The Pleasures and Pitfalls of Interdisciplinary Research in Agriculture

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Abstract: *Increasingly, interdisciplinary research is being touted as a way to solve real-life problems of interest to the taxpayers who support research at public universities. The purpose of this paper is to examine the benefits of interdisciplinary agricultural research involving economists and natural scientists, to discuss problems associated with carrying out this type of work and to offer some suggestions on how such research can be facilitated. Mutual trust and ongoing relationships can lead to better timing of collaboration and more satisfaction for all parties. Open communications are also important for success in collaboration. Within the broader university environment, it is important for tenure and promotion committees to be able to properly evaluate interdisciplinary work; otherwise, faculty will not be properly rewarded for these efforts.*

Key Words and Phrases: *Interdisciplinary research, agriculture, economics.*

In these times of dwindling resources, the public is demanding higher accountability from research scientists at state-supported universities. Research purely for the sake of advancing knowledge—or even research with strictly long-term payoffs— is thus becoming increasingly less palatable to state and federal legislators. Agricultural research may be particularly vulnerable to public scrutiny since, unlike many other fields, our research programs were initially shaped by the concept of providing service to the agricultural sector (Lockeretz and Anderson, p. 33). The current demand for applied, problem-solving research has led to renewed interest in the research community for work that crosses disciplinary lines.

Interdisciplinary work between agricultural economists and natural scientists is not new, and many papers on the issue can be found in the agricultural economics literature. In 1979, for example, at the annual meeting of the American Agricultural Economics Association, Swanson addressed this topic at length. Dobbs, in a 1987 journal article, also discussed this issue, pointing out that because agricultural economists are more likely than natural scientists to take a more "holistic" view, agricultural economics can be an "integrating" discipline in a research project.

Although agricultural production can be modeled as a physical process, farms are not experiments; they are businesses and, in many cases, homes. The natural sciences (i.e., the biological, physical and life sciences) are thus often not sufficient in themselves for adequate "service" to the agricultural sector. Real-world problems

often involve several natural science subject matters (entomology, animal science and agronomy, for example), and also have social and economic dimensions. Output-enhancing technology may be prohibitively expensive to small farms, for example, or may interact in an unfavorable way with government agricultural support programs or environmental regulations. The societal and economic impacts of some production research may even run counter to the interests of the general public. As an example, Antle and Wagenet cite recombinant-derived bovine somatotropin (rBST), which enhances production of milk, a commodity already produced in overabundance, some claim, because of the stimulus of farm programs. Some individuals are also concerned with the possible health consequences of rBST. These concerns are sociological in origin, with decided economic consequences. Social scientists may be able to foresee these types of problems and offer potential solutions.

The purpose of this paper is to discuss both the pleasures and potential pitfalls of interdisciplinary research between agricultural economists and other agricultural scientists, with a focus on how the collaborations can be facilitated in an academic setting. For the purpose of this paper, we will focus on integrated projects in which communication between individuals trained in different disciplines is essential, rather than on projects with various, essentially separate, components in which the disciplines are not integrated. This latter type of research is sometimes called "multidisciplinary" to distinguish it from true "interdisciplinary" work. (See Swanson for a discussion of the degrees of integration in research).

This paper's major purpose is not to provide an overall theory of the research process, a subject that has been handled by others (Swanson; Mitroff and Pondy; Klein), but rather to discuss specific problems and their possible solutions. This paper presents a general discussion of the nature of interdisciplinary research and then provides three independent perspectives on this topic: those of an economist, an agronomist and an agricultural research administrator.

Disciplines and the Academy

Except for individuals who are hired into branch stations and institutes, or the very few who hold joint appointments, faculty members work in departments that are organized by discipline (such as agricultural economics) or by subject matter (such as animal science). These "subject matter" departments may incorporate several narrowly focused disciplines or sub-disciplines (meat science or genetics, for example), but the emphasis normally remains on the individual's contribution to that particular field.

As Kunkel notes, disciplinary departments are primarily a device of academic organization, but the effects of the division go beyond education. Most journals carry disciplinary titles (e.g., *Agronomy Journal, American Journal of Agricultural Economics*) and most academic research is carried out along these lines. Not surprisingly, faculty rewards are often related largely to the disciplines.

Disciplines are often seen as the basis for doing "real science." Kunkel notes that "pure science, as it is usually recognized, is pursued by individuals motivated by a disinterested search for truth" (p. 26). Some sociologists and philosophers of science have argued that this view of science is more a myth than a reality, even within the disciplinary arena (see, for example, Charlesworth et al.). Regardless of its accuracy, this view of science has important normative features that affect faculty evaluation and rewards. The more a research project fits the model of pure science, the greater the value accorded to it by many members of the academy. The higher status, even within a discipline, tends to go to researchers working in basic or theoretical areas, rather than to the applied researchers. By its nature, interdisciplinary research is almost always applied in scope. Thus, an individual engaged in interdisciplinary projects may be seen by the advocates of "pure science" as engaging in an inferior substitute.

Lockeretz and Anderson point out that even the word "research" can be problematic. As early as 1960, Simons discussed the "halo" effect of the word. "Research" is often seen as the highest and best use of faculty talent, and faculty members are accordingly motivated to define their own work as "research" while denigrating as "not research" any work that they either do not understand or do not value.

