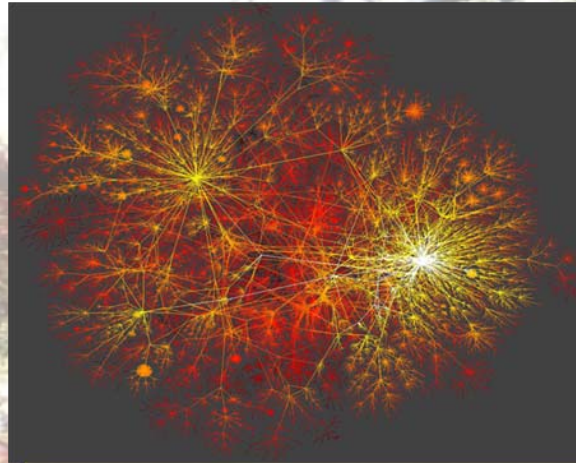
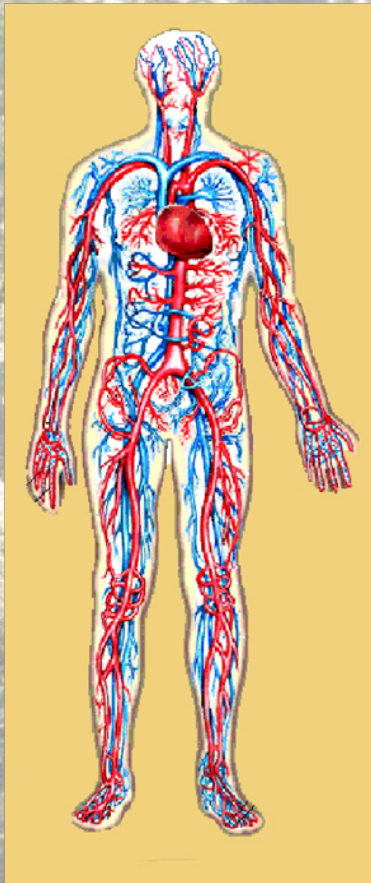




- **Natural Systems only work as wholes**
 - Technology & Economic impacts are incurred together.
 - Technology Footprint + Economic delivery system footprint
- **Macro & Micro Rebound Effects**
 - Business Development - Start-up, Maturation, Break-down
 - Economic - Feedbacks, Dependencies, Opportunity costs
 - Environment - Resource Discovery, Development, Depletion
- **Analytical Methods**
 - Whole system measure – set boundaries and find parts
 - Combining measures with different units
- **The Philosophical Problem – what we can't categorize**
 - Nature doesn't work with weighted categories, but builds networks of complementary parts that act as a whole.

- Every system counts on all its parts & is built by them



- Every part counts on ALL its systems, the lathe on the operator & the business, the business on the town and community it's finance, culture and networks of supporting industries

