Submission by the World Resources Institute to: Senate Energy and Natural Resources Committee Transportation Biofuels Conference

Conference Date: Thursday, February 1, 2007
Time and Place: 9:30-Noon and 2:30-5:00, Dirksen Building, SDG-50

Executive Summary

The World Resources Institute (WRI) is responding to Questions 1(a), 2(a), 3, 4, and 5.

Biofuels promotion is part of a larger government effort to address the complex issues of climate change and energy security: the environmental, economic, and security implications of our reliance on fossil fuels. Biofuel seems to be a win-win: it is both a "home-grown" substitute for petroleum-based fuels in the transport sector, and as it is derived from biomass, its "tank-to-wheel" emissions are far friendlier to the atmosphere relative to fossil fuels. However, behind the term 'biofuel' lies a multitude of different fuels derived from organic materials. The actual impact of these fuels in terms of fossil fuel consumption and emissions reductions, as well as other agriculture-related environmental impacts, depends heavily on the feedstocks and the conversion processes used to produce the fuel. Policies to promote a US biofuels industry must be carefully designed if we are to minimize such negative impacts.

Federal mandates are one policy approach. While they should be judged on their merits relative to other policy types (including tax incentives, direct subsidies, and other measures), mandates may be useful in stimulating commercialization of biofuel technologies by creating certainty for investors. However, mandates can also have the perverse effect of locking in technologies that are already in the marketplace (in this case, corn-based ethanol) and creating a potential barrier to more promising emerging technologies (for example cellulosic ethanol or butanol). Thus, mandates may be most effective when designed with complementary policies that ensure innovation, competition and environmental protection. Mandates, to be most effective, should also seek to set a floor, not a ceiling for ethanol.

A consumption mandate for a low-level ethanol blend, like the current RFS, has important advantages as the basis for creating a national biofuels market, at least in the near term. A future strategy should be based on deploying a standard national ethanol blend. Initially this might best be a low-level blend (e.g., 10 percent ethanol), but it could rise to higher levels over time as supplies allow and as new technologies and materials are adopted in standard vehicles. This approach would minimize the amount of investment in biofuel distribution infrastructure until we are certain that biofuel production can be increased substantially – and assuring that such increases do not exacerbate the negative environmental implications associated with current feedstock and biofuel production.

More resources should be dedicated to expediting the commercialization of emerging cellulosic technologies, as well as to understanding and defining the environmental differences associated with producing ethanol from multiple sources. As policy incentives for ethanol production advance, they should also be flexible enough to differentiate among the various feedstocks used, even within the new technology encompassed by the term “cellulosic”.

Question 1: WRI did not respond to this question.

Clarifying Question (a):

- **What are the advantages and disadvantages of federal mandates for biofuels production and consumption?**

Federal mandates are only one policy approach to biofuels. As with any policy, a mandate should be judged on its merits relative to other policy types – which for biofuels include tax incentives, direct subsidies, and other measures. A full analysis of the pros and cons of various policies is beyond the scope of this commentary. Looking narrowly at mandates, however, several issues deserve consideration.

Mandates may stimulate commercialization of biofuel technologies by creating certainty for investors. In this regard, mandates are generally better if designed to set a floor, not a ceiling, for consumption. On the other hand, mandates may have the perverse effect of locking in technologies that are already in the marketplace (in this case, corn-based ethanol) and creating a potential barrier to more promising emerging technologies (for example cellulosic ethanol or butanol), even though the emerging technologies may have superior environmental and social benefits. In light of this, mandates may be most effective when designed with complementary policies that ensure innovation, competition and environmental protection. For example, in the case of cellulosic ethanol, this technology may only benefit from a federal mandate if other measures are instituted to address risk, finance, and cost of capital issues.

There are a wide variety of federal mandates that may be used to promote biofuels. These mandates can be applied at any stage of the lifecycle of biofuels, from feedstock production to fuel production to fuel distribution and consumption. In this submission, WRI focuses on a consumption mandate, specifically a national standard for biofuel blending, because it is more market-oriented and flexible than production mandates.

At present, two basic approaches, based on the percentage of ethanol that is blended with gasoline, have been adopted to incentivize biofuel use in the United States. The first promotes a high (85 percent) blend of ethanol (E85) and is mainly used in Midwestern states with significant capacity for feedstock production (primarily corn). Other than the Renewable Fuels Standard, discussed below, most federal incentives seek to advance the market penetration of E85, doing so primarily through infrastructure investment incentives. The second approach promotes a low blend of ethanol, for example, 10 percent (E10), and is the basis for ethanol use in several states, including Montana, Louisiana, Hawaii, Minnesota and Missouri.

