"RESEARCH OPPORTUNITIES IN SUSTAINABILITY SCIENCE:"

Collaborative Large-Scale Engineering Assessment Network for Environmental Research (CLEANER),

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What is the oldest piece of environmental legislation?

- The Public Trust Doctrine- Institutes of Roman Emperor Justinian – 530 A.D.
- The Public Trust Doctrine states that all the roaming animals and natural cycles of the world belong to the commonwealth of society.
- Any use of the natural cycles by business or human enterprises is a subsidy from the commonwealth of society. Therefore, we all must benefit and be equally engaged in the decision-making process.
- Steps in that direction - Chicago Board of Trade – Acid Deposition and new Climate Exchange Program (28 of the large corporations that contribute 2% of all anthropogenic CO2 will begin trading in early 2003 - Oct 17th 2002 | CHICAGO from The Economist print edition)
Outline - Research Opportunities

- Large Scale Opportunities
- Opportunities in Discipline Integration (Social, Environmental, Economic and Industrial Ecology)
- Social Dimension and Environmental Education
- Sustainability Metrics
- Conclusions – Engineering the Quality of Life
Large Scale Sustainability Issues

What is the carrying capacity of the natural cycles in a region, nation or Globe to accept pollution and render it harmless and how much activity is sustainable? It is important to emphasize that we need to include ALL HUMAN AND INDUSTRIAL ACTIVITY and we need to tie this to personal and political decisions.

\[
\begin{bmatrix}
\text{More Pollution} \\
\text{Too Many Widgets}
\end{bmatrix} = \begin{bmatrix}
\text{Less Pollution} \\
\text{Widget}
\end{bmatrix}
\]

Decisions are being made in the absence of knowledge (by the public and designers). We need to foster life long learning about sustainable decisions.
What are the causal relationships between activities in the human, natural and industrial environments and its impact on a Region, Nation, or Globe?

- What early decisions generated the pollutants in the first place and what is their ultimate impact? (e.g., from a mechanistic point of view that includes social [personal and political choices], economic, and production processes)

- Is pollution is a necessary by-product of commerce and we are at the end of the pipe estimating its impact? Or does an uninformed society makes decisions that cause it? (Our role must education and determine the root cause.)

- Consider the personal and political choices that produce hexachlorobenzene (PBT)
Production of Some Pollutants Are Not Intended- HCB sources

- Chemicals and Allied Products Manufacturing: 2%
- MON - Continuous Processes: 5%
- Chemical Manufacturing: Alkalies and Chlorine: 9%
- Hydrochloric Acid Production: 2%
- Chlorinated Solvents Production: 23%
- Pesticide Manufacture: 18%
- Cyclic Crude and Intermediate Production: 17%
- Tire Manufacturing: 18%
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Significant progress has been made in defining new research fields to improve environmental decision making:

- **Industrial ecology**, the study of resource use and material and energy flows through the economy, including associated pollutant emissions and economic value.

- **Impact Assessment**, the study of geo- and biochemical processes that determine the fate and transport of materials through the environment and their impact on the natural and human environment.

- **Economic Impact**, the study of economy wide impact of choices.

- **Social Processes (i.e., human perception and behavior, equity and justice)**, the study of the cognitive, social, and economic factors that affect environmental decision making.
Metadiscipline and Model Development

True Value (Elkington, 1998): Economy, Environment, Social Considerations (culture, equity, quality of life)

Integrated Scientific/Social Bases for Economic/Environmental Decision-Making
Degrees of freedom in terms of choices decreases as one moves closer to product manufacture.

Important to have an informed citizenry to motivate (both in the market and in the voting booth) the selection and design of greener products.

Figure 3. Pollution Prevention (P2) Opportunities as a Function of Product Implementation
Example for Great Lakes Region:
EIO-LCA Model of Automobile Production

National results for “cradle to gate”
(per $1 million of automobile production)

- **Overall economic activity:** $2.8 million
- **Resource use**
  - Electricity: 0.62 Mkw-hr
  - Fuels: 390 metric tons
  - Ores: 226 metric tons
  - Water: 6.3 million gallons
- **Environmental releases (metric tons)**
  - Criteria Pollutants (SO$_2$, Lead, etc.): 12.1
  - Hazardous Waste: 47.4
  - Toxics: 2.0

Addressing Uncertainty and Research Prioritization

Sensitivity Analysis: Where should effort be placed to reduce uncertainty?
Addressing Uncertainty and Research Prioritization

- Intergovernmental Panel on Climate Change (IPCC)
  - virtually certain (99% or more)
  - very likely (90 to 99%),
  - likely (66 to 90%),
  - medium likelihood (33 to 66%)
  - unlikely (10 to 33%)
  - very unlikely (1 to 10%)
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Importance of the Social Dimension

“What lies behind us and what lies before us are tiny matters compared to what lies within us.”

Ralph Waldo Emerson

Human needs and desires drive political, social, and economic processes. Engineers provide technological solutions. It is important for the engineering community to educate society about their choices and allow them to make informed decisions regarding political choices and commerce.

2002 Nobel Prize in economics - DANIEL KAHNEMAN for having integrated insights from psychological research into economic science, especially concerning human judgment and decision-making under uncertainty.
Developing Environmentally Committed Citizens, Engineers, Scientists, Corporations & Community Leaders for the 21st Century (K to Gray Education Important)
Approach

Environmental Appreciation ›

Environmental Stewardship ›

Understanding ›

Commitment ›

Corporate and Personal ACTION
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Sustainability Principles: What gets measured, gets managed, and what gets managed can be improved

**Economic Sustainability**
- Productivity,
- Technological Growth,
- Profit and Employment

**Environmental Sustainability**
- Human health,
- Ecosystem health,
- Biodiversity,
- Natural resources: protection and restoration

**Societal Sustainability**
- Informed Citizenry,
- Stakeholder Participation,
- Social Justice and Equity,
- Consumer Choices, Useful Productive Lives

State of the Lakes Ecosystem Conferences - SOLEC
Other Metrics Examined

- Global Warming
- Acid Deposition
- Ozone Depletion
- Smog Formation
- Fish Toxicity
- Green Algae
- Human Carcinogenic Potential
- Difficult to compare - multicriteria decision-making will be needed.
Some Important Attributes in a Sustainable Society

What are the shared and desired characteristics/attributes of the human, natural, and industrial environments? In other words, what attributes of the natural world do we as a society wish to preserve for plants, animals and future generations.
Conclusions – Engineering the Quality of Life

- Sustainability Science is a Metadiscipline requiring the integration of economics, social processes, impact assessment and industrial ecology (more?)

- Sustainable solutions include:
  - translating and understanding societal needs into engineering solutions such as infrastructures, products, practices, and processes
  - explaining to society the long term consequences of these engineering solutions
  - making sure that no one or group is left behind such that everyone has and equal opportunity to lead useful and productive lives regardless of their ethnicity or national background or beliefs. (especially important for developing Nations)

- Numerous Challenges Ahead