PAUL A. FUNK RECOGNITION AWARD PAPERS

2009

UNIVERSITY OF ILLINOIS
COLLEGE OF AGRICULTURAL, CONSUMER
AND ENVIRONMENTAL SCIENCES

PAUL A. FUNK RECOGNITION PROGRAM

papers by the recipients of the 2009 awards

"... for outstanding achievement and major contributions to the betterment of agriculture, natural resources, and human systems."

COLLEGE OF AGRICULTURAL, CONSUMER AND ENVIRONMENTAL SCIENCES
UNIVERSITY OF ILLINOIS

The Paul A. Funk Recognition Program

The Paul A. Funk Recognition Program was established in June 1970 through an agreement between the Paul A. Funk Foundation of Bloomington, Illinois, and the College of Agricultural, Consumer and Environmental Sciences at the University of Illinois. The Funk Foundation provides the college with funds annually, which are used to honor outstanding faculty members for their service to agriculture.

The recognition program is a memorial to the late Paul A. Funk, who died in 1967. A principal in the Funk Bros. Seed Co., Paul Funk spent his life in agriculture. He attended the University of Illinois College of Agriculture and graduated in 1929.

A nominee for the Paul A. Funk Recognition Award may be a member of the faculty or any academic professional who holds a full-time appointment with the University of Illinois; has a paid appointment in the College of Agricultural, Consumer and Environmental Sciences for the current academic year; and has 10 years of consecutive service prior to the nomination.

Nominees will have made major contributions to their field of study, such as extension projects initiated, key research findings, and outstanding teaching. The nominee will be evaluated on what their career contributions have meant to producers, students, agribusiness, and consumers in Illinois, the nation, and the world.

Each year the college presents Paul A. Funk Recognition Awards to individuals; each award includes a $5,000 unrestricted personal award, $1,000 to the appropriate department or other administrative unit to support the recipient's program, a recurring salary increment of $1,000, and a recognition plaque.

In 2009, the Paul A. Funk Recognition Award was presented to Mark B. David, Michael Ellis, and Douglas F. Parrett. Each recipient has written an article about the history of their work and their personal interests in pursing their particular career path.

Contents

Mark David is an international leader in research on the biogeochemistry of agro-ecosystems and on agricultural water quality. His highly cited work on nutrient sources and sinks in agricultural watersheds represents some of the most significant research in the field. His recent work on the fate and transport of nitrogen, phosphorus, and herbicides in Illinois agricultural watersheds has been very influential in shaping the debate concerning agricultural water quality in the midwestern United States.

David goes to great lengths to share his knowledge with students, the public, and policy makers. His research quality and results provide the strong foundation on which long-term, rational management decisions should be made. He has been awarded research funds in highly competitive federal and state programs because of the critical nature of his work in providing policy makers with results and data related to agricultural production and water quality.

His departmental leadership positions have included serving as both teaching and graduate coordinator, associate head, and chair of most standing committees. David is known and respected by his peers for his ability to accomplish objectives through committee work. He also has served the scientific community as a journal editor and as a member of grant review panels and institutional reviews committees at other universities.

David's teaching contributions range from introductory environmental science classes for majors to a graduate level course on biogeochemistry. As a graduate adviser, he has produced outstanding graduate and postdoctoral students who have been accepted into competitive graduate programs at leading institutions of higher education and who have accepted positions at major universities.

The high caliber of David's research and outreach has been recognized by his appointment as a Fellow in the Soil Science Society of America, the American Society of Agronomy, and the American Association for the Advancement of Science. He is one of only 33 University of Illinois faculty to be named to the ISI Highly Cited list of researchers who have made fundamental contributions to their area of expertise.

"In these often contentious and threatening discussions of the impacts of agriculture on the environment, agricultural producers and the industry are best served by high-quality, objective science that leads to realistic and balanced decisions. Dr. David has performed great service to Illinois agriculture through his research, teaching, and outreach."

Dennis McKenna, Bureau of Environmental Programs
Illinois Department of Agriculture

AGRICULTURAL ECOSYSTEMS IN THE MIDWEST

EDUCATION

My interest in the environment began during Boy Scouts, where I enjoyed the outdoor activities and learning about natural ecosystems. I quickly achieved Eagle Scout and learned many of the leadership skills that would help me during my career.

