The Fourth Annual Frontiers in Life Sciences Conference

Sustainable Phosphorous Summit

February 3 - 5, 2011
Arizona State University - School Of Life Sciences
Memorial Union, Tempe Campus

photo credit: J. Elser

ASU SCHOOL OF Life Sciences
ARIZONA STATE UNIVERSITY

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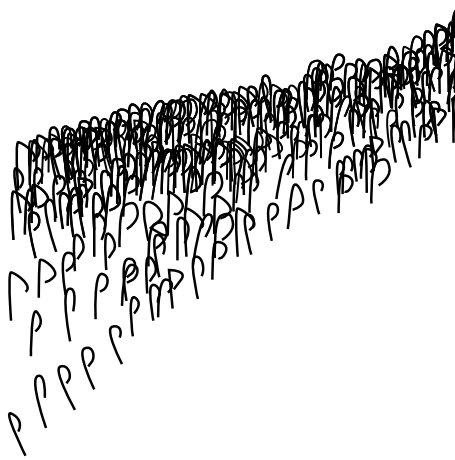
conference overview

Human activities are estimated to have increased bioavailable phosphorus (P) by 400% which has lead to severe environmental consequences. The demand for P however continues to increase while phosphate reserves, the only viable source of P, are on the decline. Certain countries are beginning to address the potential threat of long-term phosphorus scarcity, such as China and Sweden. The United States, despite being the largest P consumer, however has largely ignored the issue. The conference will explore the complex dynamics of P as a limited resource, and create a stage for constructive discourse and discussion on P sustainability. The Sustainable P Summit will bring together a diverse group of international experts to explore issues ranging from the biological importance of P to concerns of national security.
The objectives of the Summit will be to increase our understanding of: 1) what needs to be known and 2) what can be done.



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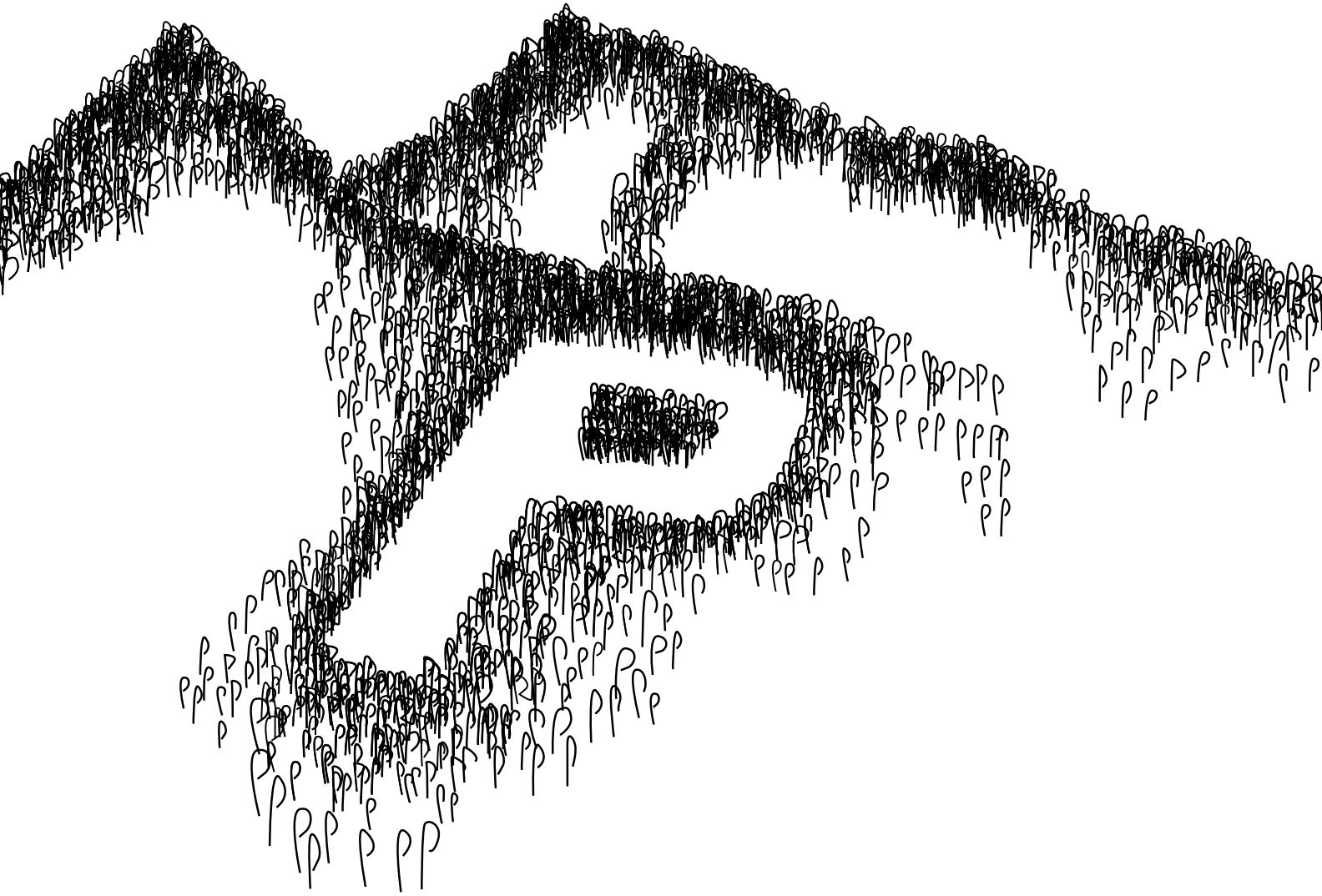


