

## 2007 Taplin Environmental Lecture

# Jeffrey D. Sachs: “The World Will Reach a Settlement on Climate Change by 2010”

Addressing the standing-room-only crowd in Bowen Hall, Jeffrey D. Sachs delivered the 2007 Taplin Environmental Lecture on April 12. Titled “Negotiating the Post-Kyoto Climate Change Framework,” Sachs spoke of his optimism that all countries, including China and India, will work together to curb greenhouse gas emissions and “reach a meaningful settlement on climate change by 2010.”

Sachs, Director of the Earth Institute at Columbia University, noted the failure of the Kyoto Protocol, traced the history of global awareness of changing

*“The single most practical issue the world faces is that China and India will soon be major emitters of carbon.”*

climate, and discussed ways in which all countries will be able to contribute to solving the problem. He said, “I am optimistic that when the next round of serious post Kyoto negotiations start, we will get somewhere. It won’t be beautiful. It will be messy. We will not have a single theme in terms of a mechanism or cost sharing device, but we will get somewhere.”

Director of PEI and Ecology and Evolutionary Biology Professor, Steve Pacala remarked at the conclusion of the event, “Sachs is pragmatic and optimistic. Let’s hope he’s right!”

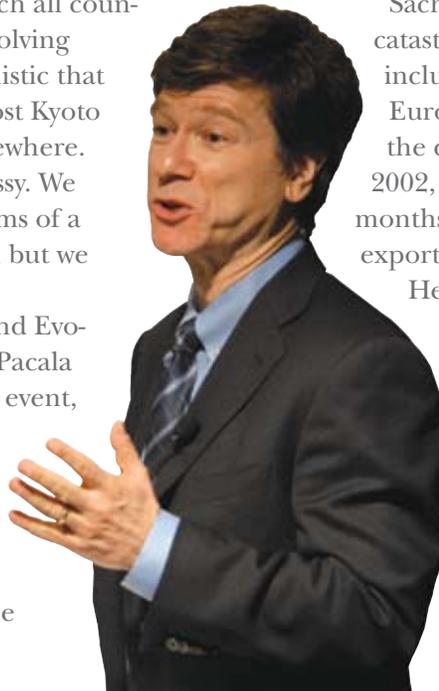
The Four Phases of the Public’s Awareness of Climate Change  
Opening his remarks by tracing the

history of the growing public awareness of climate change and its impacts, Sachs identified four phases in the process. He dated the first phase to the scientific discovery of climate change in 1896. The second phase he described as spanning the late 1970s through the 1980s, when the first models of anthropogenic CO<sub>2</sub> and other gases were made public. The third phase he dated as “Katrina.” As Sachs explained, Katrina showed the world that “Climate change is real, ongoing, persuasive, and documented. Katrina served as the shocking wake-up call that climate change can pack a devastating punch to the United States.” He further suggested that the U.S. government’s inability to respond to the crisis demonstrated both a lack of preparedness and further underscored the urgency to address the root cause.

Sachs referenced other climate-driven, catastrophic events outside of the U.S., including the August 2003 heat wave in Europe (which claimed 35,000 lives), and the drought in Australia, which began in 2002, and has been so severe in the last six months that it has led to a collapse of grain exports and changed the country’s politics.

He pointed to both of these as wake-up calls around the globe. He noted that Africa has been suffering the effects of global change for a long time, but, he explained, “When poor countries get hit, no one cares. Weather events that have impacted the core markets in the United States, Europe and Australia have caused a huge turning point.”

Jeffrey D. Sachs



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Sachs proposed that the world is now entering the fourth phase of public awareness, one marked by the involvement of big business. “The American business community is way ahead of the politicians. The utilities companies and auto producers are leading the pack with companies, such as General Electric, campaigning for aggressive action to halt climate change. There is a growing sense in the business community that the costs of action are not that large or painful, but are sufficiently modest and affordable.”



Professor Sachs answers questions following the lecture

Sachs said that for many major U.S. companies, the concept of managing greenhouse gas emissions is not new. This is particularly true of companies conducting business in the European Union where standards are already “in place.” Sachs suggested that a growing sense of obligation is now paired with a perception of manageability.

#### The world must reach an agreement by 2010

Explaining that the current Kyoto agreement expires in 2012, Sachs proposed that a global agreement must be reached by 2009 or 2010. He cautioned that not much progress will be made in 2008, because, “The United States will have elections, and China will have the Olympics.”

