New Concepts in Agroecology: A Service-Learning Course

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ABSTRACT

We describe our pedagogical approaches and experiences with a novel course in agroecology (one semester, three credit-hours, for graduate students and upper level undergraduates). Our course responds to recent proposals that agroecology expand its disciplinary focus to include human factors as well as ecological factors, thus taking a more holistic and systemic perspective. The course structure and service-learning component are organized around the focal concept of "transformation," that is, a systemic change that addresses a certain ecological problem in an agricultural system. Our goal is to help train agricultural professionals who can work effectively in collaborative efforts to implement such transformations. Toward this end, we have integrated methods from systems thinking, soft-systems methodology, and agroecosystems analysis, and used a service-learning component to provide students with an opportunity to apply and evaluate these methods in practice. Most students favorably evaluated the course. Ultimately, we expect that the course will help our students to develop a civic professionalism through which they apply their professional skills to complex public problems in agriculture.

Increasingly, the challenge of sustainability in agriculture is understood as a human problem. That is to say, people will jointly construct the future, and so sustainability is a matter of what people are willing to agree to do together (Vandenabeele and Wildemeersch, 2000). This "human factors" perspective has motivated a major transformation in the meaning of the term *agroecology* (Flora, 2001; Uphoff, 2002; Francis et al., 2003). During its development, agroecology has largely been understood as an application of ecological principles to agricultural production, focusing on factors determining production and associated environmental impacts at small spatial scales (e.g., of a farmed field). Recently, agroecology has been reconceived in broader terms (Engel, 1997; Francis et al., 2003; Rickerl and Francis, 2004).

This emerging conception of agroecology is derived from three major premises. First, ecological analysis (e.g., of nutrient cycles) should be extended far beyond field production processes, to encompass pre- and post-production food-related processes such as transport, consumption, waste disposal, and "bio-based" activities that use products of farming in nonfood sectors (e.g., biomass energy, biomass feedstocks for industrial processes). Secondly, the emerging definition of agroecology emphasizes the importance of biocomplexity (Cottingham, 2002), in which close and continual coupling is recognized between social factors (e.g., economic and cultural) and ecological–biophysical factors. Such coupling creates the potential for strong feedbacks among these factors. These "eco-social" feedbacks (Waltner-Toews et al., 2003) are seen as crucial to the structure, function, and dynamics of agroecosystems and of agricultural systems as wholes (Woodhill and Röling, 1998; Flora, 2001). The perceived importance of eco-social feedbacks warrants explicit inclusion of human factors in agroecology, not via separate disciplines (e.g., rural sociology or agricultural economics), but integrally. We note that emphasis on eco-social feedbacks and systemic analyses distinguishes agroecology from a broader field of "sustainable agriculture studies" that represents the aggregation of various theories and analytical methods of biophysical and social disciplines relevant to sustainable agriculture.

Finally, the third major premise in the emerging agroecology is the importance of collective action for "civic agriculture" (Lyson and Barham, 1998), in which groups of people work in community settings to develop an ecologically based agriculture that effectively creates public goods (Rocheleau, 1994; Röling and Maarleveld, 1999; Ison and Russell, 2000; Uphoff, 2002; Pretty and Uphoff, 2002). Worldwide, this ideal is guiding collective action in innumerable agricultural projects (Pretty, 2003), for example, the work of thousands of landcare groups in Australia and New Zealand (Campbell, 1998) and community-learning and watershed-based projects in the USA (Hesterman and Fisk, 2000; William, 2000). Implicit in these efforts is a constructive and optimistic commitment to develop sustainability via more effective and extensive collective action. According to this third premise, making progress on complex agricultural problems requires participatory learning and collective action that focus on the biocomplexity that is seen as the root cause of these problems. Thus, the emerging agroecology has a strongly values-based agenda for education and research, based on a world view (Ison and Russell, 2000), conceptual models, and methodology that depart substantially from previous, less integrated notions of agroecology.

