An Economic Analysis of Groundwater Nitrate Pollution Control in Dairy-Intensive Watersheds

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This project develops a mathematical programming model for assessing the economic costs and environmental effects of groundwater nitrate pollution control strategies in dairy-intensive watersheds. The programming model is an optimization model that derives the anticipated response of a farmer to a given set of operating conditions. This allows us to predict the effects of nitrogen regulations on farm production, farm income, and waste emissions. The model includes components for farm-level decision-making, herd and crop production, waste generation and reuse, and nitrogen emissions to the environment.

Previous work on nutrient pollution from animal feeding operations relies on models that greatly simplify the farm management problem. For example, temporal aspects of the problem are not addressed and the possibility of shifting pollution from one environmental medium to another is not considered. These simplifications can lead to prediction errors in pollution control policy simulations. Therefore we propose a much more detailed farm-level model that gives explicit treatment to temporal aspects of the farm management problem and allows for cross-media pollution effects, among other innovations.

Three sources of temporal effects are incorporated into the model. First, the dynamic nature of managing a dairy herd implies a farmer's optimal response to changing operating conditions will not necessarily be instantaneous. Rather, there may be a gradual transition from one herd profile to another. Second, dairies apply organic nitrogen which must be mineralized before it can be leached. And third, nitrogen emission rates depend on the stock of soil nitrogen which evolves through time. We also allow for modifications to the waste handling system that control how much waste nitrogen is emitted as nitrate to groundwater and as ammonia to the atmosphere.

Our findings are summarized as follows. The estimated cost to implement an effective nutrient management plan is at least twice as high as previous estimates, owing to both differences in model structure and farm characteristics. We find that in addition to off-site hauling of waste, shifting emissions from nitrate to ammonia is an important response by farmers when cross-media regulations are not implemented; and herd reductions are an important response when such regulations are implemented. With regard to temporal effects, we find that although initial reductions in nitrate leaching occur quickly, new steady state levels are not achieved for approximately 7 to 9 years.

Professional Presentations

Baerenklau, K.A. and N. Nergis, Controlling Dairy Nitrogen Emissions: A Dynamic Analysis of Herd Adjustment, Ground Water Discharges, and Air Emissions, Annual Meetings of the American Agricultural Economic Association, Long Beach, CA, July 2006.

Collaborative Efforts

This project has benefited greatly from discussions with Dr. Thomas Harter, Cooperative Extension Specialist, UC Davis.

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