STATEMENT OF JOSEPH GLAUBER, CHIEF ECONOMIST, U.S. DEPARTMENT OF AGRICULTURE BEFORE THE HOUSE AGRICULTURE COMMITTEE, SUBCOMMITTEE ON CONSERVATION, CREDIT, ENERGY, AND RESEARCH

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Mr. Chairman, members of the Subcommittee, thank you for the opportunity to discuss the indirect land use provisions that are part of the Energy Security and Independence Act of 2007 (EISA). Renewable fuels produced from renewable biomass feedstocks are defined in terms of their impact on lifecycle greenhouse gas (GHG) emissions. EISA further defined lifecycle GHG emissions to mean "the aggregate quantity of GHG emissions (including direct emissions and significant indirect emissions such as significant emissions from land use changes), as determined by the Administrator of the EPA, related to the full fuel lifecycle, including all stages of fuel and feedstock production and distribution, from feedstock generation or extraction through the distribution and delivery and use of the finished fuel to the ultimate consumer, where the mass values for all greenhouse gases are adjusted to account for their relative global warming potential."

The feedstock limitations associated with the exclusion of some sources of renewable biomass as defined in EISA-particularly with respect to cellulosic materials from both private and public forest lands-may serve to limit the opportunity to replace fossil fuels. In the future, ethanol produced from cellulosic sources, including wood biomass, has the potential to cut life cycle GHG emissions by up to 86 percent relative to gasoline (Wang et al. 2007).

Yesterday, the Administrator of the Environmental Protection Agency (EPA) signed a notice of proposed rulemaking for the Renewable Fuel Standard (RFS) included in the EISA. EPA's proposal reflects considerable input, guidance, and data from USDA. EPA’s proposal also utilized many of the same data and assumptions that USDA uses regularly in near-term forecasting agricultural product supply, demand, and pricing. They further acknowledge the uncertainty associated with the various models and input assumptions involved in their lifecycle modeling, present a number of different sensitivity analyses, and seek comment on what, if any changes should be made for the final rule.

While the effects of biofuel production on GHG emissions are expected to increase land under cultivation, existing estimates of the magnitude due to land use conversion vary. Work such as that published in *Science* by Searchinger et al. (2008) concluded that if GHG emissions from indirect land use changes were taken into account, GHG emissions from biofuel production were potentially far larger than previously estimated. On April 23, 2009, the California Air Resources Board adopted a regulation that would implement a Low Carbon Fuel Standard (LCFS) for the reduction of GHG emissions from California’s transportation fuels by 10 percent by 2020. The LCFS would take into account the GHG emissions of indirect land use from biofuel production, potentially resulting in the exclusion of corn-based ethanol produced in the Midwest from California fuel markets.

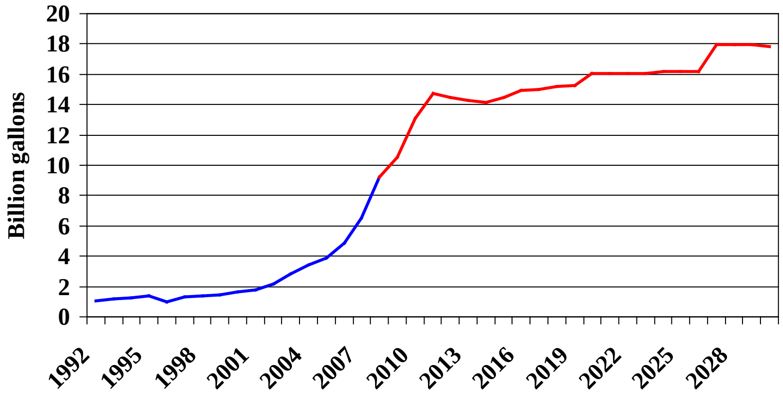
Today, I would like to discuss how biofuel production affects land use in the United States and the rest of the world, and will discuss what is meant by emissions associated with land use change. I will defer to EPA to describe the results of their most recent research, but will present some various other research on GHG emissions from renewable fuels and discuss some of the key uncertainties noted in these research efforts in estimating the effects of land use change on GHG emissions.

