Cargill - highest GHG's per bushel of corn

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Tue 1/21/2020 9:44 AM
To: Alexandra Heal <alexandraheal@tbij.com>
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1 attachments (4 MB)
CORN TRACING PAPER UMINN SCHMIT.pdf;

See attached study.

Also, thought you would be interested in this report overlaying for the first time meat and feed companies in the US with where water pollution and destruction of native prairies is happening:

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Cheers,

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Subnational mobility and consumption-based environmental accounting of US corn in animal protein and ethanol supply chains

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Corn production, and its associated inputs, is a relatively large source of greenhouse gas emissions and uses significant amounts of water and land, thus contributing to climate change, fossil fuel depletion, local air pollutants, and local water scarcity. As large consumers of this corn, corporations in the ethanol and animal protein industries are increasingly assessing and reporting sustainability impacts across their supply chains to identify, prioritize, and communicate sustainability risks and opportunities material to their operations. In doing so, many have discovered that the direct impacts of their owned operations are dwarfed by those upstream in the supply chain, requiring transparency and knowledge about environmental impacts along the supply chains. Life cycle assessments (LCAs) have been used to identify hotspots of environmental impacts at national levels, yet these provide little subnational information necessary for guiding firms' specific supply networks. In this paper, our Food System Supply-Chain Sustainability (FoodS^3) model connects spatial, firm-specific demand of corn purchasers with upstream corn production in the United States through a cost minimization transport model. This provides a means to link county-level corn production in the United States to firm-specific demand locations associated with downstream processing facilities. Our model substantially improves current LCA assessment efforts that are confined to broad national or state level impacts. In drilling down to subnational levels of environmental impacts that occur over heterogeneous areas and aggregating these landscape impacts by specific supply networks, targeted opportunities for improvements to the sustainability performance of supply chains are identified.

supply chains | environmental accounting | commodity flow modeling | food systems sustainability | life cycle assessment

One of the most pressing challenges facing society, globally, is how to meet the growing demand for food, fuel, and fiber in the face of climate change while sustaining ecosystem services. Broad scientific and practitioner agreement exists around the impact of food systems on local and global sustainability (1, 2). Food consumption contributes between 15% and 28% to total greenhouse gas emissions of developed countries (3). Agriculture uses 70–80% of global water withdrawals; it is a dominant cause of biodiversity loss; and the dramatic growth in its use of fertilizers has disrupted global nitrogen and phosphorus cycles, impacting water quality, aquatic ecosystems, and marine fisheries (4–7). Food supply chains are also among the highest energy users, with food-related energy use responsible for nearly 16% of the total US energy budget (8).

Appreciation of the environmental burdens of food production often emphasize the disproportionate role of livestock (9–17)—the 20 billion animals in global production graze on 30% of the world's terrestrial land area, consume one-third of global cropland production in feed, and account for 32% of total global freshwater consumption (18, 19). As an economic activity, livestock contributes up to 50% of global agricultural gross domestic product (20). Animal agriculture is also a major contributor of consumptive impacts. From a US dietary perspective, protein and dairy consumption represent nearly three-fourths (73%) of total annual per capita greenhouse gas (GHG) emissions of food (21). To combat these challenges, governments and voluntary initiatives have focused largely on the bookends of the food system—environmental and social impacts of high-input commercial agriculture on one end, and availability and access to healthy, affordable calories on the other. However, efforts toward improved coordination across food supply networks—e.g., among producers, processors, distributors, and retailers—occur amid severe informational deficits (22).

Although environmental impacts associated with food systems are relatively well quantified—particularly regarding carbon emissions and water impacts—most of this work has been conducted at spatial scales inconsistent with broad-reaching value chains, driven by national or subnational geopolitical boundaries, or field studies within specified biophysical and ecosystem boundaries (23–27). Numerous life cycle assessment (LCA) approaches have been carried out on food production chains, with the majority of these focused on GHG emissions (21, 23, 25, 26, 28–31). Recent research has expanded this approach to incorporate aspects of water quantity and quality, land use change, and biodiversity loss (32, 33). Although instructive, these approaches have largely been restricted in coverage to specific farm

Significance

Companies and society alike are increasingly concerned with environmental impacts across complex supply chains. Suppliers engaged in upstream intermediate transactions commonly contribute over 75% of the carbon and water impacts of products ultimately consumed by users. These impacts pose risks to downstream customer-facing companies in the form of firm image, supply disruptions, and regulatory action. Policymakers and nonprofit advocacy organizations are increasingly looking to engage actors across supply chains to encourage conservation and environmental impact reduction. Unfortunately, traceability across complex, heterogeneous supply hinders these efforts. We provide a method for estimating mobility of corn from farms through feed and fuel supply chains, making it possible to characterize the variable environmental impacts of US corn inputs into animal protein and ethanol production.

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processes, and often rely on coarse national inventory data and impact characterization factors (23–25, 29). Because of variation due to geography, year-to-year fluctuations in agricultural production environments and differences in farm management practices, current LCAs are unlikely to represent subnational production regions, let alone the numerous production locations that supply a particular value chain (26, 34–37).

At the country level, and more recently at subnational scales, consumption-based environmental accounting and footprinting approaches have been suggested. In contrast to the method of accounting for the territorial emissions of a nation in the Kyoto Protocol (also called producer responsibility), other concepts have been proposed that hold the consumer of goods and services responsible for the emissions that are caused during their production (consumer responsibility) (38, 39).

We connect the concepts of consumer and producer responsibility through a spatially explicit environmental impact analysis of the US corn supply chain. Environmental indicators are estimated for corn production at the county level, and using an optimization model, we simulate the subnational mobility of corn from production to primary use and then to final processing facilities. The model spatially links the supply chain of end-use company and facility-level buyers of corn-intensive products with corn production locations, and their associated environmental impacts. By linking the movement of corn from farms to final processing facilities of animal protein and fuel products, we make it possible to characterize spatially explicit environmental impacts associated with company-specific, corn-intensive product supply chains and locations.

This model substantially improves organizational LCA efforts, which currently are based on broad national or state level impacts over heterogeneous areas that may or may not accurately represent the specifics of a particular supply chain (40, 41). Understanding the spatial differences in environmental impacts of current corn farming practices is necessary to develop a baseline environmental profile for a facility or company supply chain, and to identify opportunities for improvements in management practices to increase the sustainability of supply chains. The spatially explicit supply chain information developed in this paper helps inform corporate-level sustainability investments (41); sector-level environmental product declarations and certification initiatives; and governmental policymakers and regulators assessing the distribution of benefits and costs across geographies and markets.

To demonstrate the variability of environmental impacts within sector-, company-, and facility-specific supply chains—i.e., subnational commodity-flow information detailing the trade of goods throughout upstream supply chain stages—we estimated the greenhouse-gas emissions [i.e., global warming potential (GWP)] and irrigated (blue) water consumption (i.e., water use) of corn production for each county in the contiguous United States. Due to the significant overall contributions from the agricultural industry and, in particular, corn production, these impact categories are important environmental metrics for agricultural producers and consumers, and are among the few impact categories that corporations and nongovernmental organizations have set targets to manage.

Methods

We estimate US corn mobility—first as a primary commodity, then as an embedded input (e.g., upstream corn consumed in intermediate animal agriculture operations)—from on-field crop production through the supply chain to primary processing (e.g., animal slaughter). We separate the supply chain into two broad stages. Stage 1 encompasses the movement of corn from the county of production to the county of direct consumption, and includes the entire supply and demand of corn. Consumption includes corn processed into ethanol and distiller's dried grains with solubles (DDGS), consumed as animal feed (corn and DDGS), exported to international markets, and processed for other uses such as in wet mills. Stage 2 incorporates the movement of animals—with embedded corn from feed—from animal farms and feedlots to final processing facilities. These approaches are presented as an integrative Food System Supply-Chain Sustainability (FoodS^3) model (see www.foods3.org for more information). FoodS^3, as described below, includes a data accounting component, a spatially explicit environmental impact LCA, and a transportation optimization component. The data accounting component estimates the supply and demand of corn at the county level in stage 1, and the supply of animals on farms at the county level and the demand for animals for each individual processing facility in stage 2. The LCA component estimates the environmental impacts of corn production in each county. Last, the transportation optimization solves the system by connecting suppliers and demanders in stages 1 and 2. The result is a link between the processing facilities of animals and ethanol and the locations and environmental impacts of the corn supplied.

Corn Data Accounting.

Stage 1: US corn supply and demand. In stage 1 of FoodS^3, the supply of, and demand for, corn is estimated at the county level for years 2007 and 2012. The years were chosen based on the available data in the two most recent Census of Agriculture (COA) reports from the US Department of Agriculture (USDA) (42, 43). Given that the year 2012 is the most recent data available in the COA, the primary focus of our results is on that year. However, US corn yields in 2012 were substantially below the average of the last 10 y, so we also include an analysis of 2007 data to verify the magnitude of the difference in movement of corn in these 2 y. We show, in Fig. 1, that there is substantially similar interstate movement of corn between the 2 y, suggesting that even in a low-yield environment there are rigid aspects to supply chains. However, for the hardest-hit regions in 2012, the environmental impacts of corn production (on a per bushel basis) were substantially higher than other years. This does not represent a trend of increasing impacts over time; rather, higher yields in recent years suggest greater efficiencies that translate into improved per unit environmental performance. Our values are meant to represent spatial differences in impacts, which may change year to year.

To estimate US county-level supply and demand, we used a top-down approach, taking national accounts of corn supply and demand by category, and then allocating each category's national total to the county level. To ensure internal consistency between supply and demand, we used a single national dataset of corn production and consumption from the Economic Research Service (ERS) of the USDA (44). COA data were used to allocate total national corn production and demand for corn as animal feed to the county level, whereas corn demand for other key categories were allocated to the county level using data from the USDA Federal Grain Inspection Service for corn exports, and the Renewable Fuels Association for ethanol (45, 46). (*Stage 1: Corn Supply and Demand Data Accounting* describes in detail the supply and demand data accounting methodology.)

The animal feed market includes an important coproduct from the corn ethanol production process: DDGS. DDGS are a large component of many animals' diets, and are a key component in the corn supply chain. FoodS^3 incorporated DDGS as a separate set of supply and demand interactions in stage 1. We account for DDGS in terms of corn equivalents, or embedded corn, from corn ethanol production. A portion of the corn consumed in an ethanol facility is allocated to ethanol and the remaining to DDGS. Although several allocation methods exist, we used the relative energy content of ethanol and DDGS to allocate impacts. This is the method advocated for by the EPA under the Renewable Fuels Standard because both ethanol and DDGS are used for their energy in respective fuel and feed applications (47). The percentage of the total energy in the ethanol facility outputs contained in the DDGS is estimated to be 40.1%.

Stage 2: Embedded corn in animals. Stage 2 of FoodS^3 connects the embedded corn in the animals as feed—from consumption of corn and DDGS—to the facilities that provide primary processing of the animals. We restricted stage 2 of FoodS^3 to the three major animal protein sectors: beef, pork, and broiler chickens. Data for stage 2 account for the supply of animals on farms and feedlots to meet the demand for animals in processing facilities.

Environmental Impact LCA. By linking the movement of corn from regions of production to downstream animal processing facilities, it is possible to characterize spatially explicit environmental impacts of animal protein supply chains. Many environmental indicators could be evaluated with this methodology. We examine GHG emissions—as CO_2 equivalents (CO_2e)—and irrigated (blue) water consumption of corn production for each county in the continental United States, using a streamlined hotspot approach as an illustration of the method's application (48–50). Given the transaction orientation of a

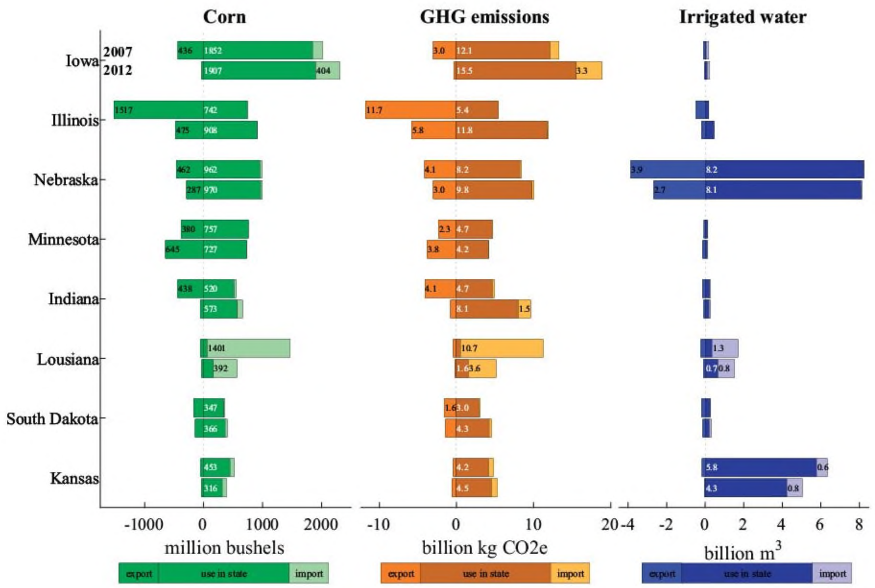

Fig. 1. State-level estimates of interstate corn trade, and consumption-based GHG and irrigated water use accounting. Note that negative values indicate exports (physical quantities and impacts) out of state. Upper bars for each state represent 2007 estimates, and lower bars represent 2012.

supply chain approach, the unit of analysis is the environmental impacts per bushel of corn produced and consumed.

GHG emissions. To represent total GHG emissions associated with the material and energy inputs and outputs of corn production, the Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) model was used (51). The GREET model represents US average corn production processes and impact factors, which are used to calculate the life cycle GHG emissions of producing a bushel of corn. A primary contributor, or hotspot, to the generation of corn production GHG emissions is the application of nitrogen fertilizer inputs, which accounts for more than 70% of total average corn GHGs, and includes the emissions associated with production and use of nitrogen fertilizers (51). Nitrogen fertilizer management practices also significantly fluctuate between locations in terms of application rates and types of nitrogen fertilizers applied. Due to the large share of total corn GHG emissions associated with nitrogen fertilizers, and spatial differences in fertilizer management practices, we replaced national average nitrogen inputs in the GREET model with inputs parameterized for each county based on the specific mix of nitrogen fertilizer types used and the state-level nitrogen fertilizer application rates per acre of corn planted.

Irrigated water use also exhibit large spatial variations. To account for the spatial variability in the GHG emissions associated with irrigation, we apply county-specific irrigation water quantities to the GREET electricity emission factor for irrigation. The GHG emissions from electricity used for irrigation are small, but in states with intensive irrigation, these emissions are a substantial fraction of the total. (*Environmental Impact LCA* has a detailed description of GHG emission estimate methodology, and Table S1 includes an emissions inventory.)

Blue water consumption. The agricultural industry is the largest user of water in the United States (52). Irrigation practices are the primary driver of anthropogenic water use decisions, and these vary by production location. To incorporate water use implications from corn production, we applied blue irrigation water use (i.e., water originating from surface and ground water sources) data from the Global Crop Water Model, which estimated water use for 1998–2002 at a scale of 0.5 degrees (53). We used 1998–2002 average county-level irrigated acres and county-level volume (m^3) to estimate average cubic meters of irrigated water used per acre. This rate was applied to the 2007 and 2012 irrigated corn acres obtained from the COA to estimate total water used to irrigate corn produced in each county.

Corn Mobility in the United States. Some corn moves a long distance, because local corn production cannot often meet local demand (54, 55). Despite the substantial availability of agricultural data in the United States, information associated with particular commodity mobility, including corn, at subnational levels is scarce (56, 57). To address this deficiency, we developed a two-stage spatial cost minimization model to estimate corn mobility. Specifically, stage 1 estimates county-level supply networks meeting primary corn demand (ethanol, animal feed, exports, etc.). Stage 2 estimates embedded corn mobility associated with animal transportation from counties of production to processing facilities. We model the optimal allocation in both stages 1 and 2 to minimize the system's transportation costs. Costs were based on existing transport lines, using railways and roads for corn movement and roads for animal movement. (*Corn Mobility Optimization Model* has a detailed description of the transportation model.)

To our knowledge, no publicly available data exist that report or estimate the movement of corn from county to county. At the state level, the Freight Analysis Framework Version 4 (FAF4) produced by Oak Ridge National Laboratory, has survey responses of the movement of animal feed from origin to destination (56). To validate the results of FoodS^3, we compare the combined quantity of corn and DDGS that we estimate are transported from state to state for use as animal feed to the survey results from FAF4 for 2012. The FAF4 data are an imperfect comparison with our model because it includes several additional categories of feed, which may explain some of the difference in the results. On average, corn and DDGS for animal feed travels 334 miles in FoodS^3, and all animal feeds travel, on average, 285 miles in the FAF4 survey. (*Stage 1: Corn Mobility from County of Production to County of Primary Demand* includes a comparison of state-to-state movement of animal feed between FoodS^3 and FAF4.)

Results

Environmental Indicators. Spatial variability associated with estimated GHG emissions and water use intensity of a bushel of corn produced across the United States in 2007 and 2012 is presented in Fig. 2. Our estimates reflect variability of key hotspot fertilization (for GHG emissions) and irrigation processes (for water use and GHG emissions) currently implemented across the US corn production system as well as spatial variation in corn yield outputs, which together drive the differences in intensity estimates. Results suggest that despite year-over-year changes in agricultural output, the underlying trends associated with production, consumption, and environmental consequences remained relatively stable between 2007 and 2012.

The substantial heterogeneity of corn production impacts is illustrated in Fig. 2 where, for example, GHG emissions associated with a bushel of corn produced in western South Dakota is estimated to be 3–4 times more carbon intensive than a similar bushel of corn produced in southern Minnesota (21 kg CO$_2$e per bushel vs. 6 kg CO$_2$e per bushel). Without estimating the subnational variation of environmental impacts, we would have only a single national estimate of GHG impacts for each bushel of corn of 9.9 kg CO$_2$e. In addition to spatial variation in GHG emissions, our results are also sensitive across growing years. For

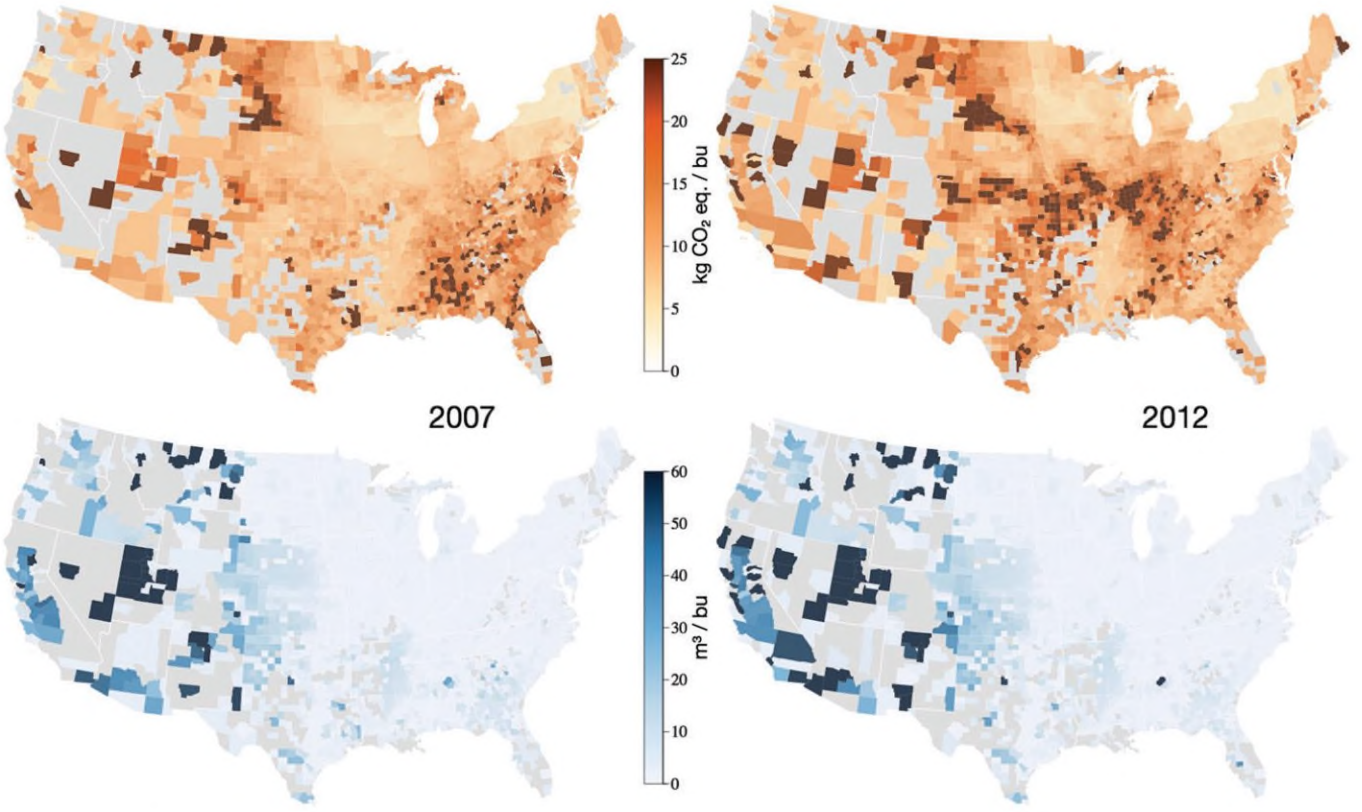

Fig. 2. Spatial and temporal variation of GHG emissions and irrigated (blue) water use intensity of US corn production.

example, drought conditions in 2012, most severely impacting the central region of the United States, are reflected in the high estimates of GHG emissions per bushel of corn produced in these regions. Compared with 2007, corn yields in Kansas, Missouri, Illinois, and Indiana, in particular, were significantly lower in 2012—~31%, 46%, 40%, and 36% lower, respectively. As such, the impact intensities of a bushel of corn produced in these areas were estimated to be significantly higher in 2012 because relatively fixed inputs (e.g., fertilizer application, farm equipment emissions, etc.) were allocated across fewer harvested bushels of corn—corn yields in 2012 were a significant outlier to the trend of increasing yields over time. The source of the spatial heterogeneity in GHG emissions per bushel is largely from the differences in yield, whereas the differences in nitrogen fertilizer type and application rate provide important, but less variability.

Irrigated water used in corn production also varied significantly across the United States. In 2012, 86% of US corn acres were not irrigated. The nonirrigating counties are largely in the Corn Belt and east into the Ohio River Valley. The largest users of water tend to be in the western plains region and the few corn producing counties in the West. Western Kansas and Nebraska tended to rely heavily on irrigation—as high as 28 m^3 per bushel—and Minnesota, Iowa, Illinois, and Indiana used very little irrigation—97.5% of corn acres in these states did not use irrigation. Our results of irrigation water intensity were much less sensitive to changes in yield from 2007 to 2012. This was largely due to the regions most impacted by the 2012 drought tending not to have irrigation equipment installed and being therefore unable to respond to the drought by irrigating their fields. GHG emissions associated with irrigation average 4% of total corn production emissions, with large variability between states. In Iowa, 0.1% of total emissions are related to irrigation, whereas in Nebraska and Kansas, irrigation emissions are 14% of the total, suggesting the potential for irrigation to be a hotspot in certain production locations.

