



# Aquaponics and Sustainability

## Links to Permaculture and Living Machines

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Ecoponics and Europonics Project Meetings

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# Resource depletion

- Man is a geologic force!!!
  - We move annually 10x more than nature
  - Now have biological extinction period
    - 25% of mammals endangered
      - Thousands of species become extinct every year
      - Ecosystems on land and in oceans endangered
  - In 30 years
    - We have used up 1/3 of Earth's resources!
      - Destroyed 30% of forests, lost 25% of soil, 50% of oil, 50% of phosphorous...
      - Metals are becoming scarce

= **Because of consumption**

# Ecological footprint



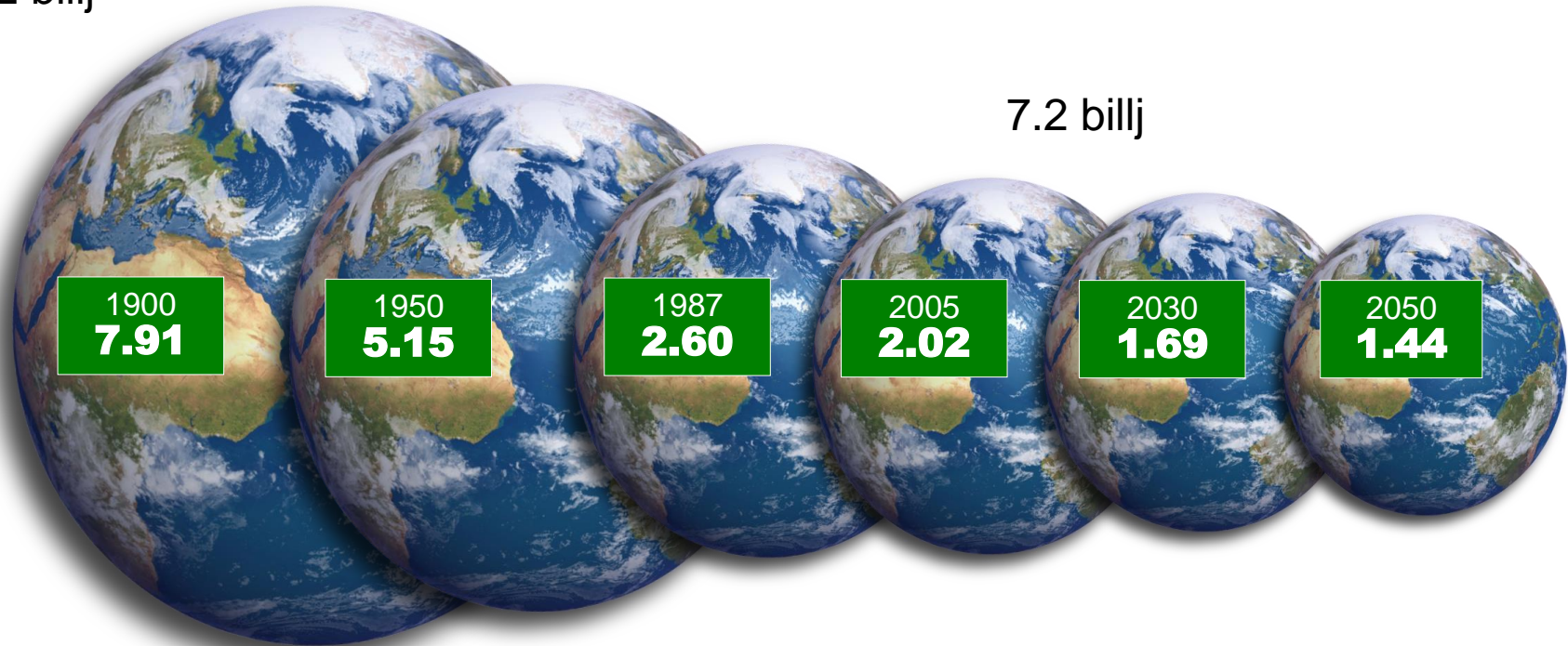
©BFF 2005



# The Earth is **shrinking**

2 billj

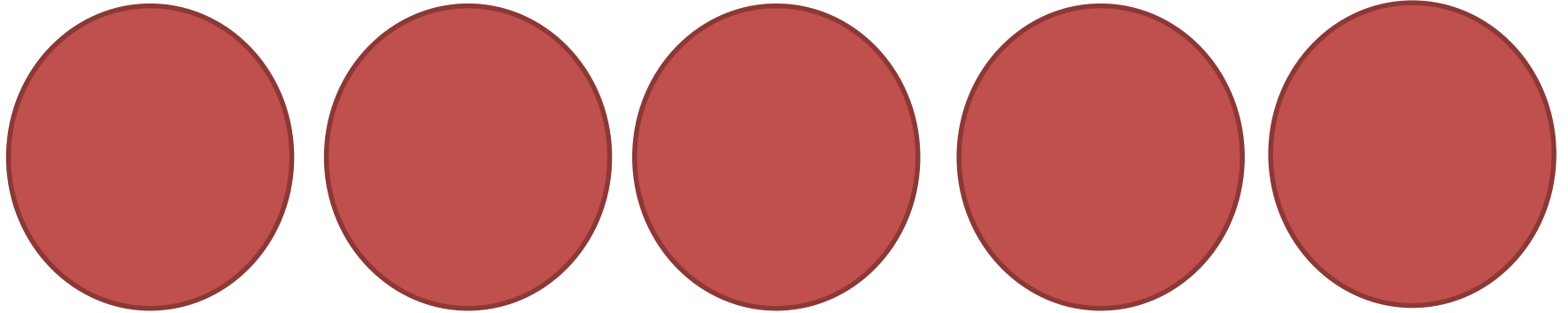
7.2 billj



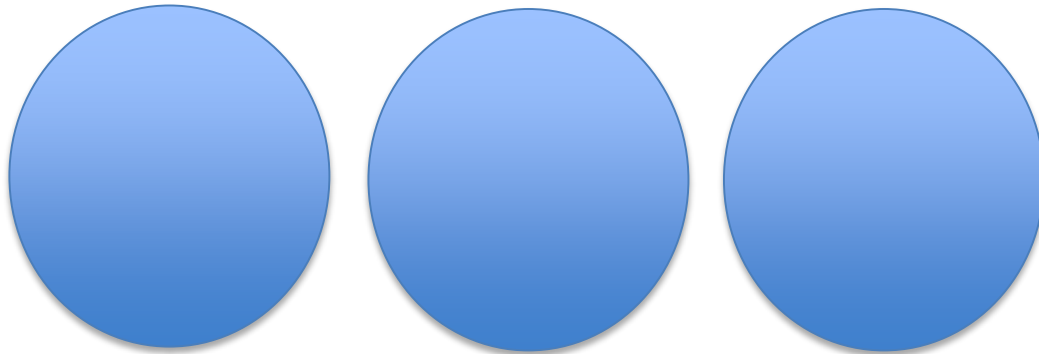
**YEAR**

**Hectares of surface per person**

Ecological footprint = the land we need to provide daily needs and take up the waste.  
Now we are using 1.5 Earths per year.