In this interim period, Sachs explained, scientists and others will need to write articles and otherwise

explore several central issues about the “post Kyoto negotiations.” These include the need to work out a global agreement regarding responsibilities by country, and establishing a mid-century goal for carbon concentration levels. He further stressed the importance of a global consensus to curb CO<sub>2</sub> and the need to define mechanisms for affecting change.

#### Sachs explains why climate change issues are particularly complicated

Sachs pointed to issues other than fossil fuel consumption that are contributing to climate change, including land use, deforestation, farm practices, and chemical processes.

Referencing articles written by PEI associated faculty members Rob Socolow and Steve Pacala\*, Sachs said, “No single technological solution will work, but my optimism that we can abate greenhouse gas emissions is based on the sense that wedges can be filled at a cost of 1% of the world’s income or less,” Sachs said.

#### China and India will soon be major carbon emitters

Sachs emphasized that the single most practical issue the world faces is that China and India will soon be major emitters of carbon. Combined, he said, the carbon emissions of China and India are likely to offset reductions elsewhere even under a scenario of concentrated efforts to lower emissions. Sachs explained that China continues to rely on coal because it is the most secure and lowest cost energy source available. If this isn’t addressed, and alternatives provided, he expects the challenge of reducing worldwide concentrations of carbon in the atmosphere to be much harder. “Can carbon be captured and sequestered?” queried Sachs. “If the answer is yes, we can manage it. If it is no, we have a much bigger problem.”

Sachs expressed optimism that increasing carbon emissions in China and India will be offset, because both countries appear eager to understand the new technologies better, and are seeking alternative fuel sources. Sachs reported that China has proposed to use public funds to build prototype plants in China and test them. Sachs suggested that U.S. and Europe should financially assist them in this endeavor, because “The key is paying for the early prototypes. Clean power is what really counts; this is a new industry waiting to

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# PEI Team Leads Interactive Climate Session at AAAS National Meeting

By Anne Catena

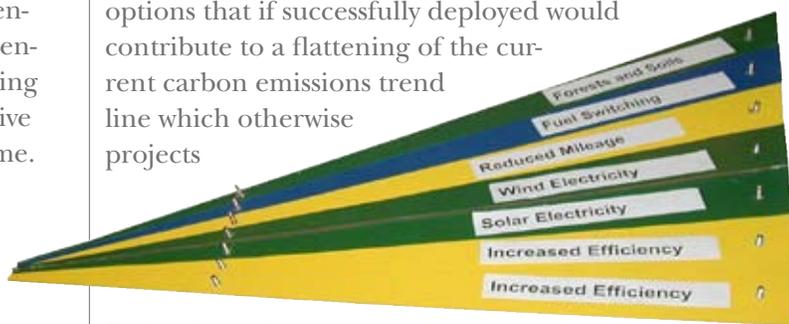
Led by a team representing the Carbon Mitigation Initiative (CMI) and Princeton Environmental Institute (PEI), scientists, teachers, students and concerned members of the public recently had the opportunity to cast their votes for carbon emission reduction strategies that could impact global climate change. “Communicating and Learning about Global Climate Change” was the theme of the Town Hall styled event that was convened in San Francisco, California on February 18, 2007 as a feature session of the annual meeting of the American Association for the Advancement of Science (AAAS). Professor Robert Socolow, co-director of CMI, and Dr. Roberta Hotinski, former information officer of CMI, spoke to an enthusiastic group of 700 scientists, educators, students and members of the general public about existing technologies for cutting carbon emissions and engaged the group in a live demonstration of the “Stabilization Wedges” game.

The “Stabilization Wedges” game is an outgrowth of the Carbon Mitigation Initiative, a research effort centered within PEI under the leadership of Professors Robert Socolow and Stephen Pacala, with corporate support of BP and the Ford Motor Company. The game has proven to be a readily accessible visualization construct for considering a range of possible solutions to what is otherwise an overwhelming tactical challenge, namely how to make sizeable reductions of worldwide carbon emissions in the next 50 years, and as a result avoid what would potentially cause devastating global impact. The goal of the game is to cut future carbon emissions by seven billion tons of carbon per year, or seven “wedges” by 2055. Socolow discussed the pros and cons of ten technological strategies available to cut future emissions at the rate of one billion tons of carbon per year (per wedge); including carbon capture and storage, fuel switching, nuclear electricity, several strategies for energy efficiency and conservation, as well as renewable energy and natural carbon sinks. Hotinski and

Anne Catena, PEI Outreach Coordinator, then led the group in the selection of seven “wedges” from among the ten strategies that together could yield the necessary annual emissions cuts to stabilize emissions at current levels.

