PROJECT TITLE: IMPROVING NITROGEN FERTILIZER MANAGEMENT IN CALIFORNIA

PROJECT LOCATION: California

DURATION: Three years

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	CDFA Request	Other Funding			Annual Total
Year		IPNI (in kind)	WPHA (in kind)	TFI (cash)	
2013	**$40,500**	$60,000	$25,000	$5,000	$130,500
2014	**$48,500**	$60,000	$25,000	$5,000	$138,500
2015	**$48,500**	$60,000	$25,000	$5,000	$138,500
Total	**$137,500**	$180,000	$75,000	$15,000	$407,500

C. EXECUTIVE SUMMARY

Problem: Groundwater is a vital resource for agriculture, urban, habitat, and industrial purposes. Recent reports have demonstrated that nitrate from agricultural activities is contributing to degradation of groundwater quality. Nitrogen fertilizer is essential to productive and sustainable agriculture. One recent report estimated that nitrogen fertilizer is responsible for the production of at least half of the global food supply (Erisman et al., 2008[†]).

To encourage more careful management, the Central Coast Regional Water Quality Board has recently enacted regulations leading to a requirement of a nitrogen budget for many growers. The Central Valley Regional Water Control Board is currently phasing in similar requirements.

It is clear that advances in the use of nitrogen fertilizer can be made through improvements in the complex management decisions that are unique to every farm and cropping situation. However the complicated dynamics of the nitrogen cycle require extensive education to integrate these factors. The 4R nutrient stewardship framework (Right Source, Right Rate, Right Time, and Right Place) provides a solid scientific foundation to make progress in improving nitrogen efficiency.

Objectives, approach, and evaluation: There is a large body of information from California research that has been conducted, but has not yet been organized into accessible educational tools. This proposal will develop useful information and tools for decision making related to nitrogen management.

Specifically, this will include:

- Development of fact sheets on the major components used in making a nitrogen budget,
- Writing crop-specific nitrogen management guides for the top nine crops that receive the highest nitrogen application rates,
- Preparation of 4R nitrogen management guides for each these nine crops,
- A web-based tool for guiding farmers and Certified Crop Advisers (CCA's) in the development of a nitrogen budget (and transfer to smartphone app)
- Integration the NRCS Soil Web database with the University of California Nitrate Hazard Index for web and smartphone use.
- Adapt educational material for on-line delivery of CEU's for CCA's

Overall project management will be conducted by WPHA, who will oversee the coordination of activities and the scientific review process. Multiple IPNI scientists will develop the educational and planning tools with support from academic and industry specialists, with a focus primarily on data from California. The material will be accompanied by citations to key scientific studies and observations. Both current and retired experts will be consulted in the development of these products.

The Web tools will be produced by PAQ Interactive, which has a successful history of developing agronomic software, such as calculating a nitrogen budget, integrating the SoilWeb and Nitrate Hazard Index, and converting material to CCA training modules

Outreach by WPHA will consist of direct contact with Certified Crop Advisors through training sessions, mailings, internet postings, and the agricultural press. Credits for "Nutrient Management" will be available for CCA's completing the on-line training sessions. IPNI and TFI will jointly contribute to the dissemination of the material through their nation-wide contacts with leading agronomists, businesses, and regulatory agencies.

[†] Erisman. J.W., M.A. Sutton, J. Galloway, Z. Klimont. and W. Winiwarter. 2008. How a century of ammonia synthesis changed the world. *Nature Geoscience* 1:636 – 639.

C. JUSTIFICATION

Problem: There is an urgent need for improvements in nitrogen fertilizer management for California agriculture. Regulatory pressures are coming from the Regional Water Quality Control Boards, the California Air Resources Board, and the San Joaquin Valley Air Pollution Control District. Additionally, academic reports resulting from the UC Davis "California Nitrogen Assessment" highlight the urgent need for improved nitrogen management. Similarly, the report commissioned by the State Legislature and chaired by Dr. Thomas Harter [SB X2-1] also urges rapid action to improve nitrogen fertilizer management.

The nitrogen fertilizer industry also has a keen interest in developing new information and tools to assist their farmer clients in an increasingly challenging production environment. This proposed project will allow California agronomists to access practical tools and information which will improve fertilizer use to meet both regulatory and economic goals.

