
# Opportunities for Computing Research and Education in a Sustainability Context

Panel on **The Present and Future of Sustainability R&D** at the

## First USENIX Workshop on Sustainable Information Technology

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# Questions to ask

## As educators

*What* should be sustained? What are the "*needs*" of future generations referenced in the Brundtland report? *Why*? Are the reasons compelling?

## As computing professionals

Is the *low hanging fruit* being implemented (e.g., distance meetings)? What are the factors influencing implementation decisions?

What are the *lifecycle* costs? What are aspirations? Lifecycle**s**$\rightarrow\infty$?

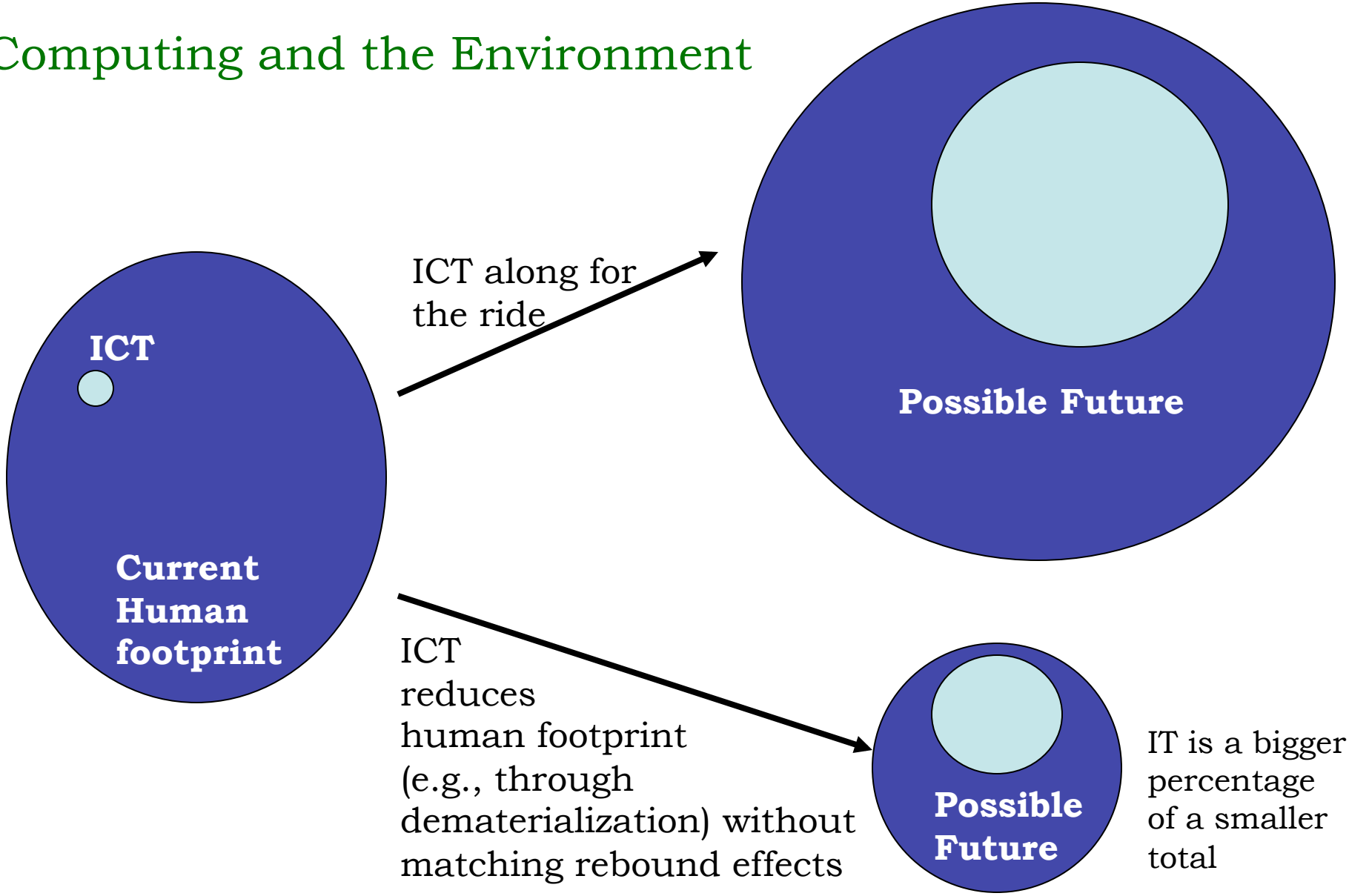
## As computer *scientists*

What is the (likely) *growth rate* (of adoption, of resource depletion, of energy demand, of improvement)? (across all societal/technical areas)

What is the *complexity class* (of growth rate, of change to growth rate)?

What *other communities* are prospective partners?

