Ecological concepts applied to industrial ecology

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Hot Topics in Ecology

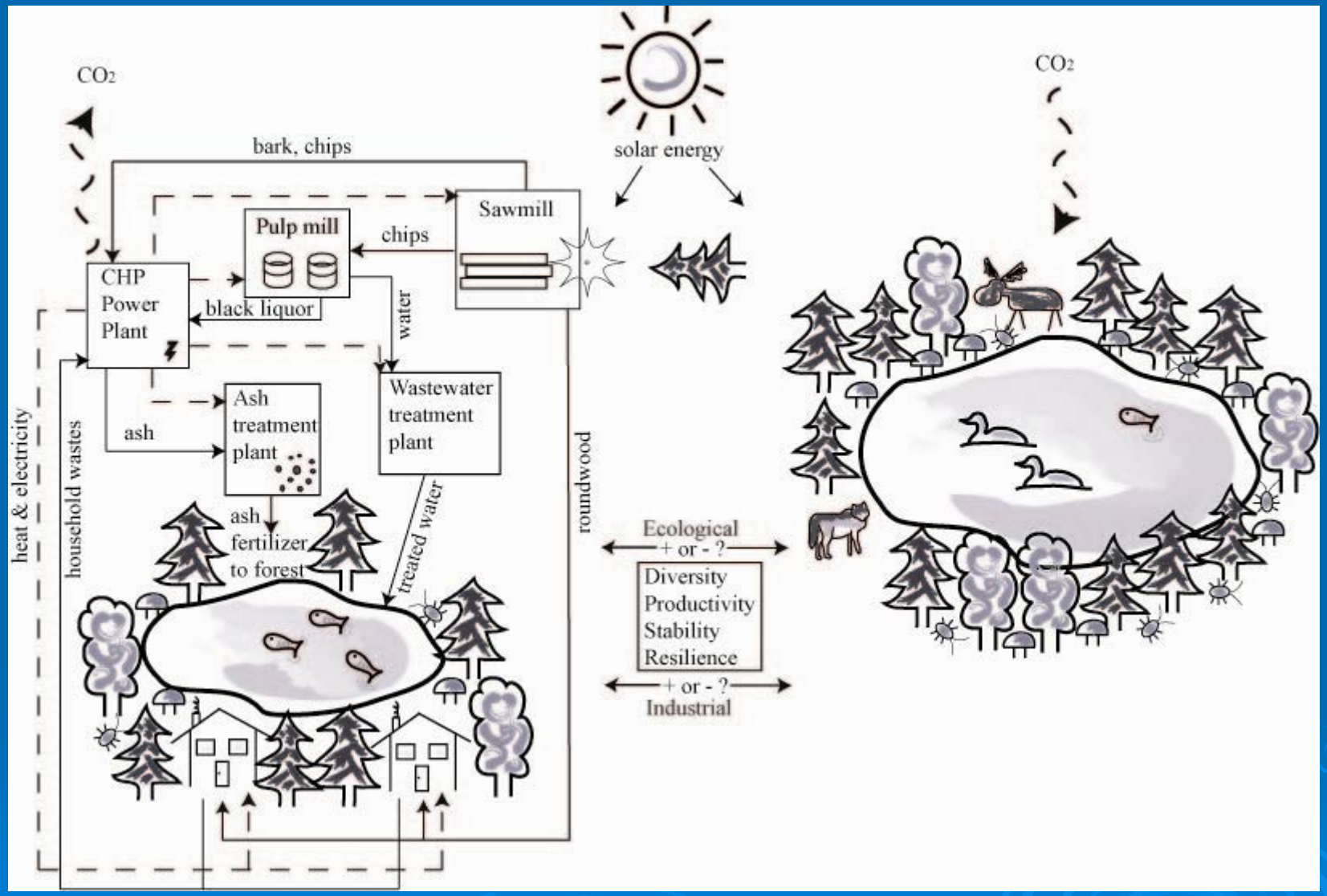
- Diversity / Productivity / Stability (Resilience) relationships
- Niche construction
- Self-organization
- Dynamic regimes, catastrophes (as related to stability/resilience)

Diversity, Productivity, Stability

- Three-way relationship is generally positive
  - Diversity → more species, more specialized species
  - Specialization allows for limited resources to be used more efficiently
  - Redundancy allows for greater stability
- However, there are exceptions and limitations
  - Fertilizer can increase productivity at the expense of diversity and stability
  - Low-diversity ecosystems can naturally be very stable and productive

… as applied to industries

- Diversity: analogous agents
  - Firm = species
  - Industry = guild
  - System of industries = community
- Productivity
  - Ecological → energy and nutrients converted to biomass
  - Industrial → several potential measures
- Stability
  - Ability to withstand internal and external disturbances
  - Ecological → fires, floods, pest outbreaks (external); species extinction, population dynamics (internal)
  - Industrial → recessions, resource/input shortage (external); labor strike (internal)


CO2
bark, chips
solar energy
Sawmill
Pulp mill
chips
CHP
Power
Plant
black liquor
water
Wastewater
treatment
plant
Ash
treatment
plant
ash
ash
fertilizer
to forest
treated water
heat & electricity
household wastes
roundwood
Ecological
+ or - ?
Diversity
Productivity
Stability
Resilience
+ or - ?
Industrial
CO2