The importance of the disciplines in tenure and promotion decisions can be illustrated with a quotation from the *Auburn University Faculty Handbook*, taken from the section on promotion criteria:

> A faculty member engaged in research/creative work has an obligation to contribute to his or her discipline through applied and/or basic research, through creative endeavors, or through interpretative scholarship. To a large extent, each discipline or department must determine how much and what quality of research/creative work is appropriate for promotion (and/or tenure) and judge its candidates accordingly (page 3:10).

Thus, at Auburn University at least, the document used for tenure guidance clearly states that research within a discipline is the primary sort of research considered for promotion and tenure purposes. Such language can certainly have a chilling effect on a junior faculty member's desire to work on interdisciplinary teams. The role of the department, a discipline-oriented unit, in determining standards of quality is also emphasized in this quotation. Tenure and promotion decisions in most universities are heavily (sometimes solely) influenced by evaluations of senior colleagues in a department. Boehlje and Levins examined 170 tenure decisions in 39 agricultural economics departments over the period 1984 to 1988. For the 37 individuals denied tenure in these decisions, Boehlje and Levins report that 16 cases were decided at the department level, 9 at the college level, 11 at the university level, and one by the Board of Regents (p. 294). They also state that twenty-three of the rejections were based explicitly on insufficient publishing (which was not defined precisely in the article), and some applicants were rejected for having "unfocused" research. As part of the

research effort, Boehlje and Levins also looked at tenure documents from the departments. They noted that many of the documents provided inadequate guidance for tenure decisions, and specifically mentioned the need for more attention to the issue of properly evaluating multidisciplinary work and even single-discipline collaboration with colleagues.

Given the importance of the department as the first step in the tenure process, and the threat that multidisciplinary research could be viewed as unfocused by more discipline-oriented colleagues, the individual who pursues interdisciplinary work to the exclusion of more narrowly focused projects within a discipline may have a difficult time achieving promotion and tenure within the university environment.

The focus on the discipline, as opposed to the university itself, in deciding what constitutes sound research probably arises from several sources beyond the administrative division of universities. First, rapid technological change has made it difficult for researchers to keep up with advances in even a narrow field of specialization. Judging "good" from "bad" science within a discipline thus has grown increasingly troublesome. Attempting to apply the same sort of judgment to works outside the field of specialization would seem, to many researchers, presumptuous and misguided. Secondly, academics, particularly "star" researchers, may change institutional affiliation many times, lessening the loyalty to any particular university. At the same time, membership in professional disciplinary societies remains relatively constant across an individual's career.

Graduate training provides a third, and compelling, reason for the focus on disciplines in determining research valuation criteria. Graduate programs often emphasize "state-of-the-art" techniques for the higher-valued "basic" research. Students with the greatest capacity to excel in this sort of research are usually given the greatest share of faculty time and resources. Other students, whose talents may be stronger in other types of endeavors, are often overlooked or even made to feel "second class." Individual competition (for grades or faculty time) is emphasized. Team work is seldom encouraged.

The narrow focus of graduate training has a consequence that is often not recognized—a communication gap between social and natural scientists as to what constitutes research. As Lockeretz and Anderson point out, true interdisciplinary research is difficult because, "each discipline's intellectual limitations and its cherished but not necessarily valid assumptions are exposed to the scrutiny of people who have not been trained to accept them unquestioningly."

For most natural scientists, research follows a set course: formation of a hypothesis, design of an experiment, collection of experimental data, and analysis of the data using a limited number of statistical techniques. Journal articles in the natural sciences tend to be short and factual, with little effort expended on justification of the methods used. By contrast, in economics research, experiments per se are seldom conducted. Most data are second-hand, and methods of analysis are numerous and often highly contested within the field. As a consequence, articles tend to be longer

on average than those in the natural sciences, with a great deal of space devoted to justification of the techniques employed.

Differences can lead to disparagement. Social scientists have been known to look down at experimental research as intellectually inferior—dull and unimaginative—because the techniques are standardized. "Feed 'em and weigh 'em" or "spray and pray" are phrases that have been used on occasion to disparage work by natural scientists. Their short, factual articles are sometimes dismissed as products of a derivative "fill-in-the-blank" writing process. In return, the natural scientists often criticize work in the social sciences for failing to follow the standards of the scientific method. The wide variety of mathematical techniques that can be used in social science research, rather than appearing to add "rigor" (as economists tend to believe), may be seen by the natural scientist as signs of sloppy or inconsistent scholarship. "That's not science," is a phrase that natural scientists may use when evaluating work in the social science fields. Only survey research, which involves primary data collection, escapes this particular criticism.

The incentives to remain within a discipline while conducting research are thus fairly strong for most faculty members. Disciplinary work is "comfortable" to anyone with standard graduate training. It leads to rewards and recognition both within the profession and within the university. Further, one need not spend time justifying the dominant research methods in one's profession to a (sometimes hostile) "outsider" if one maintains a disciplinary focus.

Facilitating an Interdisciplinary Approach

In spite of the problems of bridging the gap between natural and social sciences, interdisciplinary research offers rewards to many faculty members. To the researcher concerned with generating results that are useful to public and private-sector decision makers, an interdisciplinary approach is often unavoidable. Most natural scientists are well aware that price movements are just as important as average daily gains in determining the profits of cattle producers, or that an optimal crop rotation from an output perspective may be sub-optimal when markets or farm program provisions are considered. Lately, environmental concerns have become increasingly important in agriculture. Natural scientists often wish to work in conjunction with economists to determine the least-cost methods of reducing environmental hazards. For the economist, working with natural scientists provides access to "fresh" data and an ability to help shape experiments to answer economic as well as biological questions. Thus, in spite of the problems, strong incentives exist for work that combines disciplines.