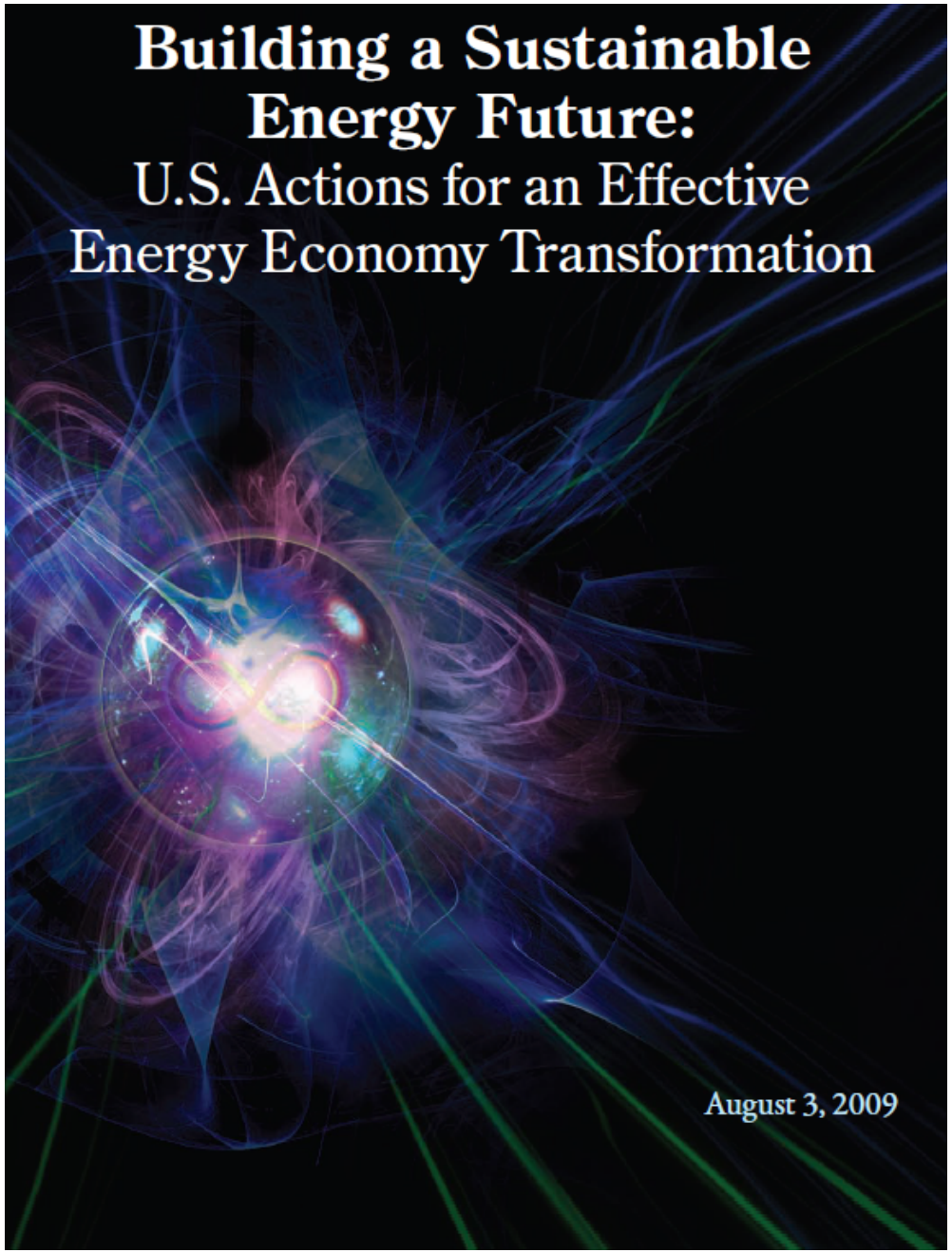
# Computing and the Environment




Don't (too) short shrift *direct* effects, because the 2% of "today" (2007) is the 30% of tomorrow (growth rates, growth rates, growth rates!)

# Context


http://www.nsf.gov




***Finding 1:*** *… A comprehensive coordinated Federal strategy is required …*

***Finding 2:*** *… Private and Federal support … R&D is inadequate.*

***Finding 3:*** *… The U.S. energy economy … does not adequately value the environment …*

***Finding 4:*** *Human capital development in the sustainable energy sector is vital.*

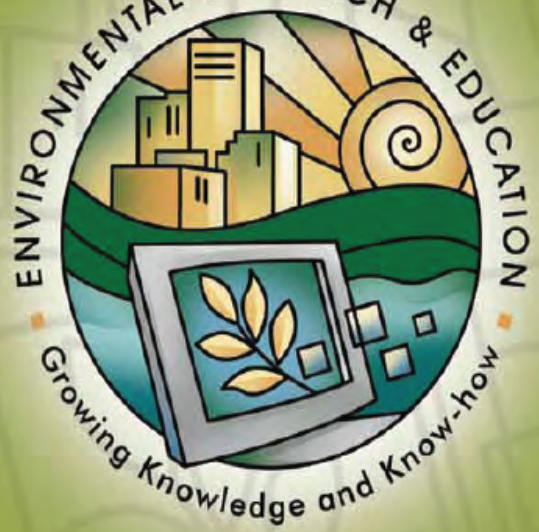
***Finding 5:*** *… Limited international engagement and collaboration inhibits progress …*

