**SUSTAINABILITY SCIENCE:**

**INTERACTIONS BETWEEN HUMAN AND ENVIRONMENTAL SYSTEMS**

***A Distributed Seminar among Univ. Minnesota, Arizona State Univ., Universidad Nacional Autótonoma de México, and Universidade de Sao Paulo***

***Semester***: Spring term 2015, First joint meeting 5 Feb., last joint meeting 30 April

***Initial meeting times***: Tues (individual sessions) and Thurs (joint session), 12:00-1:30pm **Central Time,** 11:00-12:30, **Mountain time**; 16:00-17:30 **Brasil time**. These change throughout the semester as indicated in part C.

***Central course web page***: https://ay14.moodle.umn.edu/course/view.php?id=7888.

*(This is a temporary site that will be updated. A website will by hosted by UMN that all participants can access. Individual institutions can also host their own websites.)*

***Faculty***:

***Univ. Minnesota* (UMN)*:*** Jeannine Cavender-Bares [(cavender@umn.edu](mailto:cavender@umn.edu)), Steve Polasky [(polasky@umn.edu](mailto:polasky@umn.edu) )

***Arizona State Univ***. **(ASU)**: Osvaldo Sala ([Osvaldo.Sala@asu.edu](mailto:Osvaldo.Sala@asu.edu) ), Bill Turner [(Billie.L.Turner@asu.edu](mailto:Billie.L.Turner@asu.edu) )

***Universidad Nacional Autótonoma de México* (UNAM)**: Patty Balvanera (pbalvanera@cieco.unam.mx), Tuyeni Mwampamba (tuyeni@cieco.unam.mx), Carlos Gonzalez [(cgesquivel@cieco.unam](mailto:cgesquivel@cieco.unam.mx))

*Participating faculty****:*** John Larsen, Eduardo Frapolli Garcia

***Universidade de Sao Paulo* (USP)**: Lúcia Lohmann(llohmann@usp.br)

*Participating faculty****:*** Jean Paul Metzger

***Course numbers***:

***UMN:*** EEB 8200

***ASU***: BIO 591 / GCU 591 / SOS 591

***UNAM: USP:***

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# COURSE OVERVIEW

This course is a research seminar on core ideas in sustainability science -- an emerging field of problem-driven research dealing with the interactions between human and environmental systems. The problem that motivates the course, and the field, is the challenge of sustainability: improving the well-being of present and future generations in ways that conserve the planet’s life support systems over the long term. The goal of the seminar is to introduce researchers interested in sustainability science to the field’s principle themes, cutting-edge findings, active debates and unresolved research questions. To this end, participants will critically discuss a set of presentations and papers covering the field in a systematic way, drawing on and integrating contemporary research from earth systems science, resource economics, institutional analysis, ecology, geography, development studies, health sciences, engineering, and other disciplines.

The motivation for the seminar is the need to integrate the various communities working on sustainability science. The fragmentation of those communities, by discipline, by institution, by applications focus, is a major impediment to the growth and maturation of the field. In response, we are experimenting with this distributed, interdisciplinary graduate seminar on sustainability science. The goal of this seminar is to bring together faculty and graduate students from different countries, cultures, universities, and disciplinary backgrounds, to discuss key concepts, findings and controversies in the field. An initial course along these lines was run in 2010, and the 2015 course will be the fourth iteration. This year’s version involves faculty and students at four universities recognized as leaders in sustainability science (Arizona State University, the National Autonomous University of Mexico, Sao Paulo University, and the University of Minnesota). Our specific goal for this year is to juxtapose, discuss and develop new insights arising from differing cultural, political, economic, and ecological perspectives from Latin America and the U.S.

The seminar meets twice a week. The first session each week will be conducted individually at each university to prepare for focused discussion in the second session that will be held jointly with all participants linked through web conferencing technology. We will use the Vidyo software, hosted by ASU. For each joint session, a faculty member will begin by presenting a prepared lecture to all participants through video (30 minutes). Following the lecture, an interdisciplinary team of students drawn from each institution will present a short list of questions to guide discussion of critical themes raised by the readings and lecture. All participants in the seminar will be expected to have read both the assigned readings and the discussions questions and come prepared for an in-depth discussion. A faculty moderator will guide discussion on the material, paying special attention to the discussion questions.

