U.S. Environmental Protection Agency

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ABSTRACT

The Ecological Processes and Effects Committee met on October 28-29, 1993, to review the Midwest Agrichemical Surface/Subsurface Transport and Effects Research (MASTER) Program. The MASTER Program is an inter-agency effort between EPA, the U.S. Department of Agriculture, and the U.S. Geological Survey, designed to assess the impacts of agricultural practices on the watershed scale. EPA's participation in MASTER has focused on the ecological effects of agricultural best management practices (BMPs). The Committee strongly supports EPA's involvement in research such as MASTER to assess the impacts of nonpoint source (NPS) pollution in agroecosystems and in seeking ways to attain sustainability and ecological quality in agriculture. The MASTER Program provides the opportunity to consider not only the ecological effects of toxic chemicals, but to include a broader consideration of stressors such as habitat alterations associated with various agricultural BMPs which may have ecological consequences equal to or greater than those from agrichemicals. The Committee urges the Agency to continue support for the MASTER Program beyond the development of models and baseline data in the pilot watershed so that the predicted effects of management changes in the watershed can be compared to results from field tests.

KEYWORDS: agroecosystems, best management practices, nonpoint source pollution, watershed assessment

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1. EXECUTIVE SUMMARY

The Ecological Processes and Effects Committee has reviewed the goals and progress-to-date of the Midwest Agrichemical Surface/Subsurface Transport and Effects Research (MASTER) Program. The MASTER Program is a cooperative effort between EPA, the U.S. Department of Agriculture (USDA) and the U.S. Geological Survey (USGS) to assess how agricultural practices impact overall environmental quality, including ground and surface water quality and ecological processes and populations in Midwestern farmlands. The research program is being conducted in the Walnut Creek Watershed in Iowa. EPA's participation in MASTER has been funded to-date under the Office of Research and Development's (ORD) Nonpoint Source Issue Plan at approximately $2 million in FY92 and approximately $1.5 million in FY93 and FY94. The overall goal of MASTER is to provide the scientific and ecological bases for the development and implementation of agricultural best management practices (BMPs) that both promote economically viable agroecosystems and prevent degradation of the nation's water quality and ecological resources.

The Committee strongly supports EPA's involvement in research to assess the impacts of nonpoint source (NPS) pollution in agroecosystems and in seeking ways to attain sustainability and ecological quality in agriculture. The MASTER Program represents a unique inter-agency effort to scientifically develop and test the effectiveness of alternative ecosystem design and management scenarios, and thus offers an excellent model for management at the watershed level. In addition, it was evident to the Committee that the interdisciplinary team is well-qualified, enthusiastic, and committed to the program. The team has clearly had the benefit of strong leadership and has been productive over the two years that EPA has been involved in MASTER.

We agree that EPA's unique contribution to MASTER should be in the area of ecological effects. Developing the ecological effects capability at the watershed/landscape level is an important, innovative purpose for MASTER and among the federal collaborators, only EPA is likely to provide this focus. The MASTER Program offers the opportunity to advance beyond the toxic chemical focus to a broader consideration of stressors. For example, habitat alterations associated with various agricultural management practices (e.g., loss of stream-side shading vegetation and increased turbidity from sedimentation) may have ecological consequences equal to or greater than those from toxic chemical stresses.

Among the potentially significant advantages of the MASTER approach is the use of an in-depth case study to test the effect of changes in management practices and then to select practices which provide optimal agricultural and ecological benefits. **We stress, however, that the MASTER Program's objective of reducing the ecological effects of agrichemicals and farm practices will not be realized without a long-term commitment to the program by the**

Agency. After two years of a planned five-year effort, the MASTER Program has invested considerable effort in developing the study baseline for the Walnut Creek Watershed and in developing models to predict how proposed management changes would affect the ecological indicators. The primary benefit of the case study approach (the ability to predict ecological consequences of changes in management practices in the watershed) will not be realized until the predicted effects of management changes can be compared to results from field tests.

