

# **Integrated Nutrient Management**

## **Crossing Discipline Boundaries for Improved Farm Sustainability**

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### ***Agriculture and the Environment***

Environmental legislation enacted in the 1970s and subsequent litigation challenged the agricultural community on several levels. The Clean Water Act (1972) gave the United States Environmental Protection Agency (USEPA) the authority to implement pollution control programs for industries (an initial focus on point sources). In essence, this law requires nutrient management planning to occur on farms of all sizes and innovative feed management to reduce nutrient loading. In addition, the Federal Safe Drinking Water Act (1974) required water quality standards for surface water systems such as the one that served New York City's 9 million residents. This would have meant filtration of 1.2 billion gallons of water daily coming from a 1,215,000 acre watershed, at a construction cost of 5 to 8 billion dollars, and 200 to 500 million dollars in annual operating costs (Chapman and Coombe 1996).

Faced with these challenges, policy makers, residents of New York City, farmers and landowners, looked to Cornell University for support. Dr. Danny Fox was one of the leaders in the scientific community to recognize and respond to these varied challenges and requests for support.

### ***Dairy Farm Sustainability Project***

In 1991, a lawsuit was brought against Southview, a large dairy in Wyoming County, NY. Based on provisions in the Clear Water Act, the lawsuit contended that the dairy was a Concentrated Animal Feeding Operating (CAFO), and therefore subject to federal and state regulation as a "point source" polluter. In 1993, in anticipation of even greater challenges that livestock agriculture would be facing, Dr. Danny Fox, professor at the Department of Animal Science at Cornell University, pulled together research and extension professionals from eight departments within the College of Agriculture and Life Sciences and the College of Veterinary Medicine, to establish a cross-discipline, systems approach to emerging issues. This group's expertise and teamwork was crucial in establishing multi-disciplinary scientific approaches to agricultural environmental management in New York.

Danny's "Dairy Farm Sustainability" (DFS) group was there to provide scientific guidance and one of the stipulations of the court settlement for the Southview lawsuit was that this group would receive the fine imposed on the dairy farm to provide funding for research and extension that would address the long-term sustainability of the dairy sector.

Members of the DFS group were instrumental in establishing the Agricultural Environmental Management (AEM) program, a program that over the years grew into the primary New York State body responsible for agricultural environmental policy development and regulation. Currently nearly 8,000 New York State farms participate in the AEM planning process ([www.nys-soilandwater.org](http://www.nys-soilandwater.org)).

Danny firmly believed that the ability to develop comprehensive and sustainable farm plans was limited more by the failure to integrate existing information than the lack of knowledge. "*Knowledge integration*" became the mantra of the DFS group, established and chaired by Danny. The stated goals of this group were:

*"To reduce non-point source pollution of dairy farms through the adoption of integrated nutrient-balance management systems; to test the effectiveness of farmer-based management experiments in enhancing farm profitability and environmental quality; to develop a training strategy for farmers, extension staff, students and faculty to integrate scientific knowledge through computer modeling; and to build a partnership through which farmers, extension staff, students and university faculty engage in research and extension to improve farm profitability and sustainability."* (Malvicini, 1994).

The DFS group with strong leadership from Danny and a the commitment of faculty, staff, students, Cornell Cooperative extension educators, and producers conducted four major projects over the next five years which resulted in multiple MSc and PhD projects, journal articles, numerous professional and extension presentations, popular press and extension articles and impact at farm and state levels (e.g. Fox and Tylutki, 1998; Klausner et al., 1998; Hutson et al., 1998)<sup>1</sup>.

Danny especially encouraged the active involvement of producers and extension educators and because of his unique gift to make everyone feel valued, the DFS meetings were well attended meetings with spirited discussion. Danny insisted that meetings be held on a regular schedule, discussion include substantive content, lunch be provided and that the meeting ended on time. With Danny's leadership, the group was able to transcend professional differences so that each participant's contribution fit into a "bigger picture".

### ***The Need for Computer-based Decision Aids***

In 1999 the United States Department of Agriculture (USDA) and USEPA publish a document in 1999 entitled the "Unified National Strategy for Animal Feeding Operations (AFO's)" that outlined a framework of actions that USDA and USEPA planned to take to reduce water quality and public health impacts from improperly managed animal wastes.

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<sup>1</sup> Integrating Knowledge to Improve Dairy Farm Sustainability Final Report (1996). Animal Science Dept. Mimeo 213, ABEN Staff Report no. 96-1, ARME Research Bulletin 96-07, SCAS Research Series 96-4, Cornell University, Ithaca NY. 14853.