All students will be expected to contribute regularly to an on-line discussion of the lectures and assigned literature .Students taking the course for credit will be required to meet additional requirements imposed by their home university. (See below in this syllabus). Student collaboration across institutions is highly encouraged.

The seminar is an ongoing experiment in developing approaches to the sorts of collaborative, distributed, travel-minimizing networking that almost certainly must be part of any sustainable future. Students and faculty will be asked to participate in an on-going adaptation of the seminar to better realize its objectives.

*Prerequisites*: This is primarily a doctoral seminar. Other students with research training and experience may enroll with written permission of the instructor(s) of their home institutions.

Auditors will be admitted on written application to the relevant instructor, conditional on a commitment to participate fully in the course.

# BASIC ARCHITECTURE –

**Part I** (1 week): **Introduction** to the challenges of sustainable development, and the idea of an emergent field of sustainability science organized as a problem-driven field of inquiry to address those challenges.

This section sets out the history of these concerns, the idea of interactions between humans and the environment as a complex adaptive system, and the long term trends and large scale patterns in the human-environment system that sustainability science seeks to understand and to help manage. It sets the stage for course. In doing so, we specifically highlight contrasting perspectives across cultures and disciplines on the central issues and methods of analysis.

**Part II** (4 weeks): **Conceptual frameworks** for thinking about the sustainable development challenge and the tasks of sustainability science.

We begin with the premise that there does not yet exist a truly integrative coherent and practical framework for analyzing sustainable development in terms of coupled human-environment systems. One influential attempt at creating a theoretically consistent and coherent approach to sustainable develop is the notion of “inclusive wealth” where “inclusive” signifies that attempt to include all forms of capital assets (natural capital, manufactured capital, and human capital) and institutions (social capital) that contribute to current and future human well-being. This approach integrates across biophysical, social and economic dimensions. However, the approach as currently developed is quite abstract and raises concerns around issues of measurability and equity.

{Description of Reconciling supply and demand for ecosystem services}

{A sustainability framework for assessing trade-offs in ecosystem services}

{Description of An evolutionary framework for sustainability}

**Part III** (4 weeks): **Complex system dynamics** in human-environment systems that pose special challenges to sustainable development and sustainability science, including considerations of **resilience**, accurately measuring **natural capital**, **ecosystem services** and **biodiversity**, and **measuring and monitoring** progresstoward sustainability.

The components of human-environment systems introduced in Part II interact in complex and uncertain ways that defy accurate prediction and necessitate adaptive approaches to management. Some of these interactions pose special challenges for sustainable development. Such challenges are in part due to temporal lags between human actions and environmental response, spatial heterogeneity, and the embedding of human-environment systems in multiple scales of interaction from the local to global. Complex system dynamics can generate thresholds ortipping points leading systems into rapid changes in fundamental system behavior*.* Such factors make trial-and-error adaptation difficult and highlight the importance of a better understanding of systems vulnerability and resilience.

We turn attention to what is known about socio-ecological system dynamics and natural capital, and in particular how biodiversity and ecosystem functions contribute to provision of ecosystem services that support human well-being.

A particularly difficult issue is measuring and monitoring progress towards or away from sustainability. For example, the inclusive wealth framework requires measuring the value of all forms of capital assets in a common monetary metric but many forms of human, natural, social capital are not readily measured in monetary terms. Other approaches use multiple indicators or metrics but face difficulties of how to interpret overall trends when some indicators show improvement while others deteriorate. We will discuss issues of what to measure, how to measure, and how to interpret evidence in terms of what it indicates for sustainability.

**Part IV** (3 weeks) **Governance** is an essential component of achieving sustainable development. Effective governance of complex human-environment systems requires interface between **science and policy** and linking **knowledge to action**. Knowledge is not the exclusive domain of experts and scientists, those who live and work in social-ecological systems have knowledge. We will discuss **participatory research** and impact assessment for sustainability science. In addition, policy and decisions about what *should* be done to achieve sustainable outcomes is not determined solely by knowledge or scientific information, it also involves values. A theme that will come up throughout the course are the role of values and differences in values in determining social choices regarding sustainability.

