Focus of my remarks. Thank you for the opportunity to offer my perspectives on using agricultural biomass to enhance future energy production and security.

I suggest that the following three points be among those you leave this hearing with:

1. There are foreseeable and realizable solutions to the security and sustainability challenges that we face in the United States, and biomass - particularly cellulosic biomass - has increasingly evident potential to play a major role in such solutions.

2. Widespread energy production from cellulosic biomass could transform American agriculture, providing a potent response to the overcapacity that has undermined the health of rural economies throughout most of the last hundred years.

3. The United States could do much more than it is doing now to enable and accelerate realization of the benefits of biomass energy production. In particular, I believe that an expanded and revised effort could substantially compress the time required for large-scale biomass energy production to be cost-competitive. For example, I consider pilot-scale demonstration of technology that can produce ethanol from cellulosic crops at prices competitive with gasoline today on an unsubsidized basis to be a realistic 5-year goal if we are prepared to change the way we do business.

Since my expertise is deepest with respect to points one and three, I will leave it to other speakers to elaborate the very large and important benefits of expanded biomass energy production for American agriculture and the communities that depend upon it.

The sustainability and security challenges faced by the United States arise primarily from energy conversion and utilization. Fossil fuel utilization in all sectors is the primary concern from the standpoint of sustainability. Oil utilization, particularly in the transportation sector, is the primary concern with respect to energy security. Among various forms of biomass, cellulosic materials - including perennial grasses, short rotation woody crops, and various agriculture and forest industry residues - have the greatest potential for energy production. Hence my remarks will focus on energy production from cellulosic biomass. I note that the recommendations presented herein have broadly been endorsed by the Energy Future Coalition.

The "Brave New World" of Biomass Energy. My perspective is shaped by over 20 year's experience doing research and analysis pursuant to biomass processing and utilization, and most recently by an in-progress project entitled "The Role of Biomass in America's Energy Future" which I co-lead with Nathanael Greene of the Natural Resources Defense Council and John Sheehan of the National Renewable Energy Laboratory. Technology-related analysis associated with the "RBAEF" project is sponsored by the Department of Energy Office of Energy Efficiency and Renewable Energy. Environmental and policy analysis is supported by

the Energy Foundation and the National Commission on Energy Policy. Participating institutions include - in addition to Dartmouth, the NRDC, and NREL - Princeton University, Michigan State University, the University of Tennessee, the Union of Concerned Scientists, Argonne National Laboratory, Oak Ridge National Laboratory, and the USDA Agricultural Research Service. I acknowledge the contributions of my colleagues in the RBAEF project to the remarks that follow, but take full personal responsibility for the opinions expressed herein.

The RBAEF project seeks to identify and evaluate paths by which biomass can make a large contribution to meeting future demand for energy services, and to determine what can be done to accelerate biomass energy use and in what timeframe associated benefits can be realized. There would appear to be substantial overlap between these goals and those of this hearing. This project is unprecedented with respect to the breadth of technologies considered and the diversity of participants involved - representing the technical, environmental advocacy, and policy communities. Perhaps most importantly, the project is differentiated from prior studies by adopting a "high beam" perspective focusing on mature technology that can reasonably be expected in the future given a concerted effort. I believe that this project is redefining understanding of what is possible with respect to biomass energy production, and that it is appropriate to consider an expanded and revised governmental effort in response to the expanded and revised vision that is emerging from our analysis.

Although the RBAEF project is not yet complete, our results are providing increasing evidence for an exciting set of working hypotheses that I expect will ultimately be supported by our work:

Large increases in the productivity and environmental efficacy of cellulosic energy crops can reasonably be expected to result from an aggressive and sustained R&D effort focused on these goals. For example, analysis led by Sandy McLaughlin - whose testimony follows mine - anticipates that such an effort would likely double the average productivity (in tons of biomass produced per acre per year) of switchgrass over the next two to three decades. We anticipate that similarly large productivity gains can also be made for other cellulosic crops, although we have not analyzed these in detail.

Very large increases in the cost-competitiveness and efficiency of technology for biomass conversion can reasonably be expected to result from an aggressive and sustained R&D effort focused on these goals. The RBAEF project is analyzing industrial facilities incorporating foreseeable R&D-driven advances that process cellulosic biomass to a mix of light duty and heavy duty fuels with co-production of commodity chemicals, just as oil refineries do today. Along with these products, future processes based on cellulosic biomass can be configured to also co-produce significant quantities of animal feed and electrical power. The potential for high overall process efficiency and simultaneous contributions to energy and other needs in multiple sectors becomes much more apparent when mature technology is considered.