***Finding 6:*** *… Strong public consensus and support … are needed to achieve a national transformation …*

***and 6 corresponding recommendations***

http://www.nsf.gov/pubs/2009/nsb0955/index.jsp

# Transitions and Tipping Points in Complex Environmental Systems




A Report by the NSF Advisory Committee for Environmental Research and Education

Among the report's recommendations are that:

- Increase support of interdisciplinary environmental research and coupled human and natural systems. *
- Evolve to better promote and support inter-disciplinary approaches that address environmental challenges.
- Lead in developing sensor networks that monitor environmental variables and human activities with environmental consequences.
- Redouble efforts promoting environmental education and public engagement.
- Helping policymakers develop/utilize knowledge of environmental/socio-economic systems, complexities and tipping points is a priority.
- Promote environmental literacy of all citizens
- To successfully pursue an environmental agenda, the public must be actively engaged, encouraging a greater role for "citizen scientists."

**Two recommendations *ed, but all computing-relevant**

http://www.nsf.gov/geo/ere/ereweb/advisory.cfm

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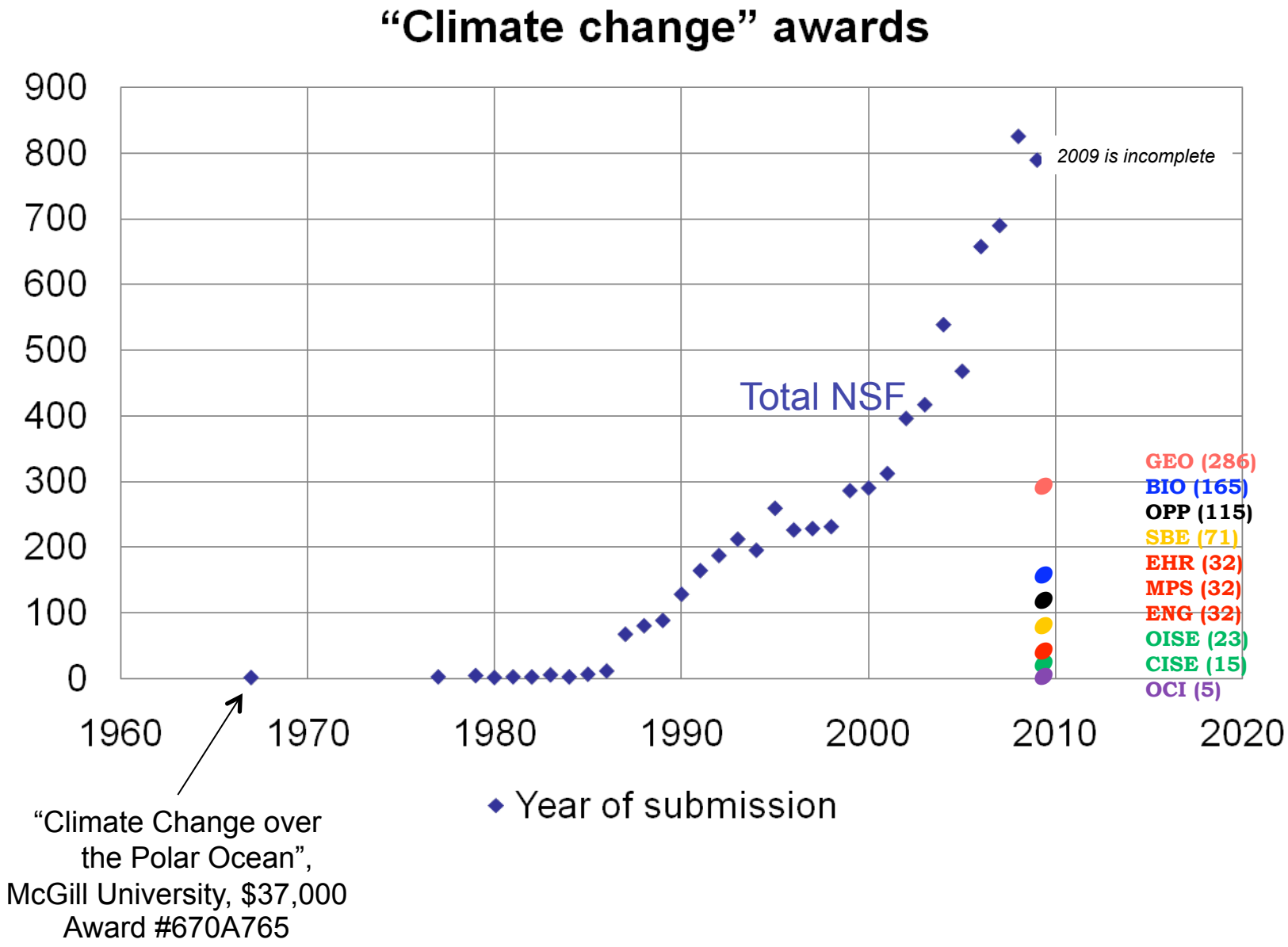
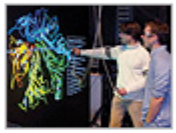
*Search done by exact match*