guest speakers

** indicates spaker has an abstract; View spaker abstracts by visiting https://sols.asu.edu/2011-sustainable-phosphorous-summit

**** Ben Chaffin** farms cash crops with his Dad and Uncle in Ithaca, Michigan. After completing his master's degree in Agricultural Economics researching risk management he returned to the farm and is part owner. He currently runs daily operations with six full-time employees and six seasonal workers. Conventional crops produced include: sugar beets, corn, corn silage, soybeans, edible beans, wheat, cucumbers, potatoes and peas. In 2008 he started growing organic crops as well which include: corn, string beans and peas. His goals include sustainable expansion and diversification.

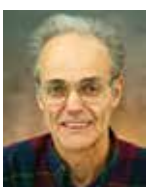
**** Dana Cordell** is Research Principal at the Institute for Sustainable Futures, University of Technology, Sydney (UTS). She co-founded the Global Phosphorus Research Initiative in 2008 with colleagues in Sweden and Australia, as an outcome of her doctoral research on the 'sustainability implications of global phosphorus scarcity for food security', which she undertook jointly at the Institute for Sustainable Futures at the University of Technology Sydney, in Australia, and, Linköping University's Department for Water and Environmental Studies in Sweden. Dana is currently a core member of an international consortium of researchers working on the Sustainable Use of Phosphorus project for the European Commission. She also has 10 years of sustainability research experience leading and undertaking interdisciplinary sustainable water, sanitation and waste management projects many of which involved high-level stakeholder engagement. Dana undertook an international masters degree in Sweden in 2004-5 on Water Resources and Livelihood Security, with a special focus on the challenges and opportunities of urine diversion and reuse.

**** Marion Dumas** is a PhD student in the Sustainable Development Program at Columbia University's School of International and Public Affairs. She graduated from the Massachusetts Institute of Technology with a B.S. degree in Earth and Atmospheric Sciences and from the Swiss Federal Institute of Technology with an M.Sc in Ecology and Evolution. She also worked as a consultant in sustainability strategies of companies in France. Her current research focuses on phosphorus scarcity and its impact on agriculture: she is building a dynamic modeling of the phosphorus cycle on a global scale and the use of such a model to evaluate the impacts on agro-ecosystems of various management strategies. Other research interests include restoration of ecosystem functions and the theory and practice of decision-making applied to sustainability.