•H.T. Odum Model

Listing Inputs to an equation

Numerical Variables

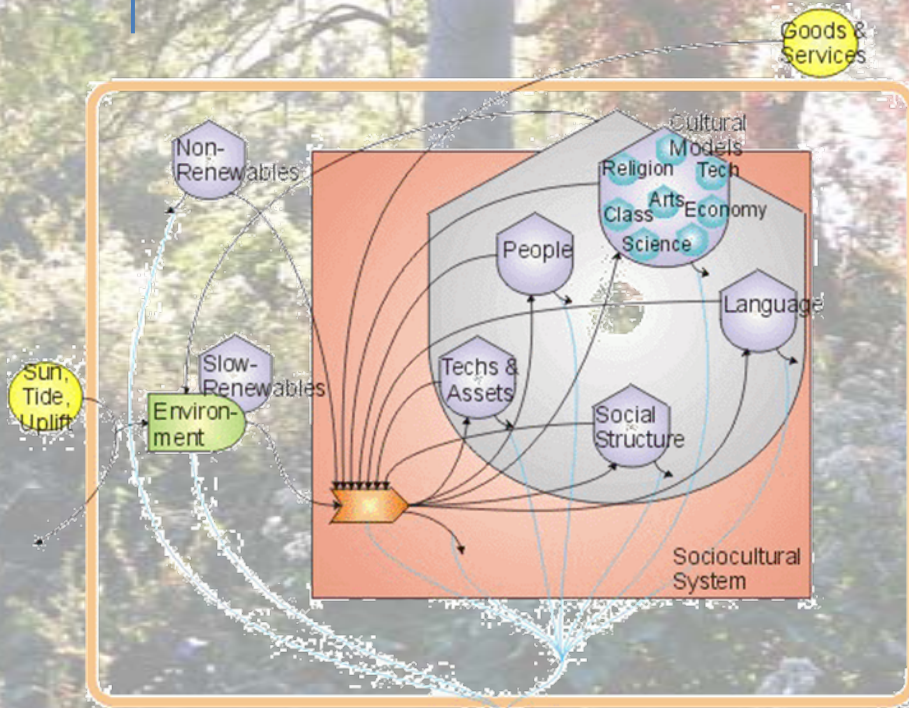
Defined Relations

•Whole System Diagram

Pointing to Individual Wholes

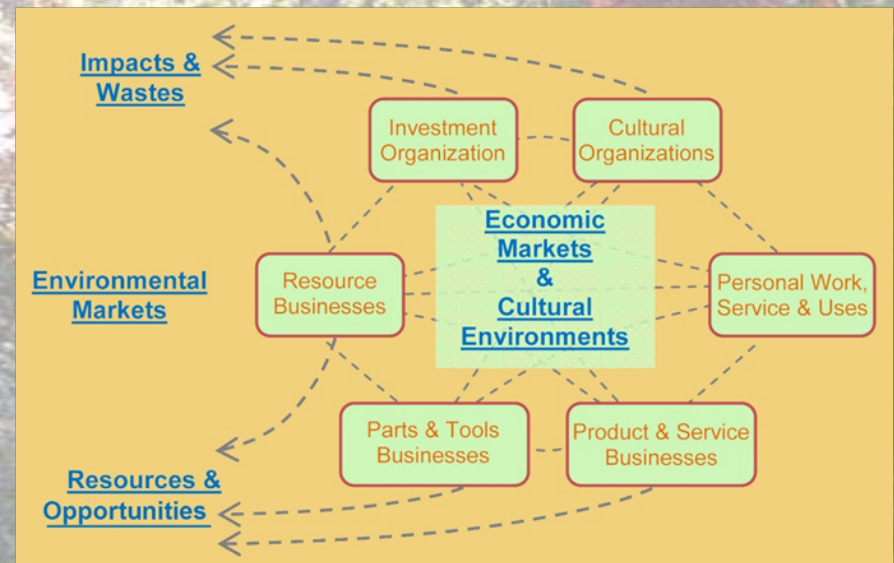
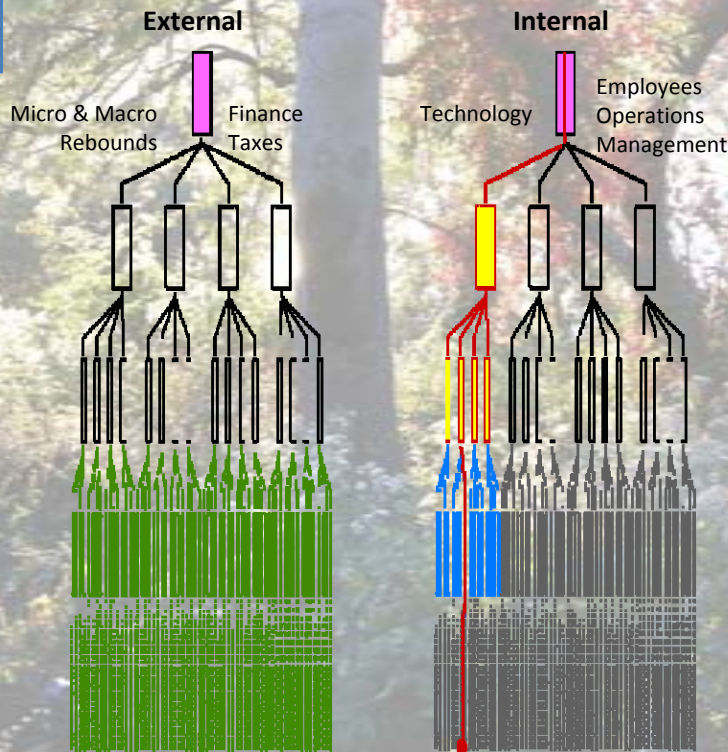
Collect-Transform-Distribute