We argue that the emerging agroecology offers powerful new means to improve the overall sustainability of agriculture. Substantially greater insights can be gained by ecological analyses of agriculture that go beyond narrow approaches focused on production and local environmental effects. For example, broader ecological analysis encompasses the great importance of "top-down" influences (e.g., of national agricultural policies; Pretty et al., 2002) on production and environmental effects. It can address post-production and nonlocal processes in agriculture, which are increasingly understood to create major environmental and social problems, including coastal eutrophication, intensive energy use, and public health problems such as the obesity and diabetes epidemics (Nestle, 2000; Kelner and Helmuth, 2003). Indeed, these problems exemplify how both ecological and social aspects of production and post-production processes interact to create the complex challenges that face contemporary agriculture.

The challenge of developing more localized food systems provides another example. Strong arguments can be made that food production, processing, marketing, and consumption should be localized to move toward social, economic, and ecological sustainability (DeLind, 2002). Yet, progress is difficult. In our region of the north central USA, development of local food systems is hindered by ecological and social factors, such as growing seasons, lack of lo-

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Abbreviations: AEA, agroecosystems analysis; GMO, genetically modified organism; MWFA, Mid-West Food Alliance; RP, regional partnership; SSM, soft-systems methodology.

cal production capacity, strongly established consumer preferences and habits, and lack of suitable distribution and marketing infrastructure. Some of these factors act to reinforce the effects of others, together creating powerful restraints on local food system development. We contend that the new conception of agroecology described above provides conceptual and practical tools that open up new approaches to such complex and seemingly intractable problems. Consequently, we believe that the emerging agroecology deserves a prominent place in university agriculture curricula, to complement (not replace) training in the more traditional approach to agroecology described above. In the USA, this curriculum development has not occurred widely yet (Bawden et al., 2000; Francis et al., 2003). In a review of graduate and undergraduate programs in agroecology and sustainable agriculture at universities in North America, we were unable to locate any examples of individual courses that extensively and explicitly address interactions among social factors and ecological–biophysical factors. While our three motivating premises are becoming more widely shared, we believe our course to be novel.

We report here our experiences with a one-semester 3 credit-hour course in the emerging agroecology for graduate students and upper-level undergraduates. The course is required for Ph.D. students enrolled in our graduate minor in sustainable agricultural systems, and is elective for all other students. Our course, Ecology of Agricultural Systems, offers key concepts for examining agriculture through the lens of the emerging agroecology, as well as some practical experiences in doing so. This discipline has not yet developed a generally accepted conceptual framework and core body of knowledge, so we must instead emphasize methods of analysis. Accordingly, we offer experiences in applying methods for "systems thinking" to complex agricultural issues. We have designed the course to be accessible to graduate students in a wide variety of disciplines (both social and natural sciences), since the graduate minor is open to all graduate students. Typically, our students have a strong interest and some background knowledge in agriculture, and training in some social or natural science; we find that these provide adequate preparation for the course, which does not have specific prerequisites.

To begin the course, we introduce fundamental concepts for systems thinking (described below). Then, our students use these concepts to create conceptual models that reflect the major factors and interrelationships that they perceive in certain agroecological problems, with emphasis on interactions that link social and ecological factors and create feedbacks among these. We aim to enable our students to create systemic models that help them to understand complex problems and to organize efforts to address these problems. Such models foster clear thinking, help elucidate what should be expected in a complex situation given available facts, and help reveal operant assumptions and premises. Through a service-learning project, students apply and evaluate models and other course concepts. Ultimately, we have designed our course to enable students to participate in collective action on agricultural problems by communicating their own understanding of a complex situation (aided by model-making), and by appreciating and analyzing the thinking of others.

