SOIL AND WATER CONSERVATION SOCIETY®

PLANNING FOR EXTREMES

A Report from a Soil and Water Conservation Society Workshop
Held in Milwaukee, Wisconsin, November 1–3, 2006

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The Soil and Water Conservation Society (SWCS) is a nonprofit scientific and educational organization that serves as an advocate for natural resource professionals and for science-based conservation policy. SWCS fosters the science and art of soil, water, and environmental management on working lands to achieve sustainability. SWCS members promote and practice an ethic that recognizes the interdependence of people and their environment.

SWCS would like to acknowledge the generous support of the Joyce Foundation, Walter and Duncan Gordon Foundation, and Natural Resources Canada, whose contributions underwrote the research, writing, and publication of this report.

Workshop participants have reviewed and commented extensively on this report, and every effort has been made to ensure that the report accurately reflects their views and judgment. Participants, however, have not been asked to individually or officially sign off on the findings, conclusions, and recommendations presented here. The content of this report is solely the responsibility of SWCS.

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Milwaukee, Wisconsin, November 1–3, 2006

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EXECUTIVE SUMMARY

This report summarizes the conclusions and recommendations developed during a Soil and Water Conservation Society workshop held to (1) evaluate the scope and magnitude of the conservation challenges and environmental threats posed to the Great Lakes ecosystem by upward trends in the amounts and intensities of precipitation and (2) recommend improvements to conservation tools, approaches, and policies to meet those challenges and to manage those threats.

Participants agreed that there is growing evidence that the climate of the Great Lakes region is changing in ways that are likely to increase nonpoint source pollution from agricultural watersheds. Climate models suggest these changes are likely to continue and potentially intensify in the future.

Workshop participants were particularly concerned that increased probability and severity of erosion, runoff, and pollution were occurring at the same time that demands on our soil, water, and agricultural watersheds are increasing. Demand for food, fiber, land, and water are increasing with population, and the emphasis on increasing production of energy from biomass will dramatically intensify the demands placed on soil, water, and agricultural resources. More intensive and effective conservation efforts are already needed to ensure that we meet these increased demands while sustaining our natural resources and ecosystems. Climate change will multiply the challenges conservationists face.

Indeed, workshop participants were concerned that current conservation efforts are not keeping up with increasing pressure on agricultural watersheds. They thought that climate change could spark a “downward spiral” caused by self-reinforcing changes in soil erosion, hydrologic cycles, and aquatic ecosystems. They worried that risks are likely to increase from climatic, demographic, and food and energy production stresses, making the status quo level of conservation on agricultural landscapes progressively less protective.

Priorities for Immediate Action

Workshop participants recommended as a first priority to make better use of current conservation tools, systems, and programs. Four opportunities are particularly promising:

1. Focus more attention in planning and program implementation processes on currently well-understood practices that reduce damage from concentrated flow.
2. Focus more attention in planning and program implementation processes on protecting or repairing stream and riparian corridors.
3. Use current models and monitoring systems to identify high-risk and high-value tributary watersheds that would benefit from focused conservation efforts.
4. Update climatic parameters used in conservation tools and planning approaches to include the most recent data and ensure that routine and periodic updates are completed in the future.

Action to take advantage of the first three opportunities is urgently needed to address existing threats to the Great Lakes under the current climate regime. The likelihood of increasing frequency, intensity, and magnitude of severe storms makes action on these three opportunities even more urgent.

Gaps and Challenges Needing to be Addressed

Participants strongly agreed that the single most important barrier to more effective use of current tools and conservation systems is a technical support and assistance network that is weak and growing weaker. All participants agreed that inadequate technical support and assistance networks will cause lasting damage to our efforts to respond to current challenges, let alone the growing challenge created by climate change.

Participants also stressed the need for better monitoring systems. Managing the risks of severe storms requires monitoring systems that can detect such events in the context of long-term time series and document their effects at appropriate temporal and spatial scales. A research and development effort should be mounted to develop and deploy affordable monitoring systems and technologies and to establish and maintain a regional data warehouse that will provide conservationists with the information needed for effective adaptive management.

Better Tools, Technology, and Policy Needed for Managing Risk

Conservation planning inherently involves making decisions about what level of probability and severity of damage to natural resources or the environment is acceptable, and what combination of practices and activities is sufficient to keep the probability and severity of damage at or below that acceptable level. The need for an explicitly risk-based approach to planning is made more urgent by the increased probability of more frequent and more severe storm events.

Planning tools designed to develop recommendations for conservation efforts at field, farm, and watershed scales can and should be developed that are capable of predicting and reporting the probability of damage from a particular storm event as well as from annual precipitation. Those tools should be able to be tailored to specific times of the year. Workshop participants were clear that all factors in a changing climate must be considered when doing risk-based assessments, planning, and implementation.

The ultimate goal of risk-based conservation planning and implementation should be to increase the capacity of agricultural landscapes to resist and recover from severe events. Greater resistance and resilience in agricultural landscapes is best achieved through conservation systems composed of multiple and mutually-reinforcing practices and activities implemented at various scales. Conservation tillage, for example, must be backed up with grassed waterways, contour grass strips, filter strips, riparian buffers, and other appropriate and feasible measures on a particular farm in a particular watershed. This layered or multitiered approach to conservation builds in redundancy that helps resist the effect of an infrequent but potentially damaging severe event.

MANAGING RISK AT THE FIELD AND FARM SCALES

Participants agreed that we cannot meet today's challenges—particularly the off-farm effects on water quality and aquatic ecosystems—without dealing effectively with concentrated flow. Among the most troubling effects of increased precipitation intensity on runoff and soil erosion will be beginning shifting the dominant processes causing damage from sheet and rill erosion to concentrated flow erosion in ephemeral or permanent gullies. Developing and implementing tools to enable conservationists to predict and manage the risks created by concentrated flow should receive high priority for adapting to a climate regime with increased probabilities of severe storms.

Participants also want to better understand at what point and under what kind of storm events do conservation practices begin to fail and what the consequences of that failure are. Current tools do not address failure, or, if they do, the assumption is that failure causes no further damage than the amount that would have been experienced if the practice was not in place. Experience, however, indicates that, in some cases, practice failure may result in greater damage than would have occurred if the practice had not been in place.

MANAGING RISK AT THE WATERSHED SCALE

Participants argued that working at the watershed or landscape scale is the only way to deal with the off-site effects in agricultural watersheds. Conservationists "have to connect the dots—make sure our work on farms adds up—that the sum of our efforts is greater than the parts."

Working at the watershed scale opens up opportunities to plan and implement different strategies that complement and increase the benefits of in-field practices. Strategies to restore wetlands, repair stream channels, and enhance riparian corridors are best implemented at the watershed scale and will reinforce the benefits of work at the farm scale *if* the efforts are effectively targeted and coordinated.

The most compelling advantage of working at the watershed scale is the ability to "focus for effect" to direct conservation efforts at the most vulnerable parts of the landscape and during the most vulnerable times of the year. Workshop participants were particularly optimistic about the opportunity to manage risk associated with watershed-scale erosion and sediment loading through improved

targeting because advances in information technology are making such targeting easier, more affordable, and more accessible to conservationists, producers, and policymakers.

Workshop participants also recommended that we maximize the communication value of new targeting tools and models to help citizens better understand the causes and effects of environmental problems in their watershed and thereby to inform and communicate problem identification and decision making. The social and economic implications of the consequences of severe storms and of alternative risk management options need to be made clear, as do the physical and ecological consequences.

ADVANCES IN PROGRAMS AND POLICIES

Participants discussed the need for programmatic and policy changes that will require more long-term attention to support risk-based assessment, planning, and implementation of conservation efforts to improve the health of the Great Lakes ecosystem.

Public policy must ensure a long-term commitment of people and resources to community-driven projects at the watershed scale. The more traditional approach of providing short-term, three- to five-year grants to communities will not work. Sustained effort and support must be available to build the local infrastructure—leadership, technical support, and monitoring systems—essential to making effective adaptive management possible. Innovative funding systems need to be developed and tested to provide sustained support to community-driven watershed projects.

More effective conservation assessment and planning tools will accomplish little, according to workshop participants, unless we find effective ways to increase the use and implementation of conservation systems and to target implementation at the most critical portions of farms and watersheds. Conservation programs must take into account the realities of current farm structure and land tenure. Landowners, producers, and increasingly farm management consultants are joint decision makers when it comes to implementing conservation practices and systems. Incentives programs must become more adept at directing the right incentives to the right decision maker.

