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Program on ecosystem change and society: an international research strategy for integrated social–ecological systems

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The Program on Ecosystem Change and Society (PECS), a new initiative within the ICSU global change programs, aims to integrate research on the stewardship of social–ecological systems, the services they generate, and the relationships among natural capital, human wellbeing, livelihoods, inequality and poverty. The vision of PECS is a world where human actions have transformed to achieve sustainable stewardship of social–ecological systems. The goal of PECS is to generate the scientific and policy-relevant knowledge of social–ecological dynamics needed to enable such a shift, including mitigation of poverty. PECS is a coordinating body for diverse independently funded research projects, not a funder of research. PECS research employs a range of transdisciplinary approaches and methods, with comparative, place-based research that is international in scope at the core.

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Introduction

Human wellbeing and the Earth system on which it depends are in transition. Human wellbeing and its distribution among peoples and places are changing, while at the same time we have clear evidence of our own role in transforming the planet. The global social–ecological system is changing in diverse dimensions such as peace and security, urbanization and migration, affluence and public health, consumption and technology, governance and institutions, and condition of the biophysical environment [1]. Global changes from human activities include profound alterations of ecosystems and the services they provide to humanity. Drivers of environmental change are likely to intensify as the human population grows and per capita consumption increases. Some of the changes to the Earth system have led to substantial gains in human wellbeing and economic development through improved access to food, water and other basic needs. At the same time, there has been degradation of many ecosystem services, increased risks of abrupt changes such as diseases and pests, and increasingly vulnerable livelihoods. The expanding understanding of these changes in social–ecological systems, as well as improvements in our capacity for action, suggest some leverage points for effective responses [2]. The challenge of sustainable development is to grasp this opportunity and transform social–ecological systems to provide food, water, energy, health and wellbeing in a manner that is economically, ecologically and socially viable for many generations in the future and for people in all parts of the world [3,4].

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Many researchers and projects have greatly advanced the basic science of social–ecological change. Resilience concepts were developed for social–ecological systems in the 1980s [5] and have emerged as one of the key frameworks for analyzing social–ecological systems [6•]. Resilience thinking is used in practical management of regional ecosystems [7,8] as well as conceptual work on global sustainability [3]. Global resilience research is coordinated by the Resilience Alliance (http://www.resalliance.org/).

Other research has focused on concepts of adaptive capacity and vulnerability [9]. Adaptations are the response to perceived risks that result from environmental hazards and human vulnerability. Vulnerability assessments address exposure to hazards as well as the sensitivity or resilience of the social–ecological system exposed to the hazards [10•].

At roughly the same time, research on science and technology for sustainability coalesced and became a vibrant discipline [11] with its own journals (for example this one) and an influential section of *Proceedings of the National Academy of Sciences* [12]. A recent network analysis demonstrates the broad footprint of sustainability science [13•]. Interestingly, Bettencourt and Kaur [13•] find that the global network of sustainability science occurred in the past 10 years as demonstrated by emergence of a ''giant component of scientific collaboration''. They conclude that ''developments demonstrate the existence of a growing scientific field of sustainability science as an unusual, inclusive and ubiquitous scientific practice and bode well for its continued impact and longevity'' [13•].

The Millennium Ecosystem Assessment (MA), published in 2005, assessed the consequences of ecosystem change for human wellbeing [14]. It introduced a new conceptual framework for analysing social–ecological systems, which has had considerable influence in policy and scientific communities. The Assessment also revealed significant gaps in current scientific knowledge of the links between ecosystem services and human wellbeing [15••]. Some of the critical gaps include the need for understanding how social–ecological systems evolve over time and respond to policy interventions. In addition,-conceptual goals of the assessment were only partly addressed by existing quantitative models. For example, nonlinear and abrupt changes in social–ecological systems were not well integrated into planning and policy; trade-offs among ecosystem services were not fully understood; and there was little information about how ecosystem services interacted with other factors that determine human wellbeing.

The Millennium Assessment encompassed both a global component and subglobal or more local ones. The conceptual framework and insights gained at the global level were very useful to provide a synthetic picture. In addition, subglobal and more local assessment were extremely informative about the ways that policies and practices link to ecosystem services, human wellbeing, livelihoods and poverty depending on the social and ecological context of particular places. Thus it became clear that many of the above-mentioned knowledge gaps should be addressed by strengthening support for place-based, long-term, social–ecological research.

In 2007, the International Council for Science (ICSU), in partnership with the United Nations Educational, Scientific and Cultural Organizations (UNESCO) and the United Nations University (UNU), established an ad hoc expert group to assess these knowledge gaps and how they might best be addressed by the scientific community. This expert group published its report on Ecosystem Change and Human Well-being in December 2008 [16]. The report included a recommendation for establishing a new 10 year research program, Programme on Ecosystem Change and Society (PECS), to foster coordinated research for understanding the dynamic relationship between humans and ecosystems. This program is jointly sponsored by ICSU and UNESCO and complements the four other ICSU sponsored global environmental change programs and the Earth Systems Science Partnership.

