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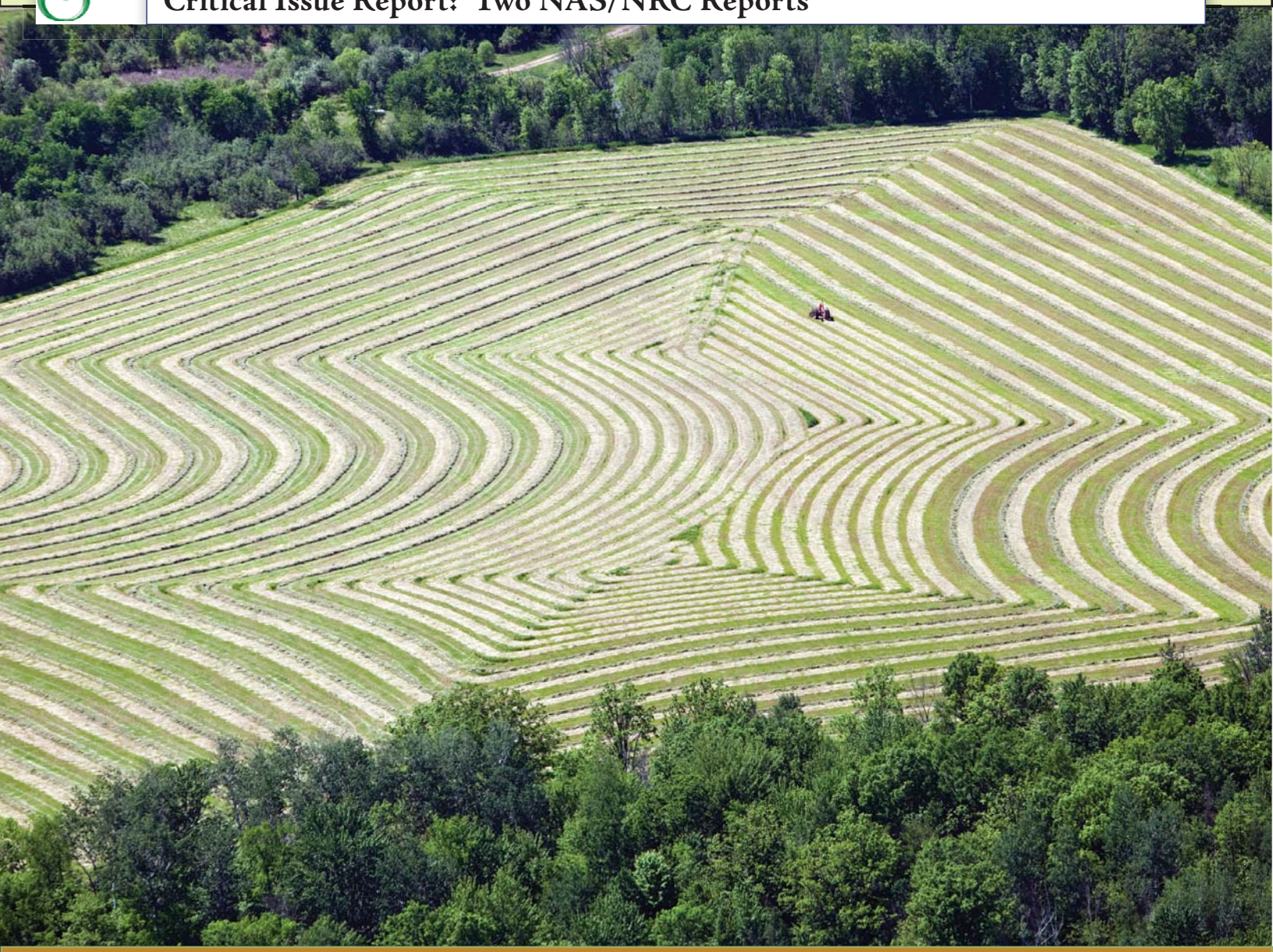
Critical Issue Report: Two NAS/NRC Reports



What Does Sustainable Agriculture Have to Offer? Conclusions and Recommendations in Two NAS/NRC Reports

by Charles Benbrook

July 2010

FOREWORD

On September 6, 1989 the National Academy of Sciences/National Research Council (NAS/NRC) released *Alternative Agriculture*, a 448-page analysis of problems confronting the agricultural system and the potential contributions of sustainable and organic agriculture in addressing economic, environmental, animal welfare, and food safety and quality issues. The report was widely read and heavily covered in the media, triggered intense interest on Capitol Hill, and impacted both the debate on, and the future direction of federal farm commodity, conservation, regulatory, and research policies. During my tenure as Executive Director of the NAS/NRC Board on Agriculture, I helped start and manage the process leading to the release of the *Alternative Agriculture* report and oversaw the work of the Board's talented staff that supported the work of the committee.

On June 29, 2010, the NAS/NRC released another major report on the same topic that, among other things, revisited the findings, conclusions, and recommendations of the 1989 report. *Toward Sustainable Agricultural Systems* in the 21st Century is the product of a nearly three year process. The fifteen-member committee met thirteen times from December, 2007 through November, 2009. The charge to the TSAS committee was multifaceted –

- Provide an overview of the current state and environmental, economic, and social sustainability of U.S. agriculture;
- Assess practices with potential to promote sustainability;
- Identify factors impacting the adoption of practices;
- Update the 1989 *Alternative Agriculture* report methodologies, revisit the case studies in the 1989 report, and carry out a new set of case studies;
- Provide research recommendations; and
- Evaluate the transferability of principles underlying farming systems and practices that could improve sustainability.

