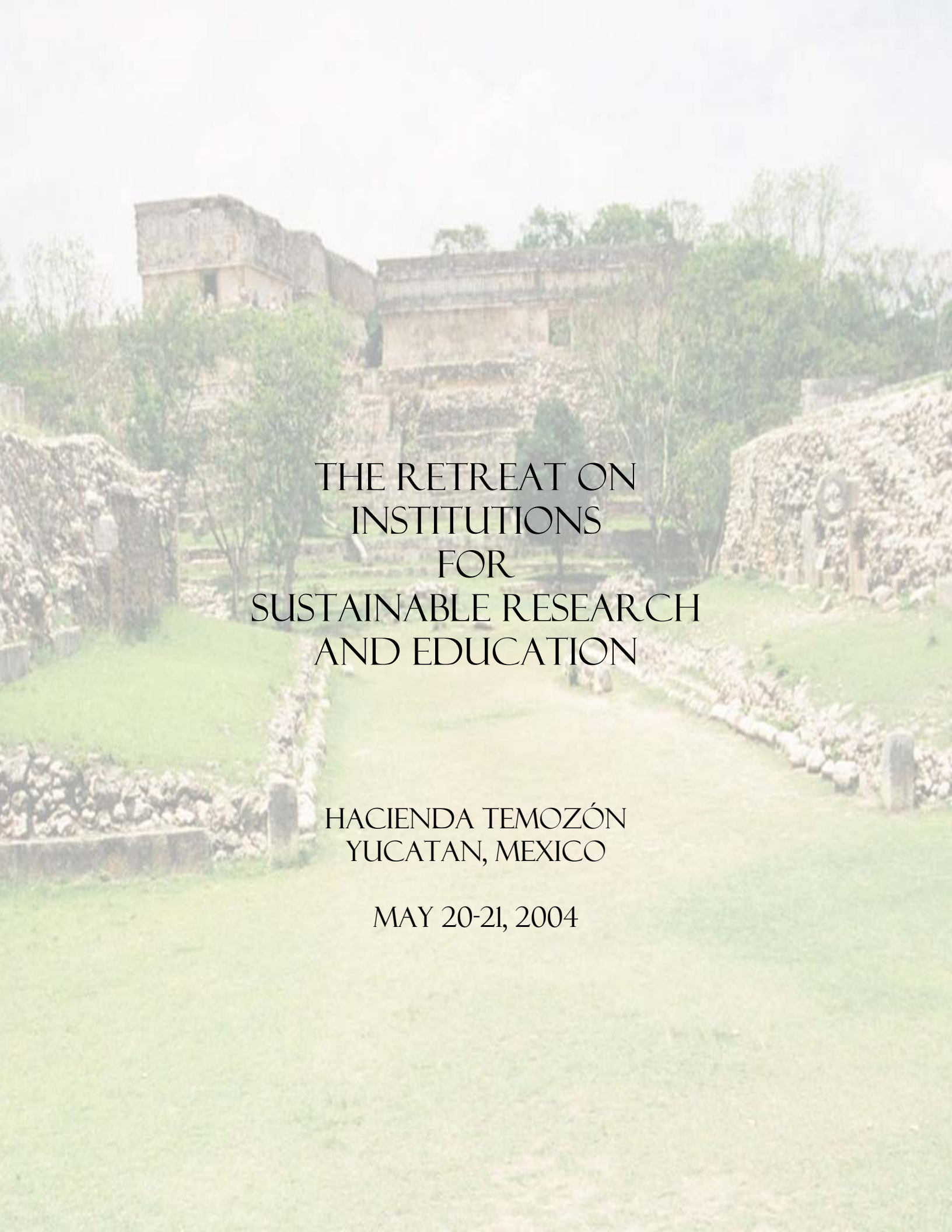


THE RETREAT ON INSTITUTIONS FOR SUSTAINABLE RESEARCH AND EDUCATION

HACIENDA TEMOZÓN
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 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 William Clark of Harvard University. They 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 which needed to be better coordinated. To explore how such joint efforts might best be designed and implemented, a select group of creative leaders in the emerging 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 their respective institutions through specific partnerships and collaborations? With one another? With other 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