Jim Elser is Regents' Professor and Parents Association Professor in the School of Life Sciences (SoLS) at Arizona State University, as well as Associate Dean of Research and Training Initiatives in SOLS. Dr. Elser's research involves the integrative field of biological stoichiometry, the

photo credit: Jason Parker-Burlingham

study of balance of energy and multiple chemical elements in living systems. While this work is primarily ecological in focus and includes studies of both aquatic and terrestrial ecosystems and biota, the approach uses an evolutionary perspective to integrate levels of organization from the molecule and cell to the ecosystem. Specific studies involve observational and experimental studies at various scales, including laboratory cultures, short-term field experiments and sustained whole-ecosystem manipulations. Over the years, field sites have included the Experimental Lakes Area in Ontario, Canada; lakes of the Arctic; lakes, forests, and grasslands of the upper Midwest; desert springs in Mexico's Chihuahuan Desert; and the surrounding Sonoran Desert. In addition, Dr. Elser collaborates extensively with mathematicians in developing quantitative theoretical approaches to these questions. In more recent work he has extended the work to investigate the connections among C:N:P stoichiometry, growth rate, rRNA physiology and genetics, and ecological dynamics in diverse biota and ecosystems and to evaluate the application of these ideas to tumor dynamics. Currently, he is an active member of the ASU's NASA-funded Astrobiology project "Follow the Elements" and a co-organizer of ASU's Sustainable Phosphorus Initiative.



Cecil Forsberg is Professor Emeritus of Microbiology at the University of Guelph in Ontario, Canada. He has a B.S.A. and M.Sc. from the University of Saskatchewan and a Ph.D. from McGill University in Microbiology and postdoctoral training in London England. He received the CSM-Roche Career Award for research in 2000 and was elected to Fellowship in the American Academy of Microbiology in 2007. His areas of research include molecular biology and biochemistry of glycosyl hydrolases, phosphohydrolases and the development of environmentally friendly, genetically enhanced swine. He was a co-inventor of the EnviropigTM, a line of Yorkshire pigs with the capacity to efficiently use plant phosphorus, which is unavailable to conventional pigs. The Enviropig bypasses the need for the farmer to add either supplemental phosphorus or phytase to the swine ration. Since no phosphorus is added to the ration, and a large proportion of the plant phosphorus is digested and incorporated into tissues, the amount of phosphorus remaining in the manure is reduced by as much as 60%. Manure from these pig has a more suitable nitrogen/phosphorus ratio for plant growth. Dr. Forsberg served as the Lead Scientist of a program of studies on Food and Environmental Safety of Enviropigs, and on an expert panel for FAO/WHO on the development of regulations for testing genetically modified domestic food animals and has participated food safety workshops sponsored by the Canadian Food Inspection agency, Health Canada and Environment Canada.

Roberto Gaxiola is an assistant professor in the School of Life Sciences (SOLS) at Arizona State University. Witnessing the steady migration of peasants into Mexico City, where their quality of life remained below the poverty line, was the injustice that stirred my passion to use the privileges of my education to serve society. Once I learned that this migration was in part triggered by the gradual salinization of arable fields, I focused my academic career toward learning how plants deal with salinity and other stresses. My academic career is at an exciting place where the promise of engineered agricultural commodities for the improvement of productivity in marginal lands is being realized. In fact, various labs throughout the world are utilizing findings from my laboratory for improved agricultural productivity.
My research is shedding light on the molecular and physiological details of how plants allocate sucrose produced by photosynthesis. Sucrose is a basic component of higher plant metabolism. It is the main substrate for respiration and biosynthesis. With my genetic engineering approach we can optimize the sucrose transport capacity from source tissues (leaves) to sink tissues (roots). Thus, an enhanced availability of sucrose results in both larger and more energized root systems that are more efficient in both water and mineral nutrients (i.e., PO43-, NO3-, and K+) uptake. In collaboration with other groups, we are currently generating transgenic lettuce, carrot, cassava, potato, and sugar cane plants.
The expectation is that these crops will have both an enhanced biomass as a result of greater sucrose transport/ production and a more efficient water and nutrient uptake capacity. It is expected that the application of this technology will have a positive impact in agriculture.