Because cellulosic biomass at a price of $50/tonne is equivalent on an energy basis to oil at ~ $14/barrel, biomass is a cost-advantageous raw material compared to petroleum. Thus the key challenge is to reduce processing costs. I am confident that processing technologies can be developed with a concerted effort that can produce on a large scale fuels, power, and coproducts at competitive prices, and that this can be achieved in much shorter timeframes than currently forecast via an expanded and effective governmental R&D program. I also expect that the RBAEF project will lend more detailed support for this view than has hitherto been available.

Analysis underway as part of the RBAEF project supports the proposition that an amount of fuel sufficient to provide for current levels of vehicular mobility in the United States could be produced from biomass, and that this could be accomplished within the existing agricultural land base while dramatically increasing the value contributed to the overall economy from the agricultural sector. RBAEF scenarios with this outcome involve high productivity cellulosic energy crops, a high-efficiency vehicle fleet, advanced conversion technology, and integration of feedstock production into existing agricultural operations. In short, these scenarios require both innovation and change, as do all paths to a sustainable and secure energy future whether based on biomass or other resources. We would do well to remind ourselves that it is fruitless to look for paths to a sustainable and secure energy future by extrapolating trends associated with our non-sustainable and insecure present.

Overall, the RBAEF project has identified to date some very large environmental benefits accompanying greatly expanded biomass energy production, and no environmental show-stoppers. Environmental consequences associated with scenarios in which biomass plays a large energy supply role are being critically evaluated as part of the RBAEF project by the Natural Resources Defense Council, the Union of Concerned Scientists, Argonne National Laboratory, and other members of the project team. Some conclusions are already quite clear, while other issues are still under investigation. Prominent in the former category is the observation that production and utilization of fuel and power derived from cellulosic crops such as switchgrass involves near-zero net emissions of greenhouse gases as well as large contributions of carbon to the soil. Such near-zero or negative emissions are a direct result of the decidedly favorable process energy balance accompanying energy production from cellulosic biomass, particularly for mature technology. The propensity of switchgrass to increase soil carbon gives rise to major benefits in terms of soil fertility, as well as potential carbon sequestration, which do not diminish under intensive harvest.

In light of these considerations, I believe that fuel produced from cellulosic biomass is a legitimate option as a primary energy carrier for the U.S. transportation sector for the indefinite future. Let me be clear that I am not talking about biomass being limited to a bit player, and I am not talking about an intermediate option that will play a necessarily transient role on the way to some other ultimate solution. Consistent with these sentiments, and based on the RBAEF

analysis, the NRDC and UCS - both long-time supporters of the hydrogen economy - issued a statement in February that: "Cellulosic ethanol is at least as likely as hydrogen to be an energy carrier of choice for a sustainable transportation sector."

We could do much more than we are doing now. Sustainability and security are poorly reflected in market prices, the market provides only limited incentive to overcome obstacles associated with first-of-a-kind technology, and reinvestment of profits from a nascent cellulose processing industry will result in but a small flow of funding for innovation-focused R&D during the critical early growth phase. For all these reasons, and regardless of one's political philosophy, it is appropriate that the government play an active role in enabling and advancing biomass energy production. In particular, it is very likely that the growth of biomass energy will be much more rapid with substantial and well-directed governmental support than without it.

How well is the government doing at providing the needed support?

Let us assume for a moment that sustainability and security challenges are deemed important to respond to, and that biomass could play a very important part in such a response, as I have argued. When viewed from these premises, the effort the United States is expending to enable and accelerate biomass energy production is far short of what it should be. The modest size of current R&D investment in biomass energy lowers the rate of progress compared to what it could be, prevents alternative technological approaches from being pursued in a parallel fashion, and is a significant impediment to aggressively pursuing both innovation and pioneer plant deployment at the same time. Moreover, the trends are not encouraging. Funding after earmarks for biomass R&D by the DOE has declined yearly for the last several years and the world's leading research program on cellulosic feedstocks, coordinated by Oak Ridge National Laboratory, has been discontinued. The creative potential of the U.S. research community is not being brought to bear on problems relevant to biomass energy as effectively as it could be, in part because of highly specified research solicitations, limited support for work at the intersection of applications and fundamentals, and discontinuities in the amount and focus of research funding. As one illustration of this, compare the extent of engagement of the U.S. research community in R&D related to health care as compared to sustainable energy production. John Holdren, former Chair of the Energy R&D Panel of the President's Council of Advisors on Science and Technology, noted in Science in 2001:

Current levels of public and private investment in energy R&D and demonstration are not remotely commensurate with the long-term challenges and opportunities, either in the United States or any other country. U.S. federal expenditures on applied energy technology R&D are about what they were, in real terms, just before the oil price shock of 1973-1974, although the country's economy is more than twice as large. U.S. private sector investments in energy R&D have been falling since the mid-1980s.

