Workshop on Frontier Research Directions and International Collaborations in Sustainability Engineering

February 24, 2007 Auckland, New Zealand

Sponsored by:
U.S. National Science Foundation (Grant No.CMMI-0652351)

Organized by:

Chris Hendrickson, Duquesne Light Professor of Eng, Carnegie Mellon
David Allen, Melven Gertz Regents Chair in Chemical Engineering, Univ. Texas Austin
Brad Allenby, Lincoln Professor of Engineering and Ethics, Arizona State University
Michael Griffin, Executive Director, Green Design Institute, Carnegie Mellon
Amy Landis, Doctoral Student, University of Illinois, Chicago
Deanna Matthews, Research Associate, Green Design Institute, Carnegie Mellon
Cindy Murphy, Res Sci., Ctr for Energy and Envr. Resources, Univ. Texas Austin
Jorge Vanegas, Professor of Architecture, Texas A&M
Heather Wakeley, Doctoral Student, Carnegie Mellon

In co-operation with
The International Centre for Sustainability Engineering and Research, University of Auckland, New Zealand

1. Summary and Recommendations

The Workshop on Frontier Research Directions and International Collaborations in Sustainability Engineering was held near Auckland, New Zealand, on February 24, 2007. Supported by the US National Science Foundation (NSF) and organized jointly with the International Centre for Sustainability Engineering and Research (ICSER, University of Auckland, New Zealand), the workshop brought together 28 US and 38 international participants. The ICSER is a group of researchers and education at the University of Auckland who act in close association with the New Zealand Society for Sustainability Engineering and Science, a special interest group of the Institute of Professional Engineers of New Zealand (see **http://nzsses.auckland.ac.nz/index.htm**).

The workshop provided numerous valuable insights for sustainability engineering and an unusual opportunity for international interaction. Some summary observations and recommendations follow, as formulated by the organizing committee.

Importance of Sustainability Engineering

There is widespread social and political interest in the topic of sustainability. For example, the New Zealand government set ambitious goals for reduced emissions of pollutants associated with global climate change, only shortly before the workshop. As another example of the interest in sustainability, the announcement of the availability of travel funds to the workshop resulted in nearly 150 US applications, well exceeding the travel budget. This occurred despite a late announcement and the workshop taking place in the middle of an academic term (in the northern half of the globe). While there is widespread interest in promoting sustainability, there are very different concepts about the policy changes needed to achieve significant movement towards sustainability. There is also considerable lack of scientific knowledge and a degree of uncertainty about sustainable technologies, impacts of human activities on natural systems, and the various trade-offs associated with different policies and technologies. Moreover, many participants emphasized the need for sustainability education for students, practitioners, policy makers and the general public.

Given this worldwide importance and a significant level of ignorance of sustainability, it is encouraging that the National Science Foundation has initiated two new programs directed at this field: 'Environmental Sustainability' and 'Energy for Sustainability.' However, the end of the NSF Materials Use: Science, Engineering, and Society (MUSES) program leaves a void for multi-disciplinary, multi-center funding for sustainability research.

Recommendation: A new NSF initiative for larger projects similar to MUSES would be valuable, solely or in partnership with other federal agencies.

Potential Research Topics

There is no lack of exciting and potentially valuable research topics in the general area of sustainability engineering. Improved understanding and management of energy, water and material flows have formed the core of initial work in sustainability engineering, but much remains to be done on these areas, especially with regard to coping with growth, new policy directions for climate change control, and new technologies. In particular, better understanding of the limits of natural systems is a critical need. Risks and vulnerabilities are also important research areas to aid in understanding the deleterious effects that policies and decisions made in isolation might have on an entire region. A systems approach is essential, typically involving several distinct specialty disciplines. Expanding engineering research to include economic, environmental, and societal goals provides opportunities for useful collaboration with social scientists and other professionals. It is this systems element that motivates the need for larger projects than a single investigator and student. The NSF Emerging Frontiers in Research and Innovation (EFRI) program has made a preliminary announcement of a topic area for FY 2008 involving sustainability: Resilient and Sustainable Infrastructures. However, this topic covers only a portion of sustainability engineering issues and is limited to a single year.

The activity of the International Panel on Climate Change (IPCC) provides an interesting model of a potential research strategy. The IPCC has issued numerous reports indicating areas of uncertainty and substantial scientific consensus. The result has been a process with growing credibility in the area of climate change research. Researchers associated with sustainable engineering could adopt a similar strategy for reporting on the state of practice, perhaps with the assistance of a relevant professional society or government organization.