When it was time to decide about college, I looked for an undergraduate major that involved the environment. In the mid-70s there were few options, so I chose to major in forest science at Pennsylvania State University in my home state. There was a tremendous wave of forestry students throughout the U.S. during the 1970s, with many like me interested in the environment. Forestry programs have never come close to those enrollment numbers since then. During my junior year I thought about graduate school, but knew little about what graduate school entailed.

1978: Mark David in Maine for master's degree work.

I applied to several forestry programs and selected the University of Maine. In my master's program, I used my forest science knowledge and applied it to studying the effect of spraying sewage effluent on a forest at Sugarloaf Mountain, Maine. This was a great project because I got to sample and measure tree foliage, soils, groundwater, and stream water to see where the sewage effluent was going and determine whether is was renovated by the forest with no loss of nutrients to ground or surface waters. It was here that I learned about soils and water quality—core areas of my research.

Sugarloaf is one of the largest ski (and now year-round resort) areas in the northeastern U.S., and in the late 1970s the community had been experimentally applying their sewage during the summer to the forest at the base of the mountain. My research showed that this system worked quite well, and today it is still used along with a winter snowfluent system. This applied project had real world results that helped to improve the environment, and this led me to focus my future research efforts in ecology.

1978: *Conducting master's research with a lysimeter in Maine.*

I then headed to Syracuse, New York, and the State University of New York, College of Environmental Science and Forestry where I had a great adviser in Myron Mitchell. I wanted a broad Ph.D. program where I could study a range of environmental factors—from soils to water quality to lakes. At that time acid rain was a huge environmental research topic, and my studies focused on sulfur, a major part of it. I looked at sulfur from entering a forest canopy in the Adirondack Mountains of New York, through the soil profile and into streams, then lakes, and finally lake sediments.

The freedom to study soils and limnology at the same time was just what I wanted, and my research led to publications in diverse journals such as *Soil Science Society of America Journal* (David et al., 1982) and *Limnology and Oceanography* (David and Mitchell, 1985), two of the top journals in their fields. My work on sulfur in forest soils was some of the first to show the importance of organic sulfur and transformations with sulfate, which was added through acid rain (David et al., 1982; David et al., 1987).

1982: *Examining soil cut in Adirondacks during Ph.D. research.*

One of the sidelights of my Ph.D. work was a study of aluminum in forest soils, which was just being shown as the cause of fish kills in acidified lakes. This paper would become my best cited by other scientists (David and Driscoll, 1984), which demonstrated that research added to take advantage of collected samples for other purposes can have as much impact as carefully planned studies.

I would guess few dissertations have such broad journal publications, but I learned the skills to study a wide range of ecosystems during this time. These skills would later be applied to other systems. I also learned the skills of designing research projects and the importance of publishing from Dr. Mitchell, which are critical aspects of conducting research.


1982: *Ph.D. work on Adirondack Lake, New York*.

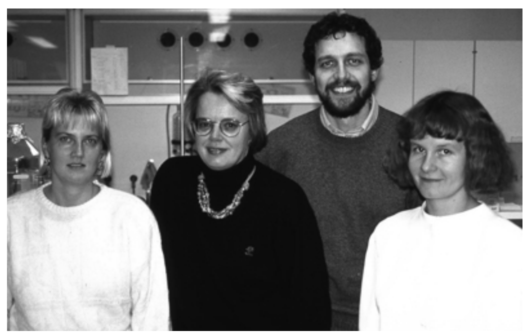
After graduate school there were few academic jobs at that time because of the recession, so I headed to Corvallis, Oregon, to work as a supervisor and research coordinator for the U.S. Environmental Protection Agency in their acid rain program. Here I learned much about how government agencies work, how funding areas are identified and money obtained, and the process that allocates funds to researchers. After two years I accepted a faculty appointment at the University of Illinois where I could conduct research and teach. I had never been to the Midwest before, but was impressed by the university and the then College of Agriculture. I started as an assistant professor in the Department of Forestry, a small unit with a strong department head in Gary Rolfe.

EARLY FOREST RESEARCH AT ILLINOIS

In my first years in Illinois, my research program focused on acid rain and sulfur, with projects in Maine, the upper Midwest, and locally at Allerton Park. I was able to obtain national research funds to work in Maine as part of a large, multi-institution U.S. EPA-funded project that acidified a watershed with simulated acid rain. It was through this project where I saw the value of working with a wide range of scientists with different skills on a manipulation-type project. The idea of changing and studying an ecosystem in the field has since become a more standard way of conducting research. I also became familiar with Illinois from my work at Allerton, studying the upland and floodplains along the Sangamon River (Bartel-Ortiz and David, 1988).