CDFA/FREP Goals: This proposal meets several priority areas identified by FREP.

1. Education and Outreach: Developing and implementing educational activities that result in more efficient fertilizer use
2. Crop Nutrients: Determining and updating crop nutrient requirements and uptake rates.
3. Improving Efficiency: Developing efficient fertilizing practices to ensure the right rate, right time, right source and product and the right place of application.

Long-term Solutions: The pressing need for accurate and useable information on nitrogen stewardship has never been greater in California. There is a wealth of scientific data that has been previously developed that now needs to be put in the hands of crop advisors and farmers in a format they can interpret and use. Many University of California experts have recently retired or are reaching the end of their careers. This timely transfer of knowledge is necessary before it is lost. Using a 4R framework provides a logical framework for improving the decision-making process for managing nitrogen fertilizer.

Related Research: WPHA has a long history of providing high-quality educational information to fertilizer users in California. Similarly, IPNI is a not-for-profit organization with the mission of providing scientific information about the management of plant nutrients. Both organizations are well suited for this project with their experience and background. The cooperation of IPNI and TFI expands the impact of this work beyond California to other areas of the country that are facing challenges with nitrogen management.

Contribution to Knowledge Base: Nitrogen fertilizer guides have been developed previously in national publications, but they are often unsuitable for California conditions. For example, the crop selection, soil types, climate, and irrigation practices in California are vastly different from the Midwestern states where the majority of nitrogen fertilizer is used in the U.S. It is essential that these educational materials are developed to suit the unique California growing and environmental conditions.

This project will require close cooperation between academic researchers, the fertilizer industry, NRCS, specific crop commodity groups, and field practitioners in California. It will help identify and close knowledge gaps, while providing a foundation of research-based information needed to make improved management decisions related to nitrogen fertilizer.

Grower Use: This educational program is intended to improve nutrient management practices at the farm level for all scales of farmers. With over 80,000 farms in California, it will be the primary goal of this project to first educate the nutrient specialists who provide information for individual farmers. In addition to CCA's, the audience will include all users of commercial fertilizers (all scales of farmers), fertilizer

retailers, and regulatory agencies. A world-wide audience is also expected to use this information to improve fertilizer management by access through the internet.

D. PROJECT OBJECTIVES:

1. Develop training materials on understanding the major factors to be considered in constructing a nitrogen budget. This will include educational articles on some of the major transformations of nitrogen and how it relates to California agriculture (using California data and examples).

2. Develop crop-specific educational materials for the top-nine nitrogen receiving crops in California (accounting for approximately 75% of nitrogen fertilizer use in California). This will include compilation of data for both total nitrogen uptake and nitrogen removal in the harvested portion of these major California crops. The materials will also provide information on the pattern on nitrogen uptake during the growing season and a description of rooting patterns where the data is available.

3. Nitrogen fertilizer management guides will be written to cover the principles of 4R decision making for the top-nine crops showing how to apply the 4R principles (Right Source, Right Rate, Right Place, and Right Time). The guides will highlight the major issues related to specific nitrogen management options and improved decision making. The accuracy of these guides will be supported by scientific review from appropriate commodity groups and academic experts.

4. A web-based tool will be developed to construct a nitrogen budget. The user will input nitrogen and crop production data from their individual operation. The tool will be supported by drop-down boxes and additional information that will guide users through the process. If the nitrogen balance is excessive, suggestions from a list of 4R management practices will be provided.

5. The adoption of smartphones and their apps is rapidly on the rise within the agriculture industry. A web-based tool for constructing nitrogen budgets in the field will be modified for smartphones and made available at no cost. This will be done in a format to meet the data requirements of the Regional Water Control Boards when their rule making is finalized.

6. Combine the information from the USDA-NRCS SoilWeb (online soil survey database) and the University of California Center for Water Resources “Nitrate Leaching Index” to rapidly identify specific fields that may be vulnerable to nitrate leaching.

7. Deliver educational material on nitrogen management in a web-based format that can be used for on-line CCA CEU credits. These products will help bridge the transfer of information from theory to specific and real-life problem solving. This training builds professional expertise for the local CCA’s who will be making the nitrogen recommendations in the field.

E. WORK PLANS AND METHODS:

Task 1. Develop training materials on the major factors to be considered in constructing a nitrogen budget.