The workshop provided numerous valuable insights for sustainability engineering and an unusual opportunity for international interaction. Without attempting to be comprehensive about research opportunities and potential collaborations, in this section the organizing committee attempts to synthesize some conclusions, observations and recommendations. A detailed discussion of the workshop follows the recommendations.

Recommendation: The international research community should review the core knowledge of sustainability engineering, emphasizing areas of international consensus and uncertainty on energy, water and materials flows.

Potential International Collaborations

Sustainability engineering research is a topic of great interest throughout the world. However, there are few programs with critical mass in all the relevant dimensions of sustainability, including areas such as engineering design, energy alternatives, life cycle assessment, materials properties, natural systems, public health, toxics and social sciences. Moreover, there are clearly different rates of scientific progress and experience around the world. As a result, international collaborations are valuable and welcome. While the workshop focused upon potential Pacific collaborations, similar opportunities exist for other areas of the world. Continuing international collaboration in this education and research domain is a priority.

Recommendation: Continuing the dialogue on international collaborations and seeking international funding in sustainability engineering is an important priority for the research community. Professional societies such as the New Zealand Institute for Professional Engineers or the International Society of Industrial Ecology can serve an important role facilitating this collaboration.

2. Introduction

The workshop was held immediately following the second, four-day International Conference on Sustainability Engineering and Science held at the University of Auckland. All of the workshop participants attended the conference in whole or in part. The workshop had a total of 66 attendees, including 18 (27%) students. Twenty-eight were from the United States, 30 from New Zealand, 6 from Australia, and 2 from the United Kingdom.

There were two primary objectives of the one-day workshop:

1. to develop priorities for frontier research directions, considering both the broader impacts and intellectual merit of potential research directions, and
2. to explore opportunities for collaborative research in sustainability engineering and science.

The audience for these initiatives included organizations that support research in sustainability as well as the research community. The morning consisted of two panel-led discussions, one focused on each of the two objectives. A breakout session in the afternoon was followed by a group discussion of results and conclusions. This report includes summaries of the discussions as well as some observations and recommendations reached by the organizing committee. An appendix contains a list of the workshop participants.

3. Panel Discussion: Research Priorities and Needs

The first panel discussion focused on sustainability engineering research priorities and needs, led by Jim Mihelcic from Michigan Technological University (USA), Scott Matthews from Carnegie Mellon University (USA), Peter Newton from Australia's Commonwealth Scientific and Industrial Research Organization (CSIRO), and Susan Krumdieck from the University of Canterbury (New Zealand).

Jim Mihelcic focused his discussion on energy, water, and material flows. He expressed the need to consider water in terms of material flows, considering its value, embodied energy, and footprint, as well as community needs for different uses. Furthermore, stormwater issues in relation to infrastructure development should be included in research concerns. New and improved models are needed to represent changes in urbanization, population, immigration, and land use. Understanding these global changes and their effects is as important as understanding climate change. The challenge will be to integrate these models with societal, environmental, and economic goals. Jim's final suggestion was to integrate and transfer knowledge between developed and developing countries.

There is potential for valuable contributions to economics and governance, as well as issues of energy and waste from developing nations and indigenous cultures, but raises the question of how to develop these exchanges with consideration for the very different cultures in different areas..

Scott Matthews stressed the importance for the research community to create and use models that will allow decision-makers to understand the complexities involved in their decisions as well as the effect on the future. This requires a broad focus, including consideration of how to think about problems, including the interconnections between products and society. A systems approach towards future decisions is necessary to include broad considerations, both quantitative and qualitative. There is clear information signaling the need for change, and there is a need to go beyond research to implementation – disseminating the knowledge in such a way, that it can help consumers and other 'users' make informed decisions. There are many opportunities to partner with social scientists. In terms of life cycle analysis (LCA), methods must be developed to transfer the information effectively to decision-makers, designers, and consumers. Furthermore, LCA is most often used to consider products, typically ignoring connections to other services. For example, when LCA is used to evaluate hydrogen as a potential important energy source, the effects of using fossil fuels or water as a source of hydrogen are not closely examined.