The release of the Unified National Strategy was followed by the signing of the “CAFO (Concentrated AFO) Final Rule” on December 15, 2002 (USEPA, 2003). This Final Rule requires CAFOs to have comprehensive nutrient management plans (CNMPs) developed and implemented by December 31, 2006.

Under current regulations, nutrient management plans in New York (like many other states) need to be developed in accordance with the New York Natural Resources Conservation Service (NRCS) 590 standard for nutrient management (NY590). The NY590 standard focuses on reducing risk to water quality as the result of over-application of fertilizer and manure, and prevention of direct manure losses to streams and lakes through the use of the phosphorus (P) runoff index, the nitrate leaching index, and Cornell University crop nutrient guidelines.

Danny Fox understood the complexity of the issues farmers and their advisors were dealing with and had realized years earlier that computer programs were needed to aid in nutrient management. Danny became well-known nationwide (and internationally) for his leadership in the development of the Cornell Net Carbohydrate and Protein System (CNCPS) and other papers in this symposium address this aspect of Danny’s career. However, few might know that it was Danny as well who obtained the initial funding to develop Cornell Cropware, CNCPS’s sister program and the NRCS approved crop, manure and fertilizer software program for nutrient management planning in New York. In the absence of a nutrient management extension faculty member in the Department of Crop and Soil Sciences (the faculty position was open at the time), Danny put together a team of people including Karl Czymmek (PRODAIRY), Caroline Rasmussen (research support specialist in Danny’s program at the time), Vijay Durbal (CNCPS programmer), and Greg Albrecht (then a MSc student with Danny). I was fortunate to be offered the nutrient management position in the Department of Crop and Soil Sciences and upon arrival at Cornell University in the fall of 2000, Danny immediately invited me to join the group. We worked together with NRCS, the New York State Department of Agriculture and Markets (NYS DAM) and Department of Environmental Conservation (NYS DEC) and stakeholders to expand upon an existing Excel-based spreadsheet (Bannon and Klausner, 1997) and developed Cornell Cropware, a Visual Basic-based software tool. The first release of Cropware (Cropware 1.0) took place in August 2001 followed by numerous training sessions for NRCS and Soil and Water Conservation District staff, extension educators, private consultants and farmers.

In 2001, Danny handed over the responsibility for the development and extension of the software to my program in the Department of Crop and Soil Sciences but we continued to develop collaborative projects focusing on both new releases of the software programs (Cropware 2.0 was released in 2003) and their integration.

### ***Multi and Interdisciplinary Programming***

Cornell Cropware is designed to integrate information on soils, crop nutrient requirements for each field and rotation, hydrologic sensitivity, the quantity and nutrient content of manure, and the New York Phosphorus Index and Nitrate Leaching Index (Ketterings et al., 2006). CNCPS is focused on balancing rations to minimize N and P excretion and optimize milk production. Danny realized it was essential for the many disciplines, research, and extension, and teaching to become integrated. Neither (herd nutrition or field crops nutrient management) could address systematic nutrient

imbalances on farms alone. Multidisciplinary teams would be essential to address the challenges faced by the dairy industry and Danny continued to work diligently to try to put these teams together. These past six years until Danny's retirement, we developed many joint projects to enhance our software tools, to better understand nutrient flows on farms, and to develop tools and design best management practices that address the long-term sustainability of the dairy sector.

### ***CALS Integrated Nutrient Management Program Work Team***

When the college extension administration introduced Program Work Teams and Councils as a means for greater stakeholder involvement in 2001, Danny played a leadership role in the establishment of the CALS Integrated Nutrient Management for Dairy and Livestock Farms in New York Program Work Team (CALS INM PWT). This PWT resulted in enhanced communication among key departments and faculty members and between campus and stakeholders, initiated discussions within CALS, and led to many multidisciplinary projects, including a workshop on "Developing and applying the next generation of tools for farm and watershed nutrient management to protect water quality" held at Cornell University in December 2001, a seminar series on "Whole-farm nutrient management on dairy farms to improve profitability and reduce environmental impacts", collaboration with The University of Wisconsin-Madison and the USDA-ARS Dairy Forage Research Center ([www.dfrc.ars.usda.gov/powell/wholefarm.html](http://www.dfrc.ars.usda.gov/powell/wholefarm.html)), and a project in collaboration with USDA-ARS Beltsville and the University of Vermont that resulted in a website on nitrogen management on dairy farms ([www.dairyN.cornell.edu](http://www.dairyN.cornell.edu)).

