitation of winter and summer half-year (left), mean annual temperature and snow cover duration (right). The maps represent the ensemble mean of the three climate projections.

From: How will climate change modify river flow regimes in Europe?
C. Schneider, C. L. R. Laiz´e, M. C. Acreman, and M. Fl¨orke
Hydrol. Earth Syst. Sci., 17, 325–339, 2013

Impact of Climate Change on Stream Flow by the 2050s

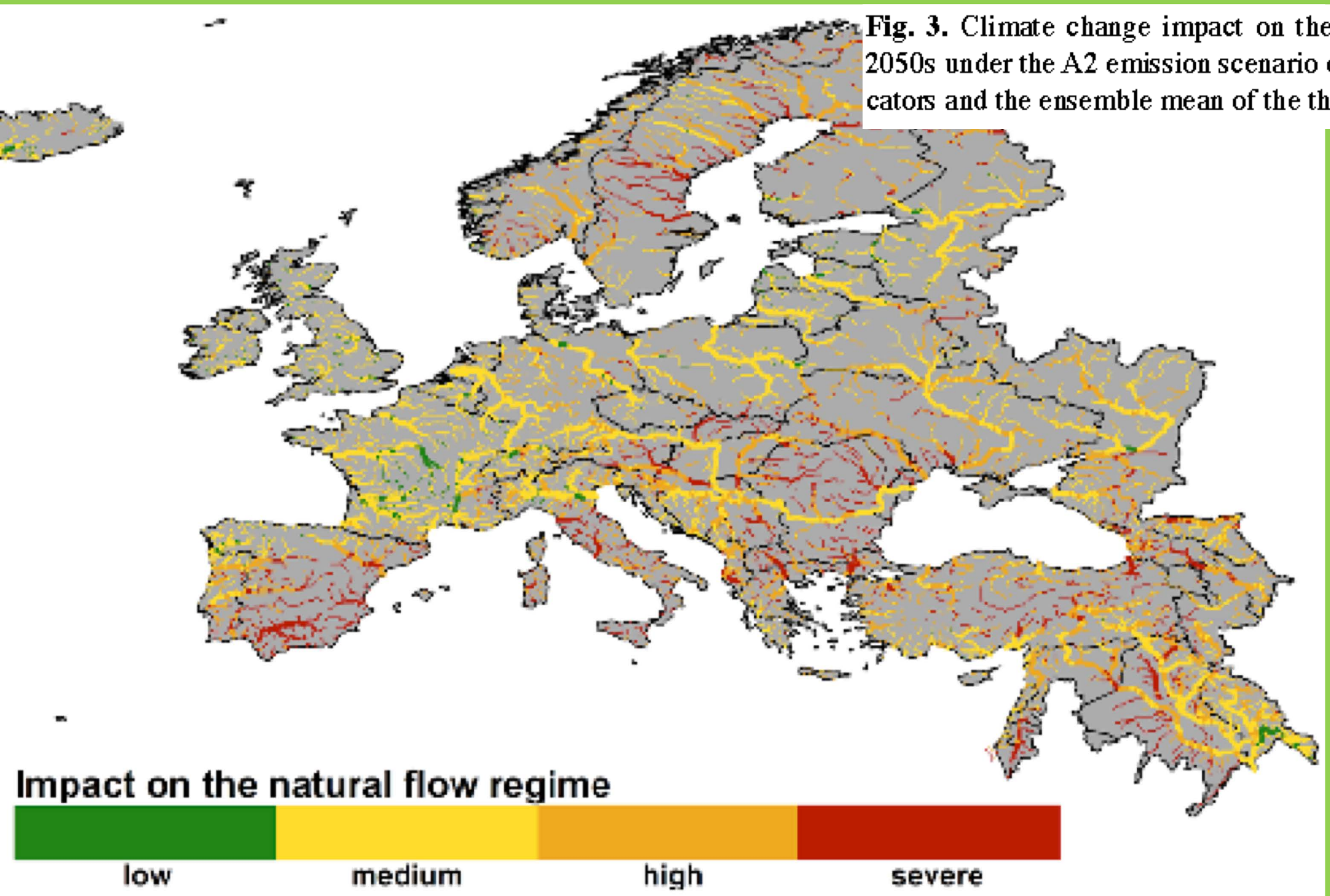


Fig. 3. Climate change impact on the natural flow regime in the 2050s under the A2 emission scenario considering 24 selected indicators and the ensemble mean of the three climate projections.