Peter Newton discussed consumption and how the key environmental indicators are growing due to consumption. Related areas for focus include policy and practices, human behavior, and disparities in dwelling performance. Peter suggested a three-horizon planning approach for sustainability. The first is to implement existing technologies. The second involves research and development in the lab, determining what is important and creating a pathway to adoption. The third is a focus on systems and will require radical shifts. There are several areas of focus for urban areas, including developing integrated urban water systems, improved planning and renewal to consider land use and allocation in terms of a sustainable future, the interpretation of waste streams as resource streams, and improving building assessment and performance technologies. Peter suggested that research be conducted on urban systems, such as consumption of water and energy, vehicle miles traveled, and waste generation.

Susan Krumdieck began by stating her opinion that sustainability is defined by tragedy of the commons, with the context being the commons. The context includes society and resource constraints. There is a need to better understand the entire problem, as well as the interconnections. One of the major questions is how to use and allocate resources, to determine which scenarios do not result in the tragedy of the commons. Markets have distorted resource allocations, thus knowledge of the constraints are also required to keep the commons from collapsing. Susan also commented that researchers have to understand anthropology, psychology, and cultural values, and questioned how this concept can be translated to engineering research.

Interesting discussions followed in response to the ideas presented by the panelists. Topics included water, education, and new ways of thinking. One idea presented was to

develop a stewardship approach to water and water resources, similar to those currently undertaken in forestry and marine areas. This could be supported by looking at embodied water, considering the embodied water in energy production, as well as the embodied energy of the water supply. A current example of this is the water framework directive in the European Union, which will influence further research in this area. This directive is intended to substantially increase the fraction of world residents with access to clean water and sanitation (See http://ec.europa.eu/research/water-initiative/index_en.html). There is also a need to re-design water use in the home. Water rights are an important policy issue, but include land tenure issues that go beyond engineering. Water systems need to be redesigned in a holistic manner, considering drinking water, sewage, and storm water as components of the same system. An additional comment was that water vapor is a greenhouse gas, but there is little consideration of how people have changed the water cycle.

Education is a crucial link between science and the public. Issues in this arena include translation of research, test of public credibility for funding research, consideration of feedback loops, and restoring public faith in science. A key focus should be educating people about how to think about their decisions. An example of one grant for $10M that included only $25,000 for translation of results to public was given, with the question that perhaps the allocation was backwards. The community and education need to be included as part of the solution.

Three important questions should be answered when identifying research projects: what? how? and why? The questions should be asked in terms of: what resources are available? How will it be accomplished (use of technology, research)? Why is this important? It is critical to determine the real issues and questions that need to be answered to be sure that the right actions are being taken to answer them. Potential barriers include the fact that sustainability and the environment crosses political boundaries.

4. Panel Discussion: Opportunities for International Collaboration

The second panel discussion covered opportunities for international collaboration. The panel members were Jorge Vanegas from Texas A&M University (USA), Amy Landis from the University of Illinois-Chicago (USA), Carol Boyle from the University of Auckland (NZ), and Peter Guthrie from the University of Cambridge (UK).

Jorge Vanegas stressed the importance of scholarship in addressing sustainability and creating new enterprises through entrepreneurship. In terms of scholarship, the first step would be to collect information, the next is to synthesize it, and finally others will build upon the new information. The focus must be on cooperative innovation. It is also important to capitalize on the information that we already have, and then enhance it through synergies. Jorge also discussed the power of entrepreneurship, and suggested a new for-profit organization, “Scholars for a Sustainable World,” the feasibility of which would demonstrate to others that investing in sustainability is economically attractive. He challenged researchers to be creative about finding funding for sustainability, citing philanthropic foundations as possible sources.

Amy Landis began by suggesting the creation of an organization, the "Global Alliance for Sustainable Progress" (GASP), which would communicate with both society and policy makers on issues of sustainability. Amy also suggested that a reward or incentive system in needed for collaboration in academia, especially for junior faculty. Many faculty tend to downplay international and interdisciplinary collaborations, so as not to be seen as 'soft' engineers by traditional departments. There is currently little infrastructure or motivation to help researchers find each other across international boundaries.

Carol Boyle felt that work in the area of sustainability can be isolating. Reviewers for standard journals create an obstacle to work in this field, as they generally do not have background knowledge of the topic. Sustainability should be an area of continuing education for professional engineers. Carol stressed the need for increased collaboration between countries, with the help of the internet, as well as collaborative conferences in the future. As opposed to creating new journals and organizations, Carol suggested talking to existing ones, and integrating topics on sustainability into the current infrastructure. The Alliance for Global Sustainability is one potential networking organization (See http://globalsustainability.org/). Enhancements in education are available through course collaboration between universities. She mentioned an example of 21 universities in New Zealand that were working together such that students studying at one could register and take classes at another without paying additional tuition and asked if this could be done across the world in sustainability.

