The Agricultural Sector Assessment

Report of a Stakeholder/Sector Assessment Team Planning Meeting

January 21st, 1999
Washington, DC

Foreword

The National Assessment is a joint activity of federal, state, local and tribal governments, and the private sector to understand the implications of climate change and climate variability for the nation. A periodic assessment of global change research and the implications of global change for the Nation was mandated by Congress when the U.S. Global Change Research Program was authorized. The federal government initiated the ongoing National Assessment activity to fulfill, in part, this requirement. The initial phase of the Assessment will result in a synthesis report to be produced by January 2000.

The National Assessment includes regional assessment activities intended to make research results relevant and useful to the conditions, issues, and concerns as they vary across the country. Sector assessment activities are also incorporated and designed to integrate across issues that cannot be dealt with easily on a regional basis. These include topics such as inter-regional and international trade and competitiveness. In addition to the Agricultural Sector Assessment, the National Assessment also includes sector assessment activities for forests, human health, coastal areas and marine resources, and water resources. While not a comprehensive list of sectors and activities affected by climate variability and potential climate change, the sector assessment activities being undertaken in this initial effort cover some of the more sensitive issue areas.

The National Assessment also includes a synthesis activity designed to combine the results from the regions and sectors to produce a summary report. This report is scheduled for completion in January 2000. Regions and sectors will also provide critical input to the synthesis activity by producing detailed reports of specific relevance to their respective stakeholders and researchers. The Agricultural Sector Assessment plans to complete and publish a report by February of 2000.

An important goal of the National Assessment is that it be participatory and engage stakeholders and the public. This philosophy flows from the belief that applied science must be applicable to the needs of those who intend to use it. It is far more likely that research will be applicable if potential users are involved throughout the assessment process. In this spirit, the Agriculture Sector Assessment held a joint workshop of its Steering Committee, composed of stakeholders and potential users of the research, and the Sector Assessment Team responsible for carrying out the assessment. This first meeting was intended to help establish topics that will be considered in the assessment.

The joint workshop included presentations of summaries of existing research and issues and initial plans of the Sector Assessment Team, presentations by Steering Committee members, and reactions to the initial plans by Steering Committee members. This brief report is intended to capture the main points raised at the workshop. The outline of the report follows closely with the agenda for the workshop. The format of the workshop included short presentations and comments by panelists with a period of open discussion.

Dr. Rosina Bierbaum, the Associate Director for Environment at the Office of Science and Technology Policy, provided an overview of the role of the National Assessment in the US Global Change Research Program. A summary of her remarks is included as an introduction to the workshop report.

The meeting opened with an introduction to the National Assessment and a brief overview of the findings and limits of research and assessments of agricultural impacts to date. The first panel focused on trends and forces that will likely shape agriculture over the next few decades. This panel provided an overview of the changing demographic, economic, technological, policy, environmental, trade, and business conditions of the agriculture sector. The capabilities of agriculture to adapt to climate change and variability depend on how these factors will change. The next panel addressed climate variability and its potential effects on the sector. It included discussion the impacts of historic variability driven by events such as the El Niño-Southern Oscillation (ENSO) phenomenon and a discussion of what General Circulation Models (GCMS) of the future global climate are projecting about possible changes in variability. Agro-environmental-climate links were covered in the next panel. The panel identified some of the principal environmental problems related to agriculture, environmental services generated from retaining land in agriculture, and how climate change and climate variability factor into these environmental issues. The final panel addressed the question of how to make the agriculture sector assessment most useful. It included perspectives from stakeholders and scientists involved in past assessments of the agriculture sector.

Comments and suggestions from the general public on this report and on the Agricultural Sector Assessment in general are welcome. Because the Assessment is an ongoing activity, comments that cannot be addressed in the current phase of the research can help shape future assessments. Please direct comments to the Sector Liaison at the National Assessment Coordination Office (NACO) at (202) 314-2230.

The Workshop was co-sponsored by the USDA through the USDA Global Change Program Office (GCPO), the USDA Economic Research Service (ERS), and the Farm Foundation. Funding was provided by the USDA GCPO utilizing money provided for the assessment by the Agricultural Research Service (ARS), Cooperative State Research, Education, and Extension Service (CSREES), ERS, Forest Service (FS), and the Natural Resources Conservation Service (NRCS). The ERS and the Farm Foundation provided additional workshop funding. The workshop was held in ERS facilities at 1800 M Street, NW in Washington, DC. We are grateful to Margot Anderson, Director of the USDA GCPO, Robbin Shoemaker, Chief of the Natural Resource and Conservation Management Branch of the ERS and Walter Armbruster, Managing Director of the Farm Foundation, for providing support from their organizations. Thanks are extended to Rosa Pitts, Carolyn Terry, Melody Mathis-Pace and the conference facility support staff at ERS for planning and facility support. Special recognition is also given to Justin Wettstein of NACO for his hard work and dedication to ensuring that the workshop and its follow-up report were a success.

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SUMMARY—WHAT HAVE WE HEARD?

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The Role of the National Assessment in the US Global Change Research Program

Rosina Bierbaum, Associate Director for Environment, Office of Science and Technology Policy

The U.S. Global Change Research Program (USGCRP) is an unusual program as Federal science research goes because involvement and responsibility cuts across most Federal agencies. An assessment, which the current National Assessment represents, was required when the USGCRP was authorized. Basic questions of concern to Congress in requesting an assessment were "What is important to know?" and "What's possible to know?" These guiding questions are framed in terms of both potential changes in climate and variability and the associated impacts of these changes.

The early years of USGCRP activities focused on climate science questions. Now the program is moving to address questions such as how fast climate will change, where it will occur, and how it will affect people. One observation from the regional workshops already conducted is that water is a central issue—whether because of too little water (with the consequence being drought), too much (resulting in flooding), or at the wrong time (e.g. due to changing snowmelt dates). Even the form of water can matter--in Alaska, thawing of ice previously held in permafrost is leading to road damage.

