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Report of the Retreat on Institutions for Sustainability Research and Education

Hacienda Temozon
Yucatan, Mexico

May 20-21, 2004

The Retreat

May 20, 2004 Michael Crow of Arizona State University and John Schellnhuber of the Tyndall Centre convened a two-day meeting in the Yucatan, Mexico to explore issues faced by leaders of institutions dedicated to sustainability research and education, and ways institutions can best collaborate to meet the challenges of bringing science and technology to bear on sustainability issues.

The idea for the Retreat came out of discussions between Crow, Schellnhuber and Bill Clark, who recognized that the small but growing number of research and teaching institutions now grappling seriously with the science and technology of sustainability are a global asset, yet need to be better coordinated. To explore how such joint efforts might best be designed and implemented, a select group of creative leaders in the emergence of the field were brought together for exploratory discussions.

Participants

William Clark (chairman) - *Harvard University,*
Michael Crow (co-convener) - *Arizona State University*
José Sarukhán - *Instituto de Ecología - UNAM*
Hans Joachim Schellnhuber (co-convener) - *Tyndall Centre for Climate Change Research*
Julia Marton-Lefèvre - *LEAD International*
Pamela Matson - *Stanford University*
Edward Miles - *University of Washington*
Jan Rotmans - *International Centre for Integrative Studies*
Sander Van der Leeuw - *Arizona State University*
Jonathan Fink (rapporteur) - *Arizona State University*
Charles Redman (rapporteur) - *Arizona State University*
James Buizer (organizer) - *Arizona State University*
Nancy Dickson (organizer) - *Harvard University*
Julie Wrigley (observer) - *The Wrigley Foundation*

Approach

The Retreat organizers framed the discussions around the following four themes and sets of questions. Background papers were identified as recommended reading in advance of the Retreat, and "lead discussant(s)" were asked to introduce each of the themes. One half day was dedicated to each theme, and discussions were relatively unstructured in order to maximize chances of "surprises" emerging from the group.

Theme I: Sustainability Science

What is emerging as the domain of sustainability science – its central questions, methods, goals and, more generally, challenges? What changes in the current character of its domain should be especially encouraged over the coming decade?

-Lead Discussants: Pamela Matson and Jon Rotmans

Theme II: Institutional Structure

How have the institutions with which the participants in this retreat work, and other institutions with which they are familiar, organized themselves to address the challenges of sustainability science? What has worked well? What hasn't? Looking to the future, what are the core principles and values that an institution dedicated to sustainability science might embrace in order to define itself?

- Lead Discussants: John Schellnhuber and Michael Crow

Theme III: Partnerships

What practical steps might the participants in this retreat take to strengthen our respective institutions through specific partnerships and collaborations? With one another? With others leading institutions?

- Lead Discussants: Julia Marton-Lefèvre and Ed Miles

Theme IV: The Way Forward

How can we, as early leaders in the field, strengthen other nascent institutions and programs that are beginning to emerge in both the earlier- and later-developing parts of the world? How can we link these emergent programs and others yet to be established into a purposeful network or community?

- Lead Discussant: Michael Crow

Discussion

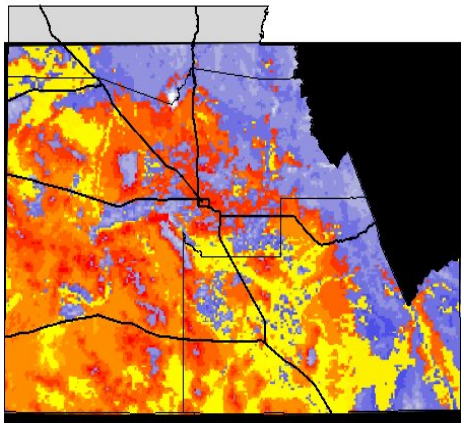
I. Sustainability Science

Most of the discussion focused on articulation of characteristics of the more successful efforts, the remaining challenges and gaps, and in proposing methods and approaches to meet these challenges.

The more successful efforts that link science to action are those that are project-focused (singularity of purpose); involve stakeholders at some level, while recognizing that there are multiple stakeholders. They embrace inter/transdisciplinarity; co-production; co-evolution and a self-organizing capacity; learning by doing and doing by learning; and system innovation rather than optimization. Scientific information is likely to be most effective in influencing the evolution of social responses to public issues when the information is perceived by relevant stakeholders to be not only *credible*, but also *salient* and *legitimate*.

Gaps and Shortcomings

Whereas people are the drivers of the sustainability problems, behavioral issues and issues of miss-aligned values and beliefs are not well addressed. The Social component is under-addressed; need to confront cultural and institutional issues…get the social scientists interested in sustainability research issues. A social conscience needs to be injected into the scientific community. Further, there is a lack of trust between disciplines, between sustainability scientists and other scientists, and between scientists and stakeholders. Some of the research challenges that remain: a) How to address issues related to scale; b) current limits in economic theories which have no capacity to value beyond multiple generations; c) Need to establish "excellence" in sustainability science (stakeholders will seek advice from the best institutions). We need to encourage a transition from supply-driven to demand-driven tools, move from predictive to exploratory approach, and from purely academic to more societally relevant.