Physical Processes



- Technology Footprint
- Economic Footprint
- Micro-Economic Rebound Effects
- Macro-Economic Rebound Effects

- Business Service Network
- Labor Resources
- Cultural Resources
- Financial Resources

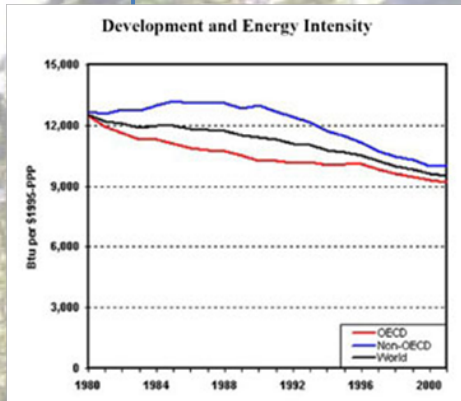


What they have in common also sets the boundary of their impacts, their value in \$ as a share of the system's total

Measure from the world as a whole

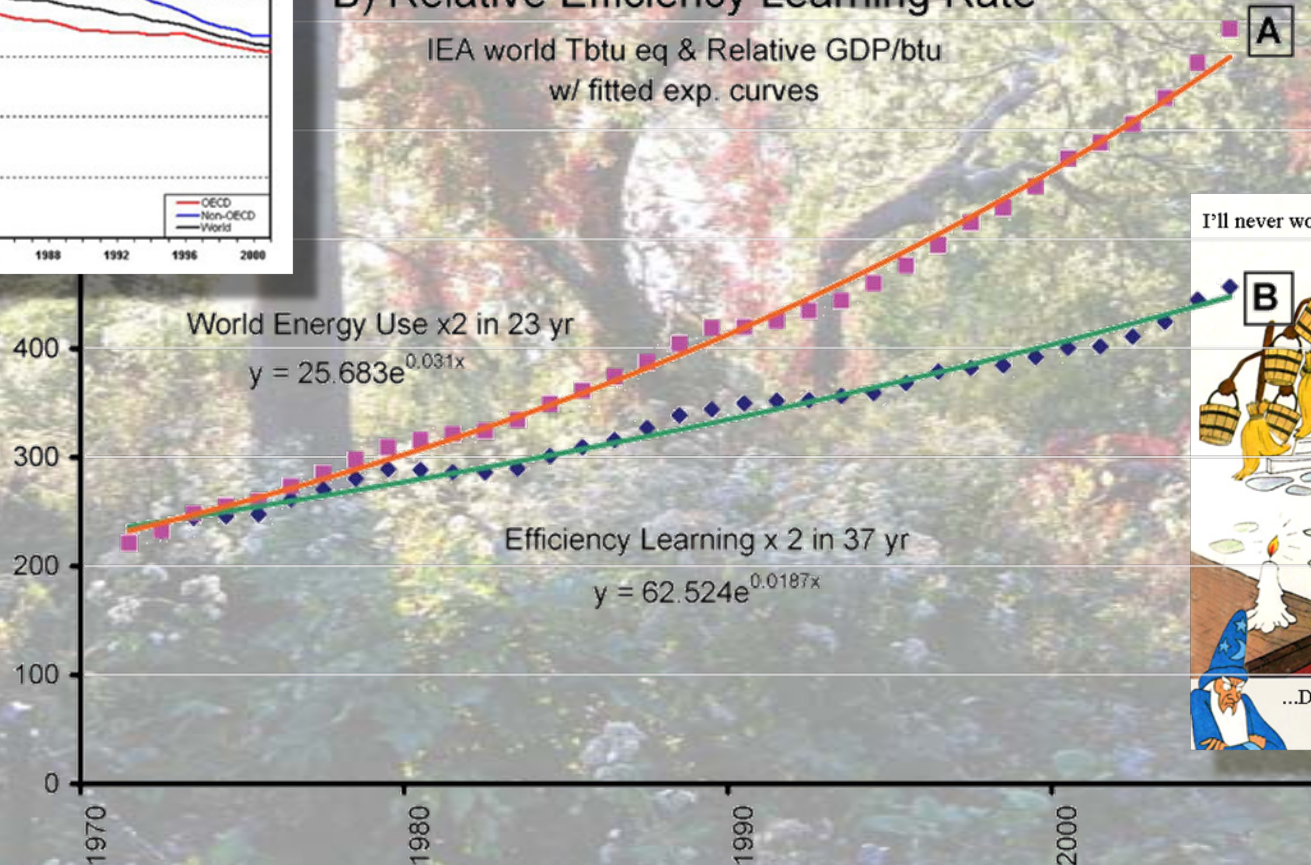
• Why efficiency improvement inevitably grows economic impacts

