An Investor Brief on Impacts that Drive Business Risks:

CORN

ENGAGE *the* CHAIN

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Ceres

This brief provides a summary of the main environmental and social factors that affect corn production *worldwide*; however, it spotlights key players in the U.S. value chain and provides examples of actions being taken by companies operating or headquartered in the U.S.

KEY TAKEAWAYS

- Most of the corn grown today is used to feed the animals we eat or as a biofuel for cars.
- The U.S. is the world's largest producer, exporter and consumer of corn grain, with nearly one-third of its cropland used for corn production. Most corn used in the U.S. is grown in the U.S.
- Because corn is a high yielding commodity and a widely used ingredient in food products a large number of companies are part of the corn value chain.
- Inefficient fertilizer practices and the demand for irrigated water contribute to environmental impacts, such as greenhouse gas emissions and poor water quality that drive business risks in corn production.
- Investors should address risk in the corn supply chain through direct engagement with their portfolio companies and by supporting relevant policies and multi-stakeholder collaborations.

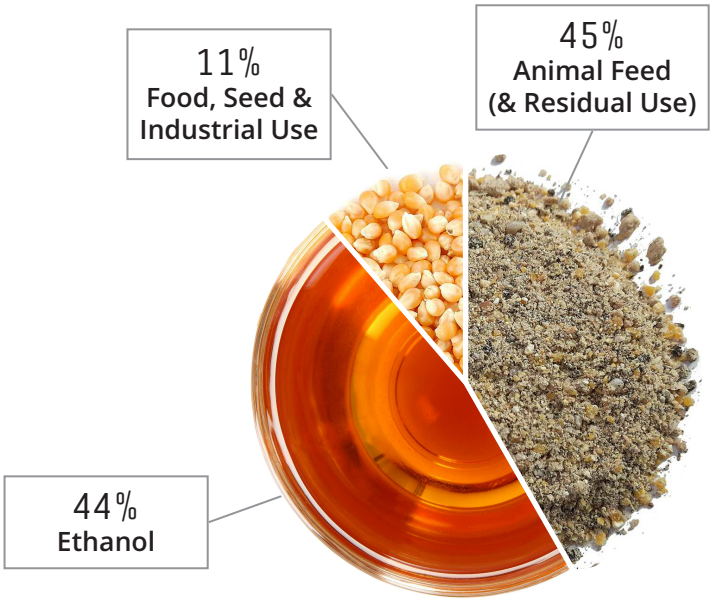
COMMODITY OVERVIEW

Most of the Corn We Grow is Used to Feed Animals or as Biofuel to Fuel Cars

The U.S. produces one third of the world's corn. On average, 45 percent of U.S. corn is used for animal feed, while 44 percent is turned into ethanol.

By comparison, in China, which grows nearly one-quarter of all the global corn, animal feed accounts for 60 percent of use.[1]

Only about 10 percent of corn grown in the U.S. is used as food and one third of that is converted into high-fructose corn syrup.[2]

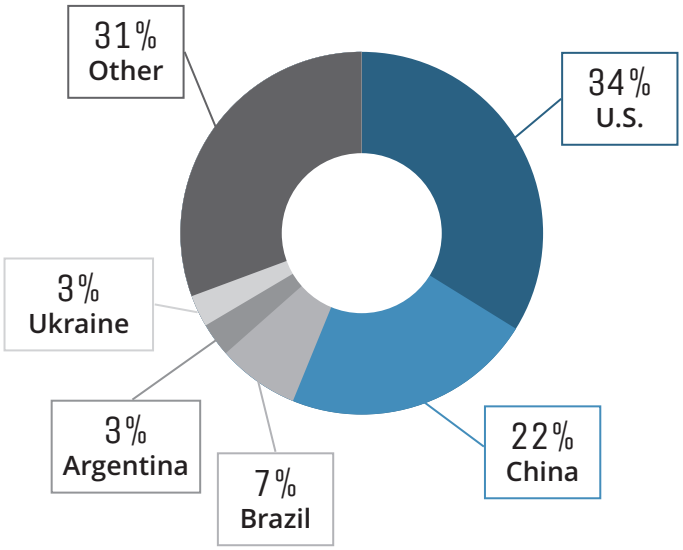


Average 2014-2016
U.S. Domestic Corn Use
(based on billions of bushels)[3]