COURSE STRUCTURE

We begin with core concepts of systems theory (Churchman, 1979; Checkland and Scholes, 1999), starting from a fundamental definition: a system is a set of factors that someone chooses to view as coordinated for some purpose (Wilson and Morren, 1990). This definition represents systems thinking as a particular way of seeing the world, in which interconnections and interactions are particularly important. Thus, systems thinking is an epistemology, that is to say, a theory of knowledge that specifies what is worth knowing and why. We present systems thinking as a practice rooted in model making. We emphasize that systems models of coordinated factors serve as useful descriptions, abstractions, and simplifications of important parts of reality, but are not the same as reality itself. Moreover, we suggest to the students that people continually create and use simplifying "mental models" of the world around them (Argyris et al., 1985), often without explicit awareness of this cognitive process. We contend that thinking and acting on the basis of mental models that are explicitly defined and carefully considered is far better than thinking and acting without conscious awareness of models. We therefore present systems thinking as a "habit of mind" that identifies and reflects critically on the simplifying models that guide attitudes and actions (Mezirow, 1995).

In our approach, systems models must have three features. First, a model must specify the emergent properties of the system. It is helpful pedagogically to think of emergent properties as what the system does. That is, if we think about the system as a collection of interacting factors, then there will be some outcome from that interplay. That outcome can be considered an emergent property. A system can have more than one emergent property, since there may be many outcomes from the workings of the system. However, some emergent properties are likely to be more relevant to the purpose of a particular modeling effort than others, so in practice only a subset of possible emergent properties needs to be considered.

This concept of emergent properties has been remarkably difficult to teach. In pedagogical practice, we have found several useful approaches to this challenge. First, one can identify an agricultural opportunity or goal, and ask whether this can be seen as an emergent property. For example, consider the goal of increasing production and consumption of "grass-fed" meat and dairy products produced by intensive rotational grazing production methods. This goal has attracted much interest because it offers a major opportunity to address multiple problems created by current methods for production of meat and dairy foods. However, progress toward this goal depends on coordinated action in multiple sectors to increase both supply and demand for grass-fed meat and dairy products. Thus, we can conceptualize a dietary shift to these foods as an emergent property of closely coupled increases in supply and demand. It is also often insightful to analyze unintended consequences, specifically, outcomes that were not foreseen when action was taken, as emergent properties of systems. For example, the fierce public opposition to genetically modified organism (GMO) crops expressed in many countries can be seen as an unintended consequence of the early commercialization of GMO crops. The public opposition might be seen as an emergent property of the interaction of organized environmental and food safety groups, our litigious society, increased public awareness of environmental hazards, limited public knowledge of GMOs, mistrust of firms commercializing GMOs, decreased credibility of scientists, and other factors. In our class meetings devoted to emergent properties, we use case studies of both successful and failed efforts at agroecological innovation (Uphoff, 2002) to explore whether and how these outcomes can be insightfully understood as emergent properties.

Second, a systems model must recognize nested (or hierarchical) structure. To do so, one considers the relative dimensions of the various parts of a system. For example, these parts can have different physical sizes, work at different speeds, or have differing degrees of power. Things that have different dimensions have different roles in a systems model. Parts of a system that are relatively large can be seen as forming the context or environment; these thus provide boundaries for the parts of the system that are smaller, and limit or constrain their function. As noted above, the influence of national agricultural policies on farming practices is a well-recognized example of this "top-down" effect: national policies impose many constraints on farm-level practices.

In addition to the value of defining boundaries, recognizing nested structure can provide additional insight. Often, large-scale contextual or environmental factors are regarded as fixed and unchanging. Fresh insights into problems and potential solutions can come from defining these encompassing factors themselves as emergent properties of a larger system, and asking how that latter system could change to transform these factors. In practice, we ask students to "look up and around" by considering what larger parts form the environment that surrounds a situation of interest. Pedagogically, we familiarize students with such thinking through model-building exercises such as identifying assumptions, policies, and relationships that structure and constrain agricultural research in universities, as well as through a case study of top-down effects of technology and social conditions on agricultural development in Kenya (Uphoff, 2002).