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Habitats at Risk in Ireland from Global Climate Warming and Poor Agricultural Practices

- **Agricultural Lands**
- **Peatlands**
- **Forests**
- **Riparian**
- **Lacustrine**
- **Coastal/Marine**

Identify pressures:

- **The first stage of our paleo data research will provide a precise assessment of the current status and potential changes of agricultural lands, forests, and peatlands in Ireland under future scenarios of climate change.**
- **Holocene Thermal Maximum analogues will allow us to provide climate parameter and ecosystem response to those climate parameters.**
- **Those conditions may under estimate the ultimate climate changes that we may see in the next decades, but they will allow us to project trends in agricultural land, forest, and peatland response from current conditions to those that will exist under conditions of increased temperature, and decreased annual precipitation, as well as shifts in seasonality of rainfall.**
- **Our studies will also assess prehistoric, historic and modern impact of human activity upon agricultural lands, forests, and peatlands**

Biodiversity:

Climate Change Impacted Factors

- Precipitation
- Annual temperature
- Soil temperature and water availability
- Geology and Soil condition
- Grazing
- Fire
- Sea level rise

Effects on Biodiversity

- Plant growth
- Reduction/deterioration of supporting habitat
- Competition between species for resources
- Spread of invasive species
- Animal welfare

Peatlands

Climate Change Impacted Factors

- Temperature
- Precipitation
- Extreme weather events
- Peatland archaeology

Effects on Peatlands

- Increase in decomposition
- Reduction in peat formation
- Increased erosion
- Possible species composition changes
- Significant loss of carbon storage potential
- Increase in CO_2 emissions
- Potential reduction in Sphagnum mosses/peat forming vegetation
- Soil/Peatland erosion may impact on archaeological site/ monument preservation conditions.
- Increased precipitation may improve preservation conditions in raised bog archaeological sites

Unique Landscapes at Risk in Ireland due to Human Activity

Peatland habitats are already under risk of extinction or to dramatic decrease in their biodiversity due to the impact of human activity. The major causes, mainly due to human activity, are highlighted on the website of the Irish Peatland Conservation Council. Among these are peat-cutting for energy use and heating (47% of loss), forest encroachment due to the government policy of afforestation (19% loss), overgrazing (5% loss), and agricultural reclamation (6% loss). Additional losses are due to dumping of garbage, burning, quarrying, wind farm installations, tourist trampling, and infrastructure development, i.e., road construction, power lines, and gas pipelines. Other destructive human behaviours are listed in a 2006 table presented by the National Parks & Wildlife Service. Between 1990 and 2000, 6.5% (76,000 ha) peatland was lost.

http://www.ipcc.ie/a-to-z-peatlands/peatland-action-plan/habitat-loss-of-peatlands/

Additional Ill-Considered Actions

New peat cutting rules published without public debate by Minister Eoghan Murphy of Housing, Planning and Local Government, allowing unmonitored large-scale peat cutting of areas of >30 hectares and supported by Minister Richard Burton of Climate Action and Environment will undermine Ireland's ability to capture carbon, and accelerate increased carbon emission through peat burning. This engenders an even greater threat to peatlands than previously.

https://www.irishtimes.com/news/environment/new-peat-cutting-rules-mean-bog-destruction-will-continue-says-action-group-1.3781929

The Additional Impact of Climate Change

As with other global resources under threat by human activity, we now have the added potentially catastrophic impact of global climate change. There is considerable research in northern Europe regarding the response of peatlands to changing climate, as well as to land use. Mauquoy and Yeloff 2007 summarise the evidence and conclude that because Greenhouse warming scenarios exceed the reconstructed Holocene record of climate changes, bog response to climate change may be extremely rapid, and that water tables beneath peatlands might drop significantly. They also conducted analyses that combined paleoecological studies of bogs affected by human activity with experimental manipulation. They conclude that peatlands, in particular, those dominated by Sphagnum moss, may not be able to respond quickly enough to survive greenhouse gas driven climate change.