Like all NAS/NRC reports, both *Alternative Agriculture* and the *Toward Sustainable Agricultural Systems* are consensus documents. Their contents and recommendations are bounded by what a diverse group of well-informed people could agree on.

Two people served on both the 1989 and 2010 report committees – Dr. Richard Harwood of Michigan State University and Dr. Sandra Batie, also of MSU. Dr. R. James Cook of Washington State University is the third individual who played a prominent role in the completion of both reports. Dr. Cook oversaw the rigorous NRC report review process for both reports.

Access a copy of the *Toward Sustainable Agricultural Systems in the 21st Century* report from the National Academy Press via http://www.nap.edu/catalog.php?record_id=12832. A summary of the report is available free of charge at the above website. The *Alternative Agriculture* report is also available from the National Academy Press.

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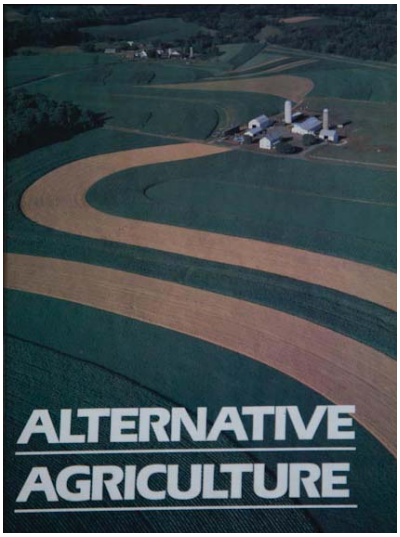
1. Defining "Sustainable Agriculture"

The definition of "sustainable agriculture" has evolved over the years, emphasizing different goals and aspects of farming system management, but the same basic themes are addressed in nearly all definitions. Some definitions are more precise and complete than others. In general, the more disagreement in a roomful of people seeking to define "sustainable agriculture," the more general and imprecise the language is likely to be that emerges from the dialogue.



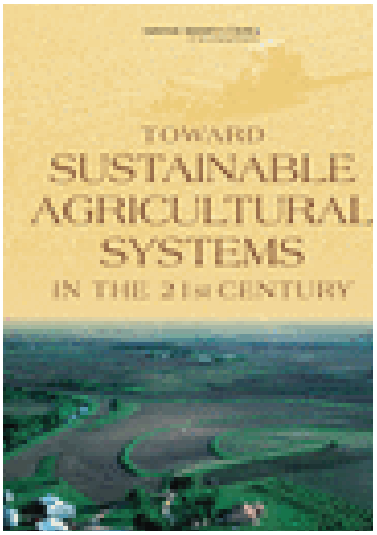
The 1989 NAS/NRC report defined "alternative agriculture" as –

> "…any system of food and fiber production that systematically pursues the following goals:
>
> - More thorough incorporation of natural processes such as nutrient cycling, nitrogen fixation, and pest-predator relationships into the agricultural production process;
> - Reduction in the use of off-farm inputs with the greatest potential to harm the environment or health of farmers and consumers;
> - Greater productive use of the biological and genetic potential of plant and animal species;
> - Improvement of the match between cropping patterns and the productive potential and physical limitations of agricultural lands to ensure long-term sustainability of current production levels; and
> - Profitable and efficient production with emphasis on improved farm management and conservation of soil, water, energy, and biological resources."

"*Alternative agriculture* is not a single system…"

"The hallmark of an alternative farming approach is not the conventional practices it rejects but the innovative practices it includes." (*Alternative Agriculture*, Executive Summary, pages 3 and 4).

The definition of "sustainable agriculture" in the 2010 *Toward Sustainable Agricultural Systems in the 21st Century* report (hereafter TSAS) differs markedly from the 1989 report's definition of "alternative agriculture," a term that was intended by the *Alternative Agriculture* Committee to mean essentially the same thing as "sustainable agriculture." The *TSAS* report does not offer a formal definition of "sustainable agriculture," and instead identifies –



> "…four generally agreed-upon goals that help define sustainable agriculture:
>
> - Satisfy human food, feed, and fiber needs, and contribute to biofuel needs.
> - Enhance environmental quality and the resource base.
> - Sustain the economic viability of agriculture.
> - Enhance the quality of life for farmers, farm workers, and society as a whole." (*TSAS*, page 4).
>
> "Sustainability is best evaluated not as a particular end state, but rather as a process that moves farming systems along a trajectory toward greater sustainability on each of the four goals."

Some of the differences in the above two definitions of "alternative" or "sustainable" agriculture are worth noting. The 1989 report's definition is more specific and comprehensive than the "four goal" based *TSAS* definition. It includes reducing the use of high-risk or environmentally damaging inputs, an objective or goal not included in the 2010 definition. Likewise, the 1989 definition highlights the need to match cropping patterns and farming enterprise choices to the physical limits of the land, given local soils and climate, a goal not mentioned in 2010.