Funding remains a serious problem. In the U.S., governmental funding for Sustainability Science is virtually non-existent, and Foundations are moving away from funding of research for solutions toward implementation of environmental actions.

An Approach to Framing

An approach to framing a Sustainability research agenda was presented as a 2-D matrix, with applications areas - use inspired/solution driven cuts at solving problems drawn along columns, and fundamental/core questions/themes in sustainability science down the rows (below). A crosscut of theory and solution driven research emerges. This construct allows both research aimed at contributing to a field and that aimed at helping the world to be equal parts of an agenda, providing a powerful guide to move us toward the design question.

Fundamental Core Themes → Applications Areas ↓	Core Theme 1	Core theme 2
Application 1		
Application 2		

It was also suggested that in some specific cases, one can increase the chances of implementing science-based solutions by identifying those areas that are "unsustainable" (manifested by persistent problems relating to health, agriculture, economic systems, etc.) This means addressing sustainability using a systems approach involving: analyzing, forecasting and hind casting, monitoring, evaluating, and designing sustainable strategies.

II. Institutional Structure

Most of the discussion mined experience on challenges and responses within institutions; less was given to network connections between institutions. Summaries of challenges and responses follow.

The academic culture is conservative and slower to change than the dynamics of (un)sustainability. We need new labels and structures, incremental change won't work. Success requires that structures be outside the normal rule (academic departments, established disciplinary areas) to set a new set of norms of what we are doing. These have a dual accountability to the academic community and users. Support and promotion for people operating in this space have to be built in.

The social science and natural science gap is huge. We need many projects where people have to work together, and acceptance that many projects will fail as we narrow this gap. We need to generate multiple models that engage lots of disciplines in order to infiltrate the system. Bottom-up and top-down influence are both important. Senior level management needs to be engaged. Funds need to be set aside to support interdisciplinary work. Undergraduate interdisciplinary programs that allow people to work together is one model.

Interdisciplinary work is not well respected. The model for Mode II science addresses natural science, engineering, social science, and humanities all of the time. The challenge for a knowledge production and learning enterprise is to construct it from the outset so that all orientations (as well as disciplines) have equal respect.

- *Natural systems:* reductionist, transdisciplinary reductionists, sytematists, contextualists
- *Built systems:* design, builders, systems designers, technology assessors
- *Social systems:* theorists, transdisciplinary theorists, dynamic systemist, normativists
- *Human ideals:* philosopher, comparativists, culturalists, normativists

Normative objectives for science are almost impossible to attain. We need slogans.

The hero culture dominates team culture in universities and the Academies, and heroes have an inordinate level of influence. We need to give resources to teams. By moving enterprises into another institutional setting the veto power of heroes can be eliminated.

There is a tension to be a traditional academic enterprise or a user-driven consulting organization. We need to build institutions so that they are perceived by relevant stakeholders to be not only credible, but also salient and legitimate. Legitimacy reflects the perception that the production of knowledge has been respectful of stakeholders' views and interests.

Distributed networks are not stable and take time to develop. Networks need to organize to look forward at least 10 years.

The development of networks that effectively engage institutions in the developing world is difficult. Models discussed included the use of training programs, interactive web tools, and dialogues.

The overhead of running distributed networks versus locally-based institutions is high and reward for leadership low.

III. Partnerships

Generalizable issues were raised regarding partnerships, their goals, purpose and functions, and on challenges faced when attempting to create and maintain partnerships. Considerable discussion was dedicated to issues related to partnerships between academic institutions and non-academic institutions, and between strong institutions and their weaker partners, with some discussion about ways to strengthen the latter through a purposeful partnership.

A structure was proposed as one model to consider. In the schematic below ("International Network of Institutions for Sustainability Research and Education"), schools A-N range from newly established and emerging programs such as that as the Arizona State University (ASU) to more established such as at Stanford or Maastricht Universities. Each is a free-standing unit, but is part of a "federation" of entities sharing common goals, objectives and collaborating in the activities. The group fully embraced the concept of a purposeful network of institutions for research and education in sustainability, and agreed to proceed with development of some of the proposed actions. A "project office" or "secretariat" was proposed to execute the administrative activities necessary to maintain progress by the network. ASU offers to host this function initially.