Legislation has been enacted to accelerate R&D-driven progress in biomass conversion technology and to more fully engage the academic research community but with limited success. A case in point is Senate Bill S.935, introduced as the "National Sustainable Fuels and Chemicals Act" in April of 1999 by then Agriculture Committee Chairman Richard Lugar (R-IN) (see inset "S.935 - a cautionary tale").

Simply put, we are not acting as if we have a lot at stake and an important solution at hand.

What might we do differently if we were to mount a more aggressive effort in the biomass energy area? In brief, I recommend:

1. Increase by several-fold the amount of funding for biomass energy R&D, with clearly demarcated support for both pre-commercial research devoted to innovation and applied fundamentals as well as cost sharing for first-of-a-kind pioneer plants. The amounts required are small on any reasonable scale and insignificant relative to both the overall national budget and the potential benefits that could be realized. Consider: Tripling funding for bioenergy R&D would cost about $500 million annually. The cumulative cost of a focused R&D effort to develop technology for producing cellulosic ethanol at a cost competitive with gasoline has been estimated at less than one year's expenditure associated with the current ethanol tax incentive*, and pales in comparison to funding for security, space exploration, or other efforts directed at achieving meaningful goals in short timeframes.

2. Commit to pursuing increased biomass energy production in ways that expand opportunities for farmers, and that achieve sustainability, security and environmental benefits. It is important that these features be realized during transition phases as well as targeted end-points.

3. Allocate research funds among technical topics and evaluate proposals in a way that is responsive to potential for sustainability and security benefits, reliant to a significant extent on open solicitations, and based on technical merit. High priority should be placed on fundamentals-inclusive and innovation-focused work related to overcoming the recalcitrance of cellulosic biomass by a variety of approaches, and to development of energy crops and cropping systems that maximize productivity and environmental efficacy. Open solicitations with evaluation based on potential to advance biomass energy technology as judged by peer-reviewed technical merit would significantly increase the effectiveness with which America's research community is engaged. If we are serious about realizing the potential of biomass energy for the national interest in the most productive and cost effective way, extensive earmarking needs to be curtailed.

Much can be done within legislative mechanisms that are already in place, for example by adding new funding authorized by the Biomass Research and Development Act to funding levels of preexisting programs, and by fully funding the biorefinery development grants portion

of the Farm Bill.

Mr. Chairman and distinguished committee members, as current events make clearer the urgent need for sustainable and secure energy sources and as analyses such as the RBAEF project make clearer the potential of biomass to serve these needs in a meaningful way, the case for business as usual in the biomass energy arena becomes progressively more weak. I urge your committee and the U.S. Congress to take decisive action.

S.935. A cautionary tale. Senator Lugar's explicit goal in proposing S.935 was to establish an intensive and focused R&D program, national in scope, to reduce processing costs for producing fuels, chemicals, and electricity from biomass to the point that these technologies become cost-competitive with conventional fossil resources. The legislation identified fundamentals-inclusive, innovation-targeted research as the sole viable means of addressing the technological challenges of biomass conversion and use. National laboratories, universities and industry were eligible to compete for grants, although emphasis was given for partnership efforts led by universities. After being renamed the "Biomass Research and Development Act", S.935 was signed into law by President Clinton in June of 2000 as part of the Crop Insurance Bill. The Act authorized $49 million/year over a five year period.

The story of what happened to this $49 million authorization is reminiscent of the progress of the Colorado River on its way to the Pacific Ocean in the face of demands for irrigation. Although $49 million per year was authorized, only $18 million per year was appropriated in the 2000 (H.R. 2605), 2001 (H.R. 4635), and 2002 (H.R. 2311) fiscal years. Moreover, the appropriation language directed that funding be derived from existing power and transportation programs. Thus what was intended to add a major influx of new funding in fact largely resulted in putting a new name on already allocated funds within programs that had only modest growth in gross funding. Whereas S.935 as originally proposed featured awards based on technical merit as determined by peer review, the lion's share of funding has in fact been claimed by earmarks. In the fiscal year ending September 2001, all but approximately $2 million of the intended $18 million was absorbed by Congressional earmarks. What starts as a strong river of funding is reduced to a trickle as a result of Congress' failure to match appropriations with authorization and the excessive use of earmarks.

This text is taken from Lynd, L.R., H. Jin, J.G. Michels, C.E. Wyman, and B. Dale. 2003. Bioenergy: Background, potential, and policy. Center for Strategic and International Studies, Washington, DC. http://www.csis.org/tech/Biotech/. One of the authors of this paper is Joe Michels, a former member of Senator Lugar's staff who had day-to-day responsibility for S. 935.