Our recommendations for strengthening the MASTER Program are summarized as follows:

a) In accordance with the Agency's *Framework for Ecological Risk Assessment*, as part of the problem formulation stage, we recommend that the MASTER research team give immediate attention to a strategic planning exercise. The output of this exercise should be a plan for the integrated assessment which lays out the interactions between the various research components of the MASTER Program. An integrated assessment framework can serve as the "road map" for interdisciplinary interactions, provide a basis for selecting priority research activities, and relate the numerous projects being leveraged with other agencies to the goals of MASTER. In addition, the assessment strategic plan should emphasize the role that MASTER can play as an intensive monitoring location for agroecosystems in the Environmental Monitoring and Assessment Program (EMAP); clearly, the MASTER Program can make a very effective contribution to EMAP and vice versa. We urge the Agency to fully explore the links between these two programs.

b) The MASTER Program's integrated assessment framework must clearly demonstrate the ability to couple ground water and surface water parameters to watershed/ecosystem characteristics. An important consideration is the degree to which the models can separate effects due to changing management practices from natural effects due to weather variations, and the degree to which observed changes can be related to practices at the farm level, particularly for management practices which do not involve changes in land use or cropping patterns. We are concerned over the lack of discussion of variability, both in terms of measurement error and heterogeneity over space and over time. Given the complex nature of the MASTER assessment structure, which includes a mosaic of models, GIS descriptive parameters, exogenous influences, and inventories of biota, it is critical that the MASTER Program develop a well articulated statistical design to ensure the appropriate level of effort, location of sampling sites, and duration of experiments.

c) A stated objective of MASTER is to provide regional assessment by "scaling-up" from field or farm scales to watershed, ecoregion, and regional scales. From the information presented by the MASTER team, however, it is clear that more effort should be put into the development of "regionalization assessment techniques." We urge the MASTER Program to utilize data from other watershed research sites for independent validation of the models developed for the Walnut Creek Watershed. The scale-up from watershed to regional scales will be a major challenge and model validation at selected other sites is a necessary step in this process.

d) We commend the MASTER Program for including the soil environment as a legitimate ecosystem worthy of independent study. We encourage the MASTER Program to incorporate soil productivity and soil quality degradation endpoints in the assessment. As measures of soil quality are developed, it must be recognized that naturally occurring soils have a broad range of chemical and physical characteristics and vary greatly in their capacity to support micro- and macro-flora and fauna. Also, the assessment of soil quality/degradation should include not only the assessment of productive capacity as used in agriculture, but broader measures of ecological health as well (e.g., diversity of soil fauna and flora, processing of carbon, and nitrogen fixation).

e) While the study recognizes the significant role of habitat characteristics in determining the diversity and abundance of terrestrial wildlife, the researchers need to clarify the time delay between instituting certain management practices and observing an effect on bird (and/or mammal) populations. Furthermore, it appears that increased abundance and diversity of terrestrial wildlife was regarded as a desirable condition or trend. However, agricultural ecosystems are highly managed systems and the selection of endpoints for such systems must be based on a recognition that land management processes are now inherent components of the ecosystem.

f) And finally, in assessing aquatic habitats and biotic communities, we urge the MASTER Program to develop a balanced assessment design which evaluates the role(s) of both chemical and non-chemical stressors, e.g., via an ecological effects model that integrates the impacts of the various exogenous forcing functions.

2. INTRODUCTION

2.1 Background

The Midwest Agrichemical Surface/Subsurface Transport and Effects Research (MASTER) Program is a cooperative effort between EPA, the U.S. Department of Agriculture (USDA) and the U.S. Geological Survey (USGS) to assess how agricultural practices impact overall environmental quality, including ground and surface water quality, ecological processes, and biological communities in Midwestern farmlands. The research program is being conducted in the Walnut Creek Watershed in Iowa. The overall goal of MASTER is to provide the scientific and ecological bases for the development and implementation of agricultural best management practices (BMPs) that both promote economically viable agroecosystems and prevent degradation of the nation's water quality and ecological resources. EPA's participation in MASTER has been funded to-date under the Office of Research and Development's (ORD) Nonpoint Source Issue Plan at approximately $2 million in FY92 and approximately $1.5 million in FY93 and FY94. EPA's focus in the program is on developing the methods to design and evaluate BMPs at the watershed level, emphasizing ecological benefits, and to assess the ecological effects of agricultural practices at the regional scale (e.g., Western Corn Belt Plains Ecoregion).

2.2 Charge to the Committee

The Ecological Processes and Effects Committee met in Washington, DC on October 28-29, 1993, to review the overall goals and progress of the MASTER Program. In particular, the MASTER Research Team requested that the Committee consider the following questions:

a) Are the goals and objectives of the program clear and appropriate for the environmental problem being addressed?

b) Is the assessment approach appropriate for defining long-term research in the Walnut Creek Watershed?

c) Is progress toward interdisciplinary integration apparent?

d) Are the ongoing and proposed projects appropriate for evaluating and reducing the ecological effects of agrichemicals and farm production practices?

e) Is the research balanced between field testing, monitoring, and development of assessment methodologies within the Walnut Creek Watershed vs. the development and application of "regionalization assessment techniques" using Walnut Creek data and results?

f) Are there other watershed sites and cooperators that should be incorporated into the MASTER Program?

