Development of a Weather Monitoring and Decision Support System for Massachusetts Agriculture

a grant proposal submitted to

The Massachusetts Agricultural Innovation Center
Department of Agricultural Resources

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Statement of Work

Rationale

While modern business has managed largely to insulate itself from the impacts of weather, agriculture remains an exception, very much dependent on what nature delivers as rain, sun, heat, cold or storms. Weather not only directly impacts crops, it also drives the development of insects and diseases that attack them. Over the past twenty-five years, growers have become better able to manage risks related to weather and pests by closely monitoring weather information and using it to predict when, for example, pesticides should be sprayed or plants should be protected from frost with irrigation. Monitoring key weather parameters, such as rainfall, wetting periods, temperature and evaporation can provide agricultural businesses with critical information.

Basically using weather information to help make decisions involves collecting accurate data and analyzing it to help make key decisions. Analysis is done using models, which are mathematical calculations and logical formulations that use weather data and other information. The model will make a recommendation as to whether some action should be taken. For example, apple growers can determine whether they need to treat for fire blight using a model. They collect daily temperatures, dew, and rainfall, and as trees come into bloom, combine this to determine whether a streptomycin spray is needed. Fire blight can kill trees and cause serious damage, so streptomycin should be used if there is risk of infection. On the other hand, unnecessary streptomycin applications waste money and increase the chances that the fire blight pathogen will become resistant to the antibiotic. Using a model such as Maryblyt enables growers to know when treatment is needed and when it isn't (Steiner & Lightner 1996). Models have been developed for many important disease and insect problems, as well as for frost prediction, timing harvest and irrigation, or optimizing fertilizer applications.

In pest management, reducing pesticides often depends on accurate weather information. It is a cornerstone of integrated pest management. It is equally important for organic producers. Growers using IPM or organic methods often receive a premium for their products. Increasingly European and other foreign markets are demanding food that is grown with minimal use of pesticides. Easily used weather and decision support can therefore reduce costs be decreasing inputs for pest management, and improve returns and markets for agricultural products.

However, growers often do not use these valuable decision support tools. In spite of technological innovations, growers often find it difficult to regularly get the weather data needed and apply it in a decision support model. To be useful, weather instruments have to be accurate and function day in and day out. Data has to get from the instruments to the grower or a computer in a form that can be readily used. Maintaining a weather station and accessing data adds tasks to an already full work day. Sometimes, it involves technological expertise. Most growers, when asked, say that they would and do use model-based forecasts when those forecasts come as simple recommended actions. But they find the process of gathering and analyzing the information themselves too difficult and/or time-consuming to do on a regular basis.

As a result, newsletters and other grower information sources will publish information based on weather data from selected locations or for a region. Subscription services, such as Skybit, also have arisen, and these provide growers with farm-specific information interpolated from off-site National Weather Service weather stations. Such information is generally useful, but variability in conditions from farm to farm, or delays in delivering it, can make recommendations less accurate (Gleason et al. 1999; Babadoost et al. 2004). To fully utilize the power of weather-based models, growers need a system that gathers accurate data and processes it for their particular farm, delivering easily understood recommendations in a timely manner.

Recent developments in wireless technology, robust weather monitoring hardware, and web-based software have made it possible to do this. Weather data can be obtained on a farm, sent frequently to a central computer server, where it can be processed in forecasting models, and then presented as recommendations in the form of web pages accessible by each grower. Similar systems have been developed in larger agricultural states (Anonymous 2007; Carroll 2007).

This proposal outlines a prototype system that would be immediately applicable to disease management for Massachusetts apple growers, and demonstrate the usefulness of a system to broad sectors of agriculture in the state. In cooperation with a Massachusetts company, the UMass Extension Fruit Team and others in the Extension Ag. and Landscape Program will develop a weather-based decision support system, the Massachusetts Agweather Network (MAGNET) that will provide growers in the state with reliable, easy to use decision support. When fully implemented, such a system would provide Massachusetts growers with a state of the art system to optimize use of inputs and facilitate implementation of IPM and integrated crop management, thereby improving overall efficiency, increasing potential returns and decreasing negative environmental impacts.