Some of the purposes suggested for a network are:

- Agenda setting
- Training/human capital development
- Joint scientific programs
- Capacity building [methods, models]
- Co-production of user-driven knowledge
- Comparison of experiences in cases of similar solution-driven work

Some functions of a network were identified:

Education/Human capacity building

- Fellows Exchange Program for pre-docs, post-docs, and faculty
- Joint degree programs (transnational training) with institutions in developing world
- Undergraduate experience: provide host institutions for summer work, thesis development
- Joint curriculum elements; i.e., certificates - less than a degree
- Building links to southern hemisphere organizations

Research

- Joint capacity for integrated assessment
- Center for methods sharing and method development to address fundamental questions
- Comparative case learning tool that could be put into a curriculum that transits from elementary to graduate school
- Tool exchange and tool standards, e.g., "Decision Theater" at ASU
- Multi-scale sustainability indicators
- Knowledge Production (research) partners – "Mode III"

Convening

- A place: joint 'sustainability hotel' a "retreat" -- Perhaps on a rotating basis – provide access to highest level thinking and conceptualizations
- Journal
- Periodic convening of people to raise awareness and have joint ownership, e.g., "Sustainability Days"
- Roundtable dialogues

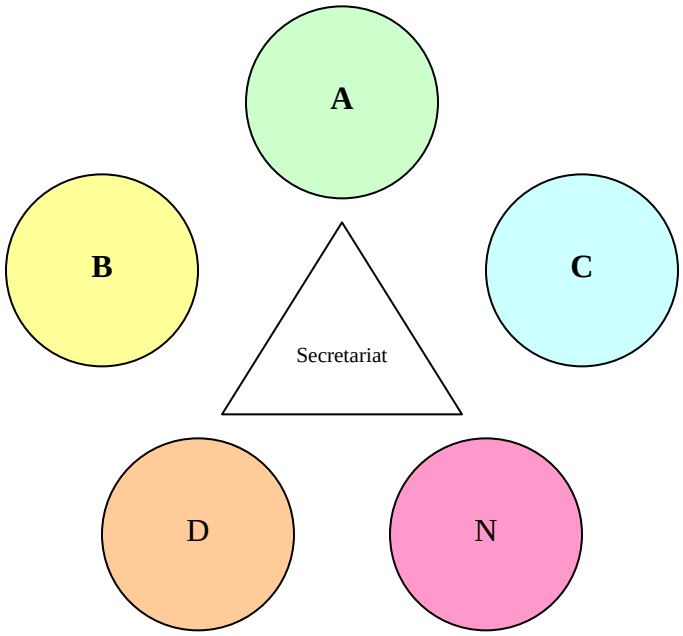
Publicity and Acknowledgement

- Joint public relations efforts to disseminate achievements
- Sustainability awards, senior achievers and program managers

Other:

- Exchange of information about how institutions are built
- Joint fundraising
- Develop integrated assessment tools; databases, cases with advisors; integration specialists; sustainability indices

International Network of Institutions for Sustainability Research and Education



IV. The Way Forward

Recommendations

In the final session, a great deal of attention was placed on practical steps the group might take to advance the notion of a purposeful network of institutions to advance research and education in sustainability. The group focused on four categories, which are summarized below.

A. Human Resource Capacity Building

A.1 Fellows Program

Training the new generation of scholars in sustainability science and practitioners in governmental and non-governmental programs is a critical part of this whole effort. The attempt, therefore is to create a second generation of scholars/practitioners by designing exchange programs among participating institutions for post-doctoral fellows, professional fellows (young practitioners), and graduate students. These programs should link educational institutions in the northern and southern hemispheres to build capacity to engage in sustainability science in a coproduction mode with potential users of the results of such research. It goes without saying that such research must be interdisciplinary.

These exchange programs should also include internships for graduate students and professional fellows. Summer courses that focus on the use of integrated assessment tools and indicators of sustainability should be central parts of the course program. Both governments and NGOs are natural sources of recruitment for such programs.

The exchange facility among participating institutions is also very important for the institutions. Each group in the network has different tools, ideas, and approaches to be pursued in the study of facilitating transitions towards sustainability An exchange dimension maximizes the benefits of this differentiation for post-doctoral and professional fellows and in return, these fellows can add resources to and share knowledge with different groups in the network.

A.2 Undergraduate transnational exchange, summer schools, internships

Undergraduate programs are considered the training ground for tomorrow's leaders; walls stifle creativity encouraging close-mindedness and one-dimensional problem solving. The opportunity to study a different approach paves the road for breakthroughs that may never have been possible without collaboration. Transnational exchanges, the flexibility of summer school programs, and the availability of diverse internships are all important elements to the development of scholars, leaders, and the drivers of our future.

Transnational exchanges at the undergraduate level lay the foundation for future collaborations and encourage openness in thought, study, and research. Knowledge cannot be harbored and protected – it is precious and must be spread and shared to

maximize creativity and results. New heights are reached by combining the familiar with the unfamiliar to create a catalyst that will further future successes in research.

