Water and Nutrient Management Planning —

A New Paradigm for the Nursery and Greenhouse Industries

In light of increased EPA regulation of the floriculture industry, growers should start evaluating fertilizer use and greenhouse runoff. A new program developed at the University of Maryland provides an easy to use model that is applicable to most growing operations.

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Writing a nutrient management plan requires close examination of every aspect of a growing operation. (All photos courtesy of John Lea-Cox.)

In 1998, the state of Maryland passed the toughest nutrient management law in the nation, requiring virtually all agricultural operations to write and implement nitrogen (N) and phosphorus (P)-based management plans by December 2002. This was in reaction to an outbreak of the organism *Pfiesteria* in some tributaries of the Chesapeake Bay that induced fish kills and had negative health effects on some local fisherman. When the governor formed a task force to determine the cause of this outbreak, it was concluded that water quality, excess nutrients and especially high levels of phosphorus in tributary waters of the Chesapeake Bay were mostly responsible.

You are probably asking, "Well, why are greenhouse operations included and what actually does this nutrient management law regulate?" Firstly, the law was written very broadly to include all of agriculture and even urban applications of inorganic fertilizer to landscapes, since nutrient runoff from all these sources can impact the Bay. Secondly, the law requires a nutrient management plan from all producers to ensure that anyone applying nutrients from either inorganic (chemical) or organic (manure) sources can account for the nutrients that are applied and to make sure that nutrients are not applied in excess of crop requirements. In other words, it is an accounting system for nutrient applications.

However, nutrient applications are just part of the story for the container nursery and greenhouse industries. Water is also an integral component of the nutrient management equation, especially in situations where irrigation or rainfall has the ability to move soluble nutrients with ease. As you will see, we have tried to formulate a water and nutrient management process that utilizes a systems-based approach. This allows us to look not only at nutrient movement from a physical point of view, but it also enables us to incorporate management factors that may influence nutrient leaching and runoff from nursery or greenhouse production sites.

THE MARYLAND SITUATION

The Maryland Water Quality Improvement Act, passed in 1998, requires nutrient management plans to be written for all agricultural operations over 10 acres in size or that have a gross annual income of more than $2,500. In effect, the last clause includes many smaller growers with far less acreage under production. The legislation also mandates the training of professionals who write these plans so that they are written effectively and meet legislative requirements. To ensure that plans are implemented, any person who applies nutrients to agricultural operations must also receive "best management practice" training.

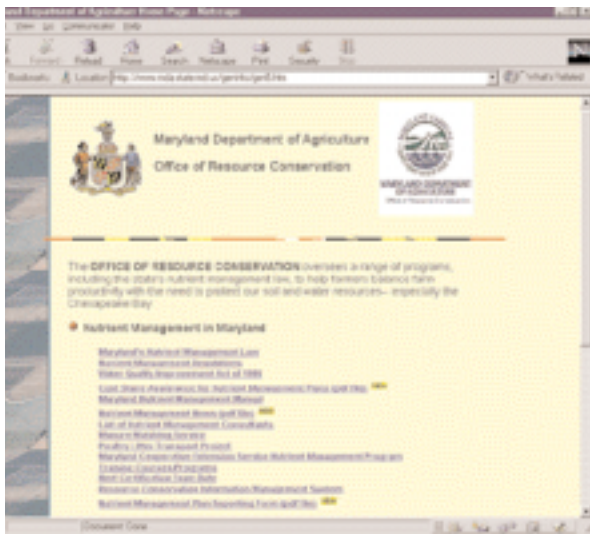
The regulations that put this law into effect were finalized by the Maryland Department of Agriculture (MDA) on May 30, 2000. Further details on the law and the nutrient management regulations can be found at the MDA Office of Resource Conservation Web site at http://www.mda.state.md.us (see Fig. 1).

