Taking ecology's temperature in a warming world

Sybille Haeussler

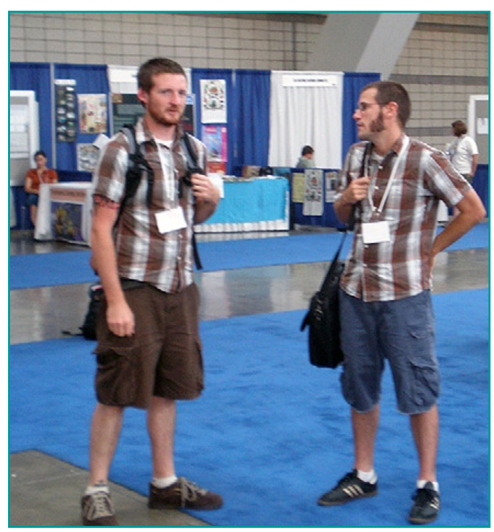
It is a truism in science that assembling a huge data set allows patterns to emerge that cannot be detected from smaller sets of observations. That being the case, what does the combined work of more than 6400 scientists tell us about the ecological effects of climate change? To find out, I spent a steamy week this summer in Pittsburgh, Pennsylvania, participating in the world's largest annual gathering of ecologists.

The Ecological Society of America (ESA) met August 1–6, 2010, to address the challenges of global warming. I attended in my capacity as Research Co-ordinator for British Columbia's Future Forest Ecosystems Scientific Council, aiming to see whether any lessons from the 713 posters and 1972 oral presentations could help to adapt the management of British Columbia's forest and rangeland ecosystems to a rapidly changing climate.

I can confidently report that ecologists are doing their bit for the planet by not spending extravagantly on high-fashion clothing and personal grooming (see opposite). After making that observation, my brain—seeking more significant truths—quickly began to feel like an ice cream cone on a hot Pittsburgh sidewalk. But having had some time to recover in northern British Columbia, I assembled my personal list of Top 10 Big Ideas emerging from the conference (see next page).

I have an overdeveloped confidence in the predictive power of science and mathematics. Thus, for me the most important take-away message was eloquently summed up by a young population biologist from Michigan who reported on 50 years of monitoring the wolf and moose populations of Isle Royale in Lake Superior, the longest continuous study of any predator–prey system in the world. His conclusion? Ecology can explain the past but it cannot predict the future. The true value of 50 years of uninterrupted data, he asserted, is that it generates a sense of wonder about Nature and shows how powerful narrative can be in communicating the marvellous complexity of ecosystems. I would add that intergenerational research like this also helps researchers become humble and wise before their time.

The exceptional variability and context-dependent behaviour of ecosystem responses to global change was a theme that repeated itself over and over throughout the week.



Justin Montemarano

ESA delegate encounters his doppelgänger.