GLOBAL PRODUCTION DATA

The U.S. and China are By Far the Largest Corn Producers, Accounting for More than Half of Global Corn Production

TOP FIVE PRODUCTION REGIONS[4]



928 MILLION METRIC TONS

Average global corn production, 2011-2013[5]

$233.1 BILLION

Global production value[6]

13 PERCENT

Proportion of global production exported[7]

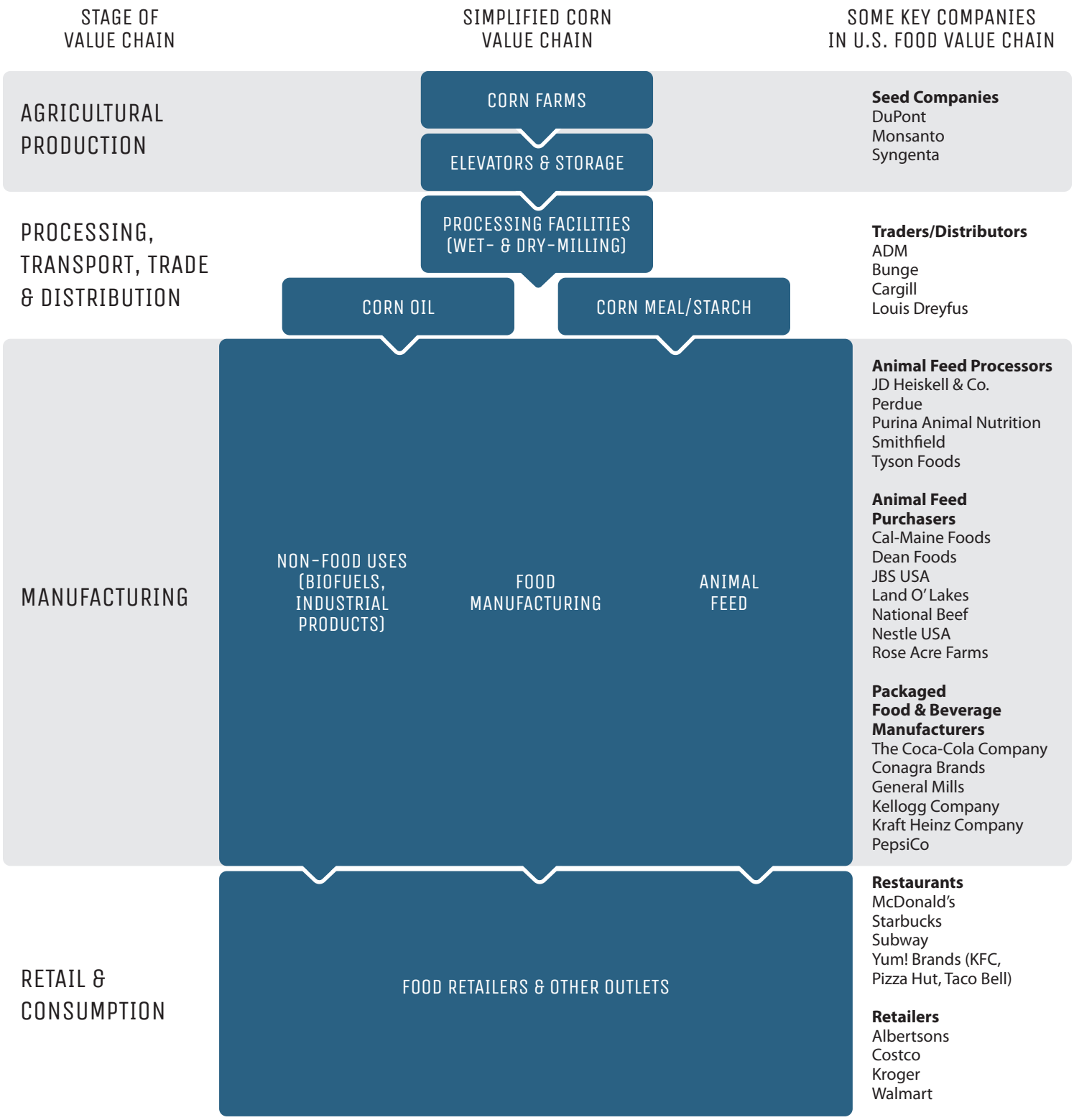
Rising Meat Consumption and Biofuel Mandates Drive Demand