American way of life – 5 planets!



EU and  
Norway  
3 planets!



Climate change

Chemical pollution

Climate change

Acidification of oceans

Chemical pollution  
(not yet quantified)

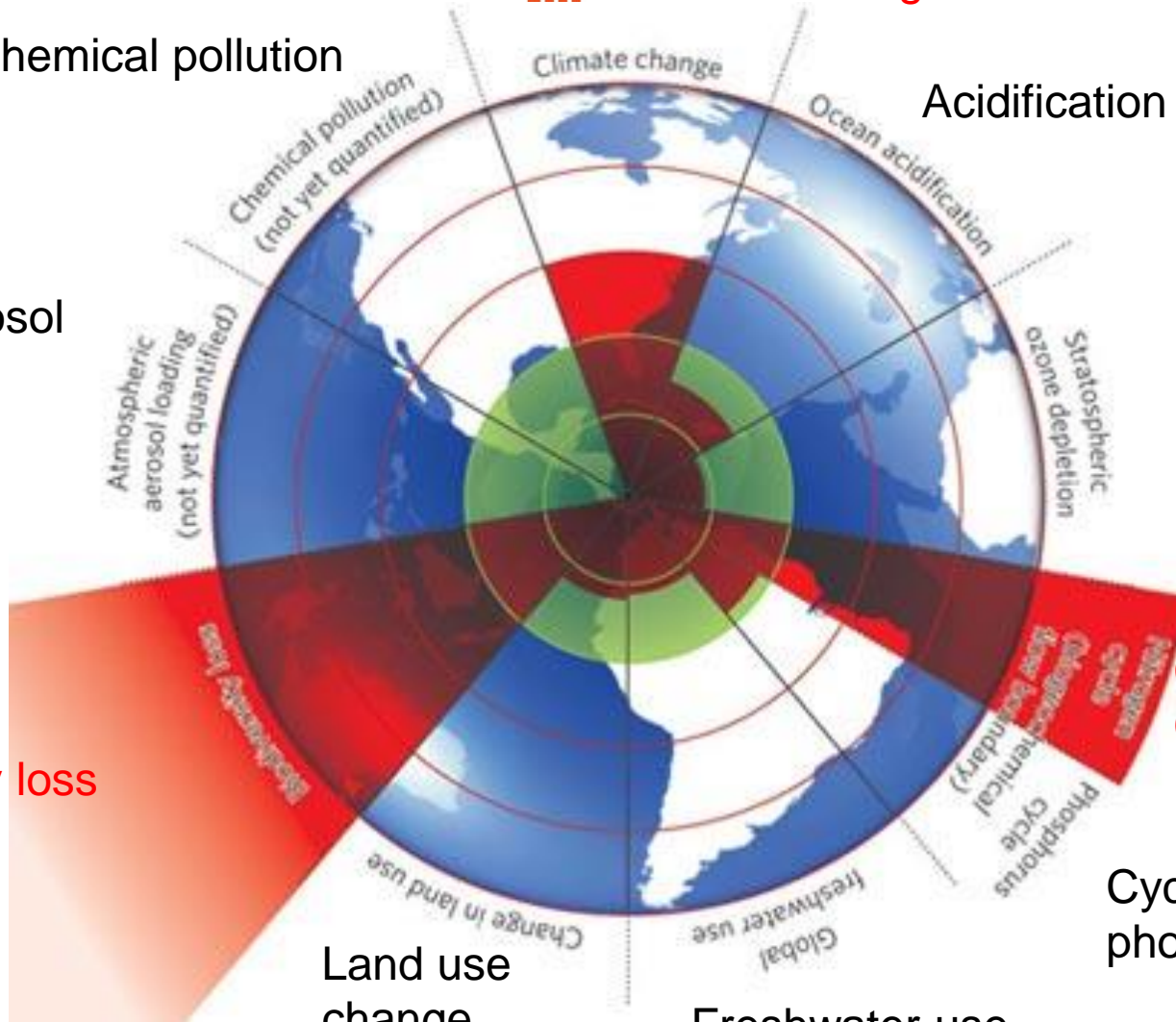
Ocean acidification

Stratospheric  
ozone depletion

Ozone in  
stratosphere

Atmospheric  
aerosol loading  
(not yet quantified)