3. GENERAL COMMENTS

3.1 The Importance of MASTER

The Committee strongly supports EPA's involvement in research to assess the impacts of nonpoint source (NPS) pollution in agroecosystems and in seeking ways to attain sustainability and ecological quality in agriculture. Nonpoint pollution and habitat alterations associated with current agricultural activities are among the greatest stressors to the integrity of ecological systems. In order to address the difficult environmental problems and issues related to nonpoint source pollution, the Agency will need increased capabilities to assess the cumulative effects of a variety of diffuse sources within a watershed. The MASTER Program represents a unique inter-agency effort to scientifically develop and test the effectiveness of alternative ecosystem design and management scenarios, and thus offers an excellent model for management at the watershed level. It appears that an excellent working relationship has been established between EPA, USDA and USGS scientists, as well as among the EPA researchers on the team (from the Environmental Research Laboratories in Athens, Duluth, Corvallis and Ada, the Environmental Monitoring Systems Laboratory in Las Vegas, and a number of university investigators and contractors). By advancing environmental science at a watershed/landscape scale, MASTER will provide a scientific basis for evaluating policy and management options for addressing NPS pollution.

The relevance of watershed-based research like MASTER is underscored by legislative proposals currently before the U.S. Congress. The reauthorization of the Clean Water Act is correctly emphasizing the need to implement proactive watershed design and management practices. Pollution prevention, using BMPs or economic incentives, is considered the most effective method for managing agricultural pollution. This requires knowledge about the effectiveness of various BMPs on both watershed and landscape scales.

In addition to the importance of the MASTER Program's goals and objectives, it was evident to the Committee that the EPA interdisciplinary team is well-qualified, enthusiastic, and committed to the program. The team has clearly had the benefit of strong leadership and has been productive over the two years that EPA has been involved in MASTER.

The USDA has a great deal of data, expertise, and methodologies to characterize the effects of alternative agricultural management practices on chemical levels in field runoff, surface and ground water. The central reason for its collaboration with EPA on this project is to attain an ability to link these chemical responses with ecological effects, a capability currently lacking in the USDA program. We agree that the central focus for MASTER should be on the ecological effects linkages, only EPA is likely to provide this capability, the highly leveraged collaboration with USDA allows that focus for EPA, and developing the ecological effects capability at the

watershed/landscape level is an important, innovative purpose for MASTER. Applied assessments such as MASTER should also serve as an important "reality check" for the assessment of agrichemicals required under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), which currently relies heavily on interpretation of extensive laboratory studies with only limited field studies.

Additionally, the MASTER Program offers the opportunity to advance beyond the toxic chemical focus to a broader consideration of natural and anthropogenic stresses. In particular, habitat alterations associated with various agricultural management practices (e.g., loss of stream-side shading vegetation and increased turbidity from sedimentation) may have ecological consequences equal to or greater than those from toxic chemical stresses. While there is some attention at present in MASTER to non-chemical stresses, these appear to be treated as confounding factors which interfere with the assessment of chemical exposure/response relationships in the real world. An alternate perspective, consistent with the goals of MASTER, would be that each stressor should be examined for its relationship to ecological effects manifested in changes in endpoints. That perspective, and the experimental design considerations commensurate with it, should be incorporated into the MASTER Program.

Among the potentially significant advantages of the MASTER approach is the use of an in-depth case study to test the effect of changes in management practices and then to select practices which provide optimal agricultural and ecological benefits. **We stress, however, that the MASTER Program's objective of reducing the ecological effects of agrichemicals and farm practices will not be realized without a long-term commitment to the program by the Agency.** Ecosystem-level assessments such as MASTER, covering an entire watershed, require data inputs from several years to test cause-effect hypotheses accurately in the face of natural physical, meteorological and year-to-year variability. Agency budgetary and staffing commitments need to reflect the longer time frame required to complete this program successfully.

After two years of a planned five-year effort, the MASTER Program has invested considerable effort in developing a study baseline for the Walnut Creek Watershed and in developing models to predict how proposed management changes would affect the ecological indicators. The primary benefit of the case study approach will not be realized, however, until the predicted effects of management changes can be compared to results from field tests. The confirmation step is important not only for scientific, but also for policy reasons, and we urge the Agency to maintain its commitment to MASTER through this important stage of the program.