Summer school programs or programs offered outside of the school term allow for intense specialized classes that cater to the growing need of flexibility for both traditional and nontraditional students. Opportunities are created for international academic exchanges without interrupting a student's regular scholastic program. The enhancement of these programs creates an education that is accessible and diverse, creating a global academic environment that is essential to expand and incorporate new program options.

Internships integrate the community into the learning experience creating non-traditional classrooms and helping students identify potential areas of focus. These opportunities encourage students to reach beyond the walls of academia to learn from and contribute to the community. Further, on an international scale, internships create a dynamic opportunity for partnerships and knowledge sharing. Experiencing real-world applications allows students to garner a greater understanding of cultural diversity, explore disciplines both in and outside of their focus areas and to profit from one-on-one mentorship.

Problems faced by society are complex and require both a broad interdisciplinary background, as well as fine-tuned expertise. These skills must be cultivated in leaders experienced in collaborations, systems thinking and conflict resolution. Academic programs should promote integrated study to champion diversity, and recognize that our solutions to the problems of both the natural and social world are incomplete and inadequate. Collaborations in research and academic programming builds bridges of knowledge, which creates an understanding thus opening the door for new opportunities.

Diversity is the means to establish the mechanisms essential to expanding our understanding of the natural and social world, and to broaden our understanding of how to solve problems in ways we cannot yet fully understand. We need to embrace diversity and encourage open access to the learning environment for all. If we sequester the scholarship and creativity that characterize our university, if we build walls around our campuses, we diminish our own potential and the magnitude of our contribution to society.

A.3 Curriculum

The world suffers from a lack of adequate fundamental and applied research capacity in the domain of sustainability science, and also needs to increase the diversity of approaches and people practicing the field. This makes it essential that we do everything possible to build the additional capacity needed in the next decades, both in the Northern and in the Southern hemisphere.

In reflecting on what some of the most important aspects of the required training would be, we believe that at a time when information provided by different disciplines is plethoric, any curriculum in Sustainability Science should take as its point of departure

that acquiring information processing skills is more important than collecting information.

Among the fundamental qualities that we would like future sustainability scientists to have are fluency in writing, oral and multimedia presentation, analytical insight, problem resolution and synthesis. No less important are the toolkits provided by the different disciplines involved. These range from physics and chemistry all the way to history, anthropology and sociology. Indeed, their range is such that it can only partly be acquired in any university study.

Thirdly, the requisite qualities include the capacity to build bridges between scientific disciplines concerned, between fundamental and policy-relevant research as well as between scientists and both the decision-making community and the general public. Finally, a strong commitment to sustainability and the philosophy and ethic behind it are at least as important.

A.4 Professional Recognition and Rewards

The existing system of rewards for scientific excellence does not recognize work which could be classified as contributing to sustainable development. Scientists today are driven by the need to be rewarded both in terms of awards and peer recognition and funding, and the systems in place today were created decades ago when neither interdisciplinary research nor sustainability science were recognized as important contributors to knowledge or problem-solving. The existing reward and recognition systems encourage work by individuals and within traditional disciplines, and these are mostly put in place by 'Northern' institutions. Thus, scientists strive to become members of traditional Academies, publish in discipline based journals, or to gain recognition through the Nobel or other such discipline-driven prizes.

While there are some awards which begin to recognize interdisciplinary work (such as the various environmental awards – Sasakawa, Green Planet, etc) or work for bridge-building (such as the AAAS Award for International Cooperation in Science), and there have been new academies created in recent years, allowing scientists from developing countries to be recognized, these are in general not taken seriously enough by the scientific community to carry their weight. The new Alcan Prize for Sustainable Development, with a large monetary reward ($1m) and aimed at a group, may contribute to begin to change this mind-set.

The institution of prestigious awards for individuals or groups who have made exceptional contributions to linking knowledge with action in pursuit of sustainability was also recommended. This international award would recognize and encourage works of excellence in the area of science and technology that has contributed significantly to sustainable development and would have a significant monetary prize attached to it. News about this award and its winner should be widely disseminated to begin to get the word out about the serious nature of the sustainability science enterprise.

A.5 Funding for Research

There is also an acute shortage of funding sources for interdisciplinary research in sustainable development. National research funding organizations in some countries do allocate such research funds, but the amounts tend to be small and focused on national priorities.

Low remuneration and a general absence of recognition therefore often prevent top-flight scientists from turning their attention to sustainable development issues.

To help lower these barriers, the group proposed therefore to establish funding mechanism addressing interdisciplinary sustainability issues, aimed at groups specifically carrying out demand-led research aimed at providing solutions to sustainable development challenges. Such funding should be available from national, regional, international and private sources.