The opportunity to develop regulatory systems that are innovative and well suited for agriculture is great. One of the most important roles for regulation is to set performance standards both at the farm and watershed levels. To the maximum extent possible, regulations should be based on performance rather than practice standards. Regulations should clearly tell producers *what* they need to accomplish, but producers and their technical advisors should have the flexibility to determine *how* to accomplish it.

Introduction

This report summarizes the conclusions and recommendations developed during a Soil and Water Conservation Society (SWCS) workshop held to (1) evaluate the scope and magnitude of the conservation challenges and environmental threats posed to the Great Lakes ecosystem by upward trends in the amounts and intensities of precipitation and (2) recommend improvements to conservation tools, approaches, and policies to meet those challenges and to manage those threats. The workshop was held on November 1–3, 2006, in Milwaukee, Wisconsin, and focused on management of agricultural landscapes. Workshop participants discussed opportunities to improve conservation planning, technologies, and programs to adapt to the risk posed by changes in the season, frequency, and severity of storms.

The workshop followed up on the findings of a previous study by SWCS, "The Conservation Implications of Climate Change: Soil Erosion and Runoff from Cropland." That synthesis report concluded that predicted—and already observed—increases in the frequency and magnitude of severe storms could increase runoff from cropland by as much as 100% and erosion from cropland by as much as 94%. The report questioned whether current approaches to conservation planning and implementation in agricultural landscapes are protective enough to address this riskier climate regime (see Conservation Implications of Climate Change sidebar).

The Milwaukee workshop was organized to specifically evaluate the need for and the most promising opportunities to adapt conservation tools, approaches, and policies in the Great Lakes region to a riskier climate regime. The workshop focused on the Great Lakes because (1) observed and predicted changes in precipitation patterns are regionally significant, (2) regional economic and environmental implications of those changes are large, and (3) a number of regional studies have been completed that provide a solid foundation for making recommendations.

The workshop brought together experts from Canada and the United States to discuss whether action is needed to adapt conservation tools, approaches, and policies in the Great Lakes region to a precipitation regime with increased probability of severe storms and damaging runoff events. Workshop participants were asked to outline the best course of action to take at the farm scale, the watershed scale, and in conservation policies and programs. Discussion at the workshop was informed by a series of background papers, including a major report from the Ontario Chapter of SWCS, *Planning for Extremes: Adapting to Impacts on Soil and Water from Higher Intensity Rains with Climate Change in the Great Lakes Basin*. Presentations were also made on key issues by selected workshop participants.

This report is a summary of the professional judgment of workshop participants regarding the key issues the workshop was designed to explore. Participants engaged in the workshop as individuals, not as official representatives of the institutions for whom they work. Participants have reviewed and commented extensively on this report and every effort has been made to ensure that the report accurately reflects their views and judgment. Participants, however, have not been asked to individually or officially sign off on the findings, conclusions, and recommendations presented here. The content of this report is solely the responsibility of SWCS.

Case for Action

Workshop participants were first asked to evaluate the evidence that action is needed to enhance and adapt conservation efforts in the Great Lakes region to adapt to a precipitation regime with higher probabilities of severe storms and damaging runoff events. A "severe" storm may be large or small in geographic extent, may produce "heavy" precipitation (a large amount of precipitation over the duration of the storm), and/or may produce "intense" precipitation (a large amount of precipitation falling in a short period of time).

NONPOINT SOURCE POLLUTION LIKELY TO INCREASE

The magnitude of nonpoint source pollution is the result of the interaction between (1) the physical landscape, (2) the type, intensity, and level of management of that landscape, and (3) the frequency, intensity, timing, and volume of precipitation. Therefore, it is highly likely that a precipitation regime with more frequent, more intense, and/or larger storms will increase the severity of nonpoint source pollution.

The evidence is clear that nonpoint source pollution is a serious threat to the Great Lakes ecosystem. Numerous studies and reports have repeatedly highlighted the current importance of controlling nonpoint source pollution in the basin (Robinson 2006). Most recently, the Great Lakes Regional Collaboration reported that nonpoint sources of pollution contribute significantly to water pollution in the Great Lakes Areas of Concern, as well as to other locations in the Great Lakes, including the open waters (see Great Lakes Regional Collaboration sidebar). The report went on to recommend that several actions be taken to reduce nonpoint pollution from agricultural landscapes (Great Lakes Regional Collaboration 2005).

Participants agreed that there is growing evidence that the climate of the Great Lakes region is changing in ways that are

Conservation Implications of Climate Change

SWCS reviewed the literature and engaged members of an expert panel in a discussion of quantitative estimates of the effects of climate change on soil and water resources in agricultural landscapes. The panel focused on one climatic variable, precipitation; two primary conservation effects, soil erosion and runoff; and one type of agricultural land, cropland. In its 2003 report, the panel concluded that conservationists should be seriously concerned about the implications of climate change—as expressed by changes in precipitation patterns—for the conservation of soil and water resources in the United States. Of special concern are the large magnitude and extent of increased soil erosion and runoff rates probable under simulated future precipitation regimes.

More importantly, the panel's review of analyses of the climate record in the United States showed that changes in precipitation patterns are already occurring—the magnitude of observed trends in precipitation and the bias toward more extreme precipitation events are, in some cases, larger than simulated by global climate change models, particularly since 1970. Extrapolating those relationships to the changes in precipitation observed over the past century suggests increases in soil erosion ranging from 4% to 95% and increases in runoff from 6% to 100% may already be evident on cropland in some locations. Unless additional protective measures are taken, the panel concluded, such increases in soil erosion and runoff from cropland—if widespread—could reverse much of the progress that has been made in reducing soil degradation and water pollution from cropland in the United States.

In sum, the panel concluded that a change in precipitation regime also produces a change in the level of risk to which agricultural land is exposed. In general, a regime with greater annual precipitation—particularly if increased storm intensity changes more than storm frequency—heightens the risk of soil erosion, runoff, and related environmental and ecological damages. In general, the risk increases at a greater rate than the increases in precipitation amount or intensity. Whether that new, more risky baseline condition translates into greater soil degradation, pollution of surface water, pollution of groundwater, or a combination of all three outcomes is highly dependent on other factors, such as land use, land management, and the degree to which conservation measures are implemented.

The panel identified three approaches as particularly promising to begin adapting soil and water conservation policies and practices to a changing precipitation regime:

1. Immediately update climatic parameters in critical conservation planning tools.
2. Undertake targeted investigations to firm up estimates of the damage that would likely occur under simulated or observed intensified climate regimes.
5. Evaluate the benefits of building the risk of damage from severe rainstorms into the conservation planning process through risk-based assessments targeted to key conservation systems and environmental outcomes.

Source: Soil and Water Conservation Society (2003).

likely to increase nonpoint source pollution from agricultural watersheds. There is strong and growing evidence that the timing, amount, duration, and intensity of precipitation has changed markedly in some regions of North America, including the Great Lakes watershed. A recent analysis of new climate data, for example, found that design storm events in the Midwestern United States have increased in magnitude by as much as 46%. This study compared the precipitation magnitude and frequency data found in the standard currently in use for such data—the National Weather Bureau Technical Paper No. 40 (Hershfield 1961) —with a new National Oceanic and Atmospheric Administration (NOAA) Atlas 14, which supersedes the earlier Technical Paper No. 40 (Davis Todd et al. 2006). In Ontario, upward trends are especially evident in spring, which is a highly vulnerable period. Changes are also indicated in the temperature regime, as are changes in spatial-temporal patterns of precipitation and temperature, including changes in water balance, flow regimes, peak flow events, and lake-effect snowfall (see Our Climate Is Changing sidebar).

Climate models suggest these changes are likely to continue and/or intensify in the future. Most recently, the United Nations Intergovernmental Panel on Climate Change (IPCC) concluded unequivocally that the climate system is warming and concluded with a high degree of certainty that human activities are contributing to that warming effect. More important to this report, the IPCC reported that precipitation has increased significantly in eastern North America and that the frequency of severe precipitation events has also increased over most land areas. The report goes on to state that it is very likely that the trend toward more total precipitation occurring in severe storms will continue into the future (IPCC 2007).

The implications of an increase in the frequency and/or magnitude of severe storms on erosion, runoff, and pollution from agricultural watersheds are serious and troubling. Precipitation intensity, duration, frequency, and timing are

Great Lakes Regional Collaboration

The Great Lakes Regional Collaboration (GLRC) resulted from Executive Order (EO) 13340 signed by President Bush in May 2004. The Executive Order created a cabinet-level task force, chaired by U.S. Environmental Protection Agency Administrator, to bring an unprecedented level of collaboration and coordination to accelerate protection and restoration of the Great Lakes. Eight strategy teams were established to develop a basin-wide strategy, including a nonpoint source team. The Collaboration published a "Strategy to Restore and Protect the Great Lakes" in July 2005 as a Draft Action Plan.