1.1 Fact sheets will be written to explain the following parts of the nitrogen cycle and how they relate to nitrogen budgets. Their application to 4R nutrient management will be highlighted as appropriate for the CCA-level audience. These sheets will include topics of:

- Nitrogen management overview
- Nitrification
- Denitrification
- Nitrate leaching processes
- Ammonia volatilization
- Plant nitrogen uptake dynamics
- Organic matter mineralization
- Immobilization
- Urea hydrolysis
- Accounting for nitrate in irrigation water
- Estimating nitrogen release from cover crops

These fact sheets will be written after an exhaustive literature search of research performed in California to gather the key relevant material. Examples of these pathways will be from California conditions whenever possible and key literature citations included. Other supporting information will be used as necessary.

1.2 Fact sheets will be reviewed by regional specialists within IPNI, national agronomists affiliated with member companies of TFI, California agronomists affiliated with WPHA, NRCS, and cooperators in the Dep. Land, Air, and Water Resources at UC Davis.

1.3 Fact sheets will be finalized and formatted by the professional editorial staff of the IPNI. The primarily vehicle for distribution will be via the internet, but printed copies will be made for the initial state-wide distribution to all Certified Crop Advisers in California and the agricultural media.

1.4 The pdf-formatted fact sheets will be made available for posting on the CDFA/FREP website (cdfa.ca.gov/is/ffldrs/frep.html), and also posted on the WPHA website (healthyplants.org),and the IPNI website (IPNI.net).

1.5 The fact sheets will be converted to web-based self-study modules for CCAs (Certified Crop Advisers) and be made available through the agronomyu.org website.

[Task 1 will be initiated immediately at the beginning of the project and be completed in the first 18 months]

Task 2. Develop crop-specific fertilizer management materials for the top-nine nitrogen receiving crops in California (lb N/A). This will include compilation of data for both total nitrogen uptake and nitrogen removal in the harvested portion of these major California crops. The materials will also provide information on the pattern on nitrogen uptake during the growing season and a description of rooting patterns where the data is available.

Top Nine N-Receiving Crops (Source: UCD-Agric. Sustainability Institute)

1. Almond
2. Cotton
3. Rice
4. Wheat
5. Tomatoes
6. Lettuce
7. Walnut
8. Broccoli
9. Citrus

2.1 Conduct a literature review of nitrogen acquisition patterns for these nine crops, crop rooting patterns, and nutrient accumulation pattern.

2.2 Contact key researchers (globally) to request additional information on nitrogen uptake patterns and root systems that may not be published in peer-reviewed journals, but still valuable for supporting information.

2.3 Contact California academic and extension experts to acquire relevant information for California conditions. Retired experts from the University of California will also be approached for assistance. Information from representatives from the fertilizer industry or leading commodity agronomists will also be requested.

2.4 Write preliminary report for each crop covering specific issues with N management, including nitrogen uptake rates, total quantity accumulated, nitrogen removal during harvest, and rooting characteristics.

2.5 Send preliminary report to applicable California commodity groups for their feedback and suggestions to make the material relevant for their member farmers.

2.6 Incorporate all appropriate review suggestions.

2.7 Technical guides will be formatted by professional editorial staff of the IPNI. The primarily vehicle for distribution will be via the internet, but printed copies will be made for the initial state-wide distribution to all Certified Crop Advisers in California and the agricultural media.

2.8 The pdf-formatted technical guides will be made available for posting on the CDFA/FREP website (cdfa.ca.gov/is/ffldrs/frep.html), the WPHA website (healthyplants.org), and the IPNI website (ipni.net) and made available for posting on the.

2.9 The technical guides will be converted to web-based self-study guides for CCAs and will be made available at http://agronomyu.org.

[Task 2 will be initiated immediately at the beginning of the project and be completed in the first 18 months]

Task 3. Develop Nitrogen Fertilizer Management Guides to cover the principles of 4R decision making for the top-nine crops. They will provide specific guidance on how to apply the 4R principles of nutrient stewardship (Right Source, Right Rate, Right Place, and Right Time) for California conditions.

3.1 Using the information gathered from Task 1 and Task 2, the principles of 4R will be developed for each of the nine crops. They will highlight the major issues related to specific nitrogen management and improved decision making for individual crops.

3.2 The 4R guides will be supported by scientific review from appropriate commodity groups and academic experts as previously outlined.