The philosophical foundation of the National Assessment is that policymakers are inherently better off if they understand the relevant science. To do this, science results must be couched in terms relevant to policy issues, but never driven by them. This philosophy is translated into practice in the National Assessment effort of the USGCRP by focusing on 4 basic policy-relevant science questions:

- What are the current stresses facing the sector?
- How does climate change imposed on these stresses exacerbate or ameliorate these stresses?
- What are the priority research needs?
- What coping options exist?

Specific issues that need attention in the agriculture assessment include:

- An integrated examination of how crops would shift under changing climate
- The CO_2 fertilization effect
- The impacts of pests on agriculture—a particularly understudied area.
- Integration of irrigation water supply for agriculture with changes in supply and demand by other water users.
- Economic influences, including international trade and competitiveness

In addition, the Agriculture Sector Assessment should focus on the following 4 issues which are important foci of all National Assessment Activities:

1. Extreme events: Floods and droughts are obviously important to agricultural production. Such events need to be considered in their full complexity, to include for example, the indirect effects of changes in pest infestations and environmental impacts that are the consequence of extreme events.
2. Scale-dependent issues: While national-level food production may not be imperiled by climate change and variability, the impacts may be felt disproportionately across regions and different types of farmers with some regions and types of farms suffering severe consequences.
3. Multiple stresses: The impact of multiple factors occurring simultaneously may have a different impact than individual stresses considered alone. For example, saltwater intrusion, changing storm patterns, and higher temperatures could simultaneously affect the South Florida Everglades even as there is further urbanization and greater demands for water. For this reason, a complete conceptual understanding of what assumptions are built into models is extremely important.
4. Surprises: How can different possible changes impact the sector and how will those changes come to pass? For example, some models predict 20-30 percent loss in soil moisture in a world with a doubled equivalent carbon dioxide concentration. How will agriculture meet this challenge and which aspects of production are most vulnerable?

THE AGRICULTURAL SECTOR ASSESSMENT--OVERVIEW

Margot Anderson, Director, USDA Global Change Program Office

Margot Anderson acknowledged the range of experience and expertise represented in the workshop. She stressed the importance of participation of the Steering Committee in helping to draft, critique, and revise products that come out of the Agriculture Sector. She related her enthusiasm about the potential for valuable input from all of the participants and anticipated a quality report. To ensure a quality report she emphasized that the Agriculture Sector report must ensure both scientific credibility and relevant topical coverage.

Jeff Graham, Meteorologist, USDA Global Change Program Office & Co-chair of the Agriculture Sector of the National Assessment

Jeff Graham, the federal co-chair for the Agriculture Sector, noted the essential nature of the Steering Committee members as representatives of the stakeholders involved in various aspect of agricultural production. He assured them that their candid responses to the effort and its initial plans were needed and would be used in setting priorities for the assessment.

John Reilly, Associate Director for Research, Joint Program on the Science and

Policy of Global Change, MIT & Co-chair of the Agriculture Sector of the National Assessment

John Reilly, the non-federal co-chair of the Agriculture Sector, discussed the mandate, approach, and proposed vision for the Agriculture Sector Assessment Report. First, he defined three purposes of the assessment effort:

- The Agriculture Sector Assessment should feed valuable information into the IPCC 3rd Assessment Report
- The Agriculture Sector Assessment should fulfill the goals of the "Global Change Research Act of 1990" through the auspices of the US Global Change Research Program
- The Agriculture Sector Assessment should bring useful scientific results to decision-makers in agriculture with the aim of providing information for better decisions.

He identified four questions to be answered in some form in the course of the assessment:

1. What are the key stresses and issues facing agriculture?
2. How will climate change and climate variability exacerbate or ameliorate current stresses?
3. What are the research priorities are most important to fill knowledge gaps?
4. What coping options exist that can build resiliency into the system?

Incorporating these topics into the framework of an assessment requires a fundamental understanding of what is important. First of all, the impacts of climate change to agriculture are really the local effects of extreme events and variability. The focus of this report is on the impacts of climate change on and the adaptation responses to these impacts for the agriculture sector. Agriculture/environment interactions, the impacts of climate variability and interactions of agricultural production and changes in water resources were identified as areas that had not been investigated in past assessments.

With these goals and general guiding thoughts formalized, a mixed approach to conducting work in the sector was suggested. By combining a literature review with the analysis of standard climate and socioeconomic scenarios being proposed by the National Assessment Synthesis Team (NAST), the Agriculture Sector team should be able to develop an informed view of what future climate change may hold. Existing assessments have focused on doubled atmospheric carbon dioxide and other stabilization scenarios. The NAST scenarios provide the opportunity to investigate decade-by-decade (transient) scenarios. It will also be important to incorporate the effects of higher greenhouse gas concentrations on photosynthetic response and water-use efficiency. Case study investigations of the impacts and responses to current variability will also be useful in understanding the options farmers and the farm sector have to respond to and cope with climate change. Improved resiliency to climate variability is likely to improve the capability to adapt to long-term changes in climate. Although the assessment is limited in what it can accomplish in this first phase due to time and resource constraints, this

assessment will set the stage for future efforts. To use the available time and resources effectively, the assessment team will need to choose key areas where understanding can be advanced and where remaining gaps can be clearly identified. The thoughts and comments of the Steering Committee will be essential to setting these priorities.

COMMENTS

Gaps in existing assessments were identified. These included rangeland agriculture and livestock and poultry production. Comments also emphasized that the assessment should focus on the ability to make short range forecasts of extreme weather events and variability, as improvements here would be most useful to stakeholders.

