

A Pilot Program to Assist CAFOs in Using Weather Data to Minimize Manure Management Risk

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Abstract

This paper summarizes a pilot project to disseminate site specific weather information that has been processed to estimate field runoff potential of land applied manure. Preliminary feedback indicate the program has value but that additional information is needed to understand how farmers use weather information to make decisions within the regulatory constraints they face.

Keywords: decision making, uncertainty, value of information, weather, manure
JEL codes: Q100 - Agriculture: General
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Background on CAFOs and Environmental Policy

The U.S. Environmental Protection Agency (EPA) recognizes agriculture as the largest contributor to impaired waters (U.S. EPA, 2000). In that vein, the EPA, revised the concentrated animal feeding operation (CAFO) rule in February, 2003.

The Revised CAFO Rule specified that weather information be used in influence management in at least 2 areas. The first specification is that “the production area is ... *operated* ... to contain all manure, litter, and process wastewater including *the runoff and the direct precipitation from a 25-year, 24-hour rainfall event.*” The second specification is that the “nutrient management plan ... addresses the ... amount, *timing* and method of application of nutrients on each field *to achieve realistic production goals, while minimizing nitrogen and phosphorus movement to surface waters*” ((U.S. EPA, 2003) *emphasis mine*).

In the same rule the EPA estimated that the number of permitted entities would increase to 15,500, of which 40% will be small businesses and of a size that does not have a person or department dedicated to environmental compliance. The CAFO Preamble notes that the “EPA intends to develop a small entity compliance guide...and additional tools to assist AFOs in complying with this requirement (U.S. EPA, 2003).” This paper documents a tool designed to assist AFOs and CAFOs in managing their manure resource in compliance with the revised CAFO rule and presents preliminary findings from a pilot study implementing this tool.

CAFOs experience a unique set of challenges in appropriately managing their manure stockpile. Because CAFOs receive a no-discharge permit they must manage their manure storage structures so that the probability of a spill is minimized and land application of manure is simultaneously agronomically beneficial and environmentally benign. For most AFOs and CAFOs, the daily decisions pertaining to managing storage and application of manure are just two activities among dozens of daily management responsibilities of the owner/manager in the overall farming business. Weather events, such as precipitation and wind conditions, in conjunction with the decisions and actions of managers, have substantial impact on the outcomes of manure management strategies.

The EPA directive to minimize the transport of phosphorus and apply it based on crop utilization will likely increase the number of manure applications and increase the geographic area used for application. Accessing more distant acres and possibly applying at a lower rate will likely increase the amount of time required to land apply a given quantity of manure. Given a set window of opportunity, any increase in application time will increase the opportunity cost of compliance.

Weather events and weather trends determine the number of and duration of opportunities for optimal manure application in the annual cycle of manure storage buildup and draw down through application. AFO and CAFO operators must make manure management decisions based on an interpretation of the weather events to date and an expectation of events in the future. The decision

to schedule manure application (e.g. tomorrow, next week) involves assessing information on cumulative precipitation and trends, on soil conditions such as moisture, temperature and trends, as well as developing expectations of various weather events in the near future. For the regulated animal feeding community, recognizing and acting upon optimal windows of opportunity is critical for meeting or exceeding the expectations of the EPA and the permitting authorities.

CAFOs tend to be geographically dispersed throughout the landscape. There are regions that have high concentration of CAFOs, frequently near processing facilities. However, even in these regions, CAFOs are located on individual, isolated parcels of ground. The varying weather conditions associated with geographic dispersion create different management needs for different CAFO operators. Environmental sensitivity is also associated with geographic dispersion. CAFOs that are separated by only a few miles can be in different watersheds with different sensitivities. This dispersion implies that the most effective programs to assist them would need to be geo-referenced with specific data layers that capture the variations in soils, historical weather and weather forecasts.

Literature Review

Batte, Jones and Schnitkey reviewed some of the applied literature on the value of information, concluding “the economic importance of a piece of information is tied to potential gains or losses involved in a particular decision.” Mjelde et al. correctly state that “for forecasts to be useful, management

strategies must be flexible” and conclude that their study implies that “climate forecasts only have value if they alter management decisions.”

Mjelde et al. reference Hilton as giving 4 general determinants of information value. They are: 1) the structure of the decision set; 2) the structure of the decision environment; 3) the manager’s initial beliefs about the distribution of the stochastic variables in the decision environment; and 4) the characteristics of the information system. They reference survey data that indicates that users of weather information value accuracy of the forecast, lead time and reliability. Their review of information studies summarizes that the value of weather forecasts is affected by the following characteristics: 1) timing of the forecast (lead time), 2) predictive accuracy, 3) the number of future periods forecast at a given point in time, 4) specificity – how many separate values or categories a given parameter can assume, 5) spatial resolution, 6) the weather parameters to be forecasted and 7) the time span covered by a given forecast.