Finally, we apply nested structure concepts to consider how parts of a system that are relatively small can interact to explain the workings of larger parts. That is to say, interactions among small parts can cause emergent properties in larger systems. Here, we ask the students to "look down and in" to examine interactions among factors that are smaller than the system as a whole, so that they will gain understanding of processes generating emergent properties of the system. Such analysis is often insightful, because frequently our students report that their mental models of how small things relate to the behavior of large things are limited and incomplete. Pedagogically, we again use simple exercises in this sort of model-building—identifying specific behaviors and interactions that, in their experience, create satisfying interpersonal relationships. This is useful because most students discover they have definite notions about this subject, but rarely have formed a coherent and explicit model that links specific behaviors and interactions to the emergent property of satisfaction in an interpersonal relationship. We build on these concepts with case studies of agroecological innovation (see below).

Third, a systems model must recognize feedback in the system. Feedback occurs when one part of a system affects a second part, which then affects the first part in return. In systems models, these reciprocal influences are seen as the mechanisms that underlie two fundamental dynamics, facilitation of change and resistance to change. Change is facilitated by positive feedback, which causes increasingly strong cycles of stimulus and response among parts of a system. Change is resisted by negative feedback, which acts to reduce stimuli that affect the system. Identifying relationships in a system that creates positive and/or negative feedback is essential to thinking clearly about complex situations, and in particular about the dynamic responses of systems to changes in their situation, circumstances, or environment. In class, we have used case studies of a grass-fire cycle (D'Antonio and Vitousek, 1992). This is a positive feedback process in which the presence of invasive grasses increases fire frequencies and thereby promote the further prevalence of these grasses. We ask students to translate accounts of the grass–fire cycle into diagrams that illustrate feedback loops that act on a variety of temporal and spatial scales. This exercise is very helpful for clearing up confusion about these concepts and developing a vocabulary for discussing feedback.

After introducing the notion of creating systems models with these three basic system concepts, we introduce a more formal method for model building. Specifically, we develop selected ideas appropriate to agroecological analysis from soft systems methodology (SSM). Soft systems methodology (Checkland and Scholes, 1999) is a set of analytical methods and heuristic modeling techniques. It provides a flexible framework for creating systems models and provides a convenient starting point for creating useful models, with emphasis on models that aim to improve a situation. Central to these system models is the notion of transformation. A transformation represents a change in an emergent property to a more desired state or condition. To formalize this idea of transformation, we introduce the SSM concept of root definition into the course. Following Checkland and Scholes (1999), a root definition defines a system (i.e., a systems model) in relation to the proposed transformation as follows:

A system to do T by M in order to persue A

T is the transformation itself. This is the intended change in the real world. Possible changes include physical changes, decisions to be made, ways to implement an idea, and changing the way we think about something.

M is the means to accomplish the T (How will T be done?).

A is the broader aim of the system (Why should T be done?).

An example of a root definition:

T: Develop local food systems.

M: By coordinated innovation in multiple sectors.

A: In order to increase food system sustainability in social, economic, and environmental terms.

A transformation focuses on emergent properties of the system that are relevant to the aims expressed in A. In the example, this is the state of the local food system, which needs to be developed. The aims define the boundaries of the larger system that embeds the system of interest. The means define the boundaries of the entities or subsystems that comprise the system of interest.

Creating these heuristic models of systemic change via SSM culminates the introductory section of the course (ca. 7 weeks). Next, we turn to the second major section of the course, methods for identifying and characterizing social and ecological factors that are important to eco-social problems. To investigate social factors, we teach certain analytical methods derived from SSM (Checkland and Scholes, 1999; Engel, 1997); these methods are used in SSM to characterize social systems that are relevant to a certain transformation.