Stage 1: Corn Mobility and Environmental Impacts. Results of our stage 1 corn mobility model are presented in Fig. 1 for years 2007 and 2012, showing the interstate transportation of corn and the associated environmental impacts. From a consumption-based environmental accounting perspective, each of the states illustrated played an important role in the US corn system, in that they produced or used substantial quantities of corn and/or high-intensity corn: Iowa is a dominant state in the corn system, producing and consuming largely nonirrigated corn; Illinois and Indiana are typically high CO$_2$e intensity producing states with significant exports; Nebraska is a high-producing, exporting state of irrigated corn; and Minnesota is a high-producing, exporting state of low CO$_2$e intensity, nonirrigated corn.

Iowa was the largest producing and consuming state in the United States—producing 1.9 billion bushels and importing another 400 million bushels from other states in 2012. Exports to other states from Iowa are estimated at less than 2% in 2012, but were nearly 19% of production in 2007, due to stronger relative production in 2007 and greater ethanol demand in 2012. Total GHG emissions associated with Iowa's production and imports were the highest in the country—19 billion kg CO$_2$e from the total quantity of corn consumed in the state in 2012—whereas irrigated water use was minimal at 0.2 billion m^3.

In contrast, Minnesota, Nebraska, and Illinois were major producers of corn, but their consumption is roughly half that of Iowa's, and their embedded CO$_2$e and irrigated water varied significantly. In 2007 and 2012, these three states exported 42% of their corn production, but growing conditions significantly shifted the share of exports across years—for example, Illinois exported 67% of production in 2007 and 34% in 2012. As a result, these three states also exported a significant share of their CO$_2$e impacts—18.2 and 12.6 billion kg in 2007 and 2012, respectively. Nebraska's corn production was water intensive, using 12.1 and 10.8 billion m^3 of water in 2007 and 2012—exporting 32% and 25% of irrigated

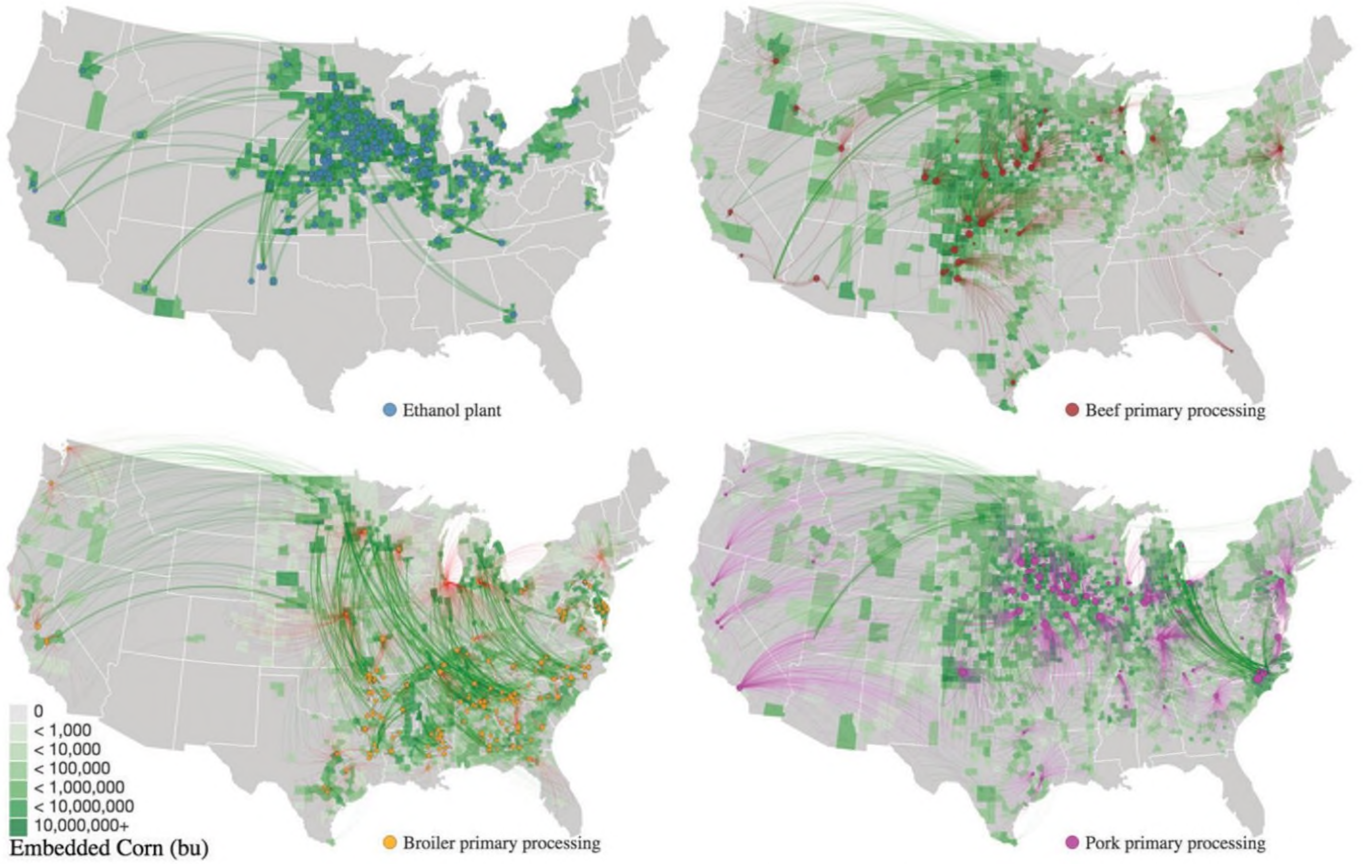

Fig. 3. The 2012 sector-level corn supply chain connections. Link between corn production and downstream demand: ethanol (stage 1 only) and animal protein processing facilities (embedded corn from stages 1 and 2). Dots represent the location and processing capacity of facilities in each sector. The shaded regions identify the location of quantity of corn sourced for each sector.

water use each year, respectively. Louisiana's large imports of corn across the United States were primarily for international export from the Port of South Louisiana.

Across the United States, we estimate that 75% of corn was consumed in the state of production for 2012, an increase from 63% in 2007. On average, corn traveled ∼220 miles from the county of production to the county of primary demand in 2012. Corn exported across state lines often traveled much greater distances—e.g., corn exports from North Dakota traveled 1,700 miles, on average. The distance corn traveled for imports varied substantially by state. Iowa's largest interstate trade partners are the neighboring corn-belt states of Illinois and Minnesota, and these imports traveled an average of only 44 miles. Imports to North Carolina, however, traveled over 900 miles, primarily from Michigan and Ohio.

Stage 2: Embedded Corn Mobility and Supply Chain Impacts. For stage 2 of the model we display the results only for the 2012 data environment. Fig. 3 illustrates the network of facilities associated with the key downstream sectors of ethanol production and animal protein processing. From each facility, the colored arcs display counties from which animals are estimated to be sourced, and green arcs depict where embedded corn is estimated to be sourced.

As commodities are produced farther from consumption, delivered prices increase, reflecting higher transport costs. In the optimization, minimizing transportation costs of corn, some corn will likely travel large distances—often shipped across the county—given the regional differences in corn production and demand. Regional differences in corn sourcing from the FoodS^3 model, presented in Fig. 3, reflect the structural spatial differences of corn supply and demand. Corn embedded in ethanol is relatively tightly sourced from the Midwest production regions, whereas beef supply chains tend to be more dependent on corn produced in the western plains of the United States. Broilers are thought to be more dependent on corn production from the Southeast, and pork's corn supply is dominated by Midwestern and north-central production.

Our FoodS^3 model estimates that corn for ethanol travels, on average, 90 miles from the farm to the facility, whereas corn for animal feed traveled much longer distances—corn for pigs, cattle, and broilers travels, on average, 160, 240, and over 500 miles, respectively. Minnesota, unintuitively, was the largest source of corn for broilers, despite producing less than 1% of US broilers, helping to explain the long distance corn traveled to meet broiler corn demand. Stage 2 of our model estimates the distance animals on farms or feedlots travels to processing facilities. We estimate broilers travel the shortest distance, 48 miles, on average, whereas pigs and cattle for beef travel ∼115 miles. These animal distances fall within the range of travel distances found in the literature. For small livestock operations (representing 40% of total US farms), the 25th to 75th percentile range for poultry (12–60 miles) and pigs (25–180 miles) encompass our modeled results (58). The 25th to 75th percentile range for cattle was below our average at 15–40 miles; however, another study of 21 large feedlots found that cattle travel an average of 434 miles (59).

Collectively, the four sectors examined account for the majority (59%) of 2012 corn used in the United States. After allocating the US corn embedded in DDGS, ethanol consumed 25%, pork consumed 12%, beef consumed 14%, and broilers

Table 1. Estimated 2012 corn supply chain CO_2e and irrigated water use for ethanol and animal protein sectors and large downstream companies

Corn consumers	Corn, million bushels	CO_2e, million kg	Irrigated water, million m^3	CO_2e, kg/bushel	Irrigated water, m^3/bushel
Sectors					
Ethanol	2,780	27,029	5,877	9.72	2.1
Beef	1,565	15,710	10,871	10.04	7.0
Pork	1,354	13,799	2,147	10.19	1.6
Broilers	854	8,240	2,076	9.65	2.4
Companies					
Tyson*,†,‡	907	8,498	3,379	9.4	3.7
JBS*,†,‡	686	6,551	3,156	9.6	4.6
Cargill*,†,§	534	6,197	3,061	11.6	5.7
ADM§	361	3,390	529	9.4	1.5
Smithfield†	352	3,593	459	10.2	1.3
POET§	327	3,504	79	10.7	0.2
Valero§	249	2,352	230	9.4	0.9
Green Plains§	202	1,929	711	9.6	3.5
National Beef*	178	1,848	2,085	10.4	11.7
Flint Hills§	153	1,232	208	8.1	1.4
Hormel†	121	1,038	144	8.6	1.2
US total	11,082	109,489	30,684	9.9	2.8

*Beef processor; †pork processor; ‡broiler processor; §produces ethanol.

consumed 8% of corn. CO_2e emissions and irrigation water embedded in the supply chains of these four sectors accounted for 59% of corn system emissions and 68% of corn system's use of irrigation water.

Table 1 provides a consumption-based accounting summary of GHG emissions and irrigation water use for each of the major downstream sectors examined. GHG emissions per bushel of corn consumed are highest for the pork industry, but differences across sectors are small. This suggests that the substantial variability in CO_2e emissions per bushel of corn grown across counties (illustrated in Fig. 2) tends to balance out when summarized at the sector level. Irrigated water use at the sector level, however, varies substantially. Corn for beef production is substantially more water-intensive than the other major sectors—four and a half times greater than corn for pork production. These differences are largely explained by beef sourcing nearly half its corn from the high-irrigating states of Nebraska, Kansas, and Texas, whereas pork sourced a majority of its corn from Iowa, Minnesota, and Illinois.

Table 1 also displays the environmental impacts of corn sourced by each company in the ethanol and animal protein sectors that consumed more than 100 million bushels of corn in 2012. Although results are based on commodity mobility simulations, and do not necessarily reflect actual sourcing locations and supply networks, the $FoodS^3$ model can help identify locations and the related environmental impacts that are more likely to be associated with company-specific supply chains based on the heuristic of minimizing economic costs.

The 11 largest corn-sourcing companies listed accounted for 37% of total US corn consumption in 2012. Compared with sector averages, GHG emission intensity of corn consumption across companies is substantial—ranging from as low as 8.1 kg CO_2e per bushel for Flint Hills (who, we estimate, obtained 72% of their corn from the low-impact, high-yield corn in Iowa) to as high as 11.6 kg CO_2e per bushel associated with Cargill's corn inputs (where all three animal protein sectors were included, with their highest GHG impact from Illinois- and Kansas-sourced corn).

Irrigated water use intensity also exhibited greater variability among the top companies. The least-irrigated corn was used in ethanol production. For example, corn estimated to be sourced by POET biorefineries consumed only 0.2 m^3 of irrigated water per bushel—91% below the national average. Our model estimated that the largest irrigation water user per bushel of corn was National Beef Packing, sourcing three quarters of their corn inputs from Kansas and Nebraska and consuming more than four times the irrigated water per bushel than the national average.

Discussion

The approaches and results provided make two primary and significant contributions to the environmental accounting and footprinting literatures. Using publicly available production and consumption data, we develop a unique cost-minimization approach to approximate subnational mobility of US corn from production to major primary and secondary consumptive activities. Although we make several simplifying assumptions (e.g., supply and demand balance annually, costs minimized are restricted to regional commodity price and transport, operational limitations such as transport congestion or organizational and regional preferences are ignored, etc.), the findings provide a reasonably robust approximation of spatial supply networks for a key commodity input of significant environmental impact to downstream fuel and animal protein sectors.

Across the 2 y examined (2007 and 2012), our results suggest that the structural relationships of supply networks across subregions may be rigid, despite significant variability between production years. We hypothesize that the physical and natural capital requirements of production–consumption systems and long-term investments in transportation and capital infrastructure serve to lock in subregional supply relationships, leading to relatively stable supply chains across time and geographies. Future research is needed to further explore the robustness of estimated supply network relationships over time and its impact on food and energy systems' ability to adapt to changing climate, water stresses, or market shocks.

By linking geographically heterogeneous indicators of environmental impact to commodity supply chain networks, we expand upon the largely country-level approaches of environmental LCA and consumption-based accounting to subnational product and organizational supply chain scales. Importantly, this work contributes to the growing call for greater transparency and accountability of sustainability performance across diverse product supply chains. Using a hotspot approach, we have focused on key processes significantly contributing to geographic variability in environmental impacts—namely, fertilizer type and application rates, and irrigation water use. In each case, estimates of spatial variability are rarely reported on a production output basis—a critical metric for the assessment of supply chain consumption-based accounting. Perhaps more important is how these embedded indicators are aggregated through the consumption of downstream ethanol and animal protein supply chain actors, providing the transparency necessary to begin managing these impacts. Although it is often reported that US ethanol and animal protein products contain significant volumes of embedded corn, and that corn inputs are major drivers of these products' emissions and water use profiles, our findings illustrate significant variability across these broad-brushed heuristics, depending upon the location of sourced corn (25, 27, 60).

As with many other commodity inputs, consumed corn is pulled through complex supply chains. For example, beef processed and packed in the Texas panhandle likely sources its cattle from east Texas and Oklahoma. Our model's results suggest that feed for cattle in these regions is most cost-effectively sourced from local farmers, but these same cattle producers will also likely purchase corn feed from as far away as Nebraska and South Dakota. In addition, these cattle will likely consume significant amounts of corn produced in Iowa and Minnesota, indirectly, in the form of DDGS. In contrast, the same beef product processed in eastern Nebraska may source, directly and indirectly, very little corn from Nebraska due to significant local competition for corn from other sectors (e.g., ethanol, pork, etc.). Instead, the supply networks for a Nebraska beef processor are much more dependent on cattle and feed from the Dakotas and Minnesota. Managing sustainability performance and regulating environmental burdens require a more sophisticated understanding of the sources and uses of high-impact commodities through supply networks.

These results shift the unit of analysis from geographic footprinting at regional or national scales to a spatially explicit consumptive-based metric for complex supply networks. Although consumption-based accounting methods have made significant contributions in the footprinting literature—attributing embedded impacts based on global country-to-country trade relationships—the approaches described in this paper attribute subnational consumptive impacts at a geographic scale more closely aligned with the heterogeneity of environmental impacts across landscapes. Future research is required to improve commodity mobility models, advance sustainability indicator measures, and develop marginal characterization factors to better assess shifts in field management or procurement decisions. However, this research takes an important step toward estimating supply chain environmental impacts of a key commodity input. Expanded to include additional heterogeneous inputs across a production system, it could potentially reduce the occurrence of wildly disparate LCA study results currently observed in the literature.

From a public policy and managerial perspective, the results presented in this paper are important spatially explicit estimates of environmental and economic performance for a major US commodity embedded in downstream consumption. The implications of these data are numerous because they provide supply chain managers with critical information for intervention strategies addressing upstream impacts important to the environmental performance of their products. These impacts are often identified in strategic and stakeholder-engaged "materiality assessments" as high-priority aspects of corporate sustainability planning; however, information and operational constraints identifying and targeting specific opportunities is difficult (61). The FoodS^3 model allows downstream firms to address sustainability performance of key input commodities through two broad strategies. First, our results can assist firm efforts to target interventions and collaborations. A growing number of large food manufacturing firms have recently made commitments to work with farmers to reduce the use of fertilizers, water use, and transport emissions. Our results help these companies and their partners—often environmental nongovernmental organizations—identify where significant carbon and water risks occur within their supply chains and where efficient solutions might reside.

Second, downstream firms can use the FoodS^3 model to shift commodity sourcing strategies away from high-impact regions to lower-impact ones as a cost-effective way to improve their relative sustainability performance vis-à-vis competitors. It should be noted that this strategy may produce little or no environmental benefit to the overall corn production–consumption system in the short term. However, it does facilitate paths for future research to explore the economic effects of large-scale demand shifts away from high-impact cropping systems. Increased demand for corn from the most ecoefficient production regions may bolster prices, supporting increased investments in improved management practices (e.g., precision fertilizer application, drip irrigation, or the adoption of cover crops through financial or purchasing agreement mechanisms).

Although our model stops at processors who are mid-supply chain actors, it does allow decision-makers to aggregate consumption-based impacts across facility, business unit, enterprise, and geopolitical boundaries. This provides new information for public–private partnerships addressing environmental and economic development efforts. Specifically, results can assist companies and local policymakers when considering the closing or acquisition of production facilities. Incorporating indirect economic, CO_2e, and water impacts, policymakers may be able to leverage resources across multiple political jurisdictions in seeking to provide economic development incentives for new facilities in locations sourcing low-impact inputs. Similarly, far-reaching unintended consequences of aggressive economic development incentives currently made in areas of high-risk sourcing could potentially be avoided. Furthermore, the FoodS^3 modeling approach allows companies and local governments with aligning risk and opportunity profiles to explore innovative approaches toward improved ecoefficiency. For example, a large corn-producing state like Minnesota may find new opportunities to engage the broiler industry in developing conservation strategies, given that a large percentage of its corn production is used to feed broilers, even though very few broiler farms reside in that state.

Another important consideration for policy and decision-making is that our approach allows for improved environmental characterizations that link domestic and global production–consumption systems. The United States, along with central Europe and small portions of South America and Asia, are the only areas operating at close to 100% yield potential (62). Therefore, it may be that high-impact corn in the United States is low relative to other regions, and thus a decrease in US production of corn could lead to a global increase in impacts if corn production increases elsewhere.

Because the United States and world struggle to deal with environmental challenges, our model provides a starting point for reducing barriers to transparency within commodity supply chains. Our work improves upon the existing methods for consumption-based environmental footprinting and creates a new tool for decision-makers seeking to target interventions for environmental improvements within supply chains.

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Supporting Information

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Stage 1: Corn Supply and Demand Data Accounting

The corn allocation model begins at the scale of the United States, and works to finer scale where data are available, often at the county level. The goal of the model was to produce spatially explicit supply and demand of corn in the United States to understand the movement of corn from suppliers to demanders. To ensure internal consistency within the model between producers and demanders of corn, a single national dataset from the ERS of the USDA is used (44). The ERS feed grains database was used to account for both total supply and demand of corn in the United States, but also as a benchmark value that must be matched exactly for each category. For instance, the ERS database provides the total bushels of corn consumed as feed by pigs in the United States. In later stages in the model we require that the sum of corn consumed by pigs in each county equals this value, as opposed to calculating corn consumption based on feed requirement at pig farms. In this way, the national numbers from ERS are paramount and supersede county- or state-level data. We feel this reduces estimation error as the model is less dependent on the assumptions in and across sources, such as animal feed requirements in different regions. Our model allocates national totals of corn consumption based on a variety of methods and data that is described in the sections below.

ERS data consists of US totals for supply and demand for corn. The relative quantities of corn supply and demand by category are demonstrated in Fig. S1 by the area of the circles, and the arrows indicate subgroups that together combine to equal the whole group. Our model uses data for 2007 and 2012 to be consistent with the most recently available data containing county-specific information from the COA, which is required to obtain spatially explicit supply and demand (42, 43). Supply is separated into current year production, imports, and the change in carryover stocks. The total supply of 11.1 billion bushels of corn in 2012 was matched by the total demand—the sum of demand from several categories. We grouped corn demand into five categories: ethanol, feed, exports, wet mills, and other demand. The major focus for this analysis is corn used for ethanol production and feed for animals. Ethanol and feed use of corn comprise 42% and 39% of total demand, respectively, totaling 81% of total corn grain use. Although most corn is used for ethanol and feed, it is necessary to account for the rest of the corn demand to reflect the real-world condition of competition. The following steps describe the process of taking the national totals from ERS and allocating them to counties.

Corn Production. Corn production data at the county level was obtained from the COA through the National Agricultural Statistics Service. The COA censors certain data points that have too few farms or facilities in a geographic unit. For corn production in 2012, 304 counties were censored. The censored counties accounted collectively for only 0.15% of US total corn production. For other data in the COA, a large share of county data is sometimes censored, as we document in the sections below. We used various methods to estimate the censored data. For corn production, the censored counties are estimated from the unaccounted-for total at the state level. For example, in Colorado there are five censored counties, and the difference between the state total production and the sum of the counties with data in Colorado is 403,000 bushels. Each censored county in Colorado is allocated an equal share of this quantity: 80,600 bushels (403,000/5).

Total supply of corn at each county is equal to production, imports, and the net change in carryover stocks. For 2012, there were net withdrawals of corn stocks, with beginning stocks exceeding ending stocks by 170 million bushels of corn, or 1.5% of total supply. Given the small contribution of change in stocks to total supply, and in the absence of better information, we assumed that the change in stocks in each county is proportional to production. Imports accounted for 1.4% of total supply, with 37% of imports from Canada, which is assumed to enter through Chicago (44). The remaining imports are assumed to enter the Port of South Louisiana.

Corn Demand. The national total demand for each demand category (e.g., ethanol, feed, wet mills, and exports) is allocated to counties based on the location of facilities and their corresponding ethanol and wet mill capacities, the location of livestock animal populations on corn feed, and port locations for exports. Total corn demand at each county is simply the sum of demand from each category.

Ethanol demand for corn. County-level demand for corn by ethanol producers was estimated based on the capacity of ethanol facilities located within each county. Ethanol facility information was obtained from the Renewable Fuels Association (RFA) that lists the location, feedstock(s), and capacity for each ethanol facility in the United States (46). For refineries with multiple feedstocks, it is assumed that each are used in an equal proportion. Ethanol capacity for each facility is converted into corn requirements using conversion factors of 2.8 gallons of ethanol per bushel corn from dry milling facilities, and 2.6 gallons of ethanol per bushel of corn from wet milling facilities (51). The corn requirements at each ethanol facility were adjusted down by 6.5% to match the ERS national total corn consumption by ethanol facilities of 4.64 billion bushels of corn.