Application of Middle Holocene Paleodata Analogues to Monitor Peatland Decline and/or Disappearance under Future Climate Scenarios: Phase A -Paleodata Collection and Analysis

- **Collect and Analyze Paleo-environmental Peatland data**
  - **Identify diverse array of bogs across Ireland;**
  - **Collect three cores from each bog;**
  - **Subsample cores to process and analyse for pollen, macrofossils, ostracods, geochemistry;**
  - **Map the geological setting of each bog;**
  - **Describe bog stratigraphy in detail including the nature of decomposition, etc.;**
  - **Create a detailed vegetation description of each of the bogs, and the state of their health;**
  - **Gather the historic record of each of the bog, including record of impacts and repeat photograph sets to monitor recent, and historic impacts;**

Application of Middle Holocene Paleodata Analogues to Monitor Peatland Decline and/or Disappearance under Future Climate Scenarios: Phase B -Data Modelling

- **Model relationships between past present and future environmental habitat data and climate parameters, and the impact of human activity on peatlands.**
  - **Model relationship between environmental habitat data and paleoclimate; parameters;**
  - **Model modern and historical peat bog response to current and historic climate;**
  - **Model impact of human activity in bog habitats (past and present);**
  - **Model predicted response of peatlands to future climate scenarios;**

Application of Middle Holocene Paleodata Analogues to Monitor Peatland Decline and/or Disappearance under Future Climate Scenarios: Phase C – Design and implementation of mitigation techniques, and data transfer

- **1) Apply new understandings to the design of permascaping applications to peatlands to rescue them; 2) Collaborate with peatland managers to develop new management protocols, and regulations. 3) Involve local community in management plan.**
  - **Year 1) Assess current peatlands, and begin assessment of their needs, and potential permascaping package applications.**
  - **Year 2) Begin application of permascaping packages in collaboration with local management staff and local communities.**
  - **Year 3) Continue work begun in year 2 and continue it to maintain the integrity of peatlands in response to climate change.**

Forests

Climate Change Impacted Factors

- **Air temperature**
- **Precipitation**
- **Extreme weather events**

Effects on Forests

- **Soil condition**
- **Animal welfare**
- **Plant growth**
- **Spread of invasive species**

Exploring the Afforestation Debate in Ireland

- The Issues:
  - Monoculture
  - Lack of biodiversity
  - Susceptible to massive die offs due to:
    - Drought stress
    - Disease
  - Uniform growth form blocks light to forest floor
  - Massive nutrient extraction from soil without replacement by diverse species
  - Inefficient ground water recharge due to lack of ground cover
  - Carbon sequestration is usually inefficient

Scientifically Informed Afforestation

- Apply natural landscape understandings regarding biodiverse - mixed forest habitats:
  - Eliminate single species forests (monocultures)
    - Promote biodiversity through mixed forest composition
    - Encourage planting of climate change resistant plants to reduce vegetation stress
      - Promote disease resistance (bark-beetle kill of Lodgepole pines in Pacific Northwest resulting massive die-off and fire)
  - Eliminate barren forest floors resulting from monocultures.
    - Promote plants favorable to bee pollination and honey production
    - Encourage development of new products
      - Native nuts and fruits
      - Fresh, frozen and canned fruits, jams and jellies
      - Medicinal plants

Scientifically Informed Fire Management in Response to Increasing Fire Frequency with Global Climate Warming

- **Maintain vegetation cover to prevent erosion during torrential rainfall events**
  - **Encourage drought resistant vegetation**
  - **Establish drought resistant plants to combat disease due to water and temperature stress**
  - **Create landscapes contoured to slow water runoff, and enable recharge of water tables**
  - **Monitor fire regime indicators, such as fire scars, as a measure of forest health in response to global climate warming and drought**

Bray Head fire scars

Coring Wetlands

They also indicate the obvious fact that the full vegetation diversity of past bogs cannot be reconstructed from single or even multiple bore holes for comparison with modern bogs.