Historic Trends in U.S. Agricultural Land Use and Biofuel Production

Before getting into each of these issues, I would like to present some context for this discussion by presenting a brief overview of the historic trends in U.S. biofuel production and agricultural land use in the United States and the rest of the world. Figure 1 shows the growth in corn and other starch based ethanol in the United States since 1992 as well as the forecasted growth in corn and other starch based ethanol to 2030 based on the latest long-term forecast from the Energy Information Administration (EIA). The chart shows that EIA forecasts much of the growth in corn and other starch based ethanol will occur in the next couple of years and then stabilize at about 15 billion gallons per year into the future. The EIA projection of a plateau of 15 billion gallons of corn and other starch based ethanol reflects the limits placed on the volume of non-advanced ethanol that may qualify for credits under the RFS in the EISA, mandated minimum levels of cellulosic-based ethanol under RFS, and projected improvements in the profitability of cellulosic-based ethanol.

In 2008/09, corn use for ethanol production is projected to be 3.7 billion bushels and account for about 31 percent of total corn use in the United States (figure 2). By 2015/16, assuming current baseline assumptions remain constant, corn use for ethanol is expected to exceed 4.8 billion bushels, about 34 percent of total corn use in the United

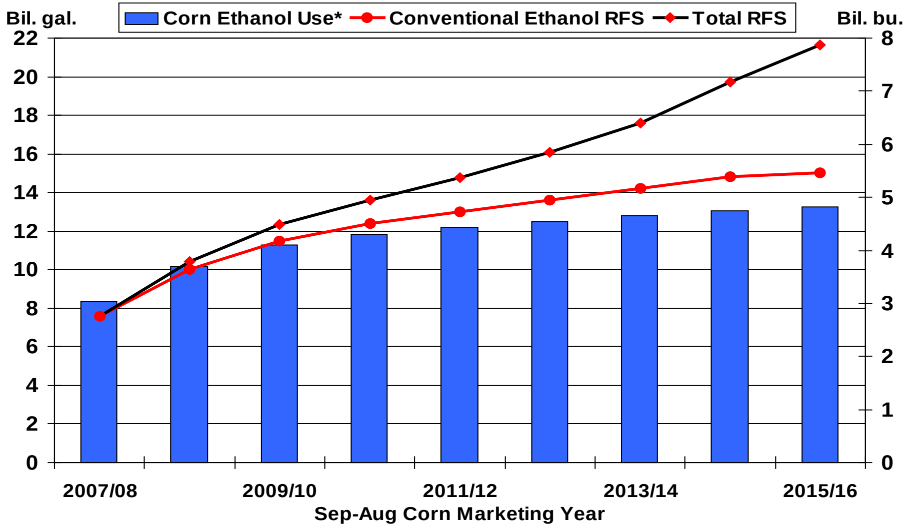
Figure 1--Corn-Starch Based Ethanol Production in the United States



Source: EIA

Primarily corn-starch based ethanol but also including minor amounts of ethanol from other crops.

Figure 2—The Renewable Fuel Standard (RFS) and Corn Ethanol Use



* 2008/09 is projected based on the *World Agricultural Supply and Demand Estimates*, April 9, 2009. 2009/10 is projected based on USDA's *Grains & Oilseeds Outlook*, Agricultural Outlook Forum, Washington, D.C., February 27, 2009. Projections for 2010/11-2015/16 are from USDA *Agricultural Projections to 2018*, February 2009.

States.   Corn production in the United States is expected to increase from 12.1 billion bushels in 2008 to 14.0 billion bushels in 2015, an increase of 15.7 percent. Corn plantings are expected to increase from 86 million acres to 90 million acres, up 4.7 percent, while yields are anticipated to increase by almost 10 percent, from 154 bushels per acre in 2008 to 169 bushels per acre in 2015.

What is the potential for expansion of cropland in the United States? Cropland use in the United States has varied considerably over the past 30 years. Figure 3 shows planted acreage to the eight row crops (wheat, corn, barley, grain sorghum, oats, soybeans, rice and cotton) since 1975. Over 297 million acres were planted to these crops in 1981. Plantings fell off to less than 245 million acres in the late 1980s and generally remained between 245 to 255 million acres during the early 1990s as land was idled. The annual Acreage Reduction Programs authorized by the 1981, 1985 and 1990 farm bills, and Conservation Reserve Program (CRP) starting under the 1985 farm bill contributed significantly to this acreage reduction. Planted acres to the eight principal crops rose to almost 261 million acres in 1996, however, as grain prices spiked.