During the early- and mid-1990s I studied a variety of forest ecosystems in the northeastern U.S., including one project where we sampled about a dozen red spruce stands from the Adirondacks in New York through Vermont, New Hampshire, and Maine. We were interested in why the red spruce were dying and hoped to show that changing calcium and aluminum concentrations in the soils (due to acid rain) were the cause. As with many aspects of plant and soil science, this was quite challenging, but we were able to show some changes and develop relationships between the soil chemistry and tree roots and growth, though the relationships never were as strong as we would have liked (Lawrence et al., 1995; David and Lawrence, 1996; Shortle et al., 1997).

During this period I also worked in Germany (David and Zech, 1988) and took a sabbatical to Finland (fall 1991), as well as hosted several German students in my laboratory. The work with German students focused on how global warming might impact dissolved organic carbon (DOC) release from soils (Gödde et al., 1996).



1991: *With Finnish colleagues during 1991 sabbatical.*

My time in Finland expanded my interest in how natural DOC in lakes and streams causes acidity and might change due to acid rain. Finland has many high DOC lakes and I worked with Pirkko Kortelainen from the Finnish Environmental Agency on a project with sites in Finland and in Norway. The Norwegian lake was artificially acidified (Kortelainen et al., 1992), extending work I had been doing in Maine on streams and lakes (David and Vance, 1991; David et al., 1992).

MOVE TO AGRICULTURE

It was during the early 1990s, after I had been at Illinois about seven years, that I teamed up with David Kovacic, a faculty member in landscape architecture, to study how wetlands could be used to reduce nutrients from drainage tiles (Kovacic et al., 2000). At that time I knew little about agriculture and water quality in Illinois or the Midwest. However, through my research I had evolved into a biogeochemist and knew I could apply my research skills to this new-to-me ecosystem. Biogeochemistry is now a widely used term, but it was not well known in the early part of the 1990s. However, the word is appropriate for researchers who study the biology, chemistry, and geology (physical) aspects of elements, such as nutrients (nitrogen or phosphorus) or other elements such as aluminum, and is more accurate and descriptive than nutrient cycling. As a biogeochemist I apply the same techniques and skills from one ecosystem to another, which is what I did in the agricultural ecosystems. Dr. Kovacic and I studied where I took my forest and aquatic knowledge and research methods and applied them to agriculture and wetland ecosystems.


1985: *Forestry department faculty photo.*

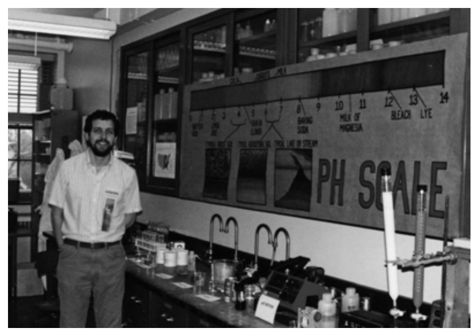
By this time I also learned the need for long-term monitoring data to assess what is happening in ecosystems, as well as measurements in the field. Many of our environmental assessments are made with computer models, but they are dependent on the input data. I have viewed my research program as one that obtains these critical field data and interprets them.


1989: *Lake sampling in Maine.*

Most of my projects have included students, postdocs, and technicians going out into the field regularly and collecting samples of soils, water, or plants. Sometimes the results are highly variable, but that is the real world. Long-term monitoring data are needed because weather varies year to year (temperature and precipitation are the two most critical aspects they drive what we see) and change often is difficult to see in the short-term noise. However, most funding agencies don't support monitoring, so I have been able to keep some going on the side that helps to support my overall program, such as water quality in the Embarras River, where we have been sampling weekly or more since 1993. Data from this river has been used to support a wide range of projects, as it is one of the more detailed records available in the state.

It was also in the mid-1990s that my department merged with others to form the Department of Natural Resources and Environmental Sciences. This new department fit me quite well because my work and teaching did not focus solely on forestry. Now all of my work easily fit into the focus of this new department and the new undergraduate major with the same name also attracted students whose interests matched mine.