• Why “average” growing impact is a good estimate to start with



A) Energy Use v.
B) Relative Efficiency Learning Rate

IEA world Tbtu eq & Relative GDP/btu
w/ fitted exp. curves



Whole system accounting

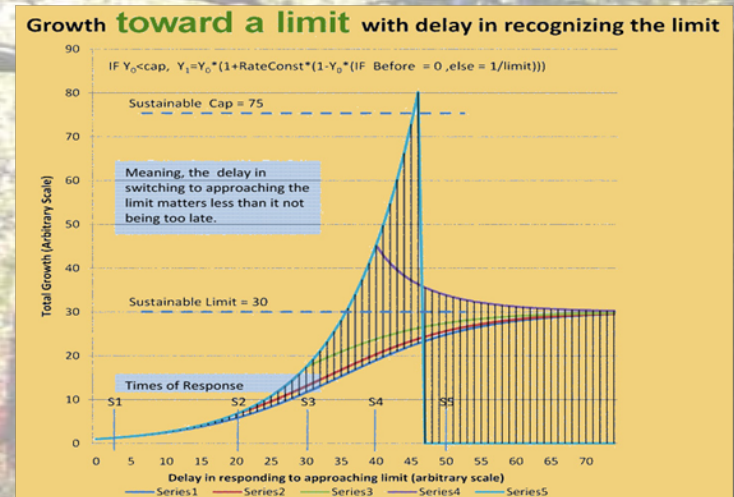
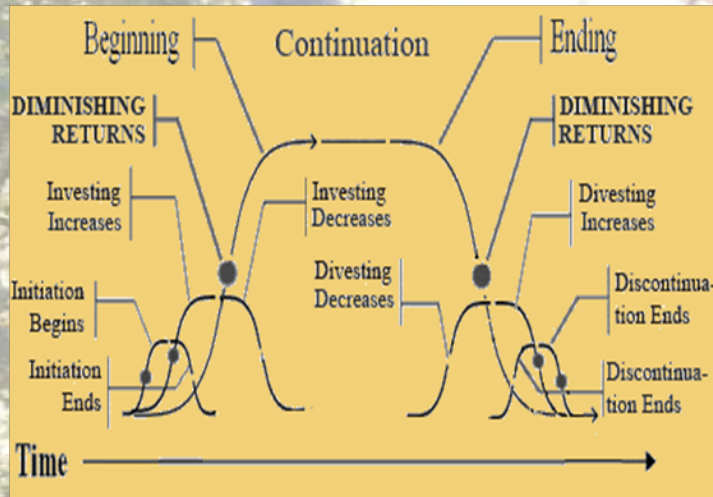
Direct impacts – how the product uses its environment
both for deterministic & opportunistic causes

- Add estimated average Economic Footprint = $\sim 6000\text{btu}/\$$ (2008\$)
- + Technological footprint within two degrees of separation
(two steps of spending on 1000 things = 1 million degrees of distribution)
- + Unique impacts, – Unique compensations = “first pass total”
- Combining “apples & oranges”, measures with dissimilar units