From 1996 to 2006, plantings to the eight row crops generally trended downward due to lower commodity prices, increased planting flexibility offered by the 1996 and subsequent farm bills which allowed producers to fallow land that had formerly been maintained in more permanent cultivation, and expansion of minor crops such as canola. With the return of higher prices in 2007, however, plantings to the eight row crops rose again, reaching 253 million acres last year. Based on producer planting intentions, NASS estimates that 246 million acres will be planted to the eight row crops in 2009.

Figure 3--Area planted to 8 principal row crops

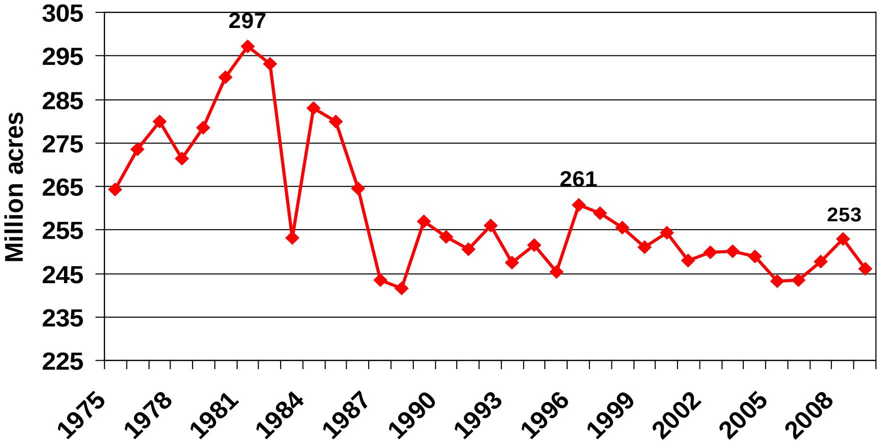


Table 1—US Planted Acreage in 1996 and 2008
(million acres)

Crop	1996	2008	Change from 1996 to 2008
Wheat	75.1	63.1	-12.0
Corn	79.2	86.0	6.8
Other feed grains	24.8	15.7	-9.1
Soybeans	64.2	75.7	11.5
Rice and cotton	17.5	12.5	-5.0
8 row crops	260.8	253.0	-7.8
Hay 1/	61.2	60.1	-1.1
Other crops	11.7	10.9	-0.8
Principal crops	333.7	324.0	-9.7
CRP	34.5	34.5	0.0
Principal crops plus CRP	368.2	358.5	-9.7

1/ Harvested acreage

Table 1 compares plantings in 1996 to plantings in 2008. Even though acreage enrolled in the CRP was unchanged between 1996 and 2008, total acreage planted to the eight row crops in 2008 was down nearly 8 million acres (about 3 percent) and acreage planted to principal crops was down almost 10 million acres from 1996 levels. Corn and soybean acreage were up by over 18 million acres in 2008 compared with 1996; however, this was more than offset by declines in wheat, small feed grains and cotton acreage. Thus, while it is clear that producers planted substantially more acreage as recently as 1996, most of the implied capacity is likely in areas more suitable for wheat and small grain production.

Estimated Land Use Effects of Biofuel Production

The literature on biofuel production and international land use has developed largely over the past 5 years. Most of the focus has been on the effects of biofuel production on U.S. agriculture (see, for example, USDA, ERS/Office of the Chief Economist 2007; FAPRI 2008; Biomass Research and Development Board 2008; de Gorter and Just 2009). However, several more recent studies attempt to also model the ripple effects that would occur in agricultural markets around the world due to increased biofuel use within the U.S., and the implications this might have on GHG emissions. Table 2 presents the results from several recent modeling efforts that estimate the effects of ethanol production on global land use. These studies attempt to quantify the market response in the United States and in other countries to increases in commodity prices due to increases in biofuel production. These studies also quantify the GHG emissions from these market responses and attribute these emissions to biofuel production. The table is not meant to be comprehensive, but shows a selected range of central estimates. Other models, such as MIT's Emissions Prediction and Policy Analysis model, have also been used to examine indirect land use change impacts (Gurgel et al. 2007; Melillo et al. 2009). Key uncertainties are discussed below.