Atmospheric aerosol  
loading



Biodiversity loss

Cycling of  
Cycling of  
nitrogen

Land use  
change

Cycling of  
phosphorous

Freshwater use

**Planetary boundaries**

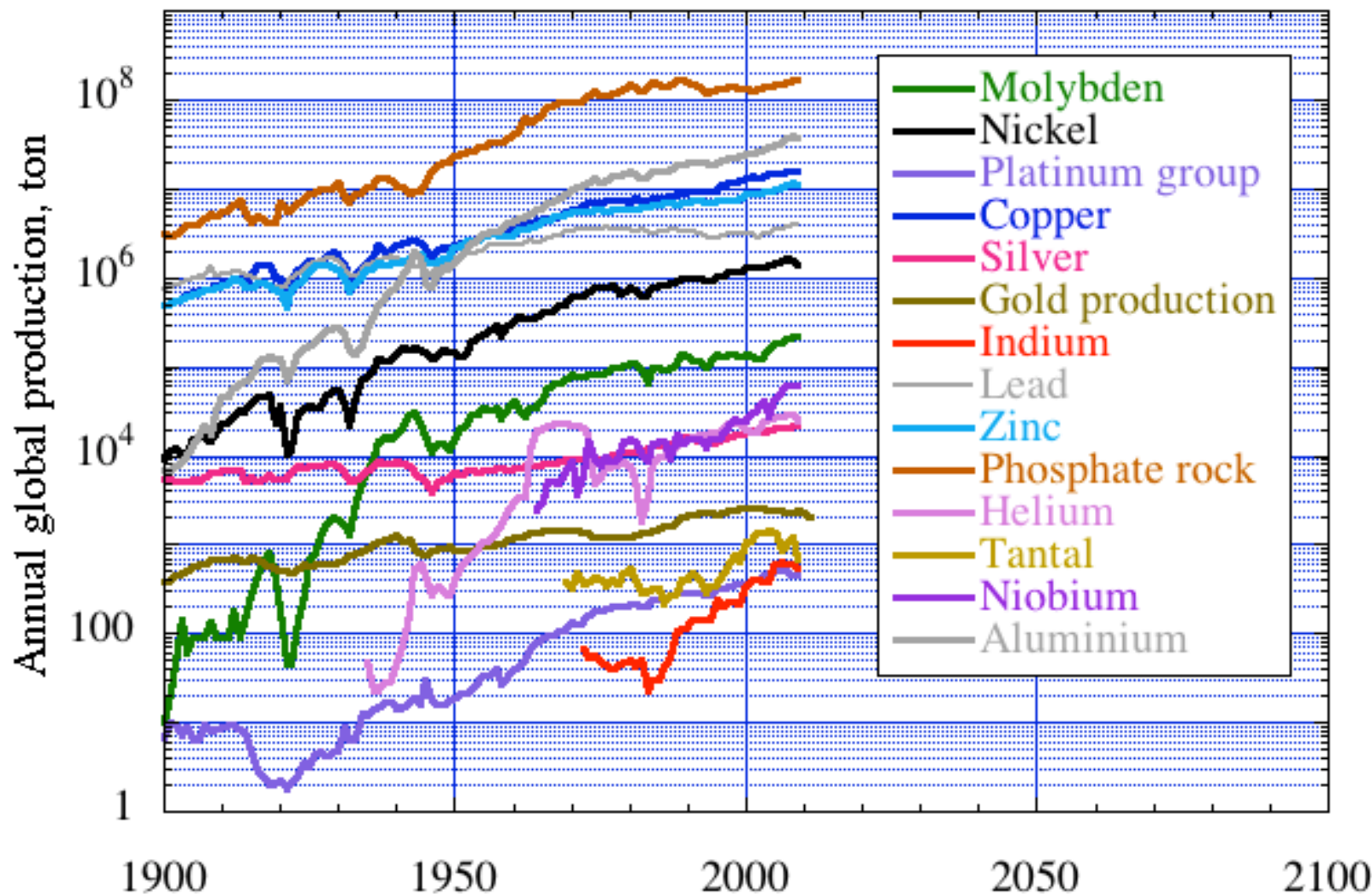
We have surpassed 3 f 9

Rockström et al. 2009





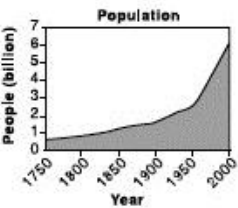
# Exponential growth forever?



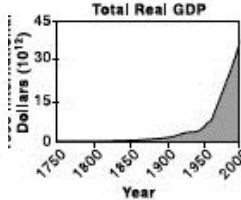


# Exponential growth 1750-2000

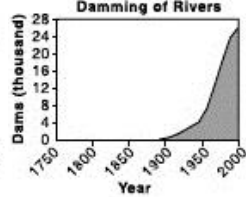
Population



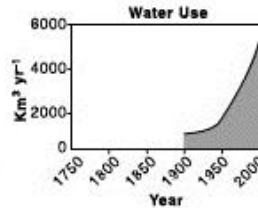
GDP



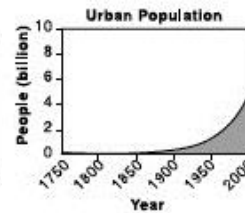
Dams on rivers



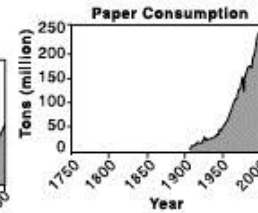
Water use



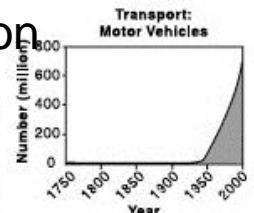
Urban population



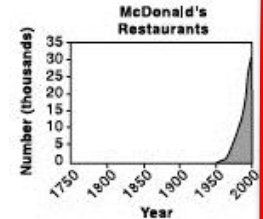
Paper consumption



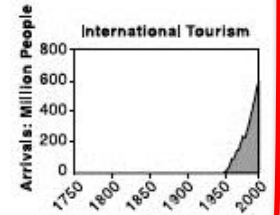
Car transport



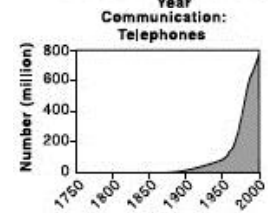
McDonalds



Tourism



Number of telephones







# Growth

“Anyone who believes that unlimited growth is possible in a limited world is either a madman or an economist”

Kenneth Boulding  
Economist

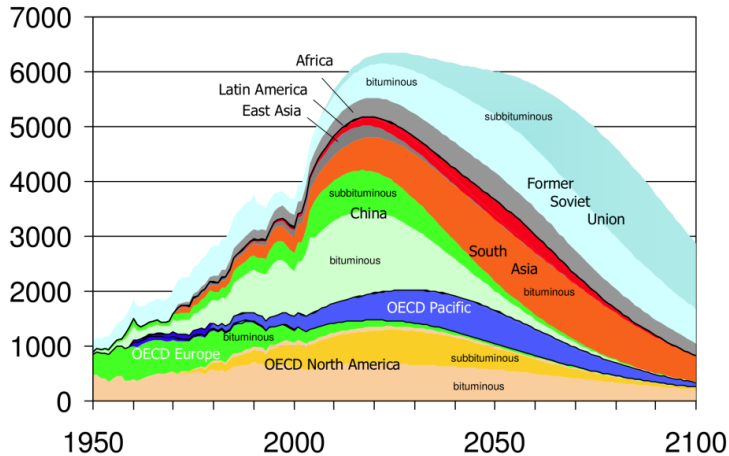
“The greatest imperfection of mankind is that it does not understand the consequences of exponential growth ”