The GLRC Strategy laid out eight key recommendations, one of which addressed nonpoint source pollution. The five main nonpoint source pollution stressors identified by the GLRC Strategy Draft Action Plan in 2005 were nutrients, contaminants, pathogens, sedimentation, and altered flow regimes.

These stressors enter the Great Lakes primarily through surface runoff, groundwater infiltration, and atmospheric deposition. Nonpoint source pollution in each of these forms damages flora and fauna in the Lakes, threatens human health, reduces recreational opportunities, and increases the costs to treat drinking water and to dredge harbors and marinas. Today, the total stressor input from nonpoint source pollution considerably exceeds that from point sources, according to the GLRC Strategy.

The GLRC Strategy recommended that several actions be taken to address nonpoint source pollution, including (1) wetland restoration, (2) improvement of cropland soil management, (3) implementation of comprehensive nutrient and manure management plans for livestock operations, and (4) improvements to the hydrology in watersheds.

Moreover, the GLRC Strategy recommended action to ensure the long-term sustainability of the Great Lakes resources, especially concentrating on the areas of land use, agriculture and forestry, transportation, industrial activity, and many others.

Source: Great Lakes Regional Collaboration (2005).

key factors driving erosion and runoff from farm fields. The percent increase in erosion and runoff from farm fields will be much larger than the percent increase in precipitation intensity (SWCS 2003). The implications of an increase in frequency and/or magnitude of severe storms, however, are more troubling than estimated increases in erosion and runoff alone. Here are some of the implications:

- There is strong evidence that severe storms cause much—if not most—of the damage to soil, water, and aquatic resources in the Great Lakes region and in general, even though they are less frequent than smaller storms.
- Increased frequency of severe storms and the resulting increases in runoff will likely shift the dominant concern on farm fields from sheet and rill erosion to more damaging ephemeral and permanent gully erosion and in agricultural watersheds to destabilization of stream channels and erosion of stream banks.
- Severe storms can increase the damage to soil, vegetation, and stream channels, thereby increasing the vulnerability of agricultural watersheds to future storms.
- Increased frequency of severe storms during spring when farm fields are most vulnerable to erosion and transport of sediment and other pollutants will multiply the risk of adverse impacts to soil, water, agricultural, and aquatic resources.
- The shift toward more precipitation falling as rain rather than snow in the spring and autumn will increase the probability of more damaging events, such as rain falling on snow or on frozen soil.
- Increased frequency and severity of storms are likely to have synergistic effects with other current and ongoing changes in climatic factors, such as seasonal patterns, temperature, and alternating dry and wet periods, increasing the probability of damage to soil, water, and aquatic resources.

Workshop participants reaffirmed and substantially strengthened the case made in the 2003 SWCS report that increased frequency and/or magnitude of severe storms will substantially increase the probability and severity of erosion, runoff, and pollution from farm fields and agricultural landscapes.

CURRENT CONSERVATION EFFORTS NOT KEEPING UP

Workshop participants were particularly concerned that the increased probability and severity of erosion, runoff, and pollution were occurring at the same time that demands on our soil, water, and agricultural watersheds are increasing. Demand for food, fiber, land, and water are increasing with population. The push to produce an increasing proportion of energy from biomass will dramatically intensify the demands placed on soil, water, and agricultural resources. Indeed, in some cases, these developments may have a greater impact on the Great Lakes ecosystem than will the changes in climate. More intensive and effective conservation efforts are already needed to ensure we meet these increased demands while sustaining our natural resources and ecosystems. Climate

Our Climate Is Changing

The SWCS's 2003 report Conservation *Implications of Climate Change: Soil Erosion and Runoff from Cropland* included a review of the scientific literature regarding recent precipitation regime changes in the United States. Indications of trends in precipitation patterns in the United States found in the observed climate record are particularly interesting because of their immediate implications for conservation. Several of the published analyses indicated that climate has changed during the past century. In the contiguous United States, those general trends include (1) increase in minimum temperature, (2) decrease in extent of spring snow cover in the West, (3) increase in near-surface humidity and cloudiness, (4) increase in mean precipitation, (5) increase in heavy and very heavy rains in the East, and (6) increase in high stream flow events in the East.

The SWCS expert panel concluded that "upward trends in total precipitation, coupled with a bias toward more extreme precipitation events, are indicated in both simulated and observed climate regimes." Over the period 1900 to 1998, most areas in the United States showed increasing trends in annual precipitation of between 10% and 40%, but some areas showed decreasing trends in annual precipitation. After about 1970, precipitation tended to remain above the 20th century mean, and averaged about 5% more over the contiguous United States than in the previous 70 years. Upward linear trends in heavy or very heavy precipitation were more pronounced than was the trend toward increased annual precipitation over the contiguous United States. The proportion of increased annual precipitation occurring in severe storms grew.

The Ontario Chapter of the Soil and Water Conservation Society undertook an analysis of precipitation trends in the Canadian portion of the Great Lakes region. Their analysis found that a number of studies indicate a trend since 1970 towards heavier rain events and more frequent intense events in the southern Ontario part of the Great Lakes basin. Maximum intensities for one-day and for 30- to 60-minute durations have been rising, on average, at rates of 3% to 5% per decade, although not all stations exhibit this upward trend. Another study shows that heavy one-day rains above a certain high threshold have been increasingly frequent in this region since 1950. Increases in frequency have been greatest in summer, but have also risen by approximately 4% per decade in early spring (March, April, May). Further preliminary analysis for a few stations suggests a shift to heavy, summer-like, rainfall events is occurring earlier in the season and especially in May. Total precipitation has increased by a lesser amount, except for increased snowfall in the lee of the more ice-free and warmer Great Lakes.

The findings of both SWCS reports have recently been confirmed in the report from Working Group 1 of the Intergovernmental Panel on Climate Change (IPCC). Their report *Climate Change 2007: The Physical Science Basis* concludes that long-term trends from 1900 to 2005 have been observed in precipitation amount over many large regions, with significantly increased precipitation in the eastern parts of North and South America, northern Europe, and northern and central Asia. Moreover, the Working Group report concludes that the frequency of heavy precipitation events has increased over most land areas, consistent with warming and observed increases of atmospheric water vapor.

The IPCC Working Group also concluded that it is very likely that the frequency of heavy precipitation events (the proportion of total rainfall from heavy rainfalls) will continue to increase in the future.

Sources: Soil and Water Conservation Society (2003); Ontario Chapter of the Soil and Water Conservation Society (2006); Intergovernmental Panel on Climate Change (2007).

change, however, will multiply the challenges conservationists face.

Indeed, workshop participants worried that current conservation efforts are not keeping up with increasing pressure on agricultural watersheds. They thought that climate change could spark a "downward spiral" caused by self-reinforcing changes in soil erosion, hydrologic cycles, and aquatic ecosystems. They worried that risks are likely to increase from climatic, demographic, and food and energy production stresses, making the status quo level of conservation on agricultural landscapes progressively less protective.

Papers presented at the State of the Lakes Ecosystem Conference, which was running concurrently to the SWCS workshop, and shared by participants attending both meetings heightened concerns. A presentation by R. Peter Richards from the National Center for Water Quality Research in particular showed troubling increases in recent years in loadings of sediment, phosphorus, and nitrogen to Lake Erie (Richards 2006). The increases were especially troubling because they followed a long period of decline in such loadings—a major accomplishment of pollution prevention efforts in the basin. Other findings indicated that phosphorus concentrations in near-shore waters periodically exceed

Impact of Severe Storms on Lake Erie

The Maumee and Sandusky River basins make up 25% of the total land area draining into Lake Erie. The two rivers contribute 35% of the phosphorus that enters Lake Erie from tributary streams and rivers. More than 90% of that phosphorus load is from nonpoint pollution.

Individual severe storms can contribute a large portion of the annual and multi-year phosphorus load. For example, as shown in figure 1, on January 1, 1991—the first day of a 12-day storm event—435 metric tons of total phosphorus (TP) was delivered to Lake Erie by the Maumee River. By the time the 12-day storm event was over, 1,531 metric tons of TP were delivered. By comparison, the 1991 total annual phosphorus load from municipal sewage treatment plants was 1,639 metric tons.