One of the first studies of the effects of biofuels on GHG emissions was published by Searchinger et al., in the February 2008 issue of *Science*. That study used a worldwide agricultural model to estimate emissions from land-use change, and reached the conclusion that corn-based ethanol nearly doubles greenhouse emissions over 30 years, and increases greenhouse gases for 167 years. In contrast, when emissions from land use change were not included in their model, corn-starch based ethanol reduced GHG emissions by 20 percent compared to gasoline. Using the multi-market, multi-commodity international FAPRI (Food and Agricultural Policy Research Institute) model, Searchinger et al. assessed the land use change and GHG implications of increasing corn ethanol production in the United States by 14.8 billion gallons and found that an additional 26.7 million acres of land would be brought into crop production world-wide (1.8 million acres per billion gallons of ethanol). In terms of GHG emissions per unit of energy produced, Searchinger et al. estimated that the emissions from land use change alone (104 grams of CO2 equivalent per MJ of energy in fuel) outweighed the emissions from gasoline (92 g CO2-eq/MJ).

Using the 2007 FAPRI baseline, Fabiosa et al. (2009) estimated that a 1-percent increase in U.S. ethanol use would result in a 0.009 percent increase in world crop area. Most of the increase in world crop area is through an increase in world corn area. Brazil and South Africa respond the most, with multipliers of 0.031 and 0.042, respectively. Fabiosa et al. did not estimate the GHG implications of the lower land requirement.

Based on the 10-year averages of U.S. ethanol use and world crop area taken from the 2007 FAPRI international baseline, and using the world area impact multiplier from Fabiosa et al. (0.009), the results suggest an impact multiplier of 1.64 million acres per 1 billion gallons of additional ethanol use, which is lower than the acreage effect estimated in the Searchinger study.

The California Air Resources Board (CARB), as part of their recent proposed low carbon fuel standard, also estimated the GHG emissions associated with renewable fuels. CARB employed the Global Trade and Analysis Project (GTAP) model and also found significantly less land is required to produce ethanol than Searchinger et al. In the CARB study, each additional billion gallons of corn-starch based ethanol requires only 726,000 acres; about 60 percent less compared to Searchinger et al. Primarily as a result of this reduced acreage, CARB estimated the GHG emissions associated with land use change were 70 percent less than those estimated by Searchinger et al. The GHG emissions due to land use change were reduced from 104 grams of CO2 equivalent per MJ of ethanol to 30 grams of CO2 equivalent per MJ of ethanol.

A more recent article by Tyner et al. (2009), which like the CARB study, employed the GTAP modeling framework, differentiated between various levels of ethanol production. Their results show smaller GHG emissions impacts from corn-starch based ethanol than the CARB study and one-forth of those estimated by Searchinger et al. Tyner et al. note their results are significantly less than Searchinger et al. due to three factors: 1) the significantly smaller change in total land use, 2) differences in which part of the world the change in land use occurs, and 3) differing assumptions regarding the percent of carbon stored in forest vegetation that is emitted when forest is converted into cropland (Searchinger et al. assumes 100 percent of carbon stored in forest vegetation is emitted while Tyner et al. assumes 75 percent of the carbon stored in forest vegetation is emitted with the remaining 25 percent stored in long-term wood products).

Table 2—Land Use Change and CO2 Emissions from Ethanol

Study	Modeling framework	Increase in ethanol production	Change in Global Land Use	Change in Global Land Use	CO2 equivalent emissions
		Billion gallons	Million acres	Million acres per bil. gal	Grams CO2-Eq. per MJ of Ethanol
Searchinger et al. 2008 1/	FAPRI/ CARD	14.8	26.73	1.81	104
Fabiosa et al. 2009 2/	FAPRI/ CARD	1.174	1.923	1.638	na
California (CARB) 2009	GTAP	13.25	9.62	0.726	30
Tyner et al. 2009 3/	GTAP				
2001 to 2006		3.085	1.8	0.576	20.8
2006 to 7 BG		2.145	1.3	0.625	22.7
7 to 9 BG		2	1.3	0.658	23.8
9 to 11 BG		2	1.4	0.689	24.9
11 to 13 BG		2	1.4	0.722	26.1
13 to 15 BG		2	1.5	0.759	27.4
2001 to 15 BG		13.23	8.77	0.663	24.0

1/ Searchinger et al. reported their results in terms of a 55.92 billion liter increase in ethanol production which resulted in a 10.8 million hectare change in global land use.

