



Soybean: The Versatile Miracle Crop

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Soy is everywhere. It can be found on the coating of fruit in the grocery store, in candy bars, and it comprises most of the vegetable oil we consume. Some experts claim Americans consume almost 40 pounds of soybean oil each year.¹ Despite its prominence in human food, the soybean is the most common item on the menu for farmed animals, who eat over 90 percent of what is grown today.² In 2021, six percent of the earth's surface was covered with soybeans.³

Over the past three decades, soybean growers in parts of South America have developed a reputation as the villains behind the acceleration of Amazonian deforestation.⁴ However, the story is not so simple, as soy is a highly politicized crop, entrenched in questions of land ownership, supply chains, and value. It is also one of the world's most genetically modified (GM) crops—in the United States alone, over 90 percent of soybeans are GM.⁵ While this has allowed soybeans to be grown in a variety of conditions while resisting weeds and pests, those same attributes make the plant dangerous to grow due to the toxicity of fertilizers and the ever-changing resistance of the plant to new chemicals.⁶



⋮ Soybean Oil, Meal, and Beans



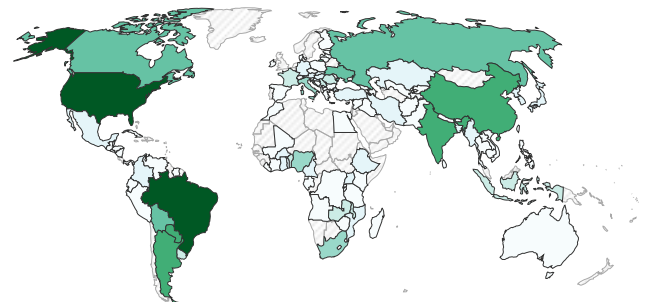
Soybean production, 2023

Soybean production is measured in tonnes.

Our World in Data

Table Map Chart

Zoom to...



1961 2023

Data source: Food and Agriculture Organization of the United Nations (2025) - [Learn more about this data](#)

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Humble Origins

Wild soybeans, *Glycine soja*, were originally found in a geographical range that “extends from Afghanistan in the west to Japan in the east, and from southern Siberia in the north to the subtropics of the Yangzi River valley.”⁷ *Glycine soja* is thought to have been “naturally distributed ... as early as 9,000 years ago.”⁸ For its first couple thousand years of domestication, however, soy, like wheat at the time, was not considered a prized food for human consumption due to its difficulty to digest without being refined and cooked.⁹



Map of Machuria



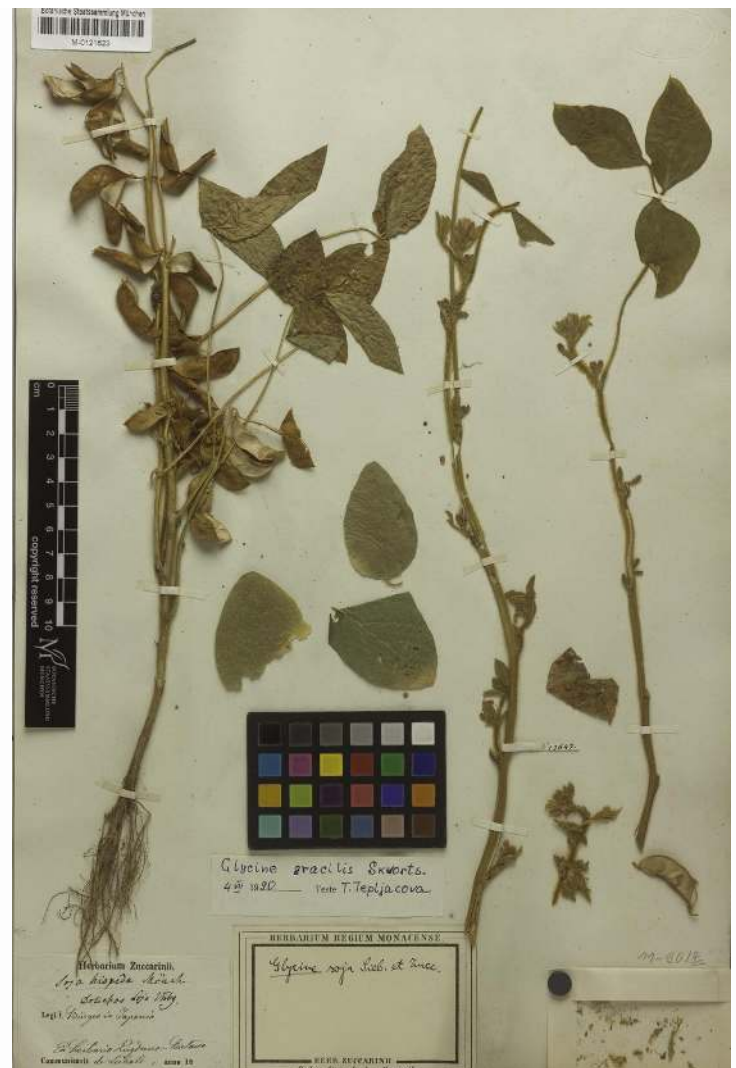
Soy's reputation as a difficult-to-digest food began to change in the third century BCE, when a fermented soy product known as shi grew in popularity in China.¹⁰ Not long after, soy appears in the *Fan Shengzhi shu*, a Han dynasty agricultural text from the first century BCE.¹¹ It provides detailed instructions on how to plant and cultivate soybeans (primarily, still, for animal feed) and even estimates what yields would be.¹²