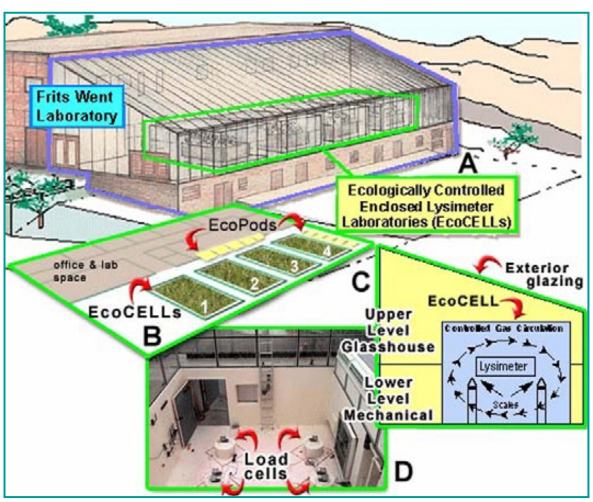
Top Ten Take-Away Ideas

1. Climate change must be addressed within an overall framework of Planetary Stewardship that radically reorients the human relationship with the biosphere so as to slow and ultimately reverse the stress placed on the Earth's life support system. Ecologists are obliged to be leaders in this change.
2. Carbon policies and climate change adaptation strategies cannot be developed without consideration of other biogeochemical cycles (water, nitrogen, silicon) and global change drivers such as oil spills and other environmental disasters, loss of biological and cultural diversity, population growth, warfare and social dislocation, invasive organisms, and trade policy.
3. Collaboration of ecologists with other natural and social scientists, traditional knowledge practitioners, resource harvesters, land managers, policy-makers, and concerned citizens is becoming the norm. Ecologists should actively engage with the public and policy-makers and not shy away from science-based advocacy.
4. Ecologists must shift their focus from "natural" systems to social-ecological systems because the biosphere and anthroposphere are inextricably coupled.
5. Science can explain the past but it cannot predict the future. There are many plausible predictions but no definitive answers. The purpose of forecasting is not to be right, but to avoid being surprised. Adaptation strategies must therefore be focussed on managing uncertainty rather than on achieving specific outcomes.
6. If we protect the diversity of structure, function, and cross-scale linkages at all levels of biological organization, ecosystems will display extraordinary adaptability—though they certainly will not behave the way we hope or expect.
7. Urban areas are complex adaptive ecosystems. Urban ecology is an excellent interface for re-engaging communities that have become disconnected from Nature, through restoration, education, and citizen science (see below).
8. Resilience and panarchy provide strong conceptual frameworks for understanding and communicating the dynamics of complex social-ecological systems, but much more work is needed to forecast ecosystem changes across multiple scales, identify thresholds, and help policy-makers and local communities put these concepts into practice.
9. Biological invasions and the ways they disrupt ecosystems have been the focus of intense study for the past 10 years. For this and other social and cultural reasons, ESA ecologists are extremely wary of assisted migration (the deliberate practice of moving plants and animals into favourable future climates). Warning to foresters in British Columbia: Proceed with caution and be sure to engage stakeholders.
10. Reframing climate change issues as "energy policy," "public health," or "wildlife conservation" opportunities can help bring skeptical or hostile audiences on board.

Connecting through urban ecology in inner-city Pittsburgh.

Several sessions summarized findings from artificial-warming experiments established at locations around the northern hemisphere. To my knowledge, none of these expensive experiments are under way in British Columbia.

In one memorable case, 12 000-kg blocks of tall-grass prairie were lifted out of the ground, encased in styrofoam insulation, and transported from the midwestern United States to a giant greenhouse complex in Nevada (see below). That study was terminated after 5 years, but others in Britain, Germany, and the eastern States have continued for 10 to 20-plus years. These experiments involve replicated combinations of soil and air warming, simulated drought or storm events, and carbon dioxide or nitrogen enrichment treatments. For logistical reasons, most are established in grasslands, heath, or soybean fields rather than forests. The results, even in "simple" systems, have been mind-bogglingly complex, with unexpected feedbacks. Typically, the initial hypotheses and predictions proved false, and early findings were often reversed as studies continued. Although many ecosystems and species were more resistant to environmental change than predicted, some were surprisingly sensitive.



Desert Research Institute

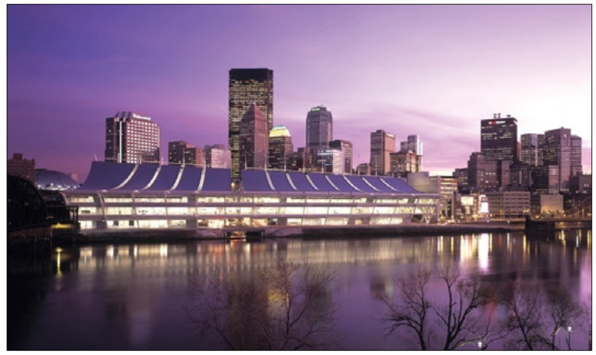
Studying tall-grass prairie response to warming in the Nevada desert.