Albert Allen Bartlett  
Mathematician

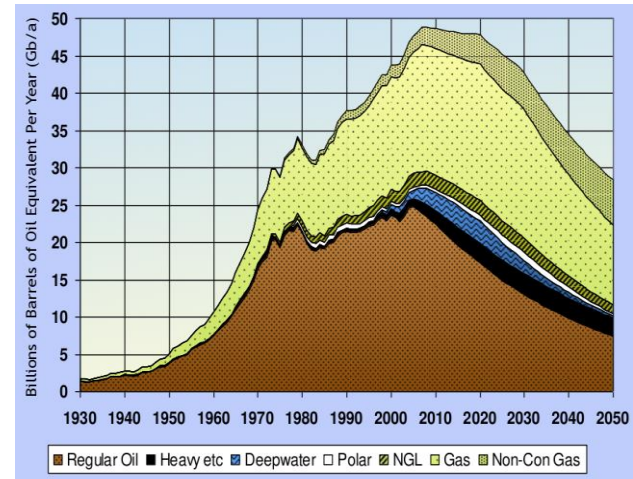
# Peak energy



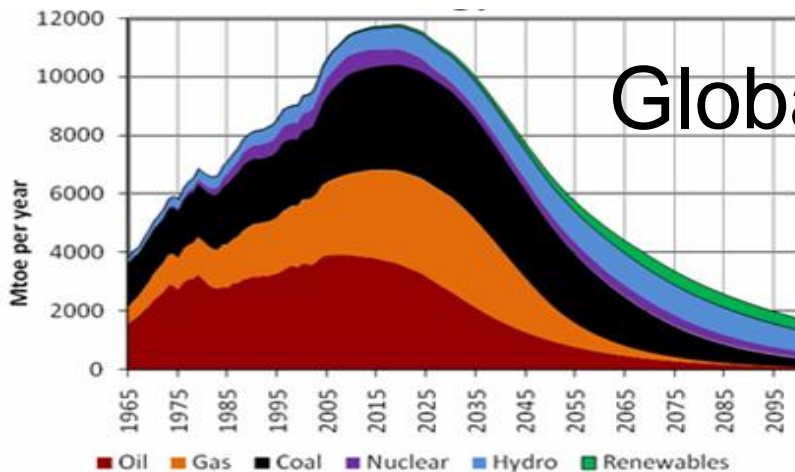
## Coal 2015



## Oil 2005



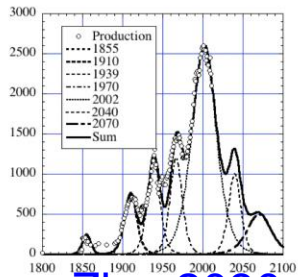
## Global energy 2020



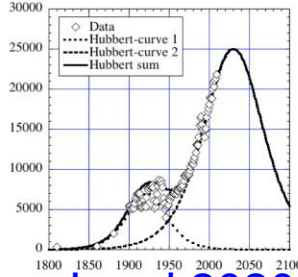
# Gold 2000

# Silver 2030

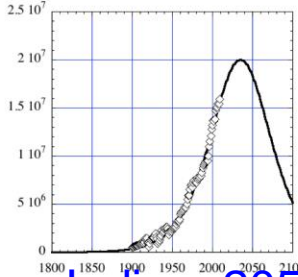
# Copper 2040



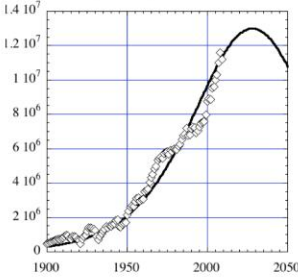
# Zinc 2030



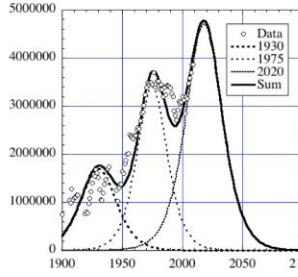
# Lead 2020



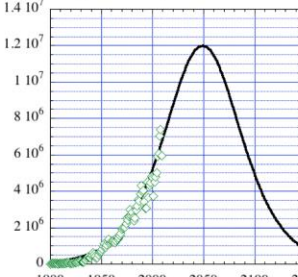
# Indium 2050



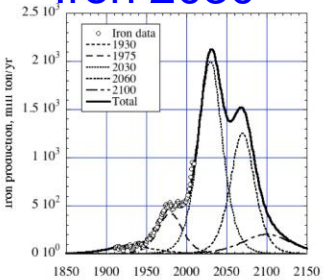
# Iron 2030



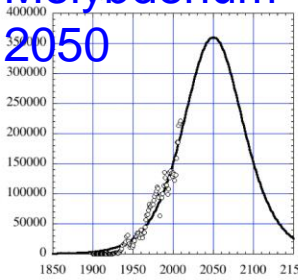
# Molybdenum 2050



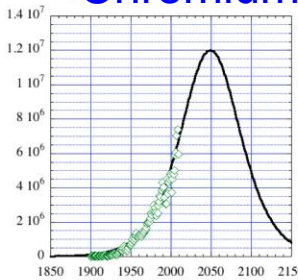
# Chromium 2050



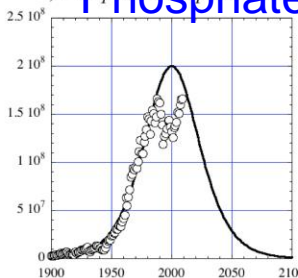
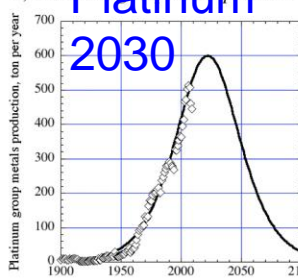
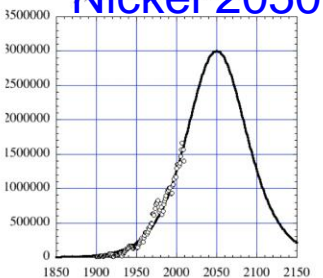
# Nickel 2050



# Platinum 2030



# Phosphate 2000



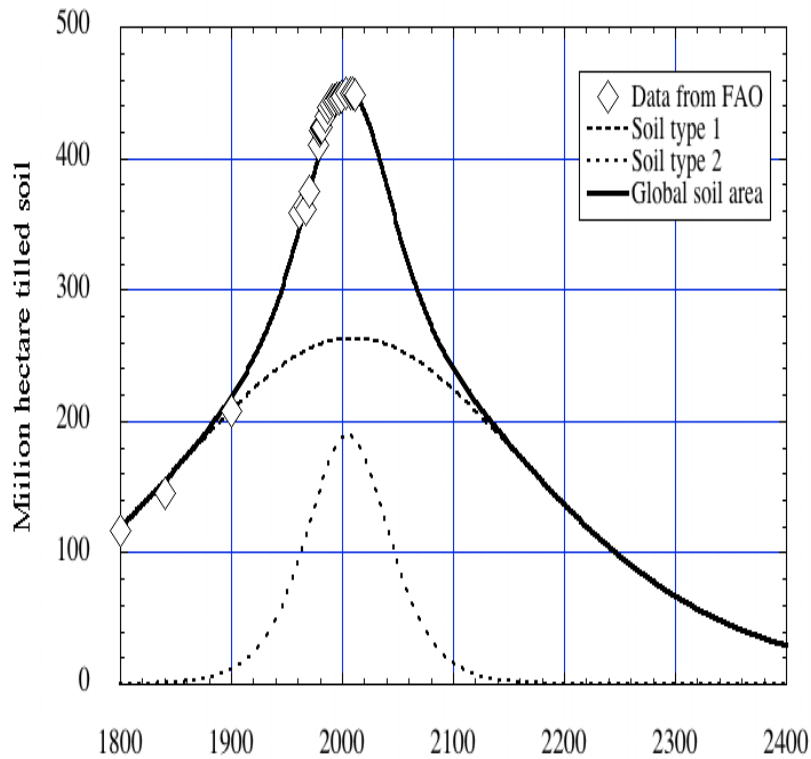
Hubberts  
„peak” curves  
for 12 key  
metals and  
materials