Peter Guthrie discussed the need for and challenge in acquiring funding for international collaboration. In terms of equity, international collaborations must include universities in developing countries. A measure of resource stewardship should be devised to encourage less resource-intensive projects, so as to avoid excess resource use through physical travel rather than virtual (electronic) communication. Finally, 20% of the funding should be dedicated to education and dissemination of information. Effectiveness of education should be measured by results in curriculum at participating universities. Finally, Peter encouraged the engagement of young researchers in the collaborations, and suggested that the principal investigators step back, allowing only junior researchers to travel internationally.

The discussion following the panel suggestions resulted in a variety of ideas. Several people agreed on using the International Panel on Climate Change (IPCC) as a model for international collaboration. The IPCC report authors were nominated by governments from six regions of the world—Africa, Europe, Asia, Southwest Pacific, North America and South America. The UN ensured there was equitable representation from each of the regions. Collaborations grew from experts working together on an assessment of climate science. Participants from developing countries were funded by a trust created by developed countries; participants from developed countries were supported by their governments. The focus of the work was not to do new science but to clarify gaps. There is no similar report that considers the state of current sustainability research and knowledge.

Another issue raised is the responsibility of developed countries to help answer questions in developing countries. However, the capacity to help them must first be created. International collaboration must be recognized as value-added and is essential in preparing the next generation of engineers, as well as in connecting faculty members around the world. Furthermore, there is great potential for learning and utilizing information from developing countries, which tend to be very resourceful and have demonstrated positive economic value in several areas of sustainability.

There was an expressed need for academic freedom to consider areas not addressed by commercial interests. Researchers should take advantage of their academic freedom and consider projects such as low-cost construction materials even if there is little commercial interest.

Questions that were raised included the logistics of networking – how to connect the pieces, as well as attract and be welcoming to people with different backgrounds and areas of expertise. A challenge is that the incentives will be different for different people. Another question was how to connect the 'masses', citing examples of "MySpace" and "YouTube". What is the best way to tap into these resources and generate a community for sustainability?

In conclusion, there are numerous benefits to collaboration, including the exponential effect of people working together, scholarship is improved more efficiently, and it helps to create stepping-stones. The focus of funding should be on how projects can give back tangible benefits to society. Finally, education of the next generation of engineers is critical, and can be supported by encouraging exchanges among students and establishing incentives to encourage junior faculty to engage in collaboration.

5. Breakout Sessions and Discussion

Workshop participants were separated into five breakout groups, which were facilitated by members of the organizing committee. The instructions for the sessions were to focus on specifics of research directions and international collaboration, avoiding philosophy issues. The breakout sessions lasted for two hours, and then the entire group reconvened for a summary of conclusions from each group and discussion. Highlights from each group discussion are included below.

Members from **Group 1** came from diverse backgrounds, but all had a common interest in sustainability. The group suggested that a "dream team" for sustainability research would include a historian, a futurist, a systems thinker, and researchers concerned with risk, urban processes, and chemical processes. The group presented the idea of a think tank to serve as a sustainability 'incubator' for students. The think tank would have two approaches, one would serve to initiate change from the status quo and the other portion would focus on radical innovations. There are differing goals for people involved in sustainability, including making money, social change, and environmental impact, but they are all interrelated and a synergism is needed. Another question that the group addressed was how to affect kindergarten through undergraduate education. The pertinent

questions include when to introduce topics of critical thinking and sustainability and how to develop 'students without borders', encouraging students to think about the world beyond the boundaries in which they live. The group also thought that service learning needs to be part of the education system. A challenge for future modeling work involves the balancing of needs with demands and wants. Models should be transparent, to allow the user to focus on the application, and should have embedded visualization (space and time) tools. There is currently information asymmetry distorting supply and demand and preventing the setting of the ideal price of goods. This asymmetry needs to be removed.