# SCHEDULE OF CLASS SESSIONS

The table below presents the schedule of topics and the lead faculty responsible for each week’s session. Lecturers (including several outside guests), readings, and student team responsibilities will be posted well in advance of each session.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Week # for joint sessions** | **Date of individual session** | **Date of joint session** | **Part and Topic** | **Lead faculty** |
| 1 | 2/3 | 2/5 | Sustainable development and sustainability science | Turner |
| 2 | 2/10 | 2/12 | Inclusive wealth | Polasky |
| 3 | 2/17 | 2/19  [*USP absent*] | Reconciling supply and demand for ecosystem services | Sala |
| 4 | 2/24 | 2/26 | A sustainability framework for assessing trade-offs in ecosystem | Cavender |
| 5 | 3/3 | 3/5 | An evolutionary framework for  sustainability | Lohmann |
| 6 | 3/10 | 3/12  [*ASU absent*] | Sustaining natural capital, ecosystem services, and biodiversity | Balvanera |
| 7 | 3/17 | 3/19  [*UMN absent*] | Social-ecological resilience – Cross scale dynamics in time and space | Sala |
| 8 | 3/24 | 3/26  [*UNAM absent*] | Towards the global measurement of sustainability | Polasky |
| 9 | 3/30 | 4/2 | MESMIS and measurement of sustainability of agroecosystems | Gonzalez- Esquivel |
| 10 | 4/7 | 4/9 | Interface between research and policy making towards sustainability | Lohmann/ USP |
| 11 | 4/14 | 4/16 | Linking knowledge to action | “Clark” |
| 12 | 4/21 | 4/23 | Participatory research and impact assessment for sustainability science | Mwampamba |
| 13 | 4/28 | 4/30 | **Wrap up** |  |

# HOW THE COURSE WILL BE RUN

The course will meet twice a week.

**Tuesday Session**: The first (Tuesday) session each week will be conducted by each university on its own.

The purpose of this session is to discuss papers assigned for Thursday lectures and be prepared to ask questions.

**Thursday (or 2nd) session**: We will meet jointly on Thursdays during the following times:

Course start: Minnesota 12:00-13:30

Arizona 11:00-12:30

Mexico 12:00-13:30

Brasil 16:00-17:30

22 February; Brasil turns clock back Minnesota 12:00-13:30

Arizona 11:00-12:30

Mexico 12:00-13:30

Brasil 15:00-16:30

March 8 – Minnesota turns clock forward; course start time changes for Arizona, Mexico, Brasil Minnesota 12:00-13:30

Arizona 10:00-11:30

Mexico 11:00-12:30

Brasil 14:00-15:30

March 29 – Mexico turns clock forward. Minnesota 12:00-13:30

Arizona 10:00-11:30

Mexico 12:00-13:30

Brasil 14:00-15:30

These sessions will be conducted among all universities participating simultaneously via appropriate A/V technology. A faculty member will moderate each session. (Technical guidelines and instructions will be provided separately). Most Thursday sessions will involve i) a presentation by the lecturer for the week; ii) general Q&A involving all participants.

## Course web site discussion lists:

A common course web site hosted through the University of Minnesota will be available to all participants enrolled in the seminar. The discussion lists on that site will be our principal mode of carrying on substantive exchanges regarding the main issues of the seminar. There will be a separate discussion area for each of the weekly topics. The “response group” responsible for leading the discussion on a given topic will be responsible for posting a set of comments and questions to anchor our discussion by the Friday before the relevant Tuesday joint session. All participants are expected to respond to one or more of these postings, or to post at least one of their own questions or comments, to the site by the end of the Wednesday after the Tuesday session. This will allow Thursday discussions at each university to pick up on the “crowd” reactions

to and views on the topic, lecture and discussion of the week. Participants are, of course, encouraged to post additional discussion items at any time.