3.3 Management guides will be formatted by professional editorial staff of the IPNI. The primarily vehicle for distribution will be via the internet, but printed copies will be made for the initial state-wide distribution to all Certified Crop Advisors in California and the agricultural media.
3.4 The pdf-formatted fact sheets will be made available for posting on the CDFA/FREP website (cdfa.ca.gov/is/ffldrs/frep.html), and will be posted on the WPHA website (healthyplants.org), and the IPNI website (IPNI.net).

3.5 The management guides will be converted to web-based self-study guides for CCAs and will be made available at http://agronomyu.org.

[Task 3 depends of the completion of Task 1 and Task 2. The 4R management guides will be developed during Year 2 of the project]

Task 4. Develop a web-based tool to construct a nitrogen budget.

4.1 PAQ Interactive will develop a web-based application for calculating a nitrogen budget for the previously mentioned nine crops. At this website, the user will input values from their individual operation and be guided through the data input process. The user will be supported by drop-down boxes and additional information that will guide them through the process. If the nitrogen balance is excessive, suggestions from a list of 4R management practices will be provided that will offer suggestions to improve the nitrogen balance to meet regulatory requirements.

4.2 PAQ will gather the specifications for calculating a budget from IPNI with assistance from other stakeholders and state agencies.

4.3 PAQ will wireframe (mockup) the interface including pick lists and instructions for creating nitrogen budget calculations at the field level. It is to be determined if the tool is to calculate a budget for a single crop or for all crops within a given year.

4.4 A user will be able to create a private account and save their field and cropping information. This will allow users to revisit the site, try alternative nutrient management practices and compare results. It will also allow a user to view their nutrient management efficiency over time for a particular field.

4.5 Prepare index of user choices to match with 4R guidelines and list these guidelines or snippets from the guidelines to the user while preparing or reviewing their nitrogen budget. For example, if a user is raising cotton, the 4R suggestions from the fact sheets, technical guides, and management guides related to cotton will be suggested to the user.

4.6 Based on the crop, the nitrogen management choices made, and the outcome of the balance calculation, the application will suggest 4R management practices that may improve their nitrogen balance and nutrient use efficiency.

4.7 PAQ will work with stakeholders to develop reports from the nitrogen budget calculator that meet the format and data requirements of the Regional Water Control Boards after the regulatory plan is finalized. PAQ will create mockups of the reports and adjust the final version to meet the requirements. The user will be able to print or email the report from the application.

4.8 PAQ will host the tool on its web servers. Additionally, it will be made available via the CDFA/FREP website (www.cdfa.ca.gov/is/ffldrs/frep.html,) WPHA website (healthyplants.org), the IPNI website (ipni.net).

4.9 PAQ will create tool tips throughout the application for instant help to users. PAQ will create an online training guide and streaming video tutorials for how to use the application. PAQ will assist in presentations and workshops for producers and crop consultants in the use of the nitrogen balance calculator.

4.10 When the web-based nitrogen budget tool is completed and forms and reports are finalized, PAQ will develop a streamlined version of the program that can be used as an app on an iOS or Android-based smartphone by coding the site in HTML5. Both of these programs will be made available at no cost to the user.

[Task 4 requires the completion of Tasks 1, 2, and 3. The framework of the nitrogen budget tool will begin in Year 1 and the addition of crop-specific 4R information will be done in Year 2 and 3. The smartphone version of the calculator requires completion of the web version and will be completed in Year 3.]

Task 5: Integrate the USDA-NRCS SoilWeb Database with UC Nitrate Leaching Index

5.1 Combine the information from the USDA-NRCS SoilWeb (online soil survey database) and the Univ. California Center for Water Resources Nitrate Hazard Index (NHI) to highlight fields and areas that are vulnerable to nitrate leaching.

The SoilWeb program allows the user to rapidly determine the soil series at any location in the United States. The NHI gathers information on the soil series, the crop being grown, and the irrigation method to predict the potential for nitrate loss by assigning a factor from 1 to 80. The NHI does not measure actual nitrate loss, but indicates a need for careful attention in certain areas of the farm. It also highlights some of the factors that are contributing to the risk of nitrate loss. Integrating these two web-based programs will allow farmers and CCA to rapidly estimate the risk on nitrate loss and factor this risk into their nutrient management planning.