TRENDS AND FORCES SHAPING U.S. AGRICULTURE

Walter Armbruster, Managing Director, Farm Foundation

Walter Armbruster described the mission of the Farm Foundation as bringing together economics, policy, and agribusiness with the intent of building the base for better policy and better decisions. The issue of climate change and the focus of the workshop fit well with this mission. He indicated that, in general, it would be very valuable for agricultural producers to understand what is known and unknown about the impacts of climate change and variability on agriculture.

Susan Offutt, Administrator, Economic Research Service

Susan Offut, Administrator of the USDA Economic Research Service, stressed one fundamental point that she suggested should guide the Agriculture Sector Assessment. She emphasized that agriculture is not a monolithic enterprise, but is quite varied in both the natural resource and climatic conditions in which farmers operate and in terms of the business enterprises engaged in farming (the structure of agriculture). The impacts of climate change and the responses to climate change are therefore likely to vary across regions with different climate and resource characteristics, business enterprise type, demographic group, and farm size among other characteristics. In order for the Agriculture Sector Assessment to manage this effectively, it must conduct a meaningful disaggregation that recognizes the different types of farms that exist. Meaningful categories that could be useful for differentiating include: 1) level of income generated, 2) type of farmer/operator, and 3) amount of acreage in production. Some of the most powerful examples that were presented to demonstrate the diversity of agriculture include:

1. The largest 8 percent of farmers account for 61 percent of the food production. In terms of food security (will climate change imperil food production), an assessment must focus heavily on this group of farmers.

2. People who do not rely on agricultural production as their primary means of income now own 55 percent of farms. This majority is important to the extent the assessment is concerned about the management of land or water resources. Retired farmers own 24 percent of the agricultural land in the United States. These farms, along with residential farms, account for half of the acreage in the Conservation Reserve Program (CRP) or Wetlands Reserve Program (WRP).
3. 44 percent of the U.S. acreage of agricultural land is in the control of small farms. If one includes farms that are primarily residences, but also produce some agricultural products, the figure rises to two-thirds of the total acreage. While large farms are important from a strict food production perspective, small farmers control much of the land. Research shows that the decisions they make are affected by many factors beyond those exclusively affecting management decisions of a business enterprise.

To be useful in terms of providing valuable information to agricultural producers, the assessment should also be aware of other major considerations that affect individual producers as well as the sector as a whole. The first is that risk-taking ability increases with farm size. As a result, smaller farms are less likely to be able to adapt or will be disadvantaged if they adapt too slowly. Second, the agricultural production that will be realized in a given area is a function of the underlying resource base. The underlying resource base links agricultural production to environmental impacts as well as the ability producers may have to adapt. In addition, many of the resource questions have a long planning horizon and may be influenced by long term climate change. Both of these considerations help to tie the resource management aspect of production to the household decisions that farmers face.

The goal should be to disaggregate agriculture to usefully portray the varying ways it might be affected while maintaining a feasibly limited number of regions and farm types.

Richard Gady, Vice President for Public Affairs and Chief Economist, ConAgra

Richard Gady emphasized the need to provide information that is most directly valuable to stakeholders. To this end, it was suggested that the assessment examine both warming and cooling trends in a short-term timeframe and differentiate between changes that may occur in winter versus those that occur in summer. He indicated that the activity should realize that many would describe our understanding of man's impact on climate as uncertain or inconclusive.

Four important forces were identified that will shape agriculture over the coming decades:

1. Biotechnology: There is great potential to improve adaptability, develop resistance to heat and drought, and change the maturation schedule of crops. Biotechnology also will give rise to entirely new streams of products and will allow the interchange of characteristics among crops.

2. Precision farming: The incorporation of information technology (e.g. computers and satellite technology) in agriculture will improve farmers' ability to manage resources and to adapt more rapidly to changing conditions.
3. Global food production and the global market place: Ever-greater linkages are the rule among suppliers around the world. These links are developing in response to the need to assure a regular and diverse product supply to consumers. Meat consumption is likely to increase in poorer nations as their wealth increases and this will place a greater pressure on resources. Climate change could exacerbate these resource problems.
4. Industrialization of agriculture: The ever-faster flow of information and the development of cropping systems that can be applied across the world will transcend national boundaries.

In general, the analysis of the impacts of climate change should not underestimate the ability of agriculture to adapt. Historical analyses may not be relevant because new technologies and systems being implemented now are fundamentally different than previous systems. An analysis based on historic responses may be a bad guide for assessing the future.

David Ervin, Chief Economist, Wallace Institute

David Ervin made three important points with respect to thinking about environment and natural resource management and climate change:

- The resource base is very heterogeneous and farming systems and farms are very diverse. People can and will adapt if we provide them the tools to do so.
- There has been a shift in responsibility for managing the environment from the federal government to state and local government. It is reasonable to assume this will continue.
- Improved scientific research to identify problems and understand causal linkages is needed to effectively address environmental problems. This is currently a weakness in the set of on-going activities.

In terms of agricultural production linkages to the environment, Ervin identified six agro-environmental issues. He included an assessment of progress agriculture has made in addressing these issues. These were:

1. Water quality and quantity: Water quality and quantity are most directly linked to extreme events. Environmental problems include soil erosion and sedimentation (considerable progress is being made in reducing this problem); excess nutrient loading of water (persistent problems remain); pesticide contamination (science about the extent of associated risks is very uncertain); irrigation related environmental problems stemming from poor drainage of irrigation systems, competition with in-stream uses of water, and land subsidence due to aquifer depletion; and degraded water ecosystem habitats (limited analysis, growing awareness). A key question is

what is the evidence that climate change will enhance the hydrological cycle and increase storm events for the United States? The evidence here is unclear.