3.2 Ecological Risk Assessment in MASTER

The goals of the MASTER Program require the explicit linkage of changes in the physical

and chemical environment, whether natural or anthropogenic, to changes in the health of the ecosystem. This should be done in the context of the Agency's *Framework for Ecological Risk Assessment*. The first step in the ecological risk (ecorisk) assessment process is problem formulation, which includes the identification and selection of appropriate ecological endpoints by which the health of the ecosystem can be evaluated. The analysis phase of ecorisk assessment then requires characterization of the changes in those selected ecological endpoints in response to the stress regime.

Although the MASTER Research Plan describes the program as following the ecorisk assessment paradigm, both the problem formulation and ecological effects analyses for selected endpoints are not sufficiently developed. This can best be remedied by the development of an integrated assessment framework, as discussed in the following section of our report. More thought should be given to how ecological effects will be characterized, what models and other analytical methodologies will be used, and how these effects assessments will fit into the overall decision-support system. The ecological effects approach should be detailed now, not delayed until data are collected or analyzed. To this end, we recommend that an ecological modeler be added to the MASTER team and that an ecological effects conceptual model be developed with explicit linkages to the physical and chemical modeling activities. This will help ensure the intimate co-development of the ecological modeling tasks with the field studies.

3.3 Integrated Assessment Framework

The MASTER Program has a clear goal to assess the impact of agricultural management practices on the sustainability of agroecosystems and ecological resources. However, the means of attaining this goal are not clear. Therefore, we recommend that the MASTER research team give immediate attention to a strategic planning exercise. The output of this exercise should be a plan for the integrated assessment which lays out the interactions between the various research components of the MASTER Program.

The assessment framework should start with potential management scenarios and end with potential effects on the system (i.e., ecological endpoints). Of course, the choice of ecological endpoints depends on the variability associated with those endpoints (i.e., highly variable endpoints will be difficult to evaluate). Therefore, going through a "strawman" assessment and considering a rough estimate of uncertainties will contribute to the selection of appropriate endpoints. In addition, the development of an assessment framework should help to clarify potential management practices and their cascading effects through the system, potential feedbacks, uncertainties in the system, spatial and temporal discongruities between research components (e.g., how data and model output from one scale will relate to information and questions at another scale), and how the MASTER Program relates to other watershed studies. The decision-support system should provide the framework for relating the research components to the ecological endpoints of interest.

Another benefit of an integrated assessment framework is that it can serve as the "road map" for interdisciplinary interactions, provide a basis for selecting priority research activities, and relate the numerous projects being leveraged with other agencies to the goals of MASTER. While we commend the MASTER program for creatively leveraging their limited funds with other research projects, it is crucial to clarify how the various projects relate to the goal of assessing the ecological impacts of farm management practices. In addition, the MASTER Program's assessment strategic plan should emphasize the role that MASTER can play as a Tier 3 (or 4?) intensive monitoring location for agroecosystems in the Environmental Monitoring and Assessment Program (EMAP) and should take into account the sampling design utilized by EMAP and other larger assessment programs to allow effective program integration.

The strategic plan should also clarify how the effects of incorporating different management practices can be traced through the models to each of the assessment endpoints. At this stage of the MASTER Program, it appears that selected elements of the project are relatively well-developed, such as the surface water and ground water models, and the baseline characterization of land uses and management practices. It is not clear, however, to what degree the effects of changing the various management practices can be characterized, particularly at the farm level and for those management practices which do not involve changes in land use or cropping patterns. In short, there are a number of apparent conceptual "disconnects" between the front and back ends of the system which could be remedied by the development of an overall strategic plan for the integrated assessment.

3.4 Hypothesis Testing and Experimental Design

The Walnut Creek Watershed represents a discrete, well-characterized ecosystem that provides a unique opportunity to test hypotheses about ecosystem design and management. The hypotheses associated with model validation involve the toxic effects of agrichemicals and the ecological effects of habitat alterations. The hypotheses associated with alternative management scenarios involve BMPs and alterations in landscape design.

The overall assessment structure is characterized by a mosaic of models (surface water and ground water), GIS descriptive parameters (surface and subsurface horizons, cropping patterns, ecological landscapes), exogenous influences (e.g., weather, pesticide applications) and inventories of biota (IBI and ICI). The system in the aggregate is too complex and interactive to test for validation and/or robustness in the total response. Therefore, modular components must be evaluated either by using opportunistic events (e.g., floods, drought) or direct perturbation experiments. Once the causal relationships have been demonstrated, then the responses to alternative BMPs and/or alternative landscape designs can be articulated. These predictions constitute hypotheses that are verifiable by direct field observations.