Currently, the primary biofuel promotion measure at the federal level is in the Energy Policy Act of 2005: the Renewable Fuels Standard (RFS). This measure phases in a renewable fuels mandate, driving the market by requiring that gasoline sold by refiners, blenders, and importers contains an increasing amount of renewable fuel, specifically ethanol (including cellulosic) and biodiesel. The requirement, 7.5 billion gallons of renewable fuel by 2012, is essentially an E3 mandate, as it requires the blending renewable fuels equal to roughly 3% of gasoline demand. An E10 mandate would therefore make the RFS obsolete, as it would surpass the requirements previously set. The ethanol market in the US will likely surpass the currently mandated 7.5 billion gallons in 2009, three years ahead of schedule, making the mandate largely obsolete. The mandate will have served its purpose though: stimulating the growth of the market.

One important component of the RFS is its targeted support of emerging technologies over corn-based ethanol: through 2012, one gallon of cellulosic or waste-derived ethanol counts for 2.5 gallons of the RFS mandated volume. Moreover, by 2012, cellulosic ethanol's contribution to the fuel mix must be at least 250 million gallons. The RFS thus attempts to avoid locking in the established technology, one of the principle dangers of the mandate approach.

Both mandate approaches, E85 or lower-level blends, offer a measure of certainty to biofuel producers and keep the market open to competition from a range of suppliers, and therefore help to stimulate a biofuels market. However, there are significant trade-offs with basing U.S. biofuels policy on one approach over the other:

- A consumption mandate for a low-level ethanol blend (E10) has important advantages as the basis for creating a national biofuels market, at least in the near term (5 to 10 years). A low-level blend avoids the need for expensive investment in a parallel infrastructure that would be necessary for distributing and using E85.
- Dependence on a low-level blend does pose some challenges. First, low-level blends present air quality issues, as they increase the emissions of criteria pollutants, such as nitrogen oxide. Second, raising the blend beyond 10% ethanol (E10) voids the warranties currently offered on most private vehicles. Growing ethanol use beyond 10% of gasoline will therefore require a change in warranty policy on the part of auto manufacturers.
- The main advantage of E85 is that it could become essentially a substitute for, rather than a complement to, petroleum fuels, and therefore has more profound implications for petroleum imports, energy security, greenhouse gas emissions, and water and soil quality.
- However, given the status of current technology and feedstock availability, an E85 standard would take decades to implement, and significant uncertainties remain concerning its feasibility on a national scale.

Investments today in E85 may be warranted to set the stage for long-term shifts in the transportation sector, though the fuel will likely be relegated to regional, "boutique" markets for some time. However, for a national standard that boosts biofuel production, increases competition, reduces costs and avoids confusion for customers, pursuing a strategy based on a low-level blend is a more logical near-term approach.

Question 2: WRI did not respond to this question

Clarifying Question (a):

- **Discuss how the government might best provide economic incentives that support the growth of the transportation biofuels industry.**

At present, two basic approaches, based on the percentage of ethanol that is blended with gasoline, have been adopted to incentivize biofuel use in the United States. The first promotes a high (85 percent) blend of ethanol (E85) and is mainly used in Midwestern states with significant capacity for feedstock production (primarily corn). Other than the RFS, most federal incentives seek to advance the market penetration of E85. The second promotes a low blend of ethanol, for example, 10 percent (E10), and is the basis for ethanol use in several states, including Montana, Louisiana, Hawaii, Minnesota and Missouri.

E10 and E85 standards will both create a market for US ethanol production. However, a policy decision is necessary. The trend towards state-based blending mandates could result in different mandated requirements across the country, which would drive up the costs for refiners. Moreover, if the federal government is putting its resources behind E85, and it wants to steer investment into E85 infrastructure and technology development, the policy signals around the country must be sufficiently clear to build investor confidence and avoid major stranded investments.

WRI's research suggests that over the next five to ten years the optimal strategy would be based on deploying a single standard national ethanol blend. Initially this would be a low-level blend, eventually reaching E10, or 10 percent ethanol. The standard could rise to higher levels over time as supplies allow and as new technologies and materials are adopted in standard vehicles.