There is, however, heavy emphasis throughout *TSAS* on gaining a better understanding of the ecological foundations of productive and sustainable agriculture. The need to redirect research and policy to achieve a more ecologically resilient and productive match of farming enterprises, soil and water resources, and agricultural inputs and practices is also strongly emphasized in many parts of the *TSAS* report.

The 2010 *TSAS* articulation of sustainable agriculture goals includes one not addressed in the 1989 report – satisfying human food, feed, and fiber needs, while contributing to biofuel needs. No doubt the extension of the goals for sustainable agriculture to encompass biofuel production triggered considerable discussion within the committee, and will be among the statements in the report that triggers debate.

2. Key Findings and Conclusions

Based on its assessment of then-current conventional and alternative farming practices, the committee that wrote the *Alternative Agriculture* report:

"…arrived at four major findings –"

1. A small number of farmers are practicing alternative agriculture and derive "significant and sustained economic and environmental benefits."
2. A wide range of federal farm, conservation, and regulatory policies "significantly influence farmers' choices of agricultural practices. As a whole, federal policies work against environmentally benign practices and the adoption of alternative agriculture systems..."
3. A systems approach to research is needed to advance the effectiveness and profitability of alternative agriculture, and agriculture as a whole; and
4. Farmer-innovators are driving the development and adoption of alternative agricultural systems, but to achieve wider adoption, "farmers need to recieve information and technical assistance..." (*Alternative Agriculture*, page 5-6).

The 2010 *TSAS* report does not offer a comparable set of findings in its summary chapter, nor in Chapter 9, "Conclusions and Recommendations." Material throughout the *TSAS* report, however, is presented as declarative statements and conclusions, much like the formal "findings" in the 1989 report. TSAS also offers several key conclusions in both the summary and concluding chapter that track closely with the findings and conclusions stated in the 1989 report.

Throughout the rest of this assessment, statements of conclusions and recommendations are drawn from the summary and Chapter 9, "Conclusions and Recommendations" in the *TSAS* report, and the "Executive Summary" in the *Alternative Agriculture* report (all conclusions and recommendations are consolidated in that report's executive summary).

The 1989 *Alternative Agriculture* report offers twelve highlighted, italicized conclusions (see pages 8-17). Each is a clear, definitive statement of the significance of one or more findings presented elsewhere in the report, focusing on the outcomes likely to follow adherence to conventional farming systems and technology, as opposed to "alternative agriculture." The 12 conclusions sought to articulate what the committee felt was at stake as the nation considered whether, how, and to what extent policy changes should be put in place to steer American agriculture in a different direction.

The 2010 *TSAS* report does not offer a similar set of distinct conclusions in the report's summary, and instead in Chapter 9, "Conclusions and Recommendations," the committee highlights a series of passages that begin with a phrase like "The committee concluded that…"

The main conclusion in the *TSAS* report is that to meet the demands of the 21st century under conditions of climate change, declining resource availability, and competition for land and water, "…agricultural production will have to substantially accelerate progress toward the four sustainability goals."

Other key conclusions are that –

- "Sustainability is best evaluated not as a particular end state, but rather as a process…"
- Both incremental and transformative change is needed to accelerate progress toward the four sustainability goals.
- "Research on the economic and social dimensions of agricultural sustainability is scarce…"
- "The transformative approach to improving agricultural sustainability would dramatically increase integrative research…"
- "The report *Alternative Agriculture* emphasized the importance of a systems approach to agricultural research 20 years ago, yet the proportion of long-term systems agricultural research remains small."
- A landscape approach to agricultural research is needed but "programs to encourage such research do not exist."

To provide deeper insight into the similarities and differences in the conclusions stated in these two NAS/NRC reports, three tables follow summarizing conclusions in each report relative to farming systems and practices, government policy, and research and extension programs and policy. In each of the below tables, concluding statements are quoted directly from each report, although a few are shortened marginally so that each table fits on one page. Moreover, when text appears in a given row in both the *Alternative Agriculture* and TSAS columns, the concluding statements address a similar topic or cover a comparable issue or aspect of sustainable agriculture. When there is text in a given row in only one column, one of the two reports did not address the issue or topic in its summary or concluding chapters.

Conclusions Regarding Farming Practices and Systems

Table 1 sets forth conclusions on the nature and performance of alternative farming practices and systems. In short, the *Alternative Agriculture* report concluded that :

1. Alternative farming systems "work" and can be productive and profitable;
2. There is great variability in alternative farming systems;
3. Alternative farming systems "nearly always use less synthetic chemical pesticides, fertilizers, and antibiotics per unit of production than comparable conventional farms" and this lowers costs, risks, and environmental impacts;
4. Alternative farming systems "typically require more information, trained labor, time, and management skills…"

Table 1. Conclusions Related to Impacts of Farming Practices and Systems Stated in the *Alternative Agriculture* and *Toward Sustainable Agricultural Systems* Reports