Between 1976 and 1995, 102 storms that resulted in stream flow rates between 7,500 and 40,000 cubic feet per second contributed 44.9% of the total phosphorus load in the Maumee River. Over that same 20-year period, 23 storms that resulted in stream flow rates greater than 40,000 cubic feet per second accounted for 32% of the total phosphorus load. Overall, 226 storms contributed 92% of the suspended solids, 86% of the phosphorus, 78% of the soluble reactive phosphorus, and 81% of the nitrate load in the Maumee River.

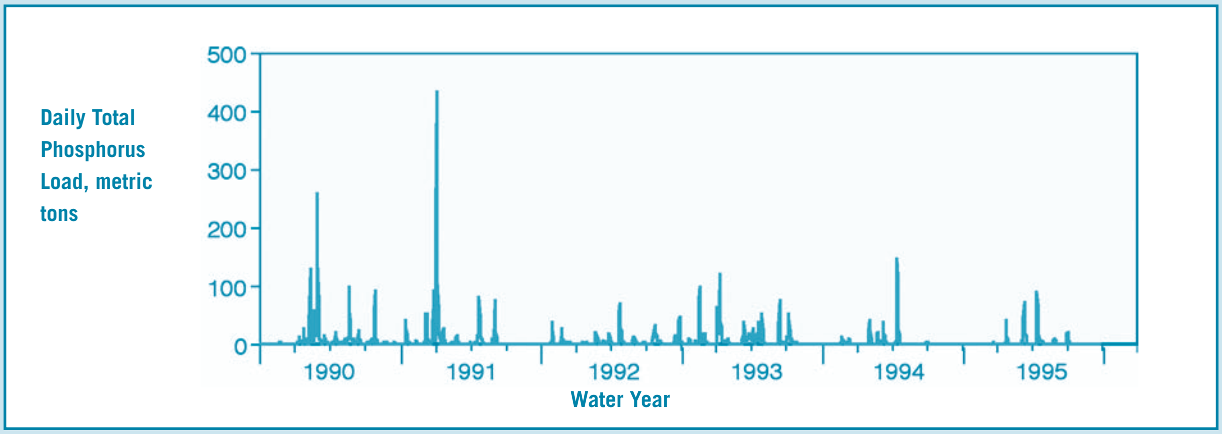

Figure 1. Daily phosphorus loads from the Maumee River, Ohio.

Note: The x-axis scale is in "water years," which are not the same as calendar years. A water year begins on October 1 and ends on September 30.

Source: Adapted from Baker and Richards (2003).

guidelines in Lakes Huron, Ontario, Erie, and Michigan, and that these areas experience nuisance algae growths. Both phenomena are associated with high tributary flows and high sediment loads to the lakes.

In addition to increased nutrient and sediment loading, the SWCS Ontario Chapter completed an analysis that identified increased risks of bacterial contamination, especially from animal feed lots, and greater discharges of pesticides to waterways (Ontario Chapter of the Soil and Water Conservation Society 2006). It is estimated that two-thirds of water-borne disease outbreaks occur after heavy rains (Patz 2001).

Participants agreed that conservation efforts must be intensified to keep up with increasing demands on soil, water, and agricultural resources, and increased probability of severe storms. In the words of one workshop participant, "We are going to have to run faster just to stay where we are."

Participants agreed that new tools and planning approaches would make an important contribution to a more effective conservation effort in the Great Lakes region. Their ideas and recommendations for such tools and approaches are presented later in this report.

Participants also strongly agreed that major progress in controlling pollution and erosion could be made immediately by making greater use of currently available tools, practices, and programs. They strongly urged that such action be taken now while important improvements to our tools and planning approaches are developed.

Current Tools, Technology, and Programs Need to be Used More Effectively

Workshop participants were adamant that more focused and intensive application of current tools and conservation systems must go hand-in-hand with efforts to produce and employ

What Is Concentrated Flow?

Concentrated flow occurs when water flowing off a farm field moves in a channel. The erosive power of the runoff water increases substantially as the depth and velocity of the flow increase in such a channel. In addition, the sediment and other pollutants carried in such channel flows are more likely to be delivered to a creek, stream, or river.

Ephemeral gullies are small channels created by concentrated flow. The channels are called "ephemeral" because they are small enough that normal tillage operations fill in the channels. See figure 2. The ephemeral gullies disappear after tillage but may well reappear during the next runoff event. Classic gullies are characterized by channels with more pronounced head cuts and sloughing off of channels side walls. Classic gullies cut deep channels that cannot be eliminated through normal tillage operations.

Ephemeral gullies can be a large source of the sediment and pollutants from crop fields even in relatively flat landscapes. Scientific research efforts in the Upper Auglaize River watershed in Ohio—a tributary to the Maumee River—identified ephemeral gully erosion as a significant source of sediment in the watershed and developed modeling techniques to predict the ephemeral gully erosion. Ephemeral gully erosion accounted for 2.5 times the soil loss caused by sheet and rill erosion. Ephemeral gullies were found to cause 72% of the erosion and to contribute 73% of the sediment loading. Controlling ephemeral gully erosion was recommended as a high priority for reducing sediment loads to Lake Erie from the Upper Auglaize River watershed.

Source: Toledo Harbor AGNPS Project Team (2005).

Figure 2. An ephemeral gully forming on a crop field in the Upper Auglaize watershed, Ohio.

enhanced tools and conservation systems. "We cannot afford to wait to act until new tools are in hand," one participant stated. Indeed, workshop participants argued that actions needed to respond to the increased probability of severe storms are already needed to manage the risks imposed by the current climate regime. Current risks are not being adequately addressed, and these risks will grow as the probability of severe storms increases.

IMMEDIATE OPPORTUNITIES

Workshop participants recommended focusing on four immediate opportunities:

1. Focus more attention and priority in the planning and program implementation processes on currently well-understood practices that reduce damage from concentrated flow.
2. Focus more attention and priority in the planning and program implementation processes on protecting or repairing stream and riparian corridors.
3. Use current models and monitoring systems to identify high-risk and high-value tributary watersheds that would benefit from focused conservation efforts.
4. Update climatic parameters used in conservation tools and planning approaches to include the most recent data; ensure routine and periodic updates are completed in the future.

Action to take advantage of the first three opportunities is already urgently needed to address existing threats to the Great Lakes under the current climate regime. The likelihood that the frequency, intensity, and magnitude of severe storms are increasing makes taking action on these three opportunities even more urgent.

Participants strongly agreed that among the most important risks imposed by an intensified precipitation regime is the onset or increase in concentrated flow. Concentrated flow occurs when rainfall or snowmelt running off farm fields coalesces into channels. If those channels are temporary and obscured by tillage, they are called *ephemeral gullies*. In severe cases, such channels can become a permanent part of the field or watershed—a result of *classic gully erosion* (see What Is Concentrated Flow? sidebar).

Concentrated flow increases the erosive power of runoff water and greatly increases the probability that eroded sediment and other pollutants will be delivered to streams, rivers, and eventually the Great Lakes. Moreover, concentrated flow greatly reduces the effectiveness of filter strips, riparian buffers, and other conservation practices and can cause some conservation practices to become ineffective. Although participants recommended that new tools and planning approaches to deal more effectively with concentrated flow must be developed, they also strongly agreed that use of existing effective conservation practices to prevent or manage concentrated flow in tributary watersheds would produce significant gains in soil and water quality and in the health of aquatic systems, even in the face of a changing climate. They recommended that more priority and emphasis be given to managing concentrated flow in conservation programs and pollution prevention programs at local, state, provincial, and federal levels.

The greater volume and intensity of runoff associated with more severe precipitation events—particularly during vulnerable seasons—also increases the risk that stream channels become destabilized so that the stream itself would become an important source of sediment and other pollutants. More could and should be done in conservation programs immediately to protect, repair, and/or restore stream channels and riparian zones.

Workshop participants also recommended that much greater effort be made to focus conservation programs, planning, and practice implementation on those limited portions of agricultural landscapes that produce most of the runoff, sediment, and other pollutants to the Great Lakes. In fact, the development of better tools to quickly and feasibly identify such "critical source areas" in the watershed is one of the most important opportunities identified by participants.

Participants agreed, however, that even in the absence of better and more quantitative tools, current models and knowledge could and should be applied to direct conservation efforts to the areas where they are most urgently needed. The benefits of focusing conservation efforts on the most vulnerable portions of watersheds are significant and well documented.

Finally, participants recommended that climatic factors used in conservation planning be updated immediately and on a regular basis to reflect current conditions—a recommendation put forward in the 2003 SWCS report and strongly reiterated during this workshop. Updated climatic factors are essential to accurate estimates of the probability of and potential for damage expected from precipitation events. Such estimates are fundamental to effective conservation planning and implementation. Participants were particularly concerned that climate records must include data since the 1970s when greenhouse gas emissions emerged as the most important climate forcing factors. Participants also noted that increased exchanges of climatic data and analyses between agencies, universities, and other entities are vital to effective conservation planning and implementation in the Great Lakes region.