# REQUIRED READINGS AND BACKGROUND MATERIAL

Our discussions in each week of the course will be anchored by readings from the primary literature. Specific assigned readings will be posted on the course web site well in advance of the week in which they will be discussed. Most of these readings will draw from the on-line compilation of [“Readings in Sustainability Science and Technology.”](http://www.hks.harvard.edu/centers/cid/publications/faculty-working-papers/cid-working-paper-no.-213) This document, edited by Robert Kates, was published in 2010 under the auspices of the Sustainability Science Program at Harvard University. It is a structured and annotated bibliography of critical readings that cover the essential topics in the field. Each week we will specify 1-2 papers from the scholarly literature as assigned readings. Given the scope of the class, its inevitable that some participants will want more basic introduction to the topic, while others will have already encountered the core reading and will therefore want something more advanced. In addition to the required core reading, we will therefore try to post as optional readings for each session at least one more basic and one more advanced paper that participants can read if they wish to do so. Faculty and students will be invited to suggest additional readings as appropriate from the literatures with which they are familiar. These additions will be considered for inclusion in future editions of the “Kates Reader.”

# RESPONSIBILITIES FOR ALL PARTICIPANTS

**All participants** in the seminar, whether they are taking it for credit or not, are expected to do all of the work listed immediately below. Additional requirements for students taking the course for credit vary by university, and are listed at the end of this section.

* 1. **Attend all sessions** of the seminar, including the joint (Tuesday) and local university (Thursday) sessions. Participants who must miss a class should inform their lead faculty in writing advance, with a copy to the lead TF Christina Ingersoll. Because this seminar is intended to accumulate knowledge as it proceeds, and to involve a lot of team work (see below), repeated absences are unfair to all. If you can’t attend regularly, don’t enroll.
  2. **Do all the assigned reading** (and lecture watching) for each week before the Tuesday class. (See section ‘E’ above). Sustainability science is a complex, interdisciplinary field. We all – faculty and students – will find ourselves bewildered by some of the assigned readings that come far from our own fields of training. That means that “dumb questions” are fine. But comments or questions uninformed by a serious effort to grapple with the readings will impose an unfair burden on everyone. So if you can’t commit to doing the readings and such in advance, don’t enroll. And if the realities of your own world means that you occasionally have not been able to get to the readings for a particular session, please constrain yourself to listening quietly.
  3. Participate actively in the **class discussions**. This means both the joint sessions on Tuesdays (for which the number of students and the electronics will admittedly pose some limitations) and the local sessions with their own universities on Thursdays.
  4. Participate actively in the **on-line discussions** associated with each week’s unit. There will be a common web site for all participants in the seminar. Each participant is expected to make at least one substantive entry on each week’s discussion. Additional substantive comments, and general contributions regarding the course, papers and events of interest, etc. will also, of course, be welcome.
  5. Participate actively in one or more **topic teams**. For each Tuesday session in Parts II-IV of the seminar, one or more interdisciplinary teams of participants from across all of the sponsoring universities will prepare and present a formal critique of the readings and lecture of the week.

These teams will be assembled by the faculty based on information supplied by the participants about their backgrounds and interests during the first weeks of the seminar. Each team will be expected to ‘meet’ in virtual space during the two weeks prior to the session in which they present to plan their approach. (How these virtual meetings take place is the choice of the team. Guidance will be available from the lead teaching fellow). Each participant can expect to participate in about 3 teams during the course of the seminar, with the actual details depending on enrollment.

* 1. Participate in a **problem-focused team** responsible for making a presentation to the seminar on one of the topics selected for Part IV of the course.

# RESPONSIBILITIES SPECIFIC TO EACH UNIVERSITY

Students taking the course for credit must meet all the general requirements noted above.

In addition, each student must (or, with instructor’s permission, team of students) participate actively in the Thursday “UMN only” sessions of the course and complete a term paper.

**Thursday sessions**: Thursday meetings of the course will generally be conducted by each university on its own. Joint (virtual) sessions with one or more groups from the other participating universities can be arranged as suggested by participants. We will generally use the Thursday sessions to i) deepen discussion of the lecture delivered the previous Tuesday; ii) provide background for the next week’s reading and lecture. We can also use the Thursdays to pursue topics of special interests to a sufficient number of our local participants. All participants in the seminar are expected to attend the Thursday sessions and to lead discussions there as appropriate.

