

Natural Resource Sustainability Summit

Dec. 12, 2012

Introduction

It is not a stretch of the imagination that natural resource scarcity (whether it is oil, land, water, or other resource), regardless of cause, would potentially have negative effects on society. The phenomenon could impact economic growth; the financial stability of individuals, businesses and governments; and the mortality and morbidity of populations. While actuaries analyze the financial consequences of risk, actuaries traditionally have not been involved in quantifying these types of risks or assisting in the development of resource risk mitigation strategies. For the past few years, the Society of Actuaries' (SOA's) research department has been looking at the topic of natural resource sustainability to identify research the SOA could be doing to educate actuaries on this topic and get actuaries thinking about how they might get involved. This information could also be used at some point by the profession to formally define a role for actuaries in this area.

The SOA is not the first actuarial organization to examine this topic. The Institute of Actuaries of Australia, the Institute and Faculty of Actuaries in the U.K., the International Actuarial Association, and the Casualty Actuarial Society (CAS) all have environmental sustainability and/or climate change committees investigating potential opportunities and roles for actuaries in this area. Individual actuaries have also studied sustainability issues and published or presented their personal views.

Among the actuarial bodies stated above, the U.K. and Australia have done more to educate their members of potential opportunities related to environmental changes. A quick review of the Institute of Actuaries of Australia website shows that there are a number of actuaries already working in the energy and climate change fields. An article in 2002 discusses how actuaries can help with problems of sustainability and the environment. It examines how market-based solutions can mitigate risk associated with environmental issues. Actuaries could provide risk management expertise to the buyers and sellers of these solutions. Increasingly, regulation includes environmental reporting, and actuaries clearly have the skill set to quantify these costs and liabilities. The site also weighs in on how actuaries can help maximize long-term returns in light of environmental influences by ensuring sufficient capital for long-term viability.

The U.K. Actuarial Profession is also taking steps to educate its members. Among the activities is commissioning research. A recently completed study, "Resource Constraints: sharing a finite world. Implications of Limits to Growth for the Actuarial Profession" discusses the economic consequences of resource constraints. The study modeled a pension fund, comparing results

between a traditional modeling approach and one that considered resource constraints for assumption development. This exercise showed lower returns and higher costs for pension schemes than the traditional “no constraints” approach. The report states:

The findings of this report suggest actuaries need to become conversant in a number of issues which are not within their traditional range of expertise, such as the relationship between energy and other resources and the economy and the economic impacts of climate change.

Besides collaborating with the CAS Climate Change Committee on research, the SOA’s research department formed the International Working Group on Actuarial Sciences and Sustainability (IWGASS), a working group to identify research needs on sustainability and examine how actuaries could assist in analyzing, measuring and mitigating the associated potential risks. Members include representatives from the committees discussed above, SOA and CAS members interested in the topic, and academic representatives from agriculture who are also studying the topic. To better evaluate the many ideas generated in light of SOA member needs, the SOA members of IWGASS thought they and SOA members needed more education of this topic. The IWGASS applied for and received funding from the Research Expanding Boundaries Pool for a summit in which thought leaders were invited to help frame the issues.

What follows is a summary of the summit held Dec.12, 2012 in Chicago. The group outlined many considerations for the SOA in what it could do to move this topic forward toward setting a specific plan of action. The group also offered insights into potential opportunities for the actuarial profession.

The SOA research department would like to thank the individuals who participated in the summit and for their time and effort in preparing and reviewing this report.

Natural Resource Sustainability Summit Summary¹

For several years the Society of Actuaries (SOA) has been following the sustainability topic, seeking to find a natural fit for actuaries to utilize skills where their sweet spot of discounting contingent cash flows can be used. There is also a reputational risk to doing nothing. If material information is available and ignored, this could impact the future viability of the profession. With this as a backdrop, the SOA asked a diverse group of thought leaders, both volunteers and staff, to listen to several presentations related to sustainability and consider where the organization should focus. Attendees were:

Jeff Beckley

Paul Brandt-Rauf

Laurie Butler

Frank Grossman

Sam Gutterman

Tim Harris

Dave Ingram

Shiraz Jetha (phone)

Aled Jones

Emily Kessler

Dave Ingram

Mary McKee

John Richardson

Max Rudolph

Leonard Sonnenschein (phone)

Ronora Stryker

Sara Teppema

Before deciding what the SOA's strategy on sustainability should be, the group agreed what it will not be. It should not be the SOA's goal to prove or disprove global warming. While this is a critical topic for this and future generations to consider, these arguments become emotional and are very hard to reach consensus. Where the actuarial skill set can be helpful is through objectivity, providing quantification where possible and peer review oversight in all cases. There

¹ Notes written by Max J. Rudolph, FSA, CERA, CFA, MAAA and Ronora Stryker, ASA, MAAA.

was support for educational, research and organizational efforts, and potential next steps were discussed.

What Is Sustainability?

This is an ongoing question, and a Google search is not definitive. At www.dictionary.com, sustainability is *the quality of not being harmful to the environment or depleting natural resources, and thereby supporting long-term ecological balance*. According to Dr. Leonard Sonnenschein, one of the presenters, it *creates and maintains the conditions under which humans and nature can exist in productive harmony, that permit fulfilling the social, economic and other requirements of present and future generations*. Wikipedia simply defines it as *the ability to endure*. Within a complex system, with constant feedback loops and unintended consequences from interactions, it is not surprising that the term lacks a standard definition.

The earth has cycles that last a day, a month, a year, decades, centuries and millennia or more. The task is to differentiate random noise from permanent trends that impact our quality of life. Recessions, for example, are random noise when viewed in the long term. Generally no structural changes are necessary for recovery. Sustainability covers events and trends with larger and longer-lasting imprints on the earth.

There are many options for actuaries considering sustainability going forward. These will determine if actuarial practice needs to evolve or endure a sudden change. Focusing on financial implications seems a natural and safe approach, but not the only one. Between environmental and financial sustainability, which is the driver and which is the end result? There are always two ways to view an issue. Maintaining perspective helps objectivity. The industrial age has viewed growth as a given for roughly 250 to 300 years, but is that really a reflection of poor accounting practices that don't take into account the impact on the environment of growth? Should we encourage a zero-growth environment, and how should that be allocated between developed and developing countries?

A discussion about sustainability requires a longer time horizon than most people are comfortable with, looking for leading indicators and tipping points while keeping in mind that implications might accelerate with only small changes in measured variables (e.g., small ocean temperature increases have had large impacts on the size of Arctic sea ice). Transparency is better than ignorance, but many won't take a stress scenario seriously even if a story is built around it (but that helps).

Could it be that the cartoon character Pogo was right when he said:

"We have met the enemy and he is us."

—Walt Kelly

Presenters

The summit was built around four presentations, followed by time for further exploration and next steps. What threads could actuaries make progress on? How does our skill set differ from others? Experts with varying perspectives shared their experiences and existing research. While brainstorming comments about future steps are attributed to attendees, presenters are recognized to put their comments in context.

- John Richardson, currently with Guggenheim Insurance but at the time with CNO Financial—Richardson provided background about how he became interested in this topic and shared some resources he has found valuable.
- Dr. Aled Jones, director of the Global Sustainability Institute (GSI) at Anglia Ruskin University in the U.K.—Resource on environmental issues in the U.K. Actuarial Profession.
- Dr. Paul Brandt-Rauf, dean of the School of Public Health at University of Illinois—Chicago—Eco-genocide: Social injustice and environmental non-sustainability.
- Dr. Leonard Sonnenschein, president of the World Aquarium and Conservation for the Oceans Foundation—Ocean and other productivity issues.
- Tim Harris, Milliman—Actuarial analysis.

Background

It is likely to take several outlier events occurring simultaneously to get the attention of the world's leaders. A hurricane hitting New York City, flooding in Beijing and a massive crop failure all occurring at the same time may be needed for the world to take notice and for behavior to change.

Richardson shared several resources that had engaged him about resource depletion. Other resources discussed are also included in the Appendix, with links to the original documents where available. It is important to keep in mind that there is a lot of good research already in the public domain. Actuaries need to pick out subject matter that makes the most sense for the profession's skill set rather than try to be all things to all people.

Much of the available material stresses the importance of being proactive about supply/demand issues as well as considering the planetary impact of the decisions we make —considering the feedback loops, interactions, and momentum of prior decisions.