5.2 PAQ Interactive has considerable technical and programming expertise in developing web-based GIS tool and integrating web applications with smartphone apps, with the smartphone apps linking to a centralized database that is shared by both platforms.

5.3 PAQ will create on online GIS (Geographic Information System) that will include the data from the SoilWeb web feature and the NHI. A user will be able to define a field boundary using the web interface. The system will then find the SoilWeb data and NHI data for that field. The web interface will highlight areas of the field that are vulnerable to nitrate leaching. If a user is logged in to their account, their field boundary will be saved and become part of their profile.

5.4 PAQ will integrate the SoilWeb and NHI into the smartphone app when it is developed. By integrating into a smartphone app, the user will be able to use the smartphone's GPS capabilities to determine field location and will assist crop advisors and farmers in estimating potential risk of nitrate loss while in the field.

5.5 The resulting field boundary will be exportable as a shapefile for use in GIS software. The resulting NHI map will also be exportable as a shapefile. The maps will be available to add to a field report if specified by the Regional Water Control Boards.

[Task 5 will be initiated immediately at the beginning of the project and the web-based version will be completed by the end of Year 2. The integration with smartphone apps will progress after the web-based version is completed. The smartphone version of the integration will be completed by the end of Year 3]

Task 6: Prepare and deliver educational material in a web-based format that can be used for on-line CCA CEU credits.

6.1 The IPNI editorial team will cooperate with PAQ Interactive to transfer the previously developed educational material into a format suitable for on-line training for CCA credits. These modules will help bridge the transfer of information from theory to specific and real-life problem solving. This training builds professional expertise for the local CCA's who will be responsible for making the nitrogen recommendations in the field. The training material will be hosted on an easily accessible website that can handle the logistics of CCA training (such as agronomyu.org, the CCA website, or the Western Farm Press website).

6.2 PAQ will repurpose the fact sheets on nitrogen into a web-friendly format suitable as a module for CCA self-study CEUs (Task 1).

6.3 PAQ will repurpose the crop-specific technical guides into a web-friendly format suitable as a module for CCA self-study CEUs (Task 2).

6.4 PAQ will repurpose the 4R management guides into a web-friendly format suitable as a module for CCA self-study CEUs (Task 3).

6.5 PAQ will file for self-study credit for each of the modules created from the educational materials developed for this project.

6.6 PAQ will create, with the assistance of IPNI and other stakeholders, online quizzes in the format required by CCA for CEU self-study credit. If taken at agronomyu.org, a CCA will be able to review the module, take the quiz, and receive instant feedback on their score. Passing scores will automatically be reported to ICCA and the CCA complete with the CEU self-study credit ID and CCA number.

[Task 6 will continue throughout the entire project. New materials will be added to the CCA training database as soon as they are developed.]

F. PROJECT MANAGEMENT, EVALUATION, and OUTREACH

Management:
The Western Plant Health Association will serve as the overall coordinator of this project. Commitments have been made from leading companies in the California fertilizer industry to support this effort, as well as from the national fertilizer association (TFI). Since WPHA consists of all the leading fertilizer companies in California, it is in a unique position to both receive guidance from key fertilizer decision makers and to rapidly disseminate this new information to their farmer clients.

The International Plant Nutrition Institute (IPNI) has a long history of developing educational materials for improving fertilizer management. This includes their newly released 4R Plant Nutrition Manual. IPNI will be responsible for the preparation and synthesis of all technical content, developing the written material, and preparing all products for final distribution. IPNI will lead the scientific discussions with agricultural experts on each topic to be developed. They will be responsible for adapting the material into a format suitable for CCA training (working with PAQ).

WPHA will coordinate the review of the materials for accuracy and relevance to plant nutrition decision makers in the field. Review of the technical content will be sought from appropriate current and retired academic professionals, NRCS, industry agronomists, and relevant commodity groups. Input from CDFA staff will also be solicited.

PAQ Interactive will be responsible for development of the web-based nitrogen budget tool. PAQ Interactive, a technology services company, recently performed the data preparation work for IPNI's NuGIS (Nutrient Use Geographic Information System) project and currently hosts online NuGIS data in tabular format and as a web-based GIS. PAQ will work with project stakeholders to develop a clean interface to creating a nitrogen budget and reporting nutrient management decisions for a field.