2. Pesticides and food safety: The Food Quality Protection Act will have consequences for agriculture by limiting pesticide use or decertifying some pesticides. A climate change assessment should consider how severely the FQPA would limit farmers' ability to adapt to climate change should climate change lead, for example, to higher pest populations.
3. Biodiversity (in terms of both habitat and germplasm): The Crop Reserve Program (CRP) had positive effects on many species, including pheasants and others, but prairie species face big problems. We inadequately protect plant germplasm and have not focused enough on non-indigenous species invasion and preservation of endangered species habitat.
4. Air quality: This has traditionally not been a big concern for agriculture but its importance is growing. The recent changes in enforcement of particulate emission regulations generated concern among farmers about the cost of air quality regulations. On the other side, tropospheric ozone reduces crop yields; farm production could benefit from regulations that reduce the concentration of this gas.
5. Climate change: This has relatively obvious impacts both on agricultural production and on the potential to respond to the threat through carbon sequestration on agricultural soils. Interest is growing in agriculture, particularly because of the potential to sell carbon sequestration in a tradable permit market or otherwise get credit for carbon sequestering activities.
6. Landscape protection: Loss of agricultural lands to urban sprawl has reemerged as a concern in many areas.

Stephanie Mercier, Chief Economist, Senate Agriculture Committee

Stephanie Mercier provided an outlook on likely legislative actions on agriculture policy over the next 2 years. The basic background for near term legislation was that Congress is likely to reconsider aspects of the Federal Agriculture Improvement and Reform Act (FAIR) Act of 1996, which passed with much fanfare and was intended to bring an end to an era of farm programs that had their origin in Great Depression legislation. Reconsideration of FAIR is likely because low prices in 1998 caused new financial stresses for agriculture and most see little prospect that prices will improve in the next few years. As such, many in Congress believe that support payments under FAIR, due to be phased out completely over 7 years, are inadequate and that $6 billion to compensate for low prices and the impacts of weather may be well justified. Given this background the major issues likely to come up in Congress over the next 2 years are:

- Will Congress revisit the 1996 Farm Bill to strengthen the safety net for farmers? It is likely that the fundamental shape of agriculture payments will continue. The current thinking on this topic is:

    1. Assistance for economic disasters needs to be thought through.
    2. There is a sense that planting flexibility in FAIR worked and will be retained.

3. There is an interest in improving crop insurance, but there are widely different ideas about what "improved" means.
4. A sense that the shift away from counter-cyclical program payments was not well thought out by Congress in the 1996 bill.
5. Federal support for agriculture will continue. Decoupling payments, the underlying approach in FAIR, was better in theory than in practice.
6. Some unresolved questions include: Will payments be linked to environmental performance in 2002 farm legislation? What happened in the hog price collapse that caused so much stress this year? Were integrated contractors responsible? Is this a sign of more fundamental issues with regard to the structure of agriculture?

- In terms of international trade; the next World Trade Organization (WTO) mini-round will be held in the US. The biggest question is whether or not Congress will pass fast track legislation authority. There is a good chance they will not. If it does pass, the US will likely seek further reductions in barriers to trade. Specific issues will be state trading and trade in genetically modified organisms. A problem facing further trade barrier reduction is that it is increasingly difficult to convince farmers that freer trade is good for them.
- Environmental pressures as they relate to agriculture are likely to become more important in the future.

Debbie Reed, Legislative Assistant, Office of Senator Robert Kerrey

Debbie Reed focused attention on the likely environmental legislative agenda in Congress. With regard to climate change and agriculture, one major issue is agriculture's role in climate mitigation strategies. A bipartisan commission has been formed to deal with how agriculture can position itself to benefit from climate mitigation strategies. This commission includes Senators Kerry, Lugar, Roberts, and Harkin. Its aim is to ensure that agriculture is able to obtain early credit for action on par with industrial activities. A major sticking point is the difficulty of measuring and/or verifying the levels of carbon sequestration that are occurring and could therefore receive such credits.

The critical issue from the legislative perspective, however, is that environmental and/or natural resources legislation is not on the priority list for either party of either house. The big stories are Social Security, Medicare, a balanced budget, what to do with any potential surplus, and tax cuts.

COMMENTS:

Questions and comments focused on how it might be possible to raise the priority of environment and natural resource issues in Congress. The general response was that it would be hard to compete with Social Security, health care, and the balanced budget in the short-term. A positive suggestion was to focus win-win situations that linked environment and resource issues to other issues such as changes in Farm legislation related to disaster or financial assistance. We should be looking for efforts to try and

enhance crop resiliency, increase the organic content of soils, and maintain soil moisture while storing carbon. This was enforced by further comments which emphasized both the importance of water resource constraints and continued incorporation of environmental and climate resiliency programs. A third comment suggested that a coordinated set of agricultural and environmental efforts in realistic areas should be the focus of future agriculture policymaking. The 1985 Farm Bill was cited as an example where natural resource issues played a prominent role with the types of lessons learned from implementation of past environmental legislation. To this end, it was noted that attention should also focus on making sure that existing monies for conservation and environment were retained for this purpose and were spent effectively. A final comment proposed that the assessment disaggregate on the basis of land ownership, rent, and control over production management decisions because these were key issues to consider in determining how and whether farmers would or could respond to climate change, variability, and incentives to improve environmental performance. A subtopic might be how much contracting and risk management different farming operations utilize.

CLIMATE VARIABILITY

Rich Adams, Professor of Agriculture and Resource Economics, Oregon State University
Bruce McCarl, Professor of Agricultural Economics, Texas A&M University
Steven Hollinger, Senior Professional Scientist, Illinois State Water Survey

This panel opened with a discussion of different ways to think about variability in agriculture. Three issues arose, focused on how a deviation is measured, the importance of scale, and the non-independence of the time sequence of events. For example:

- Over time, absolute annual yield deviations from the long-term trend are increasing but as a percent of the annual trend they have remained relatively stable because crop yields have increased.
- Variability in crop yield is relative to the crop and location (humid to sub-humid to arid transitions are key).
- Impacts can depend on the sequence of events. In years when there is a La Niña springtime but normal summers, we see significant losses in production (due to a temperature deviation which is cooler than normal).