Group 2 brought up the pyramid problem, asking where to target research. Should it be targeted towards the relatively few large consumers at the top or the millions living on the edge of poverty at the bottom? Better monitoring of data and information flow can support improved understanding of systems. Data mining for sustainability research can take advantage of existing data sources and knowledge. The group also asked what the time scale for analysis should be and if the boundaries are big enough. Suggestions for further research needs included a dynamic systems focus, socio-technical modeling, needs and demand analyses, and a feedback model to teach us about behaviors. Research directions need to consider whether a systems or a widget solution is needed to solve a particular problem. Other ideas included a resource model, similar to Sim City, the importance of education for everyone, and an international feedback loop for decisions. The group believed that education is the key to changing consumer understanding and behavior and asked whether sustainability should be considered a separate discipline or if it should be incorporated across disciplines.

Group 3 came up with a number of potential research directions and ideas. These included determining how information diffuses through society, how to evaluate and portray risk for long-term and uncertain outcomes, water systems, guidelines for sustainable design, integration of infrastructure systems, and determining an appropriate approach to problems: prevention, mitigation, or adaptation. Problems that need to be addressed include urban design issues, accommodating for increased populations, as well as preparing for the inevitable natural destructive forces of earthquakes, tsunamis, etc. They also suggested modifying the funding framework to include stakeholders in the decisions. The group agreed that a report on the state of sustainability is needed and raised other issues as to whether the medical and health system is accountable for sustainability, who should be in charge of educating the masses, and who should have the overall authority of sustainability issues. In terms of education, the question if engineers could educate a broad range of stakeholders was raised, as well as the potential to use film to reach a broader audience. They brought up the challenge to accelerate research cycles to match current cycles of political turnover, product development and market acceptance, and return on investment decisions. Fundamental research may not match well with such cycles.

Group 4 focused on educational outreach, including participatory learning. They also suggested educating a few communicators, who could then help spread information. It is critical for the public to buy into research outcomes in order for implementation to be successful. A network to share knowledge should be created that would be accessible to

people with many languages and cultures. While a sustainability research community is emerging, few current researchers have been educated in programs that focus on sustainability. A network could include case studies, definitions, and games, and could be in the form of a web-based forum. In terms of sustainability, there is a need to establish principles, goals, and benchmarks. A US example is the Center for Sustainability Engineering (See http://www.csengin.org/).

Group 5 focused on education and research. The first targets for education should be decision-makers and teachers, as they have the potential for the largest impact. It is also critical to educate the public on matters of sustainability. There is a need for more research to determine the best methods to educate the public and convince them that there is a problem and that everyone does have an impact. It is critical to provide research results and information to decision makers now while defining the uncertainty; we cannot wait until we 'know it all', as important decisions are being made every day. A report on sustainability similar to the IPCC report would be extremely helpful in guiding further research questions. This type of report is likely to have a regional focus to account for local effects. Finally, we need to take a holistic approach to research and decision-making, considering potential impacts beyond the traditional project scope. The group also indicated there is a need for funding of multi-center type work across universities, such as the Materials Use: Science, Engineering, and Society (MUSES) program from the NSF.

Appendix: List of Workshop Attendees

Workshop Frontier Attendee list

	Name	Organization	Location	Email
1	Aaron Clarkson	University of Auckland	NZ	aaron.clarkson@gmail.com
2	Amy Cornelius	University of Auckland	NZ	amysgcornelius@hotmail.com
3	Andy Hamm	University of Canterbury	NZ	samiarti@gmail.com
4	Annie Pearce	Virginia Tech	US	apearce@vt.edu
5	Barbara Nebel	Scion	NZ	barbara.nebel@scionresearch.com
6	Ben Hutcheson		NZ	benhutch@xtra.co.nz
7	Bill Wallace	Wallace Futures Group	US	bill.wallace@wallacefutures.com
8	Carol Boyle	University of Auckland	NZ	c.boyle@auckland.ac.nz
9	Chris Harris	North Shore City Council	NZ	chris.harris@northshorecity.govt.nz
10	Chris Hendrickson	Carnegie Mellon University	US	cth@cmu.edu
11	Cindy Lee	NSF	USA	cmlee@nsf.gov
12	Cindy Murphy	University of Texas at Austin	US	cfmurphy@mail.utexas.edu
13	Cliff Davidson	Carnegie Mellon University	US	cliff@cmu.edu
14	Cristina Piluso	Wayne State University	US	cpiluso@wayne.edu
15	Daniel Oerther	University of	US	daniel.oerther@uc.edu