Figure 8. Hubbert-curve fittings for gold (a) silver (b), copper (c), zinc (d) lead (e), indium (f), iron (g), molybdenum (h), chromium (i), nickel (j), platinum group metals (40% Pt, 43% Pd, 5% Rh, 5% Ru, 5% Ir, 2% Os) (k) and (l) that shows a one-curve phosphorus plot. We can see that the data suggest gold already passed the production peak. The scale on the Y-axis is production in ton per year, the x-axis is the year. Data: <http://minerals.usgs.gov/ds/2005/140/>





# Peak tilled soil



# Peak fish catch

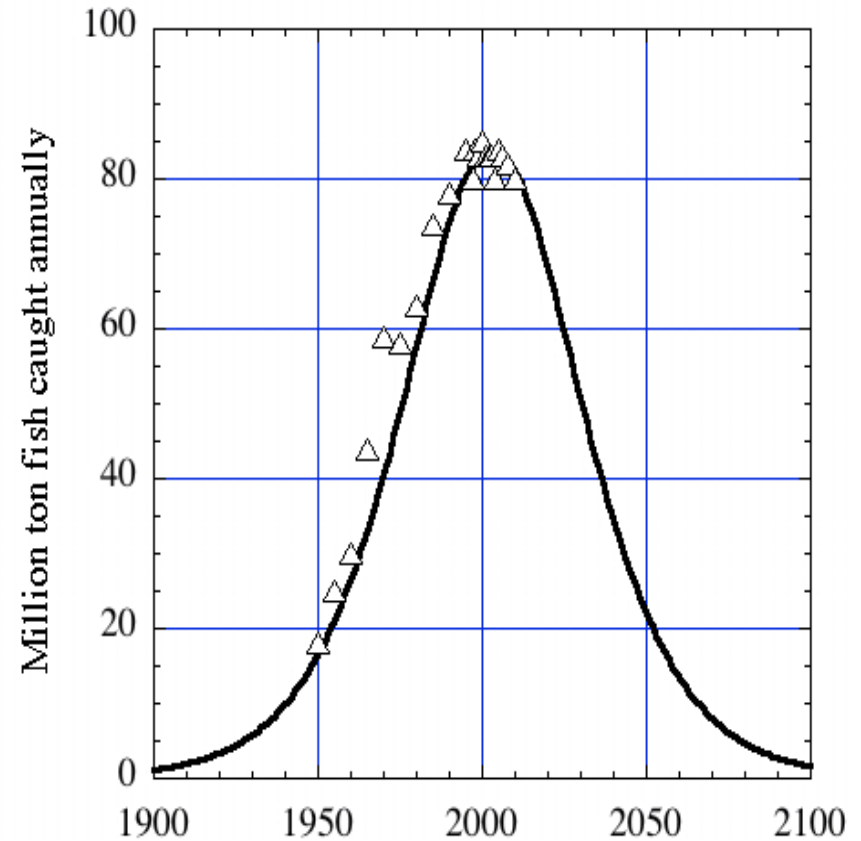
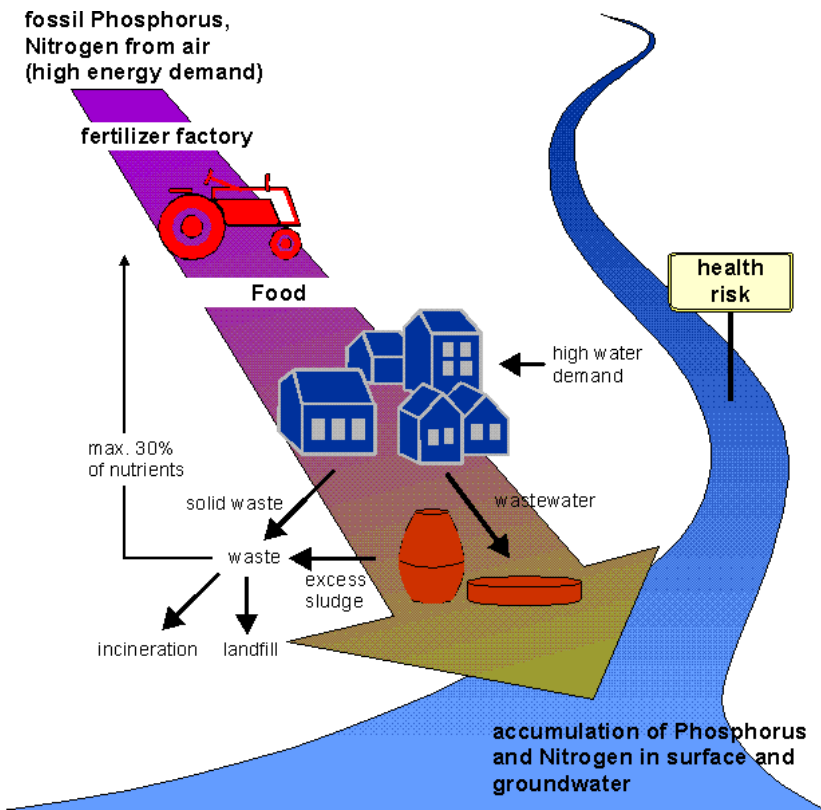


Table 4. Outputs on Hubbert-estimates for time to scarcity. (1) Business-as-usual, (2) 50% recycling (3) recycling to 90%, (4) recycling to 95%, (5) all recycling to 95%, population is reduced to 3 billion. (6) I recycling to 95%, assume one half of present per capita use, population is reduced to 3 billion.