During the past decades, farmers doubled the amount of corn they grew globally in response to higher demand for corn for animal feed and biofuels.[8] In the U.S., production ramped up after 2005 to meet the higher requirements of the U.S. Renewable Fuel Standard.[9] Globally, corn production is expected to continue growing as incomes rise and diets shift. In China, corn production jumped nearly 125 percent during the past 25 years, compared with a 7 percent increase in rice.[10]

While corn yield grew steadily during the past 20 years, thanks to new technology and farming practices, the rapid jump in production is creating new problems and exacerbating existing ones.[11] In the U.S., corn makes up 26 percent of the 5.3 million acres of highly erodible land converted between 2008 and 2012 to growing row crops.[12] Corn is a thirsty crop that also requires a good deal of fertilizer. Combined with the expansion of production, corn's attributes put it in competition for other uses in water-stressed areas while also increasing water pollution impacts.

THE CORN VALUE CHAIN

The Corn Value Chain is Extremely Broad, Encompassing Many Players and Sectors. However, a Small Group of Big Companies Control Large Volumes of Production at Key Points in the Supply Chain



KEY PLAYERS

The following provides additional information about some of the companies in the U.S. corn food value chain. While the focus is on publicly traded companies headquartered in the U.S., some of the companies mentioned are headquartered outside the U.S. and/or are privately held.

SEED COMPANIES

Monsanto, DuPont (Pioneer), and Syngenta (headquartered in Europe) are large publicly traded companies that provide seeds to farmers.

TRADERS AND DISTRIBUTORS

Archer Daniels Midland (ADM), Bunge, Cargill (privately held) and Louis Dreyfus Commodities (headquartered in Europe) control much of this link in the supply chain.

MANUFACTURERS

Animal Feed Processors: The largest companies include Cargill and ADM, poultry and pork processors (i.e., Tyson Foods, Smithfield and Perdue), Purina Animal Nutrition (subsidiary of Land O'Lakes), and J.D. Heiskell & Co. (privately held).[13]

Animal Feed Purchasers: For companies selling meat or dairy products, corn enters the supply chain as a common ingredient in animal feed. Some of the largest U.S. companies that purchase animal feed (likely to contain corn-derived ingredients) are the following:

- *Poultry Processors:* Tyson Foods, Pilgrim's (a subsidiary of JBS USA; JBS is headquartered in Brazil), and Perdue together account for 45 percent of the U.S. market[14]
- *Pork Processors:* Smithfield (the largest by far but no longer U.S. owned), Tyson Foods, and JBS USA together control more than half the U.S. market[15]
- *Beef Processors:* Tyson Foods, JBS USA, Cargill, and National Beef (privately held) collectively account for 75 percent of the U.S. market[16]
- *Dairy Processors:* Nestle USA, Dean Foods, and Land O'Lakes (a cooperative) are among the leading dairy companies
- *Egg Producers:* Cal-Maine Foods and Rose Acre Farms (privately held) lead the sector in number of hens housed[17]

Packaged Food Manufacturers: For food and beverage manufacturers, the type of corn-based ingredients used ranges widely, from cereals and starches to sweeteners such as high-fructose corn syrup. Large U.S. buyers of corn-derived ingredients include beverage companies (e.g., The Coca-Cola Company, PepsiCo), vegetable oil producers (e.g., Conagra Brands) and companies in the cereal and snack business (e.g., General Mills, Kellogg Company and The Kraft Heinz Company).