Most weather information studies tend to look at annual or season forecasts (Jones et al. and Nelson et al.). Mjelde et al. may have one of the shortest term studies when looking at seasons (early spring, late spring, etc) as the time periods of forecasts. No studies were found to deal with the day to day decisions that farmers make using daily short-term forecasts.

Bingham and Ashcroft speak of the weather stations that are being used in Utah and envisage the day when they will incorporate models for irrigation, crop management and pest management. Regarding distribution of weather information they say the “data, forecast, model prediction and market information

must be rapidly delivered.” Written prior to the internet and wireless communication they discuss TV and radio technology for distribution. Radio and TV were recognized as sources of weather information with “no explicit cost of access” (Batte, Jones and Schnitkey).

Description of Project

Objectives

The overall objective of this project is to develop an automated, cost effective system which would assist CAFO operators in their management, planning and land application of manure. It is expected that use of the system by CAFO operators will increase the likelihood of compliance with best management practices dealing with manure and reduce the likelihood of adverse water quality impacts associated with severe and chronic weather related events.

The economic principles under girding the project are those dealing with the value of information and transaction costs. Neoclassical economics assumes perfect information. As this assumption is relaxed the optimizing decision becomes less certain. Studies have indicated that some information is better than no information; perfect information is not necessary to increase decision making power. It is presumed that there is a continuum of the value of information. Some information is preferred to no information; high quality information is preferred to lower quality information.

As in other inputs, weather information is expected to have diminishing marginal returns. The profit maximizing point of weather information is not necessarily perfect information. The increased value of better information must

be considered in light of the increased cost of obtaining that information. By reducing the transaction cost of obtaining information, the quantity and quality of weather information demanded may increase leading to more optimal decisions.

Currently farmers have access to generalized information via TV, radio and other sources. This weather is presented as the best data for a relatively large geographic region. The National Weather Service (NWS) provides more site specific, gridded data than that presented via mass media. While this NWS data stream is disseminated over the internet, farmers do not have the knowledge of its existence, the software to capture it or the understanding of how to use it.

Data and Methods

The first step of the project was to assess various sources of weather information and their characteristics such as lead time, the number of future periods forecast at a given point in time, specificity, spatial resolution, and the weather parameters forecasted.

Next, the University of Missouri Agricultural Electronic Bulletin Board (AgEBB) developed an automated system of capturing the gridded weather information for specific global position coordinates. They processed this information through accepted models to provide advisories regarding animal comfort and soil runoff potential. This information was formatted into a report that could be generated daily. AgEBB then developed an email infrastructure that automatically sends reports (see figure 1) twice weekly to participants. Later in the project, AgEBB also developed individualized web pages for each

participating CAFO operator so they could access reports on a daily basis (rather than the twice weekly basis on which reports were emailed to the farmers), enter their own precipitation records and have access to other weather information sites.

The report is created at 4:00 p.m. daily. This time was chosen because the last data product of the NWS was scheduled to be updated at 2:00 p.m. but was occasionally late. Some of the information on the report would be older than other information depending on the time the product was released by the NWS. The weather report merges 7 sources of weather information into a single report. The historical information contains 3 sources of information; the forecast contains 2 additional sources of information; and the advisories contain 2 more sources of information.

Historical precipitation from the U.S. Precipitation Quality Control System and Analysis (NWS, 2005a) provides estimates of precipitation for the last 4 days for each precise geographic coordinate. The precision of this database is $.25^{\circ}$ longitude by $.25^{\circ}$ latitude (approximately 16 miles by 16 miles in Missouri). Because this product uses interpolated data from multiple weather stations and NEXRAD radar, it is an estimate that, though precise, may not be accurate. For that reason we report the precipitation for the nearest weather station on the University of Missouri Agricultural Weather Network (University of Missouri, 2005). The CAFO operator also has the option of entering their own precipitation measurements into their personal web page should they want more accurate information used in the weather advisory models.

Historical minimum and maximum temperature, soil moisture and soil temperature at the 2 and 4 inch depth is obtained from the nearest MU weather station. The nearest weather station provides more accurate and precise information than can be obtained by mass media because of the number and placement of the weather stations, and the ubiquitous nature of these climatological phenomena.