Due to the complexity of the system, however, the potential for confounding variables to contaminate the diagnostic ability of the experimental design is high. The effects of pesticides, habitat alterations, extreme weather conditions and natural variability are all co-variants in space and time. Thus, it is critical that the MASTER Program develop a well articulated statistical design to ensure the appropriate level of effort, location of sampling sites, and duration of experiments. The sequence of investigations should be articulated within the framework of the integrated assessment plan.

We encourage the MASTER researchers to make greater use of existing data as a means to develop hypotheses, extend their results to other regions or management practices, extend their results to other species, and extrapolate their results in both space and time.

3.5 Regionalization and Extrapolation

A stated objective of MASTER is to provide regional assessment by "scaling-up" from field or farm scales to watershed, ecoregion, and regional scales. From the information presented by the MASTER team, however, it is clear that more effort should be put into the development of assessment methodologies with particular focus on the "regionalization assessment techniques." Although the existing research program is using the most advanced GIS techniques to "scale-up" patterns, it is not clear how **processes** will be translated between scales. The scientific community is grappling with the problem of how to scale processes (e.g., King, 1991), and the MASTER Program can make a significant contribution in this area. We encourage the MASTER

researchers to work with EMAP scientists in addressing the scaling issues.

Distinct from the issue of regionalizing results is that of extrapolating the results and methodologies developed in the Walnut Creek Watershed to other similar-scale watersheds. As mentioned previously, one suggestion is to couple the MASTER Program with EMAP to examine heterogeneity at the watershed level across the region (e.g., using the Thematic Mapper (TM) data base, being acquired by EMAP, to characterize the Walnut Creek and other watersheds in the region). Although the large-scale EMAP hexagons dwarf the Walnut Creek Watershed, this presents the opportunity to link to EMAP's finer-scale, more process-oriented goals for intensive examination of specific systems. Further, the EMAP experimental design could well be applied to the watershed level in Walnut Creek by scaling down the EMAP hexagon structure to the scale appropriate for MASTER studies. Clearly, the MASTER Program can make a very effective contribution to EMAP and vice versa. We urge the Agency to fully explore the links between these two programs.

3.6 Coordination With Other Watershed Studies

While the MASTER Program represents a successful multi-agency, multi-disciplinary research program, there are several other sites/research centers across the country that could prove beneficial to the MASTER program if effective liaisons were established. For example, research at Clemson University's Edith Angel Research Center at Chariton, Iowa, is closely analogous to MASTER. Largely funded by the agrichemical industry, the experimental sites are located just south of the Walnut Creek Watershed. Another possible source of data and coordination is Michigan State University's Kellogg Agricultural Experiment Program, a Long-Term Ecological Research (LTER) site funded in part by the National Science Foundation.

We urge the MASTER Program to utilize data from sites such as these for independent validation of the models developed for the Walnut Creek Watershed. Validation at other MSEA sites may not be feasible since the level of information available is considerably less than the data collected in the Walnut Creek Watershed. The scale-up from watershed to regional scales will be a major challenge and model validation at selected other sites is a necessary step in this process. A more detailed discussion of the importance of confirming models with field data can be found in the SAB report, *Resolution on the Use of Mathematical Models by EPA for Regulatory Assessment and Decision-Making* (EPA-SAB-EEC-89-012).

3.7 Variability and Uncertainty

The Committee was concerned with the inattention to uncertainties. One example was the lack of error terms on hazard assessment data. We presume such statistical aspects are being addressed, but the absence of error terms in presentations of results and conclusions diminished

confidence. More important, however, is a lack of discussion of variability in the broader sense, not just in terms of measurement error, but especially in terms of heterogeneity over space and over time. As mentioned previously, the problem formulation step in the ecorisk assessment framework includes identification of the full range of potential uncertainties. This should provide the basis for the experimental design and for setting priorities among specific research hypotheses and activities. In addition, the limitations for extrapolation to other watersheds and to regional scales should be identified.

4. MASTER COMPONENT PROCESS RESEARCH

4.1 Ground Water and Surface Water Quantity and Quality

The research underway to model the subsurface geology and hydrology in the watershed is innovative and interesting. It is not clear, however, that the ground water and surface water models are linked to ecological endpoints of interest. This linkage is critical since the ultimate goal of the MASTER Program is the ability to quantify the impacts of BMPs on ecosystem values. The MASTER Program's integrated assessment framework must clearly demonstrate the ability to couple ground water parameters to watershed/ecosystem characteristics. Once ecological endpoints of interest have been selected, chemical and habitat stressor effects can be evaluated against these endpoints. For example, the ground water model will allow prediction of pesticide exposure in surface water systems of the watershed. In the case of herbicides, exposures may alter aquatic plant communities, causing insect communities associated with these plants to be adversely impacted, and this in turn (due to foodweb linkages) may have an adverse impact on bird communities. In this example, bird, small mammal and arthropod species richness and abundance represent possible ecological endpoints of concern.