Corn demand as feed for animals. Fig. S1 shows the composition of corn demand by animal type from the ERS database. These estimates are based on the number of grain consuming animal units (GCAUs), which provide a comparable unit of measure across animal types. For example, there were ~12 times as many pigs fed corn grain as there were dairy cattle; however, dairy cattle ate ~5 times as much corn grain per animal than pigs. The GCAU metric adjusts for these differences, resulting in 10.5 million GCAUs of dairy cattle and 26.5 million GCAUs of pigs in 2012, indicating that pigs collectively ate 2.5 times as much corn grain as dairy cattle. For each animal group, the number of GCAUs was converted to corn demand proportionally based on the national total of GCAUs and corn for animal feed.

For poultry, ERS provides data on the number of GCAUs for all categories of poultry, but not each of the poultry subgroups: broilers, layers, pullets, and turkeys, as in Fig. S1. We estimated the quantity of corn for each poultry subgroup based on animal sales/inventory data from the COA and ERS GCAU factors. The GCAU factors indicate that each broiler is equivalent to 0.002 GCAUs, whereas each layer is equivalent to 0.0217 GCAUs. Given these factors and the relative populations of these types of poultry, we calculate that 58% of corn for poultry is consumed by broilers, 25% by layers, 2% by pullets, and 15% by turkeys.

Corn demand for animal feed at each county is based on animal populations and regional differences in animal sizes and diets. The COA provides county-level animal populations for cattle, pigs, and poultry. These three animal groups accounted for 99.3% of corn consumption as feed in 2012. Each animal category had specific complexities regarding data interpretation, censored data, and diet variation. These issues are discussed in turn by animal type.

Cattle corn demand. Cattle populations consist of animals at various stages of development and intended uses. The ERS data separates cattle into three categories: cattle on feed, dairy cattle, and other cattle. Cattle on feed are those at a feedlot in the final stages of development being prepared for primary processing, and have the greatest feed requirements with a factor of 1.53 GCAUs per animal. Dairy cows have a less corn-intensive diet with a factor of 1.05 GCAUs per animal. All other cattle are given a GCAU factor of 0.055. For each category of cattle, we identified an equivalent category in the COA that is used to estimate cattle populations for each county. The COA has county-level data on the inventory of feed cattle, milk cows, and total cattle. The inventory of other cattle was calculated as total cattle minus feed cattle minus milk cows.

Cattle populations across the United States were given varying quantities of feed. Regional feed diets suggest that cattle in the Midwest and central states in the United States receive more corn feed than cattle in western states (63). The national total of corn for cattle on feed is allocated to each county based on the population of cattle on feed and a regional feed adjustment. The regional adjustment ensures that the relative quantities of corn per animal between regions from Klasing are preserved, while the national total corn consumption matches the ERS total for cattle on feed (63). In the model, cattle on feed in the Midwest, central, western, and all other states are fed 1,980, 1,850, 1,260, and 1,700 pounds of corn per animal, respectively. There are no regional adjustments for dairy cattle and other cattle. With these animal categories, the national total corn consumption by each group is allocated equally to each animal, and to each county based on respective animal populations.

The COA data censors some cattle inventory entries. For milk cows and cattle on feed, there was a large share of missing counties. To estimate the censored data, we start with total cattle, which had only 0.2% of counties censored. The censored values were estimated based on unaccounted-for state populations, as was done with corn production in *Corn Production*.

With milk cows, 732 counties are censored and the censored counties make up 4.8% of the total milk cow population. Here a more complicated method was used to estimate the censored data. For any state, the unaccounted-for population—total state population minus sum of county population with available data—was allocated to the counties with censored data. Rather than assuming each censored county receives an equal share of the unaccounted-for population, we instead use the county total cattle population as a proxy for each censored county to apportion the unaccounted-for population. Basing our estimated population on a proxy variable that is correlated with the variable of interest will better reflect the true value compared with apportioning the unaccounted-for population equally between the counties with censored values. As an example of this method, there are 10 censored counties in Michigan and 5,503 unaccounted-for milk cows in those counties. In these 10 counties, the total cattle population is used as a proxy to calculate the share of the unaccounted-for milk cows. In Antrim County, Michigan, the total cattle population makes up 22% of the total cattle population of the 10 censored counties. Therefore, we allocated 22% of the unaccounted-for milk cow population to Antrim county, or 1,185 milk cows.

The general formula for the estimated population of any censored data and a given proxy variable is

$$\widehat{\mathrm{pop}}_i^s = \widehat{\mathrm{pop}}^s \times \mathrm{prox}_i^s \Big/ \sum_{\text{censored}} \mathrm{prox}_i^s,$$

where $\widehat{\mathrm{pop}}_i^s$ is the censored animal population to be estimated, in state s, and county i. The term $\widehat{\mathrm{pop}}^s$ is the total unaccounted-for population in state s, and prox_i^s is the proxy variable population in state s for county i. With this estimation method for censored values, the state totals will match the COA data even though the county data are an estimate of the censored values. Thus, the error is within states, and between censored counties.

For cattle on feed, there were 525 censored counties that had an unaccounted-for population equal to 20.6% of the total population. Here we use the total cattle population minus the milk cow population as the proxy population.

Pig corn demand. Pig populations were estimated from the COA county-level pig inventories. There were various types of pig farm facilities; however, sufficient data does not exist on these facility types in the COA data at the county level. Therefore, we use the inventory as the measure of the population without distinction between the different stages of the pig life cycle. The COA censored data from 575 counties with a combined 12.1% of the total pig population. Among the variables available at the county level, the cattle on feed correlated best with pig populations. Therefore, cattle on feed populations were used as the proxy variable for estimating the censored pig population data.

According to the ERS data, there were 1.24 billion bushels of corn fed to pig in 2012. These bushels were allocated to the pigs in each county using a regional corn feed diet adjustment (63). The regional adjustments indicate that pigs in the Mid-Atlantic and Midwestern states are fed a more corn-heavy diet than are pigs in the Central states. For our model, a pig in the Mid-Atlantic, Midwest, Central, and all other states was fed 660, 620, 540, and 610 pounds of corn, respectively.

Poultry corn demand. Poultry populations were separated into several categories given the varying corn feed requirements of each animal type. Broilers consume the largest share of corn, as they are raised for meat and have short lifetimes. Layers and pullets, used for egg production, have longer lives and have a less corn-intensive diet. Turkeys, like broilers, are produced for meat and consume significant quantities of corn per animal. For broilers and turkeys, populations are based on sales data from the COA rather than the inventory data; due to the short lifetimes, annual sales are a more accurate measure of the annual number of animals that eat corn feed. Layers and pullets, with longer lifetimes, are measured based on their point-in-time inventory estimates from the COA.

For broilers, 743 counties had censored data totaling 2.6% of the broiler population. With the relatively small population of broilers data censored, the missing data were estimated by allocating equally within a state the total unaccounted-for population in the state, similar to the method used for total cattle in a county. For layers, 377 counties had censored data, totaling 50.7% of the layer population in 2012. The broiler population was used as a proxy variable for censored values of layers, pullets, and turkeys. For pullets, 748 counties had censored data totaling 40.9% of the total pullet population, and for turkeys, 832 counties had censored data totaling 11.5% of the total turkey population.

For all poultry types, ERS data estimates 1.42 billion bushels of corn were consumed as feed. Based on GCAU factors and relative animal populations, we estimated the following quantities of corn consumed by each poultry type: 810 million bushels for broilers, 364 million bushels for layers, 29 million bushels for pullets, and 212 million bushels for turkeys.

For each of layers, pullets, and turkeys, the national total of corn feed for the poultry type were allocated based on the relative animal population in each county. For broilers, the quantity of feed per head was adjusted, by state, based on the average live weight of broilers. Live weight data by state were obtained from the COA. Feed efficiency ratios—pounds of feed per pound of weight gained—were calculated for each state given the average broiler live weight and feed efficiencies (64). The total quantity of corn for broilers is allocated to each county according to the county sales of broilers and the state-calculated feed efficiency ratios.

Other livestock corn demand. Livestock, other than those discussed above, consumed 0.7% of the total corn feed in the United States in 2012. The corn consumption of these animals is not explicitly modeled. Rather, these bushels of corn are aggregated along with other miscellaneous categories of corn demand.

Other corn demand. The remaining categories of demand (wet mills, export, and miscellaneous categories) accounted for 19.2% of total corn demand in 2012. Wet mill demand was modeled at the county level based on the location and capacity of corn wet mill facilities. Export demand is modeled by the county location and quantity exported from each port. Miscellaneous demand combines corn for seed, alcohol for beverages and manufacturing use, cereal and other product use, and feed for other livestock. Corn for the miscellaneous category was allocated to counties proportionally to the combined demand in each county for feed, ethanol, wet mills, and exports. The miscellaneous corn demand category constitutes 3.5% of the total demand for 2012.

Wet mill corn demand. Data on corn wet-milling facilities comes from a report from the Ernest Orlando Lawrence Berkeley National Laboratory (65). The report identifies locations of corn wet mills in 2003 and daily milling capacities. The wet mill facilities were verified for continued operation to present day, with three found to be no longer in operation. Two additional facilities were added that appeared in a report of domestic plants from the Corn Refiners Association (66). The capacities of the two additional facilities were estimated by the footprint of the facility using Google Earth and comparing with the footprints and capacities of similar facilities for the same company. In the absence of more recent data, it is assumed that facility corn-processing capacities remained the same in 2003 and 2012.

The list of wet mills was checked against the list of ethanol facilities from the Renewable Fuels Association to identify those facilities that do and do not produce ethanol, and in what quantities. Because corn used for ethanol production is counted separately from wet mill corn use in the ERS data, it is important to calculate the quantity of corn used by wet mills to produce all goods except ethanol. The bushels of corn required to produce the quantities of ethanol are calculated for each wet mill. The remaining bushels of corn at each wet mill—total corn use minus corn used in ethanol production—were allocated to nonethanol production. Corn use from each wet mill facility for nonethanol products was adjusted down by 8.1% so that the combined total matched the ERS total of 1.03 billion bushels of corn.

Corn exports. Corn export data were obtained from the USDA Federal Grain Inspection Services Yearly Export Grain Totals report (45). The report provides export location and quantity of corn exported. In 2012, 70.6% of corn exports left from the Port of South Louisiana. The remaining corn exports were shipped or driven by truck from 23 other export points. Exports were 6.6% of total corn demand for 2012.

Distiller's Dried Grains and Solubles Supply and Demand. Distiller's dried grains and solubles (DDGS) are important for the movement and consumption of corn. DDGS are a significant coproduct from corn ethanol production as well as a key supplemental feed ingredient for cattle, pigs, and poultry. In dry-milling operations, each bushel of corn produces 2.8 gallons of ethanol and 17 pounds of DDGS. County-level production of DDGS is calculated in the model given the location and quantity of corn consumed by dry milling ethanol facilities. Total US DDGS production in 2012 was 34.3 million tons. There was an additional 0.4 million tons of DDGS imported into the United States, which we assumed were imported at the same ports and in the same proportion as corn (44). The total supply of DDGS is the sum of imports and those produced at ethanol facilities.

Demand for DDGS is separated into exports and domestic use as a feed supplement. Exports accounted for 24.4% of total demand, or 8.4 million tons (44). As with imports, we assumed that DDGS exports were shipped from the same ports and in the same proportion as corn exports. The remaining supplies of DDGS are consumed as feed for dairy cattle, beef cattle, pigs, and poultry. In 2011, beef cattle consumed 56.4% of DDGS for feed, dairy cattle consumed 26.9%, pigs consumed 10.2%, and poultry consumed 6.5%. We applied these same percentages to 2012 for DDGS demand for each animal type. For beef cattle, dairy cattle, and pigs, the US total DDGS demand for each animal type were allocated proportionately to the county level based on animal populations. DDGS for poultry were allocated to each type of poultry according to their relative consumption of corn.

Stage 2: Animal Supply and Demand

Stage 2 of FoodS^3 connects animals from farms and feedlots to primary processing facilities, tracing the quantity of embedded corn—as corn and DDGS—and the associated environmental impacts. Stage 2 was restricted to beef, pork, and broiler chicken primary processing. Data for stage 2 accounts for the supply of animals on farms and feedlots to meet the demand for animals in processing facilities.

Each of these markets are characterized by a relatively few companies owning a large share of the processing facilities. In the beef market, 25.4 million cattle were allocated to 43 processing facilities, with 21 of the facilities—accounting for approximately three quarters of all cattle—owned by Cargill, Tyson, and JBS. In the pork market, 113.6 million pigs were allocated to 74 processing facilities, with 17 facilities—accounting for an estimated 56% of pigs—owned by Smithfield, Tyson, and JBS. In the broiler market, 8.4 billion chickens were allocated to 158 processing facilities, with 70 facilities—accounting for approximately half of all broilers—owned by Tyson, Pilgrim's Pride, and Perdue Farms.

Primary processing facility locations and processing capacities were derived from industry reports, state-level slaughter totals from the 2012 COA, satellite images of facilities, and adjustments to obtain consistent results between data sources. We discuss the methods and data sources used separately for each animal type below.

Beef Processing Facilities. We obtained data on beef cattle slaughter facilities in a report from *Cattle Buyer's Weekly*, listing the top 30 beef-packing companies in the United States (67). The report includes the number of facilities and quantity slaughtered in 2012 for each company. Individual facility information was obtained from the USDA Food Safety and Inspection Service meat and poultry inspection (MPI) directory (68). The MPI directory was used to identify the location of facilities for each company listed in the *Cattle Buyer's Weekly* report.

We estimated the slaughter production of each facility by allocating the company total to the individual facilities. This estimation process required several steps, which involved making initial estimates based on the size of the facility, comparing state totals of estimated production with COA state slaughter totals, and finally making adjustments to reconcile differences.

We identified 56 processing facilities for the top 30 beef-packing companies and using the knowledge of an industry expert, we split those facilities into 30 facilities that process corn fed cattle, 13 that process dairy and beef cattle only (a distinction that is important when modeling the movement of cattle to processing facilities as described in *Stage 2: Embedded Corn Mobility to Processing Facilities*), and 13 facilities that process multiple categories of cattle. Each facility was located on Google Earth Pro, and the size of the facility was estimated using the polygon ruler tool. The measurement included all structures connected or clearly associated with the slaughter facility. The slaughter production at each facility was estimated using the facility's share of the company total facility area—sum of area of all facilities for the company—multiplied by the total slaughter for the company. This procedure produced an initial estimate of the processing capacity of each facility. Of the top 30 companies, only five had multiple facilities. Therefore, this estimation technique was unnecessary for 25 companies where the facility total is also the company total.

We compare our individual facility estimates, summed to the state level, with the COA slaughter totals by state for cattle (excluding calves). Given the uncertainty associated with our initial facility-level capacity estimates using satellite images, we determined that facility totals should be adjusted to match COA state totals. This adjustment procedure was conducted with three hierarchical principles that were sometimes in conflict with one another. The highest priority was that the sum of facility production for each state must match COA state totals. Second, the company total production should be preserved whenever possible (i.e., when it does not conflict with the state total). Third, the initial facility-level estimates should be adhered to as closely as possible.

The adjustment procedure followed these steps: (*i*) for all states with a single facility, the entire state total was allocated to that facility; (*ii*) all companies with a single (remaining) facility had the entire company total (or remaining total after step 1 allocated to this facility); (*iii*) two companies with 2–4 remaining facilities each were allocated the remaining company total according to the facility size estimate; and (*iv*) the largest three companies (Tyson, JBS, and Cargill) were allocated the remaining production in each state according to their proportion of facility area in each state for these three companies. The procedure results in the state total of the facilities equaling the state total from the COA. For all companies, except the largest three (and several smaller companies with a single facility in a state with a single facility), the company total equaled the company total from the *Cattle Weekly Report*. Finally, adjustments were made within several states between the largest three companies that maintained the state total while reallocating between the largest three companies to ensure that these company totals were met exactly.

The largest cattle slaughter companies are displayed in Table S2, showing that the top three companies control approximately two thirds of the market.

Pig Processing Facilities. Locations and production of pig processing facilities were obtained through similar methods as those used for cattle. Pig processing facilities by company were identified in the 2014 Pork Stats report from Pork Checkoff (69). The Pork Stats report lists 52 pig slaughter companies in the United States, the location of the facilities associated with each company (74 total facilities accounting for 99.1% of all pig production), and the estimated daily slaughter capacity for each facility for 2012. The report also provides an annual total for all pig production in the United States. We adjusted the facility numbers to COA numbers by multiplying the percent of total production in each facility times the 2012 COA total. We then compared our estimated state totals with COA state totals and adjusted facility capacities to match the COA state totals. The average adjustment for each facility was 8%.

Adjustments to facility production were made to perfectly match COA state slaughter totals following a similar procedure as was used to adjust cattle facility production. Table S3 identifies the largest pig slaughter companies, annual production, and market share. With pigs, the top five companies combine to process 73% of the pigs in the United States.

Broiler Processing Facilities. Data on broiler slaughter facilities comes from the 2012 poultry processing plants directory from WATT PoultryUSA, which identifies the location and associated company of all 158 broiler processing facility in the United States (70). WATT PoultryUSA also produced a report of the top broiler processing companies in 2012, which provides the estimated annual broilers slaughtered by each of 37 companies (71). As with cattle, it was necessary to allocate the company total production to facilities under each company. The area of each broiler slaughter facility was estimated using Google Earth Pro, and the company total production was allocated to each facility proportionally based on area.

The facility production estimates were adjusted to match state totals using the same method as with cattle. Given the larger number of facilities for many of the companies, it was possible to match state totals exactly with the USDA Census state slaughter totals, and match nearly every company total with the company totals from the WATT PoultryUSA 2012 top company report. Table S4 lists the largest broiler processing companies for 2012, where the largest four companies process 55% of the US total.

Environmental Impact LCA

By linking the movement of corn from regions of production to downstream animal processing facilities, we make it is possible to characterize spatially explicit environmental impacts of animal protein supply chains. Many environmental indicators can be evaluated with this methodology. We examine GHG emissions—as CO_2e—and irrigated (blue) water consumption of corn production for each county in the continental United States, using a streamlined hotspot approach. The unit of analysis is the environmental impacts per bushel of corn produced or consumed.

GHG Emissions. To represent total GHG emissions associated with the material and energy inputs and outputs of corn production, we use the GREET model (51). The GREET model represents US average corn production processes and impact factors, which are used to calculate the life cycle GHG emissions of producing a bushel of corn.

At the corn-farming stage, inputs into GREET include quantities and types of N-P-K fertilizers, lime, herbicides, insecticides, and energy sources, such as diesel, liquefied petroleum gas, gasoline, natural gas, and electricity, as well as the types of equipment used that consume the various fuels. With the exception of nitrogen fertilizers and energy for irrigated water use, we applied the default quantities and types of inputs from GREET, and assumed a yield of 150 bushels of corn per acre to understand input requirements on a per acre basis. Table S1 shows the emissions inventory, separating CO_2e impacts by category in the corn production process.

Nitrogen fertilizer inputs are treated separately because of their enormous share of GHG emissions from corn farming, accounting for ~70% of total corn GHGs (51). The production of nitrogen fertilizers emits large quantities of GHG, where each type of nitrogen fertilizer has a different emission profile. For instance, the production of ammonium nitrate emits 9.3 kg CO_2e per kg nitrogen, compared with 2.8 kg CO_2e per kg nitrogen from the production of urea. We use nitrogen fertilizer inputs parameterized for each county instead of the national average inputs in the GREET model by applying a different mix of nitrogen fertilizer types. For every state, we apply a different nitrogen fertilizer application rate per acre of corn planted.

State-level nitrogen fertilizer application rates on corn were obtained from the USDA ERS Fertilizer Use and Price dataset (72), which includes the percent of corn acres that received nitrogen fertilizer (table 9 in dataset) and the rate of fertilizer application per acre that received nitrogen (table 10 in dataset). The rate per acre of corn multiplied by the percent of acres receiving nitrogen produces the state average nitrogen application for all fertilized corn acres. These state averages were applied to counties in each state.

The nitrogen fertilizer mix by county is derived from data in the 2011 National Emissions Inventory (NEI) (73). The NEI produced estimates of emissions at each county using data from the Association of American Plant Food Control Officials. Using the NEI data, we derive quantities of nitrogen fertilizer applied in every county, separated by type of fertilizer. However, because these estimates represent total fertilizer quantities applied across all farm acres in a county, we instead use this data to estimate only the nitrogen fertilizer mix (the share of nitrogen in a county from each fertilizer type), and use the state-level nitrogen fertilizer application rates to estimate quantity. This method assumes that the nitrogen fertilizer mix on corn acres is the same as the mix for all crops.

For each county, we estimate the quantity of irrigated water used per acre of corn (described in *Blue Water Consumption*). We multiply this quantity of irrigated water by the GREET emission factor per cubic meter of water from electricity use in irrigation systems, to get the county specific irrigated water impacts per bushel of corn.

Using the quantity of nitrogen fertilizer per acre, the mix between nitrogen fertilizer types for every county, the quantity of irrigated water per acre, and the default rates from GREET for all other inputs, we calculated the GHG emissions per acre of corn produced in every county. Then, using county yield data for 2012, the GHG emissions per bushel of corn were calculated.

The spatial distribution of GHG impacts are shown in Fig. 2. Here we present an illustration of the source of the spatial variability in impacts. The two key factors that determine the differences in impacts by location are the mix and quantity of nitrogen fertilizer and the corn yield. With both of these factors removed there would be little spatial variability and most counties would be near the mean value of 9.85 kg CO_2e per bushel (bu). We apply each factor individually to isolate the impact of each, and show the distribution of impacts in each case in Fig. S2. There are four distributions (weighted by the quantity of corn production in 2012) shown in Fig. S2: (*i*) no county adjustments; (*ii*) adjusted by fertilizer mix and quantity only; (*iii*) adjusted for differences in yield only; and (*iv*) adjusted for both fertilizer mix and quantity and yield differences. When we only apply a different fertilizer mix and quantity by county but keep the corn yield the same for each county, the distribution of impacts is relatively tightly centered on the median with a 10th–90th percentile range of (7.8–11.2) kg CO_2e/bu. When we apply yield adjustments to each county but assume the same mix and quantity of nitrogen fertilizers in each location, the distribution is wider with a 10th–90th percentile range of (6.6–13.8) kg CO_2e/bu. Finally, when we adjust both the differences in nitrogen fertilizer and yield by county, the distribution is wider still with a 10th–90th percentile range of (5.7–14.3) kg CO_2e/bu. Fig. S2 shows that the greatest source of spatial variability in CO_2e impacts per bushel is based on differences in yield, and the differences in nitrogen fertilizer type and quantity contribute to relatively less variability.

Blue Water Consumption. Our water analysis focuses on corn irrigation water consumption. We use blue water irrigated hectare raster geographic information system (GIS) data and irrigated hectares of corn raster GIS data from Siebert and Doll (53). In ArcGIS, we summed up both datasets to county levels, providing average water consumption per irrigated hectares of harvested corn between 1998 and 2002, per county. From the COA we obtained 2012 county-level acres of corn grain irrigated, and applied the average water consumption per irrigated acres of harvested corn for 1998–2002 to estimate total blue water consumption of irrigated corn in 2012 for each county.

Corn Mobility Optimization Model

We develop a two-stage spatial cost minimization model to estimate corn mobility in the United States. Specifically, stage 1 estimates county-level supply networks meeting primary corn demand (ethanol, animal feed, exports, etc.). Stage 2 estimates embedded corn mobility associated with animal transportation from counties of production to processing facilities.