Project Objective 1. Develop a prototype system to gather weather and transfer data to a central web server.

Preliminary discussions with ONSET (Bourne, MA), a manufacturer of environmental data logging equipment, have explored the concept outlined in Figure 1. On-site weather data will be collected using available sensing equipment from ONSET. This can be transferred to a server managed by ONSET via wireless technology. Transfer can occur as frequently as needed for decision support models, generally once a day but as frequently as hourly during critical periods. The data stored at ONSET can be transferred to a server at UMass run by the Extension Fruit Team. The communication software allows uploads from most areas in Massachusetts.

A server hosting web sites for the UMass Fruit Team (http://www.umass.edu/fruitadvisor/) is on site at the UMass Cold Spring Orchard Research & Education Center (CSOREC), and is managed by Jon Clements. This will be the long-term server for MAGNET, though intial development will take place on computers in the Computer Science Department on the Amherst campus.

Deliverables:

1.1 Hardware and software to wirelessly collect weather data set up at 6 cooperating grower locations around the state.
1.2 Hardware and software to move information from the field to a database on a dedicated web server at the CSOREC.

Project Objective 2. Set up decision support models for tree fruit diseases in an easily used set of web pages.

When the data is on the UMass server, it can be accessed for use by decision support models. In the long term, these will be developed as resources allow for any agricultural commodity groups in the state for which useful decision support models exist. In this project, a prototype system will be developed for apples. A number of well-developed and field tested models exist for the crop, and they can be relatively easily adapted to the MAGNET decision support system. These include models for the three major disease problems, fire blight (Steiner & Lightner 1996; Smith 1999), apple scab (Gadoury & MacHardy 1982; MacHardy 2000), and the sooty blotch/flyspeck complex (Brown & Sutton 1995; Hartman et al. 1999).

A web interface will be developed by a student working under the direction of Dr. David Culp (Computer Science Dept., UMass Amherst). The interface will be designed to be used by growers. The general process will involve development of the following:

- Specialized small programs for 3 key disease models that run on the web server and compute forecasts of disease risk. Models will be provide by D. R. Cooley.
- Web server code that allows registration and customizable reports (such as those in Washington State's DAS (Anonymous 2007)).
- Stand-alone (non-web server) program for retrieving recent measurements and adding them to the database.
- A database (mysql or postgres) and a database schema that adequately captures collected weather.

Decisions will be made on whether forecasts, pathogen information, and model parameters are also stored in the database. If not, forecasts will be dynamically generated and model parameters would be embedded in the custom programs for each model.

Deliverables:.

2.1 Web database of weather data from MAGNET site operable on CSOREC server.
2.2 MAGNET web site for interaction with users operable on CSOREC server.
2.3 Written material describing principles and use of models for fire blight, apple scab, and sooty blotch/flyspeck delivered to growers

Project Objective 3. Establish Agweather Working Group with Massachusetts stakeholders.

An advisory working group of stakeholders, consisting of growers, crop advisors, Massachusetts Dept. of Agricultural Resources personnel, and UMass Extension personnel, will be established. The purpose of the group will be to advise on MAGNET development and implementation. Preliminary discussions with UMass faculty and professionals have indicated a strong interest in developing a Massachusetts weather-based decision support system from groups working with cranberries, vegetables and dairy crops. We anticipate that other groups would benefit as well. It is the role of the working group to insure that the needs of the diverse agricultural community in Massachusetts are met.

With success of the prototype apple implementation, the working group would be charged with developing a plan for broader development of MAGNET around the state. This will include analysis of the economic needs for long-term implementation and maintenance of the system.