With these examples of the complexity of what is meant by variability and how it affects agriculture, the bottom line for agriculture is to determine if climate will become more or less variable and what shape any change will take.

Changing variability results from many factors. A key approach to understand the notion of variability is to focus on what causes changes in production variability. The Pope production function, a mathematical description of production technology designed specifically to incorporate variability, relates changes to both natural variability and to the response mechanisms utilized. This conceptual approach recognizes that variability affects production directly through biophysical and technical relationships and that management decisions of farmers are also changed in response to variability. This

perspective leads us to consider how the agriculture sector currently deals with climate variability. For instance, how do decision-makers cope and manage climate variability? What types of responses are based on individual decision-maker reactions and what market-based risk-sharing mechanisms are available and utilized?

For the Agriculture Sector of the National Assessment, the important topics appear to be:

- How does the utilization of risk-sharing and risk management options change over time and/or space?
- How do farm policy decisions affect production and response to variability? For example, does subsidized insurance or disaster assistance encourage risk-taking behavior?
- How would specific scenarios of future climate change and variability affect measures of overall agricultural performance (i.e., economic welfare, income, production, costs)?
- Is there likely to be spatial correlation to changes in variability and how are they linked to production? The effects of drought on agriculture prices and national production where there is not significant spatial correlation is much different than if droughts occur on a continental scale or across many regions of the world at the same time as occurred, for example, in 1988.
- What are the economic factors relating to specific alternative production practices that may reduce the impact of variability?
- Will changes in variability affect regions differentially?
- Are there developments that may help manage variability?
- How valuable are ENSO predictions to agricultural producers?
- How should the US and local decision-makers proceed with climate-sensitive investments such as increased efficiency of water resource use or tree planting given that climate change is very uncertain and it will be difficult to detect a consistent signal given normal variability in weather?

Linda Mearns, Senior Scientist, National Center for Atmospheric Research

Linda Mearns revealed that the general topic of crop responses to climate variability is a significant focus of her work on climate change and agriculture. She suggested that it is difficult to tease out the impact of climate variability on production from historical data. Current approaches, which include the use of climate models, attempt to assist in the analysis. Models, although admittedly problematic in their predictive capabilities on some levels, are internally consistent and can directly correlate changes to agricultural response. By showing examples of the effects of high temperature extremes on corn yield, it is easy to see that changes in variability are more important in estimating changes in agricultural production than changes in the mean. This is especially evident when we think about changes in the frequency of extreme events.

An important question for the National Assessment is what can the large climate models tell us about changes in variability. Present climate models depict less variance in January, but more variance in the summer months. There is also a general trend toward a reduced diurnal temperature range. Furthermore, models predict increased atmospheric moisture in many regions, which would be likely to have a potential impact on the frequency of events. For example, more moisture in some areas has the potential to change 20-year extreme flood events into 10-year occurrences. Finally, climate model results indicated decreased daily variability of temperature in winter and increased daily variability in the summer for Northern Hemisphere mid-latitude locations.

Andrew Manale, Researcher, U.S. Environmental Protection Agency

The use of climate models, including both nested global and regional types, is appropriate for impact analysis, but applications depend on the question that is being asked. The impact of variability on agriculture is already increasing, regardless of the sort of impact that climate change may have. Especially important to agriculture is the potential trend toward an increase in 95^{th} percentile events that has potentially developed over the past 40 years. This possibility suggests that we should focus on opportunities that exist for agriculture to reduce costs currently being experienced as a result of climate variability—both now and in a potentially changing future climate. This framework would help ensure that we don't suggest options that would increase the risk farmers experience in the future.

Albert Peterlin, Chief Meteorologist, U.S. Department of Agriculture

Albert Peterlin focused on the need for improved accuracy of weather monitoring in agricultural areas and, in general, as fundamental to improving climate prediction and to improving adaptation to climate change and climate variability. An example of the impacts of variability was the $300 million or more in damage to California agriculture from the 1998 El Niño event while coupled with increased grain production both in the heartland and overseas. The foundation of improved understanding of these phenomena includes weather observations that can be used to help estimate and validate climate responses in models. The main problem is that there are significant gaps in sampling and monitoring that result in gaps in observational records. The Cooperative Monitoring Network on which we rely has not been modernized throughout its history. There is still no consistent soil moisture network in the United States and so it is difficult to assess climate model predictions of soil moisture deficits when there is no data to validate predictions even of current soil moisture conditions. In order to gain a fundamental understanding of responses, it is essential to ensure adequate data collection to drive climate response studies.

Carl Mattson, Montana Farmer

Carl Mattson focused his comments on what appears to be happening from the perspective of an agricultural producer. First, winters in Montana are not as cold as they

used to be. Glasgow, Montana went through an entire winter without sub-zero temperatures. His local area went through two of the driest summers on record.

Agricultural producers in his area are also quite vulnerable. In his region, 50-70 percent of the costs realized in a production year result from the planting of crops. Thus, if crops fail, these costs must be borne by the farmer with no revenues to offset them. This is not a trivial amount and, even with crop insurance, some producers are being slowly squeezed out of the business. Some of the potential options for reducing vulnerability are interesting but require large up front investments. As a result, precision agriculture and other investment options are not viable for small producers when, even in good years, there are limited profits to reinvest in farming. Options such as no-till cultivation are reducing costs and appear to ultimately improve profitability but require several years to implement. Production and profits often fall in the first few years of implementation so farmers must stick with the program and weather reductions in profits until the benefits are realized. Often, a particular field will take 5-6 years to yield significant benefits over status-quo tillage options. The slow payback on the investment limits the number of farmers who can consider adopting no-till agriculture. Finally, any programs designed to encourage carbon sequestration need to consider impacts on production. Many producers would not and could not participate because they need to maintain production levels for a variety of reasons. Thus, for carbon sequestration policy options to be viable in agriculture there needs to be a more realistic approach.