One should be wary, however, of what may be an evolving mind-set, that all "interdisciplinary" work is somehow more beneficial to society—more "useful"—than disciplinary work. As early as 1955, Blackwell criticized the fad of calling for interdisciplinary research for its own sake. Disciplines developed for good reasons,

in many cases, and much valuable work remains within their boundaries. An understanding of specific relationships in cell biology, for example, is best left to those with specialization in this topic; there is little a nonspecialist can add. Similarly, in agricultural economics, most work in the area of price and market analysis would probably not benefit from the input of natural scientists. In all good research, a problem is first identified, then the appropriate means of solving it found. Setting interdisciplinary work apart as consistently superior to disciplinary work is as harmful to the conduct of good science as denigrating all of it as "inferior science."

Although many faculty members may recognize the benefits of interdisciplinary work, it can be a daunting task to find the appropriate contacts in other departments needed to begin such projects. Further, going about the process the "wrong" way, can cause credibility problems, or even create hostility. Three personal perspectives on methods of bridging the "inter-department" gap follow. It is hoped these perspectives will serve to aid other scientists in their interdisciplinary endeavors.

An Economist's View: Avoiding the Pitfalls and Reaping the Rewards—Patricia A. Duffy

Although interdisciplinary work can be highly rewarding, economists can face a variety of problems in collaborating with natural scientists. These "pitfalls" take several forms: poor timing, unrealistic expectations, mutual ignorance, and different writing styles. The problems are interconnected.

Poor Timing

First, it is often the case that we are brought into the project "too late." By that, I mean the experiment is already completed and the data collected when someone in the other department decides an economic evaluation of the material would be useful. If the economists are lucky, the experimental design will allow for meaningful economic analysis. In many cases, however, it will not. Experiments set up with covariates, for example, will often provide more interesting opportunities for economic analysis than "simple" ANOVA trials with only a few data points. If economists have no say about experimental design, often the results will not be very useful from our perspective.

Other data problems can involve failure to collect information at appropriate time intervals and failure to keep adequate records on variability. These data problems are particularly annoying to the "last-minute" economist because a simple request at the beginning of the project would have ensured adequate information. Dobbs points out that some natural scientists may view economists either as "clerks," if they take direction when analyzing data obtained from natural scientists, or as "parasites" if they follow their own ideas and publish their own papers based on data someone else has

generated. He notes that both problems tend to occur when economists are brought late into a project.

To avoid "data pitfalls," an economist should make efforts to get involved in a project in the planning stages, which may mean persuading natural scientists to be more cognizant of the importance of having the economists involved early. One technique that can be helpful toward this end is to encourage department heads and agricultural research administrators to include at least one agricultural economist as an experiment station project reviewer for field experiments with potential economic dimensions. Even if the economist who performs the review does not ultimately collaborate with these natural scientists, some important suggestions on collecting useful data for economic analysis could be provided, and the researchers have at least gained some familiarity with each other's work. Co-authoring grants is another excellent way to ensure that all "team" members are involved from the outset. The increasing emphasis on "interdisciplinary" dimensions as a criteria for judging grants should lead to better communication among disciplines during the planning stages of research projects.

Unrealistic Expectations

Another problem, somewhat related to the issue of being brought into the project too late, involves the unrealistic expectations some natural scientists hold about economists. These expectations can be of two diametrically opposed types: that economists can model anything, or that economists are useless. Sometimes the second view of economics comes from disappointment of the first view. Economists cannot, for example, do much more than develop budgets when presented with simple ANOVA data. The natural scientist who makes this request may view the economist's inability to perform a more "interesting" analysis as an indictment against the field in general. After all, the experiment was "well designed" from the perspective of natural science; if the economist cannot do much with the data, then the natural scientist may reason that the entire field of economics (or at least this particular economist) is useless.

In another possible situation, natural scientists may believe that economists, if given "appropriate" data, can quickly develop a model that will provide the optimal product mix for the entire state or region. In reality, such models are major career undertakings—and provide few publication possibilities for the economists involved. The inability or the unwillingness of the economist to deliver this type of research may disappoint the natural scientist and again lead him or her to the conclusion that economists are not of much use at all.

A deep-seated difference in outlook between most economists and most natural scientists can exacerbate the problem of unrealistic expectations. While natural scientists are trained to find a single or definitive answer for most questions, economists are trained to hedge their answer. The "correct" answer to most economic

examination questions begins with the phrase, "it depends." The natural scientist may see such caution as an indication that economics provides no real answers. Further, natural science results are "long lasting" in that natural processes change only slowly over time. By contrast, economic results are usually far more ephemeral, heavily tied to the time the analysis is performed, because markets (or government policies) can change quickly. The volatility of economic processes is something that some natural scientists may not fully understand.

Swanson points out that agricultural economists and natural scientists may very well be motivated by differing overall paradigms. Agricultural economists tend to ascribe to a combination of the unidirectional-causal paradigm and the random-process paradigm (Maruyama). Standard regression analysis, with its dependent and independent variables and error term, serves this paradigm well. Biologists, on the other hand, may ascribe to a paradigm of mutual causality, with feedback loops. These fundamental differences in basic approach can also cause difficulties in cooperative research.