PECS research will be explicitly transdisciplinary and intersectoral, and will thereby break down barriers that have impeded understanding of social–ecological transformations. PECS aims to understand interactions across scales, such as fast and slow drivers of social and ecological change, thresholds, traps and time lags, in order to identify appropriate operational scales. A comparative, place-based approach, international in scope, is at the core of PECS research. PECS is a coordinating organization, not a funding agency.

Framework

PECS' guiding vision is a world where human actions have been transformed toward stewardship of social–ecological systems for global sustainability. To address this goal, PECS research will build upon and expand the Millennium Ecosystem Assessment conceptual framework [14]. Successful elements of the MA will be retained as central components of PECS research. For example, PECS will use the lens of ecosystem services as a way to understand the interdependence of social–ecological systems, and retain the focus on feedback loops between ecosystem services, human wellbeing and indirect and direct drivers of ecosystem change.

A key feature of PECS research will be the recognition that ecosystem services are not generated by ecosystems alone, but by social–ecological systems [8]. Social–ecological systems are integrated systems of people and

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nature that are nested across scales from local to global [17,18]. In essence, people are part of ecosystems and shape them. PECS explicitly connects people to the biosphere and the Earth System as a whole and aims at removing the perceived dichotomy between nature and society.

Stewardship of ecosystem services at any one location is shaped by connections to other places across temporal and spatial scales. PECS research will address the complex, multi-scale dynamics of social–ecological systems, recognizing the extensive interplay between the global and the local, the past, present and future. These dynamics include nonlinear thresholds that can lead to large, persistent changes such as salinized agricultural areas, degraded forests and rangelands, or collapsed fisheries. PECS will also focus on strategies to break out of traps into improved conditions. Social–ecological dynamics include human capacities to learn, reorganize and adapt, and these appear to be essential for avoiding or escaping traps (Folke *et al.*, 2005). Living with complexity and change requires adaptive approaches to management and modes of decision making that cope with high uncertainty [19]. These approaches are essential for social–ecological stewardship and are therefore a high priority for research.

Approaches

PECS will involve working groups, cross-cutting themes that are addressed by all working groups, and case studies. PECS will provide mechanisms for intellectual exchange among diverse projects on social–ecological systems. Heterogeneity of methods is sometimes a barrier to comparative analyses of social–ecological research, yet diverse social–ecological systems often require different methods. PECS will hold workshops to address variability in methods and standardize methods when this is appropriate. PECS will sponsor broad workshops to develop cross-cutting themes that contribute to a wide range of research on social–ecological systems. Because PECS is envisioned as a bottom-up, researcher-driven platform, diverse input and leadership will be encouraged as PECS develops.

Working groups already proposed for PECS include (1) Marine Social–Ecological Systems, (2) Urbanized Landscapes, (3) Conservation Landscapes, (4) Agroecosystems and (5) Dryland Social–Ecological Systems. The core of each working group will include 10–15 researchers from around the world, predominantly younger researchers.

Each working group will address a set of common, cross-cutting research issues.

These issues are still evolving and will be shaped partly by the working groups themselves. Examples of proposed themes are (1) Thresholds and Traps, (2) Governance and Institutions, (3) Ecosystem Services, Human Well-Being and Trade-offs, (4) Cross-Scale Feedbacks and (5) Diversity in Social–Ecological Systems.

The principal approach of PECS research is comparisons of place-based, long-term social–ecological case studies (Box 1). Place-based research addresses the particularities of specific landscapes, seascapes or coastal regions and explicitly includes the social–ecological dynamics of the system. Such research can of course occur at any spatial extent from global to local. Specific case studies will fall into one of the PECS working groups. At each of those scales and for each of those particular systems, the relative role of different drivers operating at different spatial scales will be key to understand the dynamics of the social–ecological systems.

To compare place-based social–ecological transitions, PECS will examine diverse sources of information – including narrative, qualitative and quantitative data and historical records in addition to more traditional technical monitoring tools and remote sensing – and will employ a wide range of methods. PECS will contribute to building a central database of the transdisciplinary methods employed in different case studies and the research questions they attempt to answer. A key part of the capacity-building strategy will be training workshops on core methods. Examples of such methods include qualitative analysis of narratives, various kinds of models, and scenario planning and resilience thinking. Furthermore, PECS aims to develop and apply new methodologies (aided by identification of potential gaps in the methods database described above) that enhance integration and collaboration between disciplines for social–ecological research.