Participants agreed that, if taken now, these steps could make a major contribution to managing the risk posed by a precipitation regime with higher probabilities of severe storms and would help avoid larger costs and damages in the future. Workshop participants also identified two key gaps that must be filled in the near term to increase our capacity in dealing with a riskier climate and precipitation regime: technical support and better monitoring.

URGENT ACTION NEEDED TO FILL GAPS

Workshop participants strongly recommended urgent action to (1) strengthen on-the-ground technical support and assistance networks for conservation implementation at field, farm, and watershed scales and (2) enhance monitoring systems. Participants argued that our ability to cope with increased variability and increased risk is fraying because our technical support networks and monitoring systems are weak.

Technical Support and Assistance Networks

Participants agreed strongly that the single most important barrier to more effective use of current tools and conservation systems is technical support and assistance networks that are weak and growing weaker. Canadian participants stated that their capability to deliver direct technical support and assistance to producers has nearly disappeared. U.S. participants stated that the technical network in the United States is fraying because (1) experienced personnel are retiring, (2) declining budgets are constraining the ability to replace or add staff, train personnel, and develop and transfer conservation technology, and (3) demands on technical staff are increasing to complete time-consuming administrative tasks required to manage growing financial assistance programs.

All participants agreed that inadequate technical support and assistance networks will cause lasting damage to our efforts to respond to current challenges, let alone the growing challenge created by climate change. Well-trained, experienced, and technically sound advisors are the fundamental infrastructure of the technical support and assistance networks. Once those advisors are lost, there will be long time lags before the infrastructure can be rebuilt by bringing new advisors on board and giving them the training and experience they need to perform effectively. If policymakers fund new initiatives, the shortage of technical staff may limit the effectiveness of those initiatives and hinder existing efforts as technical staff are redirected to support the new initiatives. Investment in building technical support and assistance networks must begin now and must be sustained over the foreseeable future. The best tools, practices, and programs will amount to little if the technical support and assistance is not there to translate those tools, practices, and programs into effective action at the field, farm, and watershed level.

Better Monitoring

Participants also stressed the need for better monitoring systems. Severe storms inherently vary in where and when they occur. Managing for such events requires monitoring systems that can detect such events in the context of long-term time series and document their effects at appropriate temporal and spatial scales. Such monitoring systems are essential for showing changes over time, understanding the causes and effects of damage from severe storms, validating models designed to simulate the effects of such events, determining which conservation practices and systems are most effective, and assessing where such practices and systems are best placed on the landscape.

For the most part, such monitoring systems do not currently exist, especially for monitoring episodic sediment transport. Investments should be made now to build such systems. Those investments should first focus on opportunities to knit together existing monitoring systems and to facilitate rapid and open sharing of data. Ideally, better monitoring systems would take a nested approach that can provide data over time and that has a better chance of capturing severe storm events over a range of watershed scales. Monitoring systems that "turn on" during severe events have particular advantages.

Monitoring is essential to truly understanding risk—how big the risk is and where and when the risk is greatest. Long-term monitoring will be needed to detect the occurrence and effect of severe but infrequent storms that by definition do not occur every year.

The most important contribution of well-designed monitoring systems is that they empower adaptive management. Workshop participants saw an example from a conservation authority in Ontario that made a compelling case for building a monitoring system tailored to the needs of a particular community and to the unique features of particular watershed. Participants suggested that a portion of the funding for programs to encourage adoption of conservation practices be set aside for monitoring to support adaptive management of those programs. Monitoring must be a mandatory part of watershed-scale projects.

A research and development effort should be mounted to develop and deploy monitoring systems and technologies that are affordable and to establish and maintain a regional data warehouse that will provide conservationists with the information needed for effective adaptive management. Policymakers must make a long-term commitment to sustain such monitoring systems once in place and must invest now in the design of instrument systems that are affordable to install, operate, and maintain. Participants suggested that we need to take a step back and ask basic questions about what data are really needed for risk-based assessment and planning in an adaptive management framework. Those data may well not be all the data that would be desired for research purposes or to validate a model completely. Those data may also be different from the data we have traditionally collected or may be needed at different spatial and temporal scales. Once the truly essential data needs are defined, innovative and creative technologies and approaches to securing those data must be developed to make such monitoring systems affordable. In all cases, attention must be paid to organizing the resulting data to make the information readily accessible, applicable, and understood.

Better Tools, Technology, and Policy Needed for Managing Risk

Workshop participants argued strongly for an explicit risk-based approach to conservation planning. Conservation planning inherently involves making decisions about "how much is good enough?" In other words, what level of probability and severity of damage to natural resources or the environment is acceptable, and what combination of practices and activities is sufficient to keep the probability and severity of damage at or below that acceptable level?

That risk assessment is made explicit when conservationists plan and construct engineered structures such as terraces, grassed waterways, culverts, and dams. Such structures are designed to withstand the effect of a storm that produces a certain amount of runoff and that has a certain probability of occurring. If the damage caused by failure of the structure is severe, then conservationists design the structure to withstand the effects of a more severe storm with a smaller probability of occurring.

However, the risk assessment that inherently underlies recommendations to implement one or more nonstructural conservation measures, such as conservation tillage or nutrient management, is not currently made explicit. Participants argued that making explicit such risk-based assessment and planning will increase the effectiveness of conservation planning, programs, and policy. Explicitly taking a risk-based approach to conservation is needed today to deal effectively with the "off-site" effects of agriculture—sediment, nutrients, and other pollutants transported off the farm to streams, rivers, and ultimately the Great Lakes. The need for an explicitly risk-based approach to planning is made more urgent by the increased probability of more frequent and more severe storm events.

CONSERVATION AS RISK MANAGEMENT

An effective risk-based approach to planning and implementing conservation—at all scales—must begin with answers to two questions:

1. What environmental or natural resource threats are we most concerned about? Is the most serious threat, for example, delivery of sediment, phosphorus, nitrogen, or other pollutants to tributaries of the Great Lakes, or is the threat more intense runoff events that destabilize those tributary stream channels and destroy aquatic habitat, or is it some combination of multiple specific threats?
2. How much damage is acceptable and what chance are we willing to take that such damage will occur? Specifying acceptable damage and probability of occurrence depends on the nature of the damage and the cost of preventing that damage. If the damage, for example, causes an immediate and serious threat to human health or irreversible damage to particular ecosystems then the risk we are willing to accept will be low. If the cost of lowering the probability of damage is very high, then we may have to accept a higher probability that the damage will occur.

The conservation planning approach, the scale at which such planning occurs, the time-frame the plan must consider, and the conservation practices and systems recommended for implementation must all be driven by the answers to these two questions. If, for example, we are concerned about the risk of a fish kill caused by elevated levels of ammonia in a stream during the few weeks of the year when fish are migrating upstream to spawning grounds, then the planning process must consider the probability that a single storm during that critical period might cause ammonia levels to rise above the critical biological threshold. The recommended conservation measures must be based on the crop and soil conditions during that short period when fish are spawning, the level of treatment needed to resist damage from a single storm, and the cost of implementing and maintaining those measures. On the other hand, if we are concerned about general levels of turbidity in the Great Lakes and that turbidity is contributed by multiple sources in multiple locations across a large basin, then planning should probably be based on longer precipitation periods and at a larger geographic scale.

In other words, the right answer to the question of which approach to conservation planning and implementation is best depends on the objective, acceptable risk, and the spatial and temporal scale of the problem. The choice of planning for a single storm versus annual average conditions, the period of interest or of greatest vulnerability, and the scale at which planning and implementation takes place must all be tailored to the specific threat and the acceptable probability and severity of damage.

Risk-based Planning Tools

Planning tools designed to develop recommendations for conservation efforts at field, farm, and watershed scales can and should be developed that are capable of predicting and reporting the probability of damage from a particular storm event as well as from annual precipitation. Those tools should be able to be tailored to specific times of the year.

Participants stressed that runoff is not the same as precipitation. The same storm can produce very different runoff events—and attendant erosion and pollution events—depending on the season of the year, how saturated the soil is when the storm occurs, and a number of other important factors. In many cases, the probability of a *runoff event* of a particular intensity and duration is what determines the damage to soil, water, and aquatic ecosystems. The size of the storm needed to produce such a runoff event depends on more than the intensity and duration of the precipitation produced by the storm. Risk-based planning tools must be capable of integrating events in the past that have contributed to creating current conditions, such as soil moisture, crop growth, soil cover, and other factors that determine how much runoff, erosion, and pollutant transport a particular storm causes.