Alternative Agriculture	*Toward Sustainable Agricultural Systems*
"Farmers who adopt alternative farming systems often have productive and profitable operations, even though these farms usually function with relatively little help from commodity income and price support programs or extension."	"The committee concluded that if U.S. agriculture production is to meet the challenge of maintaining long-term adequacy of food, fiber, feed, and biofuels under scarce or declining resources and under challenges posed by climate change and to minimize negative outcomes, agricultural production will have to substantially accelerate progress toward the four sustainability goals."
"Alternative farming practices are not a well-defined set of practices or management techniques. Rather, they are a range of technological and management options used on farms striving to reduce costs, protect health and environmental quality, and enhance beneficial biological interactions and natural processes."	"Sustainability is best evaluated not as a particular end state, but rather as a process that moves farming systems along a trajectory toward greater sustainability on each of the four goals."
"Well-managed alternative farming systems nearly always use less synthetic pesticides, fertilizers, and antibiotics per unit of production than comparable conventional farms. Reduced use…lowers production costs and lessens agriculture's potential for adverse environmental and health effects without necessarily decreasing-and in some cases increasing-per acre crop yields and the productivity of livestock management systems."	"Many modern agricultural practices have unintended negative consequences, or externalized costs of production, that are mostly unaccounted for in agricultural productivity measurements or by farm enterprise budgets."
"Alternative farming practices typically require more information, trained labor, time, and management skills per unit production than conventional farming."	
	"Some modern agricultural practices adversely affect soil quality by affecting soil physical, chemical, and biological factors through erosion, compaction, acidification, and salinization. They also reduce biological activity as a result of pesticide applications, excessive fertilization, and loss of organic matter."
	"Ultimately, it will be more effective to structure farms and agricultural systems toward ecosystem stability rather than to address unintended consequences through piecemeal 'technological fixes.'"

The *TSAS* report highlights the need to accelerate progress toward the four sustainability goals in order to meet the multiple demands of coming decades. Like *Alternative Agriculture*, the TSAS report emphasizes that sustainability is a process of incremental change, rather than a defined set of practices or a distinct endpoint.

TSAS acknowledges that "modern agricultural practices" can lead to unintended negative consequences not now taken into account when farming systems are evaluated for profit or productivity, whereas the *Alternative Agriculture* report concludes that alternative farming systems "nearly always" reduce the use of pesticides, fertilizers, and antibiotics per unit of production, and hence can lessen costs and unintended, adverse consequences.

Alternative Agriculture's conclusions highlight the need for more labor and management skills in pursuing sustainable agriculture, while *TSAS* does not. *TSAS*, on the other hand, concludes that "some modern agricultural practices" can adversely affect soil quality and reduce biological activity.

In one of the report's more provocative statements, *TSAS* also concludes that "it will be more effective to structure farms and agricultural systems toward ecosystem stability rather than to address unintended consequences through piecemeal 'technological fixes.'" *Alternative Agriculture* lacks a comparable conclusion addressing the capacity to avoid or prevent problems through sustainable agriculture.

Conclusions Regarding Government Policy

The wide range of government policy conclusions in the two reports are set forth in Table 2. The *Alternative Agriculture* report places much more emphasis on the impacts – and constraints – posed by government policy.

Table 2. Conclusions Related to Government Policy Stated in the *Alternative Agriculture* and *Toward Sustainable Agricultural Systems* Reports

Alternative Agriculture	*Toward Sustainable Agricultural Systems*
"Many federal policies discourage adoption of alternative practices and systems by economically penalizing [them]. Federal programs often tolerate and sometimes encourage unrealistically high yield goals, inefficient fertilizer and pesticide use, and unsustainable use of land and water. Many farmers...manage their farms to maximize present and future program benefits, sometimes at the expense of environmental quality."	
"Fertilizers and pesticides are often applied at rates that cannot be justified economically without consideration of present or future farm program payments."	
"Federal grading standards…often discourage alternative pest control practices for fruits and vegetables by imposing cosmetic and insect-part criteria that have little if any relation to nutritional quality. Meat and dairy grading standards continue to provide economic incentives for high-fat content, even though considerable evidence supports the relationship between high consumption of fats and chronic diseases, particularly heart disease."	
"Current federal pesticide regulatory policy applies a stricter standard to new pesticides and pest control technologies than to currently used older pesticides approved before 1972…a small number of currently used pesticides appears to present the vast majority of health and environmental risks associated with pesticides. This policy inhibits the marketing of [products] that may enhance opportunities for alternative agricultural production systems."	
"Significant adoption of alternative practices will not occur until economic incentives change. This change will require fundamental reforms in agricultural programs and policies."	
"If these [policy reform] conditions are met, today's alternative farming practices could become tomorrow's conventional practices, with significant benefits for farmers, the economy, and the environment."	"[The report] reveals the importance of government agencies, farmers, food industry companies, communities, and consumers to support research, policies, programs, and institutions that help U.S. agriculture move along the sustainability trajectory."

Key policy conclusions include --

- Federal policies discourage and penalize core alternative agricultural practices and "…sometimes encourage unrealistically high yield goals, inefficient fertilizer and pesticide use, and unsustainable use of land and water."
- "Fertilizers and pesticides are often applied at rates that cannot be justified economically…"
- Federal food grading standards "often discourage alternative pest controls…" and promote production of high-fat animal products;
- Current pesticide policy applies a stricter standard to new, relatively safer pesticides than to old ones that pose even greater risks, but remain on the market for lack of alternatives; and
- Significant adoption of alternative agriculture systems will not happen in the absence of economic incentives, and changes in policy will be necessary to create such incentives.

TSAS does not highlight in its summary or conclusions chapter the impacts of commodity programs, grading standards, and regulation on adoption of sustainable agriculture. These topics are discussed in detail, however, in the body of the report. In its concluding chapter, the *TSAS* report "reveals the importance of government agencies…research, policies, programs, and institutions… that help U.S. agriculture move along the sustainability trajectory."