** **Phil Haygarth** is Professor of Soil and Water Science at Lancaster Environment Centre (LEC) and Co-Director at the Centre for Sustainable Water Management (CSWM) at Lancaster University. His research interests are on soils and their interactions with connected water-bodies, from catchment to coast, plant to planet, including soil and water biogeochemistry, bio-physical processes controlling nutrient and colloid release from soils, solutions for agricultural diffuse pollution and water quality across scales. His mission with CSWM and LEC is to help nurture research and complementing teaching to understand the key biological, physical and chemical processes that interact with water, colloid & nutrient release to catchments. The research will help build and inform new models that have policy relevance for national and global water management.

** **Catherine L. Kling** is Professor of Economics at Iowa State University and the Center for Agricultural and Rural Development. She received her Ph.D. from the University of Maryland and began her professional career at the University of California, Davis. Her research interests include non-market valuation methods, especially revealed preference approaches, and interdisciplinary analyses focusing on policy design and incentives for the provision of ecosystem services from agriculture. Her research has been published in the Economic Journal, the Review of Economics and Statistics, the American Journal of Agricultural Economics, the Journal of Environmental Economics and Management, Economic Inquiry, the Journal of Public Economics, Land Economics, and elsewhere. Cathy is a Fellow of the AAEA, a member EPA's Science Advisory Board, president-elect of the Association of Environmental and Resource Economists and past board member of the AAEA. She has held editorial positions with the American

Journal of Agricultural Economics, Journal of Environmental Economics and Management, and Land Economics. She has been the principal investigator or co-principal investigator on over $7 million of grants from federal agencies such as the National Science Foundation, Environmental Protection Agency, and U.S. Department of Agriculture, as well as from a variety of state and non-profit groups.

Andrew Revkin is an educator and prize-winning journalist, online communicator and author who has spent more than a quarter of a century exploring subjects ranging from the assault on the Amazon to the Asian tsunami, from the troubled relationship of science and politics to climate change at the North Pole. Revkin has a biology degree from Brown, a master's degree in journalism from Columbia, has taught at Columbia's Graduate School of Journalism and the graduate center for environmental policy at Bard College. In 2008, he became the first science writer to receive one of journalism's top honors, the John Chancellor Award, for more than two decades of pioneering coverage of the science and politics of global warming. His work has won most of the top honors in science journalism, including the National Academy of Sciences Communication Award and two awards from the American Association for the Advancement of Science. Revkin's most recent book is The North Pole Was Here: Puzzles and Perils at the Top of the World (Kingfisher, 2006), the first account of global and Arctic climate change written for the whole family. It was named both an outstanding science book and social studies book by the Children's Book Council. In 2010, after nearly 15 years as a staff reporter at The New York Times, he became the senior fellow for environmental understanding at Pace University's Pace Academy for Applied Environmental Studies. He continues to write his Dot Earth blog for the Op-Ed pages of The Times.

Andrea E. Ulrich studied American Cultural History, Geography and Law at LMU Munich, Germany. She received a M.Sc. in Sustainable Resource Management from Technische Universität München (TUM), Germany, and is currently conducting doctoral research on phosphorus sustainability at NSSI, ETH Zurich. Grounded in a coupled human-environment zz perspective, her work focuses on phosphorus management and stewardship options derived from inter- and transdisciplinary research activities on analyzing co-mining opportunities as well as case study research on the pollutant-resource paradigm nexus.