Niche Construction

- Organisms modify their environment to increase their own success, often at the expense of competitors
  - water/hydrology
  - nutrients
  - self-produced toxins (”allelopathic”)
- ”ecosystem engineers” – those species which modify their environment at a scale much larger and longer than similar species (e.g., beaver vs. badger)
  - other species are often adapted to these modified conditions

… as applied to industries

- Modifying local environment to improve success
  - at the expense of competitors
- ”Industrial system engineer”
  - firms which modify environment (ecological, socio-economic) at fairly large scales
  - and the firms specialized to co-locate with them

Self-organization

- Pattern at the global level emerges solely from numerous interactions among the lower-level components
- **Local** rules and information govern interactions among the components are executed using only local information
  - No rules or information about pattern at global scale

Flocking behavior

- Three (local) rules:
- Separation - avoid crowding neighbors
- Cohesion – avoid getting too far away from neighbors
- Alignment - move towards average heading of neighbors

… as applied to industries

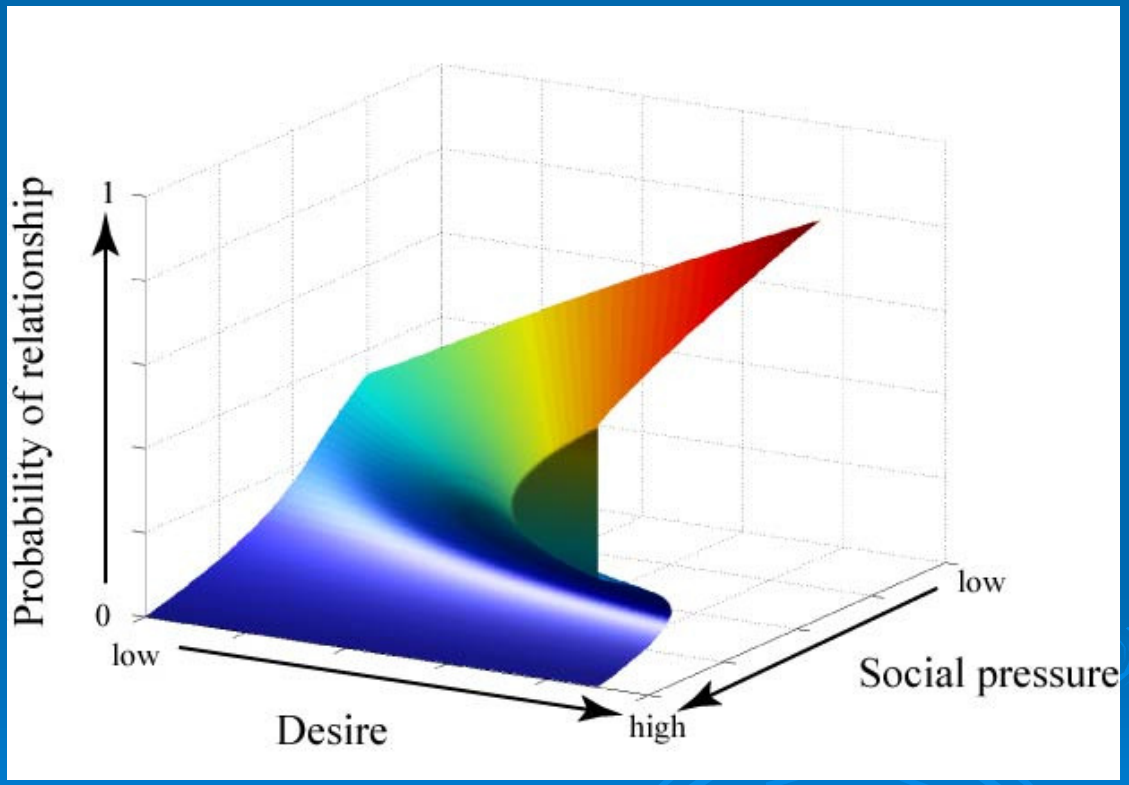
- Local drivers, global patterns
  - Local regulations, tax rate, socioeconomic characteristics
  - Minimum distance between competing firms, industries; patterns at larger scales?
- Self-organized eco-industrial parks
  - Top-down planning for parks less effective than expected

Dynamic Regimes

- Based on René Thom's mathematical work in "Catastrophe Theory"
- His work was initially criticized, but he did have his supporters
- Dynamic regimes = multiple attractors = alternative stable states = multiple equilibria

Regimes and “catastrophic” shifts between them

- Feedback loops which maintain regimes
- Disturbances
- Catastrophes
- Hysteresis



… as applied to industries

- Resilient regimes: practices which can produce the same level and quality of output/product despite disturbances
  - Which negative feedbacks lead to firm or industry resilience?
  - Which positive feedbacks lead to collapse?
- Catastrophic shifts: do firms & industries slowly decline, or sudden collapses common?

Case Studies

- Firms, industries, industrial parks which have displayed some of these patterns or behaviors
- First: conceptual foundation
- Second: gather case studies and data

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