Stage 1: Corn Mobility from County of Production to County of Primary Demand. A simulation model was built using the Gurobi Optimizer 6.5 for the optimal allocation to minimize the total delivered corn costs, including the corn price and transportation cost. The results identify the quantity of corn that moves between each pair of counties in the United States.

The county-specific unit price, P_{ij}, of corn ($/kg) at its destination, j, from origin county, i, incorporating the cost of transportation is defined as

$$P_{ij} = \min\left\{c^R\left(D^R_{ij}\right), c^T\left(D^T_{ij}\right)\right\} + p_i,$$

where $c^R(\bullet)$ and $c^T(\bullet)$ are transport cost function ($/kg) by rail and truck. The transport cost function dictates which mode of transportation is least costly from any origin county to any destination county, with truck generally more cost-effective for short distances and rail preferred for longer distances. $D^R{}_{ij}$ and $D^T{}_{ij}$ are transportation distances (km) between centroids of counties by rail and truck, respectively (74). Finally, p_i is the average farm-gate price of corn from county i (75).

Using linear programming, we estimate a US optimal allocation for direct corn consumption by each of $r = 1, \ldots, R$ demand sectors for all n counties:

$$\text{Minimize}\left\{\Sigma^R_{r=1}\Sigma^n_{i=1}\Sigma^n_{j=1}\ P_{ij} \times C^*_{r,ij}\right\}$$

subject to

$$\Sigma^N_{i=1}\ C^*_{r,ij} = C^D_{r,j},\ \text{for}\ r = 1, \ldots, R\ \text{and}\ j = 1, \ldots, n$$

$$\Sigma^R_{r=1}\Sigma^n_{j=1}\ C^*_{r,ij} \le C^S_i,\ \text{for}\ i = 1, \ldots, n$$

$$C^*_{r,ij} \ge 0,\ \text{for}\ r = 1, \ldots, R,\ i = 1, \ldots, n\ \text{and}\ j = 1, \ldots, n,$$

where, $C^*{}_{r,ij}$ is the quantity of corn (kg) transported from the origin county i to the destination county j in sector r. $C^D{}_{r,j}$ is the quantity of corn demanded for sector r at the destination county j and $C^S{}_i$ is the supply of corn at the origin county i.

To validate the outputs from stage 1 of the transportation model, we compare the state-to-state movement of corn and DDGS consumed as animal feed with the state-to-state movement of animal feed as reported in the FAF4 survey results for 2012 (56). The FAF4 data are an imperfect comparison with our FoodS^3 results because it includes several categories of animal feeds in addition to corn and DDGS, it is only at the state level, and only includes animal feed, and no other buyers of corn; however, it is the most comparable data to our results available. In our comparison, for each of the five largest corn-producing states, we examine the correlation of animal feed movement to every other state between the two sets of data. The correlations are very high (correlation coefficient of interstate animal feed movement between FoodS^3 and FAF4 for top five states: Iowa 0.99, Minnesota 0.94, Illinois 0.94, Nebraska 0.96, Indiana 0.85); these values are largely influenced by the large share of animal feed that is consumed in the same state that it is produced. We also report the correlation coefficient when we take the log of the animal feed values from each dataset, which greatly removes the influence of intrastate animal feed movement. The coefficients with the logged values are much lower (correlation coefficient of log of interstate animal feed movement: Iowa 0.63, Minnesota 0.25, Illinois 0.45, Nebraska 0.62, Indiana 0.43), indicating that there is less agreement between the datasets regarding animal feed movement between states than within states; however, two thirds of animal feed is estimated to be consumed within the state of production in both datasets.

Stage 2: Embedded Corn Mobility to Processing Facilities. In stage 2 of the model we estimate the movement of animals from farms or feedlots to processing facilities, moving only cattle, pigs, and broilers. These animals have embedded corn from their consumption of feed. With this stage we connect large animal protein processing facilities with the source of their corn's production, through the animals they purchase.

The transportation model operates separately for each animal type, and minimizes the total cost of transporting animals from counties of production to processing facilities while meeting each individual facility demand. In this stage, animals are restricted to movement by truck only. The allocation procedure is similar to the first stage model, but the second stage allocates animals to meet processing facility demand at all K facilities. For each animal type we solve

$$\text{Minimize}\left\{\Sigma_{j=1}^{n}\ \Sigma_{k=1}^{K}\ c^{TA}\left(D_{jk}^{T}\right)\times A_{jk}^{*}\right\}$$

subject to

$$\Sigma_{j=1}^{n}\ A_{jk}^{*}=A_{k}^{D},\ \text{for}\ k=1,\ \ldots,K$$

$$\Sigma_{k=1}^{K}\ A_{jk}^{*}\leq A_{j}^{S},\ \text{for}\ j=1,\ \ldots,n$$

$$A_{jk}^{*}\geq 0,\ \text{for}\ j=1,\ \ldots,n\ \text{and}\ k=1,\ \ldots,K,$$

where, A^*_{jk} is the number of animals transported from the supplying county j to the demanding facility k. $c^{T,A}(D^T_{jk})$ is the transport cost ($/head) of moving animals from demand county j to facility k by truck, given the truck distance, D^T_{jk}. A^D_k is the demand for animals by processing facility k, and A^S_j is the supply of animals in county j.

Systems Boundaries and Stages of Supply Chain Not Modeled

FoodS^3 accounts for and tracks several stages of the corn supply chain, but environmental impacts are only estimated for corn farming and its input's upstream impacts. The impacts of ethanol and DDGS only include the embedded impact from corn farming, but not the ethanol production and transportation stages. Similarly, emissions associated with manure at livestock facilities and the energy inputs at the primary processing facilities are not included. Fig. S3 demonstrates the system boundaries included (and excluded) for this analysis.

Company Corn Supply Chain Visualizations

Fig. S4 illustrates the estimated company-specific corn sourcing supply chain network and the associated life cycle GHG emissions and water use for three major protein suppliers: Tyson, Cargill, and JBS. The diverse supply chain networks and the heterogeneous environmental impacts of corn production (only partially captured in the current assessment) results in substantial variation in company-specific corn grain sourcing emission factors (e.g., kg CO_2e/bu).

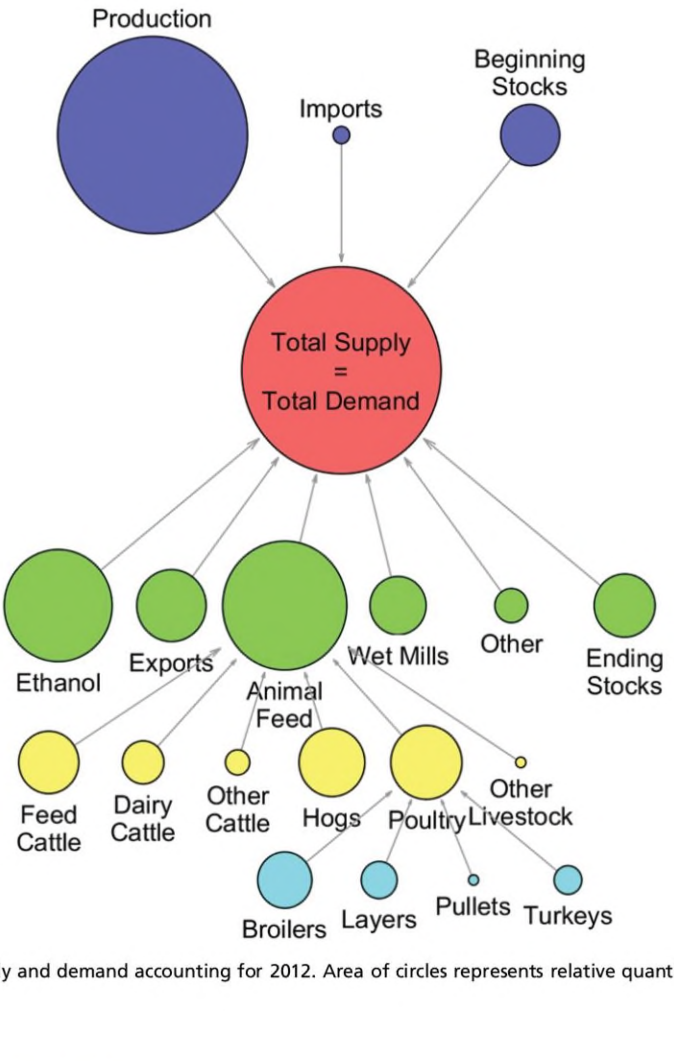

Fig. S1. ERS USDA corn supply and demand accounting for 2012. Area of circles represents relative quantity of corn for each category.

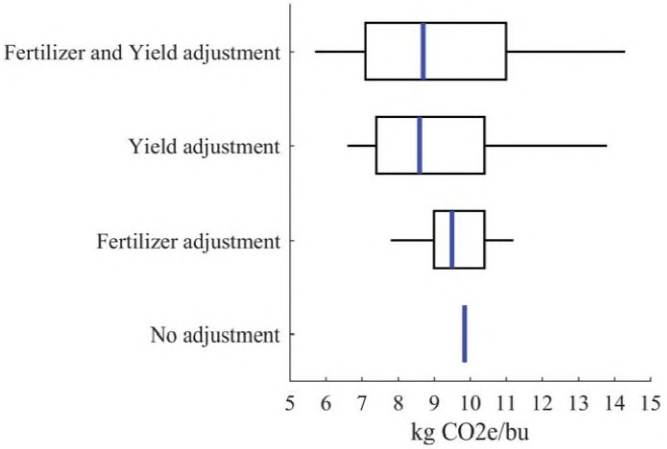

Fig. S2. Production-weighted distribution of GHG emission per bushel of corn in FoodS^3 model. The blue line represents the median of the distribution, the box extends to the 25th and 75th percentiles, and the lines extend to the 10th and 90th percentiles. The upper distribution shows the values used in the model and represent the variability when we adjust spatially for differences in nitrogen fertilizer and yield. The second distribution assumes the same quantity and mix of nitrogen fertilizer, but the yield varies. The third distribution keeps the yield fixed in each location, but the quantity and mix of nitrogen fertilizer varies. The bottom row shows the GHG emissions if we were to use a national number, which does not account for any spatial variability.

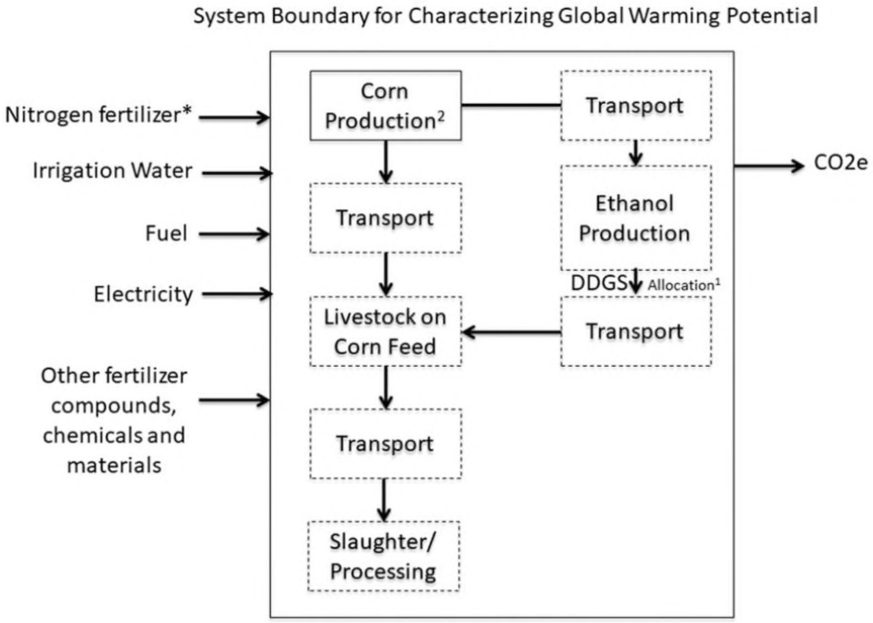

Fig. S3. Processes depicted with solid lines indicate the system boundaries with which Global Warming Potential impacts are determined. Environmental impacts associated with the dashed lines are outside the scope of the current study. *Nitrogen fertilizer inputs and types are varied to reflect the spatial heterogeneity across the United States. [1]Allocation refers to the upstream corn and transport GHG emissions allocated to DDGS based on the relative energy content of ethanol and DDGS coproducts. [2]Water depletion impacts are calculated for the corn production stage only.

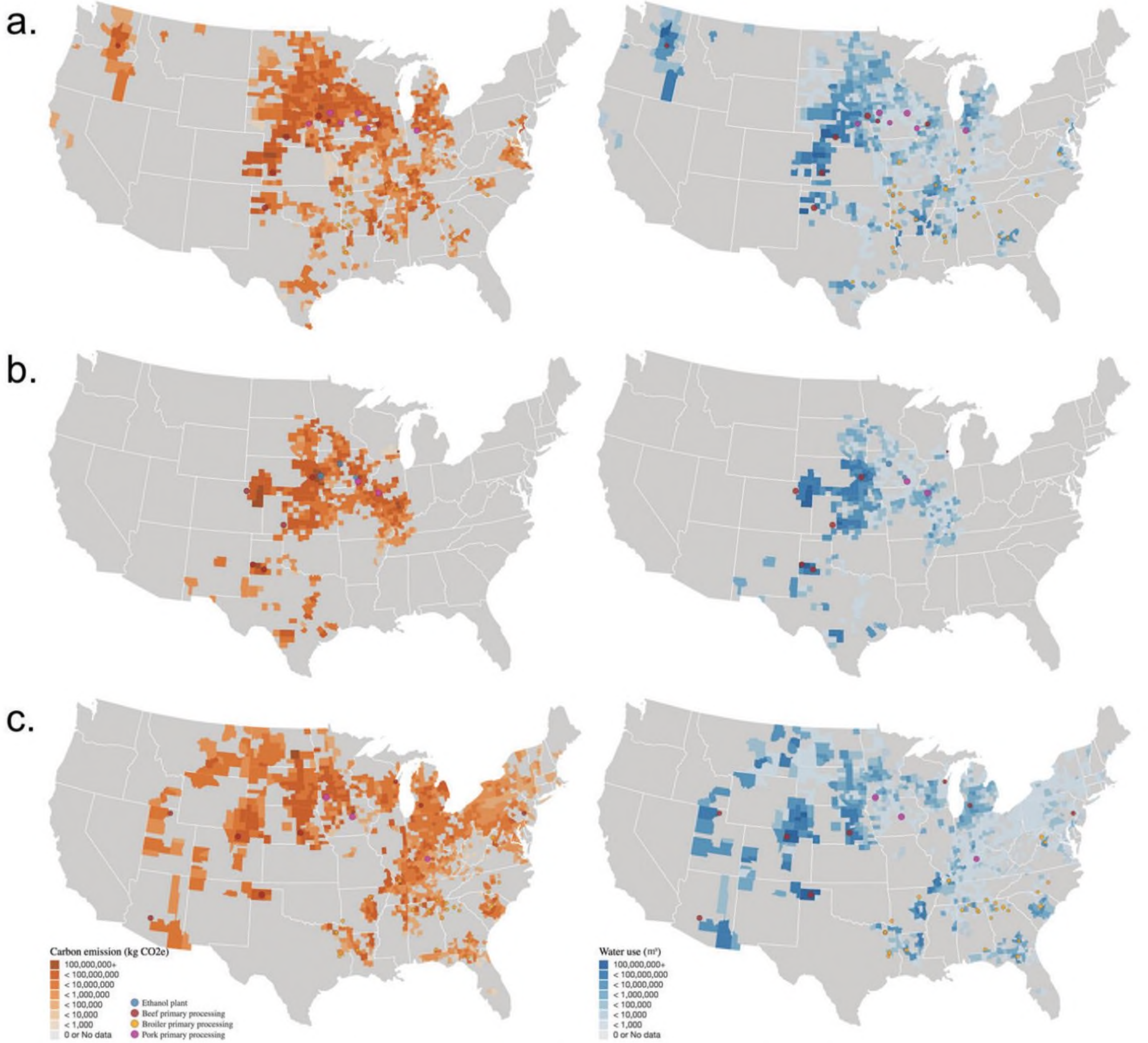

Fig. S4. Estimated 2012 firm-level corn supply chain (including corn suppliers of DDGS) CO_2e and irrigated water use of large downstream companies: (*A*) Tyson, (*B*) Cargill, and (*C*) JBS. Dots represent facility locations and processing capacity. Shaded regions show the location and quantity of embedded environmental impacts associated with the sources of corn for each company.

Table S1. Emissions inventory derived from GREET

Process	GHG intensity
	kg CO_2e/kg N
Nitrogen fertilizer production*	4.41
On-field N2O emissions	9.38
	kg CO_2e/acre
Phosphoric acid production	33.6
Potassium oxide production	15.3
Calcium carbonite production	2.5
Herbicide production	22.1
Insecticide production	0.2
Diesel fuel production	12.8
Diesel fuel combustion	76.7
Natural gas production	2.6
Natural gas combustion	13.9
Liquid petroleum gas production	4.4
Liquid petroleum gas combustion	18.0
Gasoline blendstock production	4.9
Gasoline blendstock combustion	16.7
Electricity for irrigation†	49.1

*Emission rate varies by county based on mix of nitrogen fertilizers.

†Emissions per acre vary by county based on the quantity of irrigated water use.

Table S2. Cattle slaughter and market share by company

Company	No. of facilities	2012 cattle slaughter, thousands	Market share, %
Cargill	8	7,189	22.4
Tyson	7	7,031	21.9
JBS	9	6,836	21.3
National Beef Packing	2	3,774	11.7
American Foods Group	5	1,844	5.7
US total	56	32,123	

Table S3. Pig slaughter and market share by company

Company	No. of facilities	2012 pig slaughter, thousands	Market share, %
Smithfield	8	29,227	25.7
Tyson	6	20,619	18.1
JBS/Swift	3	13,266	11.7
Hormel	3	10,299	9.1
Cargill	2	9,781	8.6
US total	74	113,629	

Table S4. Broiler slaughter and market share by company

Company	No. of facilities	2012 broiler slaughter, millions	Market share, %
Tyson	34	1,924	22.8
Pilgrim's Pride	26	1,632	19.3
Perdue Farms	10	611	7.2
Sanderson Farms	9	434	5.1
Wayne Farms	8	306	3.6
US total	158	8,439	

Other Supporting Information Files

Dataset S1 (XLSX)
Dataset S2 (XLSX)

Mighty Earth "Cocoa Accountability Map" Brings Unprecedented Transparency to Cocoa Industry in Côte d'Ivoire

Liviya James <liviya@waxmanstrategies.com>
Tue 1/21/2020 10:26 AM
To: Compliance <compliance@waxmanstrategies.com>

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Dear Friend,

For two years now, the cocoa industry and government of Cote d'Ivoire have promised in vain to develop joint monitoring mechanisms, in order to make good on their "Cocoa & Forests Initiative" November 2017 promise of ending deforestation in cocoa. They pledged the: "Adoption of a transparent satellite-based monitoring system, the results of which are independently validated, and which provide a deforestation alert, complemented with ground-truthing, as soon as possible upon signature of this Framework, which will be made publicly available for all stakeholders to measure and monitor progress on the overall deforestation target". This has not happened yet.

Failure to monitor has real impacts. Without data, without knowledge about the problem of forest destruction, without clarity on supply chains, much-needed solutions have remained incomplete or illusory. During the two long years since the Cocoa & Forests Initiative (CFI) came into being and monitoring was promised, many more forests have been lost, with Ghana and Cote d'Ivoire in fact boasting the top two increases in rates of deforestation in the world in 2018. Rather than ending deforestation, these countries in a way became the two world champions in the realm of speeding up deforestation.

Mighty Earth could not let this high-risk season go by without trying to do the basic work of a joint monitoring mechanism, to the best of our ability. The Cocoa Accountability Map seeks to spark a revolution in traceability and transparency in the Ivorian cocoa industry, in the hopes that this trend of openness will spread throughout the country – the world's top cocoa producer – and then to Ghana and beyond. Our map combines information about where deforestation is taking place, where cocoa is located, where purchase points called "cooperatives" are located, and who is certifying or buying from those cocoa cooperatives.

We at Mighty Earth have done the best we could with what we had. We now urge the industry, governments, civil society, and donors to join us, and help move the needle for an even better traceability and transparency revolution in chocolate.

You can read the full press release documenting the release of The Cocoa Accountability Map below.

Sincerely,

Etelle Higonnet
Senior Campaign Director, Mighty Earth
MIGHTY EARTH

Mighty Earth "Cocoa Accountability Map" Brings Unprecedented Transparency to Cocoa Industry in Côte d'Ivoire

(Version française ici)

Interactive map includes never-before-released information, including locations of Rainforest Alliance and Fairtrade certified co-ops and sourcing information for major chocolate companies.

In a historic first, Mighty Earth today announced the public release of its Cocoa Accountability Map for Côte d'Ivoire, an interactive map and integrated database covering almost 5,000 cocoa co-ops in the world's largest cocoa-producing country.

Datasets included in the Cocoa Accountability Map that have never before been made public include the lists of co-ops certified by Rainforest Alliance/UTZ and Fairtrade International as well as supply chain info tracking Hershey's and Cemoi chocolate down to the co-op level. Co-op information for chocolate giants like Lindt, Nestle, Valhrona, and others are also included.

"For the first time, companies and certification organizations have made their supply chain information available, allowing us – and now anyone, anywhere – to trace cocoa better and faster," said **Mighty Earth Senior Campaign Director Etelle Higonnet**. "In an industry still battling the scourges of child labor and deforestation, transparency is a vital first step to accountability and improvement. The Cocoa Accountability Map is essentially doing what the industry and government promised they would do two years ago: create a joint monitoring mechanism for cocoa. They didn't do it, so we are doing it for them."

Mighty Earth's Cocoa Accountability Map will break new ground and bring an unprecedented level of transparency to the cocoa industry. The map:

- Shows deforestation alerts nationwide in Côte d'Ivoire and will refresh automatically every 2 weeks, using the IMAGES platform from Vivid Economics and Remote Sensing Applications Consultants, a tool sponsored by the UK Space Agency.
- Shows the land-use for approximately 1/3 of the cocoa region and will expand to cover the entire country by around March
- Shows almost all the cocoa co-ops in the country, with almost 5,000 included along with information such as:
  - Name, contact information, number of farmers, area covered, and registration number of the co-op;
  - Whether or not the co-op is certified by Rainforest Alliance/UTZ or Fairtrade International;
  - How close each co-op is to a protected area;
  - And, vitally, who the co-op sells to, wherever we were given that information. Mighty Earth has incorporated supply chain info down to the co-op level for Lindt, Cemoi, Nestle, Hershey's, Valhrona, and others. Mars has begun the process of providing its information. Certain companies such as Blommer refused to embrace traceability and publish supply chain information. Some companies like ECOM have pledged to do so but have not been as fast as Nestle and others.

“The Cocoa Accountability Map will be a tremendous tool in helping to clean up the cocoa industry,” said **Higonnet**. “The government and industry can use this directly to check sourcing of their materials. A journalist can use this map to see where deforestation is happening before going to investigate the problem on the ground. An activist can conduct research into a problem like child labor or deforestation and then use the map to quickly get a sense of who might be buying the resultant goods. It’s a game-changer.”