Some efforts are already underway. Actuarial organizations in the U.K. and Australia have a head start on us, and the International Actuarial Association (IAA) has also been working on

topics related to sustainability. The next step for the SOA group is to decide what an actuary can do. There are already actuarial groups formed on this topic, but unfortunately they have not been highly publicized and have moved slowly. Some of the leaders so far have been Gail Tverberg, Susan Woerner, Oliver Bettis (U.K. Resource and Environment Member Interest Group REG), Jeff Beckley (SOA board) and Mary McKee (Indianapolis health policy). The IAA created their Environment Working Group in 2011, and Dr. Molly Jahn of University of Wisconsin, with sustainable agriculture interests, has been a strong resource. The IAA Environment Working Group held a summit, *Environment: A New Frontier for Actuaries*, in Los Angeles in 2012 that was well received, although specific follow-ups were unclear. The Australian Institute's Energy and Environment Committee is active, and a leader due to localized extreme drought and flooding (Fred Rowley is involved). The SOA formed the International Working Group on Actuarial Sciences and Sustainability (IWGASS) to identify research needs in this area and how actuaries could assist in analyzing and quantifying the potential risks.

The IWGASS developed this mission statement:

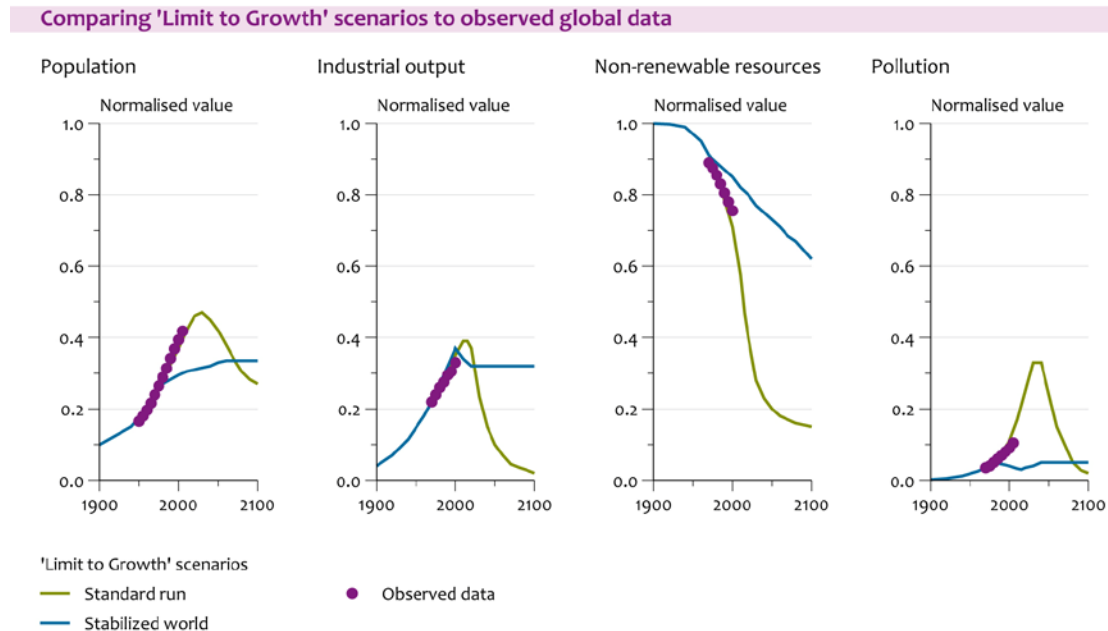
To integrate the professional expertise of individuals around the world from academia to the actuarial profession and industry to identify and analyze risks, perform research, and propose solutions related to environmental issues that threaten long-term sustainability. In particular, the actuarial skill set of risk and uncertainty management and financial analysis will be brought to bear to quantify or monetize the impact of potential risk mitigation and adaptation strategies, while members of academia, industry, and the actuarial profession will present current key issues of environmental, social and economic importance, and their relevant models and data, that can be addressed using the actuarial skill set. Specific areas of study may include (but not be limited to) climate change, natural resource depletion, water and air pollution, land management, agriculture and energy issues.

While several meetings of the IWGASS have been held, it was thought that the SOA actuaries on the committee needed a better understanding of the sustainability concept to be more effective in identifying research and other educational programs to meet the needs of the actuarial profession. This resulted in the Dec. 12, 2012 summit.

It is likely that actuarial bodies from around the world will continue to investigate the role of actuaries in natural resource sustainability issues and educating the public, policymakers and others of the actuarial skill sets for measuring financial and societal risks associated with resource depletion. It is expected that sessions will be created for the International Congress of Actuaries (ICA) 2014 meeting in Washington, D.C., along with other meetings, to educate actuaries on this important topic.

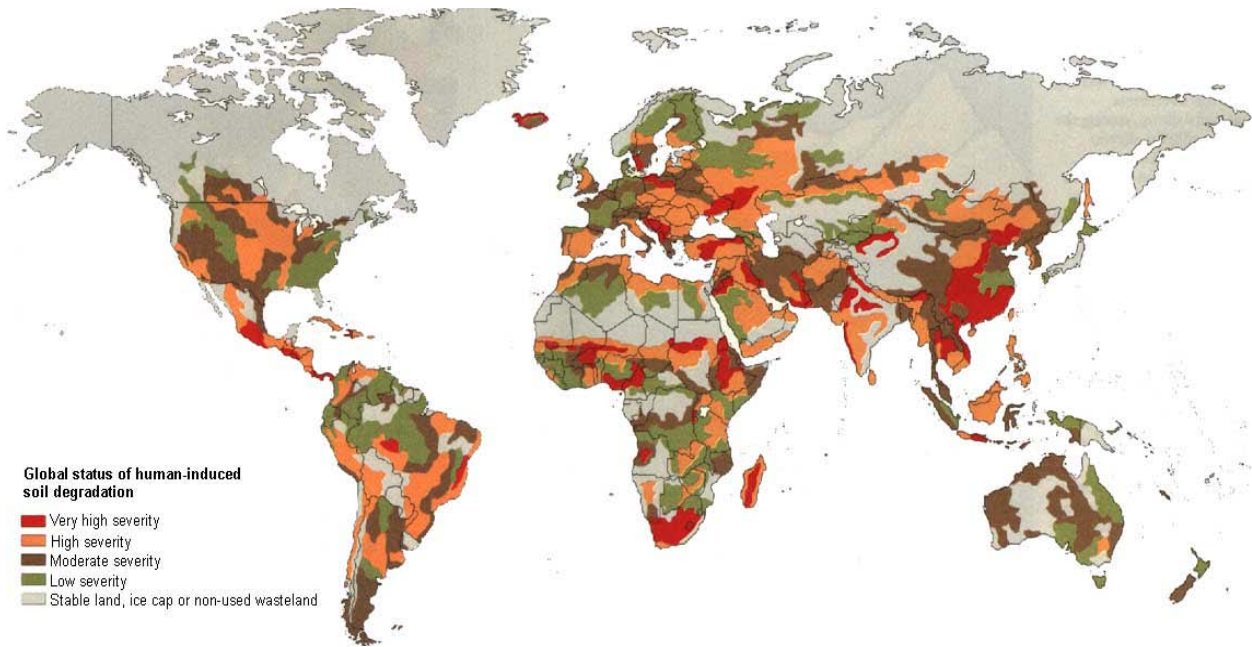
Current Status of U.K. Efforts

Dr. Aled Jones, from the Global Sustainability Institute, shared his Limits to Growth (LTG) research project. This builds on the original Limits to Growth research in 1972 (the World3 model), which has been recently investigated to see how closely the scenarios developed followed actual events.

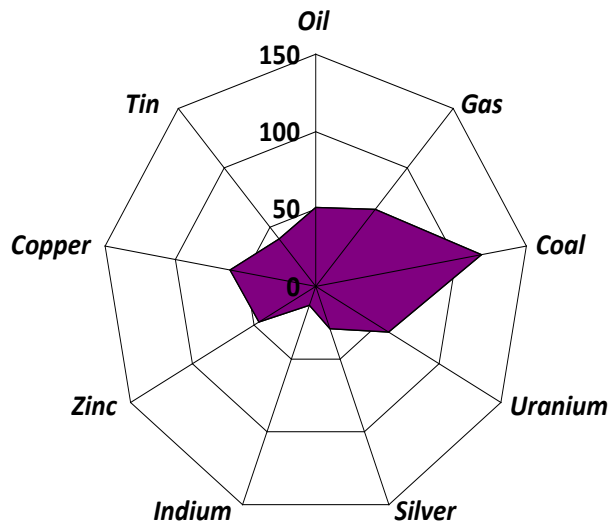


The above chart shows a comparison of World3 Limits to Growth scenarios to observed data taken from *Growing within Limits: A Report to the Global Assembly 2009 of the Club of Rome*, PBL Netherlands Environmental Assessment Agency, October 2009.