AGRICULTURE, THE ENVIRONMENT AND CLIMATE CHANGE

David Abler, Professor of Agricultural Economics, Pennsylvania State University

David Abler focused on the environmental concerns associated with agriculture as well as the environmental benefits which agriculture provides. He identified potential links with climate change, noting that very little research has been conducted on these links. Hence, the importance of these links and whether climate change would exacerbate or ameliorate effects was largely speculative at this time. Environmental concerns associated with agriculture include:

- Excess nutrients from crops and livestock: This concern incorporates the related issues of excess nitrogen and phosphorous resulting from disproportionate application of these nutrients to crops, the nitrate runoff from livestock waste, eutrophication of water bodies and the associated impacts on ecosystems, commercial fisheries, and recreation, and the nitrate pollution of drinking water systems.
- Air pollution and greenhouse gases: Agriculture has the potential to release (as well as sequester) greenhouse gases. It also can emit other gases or particles that can impact air quality.
- Contaminants in livestock waste: These include potentially high levels of Cryptospiridium and heavy metals.

- Pesticide usage: Pesticides can may enter surface water bodies or leach into groundwater supplies.

The environmental benefits which agriculture provides include:

- Open space amenities
- Rural landscape amenities
- Outdoor recreation opportunities
- Wildlife habitat

In terms of a discussion about the future, agriculture and the environment have to be considered in relation to other areas. For example, dramatic changes to the social, economic, and agricultural systems have occurred over the last century and there is no reason to expect that the pace of these changes will slow. Some potential future scenarios for agriculture in coming decades include the adoption of more biotechnology, increased control over agriculture by environmental regulation, increased utilization of precision agriculture, and preservation of farmland areas.

Climate change has a number of areas where it may potentially affect the linkage between agriculture and the environment. Some possibilities include:

1. Changing levels of nutrients and wastes in the environment may occur due to the effect of changes in precipitation, temperature, and the frequency of extreme events on the total amount of runoff and on the concentration of pollutants in the runoff. Potential mediating factors such as farm management practices and environmental policies could impact the level of change.
2. Soil erosion could be effected by climate change through the direct impacts of precipitation, extreme events, and the effects of carbon dioxide enrichment on soil stability through extent and type of plant growth. Once again, farm management practices and environmental policies may shape how potential impacts are realized.
3. Pesticide use may also change as a result of climate change due to changes in the incidence and geographic location of pest species. Mediating factors such as farm and other land management practices, environmental policies, and future pesticide policies and alternatives could alter the level and character of this impact.
4. Open space may be impacted by climate change because of the direct impacts of extreme events and carbon dioxide fertilization on agricultural land productivity. The mediating factors in this case would be farm management practices and competing demands for land.

In conclusion, the environmental impacts from climate change related to agriculture could be more important to public policy than the production impacts. Of course, major knowledge gaps remain which complicate the answers to these issues.

Eldor Paul, Professor of Soil Science, Michigan State University

Climate change could produce a number of positive effects on agriculture as well as negative ones. First of all, agricultural growth has been correlated to the concentration of carbon dioxide. In addition to this impact, the changes in soil organic matter are incredibly important to consider. For example, carbon sequestration options must increase the size of the pool of carbon actually stored and some soils will never store carbon effectively. Because of this, we need to make some judgements as to how to manage and or mitigate the impacts of climate change intelligently. One potential option is for sequestration to be focused on corn crops. For example, raising the lignin content from its current level of about 10 percent to 20 percent would potentially increase the removal of carbon dioxide from the atmosphere.

Jeff Eisenberg, Senior Policy Advisor for Agriculture, Nature Conservancy

The Nature Conservancy focuses on protecting biodiversity in whatever form or location it appears through reliance on market mechanisms rather than regulatory schemes. Many of the projects the Nature Conservancy conducts involve agricultural lands. One such example is the Mackinac River in Illinois, where altered hydrology led to flash flooding. Whether or not caused by global warming, changing the landscape to slow runoff can benefit the environment. Another example is Fish Creek in Indiana, where the Nature Conservancy worked to abate soil erosion runoff to protect the creek. In this case, there exists an overlap between conservation policy and carbon sequestration, so multiple benefits may be realized. In general, it seems that sequestration should be seen as a subset of the larger problem of soil and water conservation in agricultural areas.

The Nature Conservancy has an interest in increasing funding to protect the environment, including aspects related to agriculture. The problem is that the environment is not on congressional priority lists. There may be a potential, however, for taking advantage of aid directed for agricultural emergencies and tie this to investments in conservation efforts.

William Richards, Former Chief of USDA Natural Resources Conservation Service and Owner of Richards' Farms, Ohio

William Richards noted the many issues raised previously and focused his comments on other trends that concern producers. He observes many farms in his area heavily affected by flooding—more runoff is being generated as urbanization leads to more and more paved areas and decreasing infiltration efficiency. However, the big concern about climate change is really variability. Weather variability is what determines profit or loss for farmers. People in agricultural production can generally find ways to adapt if climate change is gradual, but if large changes in variability occur, this may become quite significant. For this reason, the engineering and design standards for public projects such as dams, flood control, water supply, and transportation systems should be revisited. In addition, our society must look at public policy holistically rather than focusing on just agricultural policy. Farmers can be part of a national effort on carbon

sequestration but they must also become better prepared for the future with technologies such as precision farming and no-till agriculture likely to be important.