“We applaud the companies that have participated and thank the government of Côte d’Ivoire’s Ministry of Agriculture and Conseil Café Cacao for their courageous leadership in providing the information about their thousands of co-ops, but more must be done. The governments of Ghana, Ecuador, and Cameroon must take similar steps to increase transparency – it is a real shame that Ghana is so far behind Côte d’Ivoire now. Companies like Ferrero and Touton, which never responded to our request for co-op data, must follow suit. And companies like Blommer Chocolate, which flat-out refused to participate, must modernize their thinking and embrace the transparency revolution sweeping their industry. Most crucially, the three largest traders – Barry Callebaut, Cargill, and Olam – must disclose the co-ops they source from.”

Mighty Earth has released this new transparency tool just ahead of the peak deforestation season in Cote d’Ivoire and Ghana – January to March – and ahead of a key meeting taking place, where major donors and Ivorian and Ghanaian government officials will be meeting to discuss the future of monitoring deforestation for the Cocoa and Forests Initiative (CFI). The Cocoa Accountability Map is a growing, evolving, and continuously improving tool – any and all additional information sent to Mighty Earth to complete the data will be welcome.

Some of Mighty Earth’s work on forests is supported by Waxman Strategies which is funded by organizations including the European

Federation for Transport and Environment, the Center for International Policy, and AidEnvironment under grants from the Norwegian Agency for Development Cooperation. Additional information is on file with the Department of Justice, Washington, D.C.

Re: Rapid Responses: Soy and Cattle, report 8

Compliance <compliance@waxmanstrategies.com>
Thu 1/23/2020 10:05 AM

To: Compliance <compliance@waxmanstrategies.com>

From: Sarah Brickman <sarah@mightyearth.org>
Sent: Tuesday, January 21, 2020 11:23 AM
To: Nick Martell-Bundock <Nick_Martell-Bundock@cargill.com>; Rapid Response <rapidresponse@mightyearth.org>
Cc: Jill Kolling <Jill_Kolling@cargill.com>; Ruth Kimmelshue <Ruth_Kimmelshue@cargill.com>; Michelle Grogg <Michelle_Grogg@cargill.com>; John Hartmann <John_Hartmann@cargill.com>; brendan.may@robertsbridgegroup.com <brendan.may@robertsbridgegroup.com>; christopher.broadbent@robertsbridgegroup.com <christopher.broadbent@robertsbridgegroup.com>
Subject: RE: Rapid Responses: Soy and Cattle, report 8

Dear Nick,

I have checked with our team regarding the Fazenda Cocal case, and I present here a series of images that provides evidence that native vegetation clearance did indeed take place, rather than pruning of eucalyptus trees. Also, as noted in report 8, the satellite imagery shows that there were fires on this farm, followed by more extensive clearance.

Please let me know what Cargill intends to do to engage Bom Futuro regarding this clearance and what remediation will take place.

Best,

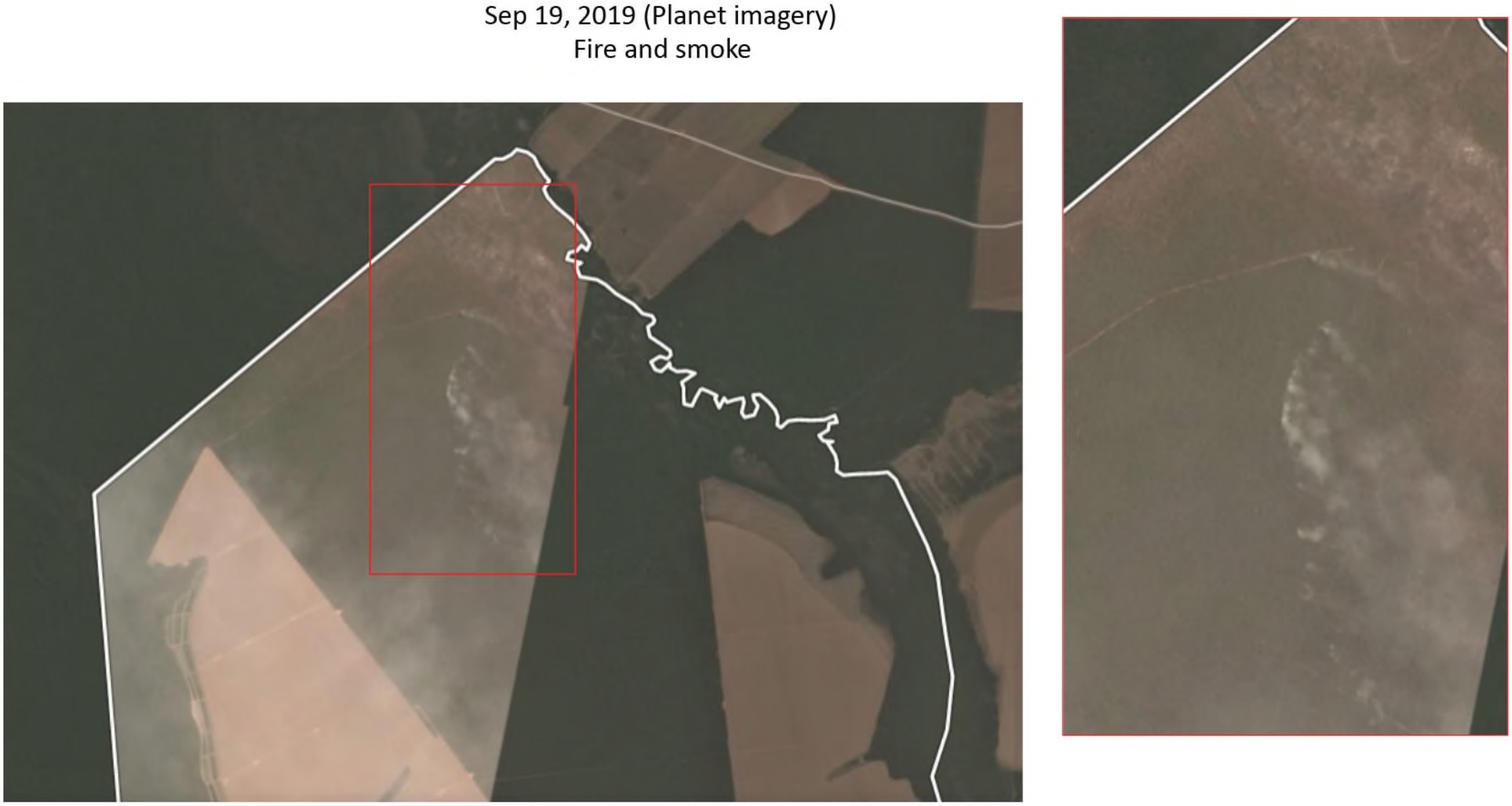
SARAH BRICKMAN I SENIOR ASSOCIATE I mightyearth.org
T +1-941-726-5851
sarah@mightyearth.org
Follow us: Facebook I Twitter

The work of Mighty Earth is supported by Waxman Strategies. Waxman Strategies' work on forest conservation is funded in part by Aidenvironment. Waxman is required under 22 U.S.C. § 614 to disclose that this material is distributed on behalf of the aforementioned organization, working under grant from the Norwegian Agency for Development Cooperation. Additional information is on file with the Department of Justice, Washington, D.C.

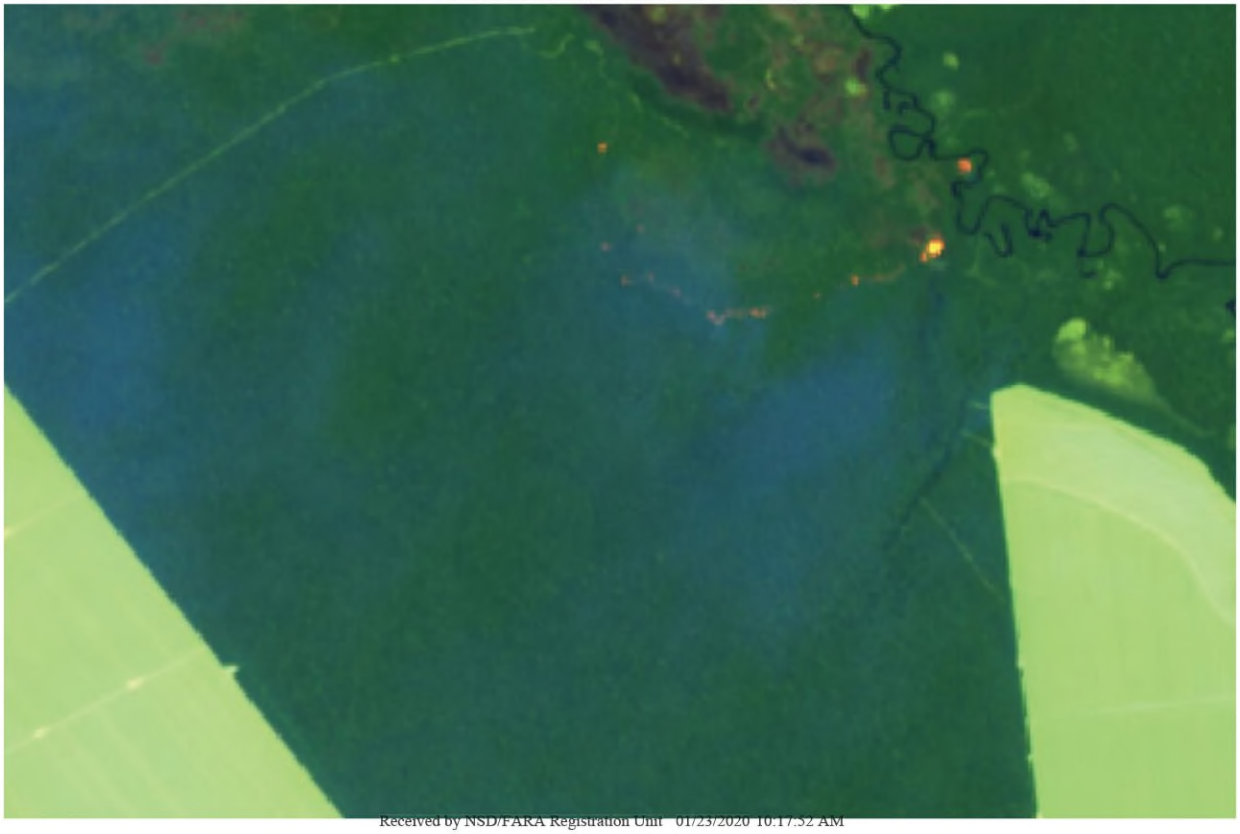
Fazenda Cocal

Sep 10, 2019 (Planet imagery)
Native vegetation

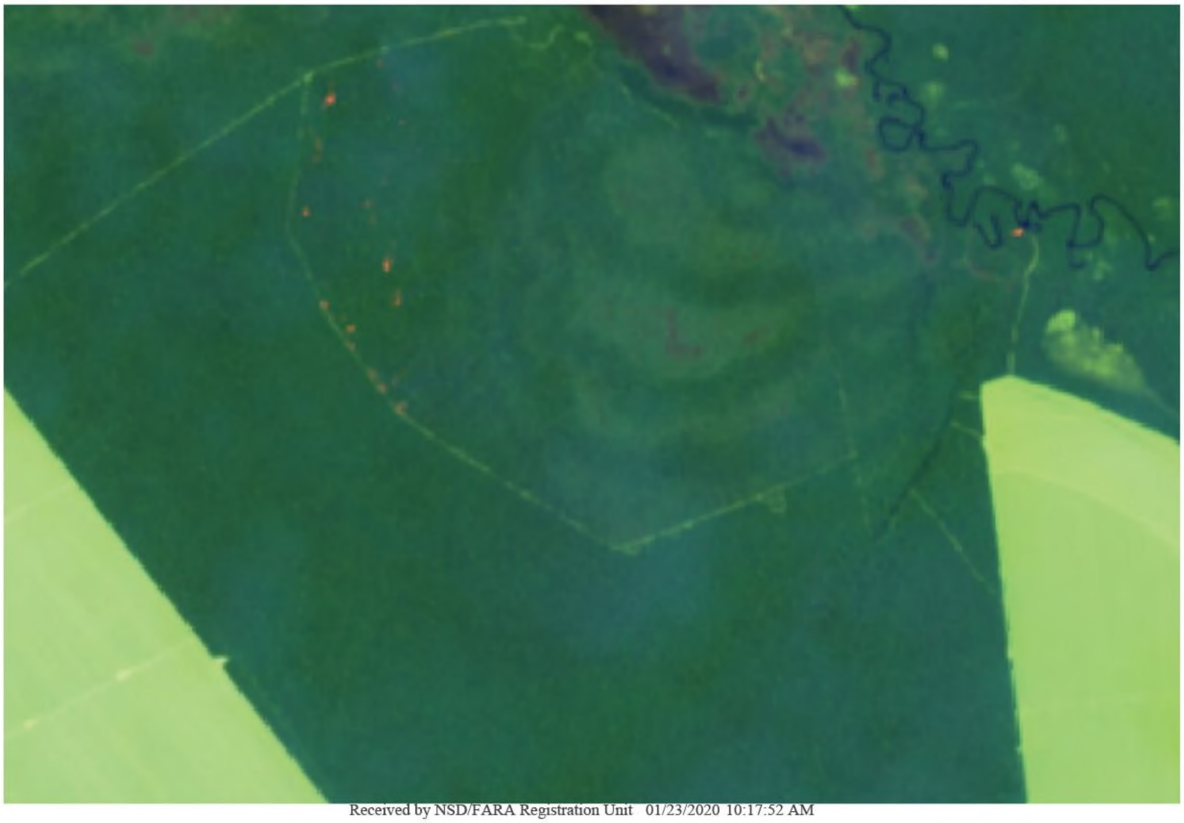
Sep 19, 2019 (Planet imagery)
Fire and smoke



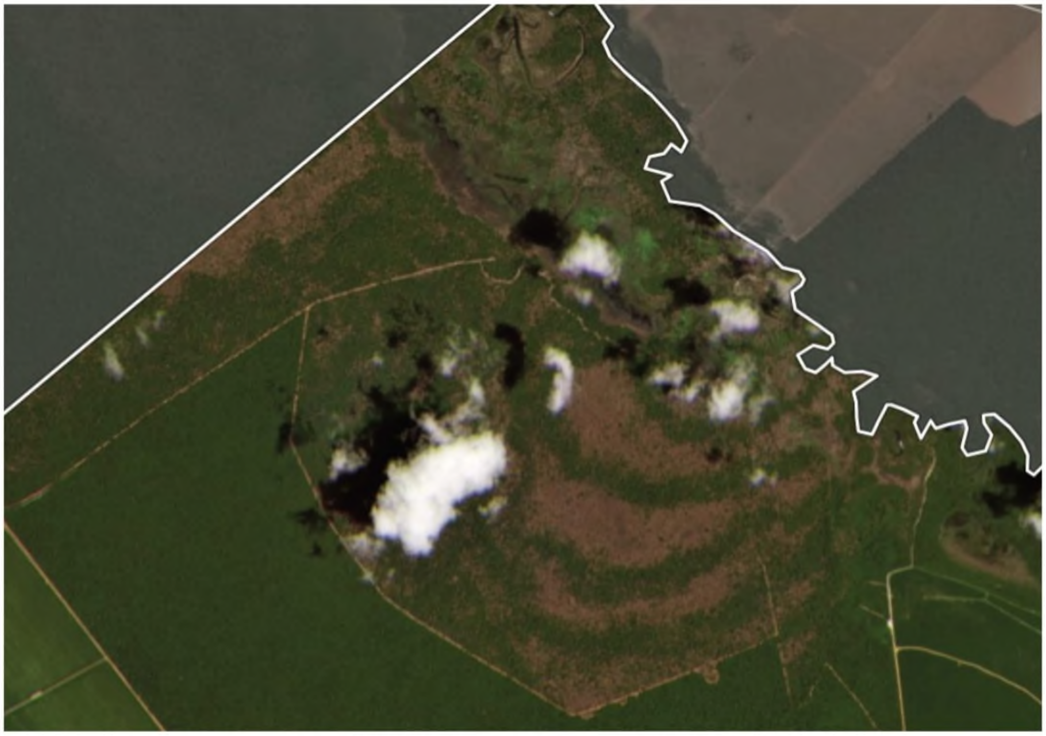
Sep 16, 2019 (EO browser processed imagery)
Active fires (red-orange dots)



Sep 21, 2019 (EO browser processed imagery)



January 14, 2020 (Planet imagery)



Re: Rapid Response: Soy and Cattle, report 8

Compliance <compliance@waxmanstrategies.com>
Thu 1/23/2020 10:06 AM
To: Compliance <compliance@waxmanstrategies.com>

From: Rapid Response <rapidresponse@mightyearth.org>
Sent: Tuesday, January 21, 2020 4:31 PM
To: Taylor, Alison <Alison.Taylor@adm.com>
Cc: ana.yaluff@adm.com <ana.yaluff@adm.com>; Sarah Brickman <sarah@mightyearth.org>
Subject: RE: Rapid Response: Soy and Cattle, report 8

Dear Alison,

I'm following up regarding report 8. I noticed that ADM's grievance log doesn't yet provide a response to this report. Please let me know when the log will be updated.

Thank you,

SARAH BRICKMAN I SENIOR ASSOCIATE I mightyearth.org
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sarah@mightyearth.org
Follow us: Facebook I Twitter

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Re: Rapid Response: Soy and Cattle, report 7

Compliance <compliance@waxmanstrategies.com>
Thu 1/23/2020 10:06 AM
To: Compliance <compliance@waxmanstrategies.com>

From: Rapid Response <rapidresponse@mightyearth.org>
Sent: Tuesday, January 21, 2020 4:33 PM
To: Taylor, Alison <Alison.Taylor@adm.com>
Cc: Sarah Brickman <sarah@mightyearth.org>
Subject: RE: Rapid Response: Soy and Cattle, report 7

Dear Alison,

I noticed that ADM's most recent grievance log lists report 7 as being "under investigation." When will you be able to provide an update?

Thank you,

SARAH BRICKMAN I SENIOR ASSOCIATE I mightyearth.org
T +1-941-726-5851
sarah@mightyearth.org
Follow us: Facebook I Twitter

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Rapid Response: Soy and Cattle, report 9

Rapid Response <rapidresponse@mightyearth.org>
Tue 1/21/2020 5:52 PM

To: Taylor, Alison <Alison.Taylor@adm.com>
Cc: ana.yaluff@adm.com <ana.yaluff@adm.com>

1 attachments (2 MB)
Rapid Response_Soy and Cattle_Report_9_January 2020.pdf;

Dear Alison,

Today, we are releasing Mighty Earth's Soy and Cattle Rapid Response report 9, which documents deforestation and native vegetation clearance on four properties in the Amazon biome and five properties in the Cerrado biome:

Soy

- Fazenda Batovi
- Fazenda Tingui / Fazenda Remansão
- Fazenda Piracicaba

Soy and Cattle

- Fazenda São João
- Fazenda Corumbá II / Fazenda Corumbá I, Fazenda Corumbá III and Fazenda Sertão
- Fazenda Novale
- Fazenda Santana I

Cattle

- Fazenda Cerejeiras / Fazenda Jaracatiá
- Fazenda São Domingos (Fazenda Cobiçada Gleba 1/1A)

By February 4, 2020, we request that your company respond to us with the following information:

- State any supply chain or other (financial, credit, joint venture, investment etc.) connection to each of the properties listed in our report (unless such information has already been communicated to Mighty Earth regarding repeat cases);
- State any connection to each of the companies and/or families listed as owners of the properties in our report (unless such information has already been communicated to Mighty Earth, as noted above);
- Update your grievance log to reflect the cases included in this report where they apply to your own supply chain or other relationships; and
- Inform of us of how you are planning to address these specific cases of native vegetation clearance.

Best,

SARAH BRICKMAN I SENIOR ASSOCIATE I mightyearth.org
T +1-941-726-5851
sarah@mightyearth.org
Follow us: Facebook I Twitter

The work of Mighty Earth is supported by Waxman Strategies. Waxman Strategies' work on forest conservation is funded in part by Aidenvironment. Waxman is required under 22 U.S.C. § 614 to disclose that this material is distributed on behalf of the aforementioned organization, working under grant from the Norwegian Agency for Development Cooperation. Additional information is on file with the Department of Justice, Washington, D.C.

[redacted]

[redacted]

Rapid Response: Soy and Cattle, report 9

Rapid Response <rapidresponse@mightyearth.org>
Tue 1/21/2020 5:53 PM

To: Michel Santos <Michel.Santos@bunge.com>
Cc: Daiana Bein Endruweit <Daiana.Endruweit@bunge.com>; Sarah Brickman <sarah@mightyearth.org>

1 attachments (2 MB)
Rapid Response_Soy and Cattle_Report_9_January 2020.pdf;

Dear Michel,

Today, we are releasing Mighty Earth's Soy and Cattle Rapid Response report 9, which documents deforestation and native vegetation clearance on four properties in the Amazon biome and five properties in the Cerrado biome:

Soy

- Fazenda Batovi
- Fazenda Tingui / Fazenda Remansão
- Fazenda Piracicaba

Soy and Cattle

- Fazenda São João
- Fazenda Corumbá II / Fazenda Corumbá I, Fazenda Corumbá III and Fazenda Sertão
- Fazenda Novale
- Fazenda Santana I

Cattle

- Fazenda Cerejeiras / Fazenda Jaracatiá
- Fazenda São Domingos (Fazenda Cobiçada Gleba 1/1A)

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- Update your grievance log to reflect the cases included in this report where they apply to your own supply chain or other relationships; and
- Inform of us of how you are planning to address these specific cases of native vegetation clearance.

Best,

SARAH BRICKMAN I SENIOR ASSOCIATE I mightyearth.org
T +1-941-726-5851
sarah@mightyearth.org
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The work of Mighty Earth is supported by Waxman Strategies. Waxman Strategies' work on forest conservation is funded in part by Aidenvironment. Waxman is required under 22 U.S.C. § 614 to disclose that this material is distributed on behalf of the aforementioned organization, working under grant from the Norwegian Agency for Development Cooperation. Additional information is on file with the Department of Justice, Washington, D.C.

MIGHTY EARTH

RAPID RESPONSE
Soy & Cattle Report

Report 9

January 2020

Prepared with

aidenvironment

Waxman

Executive Summary

This report presents nine cases of land clearing based on alerts data from DETER (System for Monitoring Deforestation on Real Time) and PRODES (Program for Deforestation Calculation) observed between October 27, 2019 and November 28, 2019 in the Brazilian Amazon and Cerrado biomes. Land clearing alerts considered in this report were visually confirmed. Four of the selected cases are in the Amazon biome and five are in the Cerrado biome.