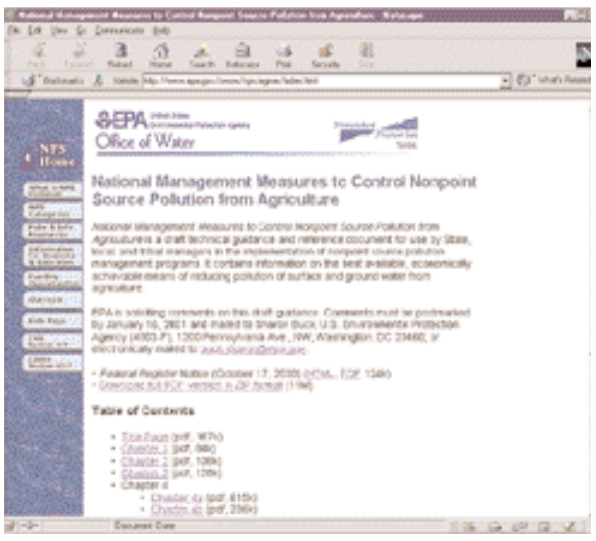
THE FEDERAL SITUATION

Maryland is not the only state now facing nutrient management regulations. The Environmental Protection Agency (EPA) announced in August 1999 that it is preparing to enforce a largely ignored part of the federal Clean Water Act of 1972, requiring states to take aggressive steps to lessen pollution in 20,000 of the nation's rivers, lakes and bays. Draft national measures to control non-point source pollution from agriculture were published in the Federal Register in October 2000 and can be found at www.epa.gov/owow/nps/agmm/index.html (see Fig. 2).

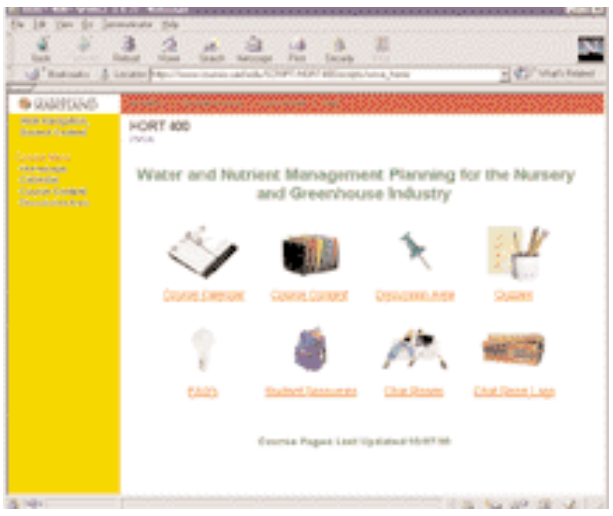
Until now, individual states have been granting permits that mainly cover the kind of technology that must be used by steel mills, wastewater plants and other specific sites of "point-source" pollution to make sure their discharges do not exceed federal health standards.

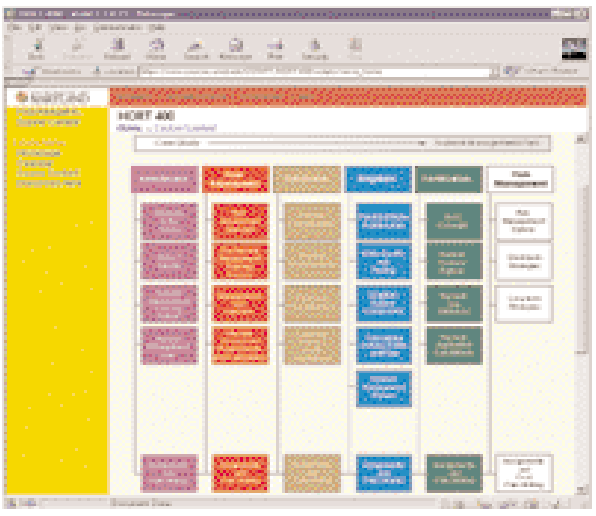
The new EPA proposal broadens the focus of the law from monitoring specific discharges of pollutants from individual point sources, to instead focus attention on the overall quality of a body of water. This takes