Robert Wolcott, Acting Deputy Assistant Administrator, U.S. Environmental Protection Agency

In addressing climate change, the agriculture sector as a whole has an opportunity to showcase the environmental quality aspects of farming as well as the potential that exists for stabilization. The largest economic consideration is to try and improve agriculture's rate of return while enhancing environmental quality. Carbon mitigation policy should be viewed as an insurance policy. The premium is relatively modest but it would offer protection against potentially large and long-term damages that could occur due to climate change.

In terms of the Agriculture Sector Assessment, the outcome should be a coordinated and systems-based demonstration of impacts and responses. Such a coordinated, externality-linked assessment could demonstrate a large number of benefits that would be used to compare with the costs of mitigation strategies.

COMMENTS

Comments addressed a number of links between agriculture and the environment. The first was that water quantity and land use should be incorporated in the discussion. How we manage agricultural land determines the quantity of water that is available. Land use changes that are already underway and anticipated can also be a major source of greenhouse gases—especially nitrous oxide and methane. Consideration of water use in this context also should include the potential for water recycling. A second issue that was raised was that some sort of balance must be struck between mitigation and impacts. Finally, it was noted that a searchable database for current sets of data on climate change and agriculture is located at http://www.ciesin.colostate.edu/USDA.

HOW CAN AN ASSESSMENT BE USEFUL FOR THE AGRICULTURAL COMMUNITY?

Ann Veneman, Former Secretary, California Department of Food and Agriculture

Ann Veneman covered three major topics: 1) The importance of California agriculture to the nation, 2) The broad forces affecting agriculture, and 3) Approaches to make the Agricultural Sector Assessment useful.

<u>California agriculture:</u>

The first thing to consider is the overall size of California agriculture. It was first in overall agricultural production in the United States with 10 percent of the total and a production value of $26.8 billion in 1997.

If California was a separate country it would be the 7th largest agricultural producer worldwide. It also is the largest dairy producing state, providing 17 percent of overall dairy production. Finally, California is the country's second largest producer of cotton.

California agriculture is also incredibly diverse, producing 350 different crops and commodities. Agriculture is also concentrated. In the US overall, 15 percent of farmers account for 85 percent of production. In California, 14 percent of farmers account for 88 percent of production. At the same time, however, there exists more and more niche production in California, an increase in the number of farms, and more direct marketing through, for example, farmers' markets.

The final consideration related to California is that it is also the leader in agricultural disasters. Floods in 1995, the El Niño of 1997-1998, the 1998-1999 La Niña, and the 1999 citrus freeze (which actually bolstered productivity in the nut crop) indicate the range of disasters to which California agriculture is subject.

Forces:

Two main forces exist which dominate changes to agriculture. The first is that agriculture is driven by a trend toward globalization. This is exemplified by the fact that 50 percent of fresh produce in the Mexican state of Baja California is generated in conjunction with U.S. growers. The second important force is technological change. Advances in irrigation technology, information technology, and packaging technology have revolutionized the market for agricultural products. Agriculture is now a demand-driven, rather than a supply-driven market. Furthermore, biotechnology will likely continue to be a huge force, creating improvements in the environment, new products related to health, and increases in world food production. Technology is also individualizing commodities. Biotechnology can create "designer" agricultural products for niche markets. In the past, agriculture has been considered a producer of bulk products. A looming trade impasse on biotechnology with the European Community is a major concern. In general, the way government deals with agriculture has to change in order to deal with the changes in the agricultural market.

How to make the Agriculture Sector Assessment useful:

Some important observations on how to ensure the usefulness of the assessment include:

1. Historical analyses should not be used in isolation. The future is changing quite rapidly.

2. Agricultural producers are most concerned about how they will be regulated—WTO is one concern but the combination of international agreements (Montreal Protocol, Biodiversity Convention, Kyoto Protocol) pose the potential for confusing, contradictory, and burdensome regulation.
3. Identify weather-related technologies—Better measurement and standardization of weather monitoring is incredibly important to agricultural producers.
4. Water supply management—Managing available water resources is a concern for a variety of competing uses.
5. Agricultural land preservation—Should the purchase of easements be encouraged?
6. Address pests and disease—Weather effects on pests are large and resulting changes in weather patterns could be detrimental. To this end, it is essential that the Agriculture Sector incorporate plant, pest, and disease specialists to help identify the range and depth of these issues and their relationship to other factors.
7. Sea level rise—Saltwater intrusion and salinity are issues for agriculture in California and other areas.
8. Remember that agriculture will adapt—Change is occurring at great speed and will continue.
9. The most useful approach would be to identify the range and breadth of potential issues—even if they cannot be quantified. This will help to begin developing strategies that could be put in place to adapt.

Robert White, Senior Professional Staff, US Senate Committee on Agriculture, Nutrition, and Forestry; Office of Senator Richard Lugar

The primary message Robert White offered was that agriculture will adjust. As someone who must deal with policy and answer questions about agriculture and climate change, he listed 16 questions he would like answered. These included:

1. How will crops and livestock be affected? The assessment should consider not only the ability to genetically alter crops and livestock in response, but also the effects of diseases and pests.
2. How will growing degree days change? Will the distribution of the current patterns change?
3. Will climate change result in changes in competition for land? How? What will the future baseline competition look like if climate changes?
4. Consider changes in the structure of agriculture—how will climate change affect operations? Will it make it harder or easier to get into agriculture?
5. How will international competitiveness be affected?
6. Consider changes in variability and also the predictability of both weather and climate. Can we predict better—remember cash is on the line for farmers if they act on predictions.
7. Consider direct and indirect effects—the interplay of water and nutrients—especially as they impact water availability and water quality.
8. How will climate change affect the environment via agriculture and will it affect the structure of natural resource management?