Element	1	2	3	4	5	6
Bulk materials for societal infrastructures						
Iron	158	254	1,285	2,574	6,007	12,014
Aluminium	132	372	1,876	3,756	8,764	17,528
Nickel	82	82	424	851	1,986	3,972
Copper	61	61	317	638	1,488	2,975
Zinc	38	72	372	748	1,745	3,490
Manganese	35	58	306	616	1,437	2,874
Strategic materials for technology						
Indium (Zn-dependent)	35	74	385	771	1,798	3,597
Lithium	47	97	496	997	2,325	3,597
Rare earths	924	1,759	8,809	17,622	41,117	82,235
Yttrium (REE dependent)	120	616	1,235	2473	5,770	11,541
Hafnium (Zr-dependent)	12,649	12,649	25,303	50,609	118,087	236,174
Zirconium	133	214	1,085	2,173	5,071	10,142
Tin	38	58	304	611	1,425	2,850
Molybdenum	94	289	728	1,459	3,405	6,809
Rhenium	99	99	252	507	1,183	2,365
Lead	43	43	181	365	852	1,703
Wolfram	62	102	523	1,049	2,447	4,894
Cobalt	227	365	1,840	3,683	8,594	17,188
Tantalum	346	556	2,795	5,594	13,053	26,106
Niobium (Mo-dependent)	88	143	731	1,466	3,420	6,841
Helium	14	32	175	353	823	1,647
Chromium	175,000	262,000	1,310,000	2,600,000	6,100,000	12,200,000
Gallium	1,017	1,425	7,139	14,282	33,325	66,650
Arsenic	60	123	627	1,258	2,936	5,872
Germanium	201	282	1,425	2,854	6,659	13,317
Titanium	813	813	4,078	8,160	19,039	38,079
Tellurium	784	784	3,942	7,888	18,405	36,809
Antimony	48	68	354	711	1,658	3,317
Selenium	422	8,500	10,600	21,200	49,600	99,200
Precious metals						
Gold	94	94	142	725	1,693	3,385
Silver	26	26	84	434	1,012	2,024
Platinum	145	145	442	2,223	5,187	10,400
Palladium	121	121	369	1,860	4,340	8,679
Rhodium	86	86	266	1,343	3,135	6,269
Fossil energy resources						
Oil and gas	100	-	-	-	330	660
Coal	174	-	-	-	574	1,150
Uranium	121	240	1,215	12,184	28,400	56,900
Thorium	379	747	3,746	37,500	87,500	175,000
Planetary life support essential element						
Phosphorus	160	258	1,303	6,527	15,200	30,460
Colour legend						
TTS range, years	0-100	100-200	200-1,000	1,000-2,000	2,000-10,000	>10,000
Colour code						

Sverdrup, Koca,  
Ragnarsdottir  
2012

# From cradle to grave to cradle to cradle



## Biomimicry – Cradle to cradle





# Sustainability

## ***Sustainability is..***

*A set of conditions and trends in a given system that can continue indefinitely*

## ***Sustainable development is..***

*A directed process of continuous innovation and systemic change in the direction of sustainability*



# Systems and sustainability

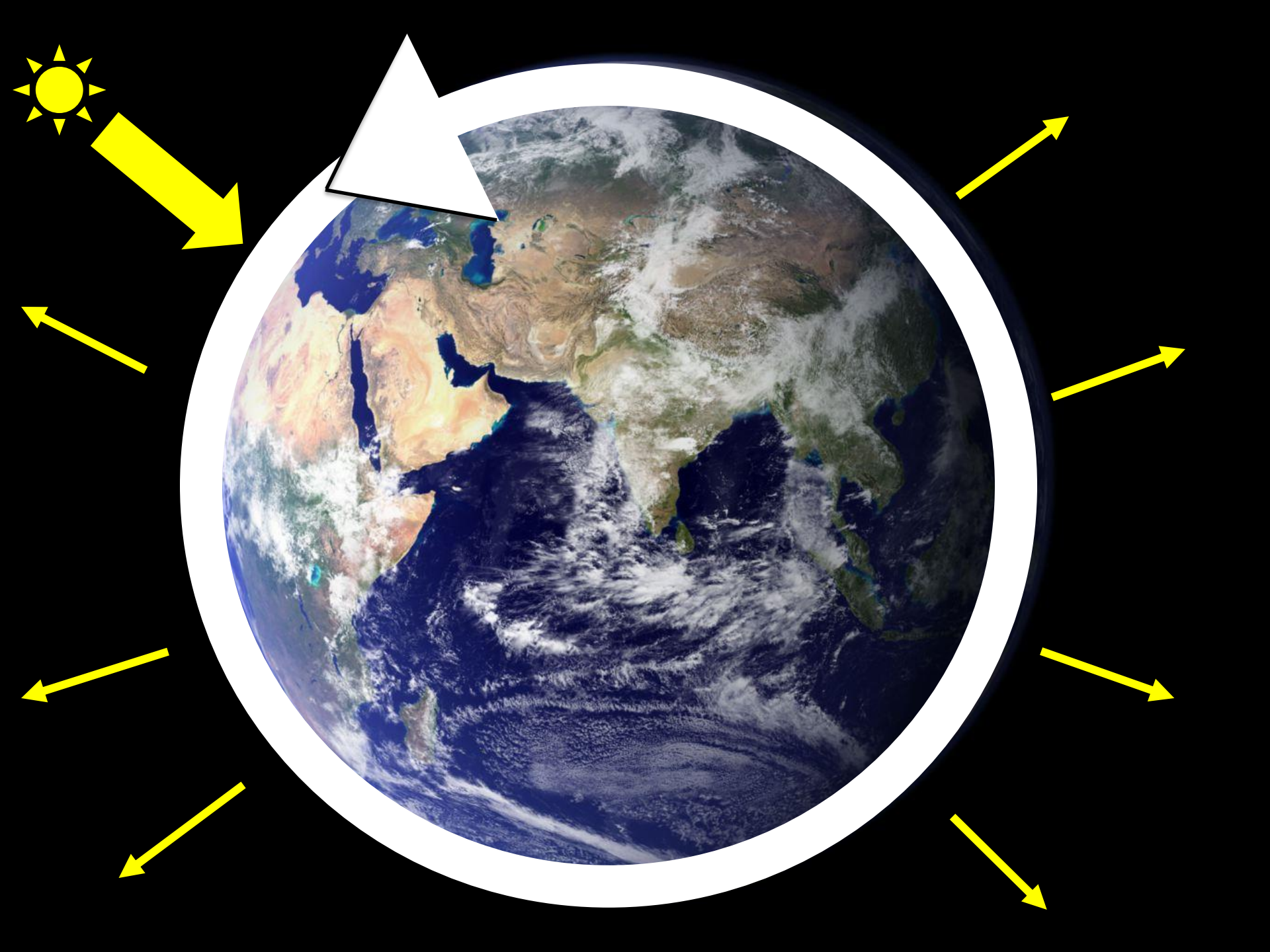
## Steps towards sustainability

- Think long term
- Understand systems
- Know limits
- Protect nature
- Change commerce
- Show equity
- Support entrepreneurship

## System thinker

- Looks for the big picture
- Looks for cycles, causes and effects
- Sees how things within the system change with time
- Looks for new angles
- Investigates causes of short-term and long-term actions
- Finds unexpected connections







# Living Machine – John Todd - USA

- Developed to clean water
- Series of tanks that are linked within a greenhouse
- Anaerobic and aerobic tanks
- Tanks have plants
- Sometimes fish also...