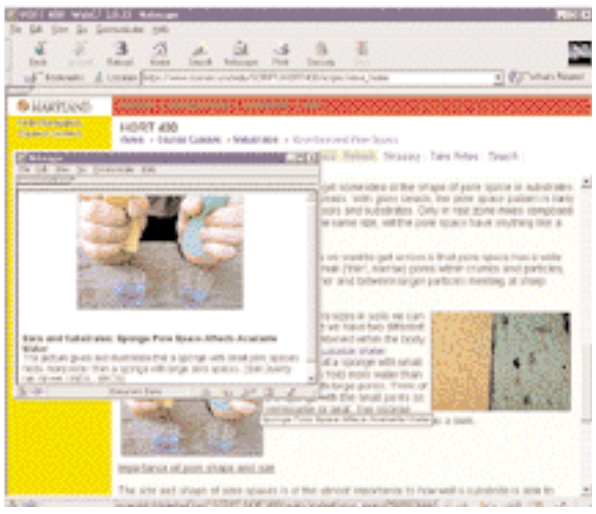


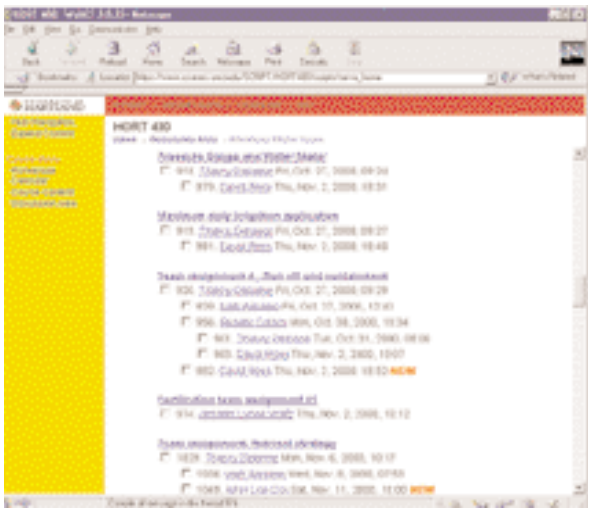
Left to right: Figure 1, Maryland Department of Agriculture nutrient management Web site; Figure 2, EPA Office of Water Web site; Figure 3, EPA Non-Point Source Web site.





Left to right: Figure 4, EPA Surf Your Watershed Page; Figure 5, HORT 400 Course Page ; Figure 6, HORT400 Course Content.





Left to right: Figure 7, HORT400 Content with Diagram overlay; Figure 8, HORT400 Discussion Fora .

into account the ability of a body of water to handle contaminants from all the point and non-point sources of pollution that enter it.

The focus on overall water quality requires each state to set a limit, known technically as a "total maximum daily load," for each body of water. So, for the first time, states would be forced to reduce "non-source" pollution from more diffuse sources, including agricultural and urban runoff. This kind of pollution is more difficult to measure and control, but it is now the major threat to the nation's rivers, streams and lakes, accounting for an estimated 60 percent of current water pollution.

For each body of contaminated water, each state will have to negotiate with all parties responsible for the pollution to determine what has to be done — and who pays for the cleanup. States will have to submit their cleanup plans within two or three years, which in some cases could involve tightening restrictions already in place for identified polluters. States will then have several additional years to make sure the plans are implemented. If a state shirks its responsibility, the federal government would have the authority to intervene.

Current estimates are that some two-fifths of the waterways in the United States do not meet these requirements. To see whether your watershed is clean, you might want to check out the EPA Office of Wetlands, Oceans and Watersheds Web site at www.epa.gov/owow/ (see Fig. 3) and "surf your watershed" for relevant information at www.epa.gov/owow/watershed/ (see Fig. 4).

THE NUTRIENT MANAGEMENT PLANNING PROCESS

The traditional (soil-based) nutrient management process usually takes a nutrient balance approach (Beegle, et al., 2000) to developing plans. This process:

- determines the presence and availability of nutrients in the soil;
- determines the nutrient removal over the season by the crop, based on knowledge of the cultivar, growth rate of the crop and the nutrient concentrations in the biomass removed, or that which remains on the land;
- adds an "efficiency factor," which is based on nutrient removal by other mechanisms (e.g., microbial use, soil fixation, soil erosion, etc.); and
- determines fertilizer application rates for each crop, soil type and/or field based on the factors outlined above.