Other Analyses

However, determination of the response of the bog environment can be achieved through the use of multiple data sets, besides macrofossil and palynological analysis. These include stable isotope analysis to assess drought stress (Wigand 1994), and carbon/nitrogen analyses to assess decomposition rate change in response to shifts between warmer-drier vs. cooler-wetter conditions (Kuhry and Vitt 1996), and paleolimnological analysis that will include ostracod and paleo-phycology, in particular, whose response is very sensitive to changes in water chemistry and temperature (Palacios-Fest 2018; Balmaki, et al. 2017). All of these data will provide a measure of peatland response to climate stress that will supplement macrofossil and pollen and spore analysis of marsh composition.

Agriculture

Climate Change Impacted Factors

- Air temperature
- Soil temperature
- Extreme weather events
- Water availability

Effects on Agriculture

- Decline in soil condition
  - Loss of topsoil
  - Loss of organic matter
- Increase in pests, pathogens and invasive species
- Increase in plant growth
- Animal welfare
- Infrastructure and access to the land

Water Quantity and Quality

Climate Change Impacted Factors

- Precipitation
- Air Temperature

Effects on Water Resources

- Increased evaporation leading to lowering of resource volumes
- More stress on water service infrastructure
- Greater concentration of pollutants/contaminants, and less assimilative capacity of waters during summer months
- Flood risk (fluvial)