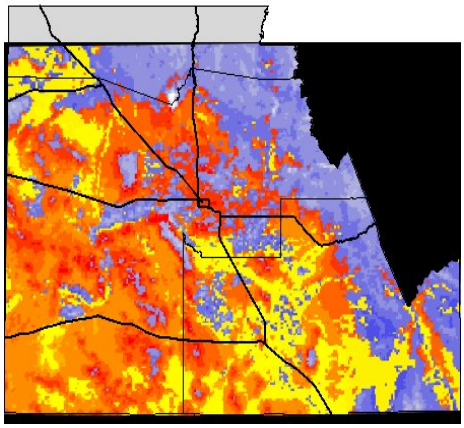
I. Sustainability Science

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) and involve stakeholders at some level, while recognizing that there are multiple stakeholders. Furthermore, they embrace inter/transdisciplinarity; co-production; co-evolution and 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 sustainability problems, behavioral issues and issues of misaligned values and beliefs are not well addressed. In other words, the social component is under-addressed. To effectively address this component, we must confront cultural and institutional issues, and get social scientists interested in sustainability research issues. A social conscience needs to be injected into the scientific community. Further, a lack of trust exists between disciplines, between sustainability scientists and other scientists, and between scientists and stakeholders. Some of the research challenges that remain are:



- How to address issues related to scale;
- Current limits in economic theories which have no capacity to value beyond multiple generations;
- The 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 a predictive to an exploratory approach and from a purely academic to an approach that is more socially 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 research for solutions toward implementation of environmental actions.

An Approach to Framing

A sustainability research agenda was presented as a 2-D matrix (below), with applications areas—use-inspired/solution-driven cuts at solving problems—drawn along columns, and sustainability science areas—fundamental/core questions/themes—depicted down the rows. In this matrix, a crosscut of theory and solution-driven research emerges. This construct allows visualization of both research aimed at contributing to a field and research 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 that involves analyzing, forecasting and hind-casting, monitoring, evaluating, and designing sustainable strategies.

II. Institutional Structure

Most of the discussion drew from attendees' experience with challenges and responses within institutions; less attention was given to network connections between institutions. Summaries of these challenges and respective responses follow:

Challenge: The academic culture is conservative and slower to change than the dynamics of unsustainability.

Responses:

- 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 cadre of norms of what we are doing. These have dual accountability to both 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 numerous models that engage a multitude 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.

Challenge: Undergraduate interdisciplinary programs that allow people to work together in one model.

Responses:

- 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, systematists, contextualists
    - *Built systems:* design, builders, systems designers, technology assessors
    - *Social systems:* theorists, transdisciplinary theorists, dynamic systemists, normativists
    - *Human ideals:* philosopher, comparativists, culturalists, normativists

Challenge: Distributed networks are not stable and take time to develop.

Responses:

- 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.

Challenge: Normative objectives for science are almost impossible to attain.

Response: We need slogans.

Challenge: The hero culture dominates team culture in universities and the Academies, and heroes have an inordinate level of influence.

Response: We need to give resources to teams. By moving enterprises into another institutional setting the veto power of heroes can be eliminated.

Challenge: There is a tension to be a traditional academic enterprise or a user-driven consulting organization.

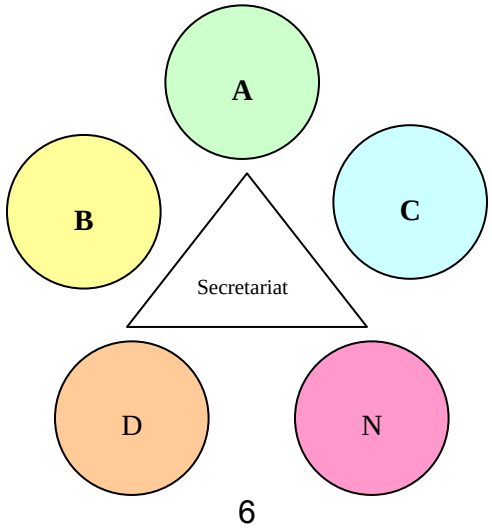
Response: We need to build institutions so that they are perceived by relevant stakeholders to be not only credible, but also salient and legitimate. Legitimacy reflects the perception that the production of knowledge has been respectful of stakeholders' views and interests.

III. Partnerships

Generalized issues were raised regarding partnerships; their goals, purpose and functions; and 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.

The schematic below, "International Network of Institutions for Sustainability Research and Education," demonstrates a proposed organizational model for these partnerships. Schools A-N range from newly established and emerging programs such as those at Arizona State University (ASU) to more established programs such as those at Stanford or Maastricht Universities. Each is a free-standing unit but is part of a "federation" of entities sharing common goals and objectives, and collaborating in activities. 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.

International Network of Institutions for Sustainability Research and Education



The group fully embraced this concept and agreed to proceed with development of some of the proposed actions.

