CSIRO

SUSTAINABILITY NETWORK

Holmes Building, CSIRO Waite Laboratories
PMB 2 GLEN OSMOND, SA 5064

Phone: (08) 8303-8406
Mobile: 0417 611 244
Fax: (08) 8303-8750
Hm Fax: (08) 8298-9790
Email: Elizabeth.Heij@exec.csiro.au

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External Members
CSIRO Sustainability Network

> ***"Sustainable development is a process of change in which the exploitation of resources, the direction of investments, the orientation of technical development, and institutional change are all in harmony and enhance both current and future potential to meet human needs and aspirations."*** [World Commission on Environment and Development]

Dear Network Friends:

Sustainability Network Update

Welcome to this first update compiled especially for new external members of the CSIRO Sustainability Network. Updates will contain a mix of technical news, research trends, and resource items. This update features the developing area of "sustainability science." While there is still argument amongst scientist themselves as to whether this is actually a new science discipline, we can certainly say that the science being built around the issues of sustainable development contains some interesting new tools and approaches.

Systems Science – "under construction"

The push towards more sustainable pathways for economic development is having a significant effect within CSIRO and other science organizations. It is affecting both the science we do and the ways in which we do it.

Traditionally, most biophysical scientists (those trained in disciplines such as physics, chemistry and biology) have tended to be analytical in their approach – defining a single biophysical problem and studying it in isolation. The issues of sustainability, however, demand that we deal with the behaviour of complex systems made up of many interacting components whose interdependencies generate new, "emergent" properties at the whole-system level. Of course, none of this is news to ecologists who are probably our original "systems scientists." They have been dealing for years with the properties of ecosystems that emerge from the many interactions of the plants, animals and landscapes within them.

The earth's climate system, for example, is a highly complex system in which a myriad of interactions occur among incoming solar radiation, rotation and tilt of the Earth, atmospheric composition, temperature gradients and convection currents in the atmosphere and oceans, land masses, vegetation cover, and – most conspicuously since the industrial revolution – human populations and their techno-culture. Many of the complex systems under consideration in the sustainability debate are like this. Their interdependent components are not just biophysical but also encompass human-related social and economic factors. Some researchers refer to them as "EESS" (for Ecological, Economic & Social Systems).

When we investigate such systems with a view to modifying them, we often need a mix of traditional biophysical sciences, social sciences and economic inputs as well. That can be a hard ask for scientists, social scientists and economists who have been trained separately and are not used to each other's jargon!

Furthermore, the traditional "off-line" laboratory experimentation method just doesn't work for an EESS. We cannot "stop the world" while we tinker with the climate system, for example. Much of what we are trying to do with sustainable development is "adaptive management" – finding the right levers to steer the Earth's "EESS" along a more sustainable pathway. You can think of it as being a bit like riding a bolting horse – you can't stop it, but by using reins, knees and feet, you just might be able to steer it into the paddock rather than the scrub!

With this background it is not really surprising that we are beginning to hear talk of a new "complex systems science" and an overlapping, but not quite identical new "sustainability science." Scientists in disciplines that previously had little or no interaction at the component level now find themselves involved together in difficult but exciting discussions of interdependencies at the next level up – the whole-system. Many scientists are beginning to feel as though they have just put on a new pair of glasses or "climbed up on the roof to look at the garden from a different angle." It can be chastening to discover that a new technology that works beautifully in isolation in the laboratory or an experimental farm plot, might never be taken up because it hasn't been matched to lifestyles, market needs, demographic trends, and other socio-economic factors. But while it may be chastening, it is also exciting – identifying the blockage offers genuine prospects for moving forward.

Thus even for scientists whose main task continues to be "component science" – the in-depth understanding and manipulation of single components of a system (eg, the genes of a pasture plant in a milk-production system), taking a "holistic" or "systems" approach can be rewarding, both in the discovery process and in the design of new technology.

There are some important new tools behind the evolving field of systems science. Some of these are concepts and theories (eg, chaos theory) while others are IT (information technology) tools for storing and manipulating large masses of data. Suppose you want to see what effect it would have on the climate of south-east Australia if the world's average temperature were to rise by 2 degrees: The climate system is too complex to predict the outcome from any mental model, but a computer is potentially powerful enough to "remember" how all of the interactions between components move around under particular conditions. Computer modeling is an increasingly important tool in systems science, but accurate predictions of the emergent properties of any system being investigated, are only possible if detailed data on all the vital component interactions are available.