Cleared land per municipality of all cases included in this report (in hectares)

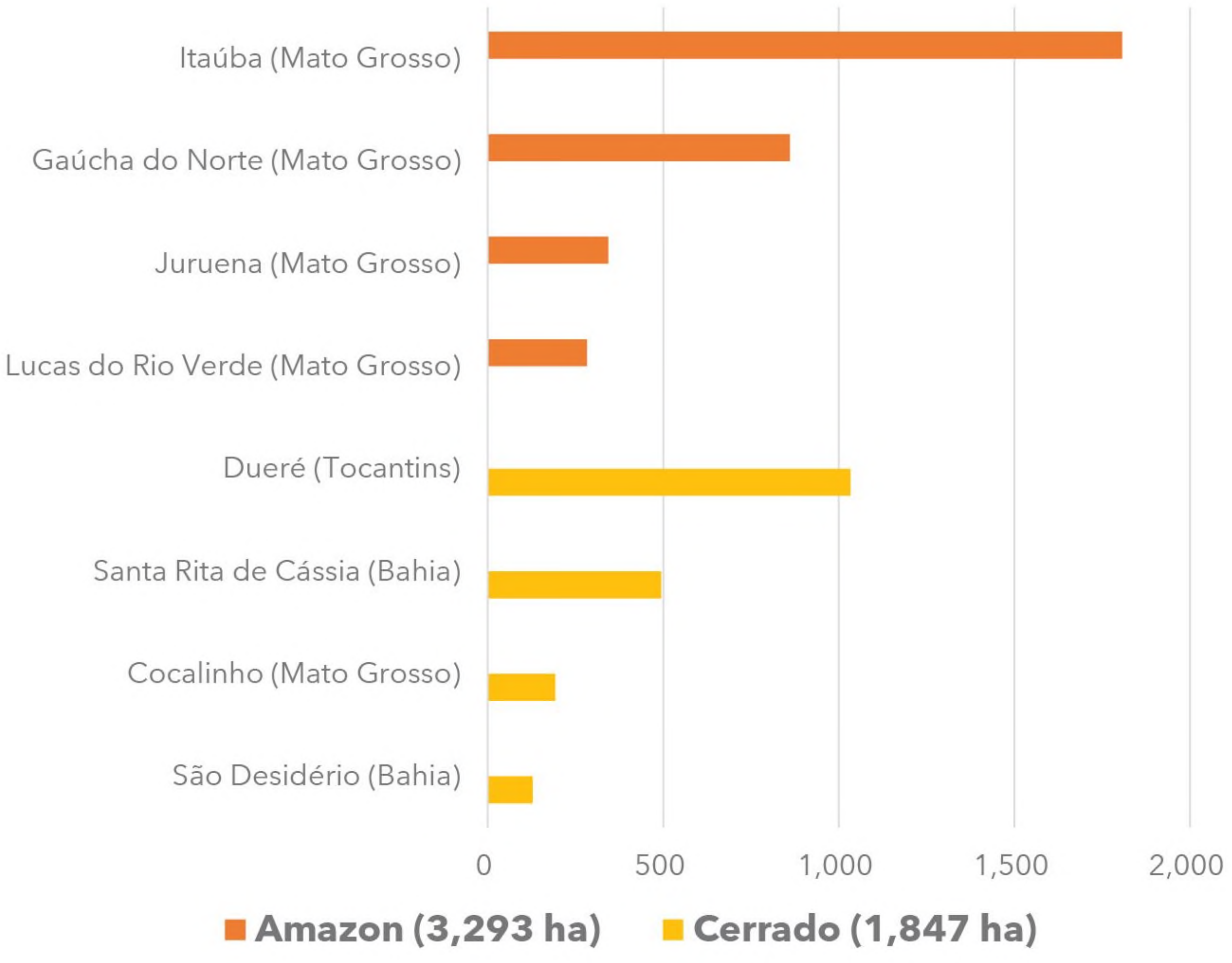


Table of Contents

Amazon Biome

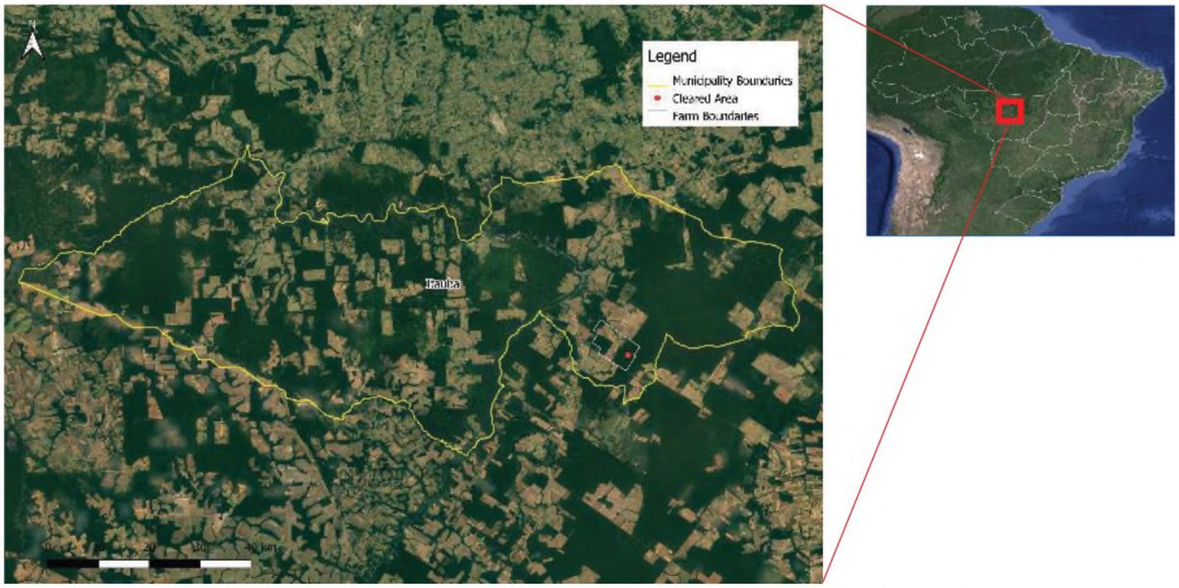
Cerrado Biome

1. Fazenda São João

Itaúba (Mato Grosso)

Amazon biome

Property Location



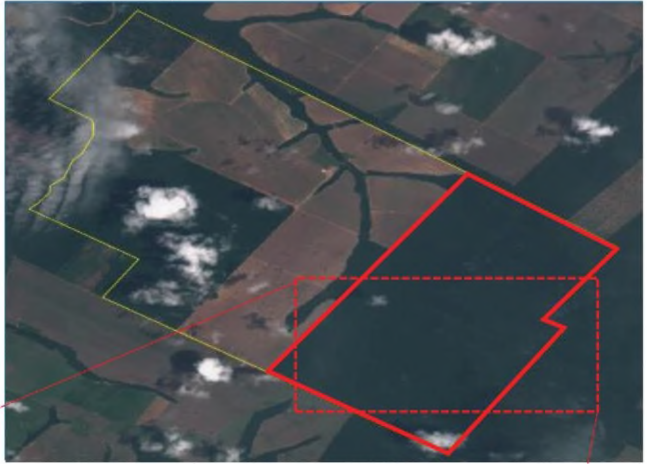
Yellow border – boundary of Itaúba (Mato Grosso) / White border – boundary of Fazenda São João / Red dot – location of cleared area

Alert Imagery (before and after clearance)

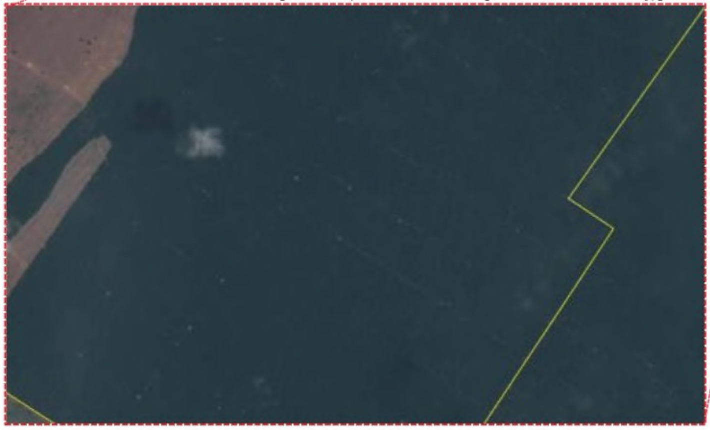
05-Aug-2019

Source: European Union, contains modified Copernicus Sentinel data 2019, processed with EO Browser

18-Nov-2019



Source: European Union, contains modified Copernicus Sentinel data 2019, processed with EO Browser



Source: European Union, contains modified Copernicus Sentinel data 2019, processed with EO Browser

1. Fazenda São João

Itaúba (Mato Grosso)

General Information				
Property; Registry		Fazenda São João		9110200312832
Size (ha); Coordinates		4,940		-55.24473, -11.20649
Land Clearance				
Period of clearing		05 Aug to 18 Nov 2019		
Size (ha); Coordinates		1,807		-55.21788, -11.22348
Inside Forest Code protected areas		Yes	1,807	ha inside declared Legal Reserve
Type of vegetation		Ombrophilous Forest transition		
Legal Status				
Embargoes		No	-	
Environmental fines		No	-	-
Natural Reserves		No	-	
Indigenous Lands		No	-	
Priority for biodiversity conservation		No		
Ownership				
Company group		no linked companies found		
Other linked properties		1 other property in Cláudia (MT): Fazenda Lagoa Azul - Esperança I (1,210 ha)		
Supply Chain				
Main commodity		Multiple		
Confirmed supply chain relation		Yes		
Soy	Main traders in municipality	Bunge (100%)		
	Warehouses within 50 km radius	28 warehouses, e.g.: 1 owned by Cargill (720,000 MT) and 3 owned by COFCO (124,000 MT)		
	Supply chain details	-		
Beef	Main traders in municipality	JBS (79%), Marfrig (11%), CP Comercial (4%), Minerva (2%) and others (4%)		
	Slaughterhouses sourcing from municipality	6 different beef processors sourced cattle from Itaúba in 2019, e.g.: 2 owned by JBS (Diamantino and Colider) and 2 owned by Vale Grande (Matupá and Nova Canaã do Norte)		
	Supply chain details	-		
Other supply chain details		-		

IBAMA named Fazenda São João on a "dirty list" of properties with environmental embargoes, and this list was the basis for a court case opened by the Federal Prosecutors in 2013 called "Pecuária Sustentável" (1). Fazenda São João was part of the court case for receiving fines for environmental degradation in 2006. In 2013, the state punishment for environmental crimes in Fazenda São João was prescribed and the court case linked to these crimes was closed by a local judge in Sinop (2). Consequently, in 2014, a Federal judge in Sinop (MT) decided to exclude Fazenda São João from the "Pecuária Sustentável" dirty list (3).

The family that owns Fazenda São João was also part of the ownership dispute of Gleba Atlântica Grandes Matas and was obliged to leave the area in 2018 (4). Other family members manage Estância Rodeio in Sinop (MT), Fazenda Santo Ângelo, Estância Berrante and Estância Velho Pai, all in Itaúba (MT), and other properties in Paranaiba (MT), Nova Santa Helena (MT) and Altamira (PA).

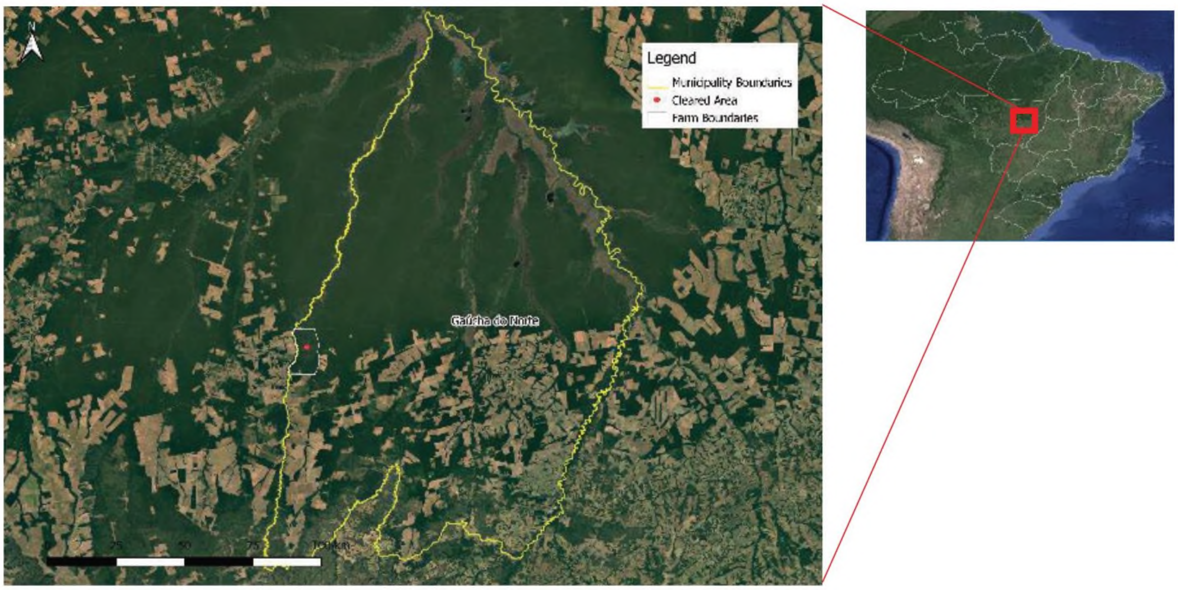
(1) http://www.mpf.mp.br/mt/sala-de-imprensa/pecuaria-sustentavel/Recomendacao_BNDES_Pecuaria%20Sustentavel.pdf
(2) https://www.jusbrasil.com.br/diarios/58221425/djmt-23-08-2013-pg-462
(3) https://www.jusbrasil.com.br/diarios/73230764/djmt-18-07-2014-pg-394
(4) http://www.folhamt.com.br/artigo/319867/Moradores-da-Gleba-Grandes-Matas-de-Sinop-terao-que-desocupar-area-por-decisao-judicial

2. Fazenda Batovi

Gaúcha do Norte (Mato Grosso)

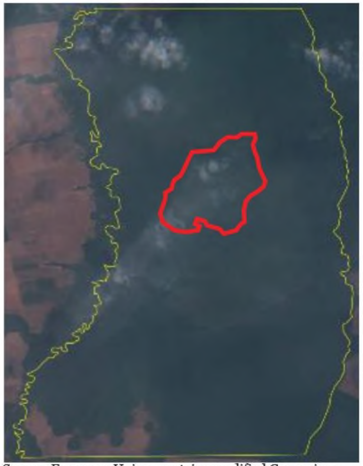
Amazon biome

Property Location



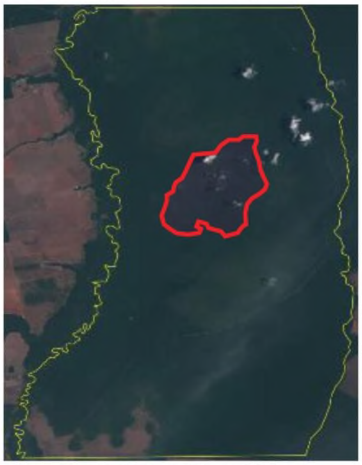
Yellow border – boundary of Gaúcha do Norte (Mato Grosso) / White border – boundary of Fazenda Batovi / Red dot – location of cleared area

Alert Imagery (before and after clearance)



01-Sep-2019

Source: European Union, contains modified Copernicus Sentinel data 2019, processed with EO Browser



31-Oct-2019

Source: European Union, contains modified Copernicus Sentinel data 2019, processed with EO Browser

Source: European Union, contains modified Copernicus Sentinel data 2019, processed with EO Browser

2. Fazenda Batovi

Gaúcha do Norte (Mato Grosso)

Amazon biome

General Information				
Property; Registry		Fazenda Batovi		9010322823752
Size (ha); Coordinates		15,031		-53.94970, -13.07999
Land Clearance				
Period of clearing		01 Sep to 31 Oct 2019		
Size (ha); Coordinates		860		-53.94110, -13.05646
Inside Forest Code protected areas		Yes	860	ha inside declared Legal Reserve and APP
Type of vegetation		Semidecidual Seasonal Forest		
Legal Status				
Embargoes		No	-	
Environmental fines		No	-	-
Natural Reserves		No	-	
Indigenous Lands		Yes	Bordering TI Batovi (Waurá) - inside the Indigenous Park of Xingu	
Priority for biodiversity conservation		High		
Ownership				
Company group		Batovi Agropecuária		
Other linked properties		no other linked properties found		
Supply Chain				
Main commodity		Soy		
Confirmed supply chain relation		No		
Soy	Main traders in municipality	Gavillon (17%), ADM (16%), Cargill (6%), Multigrain (6%), others (18%) and domestic consumption (37%)		
	Warehouses within 50 km radius	10 warehouses, e.g.: 2 owned by Macuco Agropecuária (33,000 MT) and 1 owned by Bunge (30,000 MT)		
	Supply chain details	-		
Beef	Main traders in municipality	Marfrig (85%), JBS (9%) and others (6%)		
	Slaughterhouses sourcing from municipality	6 different beef processors sourced cattle from Gaúcha do Norte in 2019, e.g.: 2 owned by JBS (Água Boa and Barra do Garças) and 2 owned by Marfrig (Paranatinga and Nova Xavantina)		
	Supply chain details	-		
Other supply chain details		-		

The company Batovi, the owner of the farm in this case, was closed in 2017 (1). There is no Environmental Database Declaration (CAR) in the area that could indicate recent operations or agricultural production.

Batovi was prosecuted and convicted in 2010 for lacking transparency regarding the use of financial benefits in an Amazon Development Agency (Sudam) program (2, 3).

During the recognition and delimitation of the Terra Indígena Batovi (Waujá people), Batovi Agropecuária alleged that the claimed area was under their ownership. The process started in 1992, and after 10 years, FUNAI recognized the Indigenous Land (4).

(1) https://www.sefaz.mt.gov.br/cadastro/emissaocartao/emissaocartaocontribuinteacessodireto
(2) https://economia.ig.com.br/empresas-de-agronegocio-terao-de-devolver-recursos-a-sudam/n1237561136844.html
(3) https://www.suinoculturaindustrial.com.br/imprensa/aplicacao-irregular/20100218-102342-F111
(4) https://pib.socioambiental.org/es/Not%C3%Adcias?id=9592

3. Fazenda Cerejeiras / Fazenda Jaracatiá

Juruena (Mato Grosso)

Amazon biome

Property Location

Yellow border – boundary of Juruena (Mato Grosso) / White border – boundary of Fazenda Cerejeiras and Fazenda Jaracatiá / Red dot – location of cleared area

Alert Imagery (before and after clearance)

02-Sep-2019

Source: European Union, contains modified Copernicus Sentinel data 2019, processed with EO Browser

26-Nov-2019

Source: European Union, contains modified Copernicus Sentinel data 2019, processed with EO Browser

Source: European Union, contains modified Copernicus Sentinel data 2019, processed with EO Browser

3. Fazenda Cerejeiras / Fazenda Jaracatiá

Juruena (Mato Grosso)

Amazon biome

General Information				
Property; Registry		Fazenda Cerejeiras / Fazenda Jaracatiá		9013771036403
Size (ha); Coordinates		8,074		-58.39609, -10.27201
Land Clearance				
Period of clearing		02 Sep to 26 Nov 2019		
Size (ha); Coordinates		343		-58.42272, -10.23518
Inside Forest Code protected areas		Yes	343	ha inside declared Legal Reserve
Type of vegetation		Ombrophilous Dense Forest		
Legal Status				
Embargoes		No	-	
Environmental fines		No	-	-
Natural Reserves		No	-	
Indigenous Lands		No	-	
Priority for biodiversity conservation		Very high		
Ownership				
Company group		no linked companies found		
Other linked properties		9 other properties, not possible to check total size. In Juruena (MT): Sítio Saraiva, Sítio Iasmim, Sítio Planície, Sítio Cachoeira, Sítio Santa Fé, Sítio Estância Firmino, Chácara Fundão and Sítio Iasmim 2. In Cotriguaçu (MT): Fazenda Vó Ivete		
Supply Chain				
Main commodity		Beef		
Confirmed supply chain relation		Yes		
Soy	Main traders in municipality	Domestic consumption (100%)		
	Warehouses within 50 km radius	No warehouses neither within 100 km radius		
	Supply chain details	-		
Beef	Main traders in municipality	Marfrig (58%), JBS (30%), Minerva (5%) and others (7%)		
	Slaughterhouses sourcing from municipality	5 different beef processors sourced cattle from Juruena in 2019, e.g.: 1 owned by JBS (Juina), 1 owned by Marfrig (Tangará da Serra), and 1 onwed by Vale Grande (Nova Canaã do Norte)		
	Supply chain details	Direct supplier to JBS (Juruena) and Marfrig (Tangará da Serra), in 2018 and 2019. Indirect supplier to JBS (Sapezal and Pontes e Lacerda) through Fazenda Rafaela, in Sapezal (MT), in 2018 and 2019		
Other supply chain details		-		

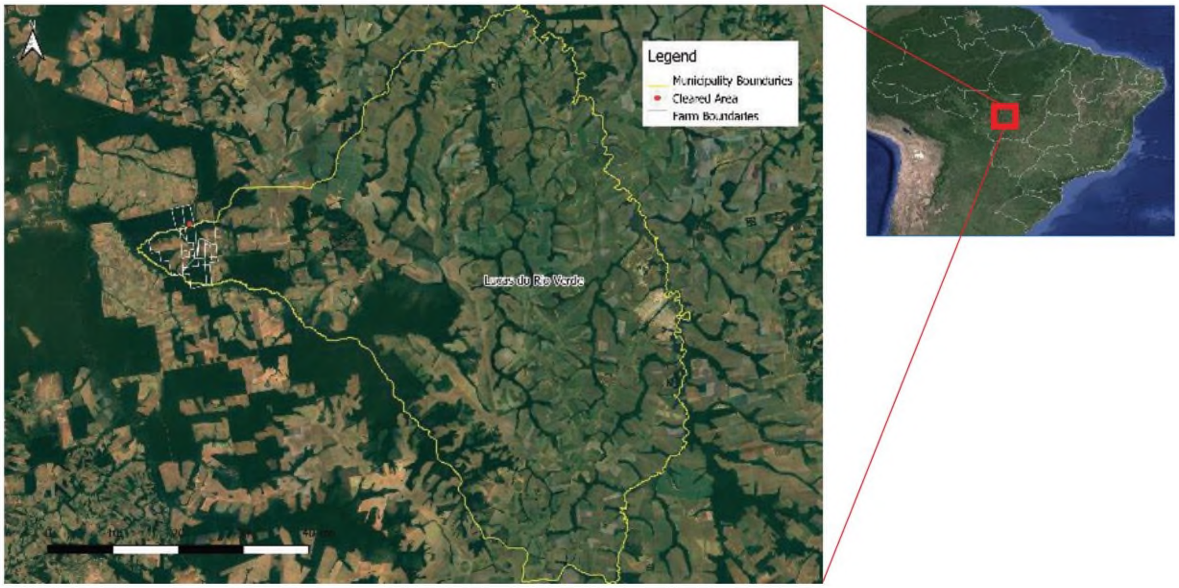
Fazenda Cerejeiras and Fazenda Jaracatiá directly supply cattle to Marfrig in Tangará da Serra (MT) and JBS in Juruena (MT). In 2010, the owners of these properties signed an agreement with the Mato Grosso environmental agency for the restoration of native vegetation after committing illegal deforestation in a property in Juruena (1).