Ethanol is hydrophilic and solvent, meaning it absorbs water and leads to pipe corrosion and fuel contamination. As a result, it cannot use the existing petroleum distribution system and requires an entirely new distribution infrastructure. Since ethanol cannot be piped to its destination, it is usually transported by rail, truck, or barge. This is true for all blends of ethanol. Where E10 and E85 differ, however, is in the end-use distribution. To dispense E85, a station must have dedicated ethanol distribution infrastructure to accommodate delivery, including either new or extensively cleaned tanks, valves, filters, hoses, and nozzles. Moreover, none of these parts can be made from aluminum, a material common in standard petroleum distribution systems, because ethanol dissolves aluminum, causing damage to vehicle engines, even those designed for E85. Using E10 does not require any additional infrastructure investment or new vehicles. It can be – and is – used today in any gas station and any vehicle.

Taking an E10 path seems to be a logical choice for another reason as well: US feedstock for corn-based ethanol is limited. In 2005, US ethanol production was just over 4 billion gallons, or roughly 3% of our gasoline consumption in that year. At the end of 2006, total

US production capacity was only 5.386 billion gallons – or nearly 4% of our gasoline demand. Even including the entirety of new plants either under construction and planned (including capacity expansions of existing plants), we only reach 8% of *current* demand. Taking a more heroic assumption, that we might convert the entire yield of all US farmland currently under corn production to ethanol, the fuel would only amount to 12% of our current gasoline demand.[1] It thus seems a more appropriate to stick to an E10 blend, which would fully absorb the entire quantity of the fuel our domestic industry can currently produce. Following this rationale, rather than promoting investment in new infrastructure, policies might better be focused on promoting the expansion of ethanol supply for use in the current distribution system.

Additionally, ethanol policies should be carefully designed so as not to create perverse incentives that subvert other policies and goals. Thus for example, care must be taken in developing standards not to exacerbate already heavy burdens from agriculture on the environment, including those related to land conservation and set-asides, increases in nutrient loading – and consequent run-off and damage to water systems, or calls for increased water demand from already stressed water regimes. Box 1 provides additional detail on one such concern.

Box 1: Closing the CAFE / FFV loophole

The current emphasis on promoting E85 infrastructure can have unintended but possibly perverse impacts. The Alternative Motors Fuels Act, on the books since 1988, was originally intended to promote alternative fuels in order to reduce oil consumption. Under the Act, automakers can get credit, capped at 1.2 mpg, toward their CAFE requirements for dual-fuel vehicles (DFV), including FFVs. Lawmakers devised a formula (see below) for calculating an adjusted fuel economy rating for FFVs that would take into account the benefits derived from operating the vehicle on alternative fuels, and therefore would not penalize the manufacturers under CAFE for the reduced efficiency that results from the use of biofuels in today's vehicle fleet.

[1] Hill J, Nelson E, Tilman D, Polasky S, Tiffany D. 2006. Environmental, economic, and energetic costs and benefits of biodiesel and ethanol biofuels. *Proceedings of the National Academy of Sciences*. 103: 11206–11210.

$$\frac{1}{\left(\dfrac{0.5^{*}}{\text{Fuel economy (mpg) on gasoline}}\right) + \left(\dfrac{0.5^{*}}{\dfrac{\text{Fuel economy (mpg) on E85}}{0.15^{**}}}\right)}$$

*This figure represents the assumption that the vehicle is fueled 50% of the time by gasoline and 50% of the time by E85.

