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Reflective Essay
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My faculty position in the Kellogg Biological Station (KBS) and the Department of Crop and Soil Sciences (CSS) has proved to be an ideal fit. The work is productive and rewarding, with outstanding research facilities and unique opportunities to collaborate at KBS and beyond.

My initial faculty position at MSU was as an Assistant Professor of Integrated Vegetable Crop Management, hired in 1999 and promoted to Associate Professor in 2004. My research and extension responsibilities were in agronomy of potato and vegetable systems. I enjoyed the position: it was a tremendous opportunity to learn and engage with extension educators, industry and growers in Michigan and beyond, and to apply ecological principles to real world challenges in horticulture. I developed a number of multidisciplinary projects, and succeeded in promoting integrated nutrient management for more sustainable production practices. In 2005 I was ready for new challenges and I applied for my current position of soils and cropping systems ecologist. I was thrilled when I was offered this position in 2006. It has been -and continues to be -a unique opportunity to make a difference in agroecology, as a co-PI on the LTER, as a KBS faculty member, and through collaborations with colleagues to extend ecological knowledge.

Integrated, inquiry-based research, teaching, and extension

My position offers a balance of research, teaching, and extension. This is an excellent fit with the integrated approach I use, where research informs my teaching and extension, and vice versa. Engaged, participatory approaches to learning are at the foundation of my program. This is in synchrony with MSU's goal to produce life-long learners. A few examples follow, with papers cited listed in my vitae. In teaching I have set up inquiry-based learning opportunities, in courses such as CSS 360 Soil Biology and CSS 431 International Agricultural Systems. In CSS 360 I devised a laboratory exercise where students designed a greenhouse experiment to investigate interactions of soil organisms and plants. Over time I fine-tuned the degree of guidance I provided in this lab, so as to provide enough structure while promoting student exploration. Student feedback has been fundamental in this evolving process, and has indicated that for some students this has been a memorable experience; it has opened new horizons for them as they developed and tested hypotheses, followed through and shared what they learned. The lab was informed by research I have conducted on cover crop traits and soil organisms, quantifying impact on soil biophysical properties and root health (Snapp et al., 2007; Wilke and Snapp, 2008). Colleagues have adapted the lab procedure for their own

courses.

Engaged activities and promoting inquiry-based learning has been the core of my extension program as well. In the 1990s I worked as a soil scientist based in southern Africa where I promoted the systematic linkage of long-term experimental research stations with farm based experimentation. I have continued this approach at MSU, where I have had the opportunity for extensive collaboration with agricultural economists and social scientists to facilitate stakeholder involvement, through surveys, advisory boards and on-farm experimentation. These approaches promote communication and co-learning, with gains in research relevance through systematic feedback from farmers and other stakeholders (Snapp et al., 2002; 2003; 2005; Snapp, 2004). I have published on these client-oriented, participatory research methods, including the 'mother and baby trial' design (Bezner-Kerr et al., 2007; Snapp, 1999; Snapp and Heong, 2003).

A number of plant breeders and agronomists have cited the 'mother and baby trial' methodology as being key to breakthroughs in developing varieties preferred by farmers, and testing integrated use of genetics with resource-conserving technologies (e.g., Virk et al. 2009. *Experimental Agric.* 45:77-91; <http://engagedscholar.msu.edu/magazine/volume4/snapp.aspx>). The design facilitates the systematic integration of farmer and researcher assessment of technologies through linking on-farm and research trials in a lattice statistical design or using mixed modeling REML. Uptake of new varieties by response-poor farmers in rain-fed systems of sub-Saharan Africa and South East Asia has been rare; what some have called the forgotten farmers by the first green revolution. Reports of 15 to 70% yield gains among smallholders, and dozens of new varieties being adopted in combination with sustainable management, are tributes to the power of the interdisciplinary, participatory approaches that I have helped pioneer¹. Participatory research and extension methodology is still under development, but shows promise as a means to address biocomplex, real world problems, MSU has leading scientists working on methods that address coupled-human natural systems, and this is a perfect fit for my program.