Human Health

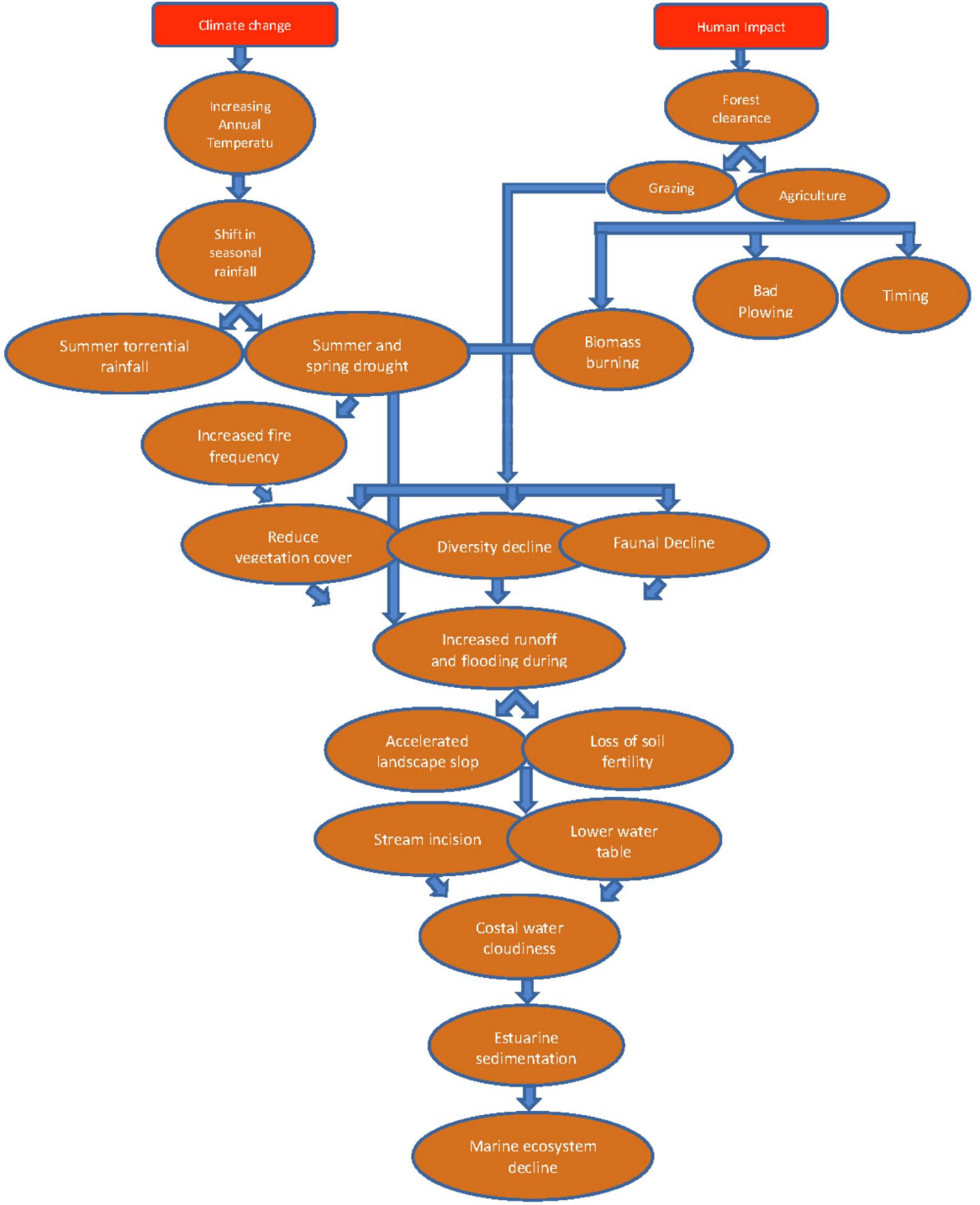
Climate Change Impacted Factors

- Temperature
- Precipitation

Effects on Human Health

- Warmer winters leads to reduced cold-related deaths
- Warmer summers may lead to increases in heat stress cases
- Unforeseen icy/flood conditions can affect the provision of critical services/emergency services/transport services
- Increased occurrence of more southerly distributed diseases, such as, malaria, West Nile virus, and cholera