Chinese Materia Dietetica, Ming: Fermented sauce...



Soybeans have an innate ability to grow almost anywhere and survive almost anything; this resiliency has led them to be referred to as “weedy.”¹³ In the beginning of the soybean story, people did not really choose the soybean—the soybean, an ideal crop with its ability to spread and resist adverse conditions, chose people.¹⁴ As the authors of a recent publication noted, “Soybeans probably began their career in agriculture not as valued crops, but as weeds that could be eaten if necessary.”¹⁵



⋮ Glycine max



International Expansion

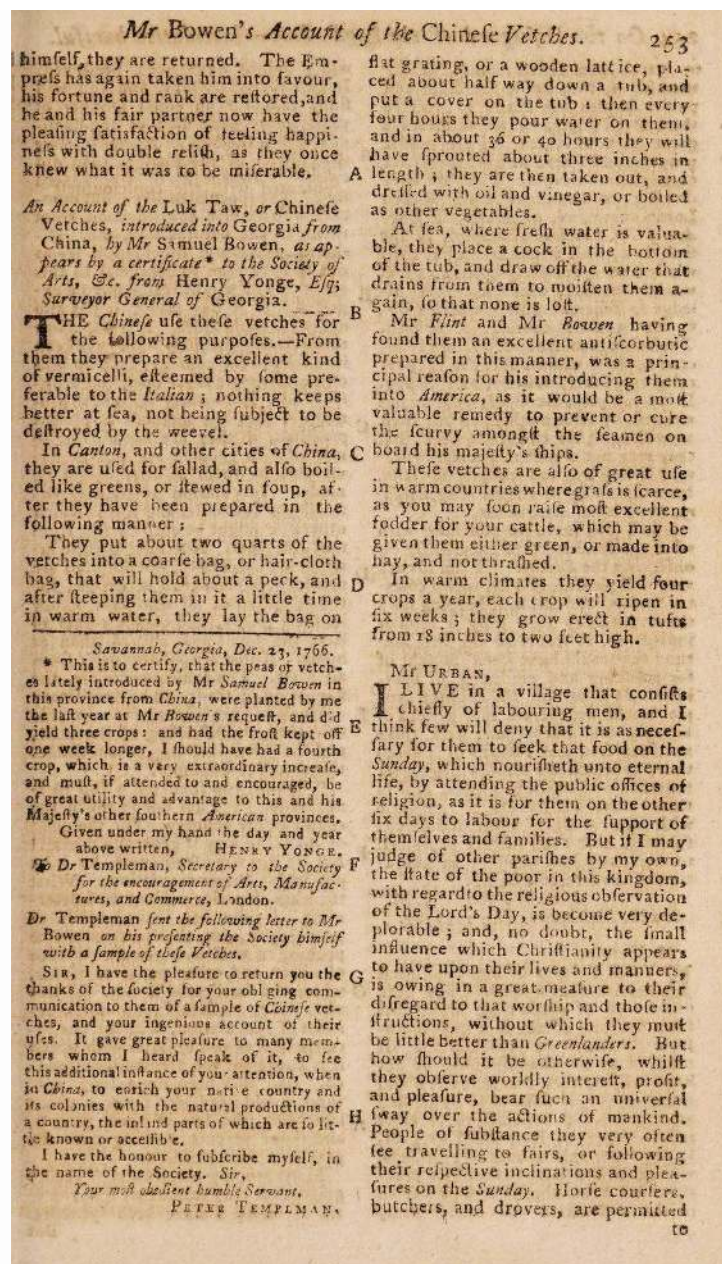
In the sixteenth century, soybeans were mentioned in herbalist Li Shizhen's medical manual *Bencao gangmu*, where he described how “virtually every part of the plant was used as medicine.”¹⁶