The U.K. Actuarial Profession has also teamed with Jones to work on resource limitations and behavioral modification. This project took a *systems view of the natural and social (human) capitals—What do scarce resources potentially mean for the system flows in a global economy and in particular to financial capital?* Focus is on energy, food, water, land, commodity, social mobility and environmental loading (quantifying a tipping point). This report consolidates publicly available data and views them from an actuarial perspective. Around 2040, when some anticipate a maximum world population of 8 billion people, key issues will be water availability, the degradation of soils, and resource depletion (consider substitution, price changes due to supply/demand). Not surprisingly, demographic assumptions like fertility and migration are found to matter a lot in these scenarios.



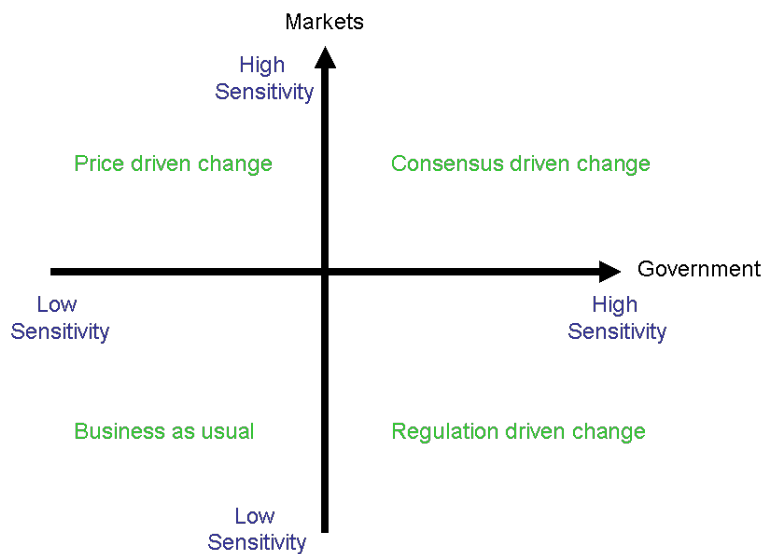
The above chart shows the global status of human-induced soil degradation and is taken from Agriculture and Consumer Protection Department—Food and Agricultural Organization of the United Nations (FAO), “Dimensions of need: An atlas of food and agriculture,” FAO Corporate Document Repository (<http://www.fao.org/docrep/u8480e/U8480E0D.HTM>) [accessed March 2012].



The above chart shows current global reserves divided by current annual consumption (assuming no growth in demand) for each of several resources to estimate the number of years remaining.

For example, it shows that oil has about a 50-year supply remaining based on this calculation. Data taken from BP Statistical Review 2012, <http://bp.com/statisticalreview> and David Cohen, “Earth's natural wealth: an audit,” *New Scientist*, Issue 2605 (23 May 2007) pp. 34–41.

Four scenarios were developed for the U.K. research using a standard grid scenario technique. The grid explores the market and government response to resources and whether each operates in a long term (high sensitivity to resource constraints) or short term (low sensitivity to resource constraints) fashion. The quadrants of the grid then form the basis for four future scenarios: business as usual; price-driven change; regulation-driven change; and consensus-driven change. For example, price-driven change is low sensitivity government and high sensitivity markets (market driven). As part of this project, pension funds were modeled under these scenarios with two examples in each quadrant, with many showing severe shortcomings (especially business as usual).



Current literature usually explores future growth either being positive, green growth (environmentally managed growth), no growth, or beyond the limits where the impacts of global warming are too severe to be managed and cause economic collapse.

How resources impact leading indicators is complex, and measuring these impacts is not straightforward. For example, you could measure water stress by measuring the spreads required to sell municipal bonds in a specific location. Managing the risks associated with these global trends is also not straightforward. Some countries are buying up large amounts of foreign land based on available resources. The defense industry, for example, is very interested in these types of projections when considering future conflicts.

Medical Ecology

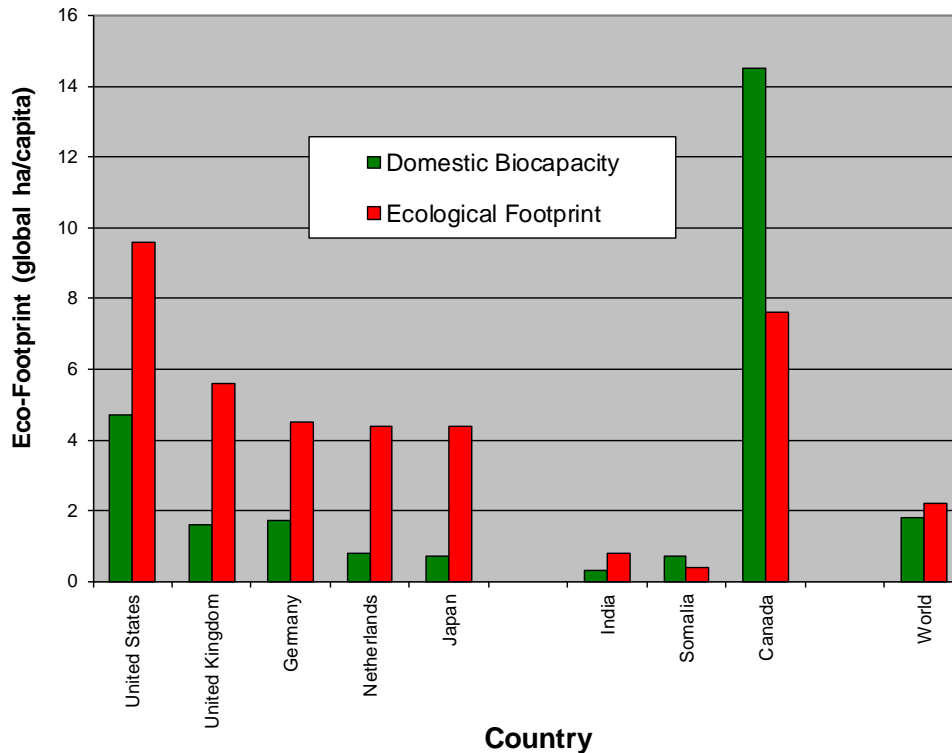
Dr. Paul Brandt-Rauf shared research about the feedback loop between humans and the natural environment. He noted that, until recently, humans had a small ecological footprint. As populations grew exponentially, the industrialized economy increasingly used up natural resources and generated pollution to increase the footprint size. This led to higher disease and premature death, with poverty intertwined with poor health. Per Paul Hawkins' commencement address at the University of Portland in 2009, we are "stealing the future, selling the present, and calling it GDP." Election cycles tend to drive the public decision-making process.

Climate change may have greatest impact on countries least able to respond, making it harder for them to develop their economy and improve living standards. The poor often live in areas characterized by toxic waste, polluted air/water and contaminated food. Where does the responsibility lie ethically to help them?

To help standardize the "ecological footprint" of a region's population, some have defined it to be *the area of land and water ecosystems required to produce the resources that the population consumes, and to assimilate the wastes that the population produces, wherever on Earth the relevant land/water may be located*. The earth has limited biocapacity, so this will impact future conflicts and displace other species from their natural environment. Current trends are unsustainable, and driven by financial disparity, yet past history shows that resources are inevitably overexploited (as seen in Jared Diamond's *Collapse*). The top in terms of most harmful ecological footprints (per capita) are in North America, certain more developed Commonwealth nations, Europe and Japan. Only Canada has the biocapacity to support its ecological footprint. In the United States the reductions necessary to be sustainable are 80 percent or greater.

The following chart provides biocapacities and ecological footprints for selected countries.

Biocapacities and Ecological Footprints of Selected Countries Compared to World Averages



Source: William Rees from the Fifteenth Granville H. Sewell Distinguished Lecture in Environmental Health Sciences at Columbia University in 2008.

Some popular myths consider the carrying capacity of the earth as infinite, or that science will always stay a step ahead with substitution options that make limited resources irrelevant. Unfortunately, economic activity degrades resources and increases entropy.