Research

Throughout my career I have been interested in the under-explored world of the plant-soil interface in row crop ecosystems, at scales from plant to field, Recently I have become interested in scaling out over space and time) to investigate consequences at the watershed and regional scale of different intensities of management and types of plant species present. My position at KBS is ideal for

¹ Ortiz-Ferrara et al., 2007. *Euphytica* 157:399-407; T.S. Walker, Background Paper on Participatory Research for World Development Report, 2008

learning about how biogeochemical processes in nutrient management and soil quality operate at different temporal and spatial scales. Since 2006 I have been one of the principal investigators on the NSF-funded Long-Term Ecological Research (LTER) row crop ecology project at KBS, with a focus on agroecological processes and agronomic practice. Long-term research trials provide unique insights into system performance and nutrient cycling at different states, transitional and equilibrium, I am particularly interested in whole system comparisons, and have used ecosystem services, profitability and energy budgets as creative ways to evaluate system performance (Gelfand et al., 2010; Snapp et al., in review).

I initiated a temporal experiment in the Living Field Laboratory, a satellite trial I manage at the LTER-KBS. This has been instrumental in testing how management practices alter equilibrium, through feedbacks that influence plant N fixation and soil C and N pools over a decade or more, This novel opportunity has facilitated my interaction and collaboration with internationally known researchers, including Laurie Drinkwater at Cornell University. I have been fortunate to work with her and colleagues on an NSF-funded project investigating cropping system interventions to retain N and protect water quality while reducing greenhouse gas emissions (Drinkwater and Snapp, 2008; McSwiney et al., 2010).

Expanding our understanding of biological processes involved in soil carbon sequestration, nitrogen dynamics, crop growth and yield potential is at the core of my research program, and is the basis for the sustainable practices I promote. This was the foundation for my previous applied position in horticultural systems at MSU, and for my current research. Investigating interactions involved in organic and inorganic nutrient management led to my research on how “recoupling” carbon and nutrients through utilizing compost and cover crops can have plant-health implications as well as environmental benefits. This was the basis for widespread adoption by Michigan potato farmers of compost and an array of cover crops, for high quality root systems, tubers, improved soils, and lower agro-chemical costs (Po et al., 2009; 2010; Snapp et al., 2005; Snapp et al., 2007).

I am particularly interested in plant-soil processes and management practices that buffer the N cycle and release temporarily captured (immobilized) nitrogen at a measured rate. This is proving essential to improve nutrient management, and efficiency, I have been fortunate to work with a talented team of students, technicians and postdoctoral scholars to pursue these questions at KBS, leading to recent publications in journals such as *Ecological Applications* and *Agriculture Ecosystems and Environment* (McSwiney et al., 2010, Snapp et al. 2010). We are documenting the role of coupled carbon-nutrient sources as an underlying principle of sustainable and organic row crop production practices. This is in addition to the role played by crop diversity from cover crops and rotation sequences.

The role of 'perennialization' in row crop systems is the other central sustainability principle that I am investigating. This term refers to extending the duration of living cover through choice of species type for cover crops and cash crops. In both temperate and tropical corn-based ecosystems we have found that perennial cover reduces excess nitrate leakage, and may support climate stabilization by contributing carbon to stable organic pools (Snapp et al., in review; Snapp et al., 2010). Uniquely, colleagues and I have documented in a country-wide experiment in Malawi that soil C status and nitrogen fertilizer efficiency can be improved through perennialization, diversifying corn with pigeonpea and other multipurpose, long-lived legumes (Beedy et al., 2010). We term this novel technology 'agroshrubbery'. This was developed through cropping systems, participatory research and evolved with a specific set of traits different from agroforestry systems. Based on input from social and biological science, we document a unique role for legume shrubs and vines that provide a wide range of ecosystem services to ensure farmer acceptability, including nutrient-enriched grains as well as soil-building residues. In combination with moderate fertilizer doses, improved fertilizer efficiency and yield stability from agroshrubbery systems could provide multiple, nutrient rich sources of grain and lead to a more 'green' revolution for smallholder farmers (Snapp et al., in review).