However, developing plans for the greenhouse industry using this method is very difficult, since

Half-day meetings at a nursery help students with specific problems unique to each nursery.

these operations grow a large (>500) number of ornamental plant species and cultivars, using a number of different fertilization and irrigation techniques. Crop cycles, ranging from a minimum of four to six weeks in greenhouse production to upwards of 10 years in nursery field production, complicate the planning process. In addition, we have an inadequate knowledge of optimal nutrient requirements for many ornamental species. Lastly, unique site characteristics and infrastructure may also contribute to water and nutrient runoff and need to be considered when writing plans.

The challenge is to identify a simple, cost-effective process that:

1. provides an accurate assessment of nutrient loss potential from this wide variety of production scenarios;

2. identifies those specific (i.e., infrastructure or management) factors that contribute most to nutrient leaching and runoff; and

3. provides a mechanism to assess the efficiency of the various production scenarios.

In reality, it comes down to a few questions. How do you capture site-specific data and write a nutrient management plan that accurately assesses the efficiency of practices in a nursery or greenhouse operation? In addition, how do you develop a simple set of assessment techniques that can be used for very different operations, but still provide an adequate measurement of the N and P leaching and runoff potential? Most importantly, how do you objectively evaluate the efficiency of the operation and formulate specific recommendations to implement a nutrient management plan without placing an undue economic burden on the business?

WRITING NUTRIENT MANAGEMENT PLANS

Working toward the goals outlined above, we have developed a relatively simple nutrient management planning process that is based on risk assessment and risk management techniques. In keeping with our systems-based approach, we consider site factors, substrate, irrigation and fertilization practices that can all contribute to nutrient runoff from the site. In consultation with the grower, the planner develops a set of "management units" that groups plant production into the least possible number of units, in order to simplify the planning process.

In greenhouse or container nursery production, we purposely do not consider plant species as management units, unless those species constitute a large proportion of the annual production (e.g., poinsettias or pot chrysanthemums). Instead, we recommend that management units are based on factors that simplify the planning process, yet integrate water and nutrient flow that can be measured by a few "key" variables.

Our preferred management unit is container size because this integrates irrigation interception efficiency (plant density), leaching fractions (irrigation duration), container height and substrate physical properties into a runoff potential equation. An assessment of the fertilizer source, the nutrient concentration (or rate) applied and the frequency of application provide nutrient loading rate data. When these data are combined, we have an objective assessment of the total maximum daily nutrient load from that management unit. The maximum daily nutrient load from each management unit is then integrated into an assessment of the production site to determine whether containment structures or riparian areas effectively mitigate this nutrient loading. In this way, we gain a more complete picture of the potential risk for nutrient runoff.

The key variables used to calculate the loading rates are measured and scored utilizing a set of criteria developed to comply with the Maryland regulations. We use a weighted risk assessment table to rate the variables within each management unit and identify the highest risk factors. By evaluating different risk reduction options for these high risk factors, the grower and the consultant can then choose economic alternatives to reduce the nutrient runoff potential.

The reason that we have chosen this approach is simple. Every nursery or greenhouse operation has different irrigation and fertilization practices, not to mention site characteristics that contribute to the chance of nutrient runoff. By developing a flexible process that can assess and manage the risk of nutrient runoff, we hope to train nutrient management planners to be able to walk into any nursery or greenhouse operation and write a nutrient management plan that will be easy to assess and implement.

Ultimately, the effectiveness of any risk assessment depends on risk management and implementation. By lowering the assessed value of a particular factor with a set of alternative best management practices, the overall system risk is reduced. For example, the effects of high concentrations of soluble fertilizers can be mitigated in a number of ways, including reducing the concentration of fertilizer, reducing the frequency and duration of nutrient application, adopting a slow-release formulation or containing the leachate and runoff in containment ponds and recycling effluent. However, it may not be economically possible or even necessary to lower the risk of all individual factors since we are measuring a matrix of factors, and one factor may have a disproportionate effect on the overall outcome. The flexibility of this risk management process is particularly useful to the grower or manager who must examine the various alternatives, evaluate the economic cost of changes and determine the practices that must be changed to achieve a reduction in risk.