Professor Stuart White is Director of the Institute for Sustainable Futures at the University of Technology, Sydney, Australia where he leads a team of researchers who create change towards sustainable futures through independent, project-based research. He is also co-organizer of the Global Phosphorus Research Initiative. With over twenty years experience in sustainability research, Professor White's work focuses on achieving sustainability outcomes at least cost for a range of government, industry and community clients across Australia and internationally. This includes both the design and evaluation of programs for improving resource use efficiency and an assessment of their impact. Professor White has written and presented widely on sustainable futures and is a regular commentator on sustainability issues in the media.

conference organizers

Arianne Cease is a Ph.D. candidate in the School of Life Sciences, working with Drs. Jon Harrison and James Elser. She studies plant-animal interactions using a combination of physiological and ecological approaches, including biological stoichiometry. Her dissertation is based in the Inner Mongolia grassland and examines how anthropogenic impacts on plant communities (livestock grazing and nitrogen deposition) affect grasshopper physiology, abundance (outbreaks), and diversity.

Elizabeth Cook is a Ph.D. student in the School of Life Sciences, working with Dr. Sharon Hall, studying urban biogeochemical cycling between the atmosphere and biosphere. She is particularly interested how long term presses (e.g. urban atmospheric pollution) affect ecosystem processes at varying temporal and spatial scales. In addition, she's interested in the social drivers and feedbacks that occur between humans and the urban ecosystem. She collaborates with colleagues from a range of social and natural science disciplines through the Urban Ecology IGERT (Integrative Graduate Education and Research Training) at ASU.

Jessica Corman is a Ph.D. student in the School of Life Sciences, working with Dr. James Elser. She studies how elements cycle in ecosystems, and particularly how physical, chemical, and biological processes affect differentially these processes. She collaborates with microbiologists, geologists, and chemists from the NASA Astrobiology Institute and develops educational materials on desert ecology with Science Foundation Arizona.

Xiaoli Dong is a Ph.D. student in the School of Life Science, working with Dr. Nancy Grimm. She studies biogeochemistry and ecosystem ecology. She is particular interested in how climate change influences state changes in aquatic ecosystems and the resilience of ecosystems.

Rebecca Hale is a PhD student in the School of Life Sciences, working with Dr. Nancy Grimm. She is studying the effects of urban drainage infrastructure systems on coupled hydrology and biogeochemistry in the Phoenix, AZ metropolitan area, especially the frequency, intensity, and location of flooding and water quality disturbances, and the importance of those disturbances for local policy change. Rebecca is currently collaborating with other graduate students to construct a phosphorus budget for Phoenix.

David Iwaniec is a PhD student in the School of Sustainability at Arizona State University and a NSF IGERT Senior Fellow in Urban Ecology. He holds a MS degree in Biological Sciences from Florida International University. His previous research was in the field of systems

photo credit: Sandra Leander

ecology and includes research on system stability, state change, valuation of ecosystem services, ecosystem-based management, and systems modeling. David's research interests have evolved toward use-inspired sustainability research on urban stability, state change, and futures analysis. He is passionate about furthering the development of sustainability science and contributing to the innovations associated with this developing field. David is strongly interested in teaching and learning both in and out of academia, especially product-driven working group models which allow for peer-teaching and facilitated collaboration.

Michelle McCrackin is a PhD candidate in the School of Life Sciences working with Dr. James Elser. For her dissertation research, she is investigating the effects of atmospheric nitrogen pollution on biogeochemical processes in lake sediments. She is also interested in the ecological effects of nutrient loading on lakes.

Mark Neff's research focuses primarily on understanding linkages between ecological science and environmental governance, with an eye toward exploring how ecological scientists establish research agendas and the broader societal impacts of those choices. Mark's primary teaching interests lie at the intersection of environmental studies, science studies and science policy, and environmental governance. His doctoral research, conducted through ASU's School of Life Sciences and CSPO, used mixed qualitative and quantitative approaches to understand how and why the ecology research agenda changes over time and what that means for societal understandings of the environment. Prior to his doctoral program in the School of Life Sciences at ASU, Mark received a master's degree in Environmental Studies from the University of Oregon. His research there focused on using scenario analysis as a tool to aid in ecological management decision-making in politically charged and uncertain situations.