The social analyses are guided by the premise that there are multiple sources of power in the social "environment" surrounding a systemic problem, and these sources can be organized to address the problem through some relevant transformation. Moreover, some of these sources can be harnessed by social groups or organizations concerned with the transformation, but others cannot, because of some mismatch with the culture of these organizations, such as its values or mission. For example, traditional U.S. agricultural research organizations tend not to recognize farmers and other nonscientists as knowledge creators, and therefore typically struggle to apply the problem-solving power of farmers to agroecological problems. For another example, government professionals can exert considerable power by focusing resources under their control for a particular purpose. However, in doing so they must not violate constraints and norms that are important in their organization. Thus, to be both willing and able to participate as an actor in a transformation, an individual or group must have some source of power that is seen as legitimate in the surrounding cultural setting. Accordingly, our social analyses of eco-social problems have two goals: to characterize the cultures of relevant organizations and groups, and to inventory relevant sources of power.

We begin with methods for cultural analyses, with the ultimate goal of providing insights that can guide efforts to recruit social actors needed for a desired transformation. We assess how potential actors are affected by three dimensions of a culture: roles, norms, and values (Checkland and Scholes, 1999). *Roles* are particular sets of actions and activities that are performed; *norms* are prevalent expectations and standards for competent performance of a given role, and *values* are the moral and ethical framework that gives meaning to norms and roles. These three aspects are seen to form an interactive complex that strongly shapes the culture of an organization or group. We emphasize that a comprehensive cultural analysis is not our goal, instead we are concerned with those aspects of group and organizational culture that are relevant to a desired transformation. In essence, we are trying to determine who does what, with what intent, and with what ultimate goals, so we can understand the forces that could motivate people to support (or resist) the transformation.

Next, we inventory sources of power and influence that are germane to a given transformation. We suggest to students that there are many forms of actual or latent power in any situation, exceeding what most students have previously considered. This viewpoint derives from contemporary theories that conceptualize social, economic, and political power as multiple and widely located, rather than being concentrated in governance structures and political elites (Fischer, 2000). For example, power to help develop more localized food systems exists in each link of supply chains linking production and consumption. Pedagogically, we give the students some exercises in thinking broadly about sources of power and then challenge them to apply this perspective in identifying sources of power in actual problem situations. We believe that students need first to appreciate the multiple sources of power before it is possible to consider how they can facilitate or impede change.

In class, we practice these social analyses in a real-world situation by asking our students individually to interview a University of Minnesota extension worker. In semi-structured, open-ended interviews, students elicit views on the culture surrounding extension work, and on salient sources of power. Through individual work and in-class discussions, students analyze interview results to characterize the culture of extension in Minnesota. We culminate this exercise by asking students to apply our results to identify actors in Minnesota who could participate in a hypothetical transformation within the University of Minnesota Extension Service. This transformation—to increased use of facilitative extension methods (Röling and Jiggins, 1998)—had been a topic of considerable discussion and debate within the Minnesota Extension Service, and thus provides a rich case study.

After our consideration of methods for analyzing social factors, we introduce agroecosystem analysis (AEA) as a means for investigation of ecological or biophysical factors. This method, originally formalized by Conway (1986), provides a process for ongoing identification, collection, and organization of information about biophysical factors relevant to an agroecological problem. Moreover, AEA provides a method for convening people who possess different knowledge about a problem (e.g., farmers and researchers), to identify key issues and uncertainties that are pertinent to the problem. The heart of AEA is a series of four mapping exercises, aimed at identifying and characterizing certain patterns in agricultural ecosystems (Conway, 1986):

- Spatial patterns—arrangements of the components of an agricultural ecosystem in space (e.g., soil maps, crop rotation diagrams, and diagrams of weedy patches in fields).
- Temporal patterns—calendars or schedules describing arrangements of agricultural ecosystem components in time. These include patterns within years (field work, labor needs, pest development, etc.) and trends over multiple years (e.g., yields, losses to pests, etc.).
- Flow patterns—patterns of flows or transformations of energies, materials, or organisms (e.g., nutrient cycles, pest life cycles, and hydrological patterns).
- Decision patterns—patterns of choices made under different circumstances and information used to make these (e.g., as depicted by "decision trees" that describe alternative management actions that are contingent on key factors such as weather patterns or market prices and result in choices conditioned on the previous decision).