**Term paper**: The purpose of this paper is to provide students with an opportunity to connect the themes of the course with the student’s own research or policy interests.

Possible topics include: i) a proposal for research on a topic of human-environment interactions that engages relevant sustainability science theory; ii) a policy analysis of a particular sustainable development problem that uses relevant sustainability science to critique current practice and advance recommendations; iii) a critical review of the literature at the intersection of a particular substantive area and the relevant literatures of sustainability science; iv) another approach that meets the goal noted above that is proposed by the student and approved by the faculty. More information on the nature of the term papers is forthcoming.

Students are invited to discuss possible paper topics with the faculty throughout the course.

Required submissions are:

1. A **proposal** submitted by **early November**. This should include a tentative title; a narrative of 100-500 words on the topic to be addressed describing its importance and connection to sustainability science; and a list of 5-10 of the principal sources from the literature [not including those from the syllabus] that the author intends to utilize in preparing the paper. Faculty will return comments to the student on the proposal.
2. A **final paper** submitted by **mid December**. This should be between 4000 and 8000 words, not including references, captions, tables and appendices.

**Grades** for students taking the course for credit will be computed as follows:

1. individual contributions to discussion through verbal comments and course site entries: 33%
2. group contributions through the “response group” to which the participant belongs: 33%
3. term paper: 34%

Students auditing the course are expected to participate fully in the discussions and responses.

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# FACULTY BIOGRAPHIES

**Jeannine Cavender-Bares** is an associate professor in the Department of Ecology, Evolution and Behavior at the University of Minnesota. Her research focuses on linking functional traits of plants and their evolutionary history with current ecological processes in order to understand the organization of plant biodiversity and its consequences. Cavender-Bares’ latest projects examine climatic niche evolution in plants from the tropics to the temperate zone, local adaptation of trees to climate, and impacts of perturbation on plant diversity and community assembly. These projects are part of a long-term effort to investigate impacts of global change on biodiversity in human- dominated landscapes. Cavender-Bares received an A.B. from Cornell University, an M.S. in Environmental Studies from Yale University, and a Ph.D in Biological Sciences from Harvard University. She was a post-doctoral fellow at the Smithsonian Environmental Research Center in Maryland and at the Center for Functional and Evolutionary Ecology in Montpellier, France. <http://environment.umn.edu/about/ione_bios/jeannine_cavenderbares.html>

**Stephen Polasky** is a Regents Professor and Fesler Lampert Professor of Ecological/Environmental Economics and an interdisciplinary chair in the Departments of Applied Economics and Ecology, Evolution and Behavior at the University of Minnesota. He joined the UMN in 1999 after serving professor positions at Boston College and Oregon State University.

Polasky’s research interests include ecosystem services; natural capital; biodiversity conservation; endangered species policy; integrating ecological and economic analysis; renewable energy; environmental regulation; and common property resources. As an Institute on the Environment resident fellow, Polasky is working to expand current integrated models showing the impact of land use on ecosystem services. In addition, he seeks to engage public and private sector groups to improve land use planning.

<http://faculty.apec.umn.edu/spolasky/>

**Osvaldo Sala** is the Foundation Professor and Julie A. Wrigley Chair at Arizona State University. He has explored several topics throughout his career from water controls on carbon and nitrogen dynamics in arid and semi-arid ecosystems to the consequences of changes in biodiversity on the functioning of ecosystems, including the development of biodiversity scenarios for the next 50 years. He is particularly interested in working with scenarios as a way of simplifying, understanding, and communicating the complex relationships that emerge from the study of social- ecological systems. He employs a wide variety of tools; especially direct observations, manipulative field experiments, and simulation modeling. He has worked in the Patagonian steppe, annual grasslands of California, steppes of Colorado and deserts of Southern Africa and currently he has experiments in the Chihuahuan Desert in New Mexico. <http://sols.asu.edu/people/faculty/osala.php>

