

Sustainability Science: Core questions, Grand challenges

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Sustainability Science?

- An emerging field of ‘use-inspired’ research and innovation that, like ‘health science’ or ‘agricultural science’ before it ...
- Is *defined* by the practical problems it addresses, in this case problems of sustainable development
- *Focuses* on (strongly) interacting human and environmental systems.
- *Discovers, draws from and integrates* a variety of practical knowledge plus findings from natural, social, engineering, and medical sciences.

Which problems?

Origins of “Sustainability” thinking

- Conservationist thinking
 - Sustainable yields, “exotic” wildlife (1800s)
 - IUCN “World Conservation Strategy” (1980)
- Environmental science thinking
 - Vernadsky’s “biosphere and noosphere” (1940s)
 - NASA’s “Mission to Planet Earth” (1980s)
- Political (“radical”) thinking
 - Ghandi’s “too much wealth, too much poverty” (1972)
 - Latin America Commission “Our Own Agenda” (1990)
 - not “how to manage”, but “who decides”...

<p>WHAT IS TO BE SUSTAINED:</p>	<p>FOR HOW LONG?</p> <p>25 years</p> <p>"Now and in the future"</p> <p>Forever</p>	<p>WHAT IS TO BE DEVELOPED:</p>
<p>NATURE</p> <p>Earth Biodiversity Ecosystems</p>		<p>PEOPLE</p> <p>Child Survival Life Expectancy Education Equity Equal Opportunity</p>
<p>LIFE SUPPORT</p> <p>Ecosystem Services Resources Environment</p>	<p>LINKED BY</p> <p><i>Only</i> <i>Mostly</i> <i>But</i> <i>And</i> <i>Or</i></p>	<p>ECONOMY</p> <p>Wealth Productive Sectors Consumption</p>
<p>COMMUNITY</p> <p>Cultures Groups Places</p>		<p>SOCIETY</p> <p>Institutions Social Capital States Regions</p>

Conceptualizing Sustainable Development

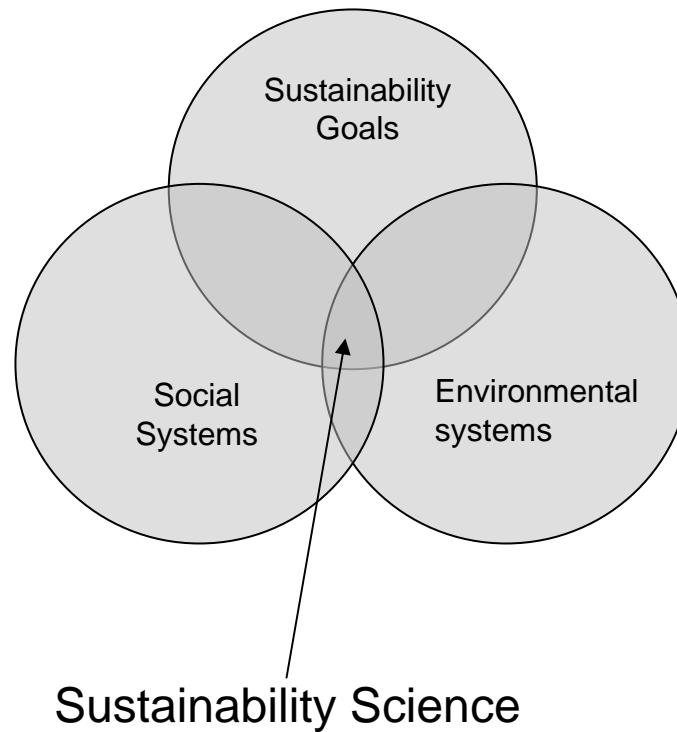
Goals for Sustainable Development

- Global consensus on international norms...
 - Meeting human needs
 - feed, house, nurture, educate, employ...
 - Preserving life support systems
 - water, air, oceans, ecosystems...
 - Reducing hunger and poverty
 - with special attention to the most vulnerable.
- Local reinvention for effective action
 - WSSD on the limits of intl. action, the need for place-based, solution-oriented partnerships...

The science focus: Interdependence among the goals of sustainable development

industry							
urban							
agriculture							
energy							
ecosystems							
land use change							
	air quality	water quality	resource degrad- ation	climate change	ozone depletion	species loss	resource limit- ations

The domain of sustainability science



Sustainability Science?

- Is *defined* by the practical problems it addresses, in this case problems of sustainable development
- *Focuses* on (strongly) interacting human and environmental systems.
- *Discovers, draws from and integrates* a variety of practical knowledge plus findings from natural, social, engineering, and medical sciences to produce...
- An emerging field of **‘use-inspired’ research and innovation** like ‘health science’ or ‘agricultural science’ before it, is neither ‘basic’ nor ‘applied’ ...