(1) https://www.jusbrasil.com.br/diarios/28225299/pg-6-diario-oficial-do-estado-do-mato-grosso-doemt-de-06-01-2011

4. Fazenda Corumbá II / Fazenda Corumbá I and III, and Fazenda Sertão – Lucas do Rio Verde (Mato Grosso)

Amazon biome

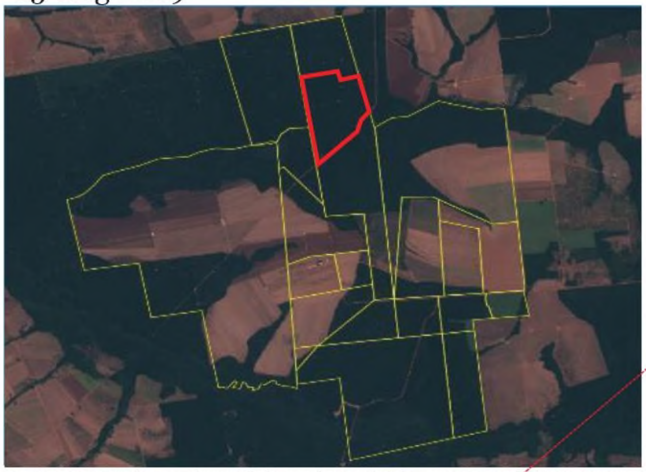
Property Location



Yellow border – boundary of Lucas do Rio Verde (Mato Grosso) / White border – boundary of Fazenda Corumbá II / Fazenda Corumbá I and III, and Fazenda Sertão / Red dot – location of cleared area

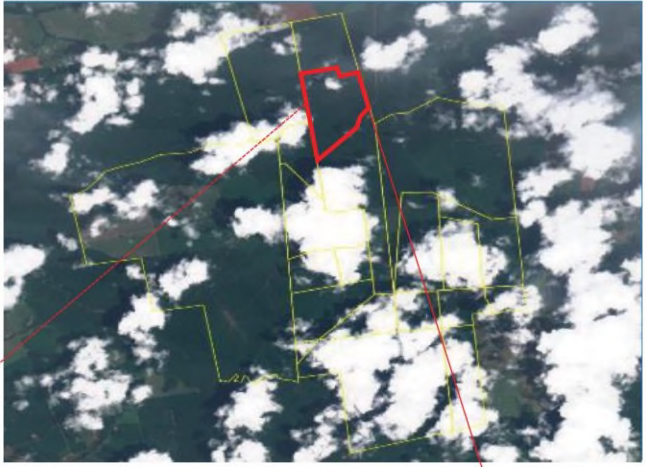
Alert Imagery (before and after clearance)

05-Aug-2019

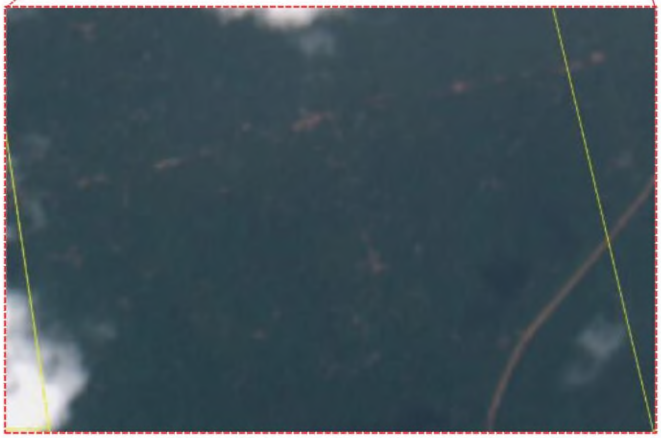


Source: European Union, contains modified Copernicus Sentinel data 2019, processed with EO Browser

08-Dec-2019



Source: European Union, contains modified Copernicus Sentinel data 2019, processed with EO Browser



Source: European Union, contains modified Copernicus Sentinel data 2019, processed with EO Browser

4. Fazenda Corumbá II / Fazenda Corumbá I and III, and Fazenda Sertão – Lucas do Rio Verde (Mato Grosso)

Amazon biome

General Information				
Property; Registry		Fazenda Corumbá II / Fazenda Corumbá I, Fazenda Corumbá III and Fazenda Sertão		9500176578918 / 9500331295774
Size (ha); Coordinates		8,009		-56.58922, -12.97719
Land Clearance				
Period of clearing		05 Aug to 08 Dec2019		
Size (ha); Coordinates		283		-45.06184, -7.91665
Inside Forest Code protected areas		Yes	283	ha inside declared Legal Reserve and APP
Type of vegetation		Ombrophilous Dense Forest		
Legal Status				
Embargoes		No	-	
Environmental fines		No	-	-
Natural Reserves		No	-	
Indigenous Lands		No	-	
Priority for biodiversity conservation		Very high		
Ownership				
Company group		no linked companies found		
Other linked properties		3 other properties totaling 3,620 ha. In Nossa Senhora do Livramento (MT): Fazenda Passárgada (1,940 ha). In Nova Mutum (MT): Gleba Matinhas (420 ha). In Juara (MT): Fazenda Sonho do Vô Gino (1,260 ha)		
Supply Chain				
Main commodity		Beef and Soy		
Confirmed supply chain relation		Yes		
Soy	Main traders in municipality	Amaggi (27%), Bunge (24%), Cargill (20%), Fiagril (11%), ADM (9%), COFCO (4%) and others (15%)		
	Warehouses within 50 km radius	42 warehouses, e.g.: 2 owned by Tauá Biodiesel (80,000 MT) and 3 owned by Marapé Agropecuária (53,000 MT)		
	Supply chain details	-		
Beef	Main traders in municipality	JBS (91%), CP Comercial (3%), Minerva (1%) and others (5%)		
	Slaughterhouses sourcing from municipality	8 different beef processors sourced cattle from Lucas do Rio Verde in 2019, e.g.: 1 owned by JBS (Dimantino), 1 owned by Naturafrig (Barra do Bugres), and 1 owned by Vale Grande (Nova Canaã do Norte)		
	Supply chain details	Linked property Fazenda Passargada, in Nossa Senhora do Livramento (MT), indirectly supplied cattle to JBS (Barra do Garças and Diamantino), Minerva (Várzea Grande), and Marfrig (Tangará da Serra) through Fazenda Jaguar, in Nortelândia (MT), in 2018		
Other supply chain details		-		

In 2010, the owner of Fazenda Corumbá I, II, and III and Fazenda Sertão signed an agreement with the Mato Grosso environmental agency for the restoration of native vegetation after the agency found environmental degradation in another property, Fazenda Sonho do Vô Gino in Juara (MT) (1).

In 2004, a company linked to the owner of the farm in this case, Jamad Indústria de Madeiras (currently not operating), was prosecuted by the Mato Grosso state attorney for illegal deforestation in a preservation area in São José do Rio Claro (MT) (2).

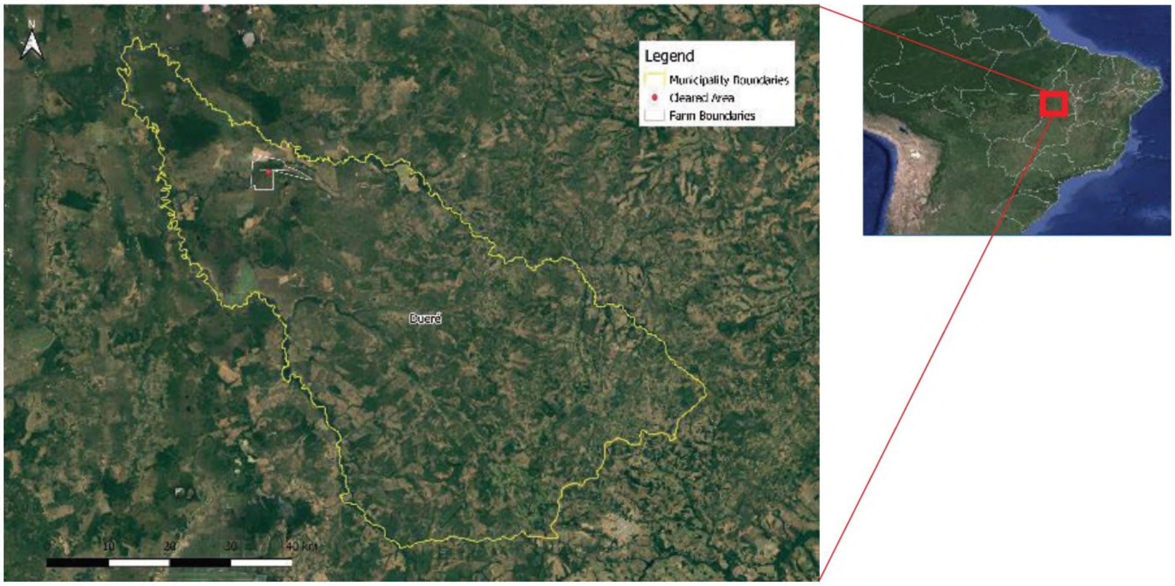
(1) https://www.jusbrasil.com.br/diarios/28223693/pg-44-diario-oficial-do-estado-do-mato-grosso-doemt-de-15-12-2010

(2) https://www.jusbrasil.com.br/diarios/30731814/pg-282-diario-de-justica-do-estado-do-mato-grosso-djmt-de-20-09-2011

5. Fazenda Tingui / Fazenda Remansão

Dueré (Tocantins)

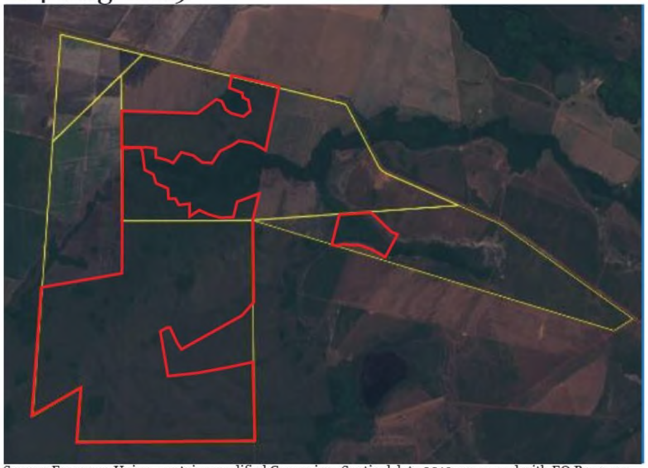
Property Location



Yellow border – boundary of Dueré (Tocantins) / White border – boundary of Fazenda Tingui and Fazenda Remansão / Red dot – location of cleared area

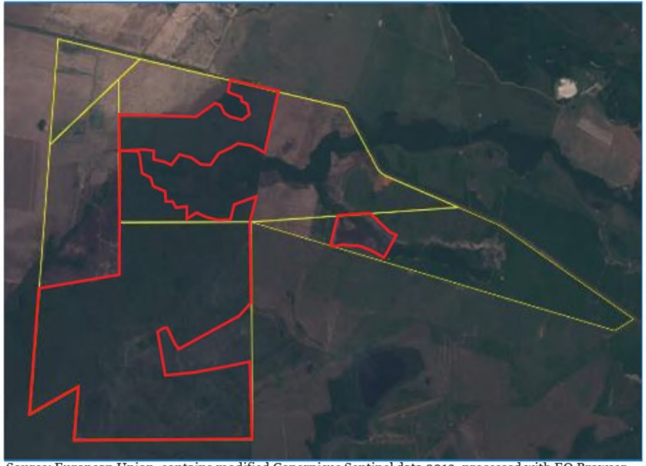
Alert Imagery (before and after clearance)

04-Aug-2019

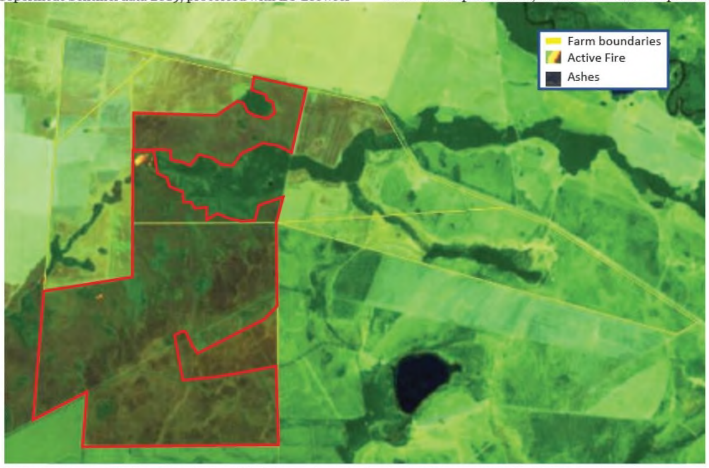


Source: European Union, contains modified Copernicus Sentinel data 2019, processed with EO Browser

12-Nov-2019



Source: European Union, contains modified Copernicus Sentinel data 2019, processed with EO Browser



Source: European Union, contains modified Copernicus Sentinel data 2019, processed with EO Browser

5. Fazenda Tingui / Fazenda Remansão

Dueré (Tocantins)

Cerrado biome

General Information				
Property; Registry		Fazenda Tingui / Fazenda Remansão		433632940 / 431261448
Size (ha); Coordinates		2,683		-49.56423, -11.20017
Land Clearance				
Period of clearing		04 Aug to 12 Nov 2019		
Size (ha); Coordinates		1,033		-49.58090, -11.19808
Inside Forest Code protected areas		Yes	1,021	ha inside declared Legal Reserve and APP
Type of vegetation		Savanna Park		
Legal Status				
Embargoes		No	-	
Environmental fines		No	-	-
Natural Reserves		No	-	
Indigenous Lands		No	-	
Priority for biodiversity conservation		No		
Ownership				
Company group		Agropecuária Quarain, Madeireira Remansão and Ciacel - Comércio, Indústria e Armazenamento de Cereais		
Other linked properties		7 bordering properties totaling 7,853 ha. In Dueré (TO): Fazenda Quarain (1,460 ha), 5 other parcels of Fazenda Remansão (6,273 ha), and another parcel of Fazenda Tingui (120 ha)		
Supply Chain				
Main commodity		Multiple		
Confirmed supply chain relation		No		
Soy	Main traders in municipality	Domestic consumption (100%)		
	Warehouses within 50 km radius	29 warehouses, e.g.: 2 owned by Marcelo Pedro de Moraes (54,000 MT), 3 owned by Lagovale - Cooperativa Industrial do Vale da Lagoa (32,000 MT) and 2 owned by Xavante Agroindustrial (16,000 MT)		
	Supply chain details	-		
Beef	Main traders in municipality	Cooperativa de Produtores de Carne e Derivados de Gurupi (76%) and Boi Brasil (24%)		
	Slaughterhouses sourcing from municipality	no data on beef processors sourcing cattle from Dueré		
	Supply chain details	-		
Other supply chain details		-		

5. Fazenda Tingui / Fazenda Remansão

Dueré (Tocantins)

The owner of Fazenda Tingui, Luiz Carlos Dal Molin, signed three agreements with environmental agencies to address environmental degradation in his properties. In 2011, he signed a TAC with the Federal environmental agency, IBAMA (1) for environmental degradation in a property in Pedro Afonso (Tocantins) (2). In 2013 (3) and 2014 (4) he signed another two agreements with the Tocantins environmental agency.

Near Fazenda Tingui, there is a settlement named "Loroty" or "Capão do Côco," where Krahô-Kanela indigenous people were relocated after some conflicts linked to the territory claimed by them in the bordering municipality of Lagoa da Confusão (5). After decades of claims, they are still waiting for their territorial rights to be guaranteed.

The Dal Molin family is also active in agribusiness activities in Amambaí (Mato Grosso do Sul) through their other company, Ciacel. Ari Dionísio Dal Molin, one of the partners of Ciacel, was president of two major wheat cooperatives in Rio Grande do Sul: Centralsul and Fecotrigo. In 1983, Brazil's Central Bank prohibited Ari from operating rural credits after having 200 million USD in debts (6). Ari was the former owner of Fazenda Sarandi, in Nonoaí (RS), whose occupation by landless workers in the 1970s inspired the creation of the Movement of Rural Landless Workers (MST) in 1985 (7).

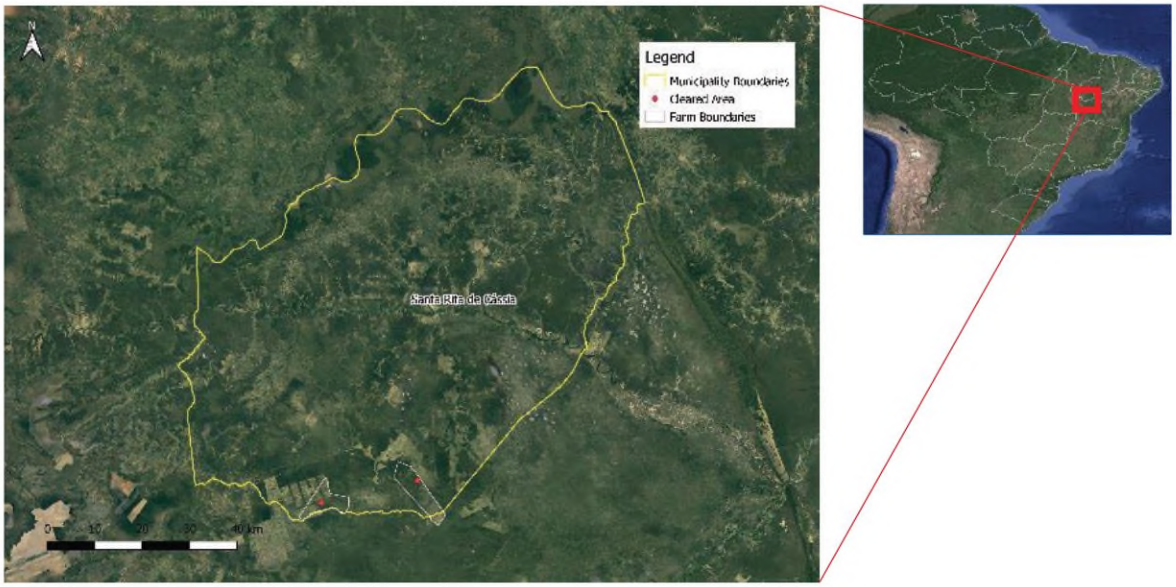
(1) https://www.jusbrasil.com.br/diarios/33205879/dou-secao-3-15-12-2011-pg-290
(2) https://servicos.ibama.gov.br/ctf/publico/areasembargadas/ConsultaPublicaAreasEmbargadas.php
(3) https://www.jusbrasil.com.br/diarios/49931156/doeto-17-01-2013-pg-50
(4) https://www.escavador.com/diarios/389558/DOETO/P/2014-12-02?page=47
(5) http://www.dhnet.org.br/w3/cdhcto/indio/funai.html
(6) https://books.google.com.br/books?id=evurDwAAQBAJ&pg=PT251&lpg=PT251&dq=Ari+Dion%C3%ADsio+Dalmolin&source=bl&ots=5Ap7j8amqo&sig=ACfU3UoMtItMPBC1VB-G517T51QbXevU1w&hl=pt-BR&sa=X&ved=2ahUKEwid-cLm9fnmAhVZD7kGHXhcBk44ChDoATAAegQICRAB#v=onepage&q=Ari%20Dion%C3%ADsio%20Dalmolin&f=false
(7) https://mst.org.br/2019/08/29/artigo-acampamento-na-fazenda-sarandi-vira-simbolo-de-resistencia/

6. Fazenda Novale

Santa Rita de Cássia (Bahia)

Cerrado biome

Property Location



Yellow border – boundary of Santa Rita de Cássia (Bahia) / White border – boundary of Fazenda Novale / Red dot – location of cleared area

Alert Imagery (before and after clearance)

07-Sep-2019

Source: European Union, contains modified Copernicus Sentinel data 2019, processed with EO Browser

21-Dec-2019

Source: European Union, contains modified Copernicus Sentinel data 2019, processed with EO Browser

6. Fazenda Novale

Santa Rita de Cássia (Bahia)

General Information				
Property; Registry		Fazenda Novale	3011080077907	
Size (ha); Coordinates		3,915	-44.72559, -11.38593	
Land Clearance				
Period of clearing		07 Sep to 21 Dec 2019		
Size (ha); Coordinates		289	-44.73109, - 11.38747	
Inside Forest Code protected areas		No	-	-
Type of vegetation		Forested Savanna		
Legal Status				
Embargoes		No	-	
Environmental fines		No	-	-
Natural Reserves		No	-	
Indigenous Lands		No	-	
Priority for biodiversity conservation		No		
Ownership				
Company group		Agropecuária A. Manjabosco, Agropecuária Mariana Manjabosco and Alvorada Sistemas Agrícolas, originally from Santa Rosa, Rio Grande do Sul (Southern Brazil)		
Other linked properties		4 other properties totaling 16,461 ha. In Riachão das Neves (BA): Fazenda Santa Maria (3,335 ha), Fazenda Santa Maria II (1,830 ha) and Fazenda Santa Marta (1,246 ha). In Formosa do Rio Preto (BA): Fazenda Triunfo (10,050 ha)		
Supply Chain				
Main commodity		Multiple		
Confirmed supply chain relation		No		
Soy	Main traders in municipality	Gavillon (46%), Copalem (3%) and domestic consumption (51%)		
	Warehouses within 50 km radius	6 warehouses, e.g.: 1 owned by Bunge (83,000 MT)		
	Supply chain details	-		
Beef	Main traders in municipality	JBS (100%)		
	Slaughterhouses sourcing from municipality	8 different regional beef processors sourced cattle from Santa Rita de Cássia in 2017, all located in Bahia		
	Supply chain details	Direct supplier to Frigorífico Vale do Sol (Jequié), Frigorífico Regional de Barreiras (Barreiras), Frigorífico Muquém de São Francisco (Muquém de São Francisco,) and Confrigo Frigorífico (Vitória da Conquista) between 2014 and 2017		
Other supply chain details		In 2014, Fazenda Triunfo supplied corn to Asa indústria e Comércio in Pernambuco		

6. Fazenda Novale

Santa Rita de Cássia (Bahia)

Fazenda Novale (Santa Rita de Cássia, Bahia) and Fazenda Triunfo (Formosa do Rio Preto, Bahia) are part of the owner's family business, which integrates cattle, soy, and timber production (1) in Western Bahia. In 2015, the family's cattle business included 2,500 animals with an expectation to double the livestock total in the following years (2). A family member is a partner of the Cooperativa dos Produtores Rurais da Bahia (Cooperfarms), present also in Goiás and Tocantins states (3). The family also owns a company that officially represents the John Deere brand in Rio Grande do Sul (4).

In November 2019, Agropecuária A. Manjabosco and Agropecuária Mariana Manjabosco were investigated as part of a federal police operation, Avati, which resulted in the companies' prosecution for tax fraud (totaling BRL 6.5 million), money laundering and criminal association together with other groups and landowners (5).