Using electronic voting “clicker” technology, akin to that used in game shows, the votes of the audience were captured and tabulated in displays projected to the front of the auditorium. The audience enjoyed being able to immediately see their preference for emissions reduction strategies. Participants voted seven times, considering the repercussions of each choice. The resulting portfolio of stabilization strategies included two wedges of increased efficiency. Other wedges included the reduction of transportation mileage, wind electricity, solar electricity, fuel switching and carbon sinks in forests and soils.

Socolow and Pacala, co-directors of CMI, created the concept of a “stabilization triangle” to demonstrate the magnitude of the carbon emissions reduction challenge. The wedges framework also introduces a variety of feasible technical and efficiency options that if successfully deployed would contribute to a flattening of the current carbon emissions trend line which otherwise projects



Final product at the AAAS Meeting

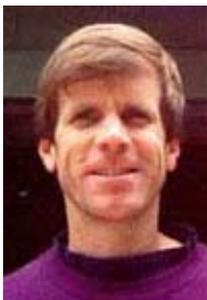
a doubling of atmospheric carbon dioxide over pre-industrial levels by 2050 or 2055 and accompanying dramatic changes in global climate. For the purposes of the game, a “stabilization wedge” represents a strategy that can be scaled up to reduce emissions by one billion tons per year (per wedge). A combined total of seven “wedges” are needed to build the stabilization triangle and freeze emissions at current levels.

The simplicity of the Wedges game enables participants to understand the scale of carbon emission cuts required to address the challenge of reversing the increase of carbon concentrations in the atmosphere, making it a popular tool with educators. In an effort to make the Wedges game more accessible, Hotinski and Catena have developed a Teachers’ Guide. For more

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## Interview with PEI's Tom Kreutz

# Course Focuses on Reduction of Campus CO<sub>2</sub> Emissions



Tom Kreutz

**PEI:** This was the first student-initiated course offered through the Environmental Studies program at PEI. How was this undergraduate course developed, and what were its goals?

**TK:** In December 2005, members of the student environmental group Greening Princeton met with Steve Pacala (Director of PEI), Tom Nyquist (Director of Engineering), and me (Research Scientist and Lecturer at PEI) to discuss how the University might reduce its greenhouse gas (GHG) emissions. Steve had the brilliant idea of pursuing the “ethical trajectory” (hence the title of the course), i.e. a massive reduction in CO<sub>2</sub> emissions. The course itself was initiated by Kathy Kunkel '06, and hosted and funded by PEI. I was the architect of the course, and taught it with the help of WWS grad student Michael Gillenwater, and a dozen marvelous guest lecturers.

The undergraduate course, called ENV ST01: Towards an Ethical CO<sub>2</sub> Emissions Trajectory for Princeton, had two primary goals. The first was to provide the University with a solid quantitative and economic framework for contemplating significant reductions in campus greenhouse gas (GHG) emissions. The GHG inventory issues are relatively simple; most of the ~125,000 tonnes of CO<sub>2</sub> that we emit each year comes from either electricity purchased from the grid or from our cogeneration plant (which provides steam heat, chilled water, and electricity to campus). The students researched many different technologies for reducing those emissions, quantifying both the size of each potential reduction opportunity as well as its cost (in \$ per tonne CO<sub>2</sub>). Their key contribution was to compare all of these technologies on an apples-to-apples basis, and thereby illuminate the tradeoffs in the various strategies that Princeton might adopt.

The second course goal was to educate 21 ex-

cited students, helping them to become knowledgeable and articulate advocates for mitigating global climate change. To that end, we were fortunate to have a long string of fantastic guest speakers who lectured on topics such as the state of climate science, the potential ramifications of global warming, our ethical responsibilities, energy consumption at Princeton, and technologies for increasing energy efficiency and reducing CO<sub>2</sub> emissions.

*“It’s easy to say ‘Let’s DO it!’, but much more difficult to determine HOW we might do it, and at what cost. The research revealed many surprises.”*

**PEI:** Will the data the students collected change how the University manages its carbon emissions?

**TK:** The results of the student’s research is currently being studied by a new subcommittee of the Princeton Sustainability Committee, whose mandate is to help the University decide what action it might take. It’s currently a very active and exciting issue – for example, the University Trustees took up the topic recently – and the work of the class is certainly helping shape everyone’s thinking.