B. Knowledge Production/Coproduction

B.1 Methods and Standards

Sustainable development is an essentially contested notion, both socially and scientifically, because it is inherently complex, normative, subjective and ambiguous. A possible way out of this sustainability dilemma is to start from the reverse mode, assessing what is unsustainability. Unsustainability manifests itself in the form of persistent problems that have crept into our social systems and cannot be solved by incremental policies. Persistent problems are highly complex, ill-structured involve many stakeholders, are surrounded by structural uncertainties, and are hard to manage. Examples of these problems can be found in many international sectors: the agricultural sector with its many symptoms of unsustainability, visible through protein-based diseases like BSE and Foot & Mouth; the water sector with symptoms like floods, droughts and water quality problems; the energy sector with its one-sided and environmentally-detrimental energy supply system, and the transport system with its concomitant air pollution and congestion. These signaled symptoms of unsustainability reflect a deeper-lying problem: the persistent problems are deeply rooted in our societal structures and institutions, whereas the persistence is the result of system failures that have crept into our societal systems. Contrary to market failures system failures concern profound flaws in our social systems which can not be corrected by the markets and that form serious barriers that prevent systems from functioning in an optimal manner. System failures operate at different levels and may be economic, social, ecological or institutional by nature. In practice, this means that issues within social systems are addressed by old institutions with old solutions and old rules. Resolving (un)sustainability, signaled as persistent problems, requires radical, fundamental changes of social systems from an unsustainable system state to a sustainable system state.

In research terms this requires a new way of thinking and acting, which we call integrated sustainability assessment. This means assessing sustainability at the systems level,

involving *analyzing* the deeper structure of the system in question, *forecasting and backcasting* (un)sustainability trends, *monitoring* (un)sustainability trends, *evaluating* the sustainability impact of policy options, and *designing* possible solutions in terms of sustainability strategies. In order to fulfill these high expectations we need a new research paradigm that better reflects the complexity and multidimensionality of sustainable development…because the traditional paradigm (single actor, single scale, single equilibrium and single failures) used for assessing sustainability has reached its limits. The new paradigm must be able to deal with multiple scales (in time, space and function), multiple equilibriums (dynamic), multiple actors (stakeholders) and multiple failures (system failures). This new paradigm is emerging from a scientific undercurrent that marks the evolution in science in general, denoted as a shift from mode-1 science to mode-2 science, where in mode-1 science the orientation is purely academic and mono-disciplinary and scientists are primarily accountable for their scientific achievements, in mode-2 science inter- and transdisciplinarity play a key role, where scientists are part of more heterogeneous networks, where their scientific tasks are part of a broader process of knowledge production, and where they are accountable for more than only scientific productivity. Another paradigm that has gained influence is that of postnormal science, which reasons from the unavoidability of uncertainty in decision-support research, which needs to be managed adequately by organizing participatory processes in which different sorts of knowledge (not only scientific knowledge) are used to inform policy-making as good as possible on complex societal problems with high stakes.

Against this background the contours of a new research paradigm underlying integrated sustainability assessment can be portrayed in terms of a number of shared research principles, where “shared” means broadly recognized by a growing group of people working within diverging networks in the field of sustainability sciences:

- Inter- and transdisciplinary research
- Co-production of knowledge
- Co-evolution of a complex system and its environment
- Learning-by-doing and doing-by-learning
- System innovation rather than system optimisation

In a simplified manner, this new paradigm can be described as: *co-evolution, co-production and co-learning.* Complex systems theory can be used as overarching mechanism to put the different pieces of the sustainability puzzle together.

The above new paradigm has profound consequences for the tools and methods to be developed for performing integrated sustainability assessment. A new generation integrated assessment tools and methods is in the making that marks the evolution over the past decades that we briefly describe in terms of the following characteristics:

- From supply-driven to demand-driven
- From technocratic to participatory
- From objective to subjective
- From predictive to explorative

- From certainty to uncertainty.

Overall, the nature of our integrated assessment tools is changing: while previous generations of tools were often considered as 'truth machines', the current and future generation of models are considered more as heuristic tools, as an aid to gain more insight into and achieve a better understanding of a persistent problem in question.

We can distinguish two types of tools and methods for integrated sustainability assessment: analytical tools, focusing on the nature of the sustainability transition using complex systems theory; and governance tools, dealing with how to manage the transition towards a sustainable society. Examples of analytical tools for integrated sustainability assessment are: *transition models* that allow for describing and explaining radical changes in between periods of dynamic equilibrium, and contain a systemic representation of the driving forces, system changes, impacts, feedbacks, potential lock-ins and lock-outs for a particular transition in a specific domain; and *transition scenarios* which contain transitional patterns, including unexpected events, surprises and discontinuities. An example of a new governance tool is *transition management*: a visionary and evolutionary learning process executed in small, incremental steps: (i) develop a long-term vision for sustainable development and a joint agenda (macro-scale); (ii) formulate and execute local innovative experiments that might contribute to the sustainability transition (micro-scale); (iii) evaluate and learn from these micro-scale experiments; and (iv) adjust the sustainability vision and strategy based on what have been learned, etc. This represents a cyclical search and learning process, denoted as evolutionary steering: a new form of intelligent planning based on learning-by-doing and doing-by-learning.