*caveats abound; the form of the function more important than the precise values*



# http://www.nsf.gov/news/priority_areas/

**Climate Change Science Program** *(PDF)*
The Climate Change Science Program (CCSP) engages thirteen U.S. agencies in a concerted interagency program of basic research, comprehensive observations, integrative modeling, and development of products for decision makers. NSF provides support for the broad range of fundamental research activities that form a sound basis for other mission-oriented agencies in the CCSP and the nation at large.



**Cyber-enabled Discovery and Innovation** *(PDF)*
The Cyber-enabled Discovery and Innovation (CDI) investment promotes the advancement of science and engineering along fundamentally new pathways opened by computational thinking.

**Cyberinfrastructure** *(PDF)*
Investments in FY 2009 are designed to capitalize on the results of the pioneering early forays into cyberinfrastructure and to advance research and education through the implementation of strategies laid out in the document, *A Cyberinfrastructure Vision for the 21st Century*.

**Dynamics of Water Processes in the Environment** *(PDF)*
The goal of investments in Dynamics of Water Processes in the Environment is to increase our fundamental understanding of the Earth's freshwater systems and provide the scientific basis for decision making about water resources.

# NATIONAL SCIENCE FOUNDATION

## FY 2011 Budget Request to Congress

**$7,424,000,000**
**$6,018,830,000 (R&RA)**


*February 1, 2010*

### SCIENCE, ENGINEERING, AND EDUCATION FOR SUSTAINABILITY (SEES)

**Goal:** To generate the discoveries and capabilities in climate and energy science and engineering needed to inform societal actions that lead to environmental and economic sustainability.

### SEES Portfolio Funding Levels

(Dollars in Millions)

| | FY 2010 Estimate | FY 2011 Request |
|---|---|---|
| Biological Sciences | $121.00 | $126.00 |
| Computer and Information Science and Engineering | 17.00 | 29.36 |
| Engineering | 108.20 | 120.00 |
| Geosciences | 195.50 | 230.70 |
| Mathematical and Physical Sciences | 87.00 | 110.50 |
| Social, Behavioral and Economic Sciences | 20.78 | 27.98 |
| Office of Cyberinfrastructure | 5.50 | 5.00 |
| Office of International Science and Engineering | 2.50 | 8.20 |
| Office of Polar Programs | 65.26 | 69.26 |
| Office of Integrative Activities | 26.50 | 26.50 |
| **Total, R&RA** | **$649.24** | **$753.50** |
| Education and Human Resources | $11.50 | $12.00 |
| **Total, NSF** | **$660.74** | **$765.50** |

Totals may not add due to rounding.

http://www.nsf.gov/about/budget/fy2011/index.jsp

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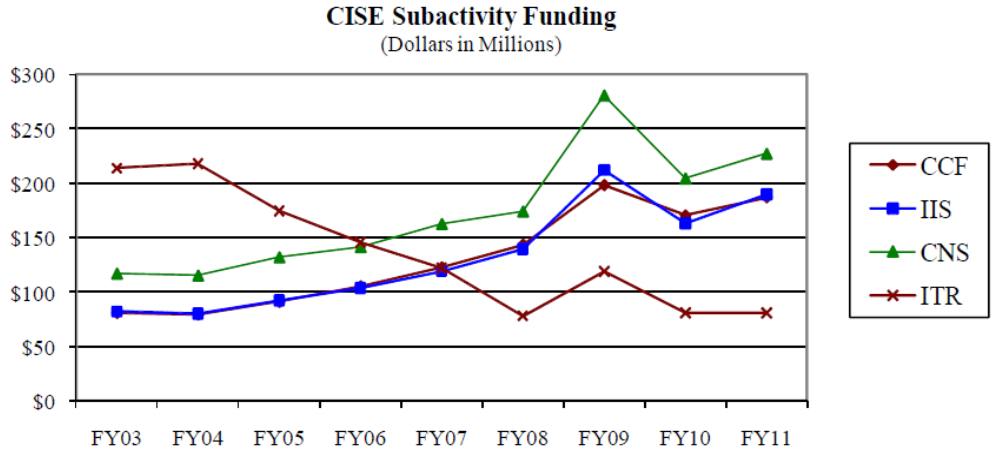
# NATIONAL SCIENCE FOUNDATION