Unrealistic expectations can often be overcome by dialogue. If the economist is able to discuss with candor and without defensiveness the uses and limits of economic analysis, and the natural scientist is able to reply with equal candor, then the dialogue will be productive. Otherwise, the conversation will degenerate into a kind of disciplinary chauvinism that will do little to advance interdisciplinary cooperation. Articulation of the underlying assumptions of a discipline requires a thorough and at least partially objective understanding of them, which may be hard to achieve after a prolonged immersion in a field. It can also be painful, as Lockeretz and Anderson point out, to listen to outsiders question or criticize our fundamental assumptions.

Another method of overcoming unrealistic expectations is to succeed at least once on some project with natural scientists. Grant dollars generated or articles successfully published are tangible accomplishments that people from all academic backgrounds can appreciate. Some projects are easier to do than others. An economist's first attempt at interdisciplinary work should probably be modest—something with a high probability of success. Failure at the first attempt, no matter what the cause, can be much worse than failure on subsequent attempts, when a track record of success can be used to balance present disappointment.

Mutual Ignorance

Mutual ignorance is a problem that feeds into unrealistic expectations. Faber and Proops, discussing interdisciplinary work on the issue of energy use, note that while collaborations between economists and natural scientists often resulted in good outcomes, there were also "some cases of mutual incomprehension and dismissive hostility." Certainly, the same problem exists in agriculture. Both natural and social scientists use specialized vocabulary that can make communication difficult. Natural scientists often use scientific names that are not commonly known. Agricultural

economists, on the other hand, use mathematical terms, such as "homothetic functions." Worse, some common words have "special" meanings in a field. To an economist, a "fixed" factor of production is an input that is only available up to a certain amount in the "short run." To many natural scientists, the term "fixed" means either something that must be used in fixed proportions in a production process or a fixed effect (discrete variable) in an ANOVA model. Unless the terms are properly defined, much confusion can result.

Because natural science techniques are more or less "standard," natural scientists may view with suspicion economists' use of alternative techniques, such as "fancy" regression models and operations research tools. In turn, economists may be frustrated by the natural scientists' limitations with respect to modeling. Even the names of some relatively "well-known" techniques (such as GARCH models or stochastic DP) may be unfamiliar to agronomists and animal scientists.

To get around the problem of mutual ignorance, economists should recognize that the technical vocabulary of natural scientists is probably closer to "normal" English than our own special vocabulary. To avoid appearing ignorant, the economist needs to become familiar with production processes, including Latin and chemical names. Specializing in a limited number of commodities makes it easier to have more in-depth knowledge. Economists should also avoid being "methods snobs." Natural scientists usually want the simplest, most direct way to get an answer. Economists should not trot out sophisticated methods unless they are truly needed. Even if they are needed, it is wise to take time at the outset to explain them (in general terms) to natural science colleagues.

Working through graduate students is perhaps one of the best strategies for coping with mutual ignorance. Graduate students are already cast in the role of "learner," rather than "expert." They are not expected to know everything about a problem, and they are usually far less defensive than faculty about their knowledge gaps. Getting involved in graduate committees outside the department is also a good way for an agricultural economist to gain perspective on a natural science problem, which is usually explained in some detail in the thesis or dissertation literature review.

Developing personal relationships or ongoing collaborations helps ease problems of mutual ignorance, poor timing and unrealistic expectations. Mutual trust is important in any research collaboration, but it can be particularly important in interdisciplinary work, where one must cede large areas of expertise to one's colleague. Because of the physical separations of most departments and the difficulty in evaluating the quality of work outside one's own specialty, this type of trust may be somewhat more difficult to achieve across disciplines. Administrators can help by inviting faculty from various departments to present work at college-wide conferences or by assigning members of different departments to college-level committees that deal with common problems. Faculty can also initiate cross-department contacts by asking out-of-department colleagues to present a paper in the department or even by inviting them to informal gatherings.

Writing Styles

A final pitfall to interdisciplinary work is the different writing styles for social science versus natural science. In my collaborations with a rural sociologist, writing style differences were no more pronounced than those I have noticed with members of my own discipline. The streamlined style of a production science journal article can be difficult for economists, however, given the type of writing normally required for publication in an economics journal.

Production journals in general: 1) do not have elaborate justifications of the research problem, 2) include a very specific objective statement near the opening, 3) have fairly "rigid" formats that must be followed, 4) favor simple, declarative sentences, and 5) publish shorter articles than the agricultural economics norms.

The most obvious way to learn to write for a production journal is by reading the targeted journal with an eye for style. It seems to me, from a perusal of journals, that interdisciplinary articles may be somewhat more welcome in the natural science publications than in the agricultural economics literature. Young found that multidisciplinary papers involving agricultural economists were most likely to be published in a multidisciplinary journal; however, one quarter of the agricultural economists in his sample had published papers in an agricultural science journal. The burden of changing style may thus be expected to fall on the agricultural economist rather than on other members of an interdisciplinary team.

The major journal for animal scientists is the *Journal of Animal Science*. The journal appears monthly, publishing some 30 to 40 articles per issue, for an annual total of 400 to 500 articles, averaging about eight folio pages each, including tables, graphs and references. The journal is sub-divided into separate sections for applied animal science, breeding and genetics, environment and behavior, meat science, ruminant nutrition, non-ruminant nutrition, pharmacology and toxicology, and physiology and endocrinology. Many pieces have five or more authors, although single author pieces are not unusual. Acceptance rates are in the 60 to 70 percent range.