RESTAURANTS AND RETAILERS

Restaurants and retailers play an important role in the corn value chain. These companies can indirectly influence production practices and supplier standards within their supply chain. Moreover, they are sensitive to external pressures as well as responsive to market trends and consumer preferences.

Restaurants are heavy users of corn-derived ingredients in many products from cooking oil to bakery items. Also, many meat products are produced with animal feed that includes corn-based ingredients. The four largest quick-service and fast-casual restaurants in the U.S. are McDonald's, Yum! Brands (Taco Bell, Pizza Hut, KFC), Starbucks, and Subway. All are headquartered in the U.S.[18] In terms of food retailers, the four largest in the U.S. are Walmart, Kroger, Costco, and Albertsons.[19]

ENVIRONMENTAL AND SOCIAL FACTORS

WATER USE & POLLUTION	CLIMATE CHANGE	LAND USE & BIODIVERSITY	LIVELIHOODS	LAND RIGHTS	DEFORESTATION	WORKING CONDITIONS
●	◑	◑	◑	○	○	○

● High Impact ◑ Medium Impact ○ Low Impact

Globally, the environmental and social issues linked to corn production include water pollution, groundwater depletion and land use impacts. The scale of the impacts depends on the practices used by individual corn growers as well as regional and local conditions.

On many fields, farmers grow multiple crops, which means that the issues may be linked to other commodities and cannot be addressed in isolation. In the U.S., for example, farmers commonly rotate corn with soybeans.

REGIONAL CONTEXT MATTERS

When assessing risks to U.S. companies, it is important to keep in mind that most corn is grown and processed in the U.S. However, the impacts linked to corn grown outside the U.S. are also relevant to U.S.-based companies that operate in other markets. U.S.-headquartered food processors operate globally and U.S. imports may include corn grown elsewhere.

1. HIGH WATER DEMAND CONTRIBUTES TO DROUGHT VULNERABILITY AND GROUNDWATER DEPLETION

Corn is a thirsty crop, and in the United States, corn requires more water for irrigation than any other crop.[20] Twenty-one percent of U.S. and 26 percent of global production respectively is irrigated.[21] In addition, some 35 percent of corn is grown in regions, including the U.S. and China, where there is high or extremely high water stress. In those areas, existing water supplies face intense competition and, in some cases, growing regulation.[22]

In the United States, around 87 percent of irrigated corn is grown in regions with high or extremely high water stress,[23] and production often relies on groundwater from critical aquifers, such as those in California's Central Valley and the High Plains Aquifer. In at least 20 counties across Nebraska, Kansas and other states that lie above the High Plains Aquifer, groundwater is dropping precipitously. This poses a risk to the harvest in those counties, which is estimated at $2.5 billion annually.[24] Severe droughts, floods and heat waves at key moments in the growing season—increasingly linked to climate change—are also becoming more common and causing year-to-year supply shocks.[25] Recent research in the U.S. suggests that corn's sensitivity to drought conditions may be increasing.[26]

It Takes

1,028 LITERS OF WATER

To Produce

1 KG CORN GRAIN

(Weighted Global Average)[27, 28]

35 PERCENT

Percentage of Production in Regions of Water Stress[29]

26 PERCENT

Percentage of Global Production Irrigated[30]

2. INEFFICIENT FERTILIZER USE THREATENS WATER QUALITY AND GENERATES GREENHOUSE GAS EMISSIONS

Corn is a nutrient-hungry crop, requiring intensive fertilizer use. Many waterways in the U.S. Corn Belt suffer from high levels of nutrient pollution linked to agricultural fertilizers that run off farm fields. Too much fertilizer in streams, rivers and lakes contributes to "dead zones"[31] that are devoid of life and contaminate local drinking water supplies. In 2014, a toxic algae bloom on Lake Erie caused primarily by agricultural runoff poisoned the water supply for nearly half a million people in Toledo, Ohio. [32] Corn and soybean production in the Mississippi River Basin contributes 52 percent of the nitrogen that enters the Gulf of Mexico, creating a seasonal dead zone the size of Connecticut.[33] Poorly managed fertilizer use can also lead to economic losses for producers, which in the Mississippi River Basin has been estimated to be $420 million annually.[34] Fertilizer production also creates nitrous oxide emissions, an extremely potent greenhouse gas.