Policy changes adopted in the 1990 and subsequent farm bills, the major reforms of pesticide policy adopted in 1996, the increasing openness of government conservation programs to sustainable agricultural practices, clear institutional support within USDA for organic farming, and gradual shifts in agricultural research priorities likely contributed to the lessened emphasis in TSAS on government policy-related constraints to the adoption of sustainable agriculture practices and systems.

Research and Extension Conclusions

The two reports share a number of research, development, and extension conclusions, as evident in Table 3. The four conclusions addressing "The State of Research and Extension" in *Alternative Agriculture* are, in brief, that –

- Disciplinary research is not sufficiently integrated and is not likely to find solutions to to major agricultural system problems and challenges;
- Alternative agriculture research and extension funding is inadequate;
- "There is inadequate scientific knowledge of economic, environmental, and social costs and thresholds for pest damage, soil erosion, water contamination, and other environmental consequences of agricultural practices" and such knowledge is needed to identify and deal with tradeoffs between goals; and
- Public and private sector researchers "should give higher priority to development and use of biological and genetic resources to reduce the use of chemicals, particularly those that threaten human health and the environment."

The *TSAS* report echoes the conclusion on the need for systems-based research, and notes that only one-third of public research support is invested in assessing the environmental, resource conservation, social and economic aspects of farming practices. The TSAS report implies, but does not state, that this level of investment is inadequate.

Both reports address the need for better ways to measure the many impacts of farming practices and systems, and note that better ways to measure and track performance are needed to guide the policy process. The TSAS report goes beyond *Alternative Agriculture* in concluding that a "landscape [or watershed] approach" to research would be useful in shaping policies, but "programs to encourage such research do not exist."

Table 3. Conclusions Related to Research and Extension Stated in the *Alternative Agriculture* and *Toward Sustainable Agricultural Systems* Reports

Alternative Agriculture	*Toward Sustainable Agricultural Systems*
"The results and design of basic, discipline-oriented research programs often are not sufficiently integrated into practical interdisciplinary efforts to understand agricultural systems and solve some major agricultural problems."	"A systems approach to agricultural research is necessary to identify and understand the significance of the linkages between farming components so that a robust system that takes advantage of synergies and balanced tradeoffs can be designed."
"Research and extension program funds to study, develop, and promote alternative farming practices are inadequate. It is unrealistic to expect more rapid progress in developing and transferring alternative practices to farmers without increased funding."	"Only one-third of public research support is devoted to exploring environmental, natural resource, social, and economic aspects of farming practices."
"There is inadequate scientific knowledge of economic, environmental, and social costs and thresholds for pest damage, soil erosion, water contamination, and other environmental consequences of agricultural practices. Such knowledge is needed to inform farm managers of the tradeoffs between on-farm practices and off-farm consequences."	"Finding ways to measure progress along a sustainability trajectory is an important part of the experimentation and adaptive management process… Developing consistent and effective indicators would facilitate assessment of the sustainability of farming practices or systems." "Research on the economic and social dimensions of agricultural sustainability complementary to research on productivity and environmental sustainability is scarce..."
"Research at private and public institutions should give higher priority to development and use of biological and genetic resouces to reduce the use of chemicals, particularly those that threaten human health and the environment."	
	"Although a landscape approach to agricultural research could inform the design of agroecosystems to maximize synergies, enhance resilience, and inform what policies would be useful in influencing collective actions, programs to encourage such research do not exist."

3. Recommendations

Fourteen recommendations were advanced in the *Alternative Agriculture* report, roughly tracking the 12 conclusions presented in that report. The recommendations were organized in three sections: "Farm and Environmental Policy," "Research and Development," and "Economics and Markets." Several individual recommendations contain multiple "action items" and initiatives.

Table 4 summarizes the farm and environmental policy recommendations in the two reports, drawing on material in the "Executive Summary" of *Alternative Agriculture* and Chapter 9, "Conclusions and Recommendations" in the *TSAS* report. Table 5 covers research and extension recommendations, and Table 6 contains recommendations related to economic performance and markets from the two reports.

Alternative Agriculture calls for changes in commodity and conservation programs to promote crop rotations and the integration of cropping and livestock in mixed farming systems. Specific suggestions were made to relax or remove constraints to biological control and Integrated Pest Management (IPM). Adjustments in regional cropping patterns to better match soil-climatic conditions were called for, when needed to promote profitability and environmental quality.

Table 4. Farm and Environmental Policy Recommendations in the *Alternative Agriculture* and *Toward Sustainable Agricultural Systems* Reports

Alternative Agriculture	***Toward Sustainable Agricultural Systems***
"Federal commodity programs must be restructured to help farmers realize the full benefits of the productivity gains possible through many alternative practices."	
"Provisions in the Food Security Act of 1985 designed to protect erodible lands and wetlands must be fully and fairly implemented."	
"Future farm programs should offer no new incentives to manage these and other fragile lands in a way that impairs environmental quality."	
"Surface water and groundwater quality monitoring must be more systematic and coupled with educational and regulatory policies that prevent future water contamination."	
"Cost-effective water quality protection provisions must be incorporated into existing conservation and commodity programs."	
"Regulations that require farmers to maintain soil and water conservation practices and structures installed with government technical or financial assistance must be enforced."	
"Adjustments in regional cropping patterns must be facilitated when such changes are necessary in order to make progress toward profitable and environmentally sustainable production systems."	
"A set of guidelines for assessing the benefits of pesticides under regulatory review should be developed. This procedure must include a definition of beneficiaries as well as an assessment of the costs and benefits of other available pest control alternatives..."	
"Public information efforts should explain to consumers the relationship of appearance to food quality and safety. Alternate means of controlling the supply and price of fruits and vegetables should be developed. Cosmetic and grading standards should be revised to emphasize the safety of food and deemphasize appearance and other secondary criteria."	
	"The committee proposes two parallel and overlapping efforts to ensure continuous improvement…incremental and transformative."