The journal provides authors' institutional affiliation, but not their professional titles; thus, it is often impossible to ascertain the discipline of the contributors. It seems, however, that the great majority of authors are either animal or veterinary scientists. Agronomists doing grazing work are also represented among the journal authors, as are biochemists, engineers, physicians, plant pathologists and entomologists. Agricultural economists appear only rarely as authors or co-authors. However, the lack of economic analysis may reflect a failure of agricultural economists to submit papers, rather than a deliberate exclusion, or it may even reflect the paucity of economics and natural science interdisciplinary work. It does not necessarily follow that such work would not be published if submitted. For example, in a recent volume of this journal, Nicholson et al. published an economics article using linear programming and other "standard" techniques of agricultural economics. The work appears to be the result of a solid collaboration between two agricultural

economists and three animal scientists, and thus truly interdisciplinary in scope.

The *Journal of Dairy Science*, another major journal in animal agriculture, appears to be quite "economist friendly." A major section of the journal, entitled "Our Industry Today," includes articles on economic issues as well as the results of applied experimental research of interest to producers. Articles authored entirely by agricultural economists have appeared in this section, as well as collaborative work. Of course, the dairy industry has been heavily influenced by national policy, which directly affects the economics of dairy production and marketing. Of the 112 agricultural economists whom Young identified through their publications as performing interdisciplinary work, 17 were found through publications in this journal, the highest of any "pure" agricultural science journal he studied.

The *Agronomy Journal* is the major journal in agronomy. This journal appears bimonthly and is organized much like the *Journal of Animal Science*, with separate topic headings for the various subdisciplines, in this case, soils, crops, agroclimatology, agronomic models and statistics. About 200 papers, averaging five or six folio pages each, are published annually in this journal. Three or four authors per piece seem to be the median, although single-author pieces and pieces with six or more authors also appear. Acceptance rates over the last ten years have ranged from 47 percent (1991) to 78 percent (1994). As in the *Journal of Animal Science*, organizational affiliations are given for the authors, but not professional titles. Most of the authors are associated with agronomy or crop science departments, however, and would thus appear to be agronomists. Statisticians and agricultural engineers appear fairly often as co-authors, but few agricultural economists contribute to this journal, a finding supported by Young's work. Opportunities for co-authorship appear good, however, in that a number of the field studies could have been enhanced by some economic analysis.

The *American Journal of Agricultural Economics*, the premier journal for agricultural economists, is published five times a year, with the December issue devoted solely to proceedings of the annual meeting. Fifteen to twenty papers appear in each of the four regular issues, and an additional thirty or forty papers appear in the December proceedings issue. Acceptance rates for the peer-reviewed papers range between 24 percent and 30 percent.

Opportunities for publishing meaningful interdisciplinary collaborations appear rather limited in this journal. Of 234 papers published in the three-year period 1993-1995, five had secondary authors who could be identified as natural scientists. (Because job titles do not always provide information on an individual's discipline, it is possible that some natural scientists were missed, but the number would not be large). Only a very small percentage of the published papers involve primary data from field experiments, and even in these papers, emphasis is generally on the techniques of analysis, rather than on the results of the experiments per se. The focus of this journal is almost entirely on problems of national or international significance (such as policy effects) or on novel uses of analysis techniques. A paper with a focus on a problem of interest to a single state or region would probably not be published in

this journal. Historically, such articles have been referred to regional outlets. Lately, however, almost all the formerly regional journals have been renamed, presumably to take on a more global perspective. It is not yet clear, given that these changes are relatively new and that other trends are also influencing journal orientation, what the long-term effect of these changes will be.

While few articles in either the *Journal of Animal Science* or *The Agronomy Journal* are truly interdisciplinary, nothing in the focus or organization of those journals appears prohibitive to such work. The current research emphasis in the *American Journal of Agriculture Economics*, however, would appear to make publication of most interdisciplinary work quite difficult in this outlet, except in special cases in which the work can also be shown to be of high general interest inside the discipline.

If the agricultural economics profession does indeed provide greater obstacles than do the natural sciences to the publication of interdisciplinary work in its top journal, this type of research may pose special problems for agricultural economists who are facing promotion and tenure decisions. As a part of a mix in a promotion packet, however, interdisciplinary articles could be viewed quite favorably, particularly if the administration is willing to support these works (Young, Padberg). As Boehlje and Levins point out, insufficient number of publications was cited as a reason to deny tenure in a number of cases. Thus, an untenured agricultural economist may wish to give some serious thought as to whether interdisciplinary work could enhance his or her overall research vita. Consultation with the department head and senior members of the department should provide guidance about how interdisciplinary work is valued in this particular group. Some departments are quite receptive to this work; others maintain the view that disciplinary work should be the primary focus of its members.

Faculty beyond the probationary phase are normally far less constrained in their choice of research endeavor. As one reviewer of this article notes, faculty careers can take various forms. Some scientists become more narrow as they mature, building up human capital in one small niche inside a discipline. Some agricultural economists, for example, spend much of their life work improving a particular type of quantitative method or extending a specific area of theory. Others are less interested in developing theory or methods, but prefer to apply techniques originally developed by others to a variety of applied problems. A portion of this second group will come to value interdisciplinary work.

Although interdisciplinary work holds special challenges and presents many possible pitfalls, the rewards can be substantial. First, there is an opportunity to do work of high usefulness. Many agricultural economists are drawn into this subfield of economics specifically because they want to do applied work that benefits agricultural producers or consumers. After all, pursuing "regular" economics has always been an option for those who are not interested in "real-world" agriculture.