3. CONVERSION OF NATURAL HABITAT LEADS TO GREENHOUSE GAS EMISSIONS AND LOSS OF BIODIVERSITY

Cutting down or plowing up natural habitats for corn production generates greenhouse gases that contribute to climate change and leads to the loss of biodiversity. Largely due to demand for biofuel feedstocks in the U.S., millions of acres of important grasslands in the Great Plains have been converted to cropland in the last several years leading to reductions in biodiversity (e.g., bird populations) and the loss of soil carbon.[35]

4. PLANTING AND FERTILIZING TECHNIQUES CAN REDUCE SOIL HEALTH

Worldwide, the rate of soil erosion is still several times greater than is sustainable. Soil erosion is a problem because it leads to both loss of valuable topsoil and contamination of waterways with agrochemicals and fertilizers. A great deal of progress has been made in the U.S. and other regions to reduce the high rates of soil erosion from growing corn by using methods such as conservation tillage, which can also increase the organic carbon content in soils. However, more work needs to be done where land classified as "highly erodible" is still being farmed for corn.

Soil compaction, which can lead to rainwater running off rather than percolating into the soil and groundwater, is also a problem on many large corn farms because corn cultivation is largely mechanized. This is particularly a concern in water-stressed growing regions. Soil health may also be damaged along with future yields where corn is over-fertilized and the crop is not rotated (e.g., in China).[36]

5. GENETICALLY MODIFIED SEEDS ARE LINKED TO HIGHER HERBICIDE USE AND CONSUMER CONCERNS

Most of the corn planted in the U.S. is genetically modified so that it is herbicide-tolerant (e.g., Roundup Ready corn) or insect-resistant (e.g., Bt corn).[37] While widespread adoption of genetically modified crops has decreased the use of insecticides, as weeds have become more resistant, there has been an increased use of weed-killing herbicides. In large doses, these herbicides can harm biodiversity and increase water and air pollution.[38]

Moreover, a number of civil society organizations that are concerned about human health and environmental impacts are raising awareness about the use of genetically modified organisms (GMOs) and promoting product labeling. Potential reputational risk may develop for companies that cater to consumers and suppliers within their supply chain. A market risk may also exist if substitution of non-GMO product is demanded.

6. USE OF CORN FOR FUEL AND FEED CONTRIBUTE TO FOOD SECURITY CONCERNS

A consistent criticism of corn production, particularly in the U.S., is that too little of the crop is used to actually feed people. While feeding animals corn does produce important sources of food, many calories and protein are lost along the way. Beef is particularly inefficient, converting just 1 percent of gross animal feed energy into food for people.[39] Yet, a substantial amount of land, natural resources and taxpayer dollars are devoted to the current U.S. corn production system. Various stakeholders in the U.S. are proposing changes to policies and practices, including altering crop subsidy programs, diversifying crop production and increasing the use of farming practices such as conservation tillage.[40]

U.S. SPOTLIGHT

Corn is the most widely grown feed grain in the U.S., with more than 90 million acres of land planted with corn.[41] One-third of U.S. cropland in 2014 was used to grow corn (which is typically grown in rotation with soybeans). This is an area greater than the equivalent to two Floridas.[42] While corn is grown in nearly all fifty states, most production is in the North and Midwest—an area collectively known as the U.S. Corn Belt.[43] Four states account for half of corn grain produced: Illinois, Iowa, Minnesota and Nebraska.[44]

Total corn production doubled between 1980 and 2011, while yield (bushels per planted acre) rose by 64 percent.[45] This increase in production has had significant environmental impacts. Even though corn production in the U.S. became more efficient across five indicators tracked on a "per bushel" basis, total resource use increased in four of those areas because of the significant increase in total production.[46]

- *Land use (+21 percent)*
- *Irrigation water applied (+27 percent)*
- *Energy use (+14 percent)*
- *Greenhouse gas emissions (+31 percent)*

Only soil erosion decreased by 31 percent, though more recent trends indicate a slight increase.