Which brings me to a final important note: We might be hearing a lot more about "systems thinking," "holistic approaches," and "synthesis," but component science remains fundamentally important. You can't see "the big picture" clearly unless all the component pieces are in focus. You can't hope to understand or model behaviour of a complex system unless you also know a lot about the characteristics of its individual components. Analysis (into component parts) is an essential partner to synthesis (into a big picture). Strong science disciplinary knowledge is just as important now as it ever was. The main difference is a heightened need for communication across science disciplines, and between science and other sectors of the community.

Example – a systems science "construction team"

"The Resilience Alliance (RA) [www.resalliance.org] is a research consortium of some 15 groups/laboratories around the world (including CSIRO) who are working on understanding the behaviour of complex ecological-economic-social systems.

The RA's approach is based on a number of propositions that have emerged during it's work. Chief amongst theses are:

- Sustainability is not an ecological issue, nor an economic one, nor a social one. It is all three, and attempts to resolve the issue via any one or two of these are at best partial solutions and will not achieve their aims. At regional scales systems of people and nature (including agricultural ecosystems) behave as dynamic, linked socio-economic-ecological systems. And the dynamics include important cross-scale effects. (An example of a "cross-scale effect" in an agricultural ecosystem might be, for example, the individual vegetation-clearing decisions of farmers leading to rising water tables and dryland salinity over broad areas of the landscape.)

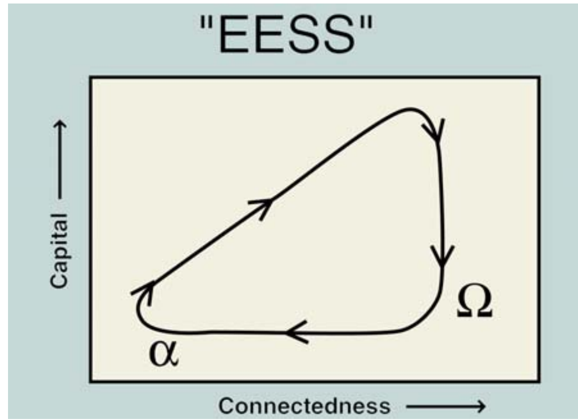
- All such systems and their components tend to exhibit cycles, involving long periods of growth and comparatively little change, and short periods of major disruption, or chaos, followed by a crucially important re-organization phase during which resilience in the system can be gained or lost. (See diagram on next page.) ("Resilience" in a system refers to how capable the system is of maintaining its major emergent properties in the face of changes in system components. If it is highly resilient, it can accommodate a lot of component changes before it collapses into chaos. Think of a rural landscape. How much vegetation clearing and overgrazing can it take before it collapses into an eroded "moonscape"? The agricultural landscapes of Western Europe tend to be more resilient than those of Australia.)

- Non-linear behaviour and threshold effects are the norm rather than the exception in the behaviour of most such systems. (This means that as changes occur in components, there may initially be no observable change at the whole-system level until some particular component passes a critical threshold, at which the whole system is rapidly disrupted.) After a disruption, there is a period of rapid, often chaotic change that could potentially give rise to a number of new stable states. Eventually, one particular new state will stabilize and prevail.

- The emphasis on increased production, increasing efficiency of resource use, optimal control-type management, etc is applicable during the early to mid phases of the growth cycle of such systems, but is inappropriate during periods of rapid change. What is needed then is an understanding of resilience and what is required to build adaptive capacity back into the system – for both socio-economic and ecological components.

Behaviour of an “EESS”

Schematic picture of the behaviour of a complex ecological-economic-social system:



The horizontal axis denotes the extent of interdependencies in the system; the vertical axis denotes the intensity of energy and resources (“capital” in the broad sense) needed to keep the system growing on a particular trajectory (ie, in a particular direction). In the “alpha phase” (bottom left), the system organizes into a particular state and begins to grow stably along that pathway. At top right it passes a threshold and collapses (“omega phase”) into chaos as the interdependencies among components are disrupted. A new alpha phase may see the system take either a similar or completely new trajectory.

Understanding the elements of resilience in the system during the disruption phase may allow us to better control the direction the system will take as it emerges into a new stable growth state. (Interesting that the great civilizations of history have followed patterns of emergence, growth and collapse very much in the above pattern!)