Finally, although the workshop focused on managing the effects of increased precipitation intensity, workshop participants were clear that all factors in a changing climate must be considered when doing risk-based assessments, planning, and implementation. Presentations and background papers clearly document that changes in seasonal precipitation patterns may be as important in determining erosion and sediment delivery as are changes in precipitation intensity. Moreover, if increased intensity occurs more frequently during a vulnerable season, the damage to soil and water will be multiplied.

We must consider a changing precipitation regime in the context of the total climate, including observed and predicted changes in seasonal patterns, temperature, snow pack, persistent wet and dry periods, and wind. Some likely changes related to weather extremes and increased storm intensities can be expected to be more of a problem due to synergistic effects that multiply impacts on terrestrial and aquatic ecosystems. For example, increased storm intensities combined with expected declines in late summer water levels can increase pollutant concentrations. Higher temperature regimes could further increase the problem through lowering of oxygen levels in the Great Lakes hypolimnia. This is likely to promote greater microbial decomposition and subsequent

Return Period/Recurrence Interval

A return period—also known as a recurrence interval—provides a way of indicating the likelihood that a storm equal to or exceeding a certain size will occur. The return period/recurrence interval is a statistical estimate made by assessing the number of times storms that equal or exceed a certain size occur over a long period of time.

The return period/recurrence interval has an inverse relationship with the probability that a storm equaling or exceeding a certain size will occur. Extreme storms may have return periods or recurrence intervals as long as 100 or even 500 years because they do not happen very often. Weak storms that happen every year or two may have a return period or recurrence interval of only 2 years.

The return period/recurrence interval is useful in risk management because it is an estimate of the probability that a severe storm will occur. For example, a storm with a 10-year return period/recurrence interval has a 0.1% or 10% chance of occurring in any one year. A storm with a 50-year return period/recurrence interval has a 0.02 (2%) chance of occurring in any one year.

Return periods/recurrence intervals are often interpreted as meaning a storm with a 10-year return period or recurrence interval will occur, on average, once every 10 years and that a 100-year storm is so infrequent that it will only occur every 100 years. This interpretation, however, is not correct. A storm with a 10-year return period/recurrence interval might happen twice or three times in a 10-year period, or it might not happen at all. The probability of getting three 10-year storms in a 10–year period is very low, but it can still happen. Special statistical techniques are often used to assess the return periods of extreme events.

release of nutrients and contaminants from sediments, thereby increasing the damage caused by nutrients and contaminants.

Explicitly risk-based planning and assessment tools would help illustrate implications for different geographic scales and time periods, enable synthesis of diverse data and knowledge, and support multi-objective decision making. Tools with many of these capabilities are already available, but they are not extensively used or verified.

To help move toward a risk-based approach to conservation planning and implementation, participants suggested creating a taxonomy of conservation planning approaches best suited to particular types of threats and risks. Such a taxonomy would be a helpful guide to conservation planners, program managers, and policy makers. Conservationists need the flexibility that such a taxonomy would provide to respond to a range of risks and events and to adapt existing solutions to the unique situations they confront.

Workshop participants agreed that the ultimate goal of risk-based conservation planning and implementation is to increase the capacity of agricultural landscapes to resist and recover from severe events that happen infrequently but that can be anticipated and for which preparations can be made. Many agricultural regions are clearly vulnerable to climate risks associated with more frequent and severe droughts, heat waves, violent storms, and flash flooding that may already be increasing in frequency.

Risk-based Conservation Implementation

Greater resistance and resilience in agricultural landscapes is best achieved through conservation systems composed of multiple and mutually-reinforcing practices and activities implemented at various scales. Conservation tillage, for example, must be backed up with grassed waterways, contour grass strips, filter strips, riparian buffers, and other appropriate and feasible measures on a particular farm in a particular watershed. This layered or multitiered approach to conservation builds in redundancy that helps resist the effect of an infrequent but potentially damaging severe event.

Even the best conservation systems, however, cannot be expected to resist the effect of very severe and very infrequent events. Contingency plans will be needed to deal with the perhaps catastrophic damage from such events.

Landowners, producers, and policymakers may find an explicit risk-based approach to assessment and planning easier to understand, according to several workshop participants, because producers and policymakers understand the risk and value of managing it. Explicitly considering the probability of alternative outcomes may well help producers and policymakers deal with the uncertainties inherent in conservation planning and lead to better decisions.

Using an effective and explicit risk-based approach to conservation planning and implementation creates both opportunities and challenges for conservation work at the field- or farm-level, the watershed-level, and for conservation policy and programs. Participants discussed those opportunities and challenges in depth during the workshop.

MANAGING RISK AT THE FIELD AND FARM SCALES

Participants agreed that the most urgent needs and promising opportunities to enhance the capacity of conservationists to manage the risks created by severe but infrequent storms and runoff events are as follows:

- Predicting and planning for more concentrated flow in ephemeral and permanent gullies.
- Predicting and understanding conservation practice performance and the effects of practice failure in severe storms.

The need for action on these two opportunities is particularly important when predicting and planning for more intense spring runoff events.

Concentrated Flow

RUSLE2, the predominant conservation planning tool currently used at the field scale, falls short in predicting damage from concentrated flow through ephemeral channels on agricultural fields. Current tools do very well in predicting sheet and rill erosion and at evaluating the benefits of conservation practices and systems in controlling sheet and rill erosion, so there is little to be gained by improving current tools to deal with sheet and rill erosion. But the need for better tools to deal with concentrated flow is already urgent. A case study in the Auglaize watershed in Ohio compellingly demonstrated the importance of ephemeral gullies to sediment loss and transport. Models based on sheet and rill erosion predicted far less sediment transport than was actually measured at gauging stations. When ephemeral gully processes were included in the modeling, conservationists discovered that those gullies were more important than sheet and rill erosion in determining the amount and type of sediment delivered. Gully erosion was found to cause more on- and off-site damage than did sheet and rill erosion. Workshop participants noted many other studies and practical experience that have documented similar results.

The evidence indicates that we cannot meet today's challenges—particularly the off-site effects on water quality and aquatic ecosystems—without dealing effectively with concentrated flow. The importance of concentrated flow will increase as precipitation intensity increases. Indeed, among the most troubling effects of increased precipitation intensity on runoff and soil erosion will be beginning shifting the dominant processes causing damage from sheet and rill erosion to concentrated flow erosion in ephemeral or permanent gullies.

The Water Erosion Prediction Project (WEPP) model currently has the capability to simulate ephemeral gully channels in a watershed simulation if the locations of the channels are specified by the user. The USDA Agricultural Research Service (ARS) is also attempting to develop and include an ephemeral gully component in RUSLE2, and related work is underway to develop new technologies that will predict the locations and extent of ephemeral gullies. Developing and implementing tools to enable conservationists to predict and manage the risks created by concentrated flow should receive high priority for adapting to a climate regime with increased probabilities of severe storms.

Practice Performance and Failure

Participants shared evidence and experience indicating that some conservation practices do not produce the same benefits under severe storms as they do under less severe storms, or as predicted under annual average conditions. That evidence is the basis for the recommendation, outlined earlier, for a layered or multitiered approach to conservation in agricultural watersheds. Participants also noted that many in-field practices have been designed to deal with in-field problems. The performance of those practices needs to be re-evaluated based on their effect on off-site problems.

We need a better understanding of "threshold effects" within conservation practices and systems. More specifically, at what point and under what kind of storm events do practices begin to fail and what are the consequences of that failure?

The consequences of practice failure were particularly important to participants. Current tools do not address failure, or, if they do, the assumption is that failure causes no more damage than the amount that would have been experienced if the practice was not in place. Experience, however, indicates that, in some cases, practice failure may result in greater damage than would have occurred if the practice had not been in place. In those cases, the increase in damage results from concentrated flow created as the practice fails.

Concentrated flow is both a major cause of practice failure and a potentially damaging result of the failure. Understanding the threshold effects of concentrated flow on practice failure and understanding the potential of particular practices to exacerbate damage from concentrated flow if they fail should be a high priority for helping understand practice performance and failure under precipitation regimes with higher probabilities of severe storms.

MANAGING RISK AT THE WATERSHED SCALE

Participants discussed at length the advantages of doing risk-based assessment, planning, and implementation at watershed or landscape scales. Indeed, participants argued that working at the watershed or landscape scale is the only way to deal with the off-site effects in agricultural watersheds. It is at the watershed scale that both the damages caused by runoff and pollution from individual farms are expressed and that the benefits of working to improve farm management are realized. Participants strongly agreed that we really cannot address the challenges of climate change and more frequent and more severe storms unless we organize our work at the watershed scale. Conservationists "have to connect the dots—make sure our work on farms adds up—that the sum of our efforts is greater than the parts."