An important consideration is the degree to which the models can separate effects due to changing management practices from natural effects due to weather variations. Similarly, we recognize that, while the model may distinguish the effects of changes in management practices at a field scale, testing of the model predictions is limited by the larger scale of the monitoring networks. It would be useful to determine up front how the limits imposed by the scale of the monitoring system, as well as variables such as the timing and amount of precipitation, will effect MASTER's ability to test model predictions. This relates to our concerns/comments about hypothesis testing and experimental design in section 3.4 of this report.

4.2 Soil Quality and Subsurface Ecology

We commend the MASTER Program for adding a soil microbiological component to the conceptual framework for this agroecosystem; we agree that the soil environment is a legitimate ecosystem worthy of independent study. Treatment of soil as an ecosystem recognizes the living and dynamic nature of soils and the need to assess the effects of BMPs on the below-ground environment. This is a relatively new idea for EPA and one that could add significantly to this and future projects.

We encourage the MASTER Program to incorporate soil productivity and soil quality degradation endpoints in the assessment. Soil ecosystem endpoints of direct relevance are total microbial biomass (e.g., bacterial, fungal and nematode biomass) and rates of specific soil

processes (e.g., soil respiration, nitrification, and denitrification). Sites of important action (biologically relevant) in the soil ecosystem are focused in the rhizosphere and in the uppermost soil horizons.

The stated goal of this effort is to assess the "assimilative capacity" of the soil ecosystem for agricultural chemicals. We strongly recommend that "fate and effects" terminology be used rather than the term "assimilative capacity." "Assimilative capacity" could also be replaced by the elements of which it is composed, including adsorption and biotic and abiotic degradation.

As measures of soil quality are developed, it must be recognized that naturally occurring soils have a broad range of chemical and physical characteristics and vary greatly in their capacity to support micro- and macro-flora and fauna. Clearly, one cannot apply the same standards of productivity to silica sand as to Iowa loess soils. In addition, soil characteristics are not static--they respond to climatic changes, are modified by agricultural practices designed to influence the productivity of crops and the diversity of soil organisms.

Given this broad range of status for soils, the MASTER Program's conceptual framework for the assessment of soil quality/degradation should include not only the assessment of productive capacity as used in agriculture, but broader measures of ecological health as well.

4.3 Terrestrial Biota and Habitat Structure

The MASTER Program's assessment of the impacts of agricultural practices on terrestrial wildlife is at an early stage. Potential effects on species diversity and numbers of individuals are being explored for birds, but not for mammals. The assessment is focusing on measures of abundance for species considered the most likely to be affected by changes in agricultural practices based upon existing information about the life histories and habitat preferences of bird species in central Iowa. Many of the land management techniques to increase avian and mammalian diversity and abundance are well understood for game animals and have been studied extensively by wildlife managers. While the study recognizes the significant role of habitat characteristics as a determinant of bird diversity and abundance, it is also important to clarify the time delay between instituting certain management practices and observing an effect on bird (and/or mammal) populations. For instance, increasing habitat structure (e.g., creation of farm

woodlots, hedgerows or wetlands) will increase species diversity, but the impact will be difficult to assess in the 5-year timeframe of the MASTER Program.

Furthermore, it appears that increased abundance and diversity of wildlife was regarded as a desirable condition or trend. In the absence of other stressors, bird and mammal populations respond well to habitat management. However, when dealing with agroecosystems, several questions may be posed: how much habitat management is desirable? how abundant and diverse should terrestrial wildlife be? Obviously, agricultural ecosystems are highly managed systems and the selection of endpoints for such systems must be based on a recognition that land management processes are now inherent components of the ecosystem.

4.4 Aquatic Habitats and Biotic Communities

The aquatic ecology component of the MASTER Program takes a multimetric approach to establishing the condition of Walnut Creek. By including assessments of habitat, ambient toxicity, and instream community structure (fish and macro-invertebrates), it may be possible to identify stressors affecting aquatic life. However, it was not explicitly clear that the aquatic assessment experiments included diagnostic indicators of non-chemical stressors. Rather, the assessment design appears to be weighted toward assessing xenobiotic chemical impacts (i.e., toxicological impacts of residual agrichemicals). Non-chemical stressors like riparian vegetation, siltation, and continuity of stream flow are used as "blocking" (random block design covariants) criteria to enhance the observability of toxicological effects. Habitat characteristics and alterations are not explicitly being analyzed as important forcing functions or "drivers". There are a number of stream studies, however, that show that habitat alterations can produce far greater effects than residual agrichemicals. We therefore urge the MASTER Program to develop a balanced assessment design which evaluates the role(s) of both chemical and non-chemical stressors (e.g., via an ecological effects model that integrates the impacts of the various exogenous forcing functions).