Time Impacts – how the business changes its environment

- Business development stages beginning & ending

- Resource development maturation or exhaustion

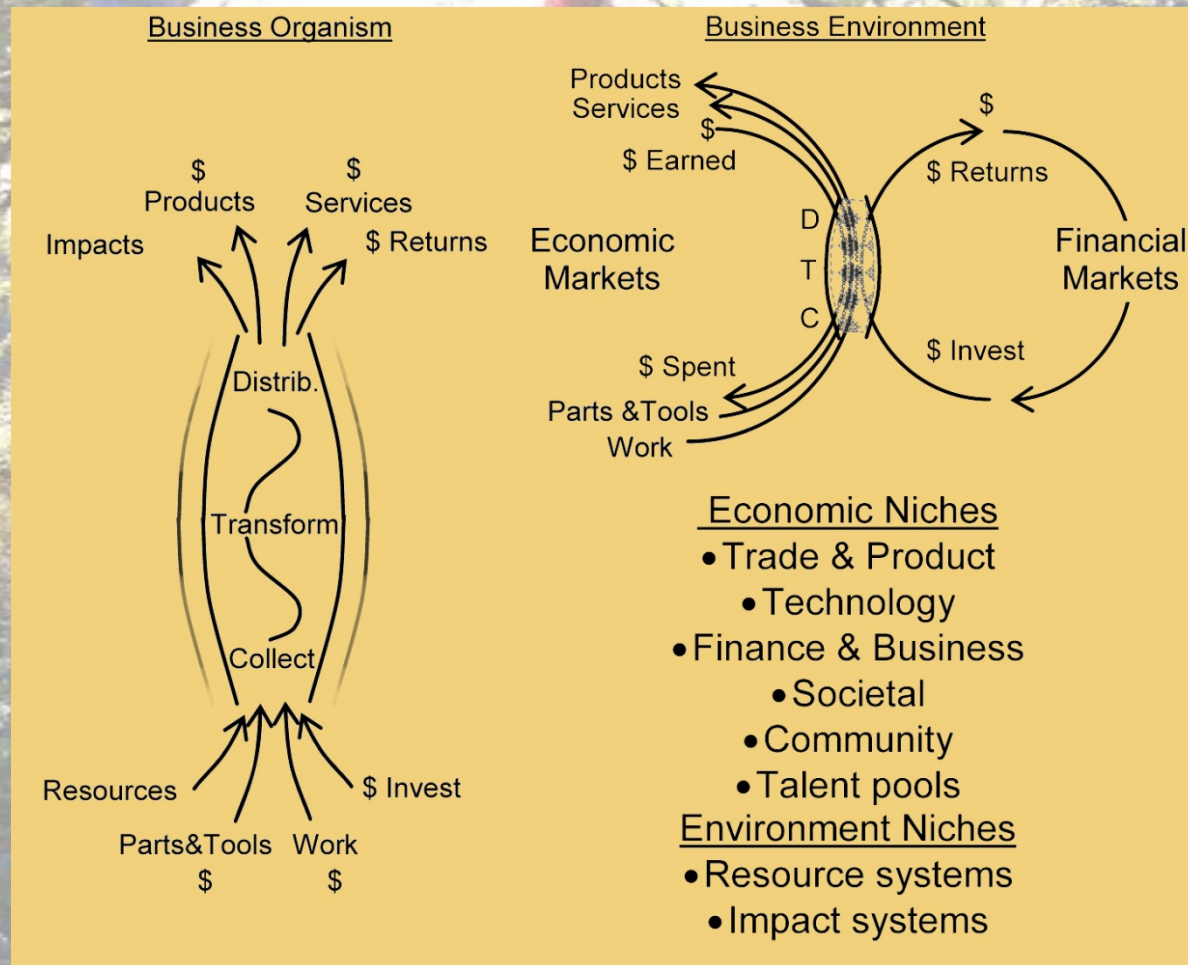


- Costs of beginning & ending
 - Development impacts share
 - Impacts of how profits used (+/-)
 - Dismantling & Restoration share
- Resource impacts
 - Sustainable development (+)
 - Depletion opportunity cost (-)

- Virtuous rebound effects
 - Sustainable circles, prompt response
 - Self-limitation & education
 - Maturation & diversity
- Vicious rebound effects
 - Unsustainable dependencies
 - Slow response to limits