**CISE requests only ($684,510,000)**

## FY 2011 Budget Request to Congress

***SEES (+ $29+ M)*** *




***Cyberlearning Transforming Education (CTE) ($15 M).***

***Science and Engineering Beyond Moore's Law (SEBML) ($15 M)***

*February 1, 2010*

**http://www.nsf.gov/about/budget/fy2011/index.jsp**

# CISE programs relevant to Environment

CNS/CCF/IIS
Cyber-physical /embedded Systems *
→ ENG
**CPS**

IIS
Artificial intelligence, Machine learning, Data Mining *

IIS/HCC
Social Computing
→ SBE
**SoCS**

CCF/CNS
* Science of Power Management
→ ENG

GEO, MPS, OCI
Mathematical Modeling (climate, eco-system, …)
→ CISE

IIS/RI,HCC
AI and (cradle to cradle) design

IIS/RI,HCC
(resource) Planning and decision making

IIS/III
Ecoinformatics *

IIS/RI(HCC)
(multi-)agent systems

IIS/RI, CCF/AF, SBE/Eco
Computational game theory and economics

**Social-Computational Systems (SoCS)**

**Cyber-Physical Systems (CPS)**

CONTACTS

| Name | Dir/Div | Name | Dir/Div |
|---|---|---|---|
| Helen Gill | CISE/CNS | Scott F. Midkiff | ENG/EFRI |

"…provide large-scale, distributed coordination (e.g., automated traffic control), are highly efficient (e.g., zero-net energy buildings),…"

**CISE Pathways to Revitalized Undergraduate Computing Education (CPATH)**

**Award Abstract #0829619**
**CPATH CDP: Integrating Sustainability Into Undergraduate Computing Education**

# Computing and the Environment

- International Initiatives
  e.g., OECD: http://www.oecd.org/sti/ict/green-ict
  EU: http://ec.europa.eu/information_society/activities/sustainable_growth/index_en.htm
  Japan: http://www.greenit-pc.jp/

- Many conferences, workshops, symposia, white papers
  e.g., http://www.cra.org/ccc/initiatives (and "visioning")

- Many corporate initiatives and programs
  e.g., GeSI: http://www.gesi.org/Media/tabid/61/Default.aspx

- Research community engagement starting to rev up (e.g.,
  http://www.computational-sustainability.org/compsust09 ;
  http://www.kd2u.org/NGDM09/;
  http://scipm.cs.vt.edu/ ;
  http://www.usenix.org/events/sustainit10/ ;
  http://www.cra.org/ccc/initiatives ;
  http://www.nsf.gov/awardsearch/showAward.do?AwardNumber=0950451)

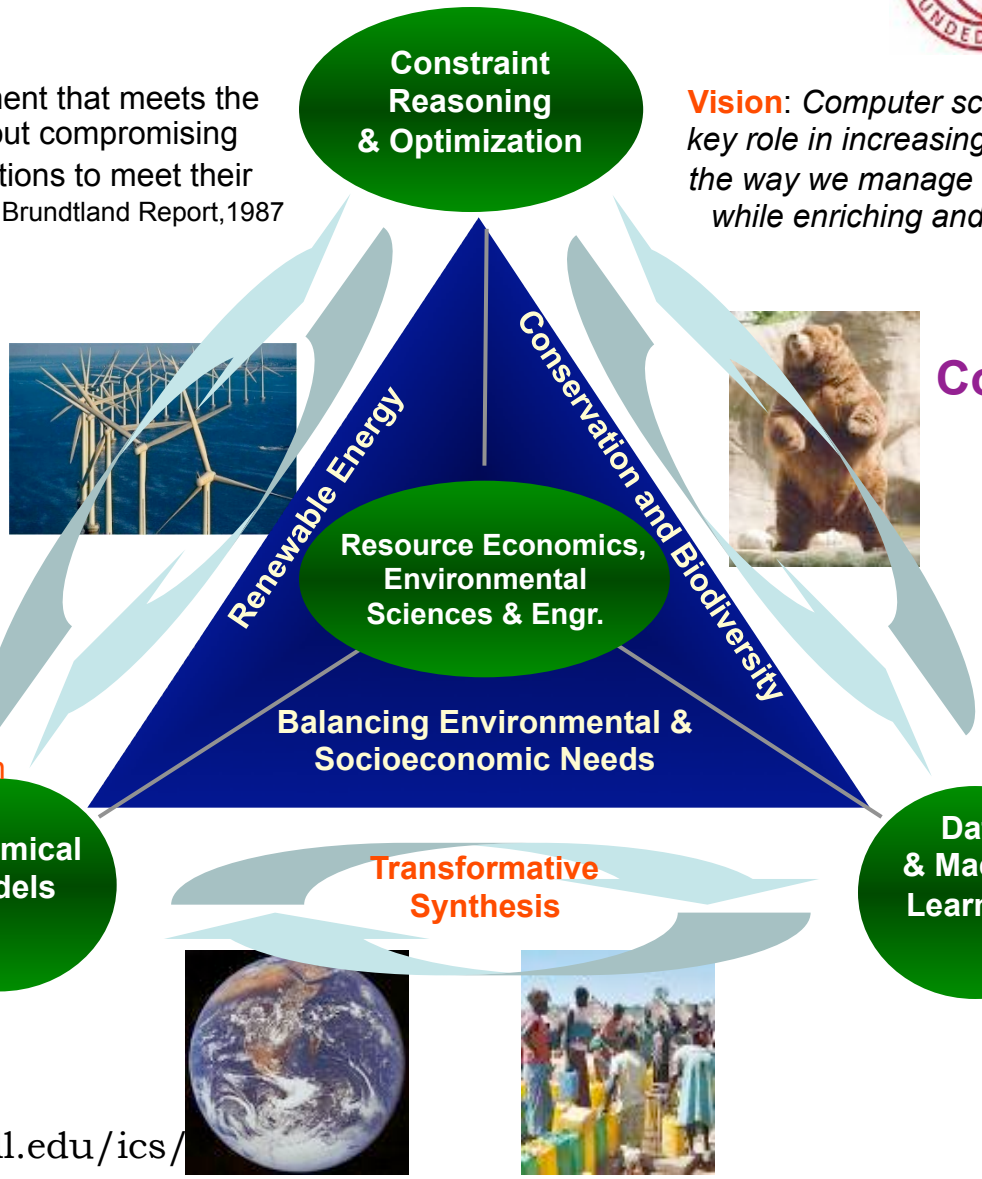
Expeditions in Computing (CISE)