**B. L. Turner II** is the Gilbert F. White Professor of Environment and Society at Arizona State University. He took his B.A. and M.A. degrees in geography from the University of Texas at Austin in 1968 and 1969 respectively, and his Ph.D. in geography from the University of Wisconsin-Madison in 1974. Turner came to ASU after 28 years in the Graduate School of Geography, Clark University. Professor Turner has examined human-environment relationships from the past to the future via examination of the rise and fall of the ancient Maya, smallholder cultivation in the tropical world, contemporary deforestation in the tropics, especially in Yucata’n, and the future of Earth’s land systems relative to ecosystem services, vulnerability, and sustainability. <http://geoplan.asu.edu/turner>; <https://sites.google.com/a/asu.edu/turner/home>

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## Universidad Nacional Autónoma de México (UNAM)

**Patricia Balvanera** studies the links between biodiversity, the functioning of ecosystems, and the benefits or services society obtains from them. Given the present rates at which biodiversity is lost as a result of human enterprise, it is crucial to understand the consequences of such loss on the way ecosystems function and the potentially negative effects on human well-being. She conducts field work on the Pacific Coast of Mexico, in a very dry and hot tropical forest that has been transformed to pastures for cattle raising and recently for tourism development. Once abandoned, these pastures host a large biodiversity and provide key benefits to the local population and to global society. At the local scale, she studies how tropical dry forest biodiversity responds to management and contributes to provision of food and other resources, climate regulation, and flood regulation. At the regional scale, she collaborates with scientists of other disciplines to understand the links between plant biodiversity and the provision of ecosystem services, as well as the socioeconomic factors that drive ecosystem management. She also develops both regional and national maps to highlight key socio-ecological tradeoffs and inform decision-making. She enjoys brainstorming and thinking collectively with students and colleagues. She teaches undergraduate and graduate courses on ecosystem services and community ecology. <http://ww2.oikos.unam.mx/CIEco/comunidades/>

**Carlos Gonzalez Esquivel** studies and teaches sustainability evaluation in agroecosystems, sustainable livestock production, intercropping, alternative crops and biological control. He has a degree in Veterinary Medicine and Animal Production from the University of the State of Mexico (1994) and a Ph.D. in Agroecology from the University of London (1998). He worked for the University of the State of Mexico from 1999 to 2008, the University of East Anglia from 2009 to 2011, and is currently a researcher at the Ecosystems Research Centre (CIEco-UNAM). He is also an invited lecturer at the Masters in Agroecology from the University of Cordoba and the International University of Andalucia, Spain. <http://www.oikos.unam.mx/agroecologia/>

**Tuyeni Mwampamba** is a researcher at the Centre for Ecosystems Research (CIEco) of the National Autonomous University of Mexico (UNAM), Morelia Campus and a native of Tanzania. She received her PhD in Ecology and a graduate certificate in Conservation Management from UC Davis in 2009. Her research interests include quantification and management of ecosystem services in community managed landscapes; policy and forest impacts of charcoal production and consumption in the Tropics; forest use and conservation; and participatory research. Her research is inter-disciplinary in nature, straddling social, ecological, and political aspects of forest management by communities, primarily in Tanzania and Mexico. Dr. Mwampamba has been working closely with the international NGO Forest Trends’ to develop good practices for community participation in assessing the social and biodiversity impacts of forest-based carbon projects and payment for watershed services schemes.

## Universidade São Paulo de Brasil (USP)

**Lúcia Lohmann** is professor of botany at the University of São Paulo in Department of Botany. She has experience in the area of botany with an emphasis on plant systematics, particularly in phylogeny, evolution, biogeography, evolutionary ecology, conservation. She has participated in numerous activities at the interface between academia, civil society and policy through the Association for Tropical Biology and Conservation and the DIVERSITAS Core Project BioGENESIS. She was President of the Association for Tropical Biology and Conservation (ATBC) from 2012-

2014 and has been a member of the Scientific Committee of BIOGENESIS since 2006; she has been involved in a variety of initiatives through this program including the transition to Future Earth.