Initial actions suggested for the network were:

- 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

Future actions were also 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 for 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

IV. The Way Forward

Recommendations

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

A. Human Resource Capacity Building

A.1 Fellows Program

Training the next generation of scholars, governmental, and non-governmental practitioners in sustainability science is a critical part of this whole effort. An attempt should be made to design exchange programs among participating institutions for post-doctoral fellows, professional fellows (young practitioners), and graduate students that emphasize sustainability science. This exchange is important as each group in the network has different tools, ideas, and approaches to pursuing and facilitating transitions toward sustainability. Such exchange maximizes the benefits for post-doctoral and professional fellows. In return, fellows add resources to and share knowledge with different groups in the network.

Programs should not only link educational institutions, both in the northern and southern hemispheres, but should link educational institutions with potential users of the research knowledge, thereby building each entity's capacity to engage in sustainability science. It goes without saying that such research must be interdisciplinary.

These exchange programs should 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 integral parts of the program as well. Both governments and NGOs are natural sources of recruitment for such programs.

A.2 Undergraduate transnational exchange, summer schools, internships

Undergraduate programs are considered the training ground for tomorrow's leaders. However, walls can stifle creativity and encourage closed-mindedness and one-dimensional problem solving. Academic leaders must recognize that current solutions to the problems of both the natural and social world are incomplete and inadequate, and promote integrated study to champion diversity. Collaboration in research and academic programming builds bridges of knowledge that foster understanding and open the door for new opportunities. These opportunities pave the road for breakthroughs that may not have been possible without collaboration. Transnational exchanges, the flexibility of summer school programs, and the availability of diverse internships are all important elements in the development of scholars, leaders, and 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 can be 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 the school term, allow for intense specialized classes, catering to both traditional and nontraditional students' growing need for flexibility. These programs create opportunities for international academic exchanges without interrupting a student's regular scholastic program. Enhancement of programs shapes an education that is both accessible and diverse, creating a global academic environment that is essential to expanding and incorporating new program options.

Internships integrate the community into the learning experience creating nontraditional 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. 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 inside and outside of their focus areas, and profit from one-on-one mentorship.

Problems faced by society are complex and require both a broad, interdisciplinary background and a fine-tuned expertise. Transnational exchanges, summer school programs, and diverse internships cultivate this expertise by encouraging diversity, collaboration, systems thinking, and real-world conflict resolution. These tools are the means by which mechanisms crucial to expanding our understanding of the natural and social world can be established, while refining problem-solving skills in ways not yet fully understood. Sequestering the scholarship and creativity that characterize universities and building walls around our campuses diminishes academia's potential and the magnitude of its contribution to society.

A.3 Curriculum

The world suffers from a lack of adequate fundamental- and applied-research capacity, diversity of approaches, and practitioners in the domain of sustainability science. It is essential that universities do everything possible to build the additional capacity needed in the next decades, world-wide. In reflecting on what the most important aspects of the required training would be, the group believes that—at a time when information generated by different disciplines is prolific—any curriculum in sustainability science should focus on information-processing skills rather than information-collection skills.

The fundamental qualities that future sustainability scientists must 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, ranging from physics and chemistry to history, anthropology, and sociology. Indeed, the range is such that it can only be partially acquired in any university study.

In addition, the requisite qualities must include the capacity to build bridges between scientific disciplines; fundamental and policy-relevant research; and scientists and the decision-making community and general public. Finally, a strong commitment to sustainability, and the philosophy and ethics behind it, are at least as important.

A.4 Professional Recognition and Rewards

The current reward system for scientific excellence does not recognize work classified as contributing to sustainable development. Existing reward, recognition, and funding encourages work within traditional disciplines; thus, scientists strive, as individuals, to become members of traditional academies, publish in discipline-based journals, or gain recognition through the Nobel or other such discipline-driven prizes. This system was created decades ago when neither interdisciplinary research nor sustainability science was recognized as an important contributor to knowledge or problem-solving, and was mostly put in place by ‘Northern’ institutions.

While new awards are beginning to recognize interdisciplinary (e.g., Sasakawa, Green Planet) or bridge-building (e.g., AAAS Award for International Cooperation in Science) work, and new academies are recognizing scientists from developing countries, these currently carry little weight in the scientific community. Hence, the development of a prestigious award for individuals or groups who have made exceptional contributions to linking knowledge with action in pursuit of sustainability was recommended.

This international award would recognize and encourage works of excellence in the area of science and technology that contribute significantly to sustainable development. It would have a significant monetary prize attached. News about this award and its winner would be widely disseminated to validate the serious nature of sustainability science.