Modeling to understand the dynamics of natural capital, ecosystem services and human wellbeing will play a key role. The MA Scenarios Working group prepared an exhaustive review of models for analyzing dynamics of ecosystem services [20]. PECS will promote the development of a new generation of transdisciplinary and intersectoral models for assessing movement toward and away from sustainability. Such models will bridge key sectors (food, water, energy, etc.), address local, regional and global processes and feedbacks across scales and account for the full portfolio of ecosystem services that flow from a given landscape or seascape. Approaches for social–ecological modeling are expanding rapidly through the evolution of approaches such as agent-based modeling, network-based modeling and others [13•].

PECS will engage multiple stakeholders, address interconnections of ecosystem services – including their physical, biological, and social aspects – develop analytical approaches to evaluate outcomes of policies and practices, design responsive monitoring strategies, and provide transparent access to information.

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Box 1 Example of a Social–Ecological Project

The Southern African Program on Ecosystem Change and Society (SAPECS) aims to produce a body of empirical evidence and develop practical theory and tools to improve the understanding of how ecosystem services can be used to build resilience for poverty alleviation and socio-economic development under conditions of rapid change and increasing vulnerability. It will build on the Southern African Millennium Ecosystem Assessment (SAfMA) [22], as well as the many ecosystem service studies that have taken place in the region during the past decade. Recognizing that the connections between resilience, ecosystem services and human development are still poorly understood, SAPECS plans to develop and share approaches for operationalising the ecosystem service concept at a local scale in a rural and linked urban developing country context. In particular it seeks to better demonstrate how ecosystem services can be used to alleviate poverty in a resilient and sustainable manner. However, SAPECS will also adopt a multiscale approach in order to account for the interactions between ecosystem services and human wellbeing between local, national and trans-national scales, as well as the socio-economic priorities and policy processes that operate across these different scales.

At the local scale SAPECS will focus initially on three connected local authorities, which house an enormous diversity of biodiversity and ecosystem services, span large wealth gradients, land tenure systems, rural and urban areas, and can be used to study rural–urban flows and interactions in terms of ecosystem services, human wellbeing and poverty. These authorities include the Eden District Municipality dominated by commercial farming and private land tenure, the largely rural and communal Amatole District Municipality, and the growing urban hub of the Cape Town Metropolitan Municipality. These authorities form the locus of land, water use and development planning and implementation, and all three lie in biodiversity hotspots. It is proposed that all three regions are experiencing massive and rapid socio-economic transformations. There are also important national and international links through agricultural (especially wine, flower, fruit exports) and lifestyle ecosystem services, as all three municipalities are major international ecotourism destinations. All three local authorities are therefore characterized by strong ecological and social diversity and gradients, highly dynamic social–ecological systems, and have a strong integrated observation base. At the local scale objectives include (1) to develop capacity and methods for assessing multiple ecosystem services and their distributional benefits, across space and time for informed integrated management, (2) to develop understanding and tools for building resilience and incorporating ecosystem service interactions into the management of natural resources in the face of uncertainty and climate change, (3) to develop an understanding of needed transitions of governance and policy systems in order to mainstream ecosystem service management in decision-making processes and (4) to develop and disseminate a toolbox, share lessons learned regionally and internationally and facilitate partnerships among local and regional African, and international institutions.

While informing decision making at the local scale is critical to achieving sustainable development in South Africa, national government has legislative competence for environmental management and for setting the agenda for economic and social development, and will therefore also be the target of SAPECS in operationalising the concept of ecosystem services in national policy and planning. South Africa's developing green economy provides an ideal platform for doing this, and SAPECS aims to pilot the mainstreaming of ecosystem services into national development planning by (1) increasing the relevance of ecosystem services in the national policy environment, through growing the evidence base of the value of ecosystem services to national policy imperatives and finding innovative ways to communicate this relevance to public and private sectors (2) increasing the role of ecosystem services in national policy by investigating possible changes in or development of new legal and regulatory mechanisms and piloting the role of ecosystem based adaptation to climate change.

Conclusion

The emergence of PECS is an opportunity to implement some key elements of Earth System Science for Global Sustainability [21]. The grand challenges of Earth System Science explicitly involve the dynamics of integrated social–ecological systems, which are the focus of PECS. Ultimately, the success of PECS will depend on the participation of excellent researchers who are motivated to link their research to the PECS network, as well as the full ensemble of global change research programs. The PECS International Program Office (IPO) is hosted by the Stockholm Resilience Centre (SRC). Please contact Albert Norström for more information. The PECS website will soon be available. Meanwhile see PECS at ICSU (http://www.icsu.org/what-we-do/interdisciplinary-bodies/pecs/about) and the PECS website at the Stockholm Resilience Centre (http://www.stockholmresilience.org/research/centrehostedresearchprogrammes/pecs.4.5686ae2012c08a47fb5800013559.html).

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