B.2 Core Questions of Sustainability Science

The group, in alliance, will seek to encourage user-based, solution-based research for sustainability in real places. Equally importantly, the network will build a new interdisciplinary field of sustainability science. To do so, we must encourage the design and analysis of sustainability research that can lead to advances in fundamental knowledge about the functioning of human-environment (nature-society) systems. We will accomplish this role by:

1) bringing together research-practitioner teams from around the world to identify and explore core questions of sustainability science, and to update them over time;
2) facilitating systematic cross-site case study analysis to test and generalize knowledge concerning specific core questions;
3) encouraging the development of standards and methods for comparative analysis across a range of use-driven research projects;
4) providing a forum for sharing of lessons learned in sustainability case study design, project implementation, and management as well as in results and application for sustainable development.

While the core questions of sustainability science can be expected to mature and evolve over time and thus must be continuously updates, previous discussions and analyses have yielded a set with which we can begin cross-site comparisons and group learning. These core questions include those offered by Kates et al (2001) as a result of the Freiberg Workshop (listed below) and also include questions of cross-scale interactions, the development of knowledge systems for sustainability, among others.

Models and Conceptualizations

How can the dynamic interactions between nature and society – including lags and inertia – be better incorporated in emerging models and conceptualizations that integrate the Earth system, human development, and sustainability?

Long-Term Trends and Transitions

How are long-term trends in environment and development, including consumption and population, reshaping nature-society interactions in ways relevant to sustainability?

Vulnerability and Resilience

What determines the vulnerability or resilience of the nature-society system in particular kinds of places and for particular types of ecosystems and human livelihoods?

Scientifically Meaningful Limits or Boundaries

Can scientifically meaningful "limits" or "boundaries" be defined that would provide effective warning of conditions beyond which the nature-society systems incur a significantly increased risk of serious degradation?

Incentive Structures

What systems of incentive structures – including markets, rules, norms and scientific information – can most effectively improve social capacity to guide interactions between nature and society toward more sustainable trajectories?

Monitoring and Reporting

How can today's operational systems for monitoring and reporting on environmental and social conditions be integrated or extended to provide more useful guidance for efforts to navigate a transition toward sustainability?

Institutions for Research, Observation, Assessment, and Decision Support

How can today's relatively independent activities of research planning, observation, assessment, and decision support be better integrated into systems for adaptive management and societal learning?

C. Forums

C.1 Places to Work

The more distributed and dynamical a Mode II entity like the Sustainability Alliance becomes, the more important it is that it has joint ownership of a concrete place – a community address, where it can meet and can be met, and where it can realize and perpetually reinvent its identity.

Given the intricacy and diversity of the challenges associated with sustainability science, this place should be neither a fully-fledged institute (like Santa Fe) nor a pure debate platform (like Chatham House) but a combination of many features and functionalities. We propose to call it the "Sustainability Hotel", which can accommodate a moderate number of senior scientists, young researchers and students, and stakeholders of all pertinent kinds for short to medium periods of time. Some of the major accomplishments of this place would be the following:

- Co-production of new insights through well-designed programs;
- Training and education of students and practices through various types of courses;
- Stakeholder dialogues and decision theaters;
- Intrinsic communications between the members of the alliance and joint decision-making processes; and
- Advancement of the public understanding of sustainability issues and science through a series of events.

In other words, the Sustainability Hotel would serve both the intrinsic integration of the Alliance's activities and its embedding into the society at large. In terms of weight, focus and construction the hotel would be a unique institution worldwide and, inter alia, a prime source of strategic advice for governments, industry, and NGOs.

The joint operation of such a facility would generate enormous cohesion among the member institutions, much like the joint establishment and use of particle colliders has helped to integrate a paradigmatic subset of the Mode I community.

C. 2 Periodic meetings

An element of our evolving strategy includes periodically engaging a much wider group of researchers and practitioners in a continuing "dialogue" about how to more effectively harness science and technology in support of sustainable development. This could include an Open Meeting and a series of "Sustainability Days" events.

A broadly inclusive Open Meeting or International Science-Practitioner Dialogue on Science and Technology for Sustainable Development would provide a platform for bringing scientists together with policy-makers, resource managers, development specialists, educators, and a wide array of other relevant stakeholders, to discuss the types of information that are most needed from the S&T community on issues of

sustainability, the challenges of linking knowledge to action, the needs for and examples of effective capacity building, the core research questions and research agenda and the institutional requirements needed in all societal sectors to respond to these issues. The core focus of the Dialogue could include themes such as the: integrated management of production/consumption systems; enhancing resilience and reducing vulnerability of coupled human-environment systems; harnessing changes in values and norms to promote sustainability; and reforming governance institutions to foster transitions toward sustainability. As part of our commitment to capacity building in sustainability science, the Dialogue would emphasize bringing together senior leaders in the field with a large number of relevant young scientists and practitioners from the developing countries. Financial support would be sought to help assure the participation of such groups. We would seek to hold the meeting in a developing country, ideally at an institution active in sustainability science.