**PEI:** Your students must have gained a very new perspective by taking this course. What aspects of the course do you hope will have a lasting impact on the students and why?

**TK:** All the students arrived eager to help build a case for reducing campus GHG emissions. However, our strong quantitative focus caught many of them off guard, forcing them to confront the economic realities of mitigating climate change. It’s easy to say “Let’s DO it!,” but much more difficult to determine HOW we might do it, and at what cost. The research revealed many surprises. Some initially exciting technologies, such as solar panels, were found to be far too expensive. Others, like compact fluorescent light bulbs, are economical but hardly reduce campus CO<sub>2</sub> emissions at all. The course required a tremendous amount of independent research, aimed at quantifying and comparing the size and cost of these technologies. The students are no longer naïve advocates; instead, they are now the world’s experts on creating a climate-friendly Princeton University! It was really exciting to facilitate that transformation.

# Colvin Award Funds Research in Kenya and South Africa

In May 2006, undergraduates Meha Jain and Aliya Sanders were co-recipients of the 2006 Becky Colvin Memorial Award. The award was established in 1995 by Dr. and Mrs. Robert Colvin in memory of their daughter, Becky Colvin '95. Becky was an ecology and evolutionary biology (EEB) major who was committed to field ecology and environmental studies. Each year, the fund supports environmental field research projects associated with the recipients' senior theses. The following is a profile of this year's co-recipients and their research.

## Meha Jain '07

Meha Jain '07, an ecology and evolutionary biology (EEB) major from Indiana, conducted research at the joint Princeton-Smithsonian Mpala Research Station in Laikipia, Kenya. Her thesis advisor, Dan Rubenstein, Chair and Professor of Ecology and Evolutionary Biology, supervised her research. Meha applied her 2006 Colvin Award to study the feeding interactions between cattle and donkey populations in order to assess the affect of cattle grazing on wild zebra populations. She intends to use her findings on donkeys to establish a model for cattle and zebra interactions. As Meha explains, "Domestic donkeys and wild zebra have very similar digestive tracts, and they eat very similar species of grass."

Meha's thesis title is called *Measuring the Interaction Between Cattle and Donkeys as a Model for the Interaction Between Cattle and Zebra in Laikipia, Kenya*.

Her research is expected to have a large impact on the scientific community because this is the first time such a project has been undertaken in Kenya. "In the United States, studies have been done looking at interactions between elk and cattle, but my research is the first to actually measure the effects of wildlife-herbivore interactions."

Meha completed her field studies and lab analyses in Kenya over the summer of 2006; however, she did all of the data analysis when she returned to Princeton in the fall. Her studies suggest that, at high densities, the donkeys are negatively affected

by the presence of the cattle, as measured by the bite rate. At low densities, she observed no change in behavior. "This was very significant and interesting," reports Meha, "because, for the first time ever, we were able to show cattle had a negative impact on wild herbivores in central Kenya."

The results of this research, which Jain is hoping to publish, will be very helpful to farmers who are raising cattle in close proximity to Africa's wildlife. It may also be extremely useful to scientists who are working to save endangered species of zebra. Meha says, "The results of this research may lead to regulation, as it will show farmers the ratio of cattle to wildlife to maintain in order to minimize the impact on wildlife. In addition, the research should enable scientists and policy makers to set guidelines for the number of cattle that farmers are allowed to raise on land bordering the reserve. Naturally, scientists will need to consider the economic interests of the farmers in making these recommendations."



Meha Jain '07 records the weight of a donkey used in the experiment. Determining the weights of the animals over time was crucial in identifying how species were interacting in the system.

Regarding her experience, Meha, said, "The Colvin Fund allowed me to pursue research in a field I am really interested in. Since entering college, I have become interested in wildlife-human interactions and plan on studying this topic in the future. The Colvin Fund gave me the chance to travel and learn about this topic first hand by conducting field research in Kenya."

Jain is considering several options for next year. One possibility is to work for an Environmental NGO. She is also interested in attending law school or a graduate program in Conservation Biology. As she explains, "I enjoy field research and strict sci-

ence, but I am also very interested in policy, and I enjoy interacting with people.”