Working at Watershed Scale is Essential

The imperative of working at the watershed scale is particularly compelling when managing the risk associated with severe, but infrequent storms. Watersheds integrate the effect of upstream runoff, erosion from farm fields, and erosion within the stream channel network that drains watersheds. A severe but geographically small storm, for example, may primarily affect farm-scale runoff and erosion. Even though the storm is severe, its geographic extent is too small to affect stream flow and stream erosion beyond the immediate storm area. A succession of less severe storms that affects a large part of the watershed over a few days, however, may lead to damaging stream flow and stream erosion in larger channels draining the watershed.

One can only deal with the implications of such spatial and temporal variability in the occurrence of severe storms by working simultaneously at the field and watershed scales. The conservation practices that are selected must be designed and located with attention to detail at the field scale, but the ultimate and accumulative off-site effects of these practices can only be assessed at the watershed scale. Furthermore, some problems associated with severe storms, such as stream corridor instability, are emergent phenomena that only develop at watershed scales. Looking at the whole watershed is also particularly important when land uses are a diverse mix of agriculture, forest, and urban. Working at the watershed scale also enables evaluation of all sources of pollution, including fields, gullies, construction sites, and stream banks.

Most important, working at the watershed scale opens up opportunities to plan and implement different strategies that complement and increase the benefits of in-field practices. Strategies to restore wetlands, repair stream channels, and enhance riparian corridors are best implemented at the watershed scale and will reinforce the benefits of work at the farm scale *if* the efforts are effectively targeted and coordinated at the watershed scale. Projects planned and implemented at the watershed scale can increase the effectiveness of conservation efforts by considering critical hydrologic factors such as water balance and budgets, base flows, pollution pathways, and the location and treatment of critical source areas and ground water recharge areas. In short, the goal of increasing the resistance and resilience of agricultural watersheds to severe storms can only be accomplished by assessing, planning, and coordinating the implementation of conservation measures at the watershed scale.

Focusing for Effect

The most compelling advantage of working at the watershed scale, according to workshop participants, is the ability to "focus for effect" to direct conservation efforts at the most vulnerable parts of the landscape and during the most vulnerable times of the year. In their presentations, background papers, and discussions, participants cited numerous studies and experience demonstrating that relatively small portions of the landscape often are the source of most of the runoff and pollution in agricultural watersheds. The evidence is compelling that giving first priority to treating these "critical source areas" would substantially increase the effectiveness of conservation programs. Delineation of critical source areas also provides a scientific foundation for determining which producers should have first priority for receiving technical and financial assistance through publicly-funded conservation programs.

Workshop participants were particularly optimistic about the opportunity to manage risk associated with watershed-scale erosion and sediment loading through improved targeting because advances in information technology are making such targeting easier, more affordable and more accessible to conservationists, producers, and policymakers. New tools, such as the High Impact Targeting tool demonstrated during the workshop, make "focusing for effect" much more feasible; clearly demonstrate the rationale for targeting to producers, policymakers, and program managers; and provide a solid basis for difficult decisions to focus resources where they will have the greatest effect.

Participants placed a high priority on research and development work to deploy tools that allow us to effectively and affordably map critical source areas at the watershed scale and to deploy simpler tools that can be used at the field and farm level to identify and focus treatment on critical source areas.

Developers of such tools, however, must recognize that the benefits of targeting will be greater in some landscapes and when applied to some problems. One component of such tools should be to identify those problems and landscapes where targeting will pay off most handsomely, and then to focus our development and deployment of tools targeted at those opportunities.

Workshop participants were adamant that while watershed models, simulations, and maps are valuable, they can never replace the need to get into the field in order to adequately assess conservation problems and to critically place conservation practices. Databases used in watershed models necessarily must simplify the details of individual fields. These details, however, are critical to the successful design, construction, and functioning of conservation practices. New tools and improved databases can ramp up the efficiency and effectiveness of the time and effort spent in the field.

Finally, participants discussed the need to work through the political and social implications of focusing for effect. Participants agreed that "we can't afford not to target—there just isn't enough money and time to do otherwise." To maintain political support, however, there also needs to be a base program that is more broadly available in the watershed. Striking the right balance between targeted efforts and more broad-based efforts will be key to maintaining political support within watersheds.

Enhancing Communication and Understanding

Workshop participants also recommended that we maximize the communication value of new targeting tools and models. GIS-based tools can and should be developed to help producers, policymakers, and citizens better understand the causes and effects of problems in their watershed and thereby to inform and communicate problem identification and decision making. The social and economic implications of the consequences of severe storms and of alternative risk management options need to be made clear, as do the physical and ecological consequences. Participants saw compelling examples of such tools during the workshop, including the following:

- The Cattaraugus Creek watershed project in New York connecting model-based decision making with landowner and community education and participatory planning.
- The Lower Maumee project in Ohio using decision support system partnerships to create a web portal tool to help local units of government identify critical source areas for sediment.
- The Credit Valley Conservation Authority in Ontario using monitoring data and modeling to develop contingency plans for flood damage control and to create a flood warning system for municipalities.

Workshop participants highlighted that developing better understanding of the processes, pathways, and timing of runoff and pollutants delivered to streams and lakes in agricultural watersheds is the single most urgent research priority for strengthening targeting tools at both watershed and field scales. Conservationists need to better understand channel processes and to what extent severe storms and runoff events drive processes at the watershed scale. Research efforts to understand and quantify these processes should be the highest priority for improving risk-based assessment, planning, and implementation at the watershed scale.

PROGRAMS AND POLICIES

Workshop participants identified four immediate opportunities and two critical gaps that need immediate programmatic and policy intervention. Those ideas and recommendations were outlined earlier in this report. Participants also discussed programmatic and policy implications that will require more long-term attention to support risk-based assessment, planning, and implementation of conservation efforts to improve the health of the Great Lakes ecosystem. Those implications include actions to ensure there is a long-term commitment of resources and people to watershed-scale projects and actions to spur wider use of conservation systems and measures.

Commitment to Watershed Projects

The advantages of focusing conservation efforts through community-driven projects at the watershed scale are compelling. Public policy must ensure a long-term commitment of people and resources to such projects. The more traditional approach of providing short-term, three- to five-year grants to communities will not work. Sustained effort and support must be available to build the local infrastructure—leadership, technical support, and monitoring systems—essential to making effective adaptive management possible.

Moreover, effective watershed projects depend on relationships and partnerships that are developed over many years. Steady funding and support are essential to sustaining those partnerships and relationships over the long term.

Innovative funding systems need to be developed and tested to provide sustained support to community-driven watershed projects. Options are needed to organize financing so that those benefiting from risk reduction help pay the costs imposed on others to achieve that reduction. Who faces the risk, who benefits, and who pays? These are questions that must be explicitly resolved at the project level to ensure that long-term financing exists to support such projects.

Increased Use of Conservation Systems

Despite substantial efforts for many years, evidence presented at the workshop suggests that well-understood conservation systems and measures are still used on less than half of the agricultural landscape—in some cases far less than half. More effective conservation assessment and planning tools will

Policy and Program Recommendations—Canadian Perspective

The Ontario Chapter of the Soil and Water Conservation Society undertook a study to determine, in part, if changes in precipitation regimes in the Canadian portion of the Great Lakes region were significant enough to warrant adaptation of policies and conservation programs. The report reviewed policies and practices in soil erosion prevention and control measures in Ontario in order to assess their adequacy in the near future. The chapter put forward a set of recommendations for necessary modifications to erosion control and prevention practices—as well as to design criteria—in order to cope with the changing climate and to minimize future soil loss and water pollution:

- Develop a relatively simple methodology for identifying and mapping those portions of rural watersheds (at a field scale) that constitute critical source areas for surface runoff, stream sediments and associated contaminants, with particular attention given to winter and spring runoff conditions.
- Expand the implementation of nutrient, pesticide, and bacteria control measures in all agricultural regions of the province, with particular attention given to those portions of rural watersheds that constitute (1) critical source areas for surface runoff and stream sediments and (2) critical source areas for groundwater recharge, with a primary focus on winter and spring conditions.
- For all farms, move toward the following goals: a reduction of pesticide use by 30%; provision for adequate containment of manure and elimination of winter spreading; minimization of chemical nutrient application, especially in spring; minimization of chemical and nutrient application outside the growing season; where beneficial, installation of buffer strips or set back zones; expansion of wetlands where they can be effective in reducing peak flows.
- Develop a plan to compensate farmers for conservation measures that reduce sediment and pollutant transport to waterways, protect soil and water quality, and sequester greenhouse gases.
- Conduct programs to increase forest and wetland land uses in critical source areas, thereby reducing movement of sediment and contaminants into waterways and the Great Lakes.
- Monitor and assess to better understand trends in the Great Lakes basin related to climate change, including especially the following: reinstate systematic sediment transport monitoring on major tributaries to Great Lakes and ensure that large runoff/erosion events are measured; provide for a more extensive network of recording rain gauges and keep up-to-date the analyses of intensity-duration-frequency data; institute a long-term small watershed study in an agricultural region tributary to the Great Lakes with instrumentation to determine impacts on sediment transport and runoff with various agricultural practices and trends of extreme events; measure and assess near-shore Great Lakes water quality in late winter and spring each year for chemical composition, turbidity, bacterial contamination, and biological production; use satellite imagery to assess sediment transport and dispersion; and analyze water quality from water intakes to assess near-shore contamination.