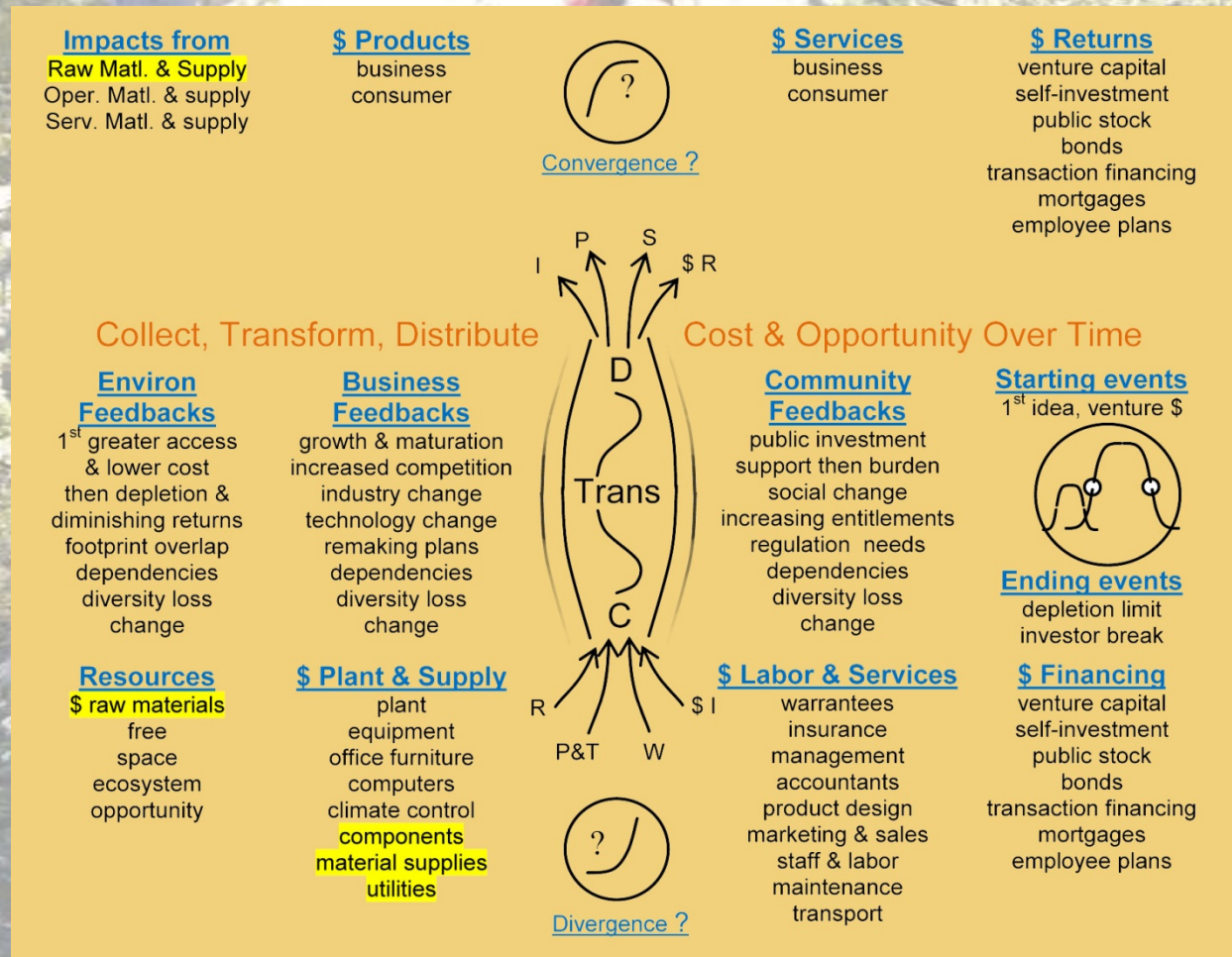
- Individual Whole System
- A product's share of whole

- Economic Niches & Finance
- Environmental Niches



Outline list of categories

- Technology system
- Economic delivery system



The Philosophical Problem

- Nature doesn't create impact systems using weighted categories, but as wholes built around complementary parts.
- Nature uses "life", storms of connections that act as a whole, building on complementary opposites somewhat beyond categorization.
- Technology & Econ impacts incurred with the same choices.
- That nature doesn't connect parts the way we think is why we need to watch systems behave as a whole.

TEA