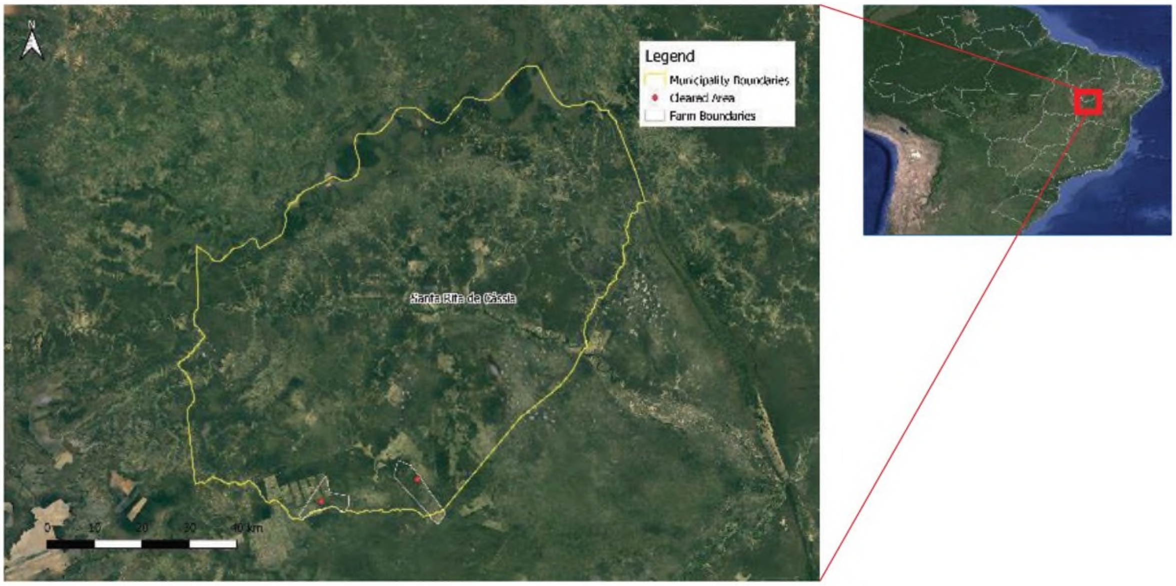
(1) https://revistagloborural.globo.com/Integracao/noticia/2016/04/integracao-da-opcao-de-renda-e-ameniza-riscos.html
(2) https://www.dinheirorural.com.br/secao/agronegocios/fantastica-fabrica-de-touros
(3) https://www.consultasocio.com/q/sa/eduardo-antonio-manjabosc
(4) http://www.alvorada-rs.com.br/content/about_us
(5) https://www.correio24horas.com.br/noticia/nid/empresas-ligadas-ao-agronegocio-sao-suspeitas-de-sonegar-r-20-milhoes-na-bahia/

7. Fazenda Piracicaba

Santa Rita de Cássia (Bahia)

Cerrado biome

Property Location



Yellow border – boundary of Santa Rita de Cássia (Bahia) / White border – boundary of Fazenda Piracicaba / Red dot – location of cleared area

Alert Imagery (before and after clearance)

07-Sep-2019

Source: European Union, contains modified Copernicus Sentinel data 2019, processed with EO Browser

21-Dec-2019

Source: European Union, contains modified Copernicus Sentinel data 2019, processed with EO Browser

7. Fazenda Piracicaba

Santa Rita de Cássia (Bahia)

General Information				
Property; Registry		Fazenda Piracicaba		3010603081613
Size (ha); Coordinates		5,243	-44.54460, -11.36682	
Land Clearance				
Period of clearing		07 Sep to 21 Dec 2019		
Size (ha); Coordinates		205	-44.54662, -11.34496	
Inside Forest Code protected areas		No	-	-
Type of vegetation		Forested Savanna		
Legal Status				
Embargoes		No	-	
Environmental fines		No	-	-
Natural Reserves		No	-	
Indigenous Lands		No	-	
Priority for biodiversity conservation		No		
Ownership				
Company group		Family group owns a building supply shop in Paulo Afonso, Bahia, and distribution companies in Bahia, Alagoas and Sergipe (baverage, coffe and gas)		
Other linked properties		2 other properties totaling 1,031 ha. In Santa Rita de Cássia (BA): Fazenda Vitória (906 ha). In Riachão das Neves (BA): Fazenda Sabiá (125 ha)		
Supply Chain				
Main commodity		Soy		
Confirmed supply chain relation		No		
Soy	Main traders in municipality	Gavillon (46%), Copalem (3%) and domestic consumption (51%)		
	Warehouses within 50 km radius	3 warehouses, e.g.: 2 warehouses owned by Leandro Volter Laurindo de Castilhos (4,900 MT) and 1 owned by Osvino Ricardi (unknown capacity)		
	Supply chain details	-		
Beef	Main traders in municipality	JBS (100%)		
	Slaughterhouses sourcing from municipality	8 different regional beef processors sourced cattle from Santa Rita de Cássia in 2017, all located in Bahia		
	Supply chain details	-		
Other supply chain details		-		

Part of Fazenda Piracicaba (around 4,320 ha) is under ownership dispute between the Onias Silva family and Equatorial Transmissora, an energy supply company, and the court has not yet resolved the case (1). Onias Silva is a family of politicians from Juazeiro, Bahia (2). They have family links with Misael Aguilar Silva Neto, a former state deputy in Bahia (2007-2011) (3), and with Misael Aguilar Silva Júnior, former mayor of Juazeiro, Bahia. Misael Aguilar Silva Júnior was condemned in 2011 to return BRL 90,000 to the mayor's office because these funds were inappropriately given to private entities, including the Trade & Agriculture Association of Juazeiro (4).

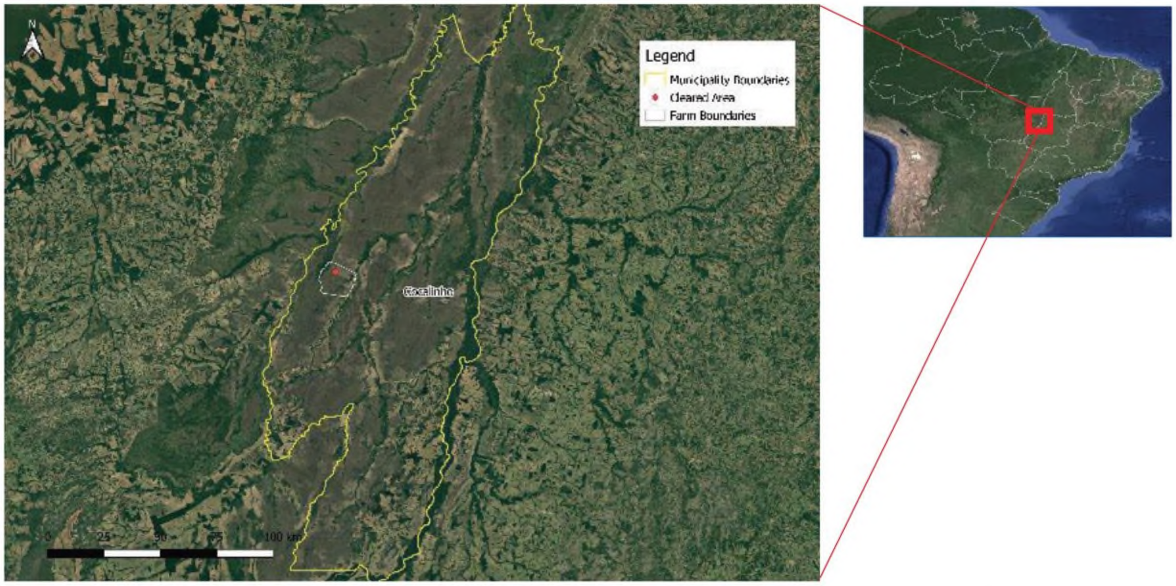
(1) https://www.jusbrasil.com.br/processos/213797492/processo-n-8000393-4820188050224-do-tjba
(2) http://www.araujo.eti.br/descend.asp?numPessoa=13654&dir=genxdir/
(3) https://www.al.ba.gov.br/deputados/ex-deputado-estadual/910647
(4) https://www.correio24horas.com.br/noticia/nid/ex-prefeito-de-juazeiro-e-condenado-a-devolver-cerca-de-r-90-mil-aos-cofres-da-cidade/

8. Fazenda São Domingos (Cobiçada Gleba 1/1A)

Cocalinho (Mato Grosso)

Cerrado biome

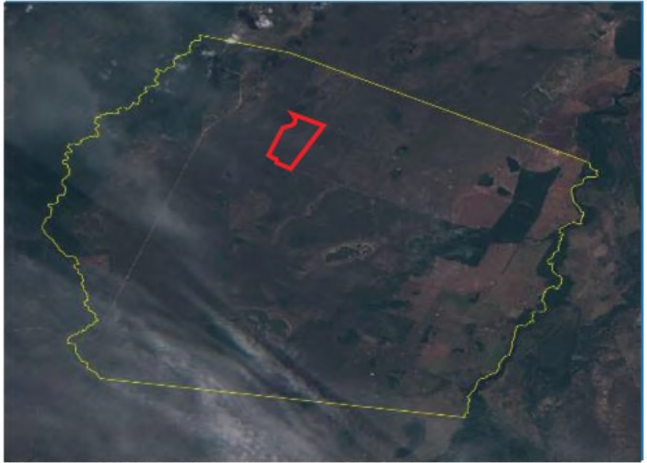
Property Location



Yellow border – boundary of Cocalinho (Mato Grosso) / White border – boundary of Fazenda São Domingos (Cobiçada - Gleba 1/1A) / Red dot – location of cleared area

Alert Imagery (before and after clearance)

06-Jun-2019



Source: European Union, contains modified Copernicus Sentinel data 2019, processed with EO Browser

02-Dec-2019

Source: European Union, contains modified Copernicus Sentinel data 2019, processed with EO Browser

8. Fazenda São Domingos (Cobiçada Gleba 1/1A)

Cocalinho (Mato Grosso)

Cerrado biome

General Information				
Property; Registry		Fazenda São Domingos (Fazenda Cobiçada Gleba 1/1A)		9050701022610
Size (ha); Coordinates		19,016	-51.42701, -13.79318	
Land Clearance				
Period of clearing		06 Jun to 02 Dec 2019		
Size (ha); Coordinates		192	-51.43153, - 13.75883	
Inside Forest Code protected areas		No	-	-
Type of vegetation		Forested Savanna		
Legal Status				
Embargoes		Yes	Clearance of 210 ha without authorization (2016)	
Environmental fines		Yes	2 fines for environmental degradation (September 2019)	BRL 556,000
Natural Reserves		No	-	
Indigenous Lands		Yes	Overlaping TI Wedezé (Xavante)	
Priority for biodiversity conservation		No		
Ownership				
Company group		no linked companies found		
Other linked properties		3 other properties, not possible to check total size. In Cocalinho (MT): Fazenda Jussara, Fazenda Cobiçada I and Fazenda Cobiçada II		
Supply Chain				
Main commodity		Beef		
Confirmed supply chain relation		Yes		
Soy	Main traders in municipality	Gavillon (41%) and domestic consumption (59%)		
	Warehouses within 50 km radius	No warehouses within 50 km radius, but 39 warehouses within 100 km radius, e.g.: 2 owned by Caramuru Alimentos (135,000 MT), 3 owned by Cargill (120,000 MT), 2 owned by Louis Dreyfus (115,000 MT), 1 owned by COFCO (67,000 MT) and 1 owned by Bunge (59,000 MT)		
	Supply chain details	-		
Beef	Main traders in municipality	JBS (91%), Minerva (2%), Marfrig (2%) and others (5%)		
	Slaughterhouses sourcing from municipality	Indirect supplier to JBS (Água Boa, Barra do Garças and Confresa) through Fazenda Amparo and Fazenda Água Preta in Cocalinho (MT), both owned by Agropecuária Água Preta, in 2018 and 2019		
	Supply chain details	-		
Other supply chain details		-		

The owner of Fazenda Cobiçada (Gleba 1 and 1A) also owns nine companies in Goiás with a total equity of BRL 80 million (1). The same owner is linked to other farms in Cocalinho (Fazenda Cobiçada I, Fazenda Cobiçada II and Fazenda Jussara). Although we found three embargoed areas linked to the farms Cobiçada I and II, it was not possible to confirm a connection between these embargoes and Fazenda São Domingos (Cobiçada Gleba 1 and 1A).

In 2011, one of the companies linked to Fazenda Cobiçada Gleba 1 and 1A was part of a court case involving the former mayor of Goiânia, Íris Rezende. The prosecution was linked to the acquisition of an under-priced area by the municipality of Goiânia resulting in a loss to the public finances (2). The owner of Fazenda Cobiçada is affiliated with the Sindicato Rural de Cocalinho (3).

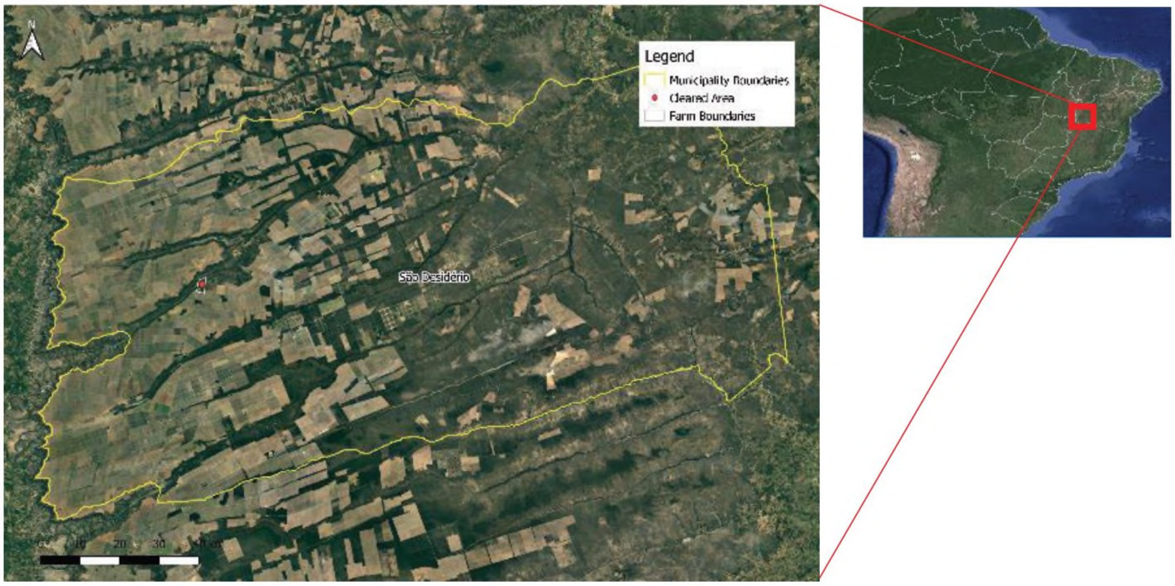
(1) https://www.consultasocio.com/q/sa/claudionor-rodrigues-fernandes
(2) https://mp-go.jusbrasil.com.br/noticias/2857633/mp-aciona-ex-prefeito-e-empresa-por-improbidade-na-permuta-de-area-publica
(3) http://www.cocalinhorural.com.br/cocalinhorural/associados.php

9. Fazenda Santana I

São Desidério (Bahia)

Cerrado biome

Property Location



Yellow border – boundary of São Desidério (Bahia) / White border – boundary of Fazenda Santana I / Red dot – location of cleared area

Alert Imagery (before and after clearance)

02-Oct-2019

Source: European Union, contains modified Copernicus Sentinel data 2019, processed with EO Browser

21-Dec-2019

Source: European Union, contains modified Copernicus Sentinel data 2019, processed with EO Browser

Source: European Union, contains modified Copernicus Sentinel data 2019, processed with EO Browser

9. Fazenda Santana I

São Desidério (Bahia)

Cerrado biome

General Information				
Property; Registry		Fazenda Santana I		2290400399854
Size (ha); Coordinates		690	-45.94458, -12.80264	
Land Clearance				
Period of clearing		02 Oct to 21 Dec 2019		
Size (ha); Coordinates		128	-45.94369, -12.79867	
Inside Forest Code protected areas		No	-	-
Type of vegetation		Woody-grass Savanna		
Legal Status				
Embargoes		No	-	
Environmental fines		No	-	-
Natural Reserves		No	-	
Indigenous Lands		No	-	
Priority for biodiversity conservation		No		
Ownership				
Company group		no linked companies found		
Other linked properties		1 bordering property in São Desidério (BA): Fazenda São Geraldo (174 ha)		
Supply Chain				
Main commodity		Beef and Soy		
Confirmed supply chain relation		No		
Soy	Main traders in municipality	ADM (23%), Multigrain (17%), Bunge (11%), Amaggi & LD Commodities (9%), Cargill (8%), COFCO (4%), others (1%) and domestic consumption (27%). In 2017, ranked 2nd in soy production in Brazil and 1st in Bahia		
	Warehouses within 50 km radius	135 warehouses, e.g.: 3 owned by Bunge (126,00 MT) and 2 owned by Cargill (45,000 MT)		
	Supply chain details	-		
Beef	Main traders in municipality	JBS (100%)		
	Slaughterhouses sourcing from municipality	3 different regional beef processors sourced cattle from São Desidério in 2017: 1 in Muquém do São Francisco, 1 in Barreiras and 1 in Brumado, all in Bahia		
	Supply chain details	Linked property Fazenda São Geraldo, in São Desidério (BA), directly supplied cattle for fattening to 3 farms in Bahia in 2016 and 2017		
Other supply chain details		-		

In 2015, the state environmental agency of Bahia authorized the conversion of 600 hectares of native vegetation in Fazenda Santana I for agricultural activities (1).

The owner of Fazenda Santana I is affiliated with the Association of Irrigators of Bahia (AIBA) (2). The family owns a building supply shop in Aparecida de Goiânia (Goiás) (3) and petrol stations in Western Bahia. In 2013, the owner of Fazenda Santana I caused a car accident that killed two people in São Desidério, Bahia (4), and the corresponding court case continues nearly seven years later.

(1) http://portaldatransparencia.com.br/prefeitura/saodesiderio/?pagina=abreDocumento&arquivo=31ED04598C4D
(2) https://aiba.org.br/wp-content/uploads/2016/01/informaiba-Janeiro-2016-1.pdf
(3) https://www.consultasocio.com/q/sa/leonidas-fernandes-lima
(4) http://www.infosaodesiderio.com/2013/09/empresario-responsavel-por-tragedia.html

Glossary

Deforestation and land clearance - Any land use change already classified as loss of native vegetation by deforestation alert systems

Agrarian conflicts - Include conflicts on land tenure, for natural resources (water, forests), slave labor, other crimes, and human right issues

Embargoed areas - Areas where any kind of activity is suspended or not authorized by the Federal Environmental Agency (IBAMA) due to environmental degradation or irregularity

Environmental fines - List of environmental infractions that resulted in fines addressed to the owner of the property where the crimes were found

Forest Code protected areas - Areas defined by the Brazilian Forest Code that have mandatory conservation status in private properties. *Legal Reserves* [80% (Amazonia biome), 35% (Cerrado biome inside Legal Amazon), 20% other areas] and *Permanent Preservation Areas (APP)* linked to water and soil conservation (close to river bases, wetlands, slopes, and high hills). The Legal Reserve and APP areas considered in this report are those self-declared within the Environmental Register System "Cadastro Ambiental Rural – CAR". In some cases, the CAR was also used to find information on ownership because even if it is a self-declared document, sometimes, it provides the most recent information on the probable ownership of a property.

Illegal deforestation - Any deforestation event happening without an authorization of the state or federal environmental agency or those that are inside a Legal Reserve or a Permanent Preservation Area (APP)

Natural Reserves - Officially recognized Natural Reserves areas according to the National System of Natural Reserves (SNUC – Sistema Nacional de Unidades de Conservação). The SNUC determines who administrates the area - federal, state or local government, or private owner -, and how the natural resources may be used by whom in each of the natural reserves' categories.

Indigenous lands - Lands under FUNAI (Nacional Foundation for Indigenous People) administration defined as a heritage right of local Indigenous populations where any activity not linked to these groups are not allowed.

Priority for Biodiversity conservation - Brazilian Ministry of Environment (MMA) study listing the Biodiversity hotspots in Brazil and the priority of actions for biodiversity conservation in these areas.

* * * *

The Rapid Response program has received support, in part, from the International Climate and Forest Initiative (NICFI) scheme managed by the Norwegian Agency for Development Cooperation (Norad). This report does not necessarily reflect the standpoints of Norad.

The work of Mighty Earth is supported by Waxman Strategies. Waxman Strategies' work on forest conservation is funded in part by Aidenvironment. Waxman is required under 22 U.S.C. § 614 to disclose that this material is distributed on behalf of the aforementioned organization, working under grant from the Norwegian Agency for Development Cooperation. Additional information is on file with the Department of Justice, Washington, D.C.

Re: Rapid Response: Soy and Cattle, report 9

Compliance <compliance@waxmanstrategies.com>
Thu 1/23/2020 10:09 AM
To: Compliance <compliance@waxmanstrategies.com>

From: Rapid Response <rapidresponse@mightyearth.org>
Sent: Wednesday, January 22, 2020 10:48 AM
To: Nick Martell-Bundock <Nick_Martell-Bundock@cargill.com>
Cc: Sarah Brickman <sarah@mightyearth.org>
Subject: RE: Rapid Response: Soy and Cattle, report 9

Hi Nick,

No problem. Our team visually confirms the cases of deforestation using high-resolution satellite imagery. We don't have enough resources to perform ground truthing, but usually the satellite imagery provides sufficient evidence.

And great, I will update my email list with the contacts that you provide below.

Thanks so much, and I look forward to learning more about Cargill's investigation into the Bom Futuro case.

Best,

SARAH BRICKMAN I SENIOR ASSOCIATE I mightyearth.org
T +1-941-726-5851
sarah@mightyearth.org
Follow us: Facebook I Twitter

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Re: Rapid Response: Soy and Cattle, report 8

Compliance <compliance@waxmanstrategies.com>
Thu 1/23/2020 10:10 AM
To: Compliance <compliance@waxmanstrategies.com>

From: Rapid Response <rapidresponse@mightyearth.org>
Sent: Wednesday, January 22, 2020 11:18 AM
To: Michel Santos <Michel.Santos@bunge.com>
Cc: Sarah Brickman <sarah@mightyearth.org>; Daiana Bein Endruweit <Daiana.Endruweit@bunge.com>; BGA Sustainability <sustainability@bunge.com>
Subject: RE: Rapid Response: Soy and Cattle, report 8

Dear Michel,

Thanks for letting me know about Bunge's relationship with Fazenda Cocal. I'm attaching here additional images of Fazenda Cocal's recent clearance, including evidence that the property used fires to clear native vegetation. While the deforestation that took place in late 2019 was not connected to last year's soy harvest, soy could be planted in the cleared area in future years. How is Bunge engaging Bom Futuro / Fazenda Cocal about this case?

Thank you for your continued engagement and transparency.

Best,

SARAH BRICKMAN I SENIOR ASSOCIATE I mightyearth.org
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sarah@mightyearth.org
Follow us: Facebook I Twitter

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Re: Rapid Response: Soy and Cattle, report 7

Compliance <compliance@waxmanstrategies.com>
Thu 1/23/2020 10:11 AM
To: Compliance <compliance@waxmanstrategies.com>

From: Rapid Response <rapidresponse@mightyearth.org>
Sent: Wednesday, January 22, 2020 3:33 PM
To: Michel Santos <Michel.Santos@bunge.com>
Cc: Daiana Bein Endruweit <Daiana.Endruweit@bunge.com>; Sarah Brickman <sarah@mightyearth.org>
Subject: RE: Rapid Response: Soy and Cattle, report 7

Hi Michel,

I see my original email regarding report 7 in the Rapid Response sent box, but it's possible that it didn't go through to you if your mailbox was full (I occasionally receive a bounce-back message when this is the case). But no worries! I appreciate you sharing this report with your team and I look forward to your response.

Best,

SARAH BRICKMAN I SENIOR ASSOCIATE I mightyearth.org
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sarah@mightyearth.org
Follow us: Facebook I Twitter

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