An application of AEA on a local farm is key to this segment of the course. The students have applied AEA to issues including weed management, integration of cover cropping, and transition from fresh-market vegetable production to a more diversified enterprise. In AEA, students first assess the farm situation via dialogue with the farmers and their own observations. Next they make first approximations of relevant spatial and temporal patterns (e.g., in production, soil attributes, and labor demands) and describe flow patterns (e.g., the farmer's understandings of nutrient cycles). Finally, students assess planning and decision-making processes.

The students then integrate the methodologies they have learned by drawing on their AEA to create a root definition that addresses the on-farm problem. This experience allows students to characterize the major ways in which biophysical factors are acting in an agroecological problem. Of course, a single field trip provides only a crude first approximation of the relevant ecological patterns and processes, and therefore most information is based on observation of broadly evident patterns and knowledge from the farmers, rather than on objective measures. Despite these limitations, AEA offers students an efficient method to assess and organize inquiries into the biophysical dimensions of agroecological problems.

SERVICE LEARNING FOR APPLICATION, INTEGRATION, AND EVALUATION

A cornerstone of our course is application of systems-thinking methods to a real agricultural problem, via service learning (Furco, 1996; Ehrlich, 2000; Cipolle, 2004). Our students work with nonprofit organizations that are working on agroecological issues, aiming to help these organizations deepen their systemic understanding of these issues. In course evaluations, students almost invariably note appreciatively that service learning helped them connect in-class to real work on agroecological issues. Most students have experienced a sense of positive emotional engagement in their service-learning work and the people they meet in the process. We believe these perceptions and experiences are powerful stimulants for learning concepts that otherwise can seem abstract and arcane. Thus, we see the service-learning project as essential to our pedagogy. Through application of systems concepts and analytical methods (e.g., AEA) to the messy and complicated problems encountered in service learning, students experience the insights that can come from applying seemingly simple analytical methods to complex problems. For example, students do not gain much from specifying a transformation and its associated root definition as an armchair exercise. The technique becomes much more interesting to students when they use it to make sense of the complexity they encounter in service learning. For example, when our students interview a range of people who have a stake in the focal issues of their service-learning project, translate individual perceptions and concerns into the terms of a root definition, and then consider the commonalities and contradictions among a number of root definitions, this modeling technique comes to life for most students as a powerful tool for thinking clearly and systemically.

Finally, an important function of the service-learning experience is to drive cycles of "action learning," a learning modality widely seen as vital in addressing complex situations (Argyris et al., 1985). In action learning, students use concepts and methods introduced early in the course to create crude initial models of their service-learning situation, proceed to test these models with further inquiry, and consequently re-evaluate and refine their models. More specifically, they gather perceptions of a variety of interested people and groups, and use these to create a variety of system models reflecting the range of perceptions they encounter. Then, they synthesize and integrate these first models, eventually creating a smaller number of models that might reflect consensus among interested parties. As service learning proceeds, the students use their models in further dialogue with stakeholders. Through this dialogue, students identify important issues in the situation, such as key areas of agreement, conflict, and uncertainty among those concerned. Thus, we have found that service learning is a very effective way to give students practical experience with the cycles of action learning.

In practice, the service-learning process begins before each semester, when we work with local nonprofit organizations to identify interesting and appropriate service-learning projects in which both

Table 1. Timetable and summary of activities for service-learning projects.

Week 1–2
Contact host, arrange meeting schedule for semester.
Read background materials.
Identify issues, concerns, opportunities as perceived by organization, and identify output and outcome goals.
Week 3–4
Initial scoping process: problem identification, situation mapping, interviews with multiple informants.
Apply systems concepts to situation (identify relevant emergent properties, nested structures).
Present initial findings to host at organization and in class.
Week 4–5
Develop first draft report, present to host person.
Revise, present to instructors.
Week 6–7
Identify suggested improvements in situation of concern, pick several for further analyses.
Develop corresponding root definitions; present to host, identify information needs to refine root definitions.
Week 7–8
Refine and elaborate systems models for root definitions.
Week 9–10
Present models to host; identify information needs for further development of models.
Present to class, apply AEA; develop second draft report.
Present to host, revise, present to instructors.
Week 11–12
Investigate key actors, map power, cultural aspects.
Suggest plan to organize collective action to implement root definition.
Meet with host for discussion.
Week 13–14
Draft final report, present to class, meet with host to discuss and identify areas for revisions.
Week 15
Revise and submit report.