4.5 Decision-Support Tools

The Committee is concerned that the decision-support component of MASTER was presented as just a "black box." In part this may reflect the mixture of MASTER personnel present at the review meeting in October, but supporting written materials also indicate an insufficient attention to the objectives, use and structure of the decision-support system. As a part of the overall assessment framework development exercise discussed in section 3.3, there should be explicit attention to specific aspects of the decision-support system.

5. SUMMARY OF FINDINGS

Overall, the MASTER Program, if carried out with the guidance of an integrated assessment framework and adequate agency funding and time commitment, is an appropriate way to assess the ecosystem effects of various agricultural management practices. We strongly urge EPA to maintain its commitment and financial support for the MASTER Program; we believe that the program offers an excellent opportunity to improve our capability to assess the effectiveness of agricultural BMPs and to manage ecological resources at the watershed scale.

With regard to the specific questions in the Charge to the Committee, our responses are summarized as follows:

a) Are the goals and objectives of the program clear and appropriate for the environmental problem being addressed?

Yes. Furthermore, the focus on agroecosystems and the assessment approach (watershed to regional analysis) are important and as yet under-represented areas of investigation for the Agency.

b) Is the assessment approach appropriate for defining the longer-term research in the Walnut Creek Watershed?

In the absence of an integrated assessment framework, it is not possible to determine whether or not the details of the proposed research program are appropriate and defensible. The development of such a strategic framework should be the top priority of the MASTER team. The framework should clarify the linkage between BMPs, hydrologic parameters, and ecosystem values (endpoints).

c) Is progress toward interdisciplinary integration apparent?

Yes. The multi-laboratory, interagency, and interdisciplinary nature of the MASTER Program is a great strength of the program. However, the effectiveness of these interactions in supporting overall program goals will be compromised until an integrated assessment framework is developed. Very effective cooperation with USDA has allowed the program to be productive with a relatively small budget. The obvious mutual respect between the primary investigators greatly enhances the potential for MASTER results to have wide-ranging influence on the management of agroecosystems in this country.

d) Are the ongoing and proposed projects appropriate for evaluating and reducing the ecological effects of agrichemicals and farm production practices?

Yes, in large part the MASTER components are appropriate for accomplishing the stated goals and are based on sound scientific approaches. The most significant benefits of the program will not be realized, however, unless the research components are successfully integrated via an assessment framework and the program continues long enough to allow predicted effects of management changes in the pilot watershed to be compared to results from field tests.

e) Is the research balanced between field testing, monitoring and development of assessment methodologies within the Walnut Creek Watershed vs. the development and application of "regionalization assessment techniques" using Walnut Creek data and results?

It is difficult to determine if MASTER is effectively balancing the research between field testing, monitoring, and developing assessment methodologies without seeing the strategic plan. However, it is clear that more effort should be put into development of assessment methodologies with particular focus on the "regionalization assessment techniques".

The ability to connect measurements made of different scales is critical to MASTER's ability to meet its goals and objectives and the eventual application of this approach to other watersheds and regions. This is not a trivial undertaking. How this will actually be accomplished should be laid out in the integrated assessment framework. Effort should be made to incorporate complimentary design elements with other regional programs such as EMAP.

f) Are there other watershed sites and cooperators that should be incorporated into the MASTER Program?

Yes. Data from sites like the Kellogg Agricultural Experiment Program in Michigan and the Edith Angel Research Center in Iowa should be used to test and validate models developed for the Walnut Creek Watershed.

6. REFERENCES CITED

King, A.W. 1991. Translating Models Across Scales in the Landscape. In Turner, M.G. and R.H. Gardiner (ed.), Quantitative Methods in Landscape Ecology. New York. Springer-Verlag. pp. 479-518.