** This figure represents the amount of gasoline in E85.

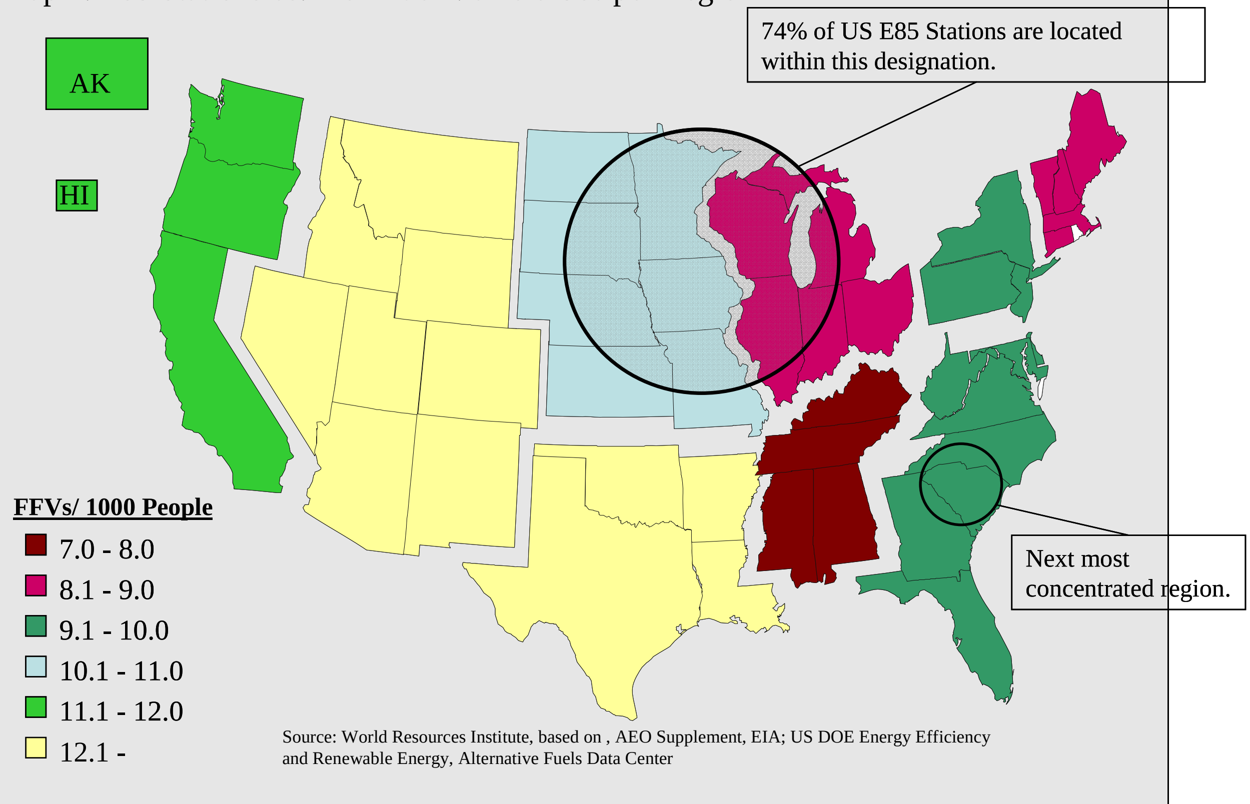
However, the assumptions used in the formula are not applicable in practice. The formula assumes that FFVs are operated on alternative fuels 50% of the time, when, in reality, they are fueled with regular gasoline more than 99% of the time. Thus, the formula incorrectly classifies FFVs as having better fuel economy than they do. In calculating the DFV fuel economy ratings for CAFE, the government only counts the 15% of E85 that is gasoline, resulting in a fuel economy rating for FFVs that is more than 65% higher than the actual fuel economy of the vehicle.

There are several proposed bills that would narrow (although not eliminate) this FFV loophole. These include the Biofuels Security Act of 2006 and the Fuel Security and Consumer Choice Act, both proposed by Senator Harkin (D-IA), and HR4673, proposed by Representative Markey (D-MA). These proposals suggest altering the formula used to arrive at the fuel economy ratings for FFVs so that they more accurately reflect reality. Under current ethanol use patterns, however, even these modifications might still considerably overestimate actual ethanol consumption in these vehicles.

Thus far, federal policies, in combination with the enthusiasm from invested companies, state and local governments, and consumers, have had some success in promoting the expansion of E85 compatible infrastructure: the number of E85 filling stations doubled in less than a year. In July of 2006 there were more than 700 stations that sell E85, whereas in August of 2005 there were only about 300. The National Ethanol Vehicle Coalition expects this number to continue to increase, reaching 2,500 by the end of 2006, approximately a 250% increase from today. However, currently less than ½ of one percent of the gas stations in the US offer E85, so there is still a long way to go before all the drivers of FFVs have convenient access to E85 refueling stations (see Map 1). FFVs provide no benefit to the country if E85 is not available in the regions where they are driven, or if their drivers choose gasoline at the pump (as most do). This mismatch must be addressed in order for an E85 promotion policy set to be beneficial.

As noted above, federal support for E85 infrastructure, including vehicles, may not be the best way of shaping the nation's ethanol market. However, if we do choose to promote E85 vehicles, it might be better done through incentives that do not undermine the CAFE standards.