2/ Based on a 10 percent increase in U.S. ethanol use using 10 year averages of US ethanol use and world crop area taken from the 2007 FAPRI baseline. Impact multiplier of 0.009 taken from Fabiosa et al., table 2.

3/ Based on data from Table 7 and Table 8 and converted to MJ of ethanol by assuming each gallon of ethanol contains 76,330 Btu's of energy and each Btu is equal to 0.00105 megajoules (MJ).

Sources of Uncertainty

Modeling the change in land use resulting from the expansion in the production of corn-starch based ethanol, requires making projections about future values of parameters that cannot be known with certainty. Therefore, judgments and assumptions must be made as to the likely values these uncertain data will take. Each assumption, whether made explicitly or implicitly in the structure and data of the model, will influence the outcome. Here is a partial list of some of the major assumptions that influence the estimate of GHG emissions from corn-starch based ethanol and other biofuels.

Yields on converted lands. Estimating the yields on converted land is one of the most important aspects associated with the GHG emissions and land use change. In the CARB analysis, a small change in the expected yields on converted land had a large impact on the amount of land necessary to meet the added demand for renewable energy and, therefore, on GHG emissions. When yields on converted land were expected to be more similar to yields on existing land, only 500,000 acres of additional cropland were required to produce each billion gallons of ethanol and the emissions associated with land use change fell to 18.3 grams of CO2 equivalent per MJ of ethanol; a reduction of almost 40 percent. Alternatively, when yields on converted land were expected to be lower than yields on existing land, 850,000 acres of additional cropland were required to produce each billion gallons of ethanol and the emissions associated with land use change increased to 35.3 grams of CO2 equivalent per MJ of ethanol; an increase of about 18 percent. Unfortunately, as discussed in the CARB analysis, there is little empirical evidence to guide modelers in selecting the appropriate value for estimating the productivity of converted land. There is even experience to suggest that yields on converted land may be higher than yields on existing land. For example, when Brazil began expanding soybean production from the temperate South into the tropical Center-West, research led to the development of a soybean variety that flourished in the tropics. As a result, soybean yields in the tropical Center-West were double that of the national average. On the other hand, in many other regions, existing crops are already on the most productive agriculture land, so yields on newly converted lands would be lower than on existing cropland. On net, we would not expect to see significantly higher yields on converted land, but there is little information on how yields may change when land is converted.

Shifts between different land uses. Converting land from one land use to another can have dramatic impacts on the emissions associated with land use change. However, it is difficult to model the specific contribution of the many factors that determine land use, especially when changing between broad land use categories. It is one thing to try to estimate the movement of land allocation among different crops, such as switching between corn and soybeans. However, land conversion between land uses, such as from forest to pastureland or cropland can be very costly and therefore driven by longer-term economic factors. For example, Midwest farmers can readily move cropland between corn and soybeans when the relative profitability of those crops change. In contrast, expansion of agricultural land into other areas will depend on the cost of conversion of that land and land supply availability. For land that is currently in active use there are decisions to be made on long term profitability, for example for land to be converted from forest to cropland, long term decisions must be made regarding the relative profitability between agricultural and forestry commodities for many years into the future. Conversion of land that does not have a current market use (grassland or unmanaged forest) would be based on costs of conversion, land availability, and in addition, there are several non-economic factors that may significantly affect land conversion decisions in a particular area or country, such as national conservation and preservation policies and programs.

Some studies have suggested that conversion of land into cropland would be associated with grassland conversion because it costs less to clear and prepare grassland than clearing and preparing forestland. In the Tyner et al. study, for example, 23 percent of the increase in cropland comes from conversion of managed forest. The remaining 77 percent of the increase in cropland is a result of the conversion of grassland to cropland. While a majority of the land conversion is from grassland to cropland, a majority of the emissions due to land use change result from the conversion of forests to cropland, due to the relatively larger GHG pulse associated with forest conversion. If we assume there is no forest conversion and only grassland conversion, the emissions associated land use change estimated by Tyner et al. would fall by 50 percent. In many studies, estimates of forest conversion surfaces as a key factor driving the lifecycle GHG results. In addition, the GTAP modeling framework used by CARB and Tyner et al. includes only managed lands. This could also influencing the type of land conversion predicted by the model.