# BedZED – community in London





# Permaculture – Permanent agriculture

- Originated in Australia in the 1970s
  - Bill Mollison – focused on the design element
  - David Holmgren – focused on the ethics

- Principles of permaculture

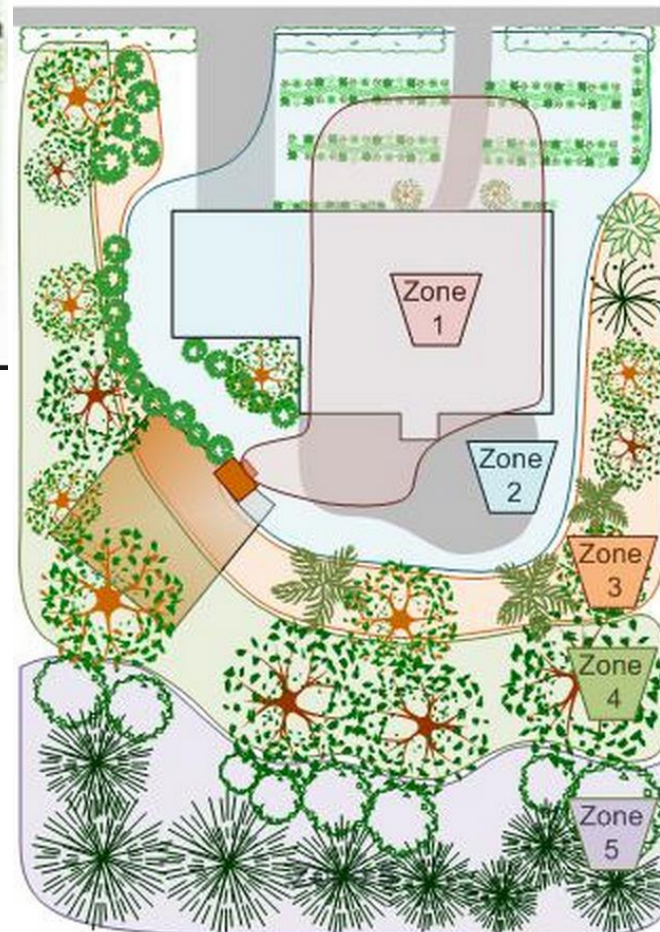
- [http://www.youtube.com/watch?v=IT\\_2VVXA7SY](http://www.youtube.com/watch?v=IT_2VVXA7SY)

# Zoning in Permaculture design



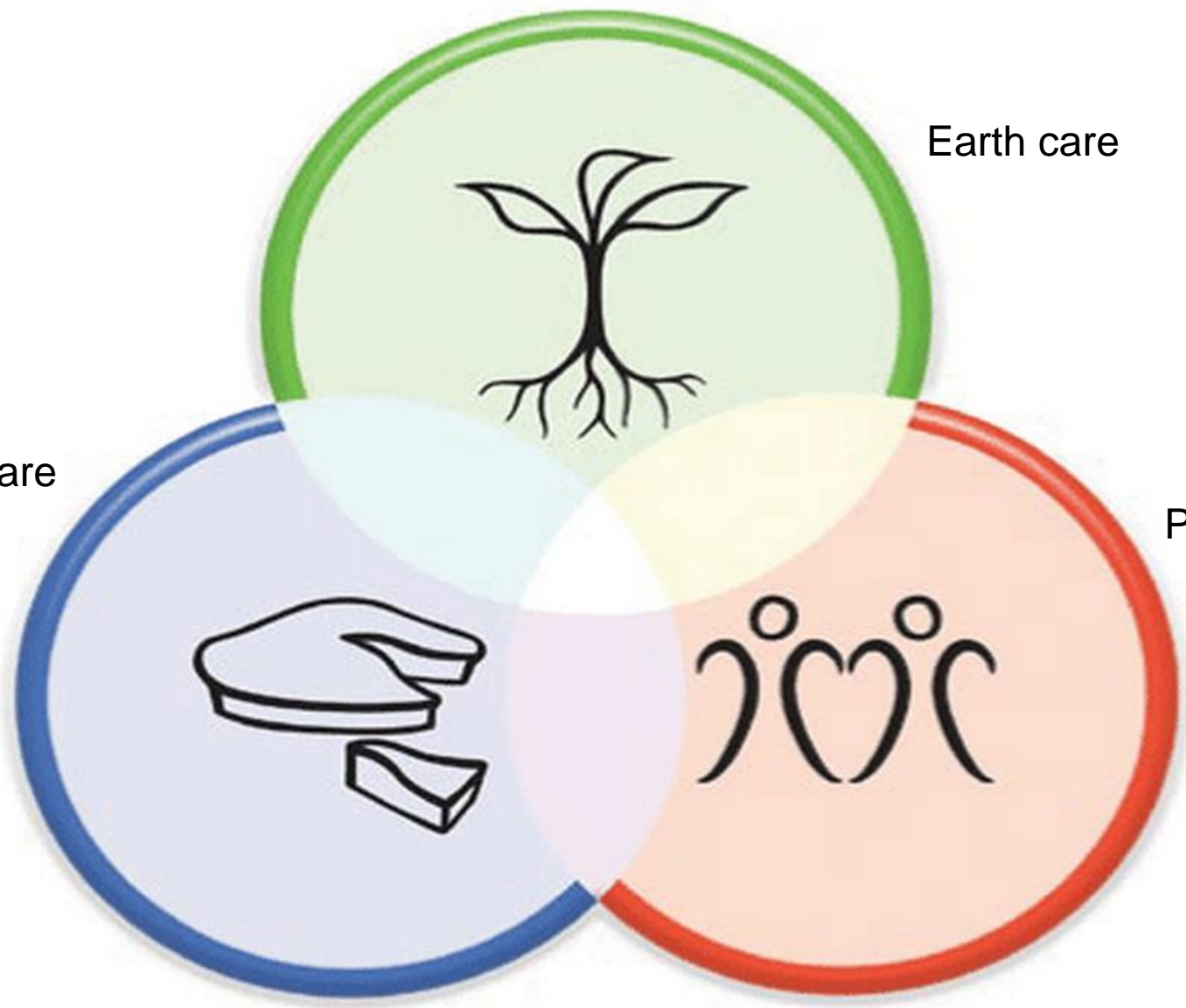
Farm

Garden



Zone 1	Every day: living areas, eggs and crops for dinner
Zone 2	Every other day: coop, house edge, berries, and garden
Zone 3	Twice a week: berries and chicken flock
Zone 4	Every week: fruit trees, chicken run
Zone 5	Every month: deer barrier & woodlot