Map 1: E85 Stations vs. Flex-Fuel Vehicle Use per Region



Question 3. What infrastructure will be required to support increased use of biofuels for transportation? Please discuss whether a national transportation and distribution network will be necessary, versus a larger number of regional networks.

The US has invested heavily in building an extensive infrastructure for distributing petroleum fuels. Shipping and piping networks allow for the cost-effective transport of fuels from wells or ports to refineries to blenders to consumers. Adding biofuels to the nation's fuel mix creates a new set of infrastructure needs. Ethanol is 'hydrophilic' and 'solvent', meaning it absorbs water and leads to pipe corrosion and fuel contamination. As a result, it cannot use the existing petroleum distribution system. Currently the ethanol industry relies on trucks, barges and rail for feedstock and fuel transport. Such transport methods are more expensive than pipelines, however, and a much-expanded biofuels industry will require planning and possibly significant new investment to ensure the cost-effective transport of both feedstocks and final fuel product.

The infrastructure requirements for an expanded ethanol market can be grouped into three stages:

1) Storage and delivery of feedstock from point of production to biorefinery
2) Transferal of ethanol from biorefinery to blender
3) Transport of gas/ethanol blend from blender to retail outlet and then to consumer

Due to the fuel characteristics mentioned above, much of the debate about ethanol infrastructure requirements has focused on how to alleviate the transportation bottlenecks arising in stage 2. Therefore, in this response we focus on the issues arising during stages 1 and 3.

Although the U.S. has considerable experience distributing traditional agricultural commodity products like corn, there are a host of new logistical difficulties associated with the high-volume, low-density feedstocks that will need to be managed for new cellulosic ethanol production. The feedstock will be harvested periodically (in the case of corn stover, for instance, harvest is limited to the fall) and large volumes will then need to be preserved and stored for up to 10 months for continuous delivery to the biorefinery throughout the rest of the year. The bulky organic material must also be transported from the point of production to the biorefineries. The expense associated with this transport limits the distance from which a biorefinery can cost-effectively pull feedstocks, and will require that these distribution networks are planned locally or regionally; it is unlikely that national distribution would ever be cost-effective for ethanol feedstocks.

At the other end of the supply chain, ethanol is blended with gasoline and, regardless of the blend of ethanol, moved from bulk storage to retail outlets in tanker trucks, as gasoline is now. Where E10 (10 percent ethanol) and E85 (85 percent ethanol) differ, however, is in the end-use distribution. To dispense E85, a station must have dedicated ethanol distribution infrastructure to accommodate this delivery, including either new or extensively cleaned tanks, valves, filters, hoses, and nozzles. Moreover, none of these parts can be made from aluminum, a common material in standard petroleum distribution systems, because ethanol dissolves aluminum, and this causes damage to vehicle engines, even those designed for E85. Using E10 does not require any additional infrastructure investment or new vehicles. It can be – and is – used today in any gas station and any vehicle.

US ethanol production in 2005 was just over 4 billion gallons, or roughly 3% of our gasoline consumption in that year. At the end of 2006, total US production capacity was only 5.386 billion gallons per year – or approximately 4% of our gasoline demand. Even including the entirety of new plants either under construction and planned (including capacity expansions of existing plants), we only barely reach 8% of *current* demand. In the near term, we can consume the entire quantity of the fuel our domestic industry can currently produce by using low-level blends, which would require no immediate investment in retail distribution infrastructure. Therefore, as we develop an industry expansion plan for ethanol, pursuing an initial path based on low-level ethanol blends such as E10 seems a more logical and lower cost choice. In the long term, the need for overhaul of retail infrastructure will depend on the extent to which we commit to pursuit of E85 as a fuel option in either national or regional markets.

Perhaps the strongest argument favoring E85, and the significant infrastructure investments that it requires, is that it could become essentially a substitute for, rather than a complement to, petroleum fuels, and therefore has more profound implications for petroleum imports, energy security, greenhouse gas emissions, and water and soil quality. Investments today in E85 may be warranted to set the stage for long-term shifts in the transportation sector, though the fuel will likely be relegated to regional, “boutique” markets for some time.

Importantly, investments in E10 versus E85 are not mutually exclusive and, depending on the point of the production lifecycle, may be complementary. For example, investments in the infrastructure needed to store and move the feedstock would support industry expansion regardless of the fuel blend. Also, an initial emphasis on E10 and other low-level blends may help build the production side and marketing of ethanol to a critical level. In effect, such early investments could create a tipping point that sets the stage for a second phase of ethanol industry development focused on higher blends and the new infrastructure investments required to allow their consumption. This would essentially be a supply-side approach in the short term, potentially setting the stage for a medium-term shift to a demand-side approach focused on retail fueling infrastructure and automobile design for higher blends.