Forecasted precipitation quantity for each of the next 4 days is obtained from the National Weather Service Hydrometeorological Prediction Center (NWS, 2005b). This data has a resolution of 32 km (approximately 20 miles) square. Forecasted weather estimates of probability of precipitation, minimum and maximum temperatures, and wind speed and direction are made by the University of Missouri Climate Center. They daily select, from a suite of weather information products, their best estimate of these phenomena for prevailing conditions.

The predominant soil hydrologic group of each farm in the project was determined by accessing the Center for Agricultural, Resource and Environmental Systems (CARES, 2005) map room. This website stores the Missouri soils database and, using ARCVIEW tools, estimates the percent of each soil type a field. Each soil type has a corresponding hydrologic group. When a field had several soil types, and corresponding hydrologic groups, we chose the most predominant hydrologic group to represent the whole field. We

viewed the field as the unit of management and did not anticipate that farmers will benefit from having different runoff estimations for portions of their fields.

CAFO operators involved in the pilot project provided a description of their farm location and an email address where they would receive routine reports. We used the description of farm location to determine a specific latitude and longitude coordinate of a point on the farm and the predominant soil hydrologic group for the fields receiving land-applied manure. The participants were later given aerial maps of the land for which they were receiving information and given the opportunity to change the location and their estimation of the predominant soil hydrologic group.

The weather information is processed through models to create two advisories included on the reports. The primary advisory is “estimated rainfall needed for runoff.” This is obtained by processing the historical precipitation, forecasted precipitation and predominant soil hydrologic group through a runoff curve equations of the USDA NRCS. The estimate is specific to numerous crops (and bare soil), crop conditions and conservation practices. Each permutation of crop, crop condition and conservation practices can yield a unique runoff estimate. These estimates are information to the user to be used in conjunction with the forecasted precipitation quantity and probability of precipitation for a personal, subjective decision of whether or not land application of manure and fertilizers is appropriate for profit and environmental goals. No recommendations are provided in the report.

The second advisory is a “livestock safety index” that alerts farmers to temperature and humidity, and temperature and wind conditions that can be harmful to livestock health. This product is added to increase the value of the report to the user so they will routinely look at it rather than only consider it when they think they might apply manure or fertilizers.

Preliminary Results and Discussion

Recruitment of CAFO operators to serve on the pilot project was more difficult than expected. The project was funded predominately by the EPA. CAFO operators were reluctant to participate, fearful that the EPA would obtain information on them and their environmental record. A second fear was the perceived legal liability associated with having more (rather than less) information. Specifically, one company would not encourage its growers to cooperate because of the inclusion of the animal comfort advisory. Their fear was that if a number of animals died due to weather stress, their liability would be higher if they had a report forecasting stress than if they did not have such a report automatically delivered to them.

The pilot study started with 19 CAFO operators in 3 counties of central Missouri. The pilot group of CAFO operators began receiving emailed reports in October, 2004. The growing season was almost over and harvest underway. Some were planning for their fall pump down of lagoons and cleanout of poultry litter.

We have collected no quantifiable data on decisions made as a result of the reports. The objective of the pilot group was to test the system and receive

feedback on how the information could be better organized, presented and processed. In follow-up meetings and discussions with pilot participants the following points were made.

First, though the emailed reports contain the most precise information available they do not necessarily present the most accurate. The reports are generated at 4:00 p.m daily and presents information that may be several hours old. The report may not be accessed and used until the next day, when weather may have changed. Radio and TV may provide more accurate, up-to-date information during volatile weather situations.

Radio weather information is still the most accessible. The weather reports are emailed in tabular form without graphics to foster quick downloads over slow rural internet connections. The 3-5 minutes that it takes to turn on the computer, connect to the internet and check email or their personal web page reports is still longer than instant radio weather information. Busy farmers view the 3-5 minutes as a hurdle to access. Participants in the pilot area of central Missouri also have access to several National Oceanic and Atmospheric Administration (NOAA) Weather Radio frequencies. These stations broadcast continuous weather information direct from a nearby NWS office. Receiving the broadcasts requires a special radio receiver but the participants indicate that their trucks and combines come equipped with these receivers.

One participant suggestion was that the daily report stored on his personalized web page be structured in such a way as to permit him to download it on his personal digital assistant (pda) every morning via AVantGo. Every

morning he puts his pda in its docking station where it downloads the latest report (along with other selected web pages) so that it is available to him throughout the day when he wants to peruse it. This feature overcomes the accessibility problem of waiting by the computer to gain an additional report. Number of visits to the personal web pages indicates that few other participants use their personal web page to access the latest weather report.