At K13S I have initiated a multi-disciplinary approach to test and deploy perennialized varieties of annual crops, including the promising new crop 'perennial wheat' This was recently supported by a million dollar USDA-OREI grant and has led to my collaboration with pioneering researchers working on developing perennial grain cropping systems, with potential for profound improvements in food and environmental security (Glover et al., 2010 Science 328:1638-1639). The LTER at KBS is an outstanding opportunity to develop a more perennial type of row crop system, that can enhance soil C and N retention, without undue loss of yield potential. I am particularly excited about the directions the LTER-KBS is planning for the next phase of research, including investigating the potential of perennialization, and exploring the social and biological science interface, which are areas of abiding interest to me. Investigating the impact of ecologically-based management at scale in terms of yield tradeoffs with other ecosystem services is LTER research is a new area of research in my program, funded in part by an EPA-funded grant with Sasha Kravchenko. These are examples of the exciting directions that we are pursuing at KBS, which are a perfect fit with my future research interests.

Extension

It is an extraordinary privilege to have a position that combines ecology with an explicit extension responsibility (25%). It is a great pleasure to interact with MSU

Extension educators, and I have been fortunate in the collaborations I have developed with extension from across the Midwest, with farmers, and with a diversity of farmer organizations (e.g., Midwest Organic and Sustainable Education Service; Corn Marketing Program of Michigan; Michigan Organic Food and Farm Alliance; and Soil Food and Healthy Communities). The research projects I have developed while at MSU have all included extension specialists and educators, agricultural advisors from private and public sectors, working closely with scientists from natural and social science disciplines. It is my experience that real world problems require time invested in communication across disciplines. It requires full integration of research and extension, as well as iterative learning that enhances research and outreach as a project evolves. Through these approaches) have played a key role in solving problems as diverse as a fruit cracking disorder afflicting the Michigan tomato industry (Huang and Snapp, 2004; 2009; Snapp, 2005) to practical cover crop options for row crop production (McSwiney et al., 2010; Snapp et al., 2005; 2010).

My goal in developing extension materials and programs is not so much to develop recommendations as to promote learning about ecological principles by extension educators, and farmers. As an example, MSUE staff and the farmer advisory board of the Corn Marketing Program of Michigan have recently expressed interest in how to maintain soil quality in the face of emerging markets for crop residues. My response has included developing extension training materials (Doll and Snapp, 2009; Snapp and Grandy, in press) and participating in MSUE programs around the state to reach hundreds of farmers. In these educational materials and presentations I have not developed recommendations on levels of residues that can safely be removed; rather, I have synthesized findings from the literature to articulate the underlying science of how residues influence soil organic matter formation, and conserve soil, while sometimes temporarily immobilizing nutrients. I have also used recent research from my field trials to quantify tradeoffs, to elucidate plant-soil processes involved, and to urge farmers to make informed management choices.

Promoting on-farm assessment of soil quality, by farmers and agricultural advisors from the private and public sector, is another aspect of my extension program. Working with a Soil Science Society of America committee on field monitoring, I published a chapter on step-by-step evaluation of soil quality, including biological, chemical and physical tests that can be conducted at a field scale (Snapp and Morrone, 2008). I am committed to providing tools for extension and farmers to carry out lifelong learning, in the spirit of Professor Liberty Hyde Bailey, and the Bailey Scholars program at MSU.

Instruction and graduate student mentoring

Promoting ecological knowledge among agricultural students is core to my teaching interests. I was instrumental in developing two new specializations in the College of Agriculture and Natural Resources-MSU which were just approved in 2009. These are Sustainable Agriculture and Food Systems (<http://www.safs.msu.edu/>, undergraduate) and Ecological Food and Farming Systems (www.effs.msu.edu, graduate). Twenty plus students are in the SAFS program, and the first EFFS student just graduated in CARRS, with six more enrolled. I enjoy working with and supervising the academic specialist responsible for promoting these new programs, which are poised to grow quickly and meet the demands of a 'greening' student population.