Source: Ontario Chapter of the Soil and Water Conservation Society (2006).

accomplish little, according to workshop participants, unless we find effective ways to increase the use and implementation of conservation systems and to target implementation at the most critical portions of farms and watersheds. Social science must play a role in understanding the reasons producers do and do not adopt conservation systems. Public policy must play a role in correctly creating the right incentives through voluntary and regulatory programs.

Conservation programs must take into account the realities of current farm structure and land tenure. In the U.S. Corn Belt, over 50% of farmland is rented, with some states having more than 70% of farmland rented. "Farms" may be composed of many individual fields spread over many miles. The traditional image of the farmstead surrounded by contiguous fields and managed by a single owner-operator is no longer the reality in much of the United States and Canada. Landowners, producers, and increasingly farm management consultants are joint decision makers when it comes to implementing conservation practices and systems. Incentive programs must become more adept at directing the right incentives to the right decision maker. The decision makers will need to understand how much they stand to lose by not using conservation systems and how much they stand to gain if they do. Different decision makers will be interested in different gains and losses, and hence in different benefits from adopting conservation measures.

Participants suggested that agriculture is losing its position as a protected industry, historically exempted from the environmental laws and regulations that affect most industries. More and more sectors of agriculture are facing regulatory requirements, particularly at the state/province and local level in the Great Lakes region. Participants expect that trend to continue and accelerate.

The opportunity to develop regulatory systems that are innovative and well suited for agriculture is great. One of the most important roles for regulation is to set performance

Policy and Program Recommendations—U.S. Perspective

The Soil and Water Conservation Society (SWCS) undertook a project—funded by the Joyce Foundation—to identify opportunities to more effectively restore the Great Lakes ecosystem by harnessing USDA conservation programs. SWCS organized four roundtable discussions to tap the ideas of people with hands-on experience with USDA conservation programs in the Great Lakes Region. The workshops focused on administrative and legislative reform of USDA conservation programs.

Participants in the roundtable discussions put forward the following ideas for reform:

- **Get real and get results.** Roundtable participants stated that protection of the Great Lakes must receive higher priority and that conservation efforts must be targeted at those critical tributary watersheds that are the source of most of the pollution in the Great Lakes. More trained people on-the-ground is critical as the current technical support and assistance network is simply not adequate to the challenge. Participants also recommended that conservation programs should focus on implementation of the key conservation practices and systems, and that much more attention needs to be paid to monitoring and evaluation. Finally, participants recommended that more emphasis be placed on regulatory programs to supplement voluntary programs.
- **Get on the same page.** Roundtable participants reported that there are too many mixed messages and static in the system among the multitude of local, state, federal, and nongovernmental institutions involved in protecting the Great Lakes. They argued for common standards and performance indicators for agricultural pollution prevention activities and efforts, and for greater success in harmonizing USDA programs with state and local initiatives.
- **Institutional reform.** Roundtable participants reported that the structure and multiplicity of institutions in the Great Lakes region creates barriers to effective pollution prevention efforts. They recommended that programs "fund projects, not practices," and that new funding mechanisms be created to allocate program dollars on a watershed project basis. Field staff and technical support must be organized around project boundaries, and accountability should be based on real results, not the amount of paperwork produced.
- **Innovation.** Roundtable participants also recommended taking more innovative approaches to pollution prevention in agricultural watersheds. They recommended that more attention be paid to restoring or repairing the hydrology in agricultural watersheds through natural stream channel restoration and by controlling drainage in tile-drained watersheds. They also recommended using improved information technology and decision support systems, and stressed the need for better monitoring systems and technology.

Source: Soil and Water Conservation Society (2007).

standards both at the farm and watershed level. Such standards answer one of the two most important questions outlined above for risk-based conservation—how much is good enough? Such standards and regulatory measures can provide real incentives to participate in voluntary programs as a means of achieving those standards. With sufficient funding, most producers could meet regulatory standards through participation in such programs. Imposition of penalties could be reserved for the minority of producers who consistently refuse to cooperate.

Innovative approaches to regulatory mechanisms would also produce greater results with fewer burdens on agricultural producers. To the maximum extent possible, regulations should be based on performance rather than practice standards. Regulations should clearly tell producers *what* they need to accomplish, but producers and their technical advisors should have the flexibility to determine *how* to accomplish it.

Moreover, innovative approaches that apply performance standards at the watershed rather than the farm scale hold great promise for producing greater results with lesser burdens. Producers, managers, and/or landowners should be encouraged to work collaboratively to achieve the goals for the watershed. Collaboration would make certain measures possible, such as modification of drainage systems, contiguous restoration or repair of riparian zones, and other such measures that cannot be effectively achieved through uncoordinated efforts of individual producers. Performance standards at the watershed level would also reward targeting effort at the most critical portions of the watershed and make possible market-based approaches to meeting regulatory goals.

REFERENCES

Baker, David, and Peter Richards. 2003. The roles of flood timing and intensity in controlling nutrient loading and bioavailability in Lake Erie. Water Quality Laboratory, Heidelberg College, unpublished.

Davis Todd, C.E., J.M. Harbor, and B.Tyner. 2006. Increasing magnitudes and frequencies of extreme precipitation events used for hydraulic analysis in the Midwest. *Journal of Soil and Water Conservation* 61(4): 179-185.

Great Lakes Regional Collaboration. 2005. Great Lakes Regional Collaboration Strategy to Restore and Protect the Great Lakes. http://www.glrc.us

Hershfield, D.M. 1961. Rainfall frequency atlas of the United States for durations from 30 minutes to 24 hours and return periods from one to 100 years. Technical Paper 40. Washington, DC: National Weather Bureau.

Intergovernmental Panel on Climate Change. 2007. Climate Change 2007: The Physical Science Basis. World Meterological Organization and the United Nations Environmental Programme, Geneva, Switzerland. http://www.ipcc.ch/SPM2feb07.pdf.

Ontario Chapter of the Soil and Water Conservation Society. 2006. Planning for Extremes: Adapting to impacts on soil and water from higher intensity rains with climate change in the Great Lakes basin. Ottawa, Ontario: Ontario Chapter of the Soil and Water Conservation Society.

Patz, J. 2001. Public health risk assessment linked to climatic and ecological change. *Human and Ecological Risk Assessment* 7: 1317-1327.

Richards, R.P. 2006. Trends in Water Quality in Lake Erie Tributaries, 1974–2004. Presentation at the State of Lakes Ecosystem Conference, Milwaukee, Wisconsin, November 1–3, 2006.

Robinson, A. Y. 2006. An Overview of Great Lakes Threats: Sources and Priorities Agricultural Nonpoint Impairments Role in Overall Problems. Briefing Paper for the Soil and Water Conservation Society Planning for Extremes Workshop, Milwaukee, Wisconsin, November 1–3, 2006. Ankeny, IA: Soil and Water Conservation Society.

Soil and Water Conservation Society. 2003. *The Conservation Implications of Climate Change: Soil Erosion and Runoff from Cropland.* Ankeny, IA: Soil and Water Conservation Society.

Soil and Water Conservation Society. 2007. Report of Roundtable Discussions from the Soil and Water Conservation Society Planning for Extremes Workshop, Milwaukee, Wisconsin, November 1–3, 2006. Ankeny, IA: Soil and Water Conservation Society, in press.

Toledo Harbor AGNPS Project Team. 2005. Upper Auglaize Watershed AGNPS Modeling Project: Final Report. A report prepared for the U.S. Army Corps of Engineers, Buffalo District.

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