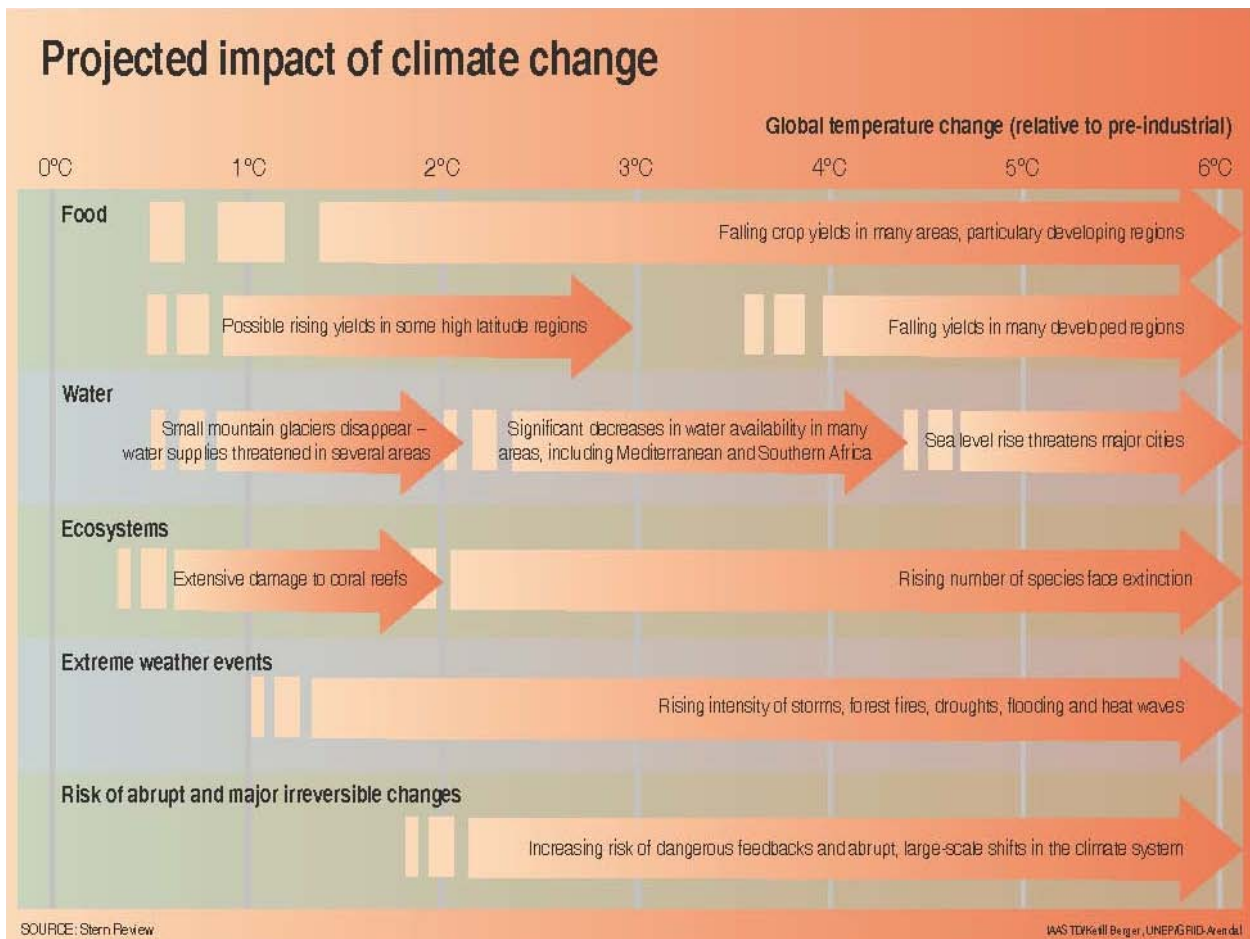
Measurement using only economic growth can be misleading as happiness surveys and life expectancy metrics do not improve with GDP. One suggested scenario is that rich countries take the resources from poorer countries, eat to excess, and die early from obesity. Yet the status quo continues even though today's technology can enable lower resource use and a higher quality of life.

Alternative measures to GDP are available for countries to measure value. The French government, among others, instituted such a so-called happiness index as one of multiple measures used.

Brandt-Rauf noted that Darwin was right and humans are in the process of selecting ourselves out. He suggests considering a smaller discount rate so far-off events matter to today's decision makers.

Lessons from the Oceans

Dr. Leonard Sonnenschein discussed the signals given by the oceans relative to climate change. He summarized a chart from the Stern Review on the Economics of Climate Change (shown below), a 2010 report from the U.K. showing the impact of global temperature changes. While some opportunities might exist, such as crop options and yields in the higher latitudes, in general higher temperatures lead to discontinuities and extreme events including accelerated species extinction. With just a few-degree rise, the risk increases of feedback and abrupt changes to the climate system.



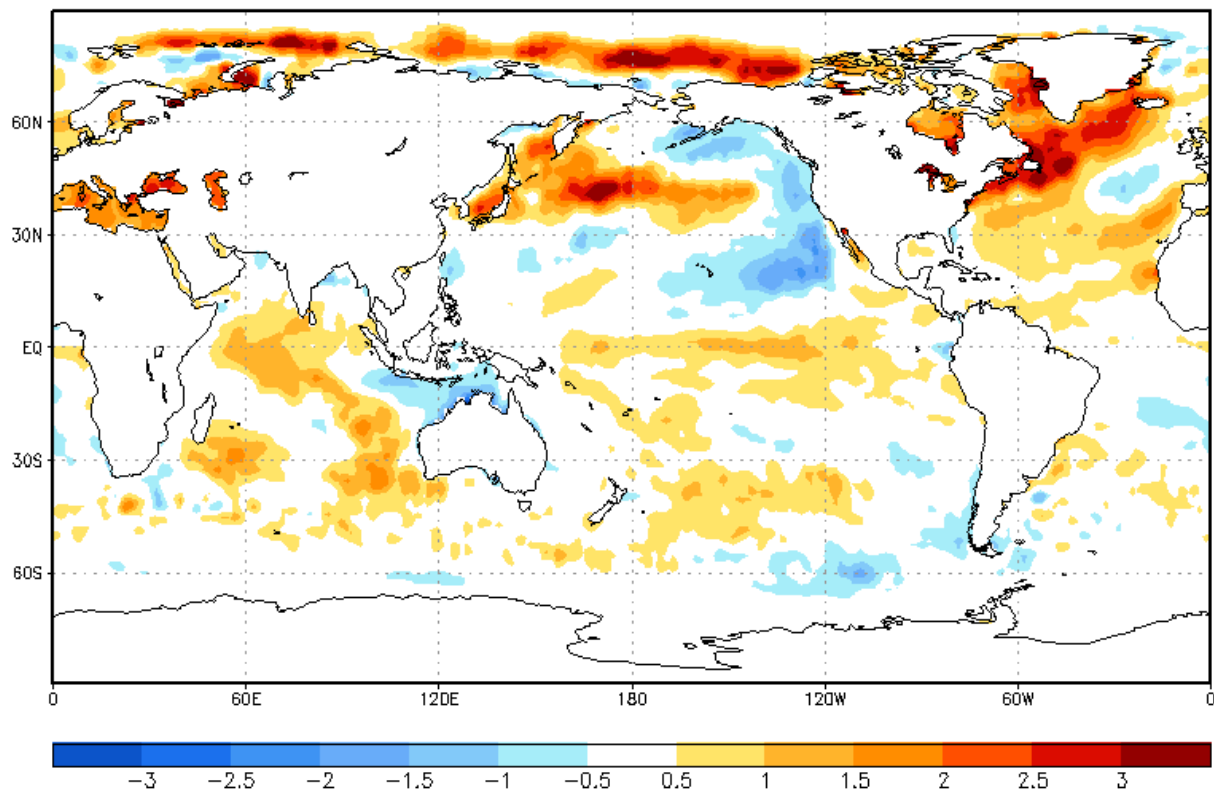
Source: Stern Review on the Economic Effects of Climate Change, http://webarchive.nationalarchives.gov.uk/20130129110402/http://www.hm-treasury.gov.uk/stern_review_report.htm.

As a specific example, he discussed the North Atlantic Conveyor. As glaciers melt, they add freshwater to the oceans. The ocean circulation conveyor belt helps balance climate. As part of the ocean conveyor belt, warm water from the tropical Atlantic moves poleward near the surface where it gives up some of its heat to the atmosphere. This process partially moderates the cold temperatures at higher latitudes. As the warm water gives up its heat it becomes more dense and sinks. This circulation loop is closed as the cooled water makes its way slowly back toward the tropics at lower depths in the ocean.

Per Sonnenschein, in addition to higher ocean levels and their impact on shoreline areas and fisheries, this lowers the ocean's salt content and increases its acidity. This increases extreme weather events such as hurricanes, tornados and convection storms by impacting the jet stream. This also appears to be a driver for the El Nino/La Nina cycle and the ocean circulation conveyor that moves warm and cold water that affects climate.

Not only have there been increases in global water temperatures, but land temperatures have also seen anomalies.