The three courses I have taught at MSU are CSS 360 Soil Biology, CSS 431 International Agricultural Systems and CSS 893 Sustainable Agriculture Field Methods, a summer intensive graduate course at KBS. I co-developed CSS 360 with Robertson, and co-taught it until recently when I was asked to re-envision and teach CSS 431 in the spring of 2009. This course is an excellent fit allowing me to draw upon my extensive African agricultural systems experience, and my abiding interest in applying the lessons of applied ecology to rural development. This led me to publish a book-which I co-edited and wrote extensive sections of -for use as a course text book (Snapp and Pound, 2008). Student evaluations were high, consistently below 2 on a scale of 1 to 5. The field methods course is also new, and had an enrollment of 10 motivated graduate students when I offered it in the summer of 2008. It was a very enjoyable course to teach, with high student participation in defining research methods and approaches to explore. It used to advantage the KBS field station tremendous diversity of ecosystems as opportunities for student projects and demonstration of above and belowground agroecology methods. Student evaluation scores were very high.

I have led a number of graduate and undergraduate seminars, with topics such as international agriculture, soil organic matter dynamics, plant mineral nutrition, participatory methods, sustainable agriculture and "Eating Green in Michigan" a UGS 101 Freshman Seminar. These have been student initiated or highly participatory and wonderful opportunities to engage with students on topics of mutual interest.

Mentoring students is one of the most satisfying aspects of my job. I have served as major advisor to 12 graduate students, in addition to the three I co-advised at University of Malawi pre-MSU, and three students who just joined my laboratory. My students often major jointly in CSS and Ecology, Evolution, Behavior and Biology (EEBB), a unique educational opportunity offered at MSU, and an enriched experience for my students at KBS. I am committed to supporting diversity in ecology and agricultural sciences through mentoring students from

underrepresented ethnic groups, which is reflected in the large number of undergrad and grad students I have mentored from diverse backgrounds (8 out of 21), and the successful outcomes in terms of 100% graduation, and their current positions (see my vitae). This has not always been easy, and I continue to learn how to adjust my advising to meet different student needs and learning styles. I am proud of having graduated two African women PhDs, who are now university lecturer and senior scientists in their home countries. I was recently chosen to be a mentor by a SEEDS fellow, which has been an outstanding opportunity to contribute to this diversity program.

Service

My service at MSU has reflected the interdisciplinary, integrated approach I take to scholarship. I have served on numerous search committees for faculty and extension educators, wearing diverse hats as the occasion merited, providing perspective as a member of the African Studies faculty, KBS faculty, or CANR faculty. I appreciate the opportunity to provide an agroecology perspective in my on-going advisory role to the director of the KBS, and as chair of the LTER-KBS agronomy committee. I have greatly enjoyed contributing to graduate education, through a formative role in setting up the new Ecology, Food and Farming Systems specialization, as the KBS representative to the Plant Science Recruitment committee and through service on the CSS Graduate Committee. I supervise the coordinator of the EFFS and SAFS specializations, and we are working to promote MSU's strengths in sustainable food systems and agroecology to a broad audience of potential students. I have been part of several MSU initiatives to respond to international agricultural research and education opportunities, including a training of Gates senior staff, the Tanzania Sustainable Development Initiative and most recently as a team member of a successful USDA-HED grant to promote curriculum development and MSU linkages with University of Malawi. I anticipate that my service will continue to expand as part of the normal professional development of a faculty member.

I also provide service through my professional societies, including on-going roles as a rapid response team member to the American Society of Agronomy Executive Board, and as an Associate Editor for the Agronomy Journal. I look forward to providing leadership in the agroecology section of ESA as chair-elect, and related opportunities I am starting to pursue to build linkages between ESA and ASA. I am committed to expanding links between long-term agricultural experimentation and the NSF-funded LTERs (where I was just appointed to the International LTER committee).

Summary

My integrated program of scholarship, instruction and extension is closely aligned with the MSU vision of a world grant. Through understanding and promoting ecologically-based management, I aim to improve resource use efficiency and promote ecosystem services from agriculture. My research has elucidated sustainability principles such as the role “perennialization” and coupling carbon and nutrient management can play in row crop production. I seek to use participatory engaged approaches to extension and education to promote learning around these topics, and am excited to see expanded use of cover crops and integrated nutrient management in the Upper Midwest, and spatial diversity in the form of multi-purpose “agroshrubbery” in southern Africa) where a greener revolution is starting to unfold.