OPPORTUNITIES FOR ACTION

Investors can encourage companies to take the following actions to reduce business risks.

1. JOIN MULTI-STAKEHOLDER SUSTAINABILITY EFFORTS

Many players, including buyers, producers, governments, NGOs and communities understand the risks at play and are collaborating to ensure the long-term sustainability of corn production. Investors should encourage companies to join these multi-stakeholder efforts to demonstrate commitment and help accelerate progress. When a company is already involved in such efforts, investors should encourage constructive participation and progress in meeting commitments.

Many of the issues affecting corn production affect other commodities as well. Multi-stakeholder efforts that address corn as well as other commodities include:

TRACEABILITY CHALLENGES

Being able to trace corn to the farms where it is grown is difficult in many supply chains because corn from a number of individual farmers is typically combined in a common silo. However, grain suppliers can often trace crops to a general sourcing region that is near their elevators or mills.

- **Field to Market Fieldprint Projects**
  Field to Market: The Alliance for Sustainable Agriculture works in the U.S. with grower groups, retailers and other supply chain businesses, along with civil society, academia and public sector partners to promote continuous improvement in row-crop production practices using an outcomes-based approach. Projects in the U.S. are collecting data on several key science-based indicators, with supply chain members providing support for continuous improvement efforts by growers. Its Supply Chain Sustainability Program enables companies to benchmark sustainability performance, catalyze continuous improvement and measure and report out on progress against environmental goals.

- **Midwest Row Crop Collaborative**
  Announced in 2016, this coalition of companies (Cargill, General Mills, Kellogg Company, Monsanto, PepsiCo and Walmart) and conservation groups (Environmental Defense Fund, The Nature Conservancy and World Wildlife Fund) is focused on supporting and accelerating sustainable solutions that address various environmental impacts from farming. The coalition will focus on three states: Illinois, Iowa and Nebraska, which produce nearly 44 percent of corn, soy and wheat. This region also sends 422 million kilogram/year of nitrogen downstream, which ultimately contributes to the annual Gulf of Mexico dead zone.[47]

- **Adapt Network**
  This collaboration of land grant university experts, farm advisors and NGOs works with farmers to help them fine-tune fertilizer application and use nutrients more efficiently.[48]

2. ENGAGE DIRECTLY WITH PRODUCERS

Where companies have visibility into their supply chains, they can work with suppliers and supporting industries (e.g., farm equipment, soil amendment or irrigation companies) to promote better management practices. Given the vast differences in farm size, soil types, local climates, water resources and farming systems among corn growers, there is no one-size-fits-all prescription that works. Still, many proven practices and relatively low-cost technologies can be used. For instance, companies are providing incentives or developing joint projects with U.S. corn producers to promote conservation tillage, cover crops and appropriate application of agrochemicals.

For example, Smithfield, Campbell Soup Company, Unilever and General Mills are collaborating upstream with United Suppliers (a cooperative of agricultural retailers that is part of Land O'Lakes) to give growers access to a platform called SUSTAIN. The platform provides field-tested products, technologies and agronomic practices for improving nutrient use efficiency, soil health and productivity.

Adopting different farming practices does more than just address impacts, such as reducing field runoff and greenhouse gas emissions. It also provides benefits to farmers, including increasing their resilience to drought and floods and improving fertilizer use efficiency. Ceres' *Water and Climate Risks Facing Corn Production* maps out a range of practices and their economic and environmental benefits being implemented in the U.S.

3. SUPPORT GOVERNMENT POLICIES

Companies can support sustainability policies in producer countries. In the U.S., for example, this includes promoting and funding voluntary conservation programs, crop subsidy programs and crop insurance that promote more sustainable practices.