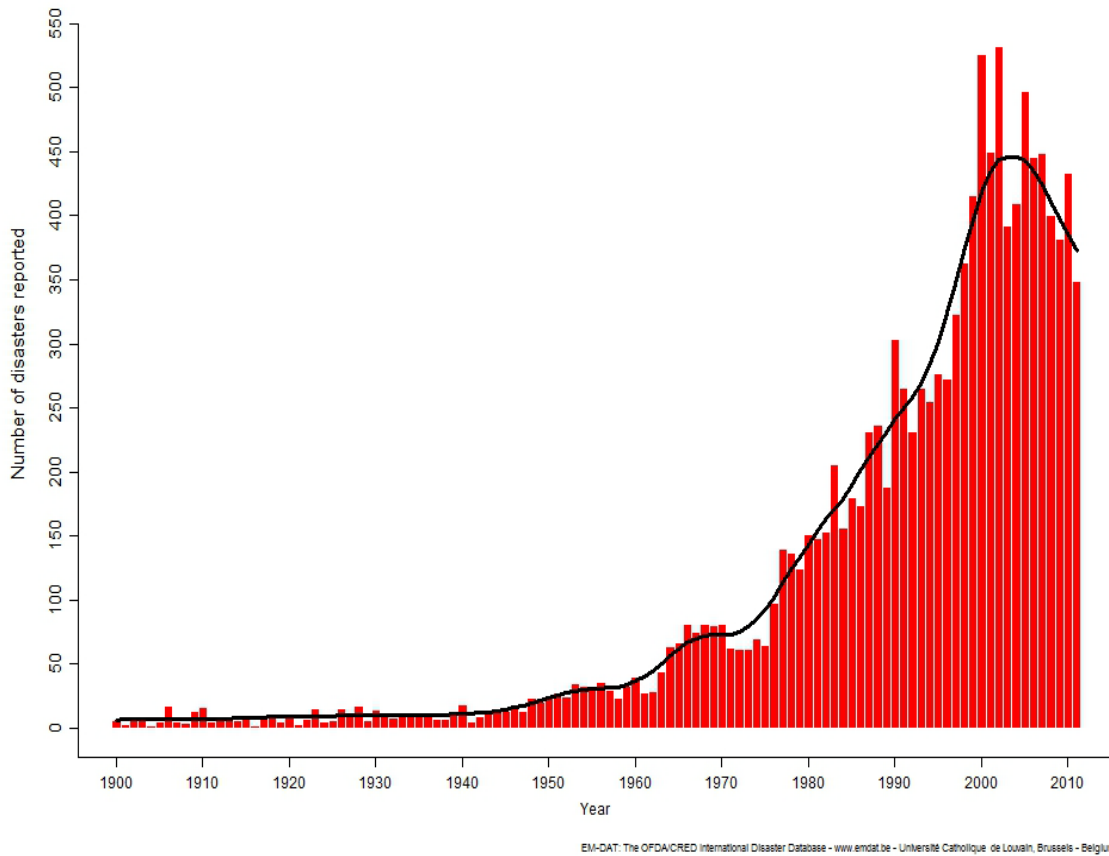
August 2012 Sea Surface Temperature Anomalies (Reynolds OI.v2)



Source: Reynolds Optimally Interpolated Sea Surface Temperature Data (OISST) available through the NOAA National Operational Model Archive & Distribution System (NOMADS).

As we saw with Hurricane Katrina in New Orleans and Sandy in New England, these storms are disruptive and costly. With each passing year, the number of natural disasters reported increases. As Sonnenschein indicated, as the global temperature increases, expect natural disasters to increase as well.

Natural disasters reported 1900 - 2011



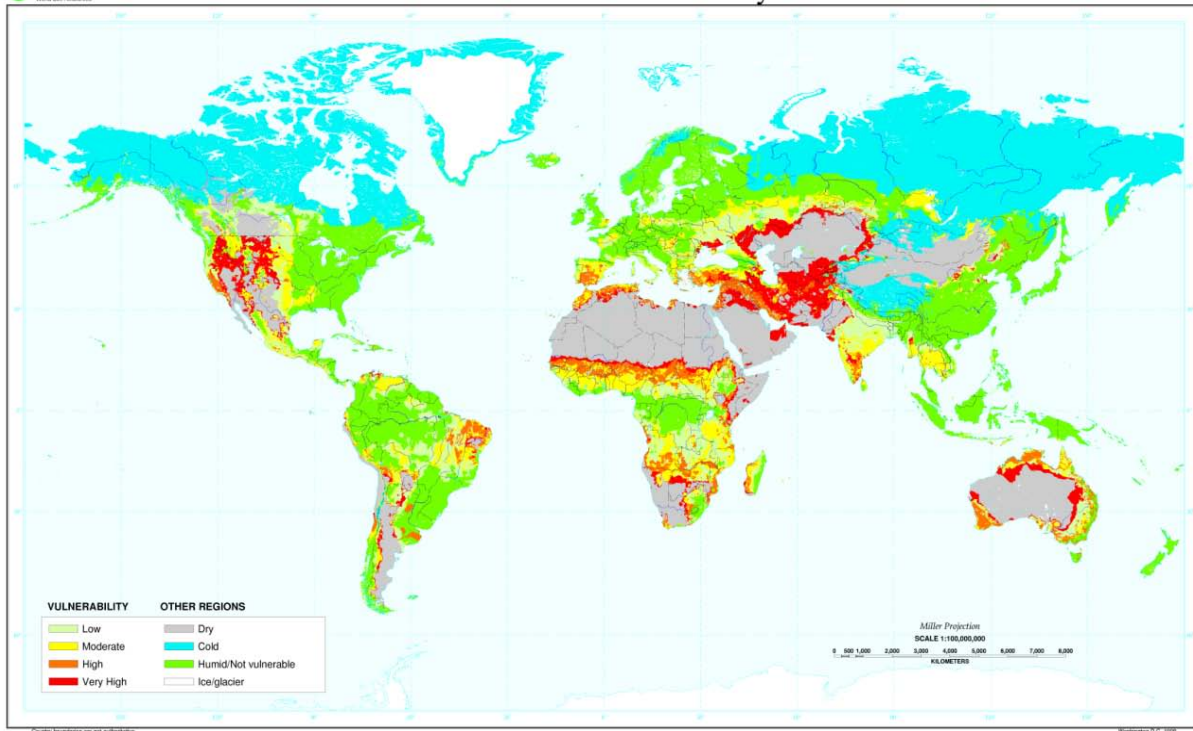
Source: EM-DAT, The International Disaster Database, <http://www.emdat.be/natural-disasters-trends>.

Desertification

Per Sonnenschein, according to the Food and Agricultural Organization of the United Nations, desertification is "land degradation in arid, semi-arid and dry subhumid areas resulting from various factors, including climatic variations and human activities."

Desertification and rising sea levels are concomitant effects of global surface temperature rise, showing the true impact of climate change. As temperatures rise and crop productivity increases in some areas, overuse and soil degradation increase the need for fertilizer and other activities to rebuild the soil.

Desertification Vulnerability



Source: U.S. Department of Agriculture, Natural Resource Conservation Service, Soil Survey Division, World Soil Resources.

Some of the human activities that can cause desertification are:

- Cultivation of soils that are fragile, or exposed to erosion by wind or water;
- Reduction in the fallow period of soils, and lack of organic or mineral fertilizers;
- Overgrazing—often selectively—of shrubs, herbs and grasses;
- Overexploitation of woody resources, in particular for fuelwood;
- Uncontrolled use of fire for regenerating pasture, for hunting, for agricultural clearing, or for settling certain social conflicts;
- Agricultural practices that destroy the soil structure, especially the use of unsuitable agricultural machinery;
- Agricultural practices that result in the net export of soil nutrients, leading to loss of the soil fertility, such as cash-cropping;
- Diversion of rivers to create irrigation schemes; or
- Irrigation of soils prone to salinization, alkalinization or even waterlogging.

Climate change affects ocean productivity. Ocean productivity is extremely important to the global economy.

- Billions of people throughout the world rely on fish as a primary source of protein, particularly in developing countries with rapidly expanding populations. Worldwide, fish provide over 2.6 billion people with more than 20 percent of their animal protein.
- The world’s fisheries generate over US\$130 billion annually, and contribute significantly to the economies of many countries. Even where fisheries are not important on a national level, they can be critical for regional employment, where entire communities of small-scale fishermen rely on fishing as their primary source of income.
- Worldwide, over 38 million people earn an income by fishing or raising fish, and if activities associated with fisheries production are included, fisheries support over 200 million people. In industrialized countries, recreational fishing also provides a large source of income.