		Cincinnati		
16	Danny Reible	University of Texas	US	reible@mail.utexas.edu
17	David Kettle	Consultant	NZ	dbkettlelimited@slingshot.co.nz
18	Deanna Matthews	Carnegie Mellon University	US	dhm@cmu.edu
19	Dennis List	University of Adelaide	AU	dennis.list@adelaide.edu.au
20	Douglas Matson	Tufts University	US	douglas.matson@tufts.edu
21	Duncan Thomason	University of Auckland	NZ	dtho086@ec.auckland.ac.nz
22	Gavin Mudd	Monash University	AU	gavin.mudd@eng.monash.edu.au
23	Heather Wakeley	Carnegie Mellon University	USA	wakeley@cmu.edu
24	Helen Lou	Lamar University	USA	helen.lou@lamar.edu
25	Ian Carter	Architect	NZ	iankcarter@enternet.co.nz
26	Jackie Issacs	Northeastern University	USA	jaisaacs@coe.neu.edu
27	James Mihelcic	Michigan Technological University	USA	jm41@mtv.edu
28	Jeff Vickers	University of Auckland	NZ	jeff.vickers@gmail.com
29	Jim Salinger	NIWA	NZ	j.salinger@niwa.co.nz
30	John Peet	University of Canterbury	NZ	john.peet@canterbury.ac.nz
31	John Russell	La Trobe University Bendigo	AU	j.russell@latrobe.edu
32	Jorge Vanegas	Texas A&M University	USA	jvanagas@tamu.edu
33	Karen High	Oklahoma State University	US	karen.high@okstate.edu
34	Katie DiBlasi	University of Maryland	USA	cath3@umbc.edu
35	Kevin Gardner	University of New Hampshire	US	kevin.gardner@unh.edu
36	Laura Brunson	University of Oklahoma	USA	lbrunson@ou.edu
37	Liv Haselbach	University of South Carolina	US	haselbac@engr.sc.edu
38	Manuel Seidel	University of Auckland	NZ	msei003@ec.auckland.ac.nz
39	Mark Glucina	University of Auckland	NZ	markglucina@clear.net.nz
40	Marlene Oliver	Environment Court NZ	NZ	marlene.oliver@justice.govt.nz
41	Michael Krausse	Landcare	NZ	KrausseM@landcareresearch.co.nz
42	Michael Overcash	North Carolina State University	US	overcash@ncsu.edu
43	Michael Griffin	Carnegie Mellon University	US	mwg@andrew.cmu.edu
44	Mohammed Imroz Sohel	University of Canterbury	NZ	mso32@student.canterbury.ac.nz
45	Oladele Ogunseitan	University of California	US	oladele.ogunseitan@uci.edu
46	Patricia Gallagher	Dexel University	US	pmg24@drexel.edu

47	Pedro Vieira	U.C.Berkeley	USA	pviera@ce.berkeley.edu
48	Peter Bosscher	University of Wisconsin-Madison	US	bosscher@wisc.edu
49	Peter Guthrie	University of Cambridge	UK	pmg31@cam.ac.nz
50	Peter Newton	CSIRO Australia	AU	Peter.Newton@csiro.au
51	Rainer Seidel	University of Auckland	NZ	rha.seidel@auckland.ac.nz
52	Ramesh Agarwal	Washington University in St Louis	USA	rka@me.wusty.edu
53	Rendt Gorter	University of Auckland	NZ	rendt@gorter.gen.nz
54	Richard Green	HERA	NZ	richard.green@hera.org.nz
55	Richard Love	Massey University	NZ	r.j.love@massey.ac.nz
56	Richard Morrison		NZ	richardmorrisondesign@paradise.net.nz
57	Ron McDowall	University of Auckland	NZ	r.mcdowall@auckland.ac.nz
58	Sam Gordon	University of Auckland	NZ	motivated.sam@gmail.com
59	Sarah Freeman	Tufts University	US	sarah.stgeorge.freeman@gmail.com
60	Sarah McLaren	Landcare NZ	NZ	mclarens@landcareresearch.co.nz
61	Stefan Fortuin	Massey University	NZ	fortland@gmail.com
62	Susan Krumdiek	University of Canterbury	NZ	susan.krumdieck@canterbury.ac.nz
63	Taylor Eighmy	University of New Hampshire	USA	taylor.eighmy@unh.edu
64	Tim O'Riordan	UK SD Commissioner	UK	t.oriordan@uea.ac.uk
65	Vineet Rajasekhar	University of Auckland	NZ	vineet.rajaselkhar@gmail.com
66	Yasenko Krpo	TSE Consultants	NZ	Yasenko.Krpo@tse.co.nz