Sustainability Science featured on “Ockham’s Razor” (24/06/01)

http://www.abc.net.au/rn/science/ockham/stories/s317194.htm

Professor Ian Lowe of Griffith University, Queensland, in a June interview with Robyn Williams for “Ockham’s Razor,” also described the need for, and the development of systems science:

> “Science needs a fundamentally different approach if we are to achieve our goal of sustainability. Case studies from all the inhabited continents show that many of our serious environmental problems are the direct result of applying narrow specialised knowledge to complex systems. Agronomists advise farmers on fertiliser use to improve pasture, but the changes have put unacceptable nutrient load on waterways. Expert advice has allowed fishing vessels to catch more seafood, leading to the depletion of fisheries. Irrigation systems have made it possible to grow new crops, but have deprived streams of the flows needed to maintain rivering ecologies. Species introduced to control one pest have driven other native biota to extinction. And energy-using technology is now releasing enough fossil carbon to change the global climate. … great damage can be done by applying narrow specialised knowledge without an appreciation of the complexity of natural systems.
>
> We need to address these issues through integrated scientific efforts that will focus on the social and ecological characteristics of particular places or regions. … So by structure and content, sustainability science will differ fundamentally from most science as we know it. …familiar forms of developing and testing hypotheses have run into difficulties; we’re studying complex non-linear systems with long time lags between actions and their consequences. And the problems are complicated by our inability to stand outside the nature-society system. …our engagement with complex natural systems can’t be based on the old model for rational, objective science. The traditional sequential steps will have to become parallel functions of social learning, and they’ll also have to incorporate the elements of action, adaptive management, and policy as experiment. Sustainability science needs to employ new methods, perhaps semi-

quantitative modelling of qualitative data and case studies, or inverse approaches that work backwards from undesirable consequences to identify pathways to avoid those outcomes. …knowledge that combines scientific excellence with social relevance.

Meeting the challenge of sustainability science will also require new styles of institutional organization to foster interdisciplinary research and to support it over the long term, building capacity for that research and integrating it into coherent systems of research planning, assessment and decision support. The present approach is too haphazard and piecemeal. The urgent task is to develop the mechanisms that will nurture those activities. Only then will we be able to shift to the social practices that will allow us to use natural systems sustainably. …its not just a challenge to the scientific community, it's also a challenge to our political institutions."

[If you want to read the whole 5-page article and can't access the above URL, let me know. I can send it to you electronically or in hard copy.]

The emerging needs of sustainability science, such as – collaboration across different disciplines, combined analytical (component science) and integrative (systems) approaches, ability to work with mixed groups of technology users and policy makers, and a solid appreciation of ecological principles – reinforce for me just how crucial it will be to remove the organisational "silos" in our society and communicate, communicate, communicate!

Sustainability – It's about time!

One of the key issues that keeps surfacing in debates about sustainability is time. Excellence in sustainability science will demand that we wear the correct multifocal "time-scale lenses" to identify the issues, define their origin, and develop options to address them. For example, where development of a problem extends over several or many human generations, a sequence of gradual changes may be essentially "invisible" until the situation "suddenly" becomes confronting. Many problems can only be fixed over timescales that are poorly compatible with current political, business and social cycles. On many issues, we will need to take action on different time scales in parallel. Although thinking in multiple time scales is not something that necessarily comes naturally, getting information and actions matched to the appropriate time scales is vital. It's worth a moment to think about cultivating the right "time-scale lenses."

World of scarcity or world of abundance?

While reading a recent issue of "RADAR," the subscription newsletter from *SustainAbility*, UK, I was struck by the concepts presented by Ulrich Goluke in his closing address to the Global Responsibility Founding Forum, Monaco, November 2000, entitled "Trust and Service in a Transparent World."

"We focussed so long on material needs and how to meet them, that that's all we know how to do. We organised our lives, our values, our everything around – scarcity. It was, still is, in our bones. It is the glasses through which we look at everything: life and death, relations and happiness, the heavens and earth. Scarcity – that is material needs – drives us to learn 'for life', to take the right job, to marry the right spouse, to defend what we have. In the extreme it drives us to war. It created, and then made pre-eminent, the dismal science – economics – because that is the science of how to allocate scarce resources.