# Computational Sustainability:
# Computational Methods for a Sustainable Environment, Economy, and Society

Lead PI: Carla Gomes, Cornell University

**Sustainability**: "development that meets the needs of the present without compromising the ability of future generations to meet their needs." Our Common Future, Brundtland Report,1987

**Vision**: *Computer scientists can — and should —play a key role in increasing the efficiency and effectiveness of the way we manage and allocate our natural resources, while enriching and transforming Computer Science.*




## Goals for Sustainability

To inject *computational thinking* into Sustainability,

- establishing *computational sustainability* as a new field
- bringing new insights to sustainability challenges
- preparing a new generation to grapple with long-term sustainability

## Goals for Computational Studies

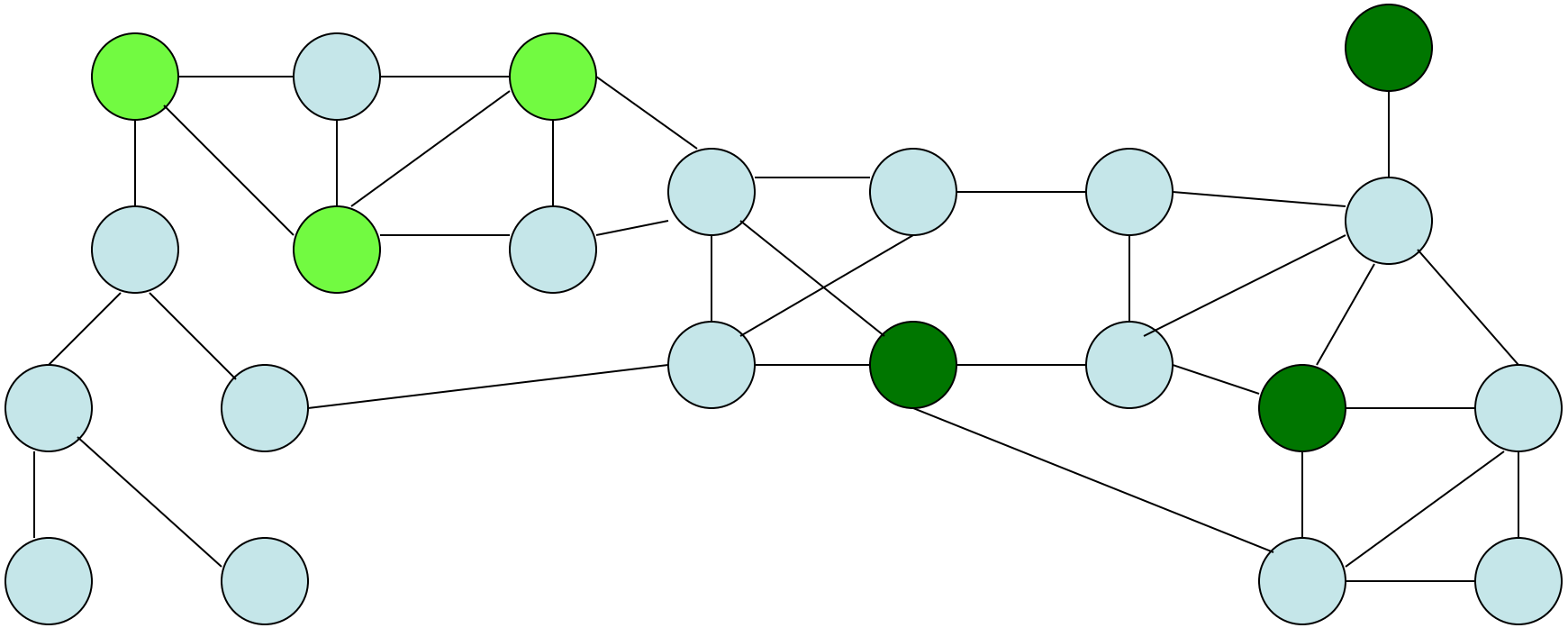
- to motivate *transformative synthesis* and new methodologies across computing sub-disciplines
- to broaden participation in the computing sciences and engineering, in part by
- broadening the public image of computing science, as a field of great societal importance