Yield growth over time. Another important factor driving the amount of land required to produce biofuels is the growth in yields that are expected to occur over time. At USDA, we estimate that corn yields in the United States will grow at 2 bushels per acre. If we assume that global corn yield growth increases at the same rate as in the

United States, by the 2015, the average corn yield in the rest of the world would be about 10 percent higher than used in the CARB study. The increase in land productivity in the rest of the world would reduce the estimated amount of land converted into cropland in the CARB study from 726,000 acres to 663,000 acres for each additional billion gallons of corn-starch based ethanol, and the average GHG emissions due to land use change would fall from 30 grams of CO2 equivalent per MJ of ethanol to 27 grams of CO2 equivalent per MJ of ethanol.

In addition, higher commodity prices due to greater demand for renewable fuels would likely result in some increase in crop yields. In the CARB analysis, each 1 percent increase in the price of corn relative to the input costs associated with growing corn was assumed to increase corn yields by 0.4 percent. Varying that assumption from a 0.1 to a 0.6 percent increase in yields for each 1 percent in the price of corn relative to inputs costs altered the estimate of GHG emissions due to land use change by 49 percent.

Substitutability of Distillers Dried Grains (DDGs). DDGs are a co-product of corn-starch based ethanol production, and can substitute for corn as feed, thereby reducing the amount of corn which goes directly into livestock feed. Thus, the more DDGs that are assumed to be used in livestock feed, the fewer total cropland acres will be needed and therefore less GHG emissions. For example, each bushel of corn generates about 2.8 gallons of ethanol and almost 18 pounds of DDGS. In the CARB study, each pound of DDGs is assumed to displace one pound of corn. However, DDGs have attributes that may allow a greater than a one-for-one displacement of corn in animal feed. DDGs have higher protein and fat content compared to corn. Tyner et al. assume each pound of DDGs replaces 1.16 pounds of corn as animal feed. Arora et al. recently found that 1 pound of DDGs displaces 1.271 pounds of conventional feed ingredients. However, DDGs cannot completely replace traditional feed.

Other Sources of Uncertainty. In addition to the uncertainties discussed above, many other modeling assumptions will influence the predicted impact of added renewable fuel production on GHG emissions, (e.g., the level of disaggregation in the underlying crop data, assumptions about international trade in agricultural commodities, assumptions about changes in fertilizer use, etc.). There are also simplifying assumptions that relate to accounting for future GHG emissions. Generally, when comparing the GHG emissions of renewable fuels to nonrenewable alternatives, studies assume that increases in GHG emissions from land use conversion occur in the year of conversion, while reductions in GHG emissions due to the production and use of renewable fuels occur over several years into the future. For example, the results from the studies referenced in this testimony assume the reduction in GHG emissions from expanded ethanol production occur over a period of 30 years. Increasing the expected time frame for renewable fuel production on converted land reduces their net GHG emissions, because the total emissions reductions associated with producing and using renewable fuels will be greater.

Conclusions

There is little question that increased biofuel production will have effects on land use in the United States and the rest of the world. The more interesting question concerns magnitude. To the degree to which the supply response to increased biofuel production is met through increased yields, cropland expansion will be less. Land use change is more likely to occur where producers are more responsive to price changes. How much pasture and forest is converted to cropland will ultimately depend on the region, national and local land use policies and the degree to which competing uses (grazing, forest products) impose constraints for expansion.

While economic modelers have a long history of policy analysis in agriculture, most of the analyses have focused on impact of various domestic or international trade policies (e.g., farm bills, trade agreements) on cropland. By contrast, the empirical literature on land use and GHG emissions is relatively young, with most studies appearing in the last two or three years. Sensitivity analysis suggests wide variation in results. In particular, much is to be learned about land conversion from forest to pasture and from pasture to cropland.

We have had a very constructive and cooperative relationship with EPA as they have developed their RFS2 proposal. Their proposal raises challenging issues for public comment and will do much to advance the scientific understanding of the lifecycle GHG emission impacts of biofuels, and in particular the land-use change impacts. USDA looks forward to continuing our relationship with EPA as they complete the work necessary to finalize the RFS2 rule.

Mr. Chairman, that concludes my statement.

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