As part of our wetlands work, Dr. Koviac and I hired Lowell Gentry to do the day-to-day field work. Gentry came from an ecology and agricultural background (in his B.S. and M.S.), and he taught me a great deal about Midwestern agriculture as we conducted our research. Our first paper from this work (David et al., 1997) showed the importance of tiles in transporting nitrate and how they dominated the nitrate exported by a local river (the Embarras). This paper also had the first of many nitrogen balances I would make, trying to clearly understand what happens to nitrogen in our agricultural systems.



c 1990: *David in his lab during ACES Open House.*

Even after more than 100 years of research on nitrogen and corn (and now soybean), understanding the complex interactions is no simple task. Nitrogen balance papers for the state of Illinois (David and Gentry, 2000; David et al., 2001) showed what they were like in the modern era, but also contrasted them with earlier agricultural periods (as far back as 1865).

When the highly productive Mollisols of Illinois (rich prairie soils) were first plowed in the last half of the nineteenth century and tile drainage was installed (mostly during the 1880s), the release of nitrogen was so great no fertilizer had to be added. It was likely some of the nitrate formed was released into ditches and streams even then. However, more than 130 years ago, a debate broke out about whether these fertile soils would ever need fertilizer.

On one side was the first head of the Department of Agronomy, Cyril Hopkins, who saw that soil nutrients would be depleted by agriculture and recommended what would be needed to sustain productivity. He argued with many in the U.S. Department of Agriculture, where some thought the rich soils would never need any addition of fertilizers. Of course Hopkins was correct, and his legacy is a proud one that those of us in the College of ACES share.

These balance papers also guided me in developing my agricultural nitrogen studies further by pointing out where there are gaps and weaknesses in our knowledge. For example, the loss of nitrate back to the atmosphere (denitrification) was poorly understood in our agricultural streams, so one of my research projects made measurements and showed that it was a minor loss (Royer et al., 2004; Opdyke et al., 2006) except when the water entered a reservoir (David et al., 2006). During the high flows in winter and spring, water moves too quickly through our rivers and there isn’t sufficient time for removal of nitrate in the sediments. But, if water with high nitrate concentrations enters a reservoir such as Lake Shelbyville where is might stay on average about three to five months, about half can be removed. Our results for streams were quite different than the prevailing knowledge, which had been developed in more pristine systems. My team also realized we needed to know more about changing nitrogen storage in soils. One research project easily leads to another, I discovered, as we identify gaps in our knowledge.

In the late 1990s hypoxia (a low oxygen zone) in the Gulf of Mexico came to the forefront and our work was right at the center of the national debate (McIsaac et al., 2001, 2002). Illinois and Iowa are the two states that have the largest export of nitrate (mainly from agriculture) down the Mississippi River to the Gulf of Mexico. The late winter/spring flows are critical times for the export of nitrate, which leads to a bloom of algae in the Gulf that then dies by midsummer. This dead algae then decays, which uses up the oxygen and leads to the “Dead Zone,” an area with oxygen levels so low that most organisms (fish) can’t tolerate it and either move away or die.

c 1990: *ACES Open House display*.

My research was now entirely focused on agricultural ecosystems in the Midwest and Illinois in particular, and I began to study other nutrients (phosphorus) and to a lesser degree herbicides. I found that anything applied to an agricultural field can end up coming out of the tile under certain conditions. However, nitrate and phosphorus are regularly lost in this way in large amounts.

The Council on Food and Agricultural Research (C-FAR) was established and I was fortunate to be granted funds for applied agricultural research from this source. I also began to speak on the subject of agricultural ecosystems and was getting to be well known regionally. I saw the complexity in how we have simplified modern agriculture in terms of corn and soybean production: little crop diversity and bare fields most of the year. This has led, on tile-drained lands, to our current environmental problems (hypoxia, high nitrate in drinking water, algal blooms from phosphorus). I also began to appreciate the social science aspects of agricultural production—as the economic side drives most of the decisions that are made—as a function of national policies.

2008: *Undergraduate class field trip to survey freshwater mussels in the Sangamon River by the Hart Woods natural area.*

For local water quality in streams and rivers, phosphorus is the critical element. I led studies where we evaluated the effects of phosphorus and other nutrients (and factors) on stream quality across the state (Morgan et al., 2006; Heatherly et al., 2007; Royer et al., 2008; Bedore et al., 2008; McDaniel et al., 2009). We sampled 138 stream locations one year, a project that led my team to all parts of the state, from Chicago to very southern Illinois. We found that nearly all streams in Illinois have very high nutrient concentrations, with most of the nitrate from agriculture, but the phosphorus comes both from agriculture and sewage effluent added to rivers by communities of all sizes, with Chicago at the top of the list.