### Aliya Sanders '07

Aliya Sanders '07, an ecology and evolutionary biology (EEB) major from New York, used her Colvin funds to travel with her advisor, EEB Professor Lars Hedin, to South Africa. There, she studied the different nutrients in the soil surrounding Acacia tree stands of varying ages to determine the affect of nutrient limitation on mature Acacia stands. Her senior thesis is titled *Nutrient Limitation in Acacia saligna stands of the Western Cape, South Africa*.

Aliya's research was inspired by her fascination with the native and endangered Fynbos tree. Scientists have found that the invasive Acacia tree is threatening the survival of the Fynbos. It is believed the Acacia increases the level of nitrogen in the soil, and the Fynbos cannot survive in such an environment. Aliya wished to add to research on invasive Acacias within the Fynbos.



Aliya at Glencamp, one of the middle aged (4-9) year sites. In this photo, Aliya is gathering all of the samples and making sure everything is accounted for since, as she says, a lot of the time, field work got a bit disorganized.

In order to conduct her research, Aliya explains, “I studied Acacias in a post fire environment. In South Africa, fire is the driving force of plant systems. Fires clear the vegetation and so doing, make room for new growth.

“We analyzed the soil surrounding trees in three different age classes. One group was 1 -3 years old, the other 4 – 9 years old, and the third, 10+

plus years old. We wanted to determine how nutrient pools differ between the age classes, and how Acacias experience nutrient limitation in an environment that is naturally extremely nutrient-poor. We studied the different percentages of nitrogen in the soil, to see if older Acacias are still fixing atmospheric nitrogen. If we saw an increase in nitrogen in the soil, in addition to a down-regulation of nodulation, which is a sign that the trees are still actively fixing nitrogen, it indicated the Acacia was not very dependent upon nitrogen in the atmosphere. If the Acacia was not as dependent, it showed they are sufficiently increasing nitrogen pools in the soil for their own use, to the detriment of native Fynbos.”

One of the challenges Aliya faced was obtaining permission from the local government to do research in certain areas, because many of the Acacia stands are on protected land. Another challenge was fitting all she had to do in a very tight schedule. “I was very rushed, as I had very little time in Africa, so I worked very long nights in the lab.”

Aliya returned to the United States with 200 pounds of soil and plant samples to analyze in the lab. As she explained, “The lab equipment we have at Princeton can't do molybdenum and phosphorous, so we sent it to a lab at the Northern Arizona University.”

Once she completed the research, it showed mature Acacia stands still actively nodulate, although they significantly increase soil nitrogen, implying that they still remain nitrogen-limited from the perspective of their own nitrogen-needs. However, from the perspective of Fynbos species, nitrogen levels are too high for successful growth.

Aliya's experience was very rewarding. As she explained, “Being one of the recipients of the Colvin Award and being able to do field work for my thesis over the summer was an incredible experience and helped me to really understand not only the long and sometimes difficult process behind research but also appreciate how much effort went into my independent work. Few undergraduates have the opportunity to engage in exciting and meaningful academic research, but the Colvin Award not only helped make it happen but also allowed for the flexibility needed to create an interesting and original project.”

After graduation, Aliya plans to spend one year as a Princeton in Africa Fellow, and then pursue a graduate degree in public health.

# PEI Research and Center News

## The Center for Biocomplexity

The Burroughs Wellcome Fund named **Joshua Weitz** a recipient of a Career Award at the Scientific Interface to study the evolutionary ecology of bacterial viruses. The award encourages research at the interface between physical/computational sciences and the biological sciences. Joshua is now a faculty member at Georgia Tech.

**Jonathan Eisen**, **Rich Lenski**, and **Joshua Weitz** joined **Simon Levin**, **Jonathan Dushoff** and members of the Levin research group in early April to discuss novel methods to analyze ocean metagenomic data as part of an ongoing research project on Fundamental Laws of Biology sponsored by DARPA.

**Akiko Satake** has started a new position as a tenure track research group leader in theoretical ecology at the Swiss Federal Institute for Aquatic Science and Technology (Eawag), located in Kastanienbaum near Lucerne in

Switzerland.

While she was in PEI, Akiko modeled the interaction between human decision-making about deforestation and forest regeneration dynamics. The model predicted that low rates of future discounting and slow rates of forest regrowth are crucial to achieving sustainable management of forest resources. At Eawag, She will apply her theory to aquatic systems to understand the interrelated dynamics of fish communities and angler behavior.