One limitation of even very large, expensive artificial-warming experiments is that they consider only a narrow range of scales and biological processes. A pervasive theme in Pittsburgh was that the interconnectedness of scale cannot be ignored. Nor can climate change be isolated from the many other stressors of global change, such as invasive species, global nitrogen and silicon cycles, and rapid changes in land use associated with warfare, population growth, and economic and geopolitical forces. The interaction of scales and agents of change is what makes the future impossibly chaotic, but it is also what makes ecosystems ceaselessly creative.

Wandering around the vast sea of poster displays with a Yuengling beer (America's oldest brewery) after a full day of back-to-back 15-minute presentations, I felt guilty about concentrating more on overarching themes and random acquisition of facts (see next page) than on returning home with a set of practical suggestions for forest and rangeland adaptation to climate change. A meeting of this type is more about new directions in science than applied solutions, but despite the vastly more intensive scientific scrutiny of problems in the United States, I was struck by the fact that other political jurisdictions did not seem to be ahead of British Columbia in implementing necessary changes or engaging with stakeholders. Because of its publicly owned land base, British Columbia has a political and economic cohesiveness that contrasts sharply with the scattergun approach south of the border. I would like to think that cohesiveness will be a strength when it comes to the kind of social adaptation needed to address climate change.

The ESA meeting opened with a graph showing that the rate of increase in global greenhouse gas emissions now exceeds the 2007 worst-case trajectory of the Intergovernmental Panel on Climate Change. It also opened with a forum on the BP oil disaster. In the chilly airport departure lounge, a television broadcast announced that NASA had declared 2010 as the hottest year on record.

After a week of listening to ecologists share their stories, I felt the same uneasy mix of despair and optimism that overcomes me every time I take a drive in the battered forests of central British Columbia. On the one hand, things have never looked worse. On the other hand, our forests, like Pittsburgh itself (see opposite), will probably keep reinventing themselves.


VisitPittsburgh

Pittsburgh is becoming a showcase for green urban design.

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Random Facts

- Pittsburgh lost 50% of its population and 60% of its housing stock after the collapse of the steel industry 30–40 years ago. Population decline continues, but the city has rebranded itself as a green/sports capital and was voted America's most liveable city in 2010 (see above). Message for northern British Columbia: ***There is life after the decline of traditional industries, but transformation will be painful and protracted.***
- Silicon, which washes down rivers and blows off the Sahara into the ocean as a consequence of soil erosion, plays a fundamental role in ocean productivity, because diatoms (one of the most common types of phytoplankton or algae) use it in their cell walls and cell contents. Almost nothing is known about how human-caused changes in the silicon cycle disrupt aquatic ecosystems and influence carbon sequestration.
- Elevated CO_2 levels stimulate photosynthesis and carbon fixation over 10- to 20-year time frames in cropland, grassland, and forest systems, but the stimulation of yield is smaller than predicted. Elevated CO_2 improves nitrogen use efficiency, decreases water use, and can mitigate some negative effects of warming temperatures, such as increased drought, but not in all circumstances.
- Ecosystems are likely to be more sensitive to changes in water availability than to direct increases in temperature. The DEW index (increase in precipitation required to offset reductions in soil water content caused by a warming of 1°C) is highest in areas with moderate precipitation, suggesting that drier Interior forests and agricultural areas of the Great Plains will be more vulnerable, on average, than wet coastal forests or deserts.
- Data assimilation is a powerful technique that takes advantage of increases in computational power and access to huge data networks to improve forecasting by repeatedly reworking data from disparate sources until a coherent model is achieved. The technique, first applied in geosciences, is now being used in ecology. Major benefits are the abilities to compare alternative model structures and quantify estimates of uncertainty.
- Last year, a widely publicized study linked recent doubling of tree mortality rates in Pacific Northwest old-growth forests to climate change. In a new study of boreal forests in western Alberta, rising mortality was fully explained by normal successional processes. No evidence of a global warming effect was found.

Citation –

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