social and ecological factors are present and interacting. Examples have included:

- Local Food System Development (Minnesota Regional Partnerships [RPs] for Sustainable Development). The RPs are a set of state-funded citizen boards that work on region-specific development issues in six regions of the state. Each board operates independently, but there are many common concerns, such as creating more locally based food systems. In this project, students worked to clarify how the RPs could together work to support local food systems.
- Developing an Ecolabeling Program (Mid-West Food Alliance [MWFA]). MWFA is a third-party "ecolabeling" program. Ecolabeling programs mediate between producers and consumers of food, certifying that practices of farmers and other food suppliers meet certain criteria. Students assisted MWFA to identify important agroecological considerations affecting certification, particularly impacts of farming practices on biodiversity conservation in farmland.

As much as possible, students are matched to service-learning projects on the basis of their personal interests, working in groups of two or three. At the host organization, students interact mainly with a single contact. It is important that the service-learning project address some significant part of that person's current work responsibilities, thus creating incentive to devote time to the student group. We ask students to invest 3 hours per week on the service-learning project (about one-third of expected out-of-class work time). We expect that groups will meet in person with their host at regular intervals during the semester to gather information and present their initial findings. The final product of the service-learning partnership is a written group report that encompasses and synthesizes all of the systems analysis done by the students during the semester. Our students' service-learning experiences are described in Table 1.

We evaluate the service-learning component of the course according to the following criteria and weights: the host's evaluation (25%), written work (50%), and in-class presentations (25%). The service-learning component defines 40% of the course grade; other components are regular attendance, preparation for and participation in class activities (40%), and completion and quality of short writing assignments (20%). In our 3 years of experience, service-learning projects have gone well; students and hosts have spoken very appreciatively of both process and product. Like all group projects, cohesion and "chemistry" of the groups requires pro-active monitoring and consultation with the groups. Likewise, it is important to be in contact with the service-learning project hosts to help them understand and integrate the dual nature of the project, which of course functions both as a consultancy with the host organization and as a crucial learning process within the course. It is also important that the students and hosts develop a good working relationship. Finally, because students are usually uncertain about how to get started and about how to communicate their findings to their hosts, pro-active consultation is needed. Clearly, instructors must make some time investments, particularly early in the projects. It is helpful if the projects are of professional interest (beyond teaching responsibilities) to the instructor since this can help create the time needed to foster and facilitate the service-learning projects.

STUDENT EVALUATIONS

Enrollment to date has been about 75% graduate students in a range of agricultural–science and social–science disciplines, with the remaining 25% being advanced undergraduates in agriculture majors. Student evaluations have been generally quite positive throughout four offerings of the course. Mean ratings (enrollments in parentheses) on a Likert scale ranging from 1 (very poor) to 7 (excellent) were 5.8 (8) for 2000, 5.6 (8) for 2001, 6.2 (11) for 2002, and 5.9 (7) for 2003, with relatively little variation among individual ratings. The introduction of the service-learning component in 2002 and 2003 caused no obvious change in mean rating scores, but received virtually unanimous favorable comments in summative reflective evaluations (Table 2) written by the students. However, it is also clear from evaluations that some students find service learning to be initially confusing and disorienting. Students described initial confusion regarding how service learning connected to other course content and regarding their "job description" in service-learning work. One related "The most frustrating part was just a lack of experience and information pertaining to the stakeholders and other details of the situation." Fortunately, comments indicated that most of this confusion was dispelled during the semester. We are responding to these concerns by increasing our initial consultations with the students to address initial confusion. However, we speculate that service learning at graduate and advanced undergraduate levels is intrinsically challenging for both students and teachers, because the students' service-learning work typically will be more complex, open-ended, and unstructured in relatively advanced courses than in introductory courses.