Deliverables:

3.1 Establishment of a stakeholder group to guide broader development of MAGNET
3.2 Plan to implement a state-wide agricultural weather system

Project Objective 4. Modify system if and as needed and verify utility of MAGNET system in cooperating orchards and demonstrate to growers.

A group of six commercial Massachusetts apple growers will receive ONSET weather stations for use during the project. Growers will commit a block of trees to management using the recommendations generated by the MAGNET system. UMass Tree Fruit Specialist J. Clements will work with growers on the farms, and the system will be adjusted to make sure that it is easily used by the growers.

During the growing season, the blocks will be monitored for pest incidence at two-week intervals. The recommendations from MAGNET will be checked against field data and results monitored. In addition, the agricultural advisory subscription service Skybit will be used at each site. Recommendations from MAGNET and Skybit will be compared to determine differences between the systems. Skybit has an advantage over on-site systems, because it doesn't require equipment on the farm. However, studies have indicated that Skybit recommendations do not match well with on-site systems (Gleason et al. 1999; Babadoost et al. 2004).

Deliverables:

4.1 Modify software and/or interface as needed according to grower and working group feedback
4.2 Field demonstration of applicability of the MAGNET
4.3 Verification of system by taking disease incidence data and spray data on farms
4.4 Comparison of the prototype with the major competing system for accuracy
4.5 Educational presentations at grower meetings on MAGNET

Timeline

Objective and Deliverable	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
1.1 Station set-up												
1.2 Data transfer to server												
2.1 Weather database up												
2.2 MAGNET site up												
2.3 Written material												
3.1 Advisory group												
3.2 Develop broad plan												
4.1 Modifications as needed												
4.2 Field demonstrations												
4.3 Verification												
4.4 Systems comparison												
4.5 Education presentations												

Facilities

Development of the system will be done at the ONSET facilities in Bourne, MA, lab facilities at the University of Massachusetts Amherst, and at the Cold Spring Orchard Research and Education Center, Belchertown, MA. Field testing will be done at commercial apple orchards in MA.

Personnel

Daniel Cooley, Ph. D. Co-principal investigator is an Associate Professor of Plant Pathology with over 25 years of field research experience in IPM of fruit crops and development of disease management models. He will coordinate the adaptation of disease management models to the MAGNET system, and work with scientists, agricultural professionals and growers to establish the Ag. Weather Working Group, and will provide overall leadership to the project.

Jon Clements, Extension Specialist, Co-principal investigator. Over 20 years experience in tree fruit production and outreach to the tree fruit industry, and in developing computer and web-based support products for the industry. He will supervise weather station placement, day to day operation of the system, and web hosting of the MAGNET site.

David Kulp, Ph. D. Assistant Professor of Computer Science with experience in computational biology and bioinformatics. He will coordinate the development of the database and web site interface for the MAGNET decision support system.

References

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Attachment 1.

Budget

Item	AIC	Match	Total
Personnel			
Technical asst., part-time (3 mos.), salary + benefits	$12,000	$12,000	$24,000
Student Programmer (3 mos.), salary + benefits	$7,000	$5,000	$12,000
Equipment			
Weather stations 6 @ $2,000	$6,000	$6,000	$12,000
Server (hardware and software)	$2,500	$2,500	$5,000
Services			
Subscription (data transmittal and raw data hosting) 6 @ $80/mo times 6 months (April-September)	$0	$2,880	$2,880
SkyBit subscription 6 @ $80/mo times 6 months (April-September)	$0	$2,880	$2,880
Server hosting	$0	$2,500	$2,500
			$0
Travel	$2,500	$3,000	$5,500
Misc. supplies	$500		$500
Total direct costs	$30,500	$36,760	$67,260
Modified Total Direct Costs (TDC - Equipment)	$22,000		
Indirect costs (26% MTDC from AIC (sponsor))	$5,720		$5,720
Total	$36,220	$36,760	$72,980

Attachment 2.

Figure 1. Information flow in the proposed Massachusetts Agweather Network.