The *TSAS* report offers six recommendations that track that report's major conclusions, just as in the case of the *Alternative Agriculture* report. In short, the 2010 report recommends that –

- USDA and state agricultural institutions "should continue publicly funded research and development (R&D) of key farming practices for improving sustainability…" (see Table 5);
- Integrated research and extension programs should be "aggressively" funded that "focus on interactions among productivity, environmental, economic, and social sustainability outcomes" (Table 5);
- USDA, EPA, NSF, land grant universities, and farmer-led sustainable agricultural organizations should develop a long-term research and extension initiative that studies the "aggregate effects of farming at a landscape or watershed scale…" to better progress toward the four sustainability goals (Table 5);
- Farmer-participatory research approaches should be encouraged and supported (Table 5);
- USDA should invest more resources in studying the ways current and proposed market structures, policies, and "knowledge institutions" create opportunities or barriers to progress toward sustainable agriculture (Table 6); and
- Agencies and foundations supporting agricultural development work in developing countries should emphasize a systems approach, adaptability, and expanding market access (Table 5).

Table 5. Research and Development Recommendations in the *Alternative Agriculture* and *Toward Sustainable Agricultural Systems* Reports

Alternative Agriculture	***Toward Sustainable Agricultural Systems***
"Develop a regional, multi-disciplinary, long-term research, demonstration, and extension program such as that initiated by the USDA's low-input sustainable agriculture (LISA) initiative. This program should focus on alternative farming practices and systems tailored for each region's major types of crop and livestock operations."	"The U.S. Department of Agriculture and state agricultural institutions and agencies should continue publicly funded research and development of key farming practices for improving sustainability…They should increase support for research that clarifies the economic and social aspects of [technologies and management practices] and that addresses issues of resilience and vulnerability in biophysical and socioeconomic terms."
"Substantial annual funding-at least $40 million-should be allocated for alternative farming research. The USDA should distribute the money through its competitive grants program to scientists from universities, private research institutions, foundations, and industry."	
	"The transformative approach to improving agricultural sustainability would dramatically increase integrative research by bringing together multiple disciplines to address key dimensions of sustainability…It would apply a systems approach to agriculture that could result in production systems and agricultural landscapes that are a significant departure from the dominant systems of present-day agriculture."
	"Federal and state agricultural R&D programs should…explore the properties of agroecosystems and the interdependencies between biophysical and socioeconomic aspects of farming systems, and how these interdependencies could make the systems robust and resilient over time."
	"The U.S. Department of Agriculture should partner with the National Science Foundation, the U.S. Environmental Protection Agency, key land-grant universities, and farmer-led sustainable agricultural organizations to develop a long-term research and extension initiative that aims to understand the aggregate effects of farming at a landscape or watershed scale..."
	"Agencies and charitable foundations that support research and development of sustainable agriculture in developing countries should ensure that funded programs emphasize a systems approach that reflects the need for adaptability of management strategies and technologies to dynamic local socioeconomic and biophysical conditions, and support efforts to increase market access."

Research recommendations in *Alternative Agriculture* call for at least $40 million in annual USDA support of alternative agriculture research – a level still not reached.

The *TSAS* report places great emphasis on new landscape and watershed scale approaches to research and more focus on the ecological foundations and impacts of farming systems in order to better appreciate – and manage around – tradeoffs between the four sustainability goals. According to the *TSAS* committee, "The transformative approach to improving agricultural sustainability would dramatically increase integrative research…[and] could result in production systems and agricultural landscapes that are a significant departure from the dominant systems of present-day agriculture."

"Economics and Markets" recommendations focused on the need for better information on the performance of different farming systems (both reports), so that policymakers will have more reliable and insightful data to draw upon in evaluating the impact of past and current polices, and projecting and monitoring the impacts of new policies. *Alternative Agriculture* also called for more research on "…consumer attitudes toward paying slightly higher prices for food with lower or no pesticide residues…"

Table 6. Economics and Markets Recommendations in the *Alternative Agriculture* and *Toward Sustainable Agricultural Systems* Reports

Alternative Agriculture	***Toward Sustainable Agricultural Systems***
"More resources should be allocated to collect and disseminate data on yields, profits, labor requirements, human health risks, threats to water quality, and other environmental hazards of conventional and alternative farming practices within a given region. These data will help policymakers and farmers make more informed choices."	"The U.S. Department of Agriculture should increase investment in empirical studies of the ways that current and proposed market structures, policies, and knowledge institutions provide opportunities or barriers to expanding the use of farming practices and systems that improve various sustainability goals so that the department can implement changes in policies and institutions that are identified as effective to meeting those goals."
"Research should be undertaken to predict the long-term impacts of various levels of adoption of alternative farming practices on the total production and prices of various agricultural commodities; use and prices of various farm inputs; international trade; employment; economic development, and incomes of various categories of farmers; and the overall structure of agriculture and viability of rural communities."	
"Research should be expanded on consumer attitudes toward paying slightly higher prices for foods with lower or no pesticide residues, even though such foods may not meet contemporary standards for appearance."	