This work also demonstrated that it is difficult to show that phosphorus (and even less so nitrate) is causing problems for stream water quality in the state, given that most streams and rivers are highly modified and have poor habitat (therefore, nutrients aren't their biggest problem). The loss of our nutrients further downstream has large consequences in terms of hypoxia in the Gulf.

I served on a national EPA panel in 2006 and 2007 that evaluated the state of hypoxia and found that large reductions of both nitrate and phosphorus (about 45% for each) were needed to greatly reduce the hypoxic zone. This lack of demonstrable problems locally (water quality where you might fish), yet environmental damage downstream and far from the source (the Gulf of Mexico), is quite a dilemma that has yet to play out.

As part of my continuing work on nitrogen balances, we studied a local watershed northwest of Champaign called the Big Ditch. Here we found what can be described as a microcosm of the tile drained Midwest and a symptom of modern agriculture. On the best tile drained soils with highly productive corn and soybean agriculture, we see a negative nitrogen balance in many or most years (Gentry et al., 2009).

Fertilizer rates have stayed steady for the past 30 years, and corn and soybean yields have steadily increased. Although corn protein concentration is decreasing (and nitrogen taken away as well), this has led to a better balance between nitrogen added to a field and taken away. However, when we factor in leaching losses, which are quite large during wet years (high precipitation during winter and spring), the balance is negative. This implies that we are "mining" nitrogen from the large amount present in the soil.

Our rich soils (such as the state soil Drummer) have only about half the nitrogen they had when they were covered in prairie, but still a large amount. However, the nitrogen is being reduced slowly to cover the losses. More fertilizer is not the answer, because it and other nitrogen transformed in the soil are so easily lost through tiles in winter and spring. So even as farmers more closely match fertilizer to yields, we continue to see the loss of large amounts of nitrate down our rivers because, under the best of conditions, our current corn and soybean system is extremely "leaky." The modern agricultural process has decoupled the nitrogen cycle from other cycles, most importantly carbon.

Something similar has happened with phosphorus as well in much of Illinois, where inputs from fertilizer are much less now than the amount in harvest corn and soybean. This is a good thing, because farmers have been building up the soil with excess phosphorus applications for many years. Farm operations are now utilizing this phosphorus, which is retained quite well in soils so that little is lost.

But again, similar to many environmental challenges, the little that is lost from fields can cause problems as discussed earlier. There is no agronomic impact from this lost phosphorus, which is different than nitrate losses where large losses can impact yields in some years. This means it is difficult to control these losses because we have a negative balance yet still are losing environmentally important amounts of phosphorus (Gentry et al., 2007).

Earlier this year, my research team took advantage of some of the meticulous notes of Cyril Hopkins in a study (David et al., 2009) where we resampled soils that Hopkins collected starting in 1901. These were the first documented soil samples in Illinois, and the field notes and laboratory results are preserved in bound books we have in an archive from that time.

NRES faculty members Ted Peck and Michelle Wander have preserved a soils archive of glass jars containing many of the original soil samples from this early period. The samples had been in the basement of Davenport Hall for many years, but needed to be moved or thrown out. Peck and Wander were able to get a building on the South Farms to store the samples in a more appropriate archive. We reanalyzed some of these 100-year-old samples, as well as resampled fields that Hopkins had visited. (My idea was to tell the landowner the U of I was back for their 100-year-old soils check-up.)

We also went to fields that the Soil Conservation Service had sampled in 1957 so that we could see what happened on our best tile drained soils during various eras of Illinois agriculture. We found that about half the carbon and nitrogen in the soils was lost from the initial plowing and draining, but that since 1957 we could find no change. However, we continue to believe that there is a slow depletion due to the high yields Illinois farmers have had the last 10 to 15 years. This study demonstrated the great need to archive samples and make meticulous notes on sampling. Cyril Hopkins did this and we were able to take advantage of his foresight.

My latest area of research is again an extension of previous work, this time as part of the Energy Biosciences Institute funded by BP. With a large group of co-investigators, I am working on the Energy Farm on the South Farms to study the environmental impact of biofuel crops, including continuous corn, Miscanthus, switchgrass, and mixed prairie species.