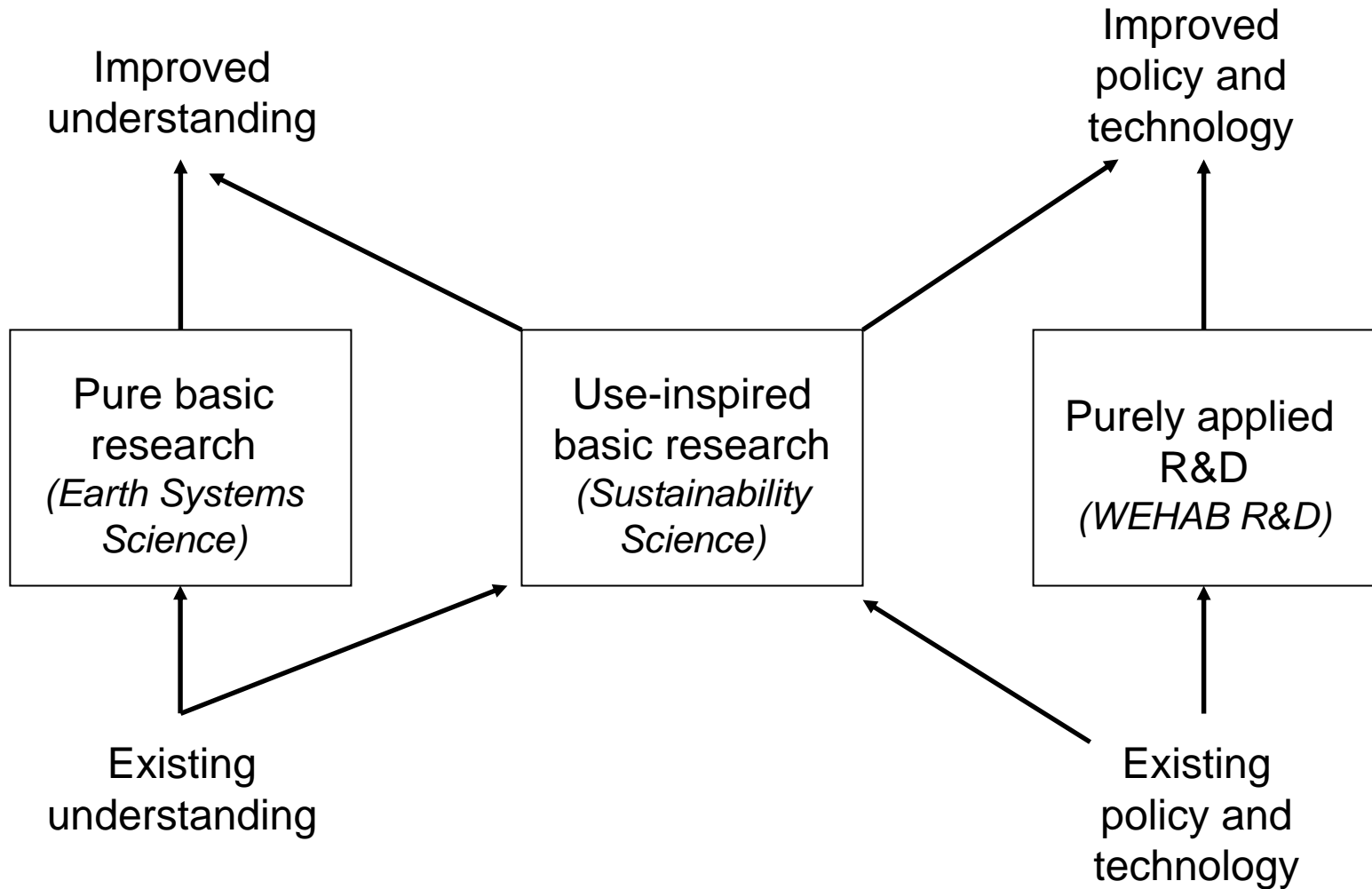
Quadrant Model of Scientific Research

		Considerations of use?	
		No	Yes
Quest for fundamental understanding ?	No	“Soaking and poking”	Pure applied research (Edison)
	Yes	Pure basic research (Bohr)	<i>Use-inspired basic research (Pasteur)</i>

(redrawn from Stokes, 1997)

“Core (scientific) Questions”

“Grand (problem-solving) Challenges”



Transcendent issues

- H-E systems as complex, adaptive systems
- Place-based integration
- Cross-scale challenges
- Epistemological dilemmas of method and quality control for integrating scientific and practical knowledge

Core Questions

- Driving forces
 - The origins of “transitions” beyond the demographic
 - Production-consumption relationships
- Impacts / consequences
 - Nature of “limits,” carrying capacities, tipping points
 - Vulnerability and resilience of couple H-E systems to multiple stresses
- Guidance
 - Incentives for environment-conserving innovation / development;
 - PES-like ventures
 - Institutions for governing H-E systems (“Beyond panaceas”)
 - Valuing outcomes in H-E systems
 - Designing effective knowledge-action systems

'Grand challenges' defined ...