> The new Alcan Prize for Sustainable Development, with its large monetary reward ($1m) designated for not-for-profit, non-governmental, and civil society organizations, is one such award that may begin to change this mindset.

A.5 Funding for Research

An acute shortage of funding sources for interdisciplinary research in sustainable development exists. National research funding organizations in some countries allocate such research funds, but the amounts tend to be small and focused on national priorities. Low remuneration and a general absence of recognition often prevent top-flight scientists from turning their attention to sustainable development issues.

To help lower these barriers, the group proposed to seek and establish funding mechanisms that address interdisciplinary sustainability issues. Funds will be directed to groups specifically carrying out demand-led research and providing solutions to sustainable development challenges. Such funding should be available from national, regional, international and private sources.

B. Knowledge Production/Co-production

B.1 Methods and Standards

Sustainable development is a socially and scientifically contested notion, because it is inherently complex, normative, subjective, and ambiguous. A possible way out of the "sustainability dilemma" is to start from the reverse mode and assess what unsustainability is. Unsustainability manifests itself in the form of persistent problems in our social systems which cannot be solved by incremental policies. Persistent problems are hard to manage and highly complex, stemming from ill-structured systems and surrounded by structural uncertainties, typically involving many stakeholders.

Examples of problems can be found in many international sectors: the agricultural sector —visible through protein-based diseases such as bovine spongiform encephalopathy (mad cow disease), and foot and mouth disease; the water sector—indicated by increasing floods, droughts and water quality problems; the energy sector—founded on a one-sided and environmentally-detrimental energy supply system; and the transport system—evidenced by concomitant air pollution and congestion.

Symptoms are consequences of system failures. Contrary to market failures, system failures result from profound flaws in the social systems. Uncorrectable by market changes, they 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, issues within social systems are addressed by old institutions with old solutions and old rules. Resolving unsustainability, signaled by persistent problems, requires radical, fundamental changes of social systems from an unsustainable-system state to a sustainable-system state.

In research, this requires a new way of thinking and formulating solutions. We call this "integrated sustainability assessment." Researchers must assess sustainability at the systems level, *analyzing* the deeper structure of the system in question, *forecasting*,

appraising and monitoring unsustainability trends, *evaluating* the sustainability impact of policy options, and *designing* possible solutions in terms of sustainability strategies. To fulfill these high expectations, a new research paradigm that better reflects the complexity and multidimensionality of sustainable development is needed.

The traditional paradigm of 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, 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.

Mode-1 science is purely academic and mono-disciplinary; scientists are primarily accountable for their scientific achievements. Mode-2 science is inter- and transdisciplinary; scientists are part of heterogeneous networks. Scientific tasks encompass a broader process of knowledge production with scientists accountable for more than scientific productivity.

Another paradigm that has gained influence is that of post-normal science, which reasons from the unavoidability of uncertainty in decision-support research. To minimize the impact of uncertainty, research must be managed by organizing participatory processes in which different types of knowledge (not only scientific knowledge) are used to thoroughly inform policy-making on all aspects of 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 principles by a growing group of people working within diverging networks in the field of sustainability sciences. These principles include:

- 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

Simply, this new paradigm can be described as: *co-evolution, co-production, and co-learning.* Complex systems theories may still be useful as overarching mechanisms to put the different pieces of the sustainability puzzle together. However, the above new paradigm has profound consequences for the tools and methods used for integrated sustainability assessment.

A new generation of integrated assessment tools and methods are in the making. These tools mark systems-theory evolution over the past decades and exhibit the following characteristic shifts:

- 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 generations of models are considered more as heuristic tools or aids to gaining insight into and achieving a better understanding of the persistent problem in question. Two types of heuristic tools for integrated sustainability assessment can be distinguished: 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 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 which will:

- Develop a long-term vision for sustainable development and a joint agenda (macro-scale);
- Formulate and execute local, innovative experiments that might contribute to the sustainability transition (micro-scale);
- Evaluate and learn from these micro-scale experiments; and
- Adjust the sustainability vision and strategy based on what has been learned.

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

Working groups, in an alliance, will seek to encourage both user-based and solution-based research for sustainability in real places. Equally important, the network will build a new interdisciplinary field of sustainability science. The design and analysis of sustainability research that can lead to advances in fundamental knowledge about the functioning of human-environment (nature-society) systems must be encouraged to build this emerging field. This may be accomplished by:

- Bringing together research-practitioner teams from around the world. These teams will identify and explore core questions of sustainability science, updating them over time;
- Encouraging the development of standards and methods for comparative analysis across a range of use-driven research projects;
- Facilitating systematic, cross-site case study analysis. This analysis will test and generalize knowledge concerning specific core questions;
- 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 updated, 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) in addition to questions of cross-scale interactions, and 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 that entity 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. The group proposes 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 the 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. These dialogues include an open meeting and a series of “Sustainability Days” events.