World Fisheries and Aquaculture Production and Utilization

	2006	2007	2008	2009	2010	2011
<i>(Million tonnes)</i>						
PRODUCTION						
Capture						
Inland	9.8	10.0	10.2	10.4	11.2	11.5
Marine	80.2	80.4	79.5	79.2	77.4	78.9
Total capture	90.0	90.3	89.7	89.6	88.6	90.4
Aquaculture						
Inland	31.3	33.4	36.0	38.1	41.7	44.3
Marine	16.0	16.6	16.9	17.6	18.1	19.3
Total aquaculture	47.3	49.9	52.9	55.7	59.9	63.6
TOTAL WORLD FISHERIES	137.3	140.2	142.6	145.3	148.5	154.0
UTILIZATION						
Human consumption	114.3	117.3	119.7	123.6	128.3	130.8
Non-food uses	23.0	23.0	22.9	21.8	20.2	23.2
Population (billions)	6.6	6.7	6.7	6.8	6.9	7.0
Per capita food fish supply (kg)	17.4	17.6	17.8	18.1	18.6	18.8

Notes: Excluding aquatic plants. Totals may not match due to rounding. Data for 2011 are provisional estimates.

Source: Food and Agriculture Organization publication, “The State of World Fisheries and Aquaculture 2012,” <http://www.fao.org/docrep/016/i2727e/i2727e00.htm>.

There are several factors that affect ocean productivity:

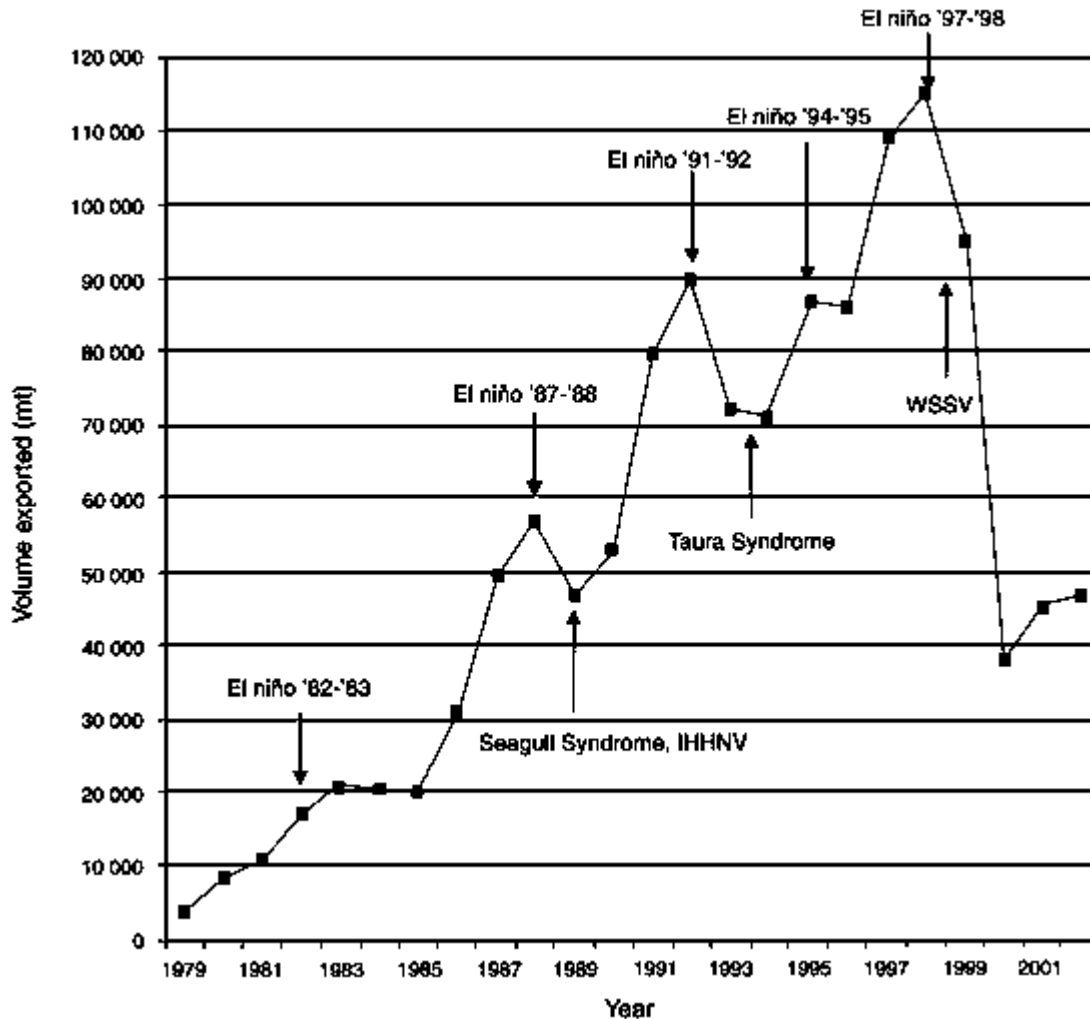
- Pollution
- Water temperature

- Unregulated fishing
- Disease.

Aquaculture is growing with demand, but fisheries could be near a tipping point as many larger fish are already gone. Pollution, water temperature, unregulated fishing and disease all interact to make this a challenging environment, with trends hard to reverse in many species. Some fish farms have been closed to allow the environment to recuperate.

Ocean Temperatures Impact Disease

Increased ocean temperatures also bring increased incidence of disease. The graph below shows shrimp aquaculture production as compared to temperature, which resulted in a disease. Please note where the “El Nino” creates a temperature increase along with a disease.



Source: Food and Agriculture Organization, "Threats and Risks of Introducing Alien Shrimp Species," <http://www.fao.org/docrep/009/a0086e/a0086e10.htm>.

What is sustainability?

- Everything that we need for our survival and well-being depends, either directly or indirectly, on our natural environment. Sustainability creates and maintains the conditions under which humans and nature can exist in productive harmony, that permit fulfilling the social, economic and other requirements of present and future generations.
- Sustainability is important in making sure that we have, and will continue to have, the water, materials and resources to protect human health and our environment.
- From an actuarial standpoint, data as renewable vs. non-renewable with peak levels of sustainability are necessary to assess a dependence mechanism for keeping productivity at functionable levels.

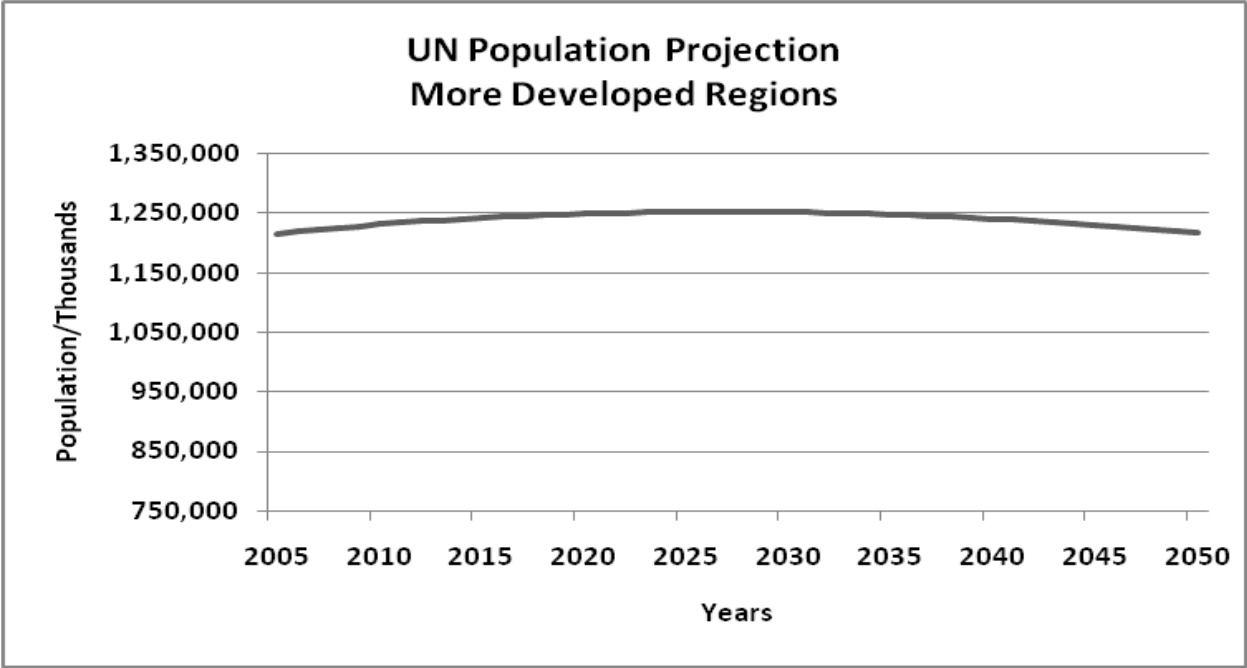
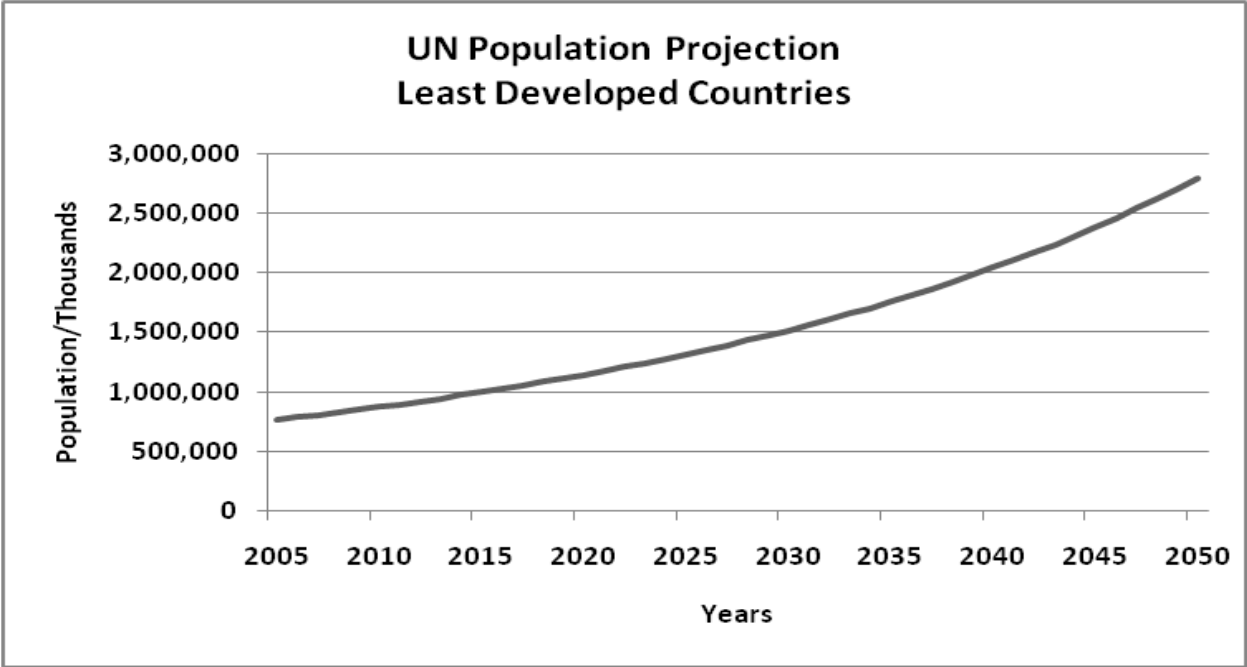
Human actions that affect sustainability:

- Increasing concentrations of carbon dioxide in the atmosphere
- Alterations in the biogeochemistry of the global nitrogen cycle
- Land use/land cover change
- Value of natural resource commodities
- Productivity
- Transportation
- Government subsidies.

At www.coolcalculator.org you can calculate your personal carbon footprint.

Where Can Actuaries Help?

Tim Harris shared his thoughts about the skill set brought to the table by actuaries. The profession's modeling expertise could be used to run static and dynamic projections that model the supply and demand of the earth's resources. These could be integrated with demographic projections to influence behavior. Other tasks could include communication of the issues to SOA members, funding research and publishing/presenting on this topic.



Discussion of Actuarial Role in Quantifying Resource Limitations and Identifying Implications

During the day the discussion was broad and far ranging. The group agreed that the goal of the actuarial profession should be to provide unbiased information that allows decision makers to work with facts. It is acknowledged that it will take many years to prove or disprove climate change theories, so looking at exposures rather than exact models may be more useful.

The actuarial profession needs to determine if this topic is important enough to allocate the resources, excitement and passion necessary to pursue it today.

Interest could come from governments (federal/state/local, politicians, regulators), scientists, environmental groups, individuals, insurers (and other financial institutions) and non-financial companies.

Brainstorming

As Fred Kilbourne famously said in 1978, “*An actuary is that professional who is trained in evaluating the current financial implication of future contingent events.*” Today an esteemed actuary might expand this to say: “*An actuary is that professional who is trained in evaluating the future financial implications of today’s decisions.*” Our skill set seems ideal (relative to others) to analyze the many “known unknowns” and “unknown unknowns” along with stable historical distributions.

The SOA impacted social behavior about smoking by quantifying the cost of secondhand smoke. Can this approach be utilized to help us jump-start efforts to quantify sustainability risks?

Not surprisingly, sustainability is not an easy topic. The group offered more questions than answers. The following is a sampling of some of the thoughts of the participants.

Do we really know what the effects of actions that threaten sustainability are? The impact on assumptions like mortality and morbidity is not measurable using a tight statistical distribution. This means that the cost to insurers and other companies is uncertain, as are the capital implications. Are the implications quantifiable over any time period, short or long? How do we put a value on externalities? Any analysis must take into account both macro issues like government interventions and micro issues, where individuals and companies adjust their decision-making process. The typical model used can be termed a growth model (capital), and seeks greater efficiency (e.g., return on capital).

Should we spend time creating unique models or understanding existing models of the environment? What does the model of the current environment tell us? We need to understand the nuances of these inherited models, and effectively communicate our own models.

Model construction should not let the perfect stand in the way of the good. For sustainability issues, backcasting won't pick up tipping points, so the recent past is not very helpful when trying to model the future. A lot of casualty models are outcome models. Life models are process models. Can we expand the process models?

How quantifiable are impacts on sustainability at the current stage? Everything will be affected, but it may not be quantifiable at the moment. Do we know enough to build the right kind of models? There are models out there. Creating reasonable assumptions may be a greater challenge than finding a realistic model. (e.g., how do we "model" the survival of a company in perpetuity? Fundamentally we are saying this is the actuary's job now!).

Some participants offered general suggestions in terms of what they believe actuarial models for sustainability might look like.

Sustainability has a time frame of forever. It's not our generation, nor our grandkids. It is a perpetuity that requires a long time horizon. These considerations should be dynamic, possibly using complexity theory and complex adaptive systems to consider future alternative scenarios. This leads directly to exposures, stress scenarios and "what-if" analysis that focuses as much on qualitative as quantitative analysis.

Models developed for public consumption need to have limitations described. If models are made free and available, we would tell them to use at their own risk. If proprietary, more discussion would need to be held about distribution of results.

What Could the SOA Do?

Discussion ensued on what the SOA could do related to sustainability. Among the considerations outlined below was developing a new area of actuarial practice around sustainability to provide basic and continuing education. Another theme was providing research or public comment on practical public policy questions, potentially partnering with others to identify, analyze and offer solutions to sustainability risks. A third common thread was organizational, providing outlets for actuaries interested in sustainability issues to interact with each other.

Education

- Develop a business case for why actuaries should be concerned about sustainability.

- Develop material for the FAP modules.
- Sponsor a roundtable, asking experts (actuaries and others) about sustainability issues. This could lead to an article in *The Actuary* and/or a podcast.
- Write a white paper hypothesizing that years of inaction look okay until we cross a tipping point and the planet can't recover.
- Write a white paper showing what actuaries can add to these discussions.
- Write one or more white papers about the impact of recent events—e.g., drought, wildfires, Sandy. Include quantitative and qualitative effects. Compare to normal events.

Research/Practical Issues

- Use the secondhand smoke study as a model for a research project.
- Research project to determine if the sustainability target distribution is moving.
- Research project on sustainability of agricultural practices.
- Research project on the impact of demography on sustainability topics.
- Issue a series of white papers (using ideas suggested elsewhere) on risk topics that could affect actuarial practice. Put in a stress scenario as part of each report. This would extend beyond climate change/sustainability scenarios.
- Write a series of case studies based on emerging risks. This could include current topics like health care reform and not be limited to sustainability events.
- Write position papers modeled after those created by RMS dealing with specific risk scenarios.
- Develop a set of sustainability scenarios and their impact. Although many of these risks are interrelated, we need to make this more about sustainability (resilience) versus specifically climate change. How does our species survive? If we're going to do multiple scenarios, we should look at resource depletion or other issues beyond climate change. Perhaps we would partner with other, non-actuarial, organizations such as the Gates Foundation.

Organizational

- Create a new section (or get the Social Insurance and Public Finance Section interested in this topic). Consider making it a joint section with the CAS and CIA.
- Local audiences may be more easily engaged, but this requires a broader commitment by members and local actuarial clubs.

Conclusion

Natural resource sustainability is a broad global topic, as illustrated by the summit's diverse presenters. The potential implications to all facets of society make it imperative to manage these risks. The summit identified areas for actuarial involvement to quantify and measure potential financial implications of the risks, with opportunities to partner with other disciplines and organizations to analyze and model resource supply and demand.