Further, interdisciplinary work expands one's contacts within the university and can make the economists on the faculty more integral to its diverse functions. Although

the top agricultural economics journal is unlikely to publish much highly interdisciplinary work, many good journals and other outlets exist for it (Young). Production journals and interdisciplinary journals such as the *Journal of Production Agriculture* or the *Journal of Soil and Water Conservation* offer quality outlets for an agricultural economist's interdisciplinary work. Writing and publishing articles in these journals can enhance a vita that might look rather "sparse" if only disciplinary articles had been pursued.

Interdisciplinary work can result in rewards of two types: tangible rewards (articles, grants) and intangible ones (an increase in human capital). A recent interdisciplinary project I pursued with some agronomists resulted in two referred journal articles, several other publications, and a competitive grant. It also increased my understanding of certain production systems, knowledge I was able to carry into the classroom and use to illustrate economic concepts. A colleague in my department, who holds a mixed research and extension appointment, reports that an ongoing collaboration with an agronomist has resulted in three journal articles, a competitive grant, a book chapter, and ten other publications. He also finds the collaboration with a production scientist improves his ability to interact with farmers on technical issues relative to producing specific crops.

An associate professor in our department, who was recently tenured, has co-authored five of his last eight papers with at least one person from another discipline and has two other such papers in progress. He has been able to focus his work in such a way that many of the papers have appeared in disciplinary outlets, including the *American Journal of Agricultural Economics*. He notes that he finds the work enjoyable, and feels he learns a great deal from the interactions. Because he has worked with plant breeders and agronomists so extensively, he was recently able to interview the famous plant breeders Norman Borlaug and Sanjaya Rajaram to collect information for a paper in progress. This individual's career indicates that a very well-focused, high-quality interdisciplinary program can be well accepted by one's more discipline-oriented senior colleagues.

Finally, an added benefit of interdisciplinary work is that it can force the economist to reexamine the basic assumptions used or models developed in our field. Such examination can have payoffs in the disciplinary arena as well. The experience of explaining these concepts or models in simple terms can improve an economist's ability to write clear, convincing articles for disciplinary audiences. Through collaboration, standard tools can also be "imported" from one field to another. Regression analysis, for example, is perhaps the most common tool of agricultural economists and may be under-exploited by natural scientists. Similarly, agricultural economists may overlook possibilities of applying other types of statistical analyses to data. Ongoing collaborations between economists and natural scientists can lead to a sort of intellectual cross-fertilization, expanding the arsenal of techniques available to both parties.

Economists and Agronomists: A Logical Collaboration—Elizabeth A. Guertal

The centuries-old science of agronomy contributed much to agriculture, as generations of plant breeders, soil fertility specialists and crop management experts developed new and better ways to maximize yield. Hybrid corn, no-till production and transgenic crops are a few examples of successful agronomic advances, and the list of such developments could extend for pages.

In the quest for increased yield, another valuable question often goes unanswered: Will this procedure/crop/technique make the producer a greater profit? The term "profit" is loosely used; "profit" may be a true monetary increase, or it may be savings realized from a cleaner environment, safer production practices or some other secondary benefit that conserves resources. Agronomists are usually unprepared to answer the economic questions. Our research emphasis is placed on biological, and not economic, yield. A likely solution would be agronomist and agricultural economist collaborations that attempt to answer both questions: Are yields greater? Can a profit be realized? Collaborative research is certainly encouraged in today's competitive granting climate, and a new emphasis on relevant research on sustainable production should mean that evidence of the economic value of the research is important.

The key to successful agronomist/agricultural economist collaborations is to avoid research pitfalls by early collaboration and continued discussion. Successful collaboration with an economist begins by including the economist at the earliest planning stages of the research. Agronomists often include the economist as a last-minute addition, well after the crop is planted or even after the harvest is over. This may affect the quality of the economic analysis, especially with crops that have wide variations in planting and harvest dates. For example, watermelons harvested before the 4th of July will likely earn a greater per unit profit than watermelons harvested in late July. Research studies are rarely planned so that a harvest fits a specific market window, yet vegetable growers often plant to meet a deadline such as the 4th of July or Labor Day, or to be first to market. Consulting with an economist before the crop is planted will allow a sharpening of research objectives to provide data with an increased "real-world" value. Also, as one reviewer notes, early collaboration can lead to a more equitable funding situation for the economist.

Agronomists must recognize that economists have value. An unfortunate effect of "tacked-on" economic data analysis is that the economist is rarely rewarded as well as those collaborators who initially join the project. Lack of reward occurs with both funding and publication authorship. I have heard a colleague remark in jest that economists are cheap to include on a grant because they only need money for a new computer and some overheads. In truth, all faculty need funds to travel to meetings, publish manuscripts and employ graduate students. This is especially true as Agricultural Experiment Station projects become little more than expenditure and progress reporting instruments and less a source of actual direct support. While it is true that agricultural economists do not require funds to purchase laboratory supplies,

field equipment or any of the myriad other items agronomists buy, financial support for the project economist is necessary.

Economists are often asked to analyze collected data and publish a paper from the results. Agronomists have a habit of arriving at the economist's door with ten years of collected data and announcing that they think it would make a good economics paper. A more rewarding scenario would be an exchange of ideas as the agronomist indicates the objectives of an economic analysis, and the agricultural economist determines if the objectives can be reached with the data at hand. Such discussions help all the researchers determine if standard developed techniques will answer the questions, or if a separate research question on model development is necessary.