### ***Cornell Undergraduate Teaching***

In 1997, as it became obvious that managing environmental impacts of farming and operating according to regulations would become a required responsibility of those working in agricultural production, Danny and colleagues in the Department of Animal Science at Cornell University started teaching a course "Livestock and the Environment" (AS 412) to educate students on issues surrounding the use of animals for food and managing nutrients more efficiently across the whole farm to reduce their impact on the environment. Greg Albrecht was the teaching assistant of the course during his graduate program. Following graduation, Greg joined my newly established Nutrient Management Spear Program (2002) and together with Danny, we revised AS 412 into a cross-listed course (AS/CSS 412) entitled "Whole Farm Nutrient Management". The revised course, first taught in its current format in 2003, was developed with two modules. Module I addressed agricultural environmental policy, the basics of soil and crop nutrient management, and the development of a nutrient management plan for an actual dairy farm (Albrecht et al., 2006). The second module was designed to teach students how to manage nutrients more efficiently in feeding the dairy herd to reduce excess nutrients on the farm. This course, in its current format, has been taken by 140 students.

### ***The Future: Whole Farm Nutrient Management***

Whole farm nutrient management requires a means to measure, track and analyze the impacts of management on nutrient flows across all farm systems (i.e. from soil and

manure to crops to storage to feed to milk). To address current challenges, research should focus on identifying opportunities for greater on-farm nutrient cycling and more balanced production systems that protect the environment and are economically sustainable. Actual water quality monitoring data are difficult (time-consuming and very expensive) to obtain. A more practical and more sustainable approach is to use computerized feed rationing models and nutrient management planning tools to assess nutrient imports and farm balances over time (annually) on both the whole farm and the watershed level. We still have work to do but it is thanks to the foresight, dedication, and management skills of Danny Fox that department and discipline boundaries were broken down and collaborations built up. Thanks Danny!

### *References*

1. Albrecht, G.L., Q.M. Ketterings, K.J. Czymmek, M. van Amburgh, and D.G. Fox (2006). Whole Farm Nutrient Management: Capstone course on environmental management of dairy farms. *Journal of Natural Resources and Life Science Education* 35: 12-23.
2. Bannon, C.D. and S.D. Klausner (1997). Application of the Cornell Nutrient Management Planning Systems: predicting crop requirements and optimum manure management. *In: Cornell Nutrition Conference for Feed Manufacturers*. Ithaca, NY. October 21-23, 1997.
3. Chapman, D. and R.I. Coombe (1996). The Watershed Agricultural Program of the New York City Watersheds: People, Pathogens, and Phosphorus. *In: Proceedings from the Animal Agriculture and the Environment Conference*. NRAES-96. Rochester, NY. December 11-13, 1996.
4. Fox, D.G. and T.P. Tylutki (1998). Dairy Farming and Water Quality I: Problems and Solutions. *In: Proceedings from the Dairy Feeding Systems Management, Components and Nutrients Conference*. NRAES-116. Camp Hill, PA. December 8-10, 1998.
5. Hutson, J.L., R.E. Pitt, P.K. Loelsch, J.B. Houser, and R.J. Wagenet (1998). Improving Dairy Farm Sustainability II: Environmental losses and nutrient flows. *Journal of Production Agriculture* 11(2): 223.
6. Ketterings, Q.M., G.L. Albrecht, C.N. Rasmussen, and K.J. Czymmek (2006). Cornell Cropware: Decision support tool for fertilizer and manure nutrient management planning. *Journal of Natural Resources and Life Sciences Education* 35: 140-151.
7. Klausner, S.D., D.G. Fox, C.N. Rasmussen, R.E. Pitt, T.P. Tylutki, P.E. Wright, L.E. Chase, and W.C. Stone (1998). Improving Dairy Farm Sustainability I: An approach to animal and crop nutrient management planning. *Journal of Production Agriculture* 11(2):163.
8. Mulvicini, C. (1994). Integrating Knowledge to Improve the Sustainability of Dairy Farms in New York State Progress Report. Cornell University, Ithaca NY. 14853.
9. U.S. Environmental Protection Agency (2003). Concentrated animal feeding operations (CAFO) - Final Rule (68FR7176). Available at <http://cfpub.epa.gov/npdes/afo/cafofinalrule.cfm> (verified September 10, 2006).