April 2009: Biogeochemistry group.

Biofuel crops could help to provide some of our energy needs, but we need to know how they affect the environment so we don't repeat some of the problems we have had in modern agricultural production. The university has one of the top biofuel studies in the world, and I lead the nitrogen biogeochemistry aspects of the work. Biofuel crops would seem to have many environmental pluses, but we need to document this with the long-term research that is now underway.

At the end of the first decade of the new century, I continue my research to further understand and develop methods to improve agricultural production in the Midwest, and Illinois in particular. I see how techniques such as cover crops, more diverse rotations, biofuel crops, modified tile drainage systems, buffer strips, and wetlands can all be used to reduce nutrient losses from fields. Few of these changes are now in place, as we have created an agricultural system where the policies and economics do not support anything other than yield.

The many barriers to the implementation of these techniques has led to no changes in water quality (such as in the Embarras River) during my 16 years of study. I am optimistic that my research and publications will help to provide the information needed to influence policy decisions that can lead us to a productive—yet more environmentally less damaging—agriculture system.

To further this aspect of my life's work, I have greatly expanded my outreach role by giving more talks in the last five years than earlier in my career. As my work in agriculture and nutrient losses has expanded, so have my speaking invitations from a wide range of groups. I feel it is important to get our results and thoughts out to many groups, from agricultural to environmental, so we can all work together to try to reduce the environmental impacts of agricultural production.

TEACHING

The other aspect of my career at Illinois has been teaching, both formally in the classroom and informally as an adviser to graduate students. I have taught courses ranging from freshman to graduate students, including field courses that are critical to students understanding the environment.

I have always believed that students need to understand the many facets and complexities of environmental topics and then make up their own minds about their behavior. That is the way I have taught my undergraduate courses, particularly the required introductory course for the natural resources and environmental sciences major. In this course, I introduce first semester freshmen to a wide range of environmental topics including population, water scarcity, soils, forestry, climate change, ozone depletion, and water quality. Through assignments and class discussion, I try to have students understand the issues, how we contribute, and what we could do to make a positive difference.

The NRES majors write papers and interview others to help see how their views might be different (or similar) to other students not in an environmental major. I want the NRES majors to understand the complexity of environmental issues and prepare them for the more detailed studies they will make during their studies. The class is a great opportunity to interact with our wide range of students, and I particularly enjoy engaging the first semester freshmen.

I also think students need to get out into the field and take measurements of various ecosystems. As chair of a small curriculum committee, I led a restructuring of our major that added a field course requirement. In my class on soil and water monitoring, students take measurements, summarize them, and then interpret/comment on what the numbers mean. They come away from the class with an understanding that the environment is complex and that numerous measurements are needed to determine the single number that may be used to describe a problem.

Graduate student and postdoctoral student education has also been something I have focused on throughout my career. Both groups have conducted much of my research with me, and I greatly enjoy working with them and seeing their development. This is particularly true for masters students, who generally start with little understanding of research and usually leave having written their first scientific publication—their thesis. This is challenging for both of us, but quite rewarding to me and, I hope, to them.

NOTE OF THANKS

I was honored to be named a 2009 College of ACES Paul A. Funk Recognition Award recipient and express my appreciation to the Paul A. Funk Foundation for the long-term support of this recognition program and to the College of ACES. The list of faculty members who have received the Paul A. Funk Recognition Award since its inception in 1971 is impressive, and I am privileged to join this prestigious group.

I have many to thank for my career, but foremost is my wife, Ginny, who has always supported me through the years. Her love and day-to-day input has been truly the foundation of my work. I also thank department heads Gary Rolfe, Mary Ann Lila, and Wes Jarrell, who were very supportive.

Lowell Gentry, with whom I have worked with for many years as we figured out the complexities of agricultural nutrient cycling, has been a major influence on my research. Mr. Gentry taught me a great deal about agriculture in Illinois, and we have had many long and interesting discussions as we figured out what was going on, or at least what we *thought* was going on.

I also have been fortunate enough to work with an excellent group of graduate and undergraduate students, postdocs, technicians, and colleagues, both here and at other institutions. Again, my thanks to everyone who has collaborated with me as they have all helped me to reach this point in my career. The University of Illinois has been, and is, a great place to work.

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