Lisa Taylor studies sexual selection and coloration in Habronattus jumping spiders. Males of this genus are often highly ornamented with bright (sometimes iridescent) colors which they display for females in elaborate courtship dances. The goal of her research is to understand how variation in male color affects female choice, and ultimately, what a male's colors might tell a female about his quality as a mate.

Laura Turnbull obtained a B.Sc. in Geography from the University of Durham, UK, followed by an M.Sc. in Environmental Monitoring, Modelling and Management at King's College London, UK. She then carried out her PhD research at The University of Sheffield, UK, where she studied the ecohydrological

dynamics and consequences of shrub invasion into semi-arid grassland. In June 2009, Laura started a post-doctoral research fellowship at the Global Institute of Sustainability at Arizona State University, with Professor Dan Childers and the Central Arizona Phoenix Long Term Ecological Research site. At ASU, Laura is carrying out research into the ecohydrology of urban ecosystems, with particular emphasis on the scaling of hydrology, erosion, and Nitrogen, Phosphorus and Carbon dynamics associated with urban stormwater flow.

Christina Wong is a PhD student in the School of Sustainability, working with Dr. Nancy Grimm. She is interested in examining the impacts of urbanization on upstream riparian ecosystems to evaluate the tradeoffs amongst ecosystem services to cities and rural communities. She aims to enhance the quantification and valuation of ecosystem services to improve the linkage between ecosystems and human well-being. She hopes her research will increase the capacity of societies to sustainably manage regional resources.

Karl A. Wyant is a Ph.D. student in the School of Life Sciences, working with Dr. John Sabo. His research focuses on detrital food webs in the Sonoran Desert. He is particularly interested in how food webs change across the watershed and with availability to water.

photo credit: James Elser

consensus statement

The Phoenix Phosphorus Declaration

We have achieved broad agreement on important issues surrounding phosphorus sustainability challenges and opportunities and seek to raise global awareness about them among all those with a stake in the future of food, water, and the biosphere. All of humanity, and indeed all living species, has this stake.

We find:

- Essential and limited. Phosphorus is essential for all life because it is part of critical molecules like DNA. It is a limited natural resource needed to sustain the vitality and productivity of all ecosystems, including farms.

- Imbalanced cycle. Mining of phosphorus for fertilizer production has massively altered the cycling of phosphorus on Earth. This increased phosphorus use has greatly expanded global capacity for food production but also has led to amplified phosphorus losses from cities, towns, and farms that can lead to degraded water quality, impair freshwater and marine fisheries, and alter natural biodiversity.

- Food security. Phosphorus has a key role in global food security, as reliable access to affordable fertilizer can allow farmers to improve yields and increase quality of life, especially in the developing world.

- Recycle and reuse. Currently, much phosphorus is lost in crop waste, food spoilage, and animal & human waste. Recycling this phosphorus can reduce geopolitical and other uncertainties surrounding phosphorus fertilizer markets and enhance farmer prosperity.

- Reduce demand. Phosphorus natural resources can be extended by improving efficiency of use in agriculture, reducing erosion, limiting losses in mining & industry, and eating lower in the food chain.

- Interconnected. Phosphorus stewardship is coupled to other major global sustainability challenges, including those involving energy, water, and other chemical elements.

- Entrepreneurship. There are great economic opportunities to innovate and create new industries for phosphorus supply diversification and for improved agricultural phosphorus efficiency. However, the suitability of such measures will differ for different environments, cultures, and contexts.

- By closing the human phosphorus cycle and transforming wastes into resources and uncertainty into security, humanity can implement a “new alchemy” in which people become more secure and enjoy greater well-being in a healthy environment.

Participants in the 2011
Sustainable Phosphorus Summit
Tempe, Arizona, USA

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