Question 4. What are the key environmental impacts of increased biofuels consumption? If some of the environmental impacts are adverse, what policy responses would be appropriate?

Potential environmental impacts from increased consumption of ethanol arise throughout the fuel's life cycle, from production of feedstocks, to processing those feedstocks into fuel, to combustion of that fuel for transportation energy. In this response WRI focuses on the key environmental impacts associated with increased production of feedstocks for bioethanol.

Currently, most ethanol production in the United States uses corn kernels as its feedstock. Corn is one of the most input- and management-intensive row crops grown in the U.S., and intensive corn production grown according to conventional methods has several negative environmental impacts. The major issues of concern are:

- Intensive use of agrochemicals, including pesticides and fertilizers, which increase nutrient loads into streams and rivers and exacerbate agriculture-related problems such as the degradation of the Chesapeake Bay and the "dead zone" in the Gulf of Mexico.
- Impaired soil quality through erosion and degradation (loss of soil carbon).
- Increased greenhouse gas emissions in the agricultural sector, particularly through loss of soil carbon, production of agrochemicals, and direct off-gassing from nitrogen fertilizer application.
- Increased irrigation needs and increasing competition for limited water supplies.

WRI's research finds that an expanding market for ethanol from corn will exacerbate water and soil quality problems in the United States.[2] The incentive for corn production provided by the increased value of corn (driven by demand for ethanol use) results in additional land being brought into agricultural production, lowered enrollments in the Conservation Reserve Program, an increase in acreage dedicated to intensively managed, and environmentally damaging, continuous corn rotations, and a decline in acreage managed using conservation tillage techniques. This change in production behavior results in increased fertilizer use, increased nutrient run-off and associated issues related to surface and coastal water quality, increased soil erosion, and increases in greenhouse gas emissions from the agricultural sector (which slightly erode some of the GHG benefits accrued when the ethanol displaces gasoline consumption at the other end of its life cycle).

The increased rates of nutrient and soil loss, as well as of agricultural GHG emissions, are disproportionately larger than the rate at which acreage is brought into production. Stimulated by the ethanol market, the increase in agriculture's environmental impact is due to more than simply increased crop acreage; growers respond to the changing market conditions by moving away from more environmentally benign rotations and tillage

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[2] Liz Marshall and Suzie Greenhalgh, 2006, "Beyond the RFS: The Environmental and Economic Impacts of Increased Grain Ethanol Production in the U.S.", World Resources Institute. Available online at http://pdf.wri.org/beyondrfs.pdf

practices in favor of cropping practices that are more nitrogen and management intensive and that have greater negative environmental impacts.

Although corn kernels are currently the feedstock of choice, in previewing the future of the ethanol industry most attention is on cellulosic ethanol. Cellulosic technology, which will permit the production of ethanol from the green, leafy portions of the plant, is months to years away from commercialization. However, cellulosic ethanol is widely touted as a significant environmental improvement in ethanol production. When harvesting crops for cellulosic ethanol, the entire plant is transported to the biorefinery for the cellulose to be extracted. The lignin left behind—the nonfermentable part of the plant—can then be burned to provide the energy needed to process the feedstock into ethanol. This provides significant greenhouse gas and energy benefits over our current ethanol technology, as process energy is currently provided predominantly by coal and natural gas.

In the rush to cellulose, however, insufficient attention has been paid to the environmental impacts at the beginning of the fuel's life cycle—at the point where the feedstock is produced. Cellulosic feedstocks are not equal with respect to the environment. Significant differences in the environmental impacts of two major proposed cellulosic feedstocks—corn stover and switchgrass—are likely. Corn stover is a byproduct of corn production, so it is tempting to assume that it is "free" of environmental impacts in the sense that those impacts are already attributed to the production of the kernels for other uses. However, much of that corn residue is currently returned to the soil, and little is understood about the long-term soil quality impacts of extensive residue removal. The "free lunch" reasoning also ignores the predictable economic response of farmers to the increased value of corn production, which in the presence of a market for stover will provide returns to both the kernels and the residue. As returns to corn production increase, so too does the incentive to produce corn, and more corn, together with its negative impacts, will be produced.