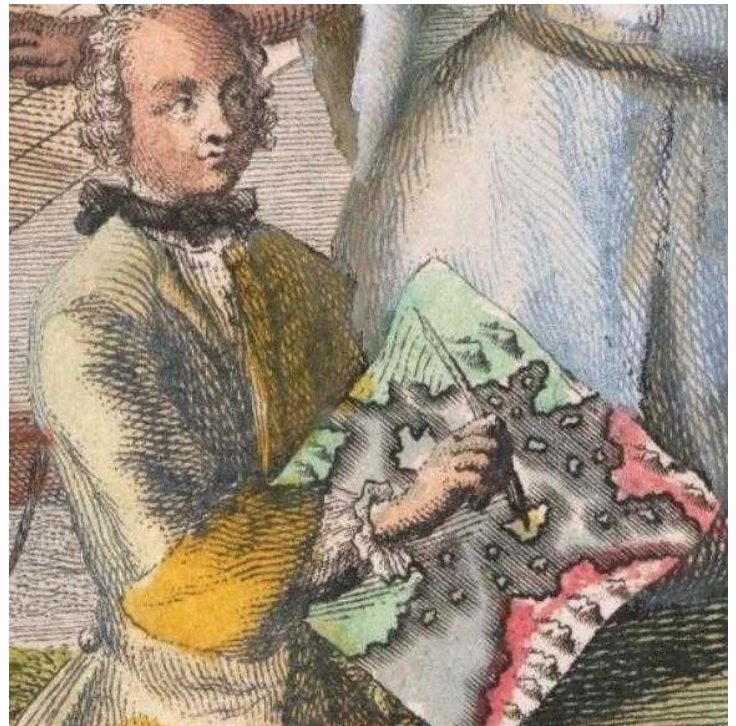
Portrait of Li Shizhen



In 1765, Samuel Bowen, an Englishman who traveled to China with the British East India Company, brought soy seeds to the United States. He asked the surveyor general of Georgia to plant them for him, providing detailed notes about what soybeans could be used for including making soy sauce for export to England.¹⁷ Bowen also described how the Chinese produced vermicelli, a type of noodle, from soybeans. The surveyor general subsequently reported that the soybeans yielded three crops and might have yielded a fourth had there not been a frost.¹⁸ By the eighteenth century, demand for soybean was beginning to boom, and merchants were exporting soybeans from Manchuria, a fertile region of Northeast China, to other areas, including "Shanghai and Amoy, where the beans were processed into condiments or pressed for oil."¹⁹ The European word for soy, "soya" comes from the Japanese word shoyu, or soy sauce; "the bean was named, in other words, for its processed product."²⁰ Centuries later, the soybean was taxonomized by Carl Linnaeus as *glycine*, meaning sweet, and *max* due to its large nitrogen-fixing nodules.²¹



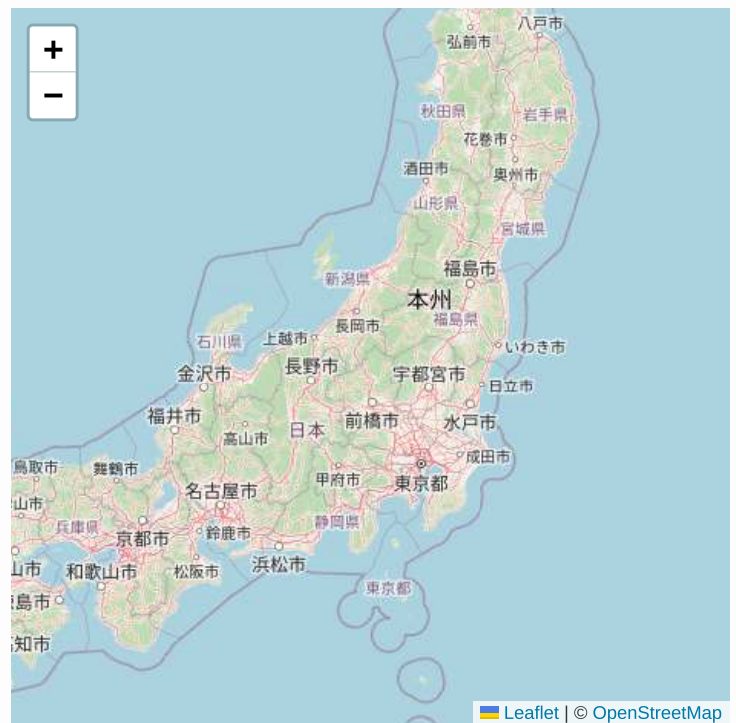
In Germany in 1712, explorer and botanist Engelbert Kaempfer “published a 900-page description of Japan” in which he detailed the soy plant and the multiple products that could be made from it.²² It wasn’t until the late nineteenth century, however, that soy took off in Europe. At the Universal Exposition of 1873, a world’s fair held in Vienna, soybeans “grown in China, Japan, Mongolia, Transcaucasia and even Tunisia,” were displayed.²³