4. Some Differences in the Tone and Content in Two NAS/NRC Reports on Sustainable Agriculture

The 1989 *Alternative Agriculture* report is, in general, more direct and specific than the 2010 *TSAS* report when addressing the consequences and impacts of then-conventional production practices, and in projecting the likely benefits of alternative farming systems. Compared to the 2010 *TSAS* report, the 1989 report's major findings, conclusions, and recommendations are more concrete, while the conclusions and recommendations in the *TSAS* report are more conceptual and goal-oriented.

The 2010 *TSAS* report says relatively little in its Summary about food quality and safety, and almost nothing about animal welfare and health issues, whereas these aspects of agricultural system performance are addressed in several places in the Executive Summary of *Alternative Agriculture*.

The Role and Impact of Research

Based on the mix of recommendations offered in the two reports, the *TSAS* committee appears to place greater confidence in the role of research and science in bringing about change, while the *Alternative Agriculture* committee chose to place greater emphasis on removing constraints via policy change. This change in emphasis reflects, no doubt, the relaxation of some of the policy-related constraints highlighted in the *Alternative Agriculture* as a result of policy reforms adopted over the past 20 years.

Moreover, sustainable practices and systems are in place on a much larger percentage of farms and the agricultural land base today than in the late 1980s, suggesting that for many contemporary farmers, past-constraints have been overcome or relaxed. According to the most recent Organic Trade Association industry survey, organic fresh fruit and vegetable production now accounts for over 11% of total industry sales and organic milk and dairy products account for nearly 9% of total sales.

There is an unstated presumption embedded in the *TSAS* report's conclusions and recommendations that if more systems-oriented, integrative research is done,

it will produce deeper insights in the impacts of farming systems and practices on the four goals of agricultural sustainability, and these insights will set the stage for and trigger "transformative" changes in farming systems.

The impacts of cropping systems, animal health, food quality, and food safety research over the last twenty years suggest that this confidence might need to be tempered. The efficiency of nitrogen fertilizer use in corn production has incrementally fallen for several decades, imposing steadily rising adverse impacts on soil and water quality, and increasing greenhouse gas emissions, yet no serious policy reforms, technological changes, or on-farm innovations have been adopted to alter these well-documented and unambiguously negative trends.

Evidence has mounted for 20 years supporting the now-consensus scientific position that subtherapeutic use of antibiotics in livestock agriculture for growth promotion and disease prevention contributes to the emergence of antibiotic resistance genes that find their way to human pathogens, triggering harder-to-control infections. No meaningful policy changes have been taken in response to this new science, although both the FDA and Congress are now considering such action.

Many of the primary mechanisms through which pesticides can trigger secondary pest outbreaks and resistance are well understood and the insights gained from past research are broadly applicable and have proven robust in terms of the ability of scientists to predict where and when secondary outbreaks or resistance can be expected. Moreover, clearly, both problems are growing more serious, especially resistance, in part as a result of the now widespread planting of genetically engineered crops expressing *Bt* endotoxins or rendering corn, soybeans, cotton, or canola resistant to a single herbicide (glyphosate).

The impact of beef and dairy cattle diet formulation and management on the shedding of *E. coli* O157, and other pathogenic *E. coli*, is reasonably well understood, as are the routes of transmission for dangerous *E. coli* bacteria to leafy greens, other produce, and meat products, and in particular hamburger. Despite the heavy media attention on these issues, and the high cost of illness outbreaks to society as a whole, relatively little has been done to translate new scientific insights into either preventive practices at the farm level, or polices designed to expand margins of safety as food moves from the farm, and feedlot, to consumers.

Despite rapid advances in scientific understanding of the factors leading to these and other problems rooted in farming practices, systems, and policy, there has been little effort by either the private sector or government to prevent these problems from occurring. Much more effort has been invested in treating the symptoms of systemic, management-system based problems than in preventing them through promotion of ecosystem stability, as the TSAS committee recommends.

The *Alternative Agriculture* report placed heavy emphasis on policy changes to encourage positive change and reinforce new research and extension initiatives and insights. The committee's emphasis on the need for policy change has been, to some degree, vindicated over the last 20 years.

Of the major problems highlighted by *Alternative Agriculture*, significant progress has been achieved in reducing soil erosion and risks triggered by pesticide residues in food. The former accomplishment was brought about largely through major changes in conservation programs and policy, beginning with the implementation of the 1985 farm bill. The ongoing willingness of Congress in subsequent years to appropriate the substantial sums required to implement the 1985 and 1990 farm bill's new conservation programs, especially the Conservation Reserve Program, was also a notable policy shift.