Student evaluations suggest several other points related to service learning. First, roughly equal numbers of positive and negative comments on the overall coherence and integration of the course were expressed in 2000 and 2001 evaluations, while positive comments increased and negative comments were nearly absent in the latter 2 years. In each of these latter years, several students identified the service-learning component as being very important to their sense of the coherence of the course. These trends in comments on coherence are consistent with our own perceptions that the service-learning experience increases the students' sense that the course content is useful and engaging. However, many students commented that they would have valued more emphasis on AEA and less on social analyses, and some students have expressed some regret that the

Table 2. A sampling of student comments on positive and negative experiences in service-learning projects.

Positive comments
I really liked talking to real people and that this was a real project going on now—not something make-believe.
The service-learning project connected quite well with the in-class material and should always be included.
Working with others and being forced to deal with people with different long- and short-term goals and aspirations is good.
Negative comments
Most of the term, it was unclear what we were supposed to do for the class project as opposed to for the service-learning host.
In the beginning, the service-learning felt very disconnected from the course…near the end everything lined-up.
Our project strayed a little too far from topic of agriculture…it is important to include humans, but our project was (too) human-centered.

course takes an eco-social approach at the expense of the more narrow, biophysical approach to agroecology. In response, we have now increased time devoted to AEA. Finally, we continue to wrestle with several challenges. Graduate curricula are very full and we have experienced low enrollment, despite positive evaluations. Currently, we are working to recruit more undergraduates who are interested in agriculture from a systemic perspective, specifically from high-enrollment programs in global studies and environmental horticulture. The time requirements of service learning, however, could become problematic for instructors with high enrollment because meeting with groups and staying in touch with host organizations are significant time commitments.

CONCLUSIONS

In teaching a methodological course for the emerging agroecology, practical application of methods is of course necessary, and we have found service learning invaluable for this purpose. Experiences in service learning also allow students to deepen their appreciation of the three tenets of the emerging agroecology: they see how much of agriculture takes place outside of production, they view the ongoing action of eco-social feedback; and they get a taste of collective action on agricultural problems. For students of other managed ecosystems (e.g., forestry or wildlife systems), analogous learning outcomes would likely be useful and our course may be helpful in curriculum development for these students.

More broadly, our course is responsive to critics who question the ability of science to address complex and controversial problems effectively. These observers (e.g., Irwin, 1995; Ravetz and Funtowicz, 1999; Fischer, 2000) charge that scientists limit their effectiveness in problem-solving efforts by failing to attend to the systemic context of problems (i.e., factors and feedbacks on multiple scales that frame focal problems and strongly affect efforts to address these problems). Scientists are also accused of typically failing to recognize nonscientific rationalities and forms of knowledge (e.g., cultural, historical, or ethical) as relevant to complex public problems (Fischer, 2000). With its emphasis on systemic thinking and social analyses, our course aims to help train scientists who are better equipped to address complex and controversial problems.

More broadly still, we aim to enhance the civic dimensions of our students' professional identities and practices by helping them to take a stance of civic professionalism (Bender, 2001; Sullivan, 1995). In essence, civic professionalism calls on professionals to orient their work, at least in part, toward projects of civic innovation and renewal (Boyte and Kari, 1996). In these projects, civic groups strive to collectively understand and act upon complex public issues and problems ((Boyte and Kari, 1996; Sirianni and Friedland, 2001). Through participation in this work, civic professionals direct their expertise and professional practice toward complex public problems. In science, civic professionalism would encourage scientists to see themselves as participating as scientists in civic life, rather than working apart from or above it. We believe it is crucial to develop graduate and undergraduate curricula that help students practice civic professionalism in food systems and other professional domains (Ehrlich, 2000; Bender, 2001). With its focus on training scientists to use agroecological methods and analyses in collective action, our course represents an experimental step in that direction.

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