⋮ Engelbert Kaempfer drawing a map of Japan



In Asia, Japan’s global influence was growing after its 1905 victory in the Russo-Japanese war—a war in which “soy was an incentive for conflict.”²⁴ Japan’s victory led to dramatic gains in the country’s mainland territorial control, and subsequently, an increase in soybean production: “between 1906 and 1921, soybean production grew from 600,000 to 4.5 million metric tons.”²⁵ After the war, Poles who fought in the war brought back many different seeds, including soybean seeds, to Poland. Many Poles subsequently began growing what they referred to as “Japanese beans,” in [Poland](#).²⁶ Research on soybeans flourished in Poland after it gained independence from Russia; in 1930, Polish entomologist and crop scientist Czesław Marjan Bieżanko moved to South America—living first in Argentina and later in a Polish settlement in [Brazil](#)—to teach Polish immigrants how to grow soybeans.²⁷ In this roundabout way, soybean made landfall in Brazil.



In North America, soy was becoming known for being a protein-packed crop that could prevent food shortages during World War I. In a 1918 Farmers' Bulletin, a United States Department of Agriculture bulletin series given to members of Congress and sent to U.S. farmers upon request, scientific assistant William Morse published a list of potential uses for soybean. Some options included infant foods, diabetic foods, explosives, and varnish.²⁸ An author of a 1917 article in the Missouri-based *Chicago Packer* farming magazine wrote of soybeans: "In China the soy bean replaces in turn meat, milk, flour, eggs for the human population and fodder and silage for the animals ... In the United States it can do the same..."²⁹ The author emphasized that soybeans were seen as a potential alternative to the products of industries that were more reliant on human labor, which was scarce in wartime, such as the dairy industry. "The soy bean does not keep union hours. It does not hesitate to supplant any and all foods. It has no respect for the division of labor and for specialization of industry. It is prepared to break strikes. Why should any one worry about a milk strike when the soy bean can become at a moment's notice, a very acceptable cow?"³⁰

quantities of fertilizer the soy bean thrives well on the sandy soils of the Coastal Plains area. On the vegetable-mold soils of eastern North Carolina excellent yields of beans and forage are obtained, and the crop occupies an important place in the farming systems of this region.

The soy bean does not require a well-drained soil for its best development, although it will not succeed where water stands for any considerable length of time. Swamp and peat soils after being drained and limed have usually been found to produce this crop very well. Soy beans will thrive on soils that are too acid for the successful culture of red clover.

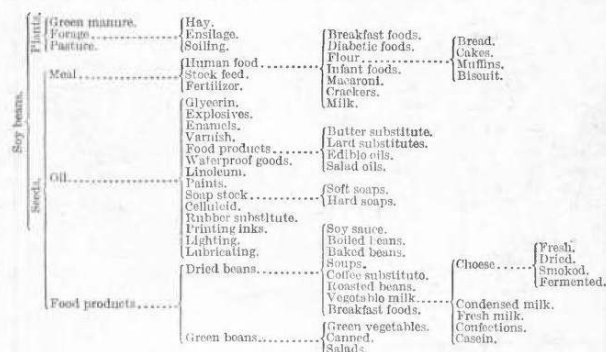


FIG. 2.—Diagram showing the various ways in which the plants and seeds of soy beans are utilized.

PREPARATION OF THE SEED BED.

The preparation of the soil for the soy bean is similar to that for corn, and it, like corn, readily responds to any extra preparation. The land should be plowed early and deep, fitted, and then harrowed at intervals until the beans are planted; otherwise, weeds are likely to choke out the young plants. Disking will give the proper preparation after a crop of early potatoes or peas or for stubble land after wheat or winter oats, provided the soil is moist and mellow. A firm seed bed with a light, loose covering of fine soil, well smoothed by the harrow, is conducive to uniform depth in planting and to a good stand of plants. A soil free from clods insures the best results, especially in seeding broadcast, which may be desirable on the better types of soil.

FERTILIZERS.