The impacts of a switchgrass market on patterns of agricultural production, and its environmental impacts, are likely to be completely different but are also poorly understood. Switchgrass-- a hardy perennial grass-- is a relatively low-impact crop that requires less fertilization and irrigation, and fewer management practices related to planting, weed control, and insect control relative to corn, and therefore is likely to have relative benefits in the areas of erosion, nutrient runoff, and greenhouse gas emissions. Also, some researchers suggest that switchgrass's vast root system would actually result in a net absorption of carbon dioxide from the atmosphere into the soil.[3] However, switchgrass's ability to generate net agricultural improvements will be contingent on the extent to which switchgrass production displaces other, more intensive, agricultural production. If, instead, switchgrass production merely spreads onto marginal lands that

[3] Ocumpaugh, W., et al., 2002, Evaluation of Switchgrass Cultivars and Cultural Methods for Biomass Production in the South Central U.S., Texas A&M University, ORNL/SUB-03-19XSY091C/01,.

McLaughlin, S.B., et al, 2002, "High-Value Renewable Energy from Prairie Grasses," Environmental Science & Technology, 36:2122:2129.

are currently not in production, or on land intentionally retired from production such as land in the Conservation Reserve Program, there are unlikely to be net agricultural improvements associated with the new market, and there may be significant losses associated with habitat quality as more natural marginal lands move into monoculture and harvesting disrupts wildlife reproductive cycles (particularly for ground-nesting birds).

Most of the negative impacts described here are existing problems associated with agriculture, and are not unique to feedstock production. Given the boost that biofuels will provide for the farm community, and the imminent renewal of the Farm Bill, now is a logical time to push for the types of farm practice changes that will make agriculture in general—for food as well as fuel—more sustainable. WRI's research indicates that the increased value of corn for ethanol will drive up its price, freeing up federal government dollars that might otherwise go into farm support for the corn sector.[4] These savings usefully could be re-directed toward agricultural conservation programs to promote conservation tillage practices and precision management of nitrogen fertilizer (through timing and method of application). Potential policies to achieve these goals include:

- incentive payments
- nutrient management plan requirements
- expanded farmer education and extension programs, and
- improved access to technology and technical information about nitrogen management.

Looking to the future of ethanol production, it is critical to improve our understanding of the impacts, both economic and environmental, associated with the various sources of cellulose. Dedicating more policy resources would expedite the commercialization of cellulosic technology, but policy should also focus on improving our understanding and defining of the environmental differences associated with different cellulose production sources. Such increases could reverse the steady decline in federal R&D appropriations in biomass research and development, which have fallen well short of their authorization levels in recent years.

As policy incentives for ethanol production advance, they should also be flexible enough to differentiate among the various feedstocks used, even within the new technology encompassed by the term "cellulosic". The trading program designed for implementation of the Renewable Fuel Standard mandate has established a valuable precedent in awarding credits that are differentiated according to the ethanol feedstock used, with cellulosic ethanol receiving 2.5 times the credit that corn-based ethanol receives. Variations on this structure, designed to provide additional incentives to stimulate a new technology, could also be built into new policy measures to reward technologies and feedstocks differentially in a way that corresponds to their aggregate environmental impacts. Successful design of such measures requires a more detailed understanding than we currently possess of what those environmental impacts are likely to be. This in turn

[4] Liz Marshall and Suzie Greenhalgh, 2006, "Beyond the RFS: The Environmental and Economic Impacts of Increased Grain Ethanol Production in the U.S.", World Resources Institute. Available online at http://pdf.wri.org/beyondrfs.pdf

suggests that environmental impact analysis of feedstock production must become a R&D priority if we intend for our agricultural and energy policy to stimulate renewable energy production in a sustainable way.

Question 5. How should government support research and development efforts related to transportation biofuels?

Biofuels promotion is part of a larger government effort to address the complex issues of climate change and energy security: the environmental, economic, and security implications of our reliance on fossil fuels. Biofuel seems to be a win-win: a "home-grown" substitute for petroleum-based fuels in the transport sector, biofuel could displace a portion of US oil consumption, and as it is derived from biomass, its "tank-to-wheel" emissions are far friendlier to the atmosphere relative to fossil fuels. However, behind the term 'biofuel' lies a multitude of different fuels derived from organic materials, and some of these fuels offer greater benefits than others. The actual impact in terms of fossil fuel consumption and emissions reductions, as well as other agriculture-related environmental impacts, depends heavily on the feedstocks and the conversion processes used to produce the fuel. Government support for research and development should therefore be carefully designed. It must be specifically targeted, and recognize the differences hidden by the blanket term "biofuels," so as to promote the development of a biofuels industry that will, in fact, be beneficial to the US.