TRAINING NUTRIENT MANAGEMENT PLANNERS

Since no state has required mandatory nutrient management plans from nursery or greenhouse operations up until this time, few people have had the incentive to formulate approaches to deal with this kind of regulation. Also, since the environmental risk assessment/risk management concept is relatively new in agriculture, it has necessitated that we provide a readily accessible learning environment to teach these principles.

The preparation of these types of nutrient management plans requires the synthesis of knowledge and skills from a number of different disciplines, including soils and soilless substrates, plant nutrition, irrigation and surface water management, which are then integrated into the risk assessment/ management process.

We chose a Web-based format for delivering the course, since nursery and greenhouse professionals are busy and widely dispersed

throughout the state. The course content is made available using WebCT courseware, an online learning environment. Registered students can access the course any time and any place convenient to them by logging on through the World Wide Web using any type of Web browser (see Fig. 5). The course consists of six content modules covering the areas necessary to understand the water and nutrient management planning process (see Fig. 6). These six modules are supported and enhanced by text resources, hypertext links to external Web sites and resources, photographs, graphic illustrations, Powerpoint slides and video clips (see Fig. 7).

An unusual feature of the course is that we partner the students in the course — growers, consultants, extension professionals and university students — into teams. Each team writes a nutrient management plan for a real nursery or greenhouse operation during the course (see Fig. 8). This is very often the operation of the grower on the team. By teaming these students, they not only apply the theoretical knowledge from the course, but also capture the experiential knowledge of the various professionals on the team, in situations where teams are faced with real-life challenges. The emphasis is on critical thinking skills, which are prerequisites for writing site-specific nutrient management plans. Involving the industry professionals also allows us (the instructors) to capture practical methods to achieve these goals and refine the process through critical feedback.

We use individual and team discussion forums in the course to post information about each operation, exchange ideas and discuss problems. By sharing the development process for a number of different plans, each person has the opportunity to critically assess and learn from the approach taken by other teams when unusual situations arise. The site-specific nutrient management plan is the final product for the course.

This Web-course is delivered over a 16-week period, as the content requires time to assimilate and plan development is often detailed. Based on a beta-test of the course in 1999, we added five half-day "face-to-face" meetings at various nursery and greenhouse locations during the course delivered in fall 2000 (see Fig. 10). These on-site meetings allow the teams to not only see the physical layout of each operation, but also gives them time to exchange ideas and ask direct questions. We have found that this motivates individual team members with individual and team assignments, and allows us to pace the course more effectively.

Thus, this process not only gives the manager an assessment of the nutrient runoff potential from the

nursery or greenhouse operation, but it also gives an insight into the cost-effectiveness of major cultural inputs and decisions in their business. The process can also provide the grower with data on the efficiency of the business and a range of alternatives to improve production and perhaps increase profitability.

OUTREACH

Since there appears to be a growing interest in nutrient management planning for nursery and greenhouse operations, we have developed a Web site to regularly provide information updates on our process. The site was developed with four major objectives in mind:

- to provide a synopsis of the various provisions of the Water Quality Improvement Act (the Maryland law) and links to full copies of the regulations;
- to provide technical information on the nutrient management planning process, with explanations of the various requirements;
- to provide links to nutrient management resources and tools; and
- to provide a repository of up-to-date information on water and nutrient management research.

Although this Web site, at www.agnr.umd.edu/users/nutrient/nursery/home.html, is specifically geared towards the Maryland situation, we feel that many of the same principles and techniques will also apply to a wide range of situations throughout the United States.

By taking a tributary strategies approach to reducing non-point nitrogen and phosphorus in rivers and streams that flow into the Chesapeake Bay, Maryland is leading the nation in formulating agricultural clean water programs at all levels. Our task is to ensure that the nutrient management process is as easy and cost-effective as possible, and that it maintains the profitability of all farm-based businesses.

RESOURCES

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