Fair share



Earth care

People care

Central to permaculture are the three ethics

# Permaculture 12 Principles



## 1. Observe & interact

"Beauty is in the eye of the beholder"



## 2. Catch & store energy

"Make hay while the sun shines"



## 3. Obtain a yield

"You can't work on an empty stomach"



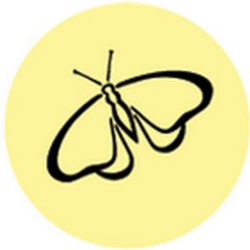
## 4. Apply self regulation & accept feedback

"The sins of the fathers are visited on the children of the seventh generation"



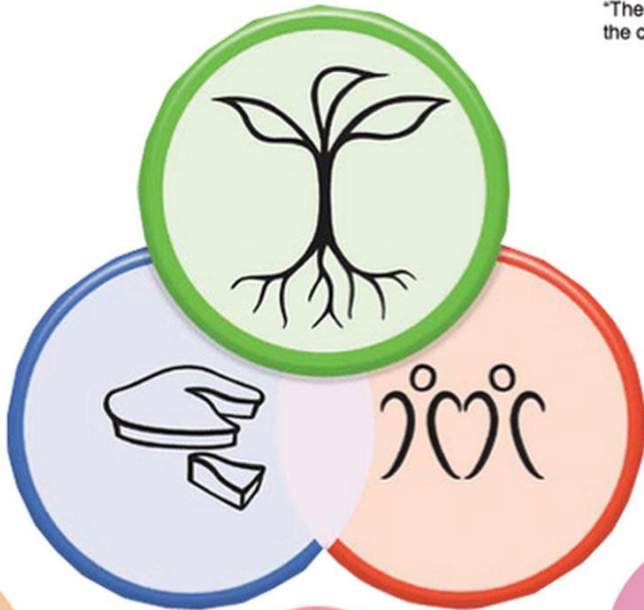
## 5. Use & value renewable resources & services

"Let nature take its course"



## 12. Creatively use & respond to change

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



## 6. Produce no waste

"A stitch in time saves nine"  
"Waste not, Want not"



## 11. Use edges & value the marginal

"Don't think you are on the right track just because it's a well-beaten path"



## 10. Use & value diversity

"Don't put all your eggs in one basket"



## 9. Use small & slow solutions

"The bigger they are, the harder they fall"  
"Slow and steady wins the race"



## 8. Integrate rather than segregate

"Many hands make light work"



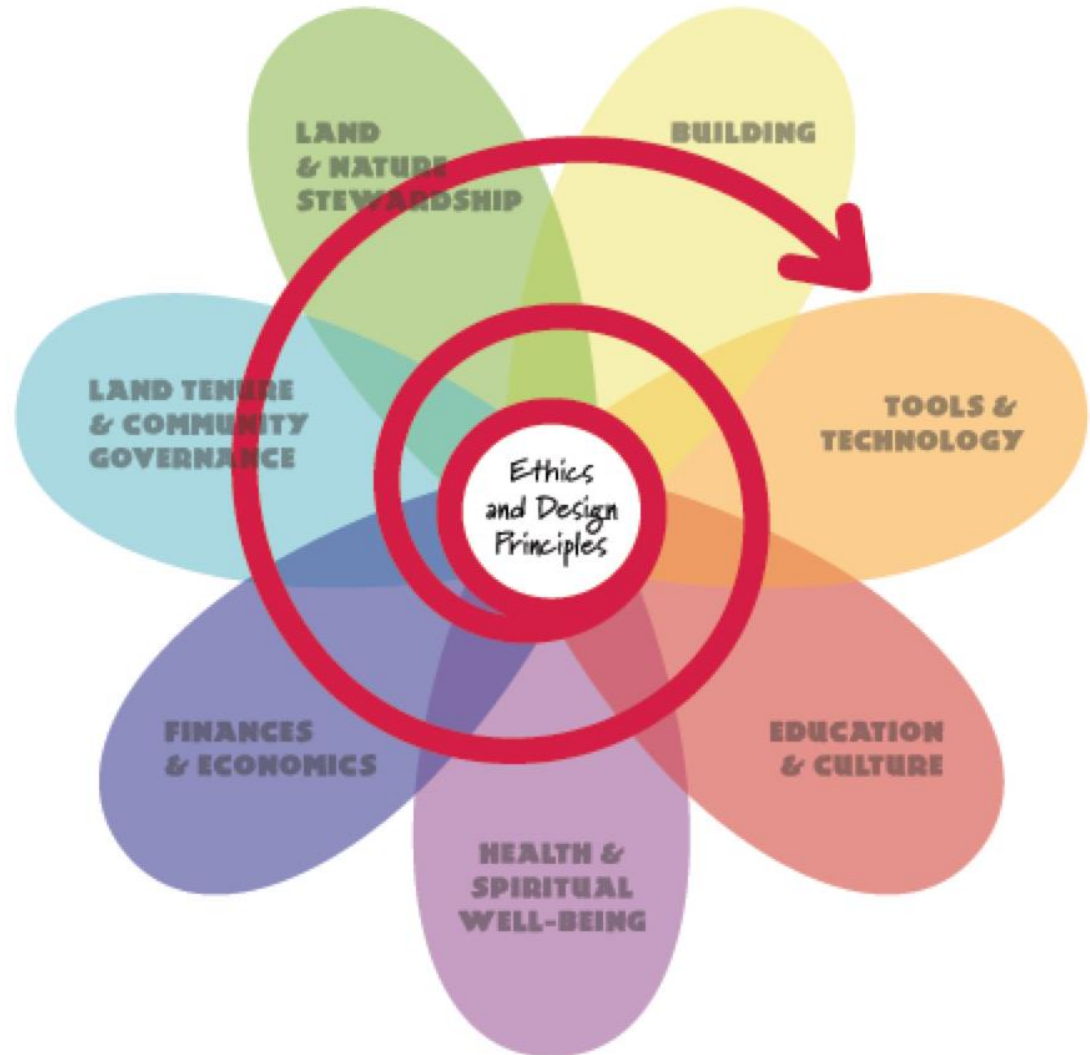
## 7. Design from patterns to details

"Can't see the forest for the trees"



Permaculture  
flower

Permaculture  
petals







# Garden design



University of Massachusetts, Amherst



# Were are these approaches used?

## Living machines

- Buildings
- Communities
- Breweries
  
- Problem
  - Patented technology

## Permaculture

- Ecovillages
- Transition Towns
- Individual citizen
- Farmers
  
- Open source
  - Permaculture Design Courses



# Conclusions

- Learning from nature is a key to the future
- Aquaponics is one step in the right direction
- Good luck with all your efforts!

Thank you for listening!