The broadly inclusive open meeting, referred to as the International Science-Practitioner Dialogue on Science and Technology for Sustainable Development, provides 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 dialogues includes themes such as:

- integrating 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 the commitment to capacity building in sustainability science, the dialogue must emphasize bringing together senior leaders in the field with a large number of relevant young scientists and practitioners from developing countries and around the world. Financial support will help to assure the participation of such groups, and meetings will be held at institutions active in sustainability science and, ideally, in developing countries.

Recently, three high-profile events addressing how to create a more sustainable way of living, or “Sustainability Day” events, 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. A fourth is scheduled for 13-17 October 2004 at Stanford University. These Sustainability Day events consist of a series of seminars, workshops, conferences, and lectures featuring transdisciplinary research that connects environmental science with policymaking. The events provide researchers and practitioners with an opportunity to engage, interact, and shape new research agendas that more strongly connect society’s need for sustainable development, and address local and regional issues as well as global-scale challenges.

A number of additional sustainability related events are scheduled, including a December 2004 U.S. National Academies Keck Conference; a December 2004 conference in Japan on technology for sustainability; a EU sponsored European Summit on Sustainable Development; a February 2005 AAAS annual meeting on science and sustainability; and an October 2005 International Human Dimensions Programme (IHDP) on Global Environmental Change open meeting.

D. Service

D.1 Oracle

As with any truly innovative change in human culture, the guidance role of those who have conceived the change or have become "experts" because they have thought about the issue is very important. This "oracle" is a permanent idea generator and a conceptual guidance mechanism for the primary principles of sustainable development (SD): a) the science which fundamentally underlies it, and; b) the role which science plays in contributing to attaining a transition towards it.

This group of experts is composed of 6-8 visionaries who have devoted a good deal of their lives to thinking about the above two issues. It is supposed that these personalities do exist and are sufficiently committed to the idea of SD; such that 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 seriously committed and are currently working on issues of sustainable development. This group can be composed of decision makers from both the private and the public sector, and 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 in 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).

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

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

The members of the oracle should be subject to change periodically, to allow the most innovative and creative minds to form the 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.

A better understanding of the principles of sustainable development will provide something of relevance and significance for the world beyond the academic community, and will have a positive impact on future generations as well. Moreover, these principles must be easy to comprehend, should provide the foundation for a consensual approach to global development, and will, we predict, stimulate a swell of public support that will drive 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 practice 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 effective communication presents 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 human 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 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 there is no extra effort placed on 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 efforts oriented toward grades 6 through 12 (or equivalent) whose students are sophisticated enough to understand the concepts while retaining an enthusiasm for the environment, and who often become disenchanted in the absence of meaningful alternatives. In addition, we recognize the importance of diversity in 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.

Goals should be to: 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 ongoing case studies.

This 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, emphasizing teacher education programs through multiple series of school-year workshops with ample opportunity for teachers to reflect upon implementing classroom lessons will be needed.

The group also anticipates developing workshops and internships that link teachers with scientists, managers, and policy-makers in a manner that gives the teachers sustained exposure to the real life challenges of sustainable development.

New majors in sustainability science at the undergraduate level are not being recommended at this time. Instead, institutions are being encouraged 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, programs associated with SD 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. It 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 more aggressively to 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. The mission is both to train the next generation of sustainable-inclined professionals and to infuse these principles into the daily lives of the broadest possible audience.

D.3 Mode II Learning

Current needs to increase knowledge transfer and utilization are requiring that the institutional basis of research and science make fairly dramatic changes. Mode II knowledge production refers to knowledge 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. This type of knowledge production tends to focus on transdisciplinarity rather than on the individual disciplines. In addition, Research is contextualized for a specific problem and place, resulting in diversification and de-institutionalization of knowledge diffusion activities.

Moving from the more traditional research-based model of knowledge production and communication to one that embraces the Mode II model of knowledge as being of equal value is an important transition that needs 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.

Arizona State University (ASU) is establishing the “Sustainability Partnership Enterprise” (SPE), a small interdisciplinary organization established within ASU’s Global Institute of Sustainability, 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 will play a critical role in the fusion of the knowledge modes; 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, sharing 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