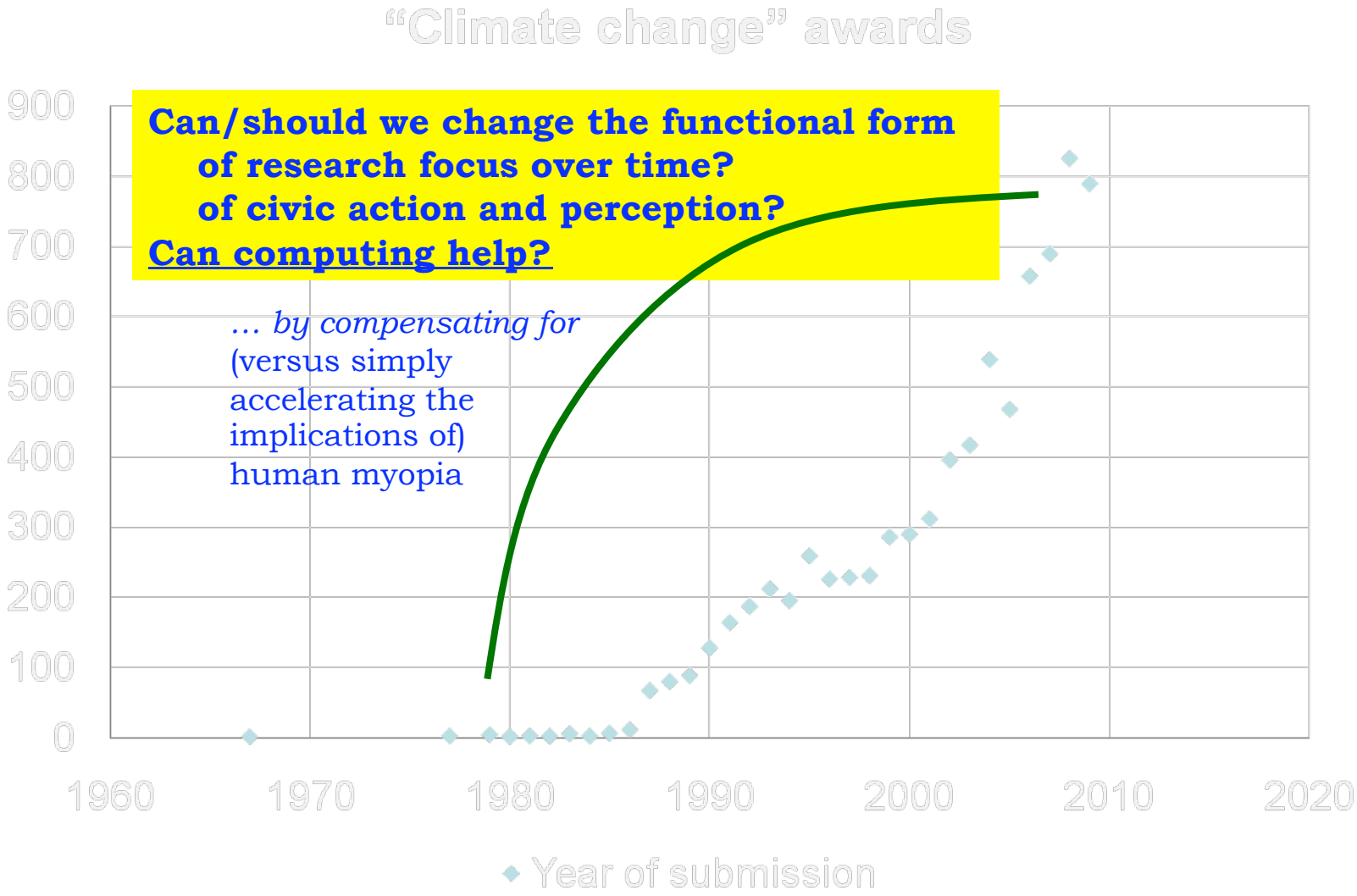
http://www.cis.cornell.edu/ics/

**Vision**: *Computer scientists can — and should —play a key role in increasing the efficiency and effectiveness of the way we manage and allocate our natural resources, while enriching and transforming Computer Science.*