What Paleoenvironmental Data Indicate about future Ecosystem Response

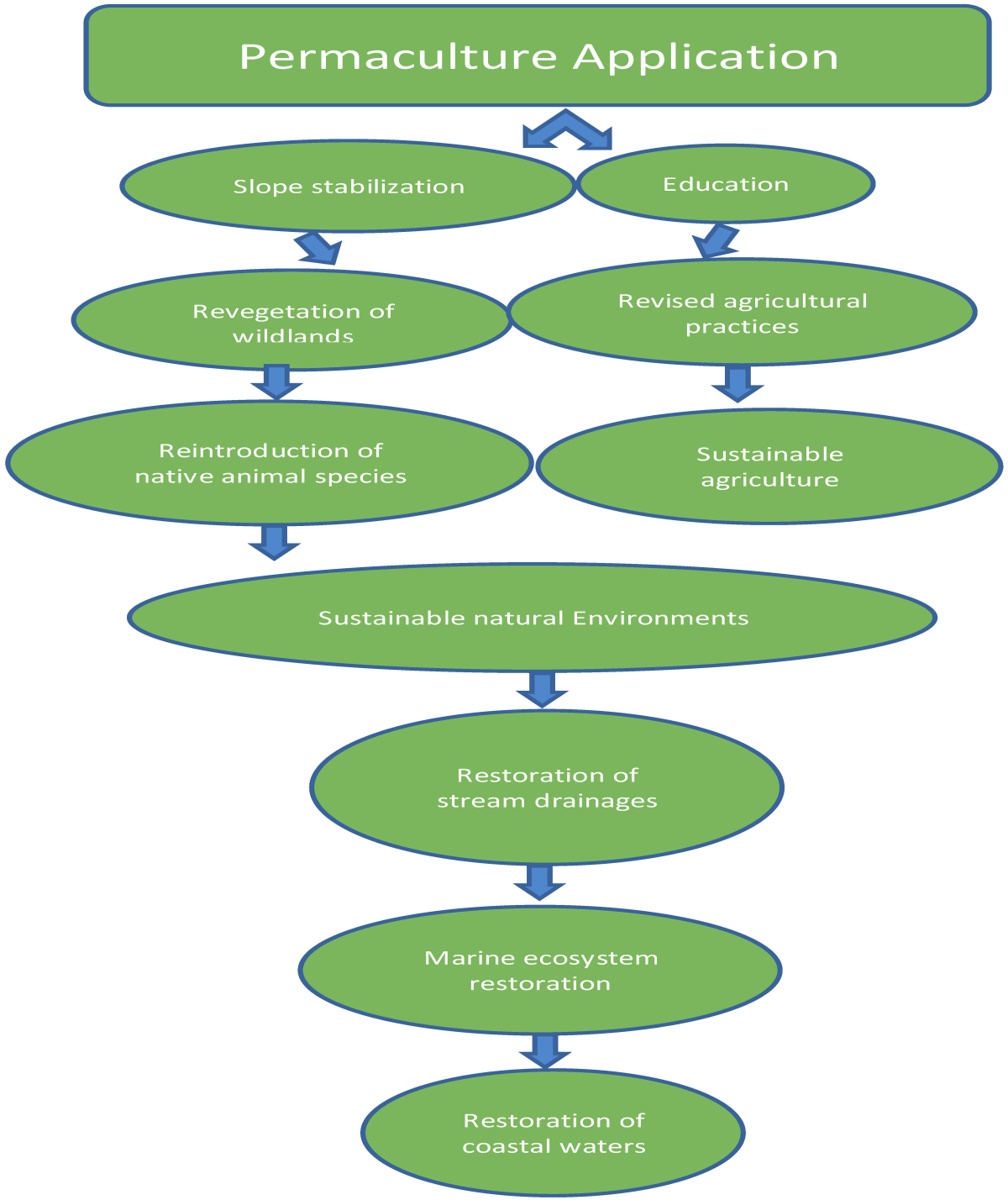


Inform policy:

The data generated by stage one, will be used to assess the efficacy of current management of peatlands, and the need for revision of both regulations and management of these habitats. Modelling of potential outcomes will allow us to project current trends, and guide the development of management practices to achieve better survival of peatlands during the coming decades. This might indicate the need for the revision of current regulations governing peatland management. It may also require the accelerated implementation of certain management milestones e.g., the 2030 target for cessation of peat cutting.

Develop solutions:

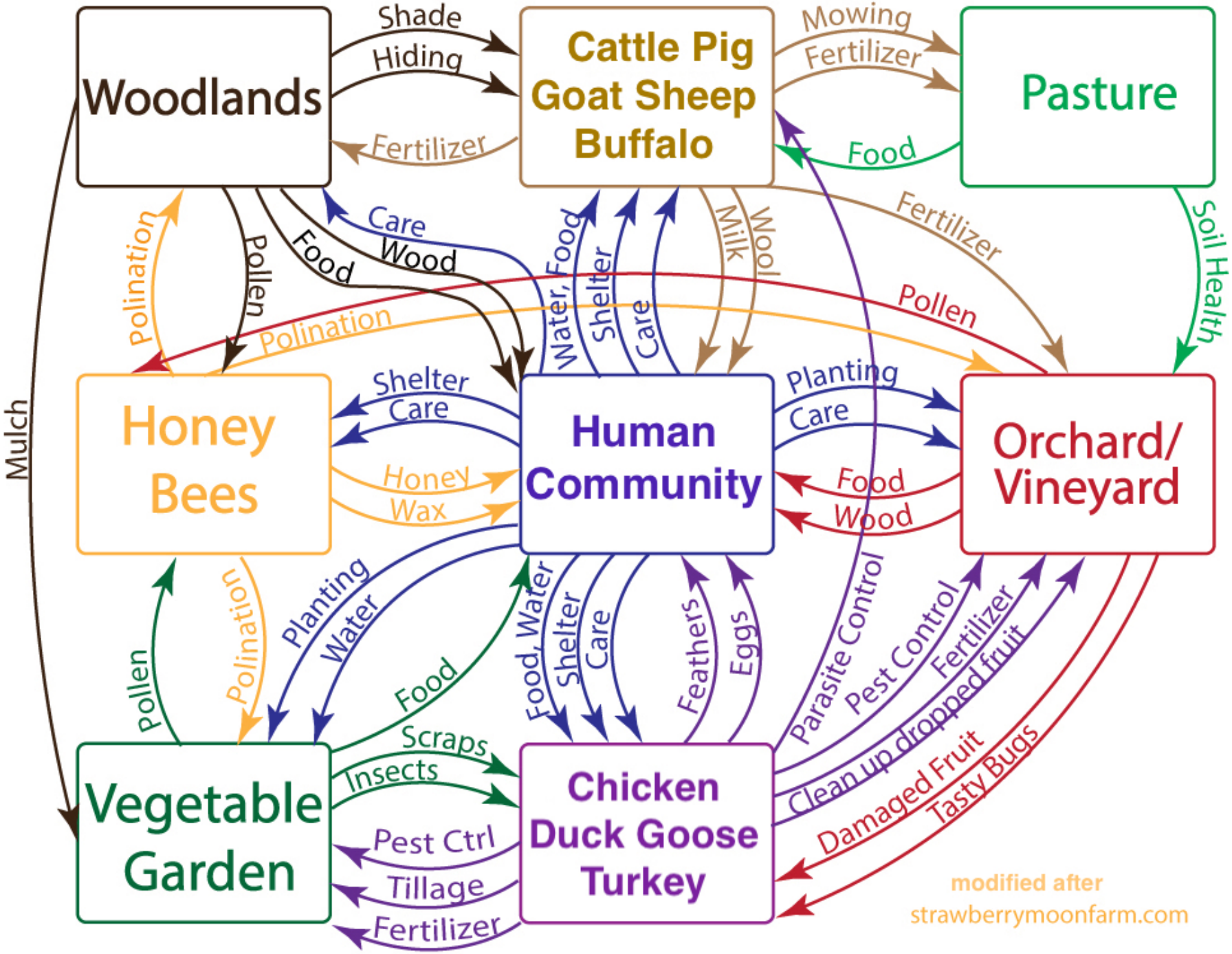
At present rates of greenhouse gas accumulation in the atmosphere, climate warming trends and associated decline in annual rainfall amount and seasonality may not be significantly slowed. Therefore, in lieu of significant changes in climate, other factors impacting the decline of peatlands will have to be implemented. These will specifically need to address lowering of the water table under bogs. Techniques inhibiting runoff from the surface of bogs through damming, or eliminating intrusive vegetation, e.g., trees and shrubs, and even introducing water into peatlands piped in from desalinization plants may have to be used. To address each of these measures a need will be create for new green economy services.