Three high-profile events addressing how to create a more sustainable way of living have been held at institutes promoting sustainability science, including the Potsdam Institute for Climate Impact Research (PIK), Columbia University, and the Tyndall Centre for Climate Change Research. The fourth is scheduled for 13-17 October 2004 at Stanford University. Sustainability Days consist of a series of seminars, workshops, conferences, and lectures featuring transdisciplinary research that connects environmental science with policymaking. The event provides researchers and practitioners with an opportunity to engage, interact, and shape new research agendas that more strongly connect society's need for sustainable development, addressing local and regional issues as well as global-scale challenges.

A number of additional sustainability related events are scheduled for 2005/06, including Feb 2005 AAAS annual meeting on science and sustainability; IHDP Open Meeting, US National Academies Keck Conference, a EU sponsored European Summit on Sustainable Development, and a December 2004 conference in Japan on technology for sustainability.

D. Service

D.1 Oracle

As with any truly innovative change in human culture, the guidance role of those who have conceived that change or have become "experts" because they have thought about the issue is very important. The so-called "oracle" is a permanent idea generator and a conceptual guidance mechanism on issues related to: a) sustainable development and to the science which fundamentally underlies SD and b) the role it plays in contributing to attain a transition towards it.

It is composed of the 6-8 most visionary and bright minds that have devoted a good deal of the latest part of their lives to think about the above two issues. It is obviously assumed these personalities do exist, are sufficiently committed to the idea of SD so they are prepared to devote time to discuss their advances on thinking about the subject, as well as

what they see to be most salient or core questions in a context of an evolving global scenario for the next 2-3 decades.

They should be prepared to meet 2-3 times a year (2-3 days) with a group of people who are themselves also seriously committed and are currently working on issues of sustainable development. This group can be composed of decision makers both from the private and the public sector, leaders of influential NGO's and academics. Besides holding these meetings, they will make available their current ideas and understanding of the advances in the field of SD in a manner that is accessible electronically or otherwise by whoever is interested on the subject. They will not be dealing with concrete problems (e.g., a project to achieve a more sustainable energy program for country X or region Z).

It should geographically be so placed as to minimize or avoid any perceived or real regional, cultural (or any other) bias in the focusing of global sustainability problems.

There would be a need to define how that group of interested stakeholders is going to be selected to always allow group sizes that can truly interact with the components of the "oracle".

The members of the "oracle" should be subject of change with a periodicity that will allow always to have the most innovative and creative minds forming that group. Very ample social recognition should be given to those members that stop being part of the "oracle"

D. 2 Public Education and Outreach

The inherent appeal and potential contribution of sustainability science to the current and future well being of all people demand that special efforts be invested in communicating this perspective to the widest possible audience. Unlike many other academic pursuits, a better understanding of the principles of sustainable development would provide something of relevance and significance for the world beyond the academic community and would have a positive impact on future generations as well. Moreover, these principles are easy to comprehend, could provide the foundation for a consensual approach to global development and we predict will stimulate a swell of public support that would provide the political will to underwrite their implementation. The key is to speak with a voice that is sufficiently loud to get attention and to focus on how to think about and do sustainability through the case projects that have immediate relevance for people in each part of the world.

Public education and outreach related to sustainable development relies on principles and information derived from natural science, social science, humanities, and engineering. It is, perhaps, the most interdisciplinary of subjects and therefore its effective communication is both a great challenge and an unlimited opportunity. A comprehensive understanding of the operation of earth and life systems, the economics, social behavior, and political organization of humans groups, the perception, valuation, and expression of individuals, and the technologies required to implement these ideas and sustain these

systems are all required for sustainable development. Just as we acknowledge that no single approach will lead to sustainability in all situations, programs in public education and outreach must be diverse, flexible, and tailored to age-group, audience, and cultural perspectives. In designing lesson plans and working with local teachers it is essential to design this approach to fit into local curricular requirements so that this is not extra effort for teachers, but become the core around which many subjects can be offered, simplifying the teacher's job while enhancing its effectiveness (Lieberman and Hoody 1998).