The choice of economist may well depend upon the research questions that are posed. As agronomists, we find it perfectly natural that we all have a small niche of agronomic expertise. The turfgrass management experts are vaguely aware of general aspects of cotton production, but specifics of that crop are largely foreign to them. However, beyond separating social scientists into some quasi-grouping of "rural sociologists" or "cost accountants," most agronomists have no idea of the various specialties that economists pursue. This lack of understanding may cause agronomists to seek out economists who are not familiar with the research area of interest. Honesty and a certain amount of humility are required for the first economist to send the agronomist to the individual with the appropriate expertise.

The selection of an appropriate research economist might be most important when the research project is market-based. Development of a new crop or crop rotation is a moot point if there is no market for the crop or rotation crop. No matter how sustainable the cropping sequence, growers will not use that rotation if they cannot make money. Market economists have the skill base to determine the economic viability and market acceptance of new crops. Such information is invaluable when seeking extramural funding, as surveys and market reports prepared by economists lend valuable credence to new crop research.

Agriculture and government policy are strongly linked, and an economist can often add new interpretations to yield data when the value of that product is controlled by governmental policy. Such evaluations become increasingly important in an era of budget cutting, when commodity price supports are the first item to be cut. For example, inputs required for profitable production often change with farm program provisions. Secondary programs such as crop reserve programs, land set-aside initiatives or dairy buy-outs may all affect production practices, but an economist's assessment of government/production entanglements is necessary to quantify such effects.

The bottom line for all agronomic research is that the new crop, added input or different technique must offer an intrinsic value to the producer. Properly-designed research projects that allow agronomists to assess biological yields and economists to evaluate the economic health of the system will result in sustainable agricultural production systems. Such projects will benefit the researchers, who gain added

knowledge and published resources, and members of the public, who gain added insight about the costs of agricultural production systems.

The Administrative Perspective: Evaluating Interdisciplinary Research—Russell B. Muntifering

Researchable questions—certainly the more applied questions—in the agricultural and life sciences are increasingly multifaceted and complex. Consequently, progress toward their resolution is often best achieved through integration of several scientific disciplines (National Research Council). In contrast to basic or disciplinary research conducted in the more traditional academic disciplines such as chemistry, physics or economics, interdisciplinary research generally addresses a specific problem or sets of problems in defined subject matters. Interdisciplinary research must not be confused with other types of multidisciplinary research. To illustrate, universities by definition are multidisciplinary, and a department of animal sciences, for instance, is multidisciplinary to the extent that it contains expertise in specific disciplines such as nutrition, genetics, physiology and biochemistry. Neither is interdisciplinary research synonymous with cross-disciplinary research performed by individuals or small groups (e.g., chemical or biological process engineering). Not until truly interdependent collaboration among disciplines is achieved can a research endeavor be described as interdisciplinary. Viewed yet another way, interdisciplinary research does not necessarily have to transcend departmental lines, but can flourish even within academic subject matter departments such as exist in colleges of agriculture.

Specific advantages of interdisciplinary research include:

- Enabling scientists and institutions to focus attention and resources on issues for which mutually-acceptable bases for collaboration exist (National Research Council);
- Synergy, or the capacity to achieve more by working together than as individuals (Cornesky);
- Bridging the knowledge gap among different branches of science and promoting intellectual cross-fertilization (Moffat, 1993);
- Greater celebration value for team than individual accomplishment and success (Cornesky);
- Enabling institutions and programs to optimize balance with disciplinary research consistent with public expectations, values and needs (Johnson); and
- Consistency with the emerging national trend toward more broad-based, flexible graduate student education and training (Moffat, 1995).

The unique governance structure and resulting academic culture in universities should ideally and spontaneously lead to timely interdisciplinary research wherein mutually acceptable bases for scientific collaboration already exist or can be developed with minimal intervention and guidance from administration. Interestingly, experience reveals that productive interdisciplinary research generally requires *more* administration than conventional disciplinary research to help faculty overcome disciplinary barriers, procure long-term funding for new interdisciplinary research ventures, and achieve (possibly modified) career advancement goals tied to team rather than individual accomplishment (Johnson). It is not coincidental that high-quality and skillful administrative work is invariably found in academic departments and institutions producing quality interdisciplinary research. Ability to bring together scientists into interdisciplinary configurations requires that administrators know the opportunities, faculty disciplinarians and institutional subject matter expertise that can be brought to bear on such interdisciplinary research topics as sustainable agriculture, integrated pest management and food safety.

Research administrators in state agricultural experiment stations (SAES) can encourage, reward and provide for the advancement of interdisciplinary research in a number of ways. Beginning with development and review of in-house research projects (Hatch, Mcintire-Stennis, non-Federal, etc.) for scientific merit and technical soundness, a specific outcome of this process might also include identification of potential collaborators—both within and external to the SAES—who could be engaged to bring about a new interdisciplinary research effort if and where appropriate. Also, some SAES use internal competitive grants programs to allocate portions of their institutional funds and other resources. Faculty have few financial incentives to becoming involved in interdisciplinary research at the expense of their own disciplinary pursuits, and an internal competitive grants program could introduce such incentives by giving award preferences to such research. Furthermore, such competitions should be open to all faculty in the university who possess the needed expertise to address the problems of agricultural, natural and human resources (Vaux, Jr.). Historically, undue loyalty to existing administrative arrangements in SAES has made it difficult to configure personnel and expertise from different departments for reconstitution into interdisciplinary teams (Johnson). Separation of the SAES from the remainder of the university only serves to accentuate the problem and frustrate administrative efforts to encourage interdisciplinary research.