EPA-SAB-EPEC-94-012

May 4, 1994

Honorable Carol M. Browner
Administrator
U.S. Environmental Protection Agency
401 M Street, S.W.
Washington, DC 20460

Subject: Review of Midwest Agrichemical Surface/Subsurface Transport and Effects Research (MASTER) Program

Dear Ms. Browner:

On October 28-29, 1993, the Ecological Processes and Effects Committee met to review the Midwest Agrichemical Surface/Subsurface Transport and Effects Research (MASTER) Program. The MASTER Program is an inter-agency effort, involving the EPA, U.S. Department of Agriculture, and the U.S. Geological Survey, designed to assess the impacts of agricultural practices on the watershed scale. EPA's participation, funded to-date under the Office of Research and Development's (ORD) Nonpoint Source Issue Plan at approximately $2 million in FY92 and approximately $1.5 million in FY93 and FY94, has focused on the **ecological effects** of agricultural management practices. The research program is being conducted in the Walnut Creek Watershed in Iowa. The Charge to the Committee from ORD was to evaluate the MASTER Program with respect to the following issues: a) overall program goals and objectives; b) assessment approach;
c) interdisciplinary integration; d) suitability for evaluating and reducing ecological effects of agrichemicals and farm practices; e) balance of research between assessment in the pilot watershed vs. extension of the assessment techniques to the regional scale; and f) other watershed studies which should be incorporated into the program.

The Committee strongly supports EPA's involvement in research to assess the impacts of nonpoint source (NPS) pollution in agroecosystems and in seeking ways to attain sustainability and ecological quality in agriculture. The MASTER Program offers a unique opportunity to develop and test the effectiveness of alternative ecosystem design and management scenarios, and thus may yield an excellent model for management at the watershed level. We agree that EPA's unique contribution to MASTER should be in the area of ecological effects; of the federal collaborators, only EPA is likely to provide this focus. The MASTER Program provides the opportunity to consider not only the ecological effects of toxic chemicals, but to include a broader consideration of stressors. For example, habitat alterations associated with various agricultural management practices

(e.g., loss of stream-side shading vegetation and increased turbidity from sedimentation) may have ecological consequences equal to or greater than those from toxic chemicals. The scale-up from watershed to regional scales will be a major challenge and will require validation of the Walnut Creek Watershed models at selected other sites.

Among the potentially significant advantages of the MASTER approach is the use of an in-depth case study to test the effect of changes in management practices and then to select practices which provide optimal agricultural and ecological benefits. We stress, however, that the MASTER Program's objective of reducing the ecological effects of agrichemicals and farm practices will not be realized without a long-term commitment to the program by the Agency. After two years of a planned five-year endeavor, the MASTER Program has invested considerable effort in developing a study baseline for the Walnut Creek Watershed and in developing models to predict how proposed management changes would affect ecological indicators. The potential of the case study approach will not be realized until the predicted effects of management changes can be compared to results from field tests.

As described in the Agency's *Framework for Ecological Risk Assessment*, the first step in ecological risk (ecorisk) assessment is problem formulation, which includes the identification and selection of appropriate endpoints by which the health of the ecosystem can be evaluated. The analysis phase of ecorisk assessment then requires characterization of the changes in those selected ecological endpoints in response to the stress regime. Although the MASTER Research Plan describes the program as following the ecorisk assessment paradigm, both the problem formulation and ecological effects analyses for selected endpoints are not sufficiently developed. In our report, we have made a number of recommendations for strengthening the MASTER Program, including the addition of an ecological modeler to the MASTER team, development of an ecological effects conceptual model, and development of an integrated assessment framework to guide interdisciplinary interactions, provide a basis for selecting priority research activities, and relate the projects being leveraged with other agencies to the goals of MASTER.

Overall, the MASTER Program, if carried out with the guidance of an integrated assessment framework and adequate agency funding and time commitment, is an appropriate way to assess the ecosystem effects of various agricultural management practices. We strongly urge EPA to maintain its commitment and financial support for the program; we believe that the program offers an excellent opportunity to improve our capability to assess the effectiveness of agricultural "best management practices" and to manage ecological resources at the watershed scale.

We appreciate the opportunity to review this important program, and we hope that our comments will be helpful to you.

Sincerely,

/signed/
Dr. Genevieve M. Matanoski, Chair
Executive Committee

/signed/
Dr. Kenneth L. Dickson, Chair
Ecological Processes and
Effects Committee

/signed/
Dr. Alan W. Maki, Chair
MASTER Review Subcommittee

United States
Environmental
Protection Agency

Science Advisory Board
1400F
Washington, DC

EPA-SAB-EPEC-94-012
May 1994

EPA

AN SAB REPORT: REVIEW OF THE MIDWEST AGRICHEMICAL SURFACE/SUBSURFACE TRANSPORT AND EFFECTS RESEARCH (MASTER) PROGRAM

PREPARED BY THE ECOLOGICAL PROCESSES AND EFFECTS COMMITTEE

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