Teaching units on sustainable development should not be limited to ecology and economics, but are an appropriate core around which to convey ideas of the full range of natural and physical sciences, mathematics, economics, politics, anthropology, geography, art, writing skills, literature, and poetry. Of particular significance will be our efforts oriented toward grade 6 through 12 (or equivalent) where the students are sophisticated enough to understand the concepts, retain an enthusiasm for the environment, and often become disenchanted in the absence of meaningful alternatives. In addition we recognize the importance of diversity in our education efforts and will actively recruit minority and underrepresented students at all levels in developed countries and invest special efforts to insure that these education programs are implemented in developing nations. Our goals would to be 1) expose young people to central concepts of sustainable development; 2) teach young people the process of scientific inquiry and the critical thinking associated with social science; and 3) empower teachers with local field experiences and lesson plans related to on-going case studies. Our approach challenges teachers and students to first understand their local region and then broaden their thinking to national and global levels. The success of any educational program, especially one with such ambitious goals and vast scope, depends on how positively attuned the teacher is to its implementation (Ebenezer and Zoller 1993). Thus, we will emphasize teacher education programs through multiple series of school-year workshops with ample opportunity for teachers to reflect upon implementing classroom lessons. We also anticipate developing workshops and internships that would link teachers with scientists, managers, and policy-makers in a manner that would give the teachers sustained exposure to the real life challenges of sustainable development.

We are not recommending new majors in sustainability science at the undergraduate level at this time. Instead, we are urging institutions to seek to infuse the principles of sustainability into core curricula in many disciplines and to encourage innovative majors that assemble subjects that too often have been pursued in isolation.

Graduate education will take many forms, but all of them will be designed to meet the challenge of bringing multiple disciplines together to make available advanced training for students so that they can understand and manage a livable, sustainable world in a manner that maintains regional and global scale ecological values. Training programs will involve interdisciplinary team research with explicit attention to collaboration, group dynamics, and the responsible conduct of research and the engagement of science with law, policy, and the public sphere. Unlike most graduate programs that are based on scientific independence, program associated with us will both use and investigate the

efficacy of interdependence as a research mode. These programs will thus provide innovative graduate training appropriate to multi-investigator, multidisciplinary research that seeks solutions and is socially engaged.

Education concerning the principles underlying sustainable development cannot be limited to the formal educational system, but must be made available to the widest possible audience with special opportunities for retraining and enrichment for those in professional and policy positions. To reach this vast audience it is imperative to partner with local institutions, agencies, as well as universities. Zoos, botanical gardens, museums, and conservation groups are often predisposed to accept the framework of sustainable development and can be particularly effective in carrying this message to their constituency. Media outlets must become better informed and cultivated to more aggressively carry the principles of sustainability in their regular programming and publications and to encourage in-depth coverage of sustainability projects in their region and elsewhere. Our mission is both to train the next generation of sustainable inclined professionals and to inculcate these principles into the daily lives of the broadest possible audience.

D.3 Mode II Learning

Mode II knowledge production refers to the knowledge that is acquired through experience, as compared to that which is acquired through research. In Mode II, problem-solving (application) is the main objective of knowledge production. The knowledge production tends to focus on transdisciplinarity rather than on the individual disciplines. Research is contextualized for the specific problem and place, resulting in a diversification and de-institutionalization of knowledge diffusion activities. Current needs to increase knowledge transfer and utilization are requiring that the institutional basis of research and science make fairly dramatic changes.

Moving from the more traditional research-based model of knowledge production and communication to one that embraces Mode II knowledge as being of equal value, is an important transition to be made by institutions taking on the challenge of sustainability science and education. Even further, it is crucial that in this more “interactive model” the linkages between scientists and practitioners are valuable in themselves. This goes even beyond a “problem-defined” model, where the main value of science is captured by stakeholders.

The Arizona State University (ASU) is establishing the “Sustainability Partnership Enterprise” (SPE), a small interdisciplinary organization established within ASU’s International Institute for Sustainable Futures, dedicated to producing timely, practical products for local community leaders and resource managers. Through university extension, consulting, research and training projects the SPE will produce technical reports, policy analysis and recommendations to aid state and local government decision making and program implementation. The SPE will build on the strengths of Arizona’s universities in science, policy and economic issues concerning land use planning, urban growth, water resources, air quality, and related areas. The innovative function of SPE

will be to successfully span the boundaries that currently exist between researchers, educators, policy makers and practitioners. Critical to its success, is the early incorporation of tacit (Mode II) knowledge into the analyses performed at, and through the SPE; success that will be measured in the number of science-based solutions that are actually used.

Boundary-spanning organizations can play a critical role in the fusion of the knowledge modes, and in the advancement of the knowledge in sustainability, and the creation, transfer and application of knowledge for sustainable development. The international network should work toward promoting and supporting such bridging organizations, and share experiences in doing so. ASU stands prepared to collaborate with partner institutions.

Reporting out of the Retreat

Possible ways to report out of the retreat include:

- Publication of the Retreat Report
- Produce a Review Article on Sustainability Science for the *Annual Review*
- Establish a website