In evaluating in-house research proposals with a view toward enhanced interdisciplinary research, SAES administrators must be careful to avoid undue disciplinary biases in faculty peer review committees; ensure that interdisciplinary research initiatives are properly focused on scientific advancement and not solely on solutions to practical problems; and continually evaluate results and processes used so that they become a basis for increasing the effectiveness of subsequent interdisciplinary research (National Research Council). Administrators should

view their primary work in this process as one of catalysis, facilitation and coordination, keeping in mind that if interdisciplinary research is to be successful, it must—like disciplinary research—be a flexible, *faculty*-initiated and organized activity which sometimes evolves slowly over time and often changes directions rapidly and unexpectedly. A forceful, peremptory administrative style is not only ineffective, but is highly and justifiably resented by faculty. Also, administrators should seek to achieve an optimum balance between disciplinary research and interdisciplinary research at the level of the overall SAES portfolio, not at the level of the individual faculty research program. Stated another way, interdisciplinary research is not and should not be for everybody! Fundamental research done by an individual scientist within one discipline or by a small group of scientists in closely related disciplines has always been, and will remain, the primary cornerstone of scientific advancement (National Research Council). To improve the professional advancement and recognition of all research scientists, universities, beginning with administrators but not excluding faculty, must respect both disciplinary research and interdisciplinary research, seek a balance among them and other forms of applied subject matter research, and recognize excellence in doing all forms of research (Johnson).

In addition to the conceptual and practical difficulties challenging faculty participating in interdisciplinary research, other management and leadership issues dealing with reward, advancement and satisfaction with the profession and university environment must be resolved if interdisciplinary research is to be successful and prosper over the long term. Nowhere are these issues more evident than in faculty evaluation for promotion and tenure. In some universities, for example, in-house SAES publications simply are not credited toward faculty tenure, promotion or professional recognition. In many instances, disciplinary research articles in prestigious journals are more highly valued than interdisciplinary research and other applied research publications. In most cases, both administrators and faculty are guilty of a brand of academic elitism which elevates single-investigator, disciplinary accomplishment while denigrating more applied activities such as interdisciplinary research. Such bias is both anti-intellectual and inappropriate in a university setting (Johnson). New or renewed emphasis on interdisciplinary research may require major, perhaps bold, modification of procedures and criteria for evaluating faculty and awarding promotion and/or tenure. For example, the composition of faculty tenure and promotion committees might need to be altered or at least augmented so that individuals experienced largely in interdisciplinary research and other forms of applied research are more equitably represented. Several universities have recently added new categories to their promotion and tenure dossiers for documentation of team achievements. Ultimately, resolution of this issue will require a more creative and contemporary view of the concepts of academic excellence and scholarship as proposed by Boyer.

Some of the current backlash against *all* university and SAES research can be traced to a perceived abandonment of publicly-supported problem-solving research in favor of more basic disciplinary research. Universities can ill afford to continue to embrace an elitism and value system that differentially rewards individual disciplinary accomplishment at the expense of team accomplishment in more applied endeavors such as interdisciplinary research. The more rational approach would be to strive for an academic and culture system that promotes and builds support for an optimum balance of *all* types of research consistent with public expectations for relevancy and resource-use efficiency. This issue is not separable from, but is intrinsically linked to, public unrest over the "teaching vs. research" issue.

Its difficulties and challenges notwithstanding, interdisciplinary research is simply worth doing. A parting word of caution: Its oftentimes unanticipated synergism, creativity and excitement can be contagious!

General Conclusions

The purpose of this article has been to present some general information on interdisciplinary research and to provide three independent perspectives on the topic, those of an agricultural economist, an agronomist, and a former agricultural research administrator.

A major concern of both the agricultural economist and the agronomist is the timing of collaboration. Both agree that early communication is important if the research team is to deal most effectively with the issues at hand. Disciplinary boundaries and even physical separation of departments are obstacles to early collaboration, however. Mutual trust and ongoing relationships can foster better timing, as can pursuing grants together. Administrators can facilitate better communication between departments in a number of ways, including providing financial incentives for certain types of projects, but as the administrator notes, mandated collaborations can be expected to elicit faculty resentment. Facilitation—providing opportunities and rewarding good work—is the key.

Evaluation of interdisciplinary work was a concern for both the agricultural economist and the administrator. The administrator suggests that the composition of university promotion and tenure committees may need to be changed if interdisciplinary work is to be evaluated fairly. He further notes that the university mix of research activity need not be balanced at the level of the individual faculty members, and warns against the type of academic elitism that can discourage interdisciplinary work. For faculty at the junior ranks, the agricultural economist advises an awareness of local expectations. Dialogue with senior colleagues and administrators should provide guidance to the junior faculty member as to how interdisciplinary work will affect chances for promotion and tenure.

All three authors recognize the potential value of interdisciplinary work for advancing certain types of knowledge. Agricultural systems in the real world are composed of many parts crossing several disciplines. Some applied problems do not yield very well to a single-discipline focus. Some individuals work better in teams than others. The challenge for the department, the college, and the university, is to guide research and direct resources so the total faculty output is enhanced and a good mixture of work—disciplinary as well as interdisciplinary—develops. Flexibility, communication and proper rewards are essential ingredients if this challenge is to be met.

Notes

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