> Well, the simple truth – in this story, mind you – is that we've done it – but we have not noticed. We still carry our habits and our instincts from a scarce world forward (to this abundant world) without a thought." …. "Kings and queens have always lived in this world of abundance – now we all do, all the time. And like royalty of the past, we sometimes fill our days with frivolous activities. But little by little we are learning to live our lives by creating and exchanging trust and service, purpose and meaning, about who you are and how I behave, about why you are here and what I will leave behind, and not simply about *things* – something our grandparents would never have thought possible."

Moving towards a more sustainable society means reducing the amounts of materials and energy going into our manufactured environment, and shifting emphasis from products to services and social values. The trend will certainly affect the science we do and the ways we apply it.

If you would like a hard copy of the full article, let me know by e-mail and I will send one to you. It relates the above points to a more sustainable world view and provides interesting food for thought.

Websites of possible interest:

If you are interested in sustainability information sources, you might want to check the following websites if you haven't found them already:

Department of Industry Science and Resources Program "Energy Efficiency Best Practice (EEBP)"

www.isr.gov.au/energybestpractice

The EEBP Program works together with companies in specific industry sectors to help them achieve the financial, social and environmental benefits of smart energy practice. The selected sectors are medium to large energy users, eg, aluminium production, dairy processing, milling and baking, wine making, beverage and containers manufacturing, hotel management and vehicle fleet management. The Program also encompasses cross-sectoral strategies for motor systems and energy performance contracting. The approach to working with industry for sustainable outcomes deserves a look.

Environment Australia: The Australian Public Environmental Reporting website.

www.environment.gov.au/per/index.html

Provides information and examples for companies and organizations wishing to develop a PER, and to researchers and investors with an interest in environmental performance and environmental reporting. The website is a clearing-house for electronically available Public Environmental Reports, with links to company sites, publications and other resources.

Redefining Progress (RP)

www.rprogress.org

Redefining Progress: for People, Nature & the Economy is a nonprofit public policy organization, based in California, that seeks to ensure a more sustainable and socially equitable world. Working both within and beyond the traditional economic framework, RP generates and refines innovative policies, tools and concepts to reorient the economy to value people and nature first. Their policy work has a primary American focus, but the associated concepts are worth checking out for local applicability.

Network of European Environment Councils (EEAC)

www.eeac-network.org/content.htm

A participatory website currently used by around 30 Advisory Councils for environmental policy and sustainable development in 13 EU and 8 accession countries. Participation and collaboration are aimed at improving the quality of policy advice at national and regional levels. The site posts news and discussion items relating to sustainable development, and also programs and proceedings of meetings and events.

The Foresight Programme, UK
www.foresight.gov.uk
The British Foresight Programme involves business, the science base, Government, the voluntary sector and others in thirteen sectorally based Foresight panels to think about what might happen in the future and what can be done about it now to increase prosperity and sustainability. The sight provides access to a range of trend information, publications, future scenarios and statistics.

Two sites for family members:
www.kids-for-the-environment.com.au
This is a great site for your school-age kids (or grand-kids) if they have not found it already. It is sponsored by the Foster Foundation, Victoria, and designed by young people for young people worldwide to enable them to make contact over topics relating to caring for our environment. Topics can be aired and shared – questions, bright ideas, new technology etc. – and many of the site's activities are supported by curriculum-based notes for teachers and parents.

www.ecoworld.com
A "folksy" American site providing "Information and answers about Earth's energy and food supply, species, ecosystems and projects to preserve them, and a guide to earth-friendly products & services, tours and green investing. Also provides an e-mail newsletter "Upward Trend" with the theme of "nature & technology in harmony." Although specifics are American, themes and news are of more general interest. EcoWorld Inc., based in California, is a media company with a mission to provide information on ecosystems and conservation projects worldwide.

Notes and reminders

- **Pass it on!** The Sustainability Network is intended to be inclusive rather than exclusive. If you know someone who might be interested in this newsletter, by all means forward it to them.
- **Want to make contact with scientists?** If you can see an application for the science featured in these newsletters and need to contact the scientists involved, let me know by email.
- **Want to see a particular area of sustainability science featured?** If there is a particular area of sustainability-related science that you would like to see featured as a "spot" in a future newsletter, send me an email or call me by phone to discuss it.
- **Give me your feedback.** I would be interested in your comments as to whether these newsletters are interesting, useful, and pitched at the right level for your particular purposes. Do you have suggestions?

That's it for this update.

Sincerely,

Elizabeth G. Heij
Network Facilitator