PAQ will also be responsible for the synthesis of the USDA-NRCS Soil Web database with the UC Center for Water Resources Nitrate Hazard Index. This will initially result in a web-based tool that will allow users to integrate the data from these databases into their nutrient management plan for a field. This component will add a spatial component to the field nitrogen budget calculator.

PAQ will be responsible for the development of iOS and Android compatible smartphone applications. One will be the nitrogen budget tool. One will be the integration of the SoilWeb and NHI.

PAQ will be responsible for repurposing the educational materials developed through this project into CCA self-study modules and quizzes suitable for hosting on websites such as agronomyu.org.

The primary contribution of TFI will occur during the promotion and outreach phase as they coordinate with IPNI for the national distribution of the material.

Evaluation:
The major product of this project will be educational materials that will enhance the management of nitrogen fertilizer in California. The products will be primarily accessible through the internet to users in California and throughout the world. The on-line tools for developing a nitrogen budget will be useful for demonstrating how the 4R principles can be applied to specific California conditions. They will also help growers meet the regulatory requirements set by state agencies.

The evaluation of the educational material will occur in two phases. During their development, continual review of the products by academic and government scientists and professional agronomists will provide feedback the material is of high scientific quality and also useful in the field. None of the educational tools will be released without thorough review by key stakeholders.

During the outreach phase, evaluation of the materials will occur in group settings and by feedback from individual agronomists each year. Surveys will be conducted among practicing CCA's following distribution of the materials at the multiple WPHA Nutrient Seminars each year. Feedback from their suggestions and critique will be implemented to modify existing material or improve future products. Selected practicing CCA's will be individually solicited by phone each year to comment on the printed and on-line material (related to their crop expertise) and make suggestions for improvements. Comments from leaders of the regional water coalition groups will also be solicited by phone.

PAQ and IPNI will work with members of the Regional Water Control Boards to determine what components they will require in a nitrogen management plan. Interaction with the regulatory agencies will steer the software development into useable and practical tools.

Outreach:
Certified Crop Advisers have been enlisted by the Regional Water Quality Control Boards to assist in the improved management of nitrogen fertilizer. This proposed work will provide a variety of educational tools to help them be successful in maintaining a productive and sustainable agriculture in California. Distribution of the materials will be made through CDFA, the California CCA Board, the California CCA membership and the >600 people on the IPNI mailing list in California. WPHA will make materials available to grower coalitions for distribution to their grower members.

The educational materials will be discussed and made available as printed copies at annual CCA Nutrient Seminars organized by WPHA in multiple locations across California during the three-year period. The materials will also be annually presented and distributed at the FREP Conference.

The web portion of the project (Developing a nitrogen budget) will be launched and demonstrated at the multiple CCA training sessions. Notice of this tool will be widely distributed in the California and national agricultural media. It is expected that the tools will be well used, as emerging regulations will require this action.

WPHA has a long-term history of close cooperation with the agricultural media in California. For example, Richard Cornett, the WPHA Director of Communications, regularly communicates with key industry, government,

and media personnel on the latest developments. His contact and expertise will be valuable in delivering the information on improved nitrogen management to the popular farm press.

Since this project is closely linked with the principles of 4R Nutrient Management, both IPNI and TFI will make this information available to their members across North America. Although the information developed in this project will relate primarily to California conditions, the general principles will serve as an example for other parts of the country. TFI will also post appropriate material on the 4R Nutrient Stewardship website (nutrientstewardship.com), which is the key repository of 4R nutrient management information.

Two articles will be submitted to the magazine distributed to all CCA's (Crops and Soils) describing the progress of this project, so that all CCA's in North America can benefit from this work.

The final products will be joint property of CDFA, WPHA, and IPNI. Any of these organizations can freely distribute the material for educational purposes. Other organizations can also freely use the material without restriction.

It is unrealistic to assume that dramatic changes in nitrogen fertilization practices will occur during the three-year period of this proposal. However, these tools will support significant, on-going progress in synthesizing widely scattered information into a user-friendly format for educating farmers on how to make continual improvements in nitrogen management. The need for this information is very timely and is expected to be well-received by the agricultural community.

(note: close cooperation is anticipated with the California NRCS office. The position of State Agronomist is currently vacant, but recent conversations indicate that it is expected to be filled by mid-summer 2012.)