In other parts of the world, widespread environmental/climate shifts, whether temporary or permanent, have necessitated governments, businesses, professions and support systems to take action. In the United States, to date this has not been the case. Given the SOA's strategic objectives to be a global organization and the leading technical information resource for the actuarial profession, the role of the actuary and the actuarial profession in sustainability issues may need to receive a higher priority from the SOA's board of directors.

The summit began framing these issues, brainstorming how actuaries might include these types of contingent events, who the audience might be for the information, and suggestions on what the SOA could be doing on this topic. To move forward and determine the appropriate avenue for the SOA and the actuarial profession, additional consideration and guidance will be needed. In the meantime, the IWGASS will continue to explore research ideas, educating members and others on how actuaries can assist in analyzing, measuring and mitigating the potential risks associated with natural resource limitations.

Appendix

These resources were mentioned as valuable during the Natural Resource Sustainability Summit in December 2012.

Our Finite World—Implications for Actuaries by Gail Tverberg, May/June 2007 *Contingencies*. <http://www.contingencies.org/mayjun07/finite.pdf>.

Uncertainty about Future Oil Supply Makes It Important to Develop a Strategy for Addressing a Peak and Decline in Oil Production, February 2007 GAO report. <http://www.gao.gov/products/GAO-07-283>

Hirsch Report for U.S. Department of Energy—Peaking of World Oil Production: Impacts, Mitigation, and Risk Management. http://www.netl.doe.gov/publications/others/pdf/oil_peaking_netl.pdf

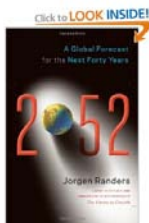
The Long Emergency. <http://www.amazon.com/Long-Emergency-Converging-Catastrophes-Twenty-First/dp/B0018SWA0Q>

Ishmael. http://www.amazon.com/Ishmael-Adventure-Spirit-Daniel-Quinn/dp/0553375407/ref=sr_1_1?s=books&ie=UTF8&qid=1365552120&sr=1-1&keywords=ishmael+by+daniel+quinn

Plan C. http://www.amazon.com/Plan-Community-Survival-Strategies-Climate/dp/0865716072/ref=sr_1_2?s=books&ie=UTF8&qid=1365552216&sr=1-2&keywords=plan+c

www.energybulletin.net

World Economic Forum—More with Less: Scaling Sustainable Consumption and Resource Efficiency from January 2012. <http://www.weforum.org/issues/sustainable-consumption>



This book is an update of the original *Limits to Growth*. Peak population is expected to be 2052, but no economic collapse is predicted before 2052; however, growth is significantly lower than traditionally modeled. http://www.amazon.com/2052-Global-Forecast-Forty-Years/dp/1603584218/ref=sr_1_1?s=books&ie=UTF8&qid=1369334634&sr=1-1&keywords=2052



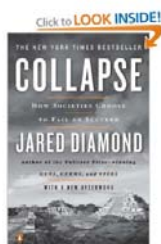
Originally printed in 1972 with peak population in 2040. The projections have played out fairly well to date. Mass starvation in the second half of the 21st century is predicted. http://www.amazon.com/Limits-Growth-Donella-H-Meadows/dp/0451057678/ref=sr_1_2?s=books&ie=UTF8&qid=1369334692&sr=1-2&keywords=limits+to+growth

The Effects of 'Limits to Growth' on Financial Markets and Consequential Impacts on Actuarial Advice. <http://www.actuaries.org.uk/events/one-day/effects-limits-growth-financial-markets-and-consequential-impacts-actuarial-advice>

Climate Change and Resource Depletion: The Challenges for Actuaries. Review of literature 2010. I. Allen, N.G. Aspinall, S.D. Baxter, O.D. Bettis, S.J.R. Brimblecombe, F. M. Brofman-Epelbaum, C. Fitzgerald, S. Harrison, V.J. Hodge, C.C. Jones, B.P. Maher, E.H. McNeill, P.G. Meins, A. Mookerjee, G. Morrison, N. Niami, N.G. Silver, T. Zalk, Institute and Faculty of Actuaries. <http://www.actuaries.org.uk/research-and-resources/documents/climate-change-and-resource-depletion-challenges-actuaries>

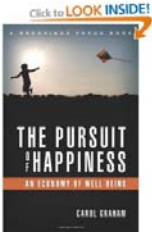
Climate Change and Resource Depletion: The Challenges for Actuaries. Review of literature 2011. I. Allen, N.G. Aspinall, S.D. Baxter, O.D. Bettis, S.J.R. Brimblecombe, F.M. Brofman-Epelbaum, C. Fitzgerald, Dr S. Harrison, V.J. Hodge, C.C. Jones, B.P. Maher, E.H. McNeill, P.G. Meins, A. Mookerjee, G. Morrison, N. Niami, N.G. Silver, T. Zalk. <http://www.actuaries.org.uk/research-and-resources/documents/climate-change-and-resource-depletion-challenges-actuaries-review-1>

A third monograph will be released in 2013 (with professor Richard Werner) detailing the sustainability of the financial system.



Jared Diamond's book *Collapse* looks at various groups that failed to adapt as their environment evolved and reacted to their actions. http://www.amazon.com/Collapse-Societies-Choose-Succeed-Revised/dp/0143117009/ref=sr_1_1?s=books&ie=UTF8&qid=1369334734&sr=1-1&keywords=collapse+how+societies+choose+to+fail+or+succeed

National Intelligence Council, Global Trends 2030: Alternative Worlds, December 2012.
http://www.dni.gov/files/documents/GlobalTrends_2030.pdf



Carol Graham at the University of Maryland has written a small book looking at alternatives to economic measures of growth.

Stern Review on the Economics of Climate Change
http://webarchive.nationalarchives.gov.uk/+http://www.hm-treasury.gov.uk/sternreview_index.htm

Cultural Theory, Climate Change and Clumsiness by Michael Thompson is available at www.jstor.org.

Introduction to Complexity Science, Alan Mills. <http://www.soa.org/research/research-projects/health/research-complexity-science.aspx>

Calculate your personal carbon footprint at www.coolcalculator.org.

Munich Re 2012 climate change paper.
http://www.munichre.com/en/group/focus/climate_change/default.aspx

RMS website: www.rms.com.

Other resources that might be of interest to actuaries:

Actuaries and the Environment in Australia, Jill Green, *The Independent Consultant*, November 2008, Society of Actuaries.
<http://newsletters.soa.org/soaic/issues/2008-11-15/2.html>

Resource Constraints: Sharing a Finite World. Implications of Limits to Growth for the Actuarial Profession. Dr Aled Jones, Irma Allen, Nick Silver, Catherine Cameron, Candice Howarth and Ben Caldecott, Institute and Faculty of Actuaries. <http://www.actuaries.org.uk/research-and-resources/documents/research-report-resource-constraints-sharing-finite-world-implicati>

Environment: Carbon Accounting, *The Actuary*, Institute and Faculty of Actuaries.
<http://www.theactuary.com/archive/old-articles/part-6/environment-3A-carbon-accounting/>

Environment: The Green Guardians. Louise Prior and Tracey Zalk, *The Actuary*, June 2013, Institute and Faculty of Actuaries.

<http://www.theactuary.com/features/2013/06/environment-the-green-guardians/>

The Environment: What Are Actuaries Doing? Therese Kieve, *The Actuary*, August 2012, Institute and Faculty of Actuaries.

<http://www.theactuary.com/features/2012/08/the-environment-what-are-actuaries-doing/>

How Actuaries Can Help with Problems of Sustainability and the Environment, *The Actuary*, Institute and Faculty of Actuaries.

<http://www.theactuary.com/archive/old-articles/part-3/how-actuaries-can-help-with-problems-of-sustainability-and-the-environment/>

Resources and Environment: A New Challenge for Actuaries, Yves Guérard.

http://www.actuary.org/files/Actuaries-JUN180-2013_P10-12.pdf

Sustainable Development and the Actuary, *The Actuary*, Institute and Faculty of Actuaries

<http://www.theactuary.com/archive/old-articles/part-3/sustainable-development-and-the-actuary/>

Institute of Actuaries of Australia website:

<http://www.actuaries.asn.au/>

International Actuarial Association's Resource and Environment Working Group Web page:

http://www.actuaries.org/index.cfm?lang=EN&DSP=CTTEES_ENVIRO&ACT=INDEX

Institute and Faculty of Actuaries Resource and Environment Member Interest Group Web page:

<http://www.actuaries.org.uk/members/pages/resource-and-environment-member-interest-group-reg-mig>