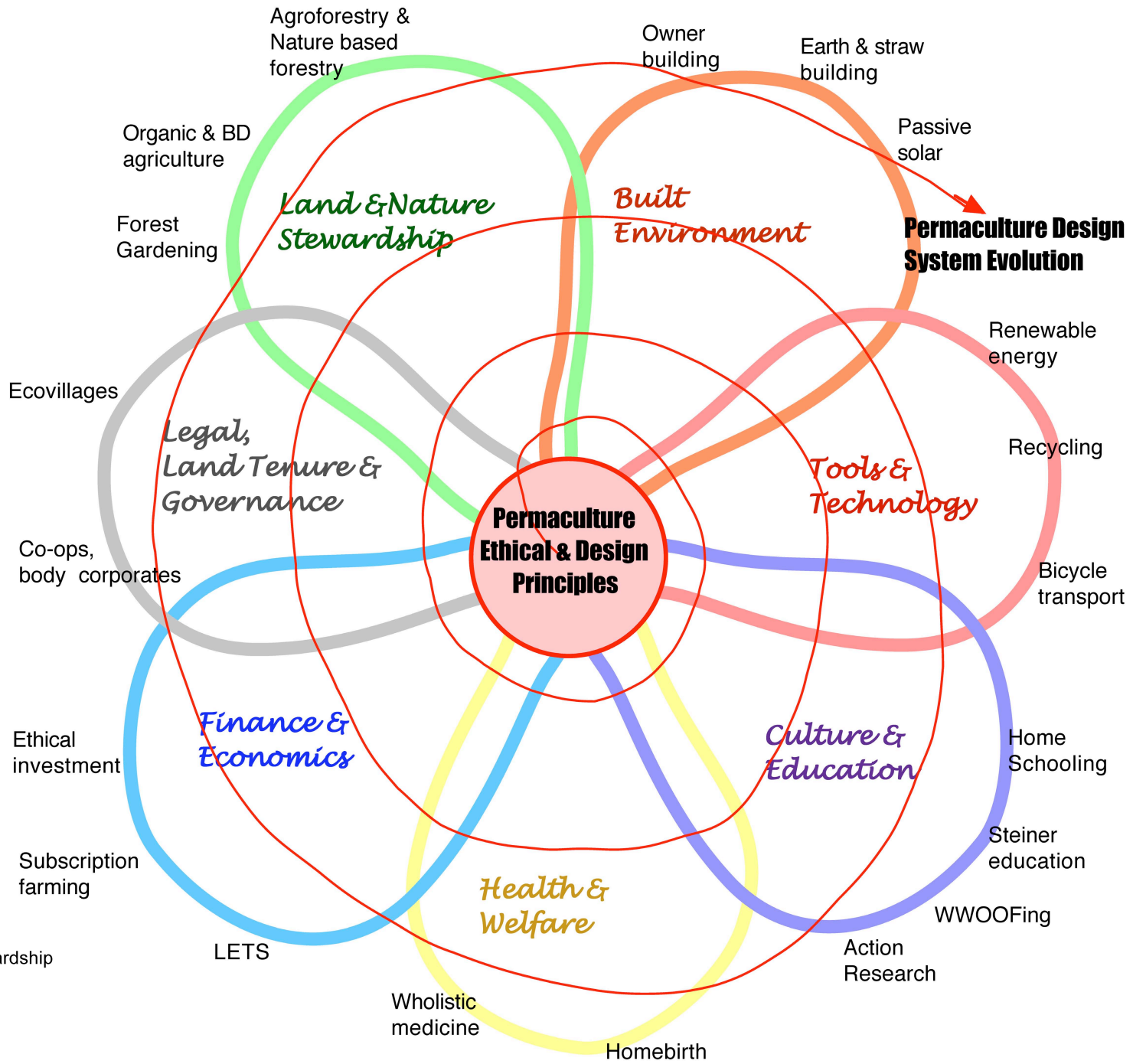
Develop Sustainable Ecosystem Solutions


BBC
Potential Natural Irish Biodiversity

Permaculture Connections



Holmgren's Aspects of the Permaculture Concept



The Permaculture Design System Flower

Starting with ethics and principles focused on the critical domain of land and nature stewardship (gardening, agriculture etc) permaculture is evolving as a design system by progressive application and integration of all seven domains necessary for a sustainable culture.

Essence Of Permaculture by David Holmgren 2001

Integration of Natural and Agricultural Diverse Ecosystem Habitats

Design and Planning of Biodiverse Habitat

- **Meet with the land owner**
  - **Survey the property**
    - **Describe the topography**
    - **Describe the drainage and water patterns**
    - **Describe the soils**
    - **Identify what is currently growing there**
  - **Find out the landowner's expectations**
    - **Discuss the kind of vegetation that could be grown there**
    - **Discuss the pros and cons**
    - **Discuss their economic possibilities**
      - **Wood (lumber, paper, furniture)**
      - **Fruit (jams, jellies, juices, liquor, medicinal) and nuts (whole nuts, butter, flour)**
      - **Pollinator plants (bee hives, honey, pollen)**
    - **Discuss grazing animals (sheep, goats, cattle, buffalo, boar)**
    - **Discuss avian fauna (chickens, ducks, geese, turkey, pheasant)**

Setup of Biodiverse Habitat

- **Arrive at mutual agreement with the landowner as to the landscape design and what plants and animals should be introduced**
- **Describe and map the landscape in detail**
- **Initiate landscape reshaping**
- **Initiate planting regime**
  - **Arrange planting to maximize the cost benefit to the owner**
- **Design and establish locations and routines for grazing animals and avian fauna to minimize landscape impact, and maximize their benefit**
- **Enlist and train volunteers and potential employees**
- **Formulate business plan if eco-product production is contemplated**
  - **Identify nearest processing areas and markets to minimize fuel use (reduce carbon foot print)**
- **Expand the project if other landowners come on board**

Ongoing Maintenance and Evolution of Permascape

- **Maintain and enhance the agriculture habitat**
- **Enhance the natural habitat biodiversity in concert with that of the the agricultural habitat**
- **Introduce new tree or shrub species if desired**

Humanity in tune with nature!