Today, many believe the future of the ethanol industry lies in cellulosic ethanol. Cellulosic technology, which will permit the production of ethanol from the green, leafy portions of the plant, is months to years away from commercialization. However, cellulosic ethanol is widely touted as a significant environmental improvement in ethanol production. When harvesting crops for cellulosic ethanol, the entire plant is transported to the biorefinery for the cellulose to be extracted. The lignin left behind—the nonfermentable part of the plant—can then be burned to provide the energy needed to process the feedstock into ethanol. This provides significant greenhouse gas and energy benefits over our current ethanol technology, as process energy is currently provided predominantly by coal and natural gas. Given its potential to reduce emissions and fossil fuel consumption, many believe that government attention should be focused on supporting commercialization and deployment of cellulosic ethanol.

In the rush to cellulose, however, insufficient attention has been paid to the environmental impacts at the beginning of the fuel's life cycle—at the point where the feedstock is produced. Cellulosic feedstocks are not equal with respect to the environment. Significant differences in the environmental impacts of two major proposed cellulosic feedstocks—corn stover and switchgrass—are likely. Corn stover is a byproduct of corn production, so it is tempting to assume that it is "free" of environmental impacts in the sense that those impacts are already attributed to the production of the kernels for other uses. However, much of that corn residue is currently returned to the soil, and little is understood about the long-term soil quality impacts of extensive residue removal. The "free lunch" reasoning also ignores the predictable economic response of farmers to the increased value of corn production, which in the presence of a market for stover will provide returns to both the kernels and the residue. As returns to corn production increase, so too does the incentive to produce corn, and more corn, together with its negative impacts, will be produced.

The impacts of a switchgrass market on patterns of agricultural production, and its environmental impacts, are likely to be completely different but are poorly understood. Switchgrass-- a hardy perennial grass-- is a relatively low-impact crop that requires less fertilization and irrigation, and fewer management practices related to planting, weed control, and insect control relative to corn, and therefore is likely to have relative benefits in the areas of erosion, nutrient runoff, and greenhouse gas emissions. Also, some researchers suggest that switchgrass's vast root system would actually result in a net absorption of carbon dioxide from the atmosphere into the soil.[5] However, switchgrass's ability to generate net agricultural improvements will be contingent on the extent to which switchgrass production displaces other, more intensive, agricultural production. If, instead, switchgrass production merely spreads onto marginal lands that are currently not in production, or on land intentionally retired from production such as land in the Conservation Reserve Program, there are unlikely to be net agricultural improvements associated with the new market, and there may be significant losses associated with habitat quality as more natural marginal lands move into monoculture and harvesting disrupts wildlife reproductive cycles (particularly for ground-nesting birds).

Looking to the future of ethanol production, it is thus critical to improve our understanding of the impacts, both economic and environmental, associated with the various sources of cellulose. Resources might be allocated in several areas, including supporting the efforts at research institutions to better understand the impacts of both corn-based and cellulosic ethanol feedstocks. This could include support for plant breeding programs, land use management practices for dedicated energy crops, input use and the technologies for ethanol conversion.

On the commercialization of ethanol, additional resources are also needed. In particular, funds must be dedicated to expediting the commercialization of cellulosic technology – while assuring that such support is designed and directed with an understanding of the environmental differences associated with producing the potential sources of cellulose, and tailored toward the promotion of fuels from environmentally sustainable feedstocks and production processes.

As the private sector is already so heavily involved in the development and commercialization of cellulosic technologies, this is an ideal opportunity for public/private cost and risk sharing. According to cellulosic developers, one of the primary barriers to the deployment of cellulosic technologies is the cost of capital and the risk associated with new technologies that have not been proven in the market. The government can in part help support private sector efforts to commercialize technological advances in cellulosic by assuming a portion of the risk involved in these endeavors.

[5] Ocumpaugh, W., et al., 2002, Evaluation of Switchgrass Cultivars and Cultural Methods for Biomass Production in the South Central U.S., Texas A&M University, ORNL/SUB-03-19XSY091C/01.

McLaughlin, S.B., et al, 2002, "High-Value Renewable Energy from Prairie Grasses," Environmental Science & Technology, 36:2122:2129.