- Of the most important problems of sustainable development, those for which...
- Science and technology have the potential for making important contributions to practical solutions, but...
- That potential is not being realized due to barriers of one sort or another (e.g. inadequate theory, methods, data; insufficient training or other capacity; shortfalls in funding or other motivations for scientists and engineers).
- 'Grand Challenges' are to identify those problems and to remove the barriers that impede progress.

Grand challenge candidates (pre-AAAS)

- Accelerate trends in fertility reduction
- Reverse declining trends in agricultural production in Africa, sustain elsewhere
- Accelerate improvements in use of energy and materials;
- Accommodate 2-3x increase of today's urban population in sustainable manner;
- Restore degraded ecosystems, while conserving biodiversity elsewhere.

What research is being done today?

- Analysis of papers in the sustainability science domain published over the last decade shows
 - use-inspired core
 - multidisciplinary character
 - new institutions blooming... (AAAS)
 - dispersion of publishing/ presentation venues...

Disciplinary foundations

- Environmental sciences and studies ~30%
- Ecology ~15%
- Engineering ~10%
- Planning ~10%
- Water ~ 5%
- Economics ~ 5%
- Agriculture ~ 5%
- Energy ~ 5%
- Geography ~ 5%
- Urban studies ~ 5%

Where sustainability science is published

- Growth rate of >15%/year, with >150 excellent papers now each year
- No dominant journal...
 - Annals Assoc Amer Geogr. ~5%
 - Environmental Science and Technology ~4%
 - Ecological economics ~3%
 - Intl. j. sustainable development and world ecology ~3%
 - J. of cleaner production ~2%
 - Agricultural ecosystems and environment ~2%
 - Sustainable development ~2%
 - Water science and technology ~2%
 - Forest ecology and management ~2%
 - Energy policy ~1%
 - Climate policy ~1%
 - Geographical journal ~1%

Solutions to dispersion?

- (virtual) Forum on Science and Innovation for Sustainability
 - sustainabilityscience.org
- Annual research meeting / San Servolo (?)
- Publication venues
 - Reviews: Annual Review of Environment and Resources
 - Policy: Environment – Science and policy for sustainable development
 - Research:
 - Proceedings of the National Academies: Sustainability Science
 - Environment, Development and Sustainability
 - International Journal of Environment and Sustainable Development
 - Journal of Environment and Development
 - Sustainability Science
 - Sustainability: Science, Practice and Policy

Recent PNAS articles on Sustainability Science

- Armsworth, P. R., **G. C. Daily**, P. Kareiva and J. N. Sanchirico (2006). "Land market feedbacks can undermine biodiversity conservation."
- Auffhammer, M., **V. Ramanathan** and J. R. **Vincent** (2006). "Integrated model shows that atmospheric brown clouds and greenhouse gases have reduced rice harvests in India."
- Chapin, F. S., III, **R. L. Naylor**, et al. (2006). "Policy strategies to address sustainability of Alaskan boreal forests in response to a directionally changing climate."
- Eisenberg, J. N. S., W. Cevallos, K. Ponce, K. Levy, S. J. Bates, J. C. Scott, **J. Trostle** et al. (2006). "Environmental change and infectious disease: How new roads affect the transmission of diarrheal pathogens in rural Ecuador."
- Gordon, R. B., M. Bertram and T. E. **Graedel** (2006). "Metal stocks and sustainability."
- Hill, J., E. Nelson, **D. Tilman**, S. Polasky and D. Tiffany (2006). "Environmental, economic, and energetic costs and benefits of biodiesel and ethanol biofuels."
- **Kates**, R. W., et al. (2006). "Reconstruction of New Orleans after Hurricane Katrina."
- **Miles**, E. L., A. K. Snover, et al. (2006). "An approach to designing a national climate service."
- Morton, D. C., R. S. **DeFries**, Y. E. Shimabukuro, L. O. Anderson, E. Arai, F. del Bon Espirito-Santo, R. Freitas and J. Morissette (2006). "Cropland expansion changes deforestation dynamics in the southern Brazilian Amazon."
- **Nordhaus**, W. D. (2006). "Geography and macroeconomics: New data and new findings."
- **Ostrom**, E. and H. Nagendra (2006). "Insights on linking forests, trees, and people from the air, on the ground, and in the laboratory."
- Pimm, S., P. **Raven**, A. Peterson, C. H. Sekercioglu and P. R. **Ehrlich** (2006). "Human impacts on the rates of recent, present, and future bird extinctions."
- Tatem, A. J., S. I. Hay and D. J. Rogers (2006). "Global traffic and disease vector dispersal."