The reduction now evident in pesticide dietary risks associated with domestically grown fruits and vegetables can be directly traced to passage in 1996 of the "Food Quality Protection Act," a major act of Congress that responded effectively to the recommendation in *Alternative Agriculture* to remove the inherent bias in then-current federal pesticide law against newer, safer pesticides. (Another NAS/NRC report issued in 1993 – *Pesticides in the Diets of Infants and Children* – had a far greater impact on the content of the FQPA. It also helped create the political support needed for the passage of such controversial legislation).

As noted multiple times in the 2010 *TSAS* report, little or no action was taken in response to several recommendations in the *Alternative Agriculture* report, and as a result, some problems and challenges that were emerging in the late 1980s have been allowed to fester and mature, and some have grown into much more complex and costly problems. Examples include water quality -- there have been no major changes in programs or policies addressing agriculture's negative impact on water quality, and hence it is not surprising that the frequency and levels of surface and groundwater contamination with pesticides and fertilizers have either remained largely unchanged or grown more worrisome. The same could be said for manure management on concentrated animal feeding operations. No substantive changes have been adopted in regulatory policies governing subtherapeutic use of antibiotics in livestock production, and the problem has continued to grow more serious, as anticipated by the *Alternative Agriculture* committee. Few, if any, steps have been taken by EPA or USDA to require adherence to herbicide resistance management plans, so the problems and costs triggered by resistant weeds have grown markedly more serious.

Clearly, very modest progress has been made over the last two decades in creating programs and funding dedicated to systems-based, multidisciplinary, problem-solving research of the sort called for by both NAS/NRC reports. The

ongoing lack of tools to evaluate the impacts of farming systems relative to sustainable agriculture goals is a direct result, as stressed by the *TSAS* committee.

Throughout its three years of work, the *TSAS* committee must have had many animated discussions about the roots of today's food safety and quality, environmental, farm economics, and plant and animal health problems, and equally or even more impassioned discussions of the surest path forward toward sustainable solutions. If more of the recommendations in the *Alternative Agriculture* report had been implemented and steadily fine-tuned over the last twenty years, valuable insights and experience would have been gained that would have collectively made the task facing the *TSAS* committee a bit more manageable.

"The Times They are A-Changin'"

These two NAS/NRC reports were carried out in very different times. The *TSAS* committee had a far more robust base of science to draw upon in evaluating farming system performance and the impacts of specific practices on natural resources, food safety and quality, soil, plant and animal health, and the economics of agriculture. The number and diversity of scientists, programs, and institutions sponsoring and carrying out research relevant to agricultural sustainability, here and around the world, has clearly increased dramatically compared to the late 1980s.

Moreover, the number, diversity, and sophistication of farms well along the trajectory toward sustainability were far greater and more advanced in the case of the *TSAS* committee, compared to when the *Alternative Agriculture* committee carried out its work. Many well-designed, systems-based studies have been carried out in the last decade comparing the design, performance, and impacts of conventional, reduced input, and organic farming systems. The science and practice of life-cycle assessment is far more advanced today than in the late 1980s. These factors must have helped the *TSAS* committee reach its conclusions and craft its recommendations, compared to the information base available to the *Alternative Agriculture* committee.

The political and ideological climate in which these reports were completed has also changed. There is clearly less confidence today in the ability of government to constructively guide changes in agricultural systems, compared to 20 years ago. When *Alternative Agriculture* was completed, publicly funded research still drove innovation and significant changes in policy and spending priorities were actively under consideration and fell within the realm of the politically feasible.

The work, findings, and recommendations of USDA and land grant university agricultural scientists were closely followed by farmers seeking insights on new production practices, inputs, and technology, and experts working for publicly funded institutions had a major impact, if not a dominate impact, on regulatory decisions and the policy reform process. Today, the private sector dominates to a much greater degree the direction of research and both the regulatory and policy processes, and increasingly controls the generation and flow of information to farmers about new practices, inputs, technologies, and systems.

Given the political gridlock in Congress and among the major political parties, and the intense pressure to keep federal spending in check, coupled with the declining fiscal health of most state governments, it is hard to imagine a scenario leading to the appropriation of substantial new sums to implement new ecologically-based public research programs and priorities. The focus and results of such research tend to be heavily weighted toward management-oriented adjustments in core system characteristics, such as cropping patterns, animal feeding practices, and steps to promote biodiversity and biological insect control, rather than the discovery of new, marketable inputs. For this reason, private sector R+D funding tends not to flow in this direction to any significant extent.

Over the 20 years between these two reports, science and technology has produced far deeper, and in some cases more worrisome insights into the problems with American agriculture and our food system. It has also solved many problems, made it possible for organic farming to expand, and led to the development and commercialization of a much wider array of farm inputs, including many new chemicals, animal drugs, plant and animal genetics, machines, practices, and tillage, planting, irrigation, and harvest systems.

The introduction of genetically engineered crops in 1996, their rapid adoption, and consequences over the last 15 years have deepened divisions among the public, farmers, policymakers, and various stakeholders regarding the surest path forward in pursuit of sustainable agriculture. The prospect that cloned and genetically engineered animals and fish will soon enter the food supply raises new ethical, animal welfare, and food safety concerns in some segments of society.

One would predict -- and hope -- that today's far bigger agricultural technology toolkit and our deeper insights into the workings of farming systems relative to the goals of sustainable agriculture would make it easier for society to reach agreement on the best way forward, but that has certainly not proven to be the case in recent years. Perhaps the next NAS/NRC report on this important topic should include an assessment of why.