Another enhancement that has been requested is that more advisory information be provided by processing the weather information through more scientific models that use weather data. Specifically requested models include grain storage and drying advice, and hay curing estimates. Recent funding has been obtained to add weed scouting advisories that use growing degree days to forecast when specific weeds will emerge. The more advisories that are made available, the more useful the information becomes to those wanting those advisories. We are currently adjusting the personalized web pages to allow users to pick from a list of advisories the ones they wish to receive.

One of the preliminary findings that we have made is that we really do not know how farmers use weather information to make decisions. Mjelde et al. (1988) used discrete stochastic programming to model the fact that prior actions and states of nature affect subsequent decisions. But no other literature was found that attempted to look at how farmers use weather information from a dynamic decision making perspective.

An interesting example was how CAFO operators ranked some regulations as more constraining on their actions than other regulations.

Missouri CAFO regulations very specifically state that if lagoon level rises above the maximum pump down level a violation has occurred and must be reported to the Department of Natural Resources. The same regulations state that manure application should be timed to minimize nitrogen and phosphorus movement to waters. But there is no clear demarcation of a violation of timing that must be reported. The CAFO operators indicated that even if the weather reports indicated a high probability of runoff they would land apply manure if they were approaching a lagoon storage violation. They would rather risk a potential violation than a clear violation.

This type of information is useful in designing regulations. It is conceivable that the application of lagoon effluent when the probability of runoff is high is a greater environmental hazard than having the lagoon level reach above its maximum pump down level. But the incentives from the regulatory agencies are to manage the storage level at the expense of increased runoff from land. Understanding where the greatest environmental risk lies, how CAFO operators view information in deciding how to manage their operations and writing regulations flexible enough to minimize those risks would potentially aid environmental quality.

The participants in the pilot study think the project provides valuable information and has the potential to provide more beneficial advisories. The current major advisory of probability of runoff is seasonally needed and not perceived as the greatest need by the CAFO operators. All have expressed a desire to continue the program. All polled indicated that they would encourage

others to use the service. It is unclear how much they would be willing to pay for the service should it become a fee based program.

Because the infrastructure has been developed and communication exists over the internet, the operating cost of the program is minimal. Registering participants and finding their site specific information is the greatest cost to the University. Much of the information provided by the NWS is being provided on a trial basis. Should they decide that the information is not being used enough to justify its expense, our program would be unable to continue.

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Figure 1. Sample weather report

January 11, 2005

Notice:
Remember, your "Weekly Weather Report" is prepared each day based on new weather information. You can retrieve your report on any given day by using your personal web page for this project. The address to access your web page is ag3.agebb.missouri.edu/moagweatherpilot/clientdata/login.asp . If you need assistance with logging into the system, please contact John Travlos at agebb@missouri.edu or 573-882-4827.

Weekly Weather Report for Chad Murphy - Field #1

Advisories:	
Livestock Safety Index	
Today	COMFORT
Tonight	COMFORT
Tomorrow	COMFORT

Est. Rainfall Needed for Runoff (Soil Category: Very Slow Infiltration Soil)			
	01/11	01/12	01/13
Bare Soil	0.30	0.13	0.13
Row Crop - Conservation practices in place.	1.12	0.47	0.47
Row Crop - Without conservation practices.	0.47	0.20	0.20
Hay	1.34	0.56	0.56
Pasture (Cool Season) - Good condition.	1.19	0.50	0.50
Pasture (Cool Season) - Poor condition.	0.59	0.25	0.25

Pasture (Warm Season) - Good condition.	1.19	0.50	0.50
Pasture (Warm Season) - Poor condition.	0.59	0.25	0.25

Forecast Information:				
Date	01/11	01/12	01/13	01/14
Precipitation				
Inches	0.05	0.58	0.00	0.00
Probability	50%	90%	40%	10%
Temperature				
Min (°F)	--	34	28	6
Max (°F)	35	57	30	13
Wind				
MPH	10-15	10-15	15-20	
Direction	NE	SE	N	

Historical Information:				
Date	01/07	01/08	01/09	01/10
Precipitation in Inches				
Versailles	0.00	0.00	0.01	0.20
NWS	0.00	0.11	0.00	0.00
At Farm	na	na	na	na
Temperature				
Min (°F)	18	25	27	32
Max (°F)	32	32	57	47
Soil Conditions				
Moisture 2"	0.54	0.57	0.59	0.59
Temp 2" (°F)	33	34	36	38
Temp 4" (°F)	35	35	36	38