## The Cooperative Institute for Climate Science (CICS)

An international team of researchers led by AOS and CICS scientists **Andy Jacobson** (now at NOAA-ESRL), **Sara Mikaloff Fletcher**, **Jorge Sarmiento**, and **Niki Gruber** (ETH, Zurich) have found new evidence that suggests that there is not a significant terrestrial carbon sink due to CO<sub>2</sub> fertilization

in the tropics. They estimated that there must be a net source of 1.8 billion metric tons of carbon per year from tropical and southern hemisphere land regions using a combination of atmospheric and oceanic observations and models.

The net terrestrial flux in the tropics represents the sum of emissions due to deforestation and a sink from plant fertilization via increasing atmospheric CO<sub>2</sub> levels. However, the net source estimated in this study is similar to independent estimates of the tropical carbon source due to deforestation alone, suggesting that the proposed tropical CO<sub>2</sub> fertilization sink is smaller than previously thought.

The carbon fertilization sink reduces the amount of mitigation required to stabilize atmospheric CO<sub>2</sub> by about half. Without such a CO<sub>2</sub> fertilization sink, the challenge of stabilizing atmospheric CO<sub>2</sub> becomes much greater.

## PEI Faculty Awards

**Michael Celia**, chair and professor of civil and environmental engineering and PEI associated faculty member, was chosen on May 10 as the 2008 Henry Darcy Distinguished Lecturer by The National Ground Water Association. The prestigious honor, awarded annually since its establishment in 1986, supports the travel of one expert to share his or her work in lectures at universities throughout the world.

**George Hawkins '83**, Executive Director of NJ Future in

Trenton, and Lecturer in Public and International Affairs, Woodrow Wilson School and PEI, has accepted a new position as the Director of the Department of the Environment for Washington, D.C. Mr. Hawkins taught ENV 310: Environmental Law and Moot Court for over eight years.

**Simon Levin** received the 2007 Distinguished Scientist Award from The American Institute of Biological Sciences in Washington, DC on May 14. Levin, professor of ecology and evolutionary bi-

ology and founding director of PEI, and co-principal investigator of the Center for BioComplexity, will be presented with a plaque and lifetime membership in AIBS at the organization's annual meeting.

**Tullis Onstott**, professor of geosciences and PEI associated faculty member, was listed in the May 14, 2007 edition of *Time* magazine, as one of the "Time 100," *Time's* annual list of "The World's Most Influential People." Listed on page 118

under "Scientists and Thinkers," he is lauded because, as *Time* says, "His earthly critters may provide a clue to alien life."

**Stephen W. Pacala**, director of PEI and professor of ecology and evolutionary biology, was elected a member of the National Academy of Sciences on May 1. The National Academy of Sciences is a private organization of scientists and engineers dedicated to the furtherance of science and its use for the general welfare.

## Sachs *Continued from page 2*

be developed. If we will help finance this, it will be a practical approach. This is what they are looking for and what we all need.”

Sachs asserted that climate change is having a deleterious impact on the poorer and developing world than on the more affluent economies in the West. He suggested that it would be appropriate for the global community to address issues of adaptation, compensation and equity, account for historical roles in the release of carbon, and allocate responsibility for it between the rich and poor countries. He further cautioned about the difficulty that negotiators will have in finding a shared set of values, and posed this as an enormous challenge.

## Sachs is optimistic we will reach a global solution

In his concluding remarks, Sachs emphasized that he remains optimistic that by 2010 all countries will have joined forces to create a long-term framework to solve the climate change crisis. He believes the world is close to developing smart technologies to “keep the long-term annual cost of greenhouse gas emissions at below one percent of the global gross domestic product.”

*\* (“Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies,” S. Pacala and R. Socolow, Science, Vol. 305, Issue 5686, pp. 968-972, August 13, 2004 and “A Plan to Keep Carbon in Check,” Robert Socolow and Stephen Pacala. Scientific American, Vol. 295, No. 3, pp. 50-57, September 2006.)*

## AAAS Meeting *Continued from page 3*

information see <http://www.princeton.edu/~cmi/resources/stabwedge.htm>.

The town hall event was moderated by John Holdren, AAAS



AAAS audience cast their votes for Wedges.

President who warned the audience that “Global climate change is the most dangerous environmental problem humans have ever created.”

Other presenters included Lonnie Thompson, Ohio State University, Margaret Leinen, Climos, Inc., Amory Lovins, Rocky Mountain Institute and P. John Whitsett, President-Elect of the National Science Teachers Association.



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