4. ENCOURAGE USE AND DEVELOPMENT OF SUSTAINABILITY STANDARDS

There are few third-party standards exclusively for corn production; however, some global standards for multiple commodities apply to corn. These include organic standards,[49] the Non-GMO Project Standard and where corn is used as a biofuel feedstock, the International Sustainability and Carbon Certification (ISCC) and the Roundtable on Sustainable Biomaterials (RSB).

Ceres has not evaluated the robustness and effectiveness of these standards but is providing them as options to consider. Ideally, standards are comprehensive and focus on measuring improvements across environmental and social issues.

COMPANIES IN ACTION

- General Mills' stated goal is to sustainably source 100 percent of its 10 priority ingredients by 2020, including dry milled corn. In 2014, the company launched a Field to Market pilot program targeting 20 eastern Wisconsin corn growers with the aim to reduce greenhouse gas emissions and nutrient utilization, while increasing biodiversity. [50]
- The Coca-Cola Company committed to sustainably sourcing by 2020 all its key agricultural ingredients, including the corn that goes into its high-fructose corn syrup.[51] By 2020, it aims to engage farmers that collectively represent up to 1 million acres, or roughly 50 percent of the company's global corn supply, in implementing this commitment.[52]
- For over five years, Kellogg Company along with its leading corn supplier, Bunge Milling, and The Nature Conservancy have been working with farmers in Nebraska to implement best management practices, track farm-level and watershed outcomes, and measure continuous improvement of on-farm practices using Field to Market metrics. In 2014, efforts to improve water use efficiency were expanded to include corn growers in Illinois, Indiana and Kansas.[53]
- Smithfield—as a pork producer—purchases large quantities of animal feed containing corn, and has set a goal to have 75 percent of its Southeast grain-sourcing acres participate in a fertilizer optimization and soil health program by 2018.[54]

ADDITIONAL RESOURCES

- The U.S. Department of Agriculture conducts research on multiple commodities, including corn. This includes data on production and consumption, prices and trade and is published through the Economic Research Service, Foreign Agricultural Service, and National Agricultural Statistics Service.
- The Sustainability Consortium offers high-level insights and analysis about potential risks and opportunities across a number of commodities, including corn.
- The *Plowprint Report* (2016) by World Wildlife Fund tracks year-to-year grassland conversion to cropland across the focal regions of the Mississippi River Basin and Great Plains.
- *Water & Climate Risks Facing U.S. Corn Production* (2014) by Ceres provides data and interactive maps on the issues facing U.S. corn production, as well as detailed recommendations for how corn-buying companies and their investors can catalyze more sustainable agricultural practices that will reduce risk, preserve and enhance yields, and protect precious water resources.
- *It's Time to Rethink America's Corn System* (2013) by Jonathan Foley, director of the Institute on the Environment at the University of Minnesota, offers a view of challenges with the current corn farming system and possible alternatives.
- Climate and Corn-Based Cropping Systems Coordinated Agricultural Project, a collaborative project among 10 Midwest land grant universities and a USDA agricultural research service, is focused on farm management practices and their potential for making corn-based agriculture more resilient.
- *Greater Sensitivity to Drought Accompanies Maize Yield Increase in the U.S. Midwest* (2014), published in *Science* magazine examines corn's increasing sensitivity to drought conditions.

Engage the Chain offers briefs on seven other key commodities, a compelling case for sustainable agriculture and opportunities for action that cut across all types of agricultural commodities.

ENDNOTES

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21 *Note: Although irrigated production accounts for about 21 percent of all corn bushels harvested, corn uses the most irrigation water of all U.S. crops, consuming a total of 15.4 million acre-feet in 2008, or 17 percent of all water used in the country for agricultural irrigation. On a per acre basis, however, corn production is relatively water-efficient compared to crops such as rice and alfalfa, with corn farmers applying on average 1.2 acre-feet of water per acre in 2008 for corn grain and silage production combined.* Ceres, "Water & Climate Risks Facing U.S. Corn Production", June 2014, Page 34, https://www.ceres.org/issues/water/agriculture/the-cost-of-corn

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March 2017