For example, corridor design as a connection sub-graph problem:

Given a graph, G, which includes properties, to include reserves
Find a sub-graph that (a) contains the reserves, (b) is connected,
(c) has a 'cost' within budget, and (d) has acceptable utility



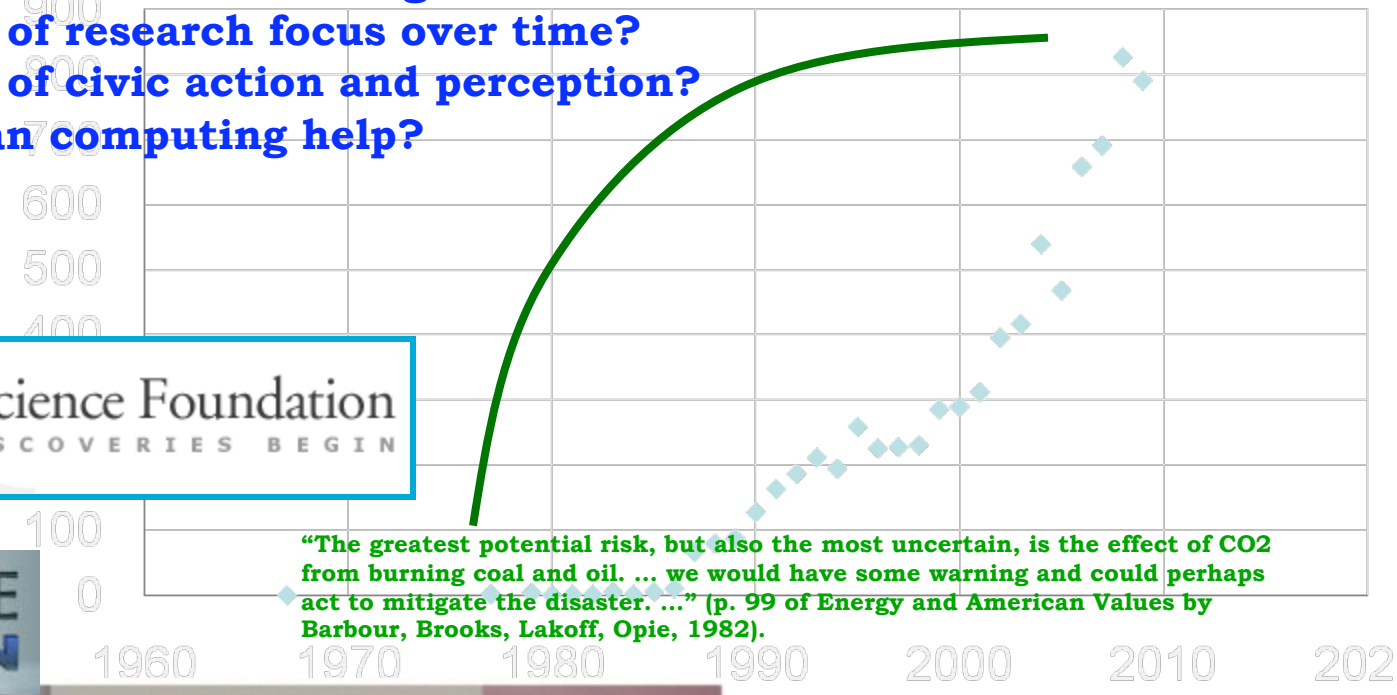



elaborating on the systemic

# elaborating on the systemic

**Can/should we change the functional form**
- **of research focus over time?**
- **of civic action and perception?**

**Can computing help?**




**"The greatest potential risk, but also the most uncertain, is the effect of CO2 from burning coal and oil. ... we would have some warning and could perhaps act to mitigate the disaster. ..." (p. 99 of Energy and American Values by Barbour, Brooks, Lakoff, Opie, 1982).**

National Science Foundation
WHERE DISCOVERIES BEGIN

SCIENCE NATION

November 9, 2009

**Virtual Newscast: News at Seven**

*News Anchors: The Next Endangered Species?*

**(PI: Kris Hammond, Northwestern Univ)**

http://www.nsf.gov/news/special_reports/science_nation/virtualnewscast.jsp

# Concluding Remarks

• Growth rates, growth rates, growth rates -- it's not all (or even mostly) about efficiency – characterizing the complexity class of growth rate, as well as worrying about "the constant"

• Lifecycle, lifecycle, lifecycle, with aspirations to lifetime energy requirements and cradle to cradle.

• Researchers are often educators too – infuse sustainability into the curricula, particularly if we want to *look beyond emergencies*. What is to be sustained and why? The role of historians in learning from humanity's reaction to climate change.

• Computing research and development has direct, indirect and systemic effects (pro and con) on the environment – what are the indirect and systemic effects, in particular?