9. Where will the regions that gain competitive advantage be?
10. What will be the impacts on transportation, ports, and lock and dam structures? They are currently in bad shape. Where should we build or abandon?
11. Where will processing plants exist? Do they need to co-locate with production? What if production shifts?
12. What about risk management strategies in terms of agriculture credit services? What will agriculture creditors demand as proof of ability to repay loans of farmers if production is much more variable?
13. How will federal, state, and local policymaking be affected? For example, the local tax base is dependent on property values—how will this tax base change? How will this affect school systems through tax base erosion and/or a declining population? Will there be a return to price supports at a federal level? How important or necessary are current federal policies with respect to risk? Will there be more regulations at the state, federal, or international levels and what might their impact be?
14. What will be the effect on the labor supply for agriculture? Labor is already tight in this sector.
15. Will there be adequate funding for research? What research should be funded?
16. Where will the new customers be so that better marketing strategies can be designed?

Cynthia Rosenzweig, Scientist, Goddard Institute for Space Studies

Cynthia Rosenzweig's main point centered on previous assessment efforts to try and gain some insight. Results from previous work imply that the combined impacts of warming, precipitation change, and carbon dioxide concentration increases vary by location and crop. Winners and losers have also been identified, but the aggregate economic effects on agriculture are small. The adaptations taken in response matter, but other issues are equally important—such as spatial heterogeneity and the impacts of better climate forecasting. Uncertainty regarding the distribution of climatic change trumps other sensitivities. In general, however, U.S. producers are prepared to gain from climate change. Inherent in that result, however, is the caveat that trade assumptions are key to understanding the impact. Climate change will change many factors, including demand, resource allocation, and the environmental performance of agriculture. In general, however, it is foolish to believe any of the specific numbers resulting from climate modeling exercises.

For the current Agriculture Sector Assessment, some suggestions can be gleaned from past work. First, create a design that describes aspects considered important to cover (either through a matrix or a flow chart. Use this to consider and describe important implicit and explicit variables. Utilize the full range of scenarios available including General Circulation Models (GCMs), incorporating those with and without aerosols and/or stabilization runs. Next, make sure to incorporate the U.S. versus international context in terms of vulnerability, adaptation, mitigation options, and impacts. Finally, try and point out key sensitivities to extremes, including El Niño, carbon dioxide fertilization effects, and the impact of multiple stresses.

John Hickman, Senior Agronomist, Deere and Company

From a wide range of viewpoints, the best way for the assessment to be useful is for it to be accurate and scientifically credible. It is important to identify what stages and/or portions of models are the most reliable and which contain the most error. Make sure to depict a balanced approach to the proposed solutions. Cover agriculture broadly and make sure that important issues such as grasslands and livestock receive more attention than has been presented so far. Be cautious about the use of tools such as models—use them where appropriate. Be sure to include the concept of risk management in terms of how agricultural producers will respond. To meet all these goals, propose a logical, systematic order to the assessment and learn from the previous assessments that have been conducted.

Chuck Beretz, Federal Policy Manager, American Farmland Trust

Stopping the loss of productive farmland to urbanization is a necessary precursor to any attempt at sequestration. Removing land from production and placing it under asphalt forever eliminates that land as a possible carbon sink. Sequestration aside, there are other reasons to protect our best land from development. More than half of agricultural production is realized in rapidly urbanizing counties. The public is demanding that farmers not only produce food but also wildlife habitat, water quality and erosion reduction. The ability of farmland to sequester carbon is one more public good that farmers currently produce for free. Success in mitigation of greenhouse gas emissions depends on the cooperation of farmers. They own the land that is up for grabs as competition over its use increases.

COMMENTS

A number of comments were solicited from the session on the usefulness of the assessment. The first was in regard to the inclusion of small ranches in the assessment. It was asserted that they react differently to policy and other decisions than the rest of the agricultural community. The second comment asserted that talking about mitigation solutions might be slightly preliminary given the pre ratification status of the Kyoto Protocol in the Senate. A response to this comment hypothesized that it is important to know where agriculture is going even if policy is slow to respond. A third issue highlighted that who is impacted is a critical issue in the debate as well as what the overall impacts may be. There is a significant potential for larger farms to replace smaller farms throughout the marketplace in some scenarios. Fourth, many of the technological options proposed are inappropriate and difficult for many farmers to implement due to budget constraints on resources and training. Fifth, agriculture may be far more fragile than it was presented in the workshop. The final comment indicated that in terms of water availability and fertilization options, it may be useful to highlight the potential for wastewater reuse and the use of wastewater sludge as a potential adaptation option for agriculture.

SUMMARY—WHAT HAVE WE HEARD?

John Reilly (Co-chair of the Agriculture Sector Assessment)

John Reilly condensed the day into nine major points that were raised and repeated throughout the workshop as key issues with which the Agriculture Assessment must grapple. These were:

1. Agriculture is diverse. We must speak to the diverse elements that exist. Different concerns require that the assessment activity take different cuts on agriculture.
2. Agriculture is changing rapidly—biotechnology, computers, GPS, information technology, and the changing structure of production have collectively altered the sector. It is becoming an increasingly specialized, technology-driven enterprise and this means that farmers need a high level of training to operate successfully.
3. The assessment needs to be more integrated than previous efforts. Inter-related issues such as water, pests, land use, and ozone levels must all be dealt with effectively.
4. Variability is a big concern. It wreaks havoc on farmers.
5. Environmental links are unexplored but could be very important—opportunities for win-win solutions exist and should be further investigated.
6. The policy environment will be affected by climate change and will affect the ability of agriculture to adapt.
7. Think heavily about the structure of the assessment—learn from past efforts.
8. Worry about the accuracy of scenarios and analyses and where the errors are.
9. The assessment will be useful if we identify the range and breadth of issues (e.g., potential surprises) even if we cannot quantify all of these.

Appendix—List of Participants

WORKSHOP ATTENDEES

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Pennsylvania State University

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