When grown on land giving good yields of corn or following corn, as it frequently does, a good crop of soy beans should be produced without direct applications of fertilizers. The use of fertilizers is

A Certain Crop During Uncertain Times

Immediately after World War I, U.S. farmers in agricultural systems developed on an industrial scale faced a soil crisis. To keep soldiers fed during the war, many farmers turned to monocropping, a farming technique that plants the same plant year after year, while depleting the soil of nutrients. To address this problem, many farmers turned to soybeans because of their ability to restore the soil quality through nitrogen fixation.³¹ The plant that was once looked down upon for its “weediness,” was now being lauded for its potential to feed whole nations and save agricultural soil.

Soybeans also gained certain notoriety during the uncertainty of World War II. While they were prized due to their oiliness, which could be used for food, plastic, and even fuel, farmers and scientists continued to search for other uses for the plant. One innovator, Ford Motor Company founder Henry Ford, went so far as to build a plastic-bodied car using soybeans.³² He envisioned soybeans as a crop that could be industrialized, including having soybeans replace milk, and eventually, cows.³³ In the early years of World War II, the United States doubled its soybean production to meet wartime demands for “oil and soy by-products.”³⁴ By the end of the war, soy was being used in “margarine, paint, mayonnaise, wallpaper, glue, and dynamite, to mention just a few,” putting the United States on the map as the world’s top soybean producer.³⁵ The country continued to hold this status until 2019, when the top producer, for the first time in history, was in the southern hemisphere.³⁶

Different Uses for Soybeans The ...



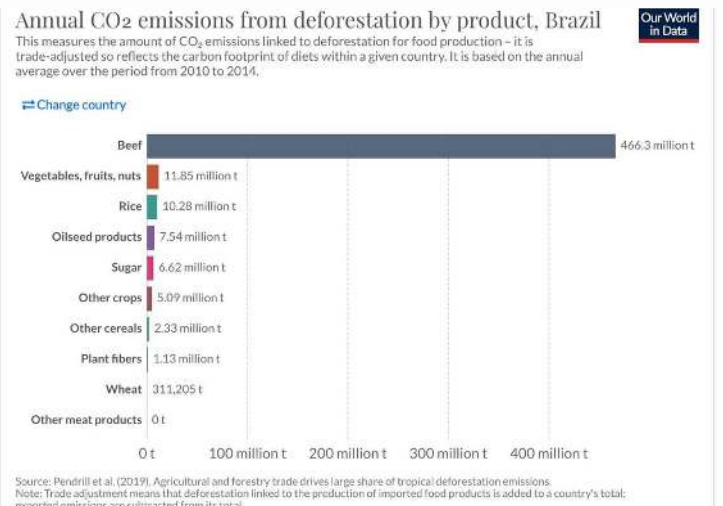
The Changing Amazon

Sojización is the term used to describe the change in the Amazonian landscape—its evolution from rainforest to soybean fields.³⁷ This process began in what is called the “Second Great Acceleration,” a period that began around 1950, when “the [center] of gravity of soy’s trade network shifted from the Global North to the Global South.”³⁸ It comprised mass-scale interventions marking “the shift of worldwide resource extraction, exchange, processing, usage and deposition on an unprecedented scale from the mid-twentieth century onwards.”³⁹ A hallmark of this extractive approach in South America was sojización, since almost all soy produced in South America is exported to Asia or Europe. As a result, the natural resources of the region, especially its rainforest, are being depleted for consumption in countries abroad, creating ecosystems known as “ghost acres.”⁴⁰



⋮ Satellite Image of Cultivated Land in the Amazon ⌘

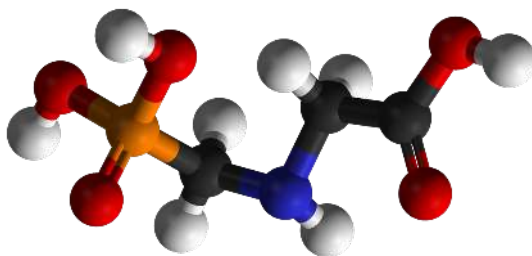
The unending demand for soybeans is due to their continued use as a high-protein animal feed. In 1995, the Chinese government began prioritizing the cultivation of human-food crops, such as rice and wheat, due to the increase in its population. As a result, China reduced the production of animal-feed crops such as soy, turning to other countries, including Brazil, for import.⁴¹ In 2018, the annual cost of soybeans exported from Brazil to China was 27 million USD, while “the associated deforestation risk amounted to 61,500 hectares, from which 34,600 hectares resulted from the Brazilian-Chinese trade. Since forests serve as a sink of greenhouse gases, Brazilian deforestation caused 10.0 metric tons of emissions of carbon dioxide into the atmosphere, of which the Chinese share was 5.6 metric tons.”⁴²



⋮ Annual CO2 emissions from deforestation by product, Brazil ⌘

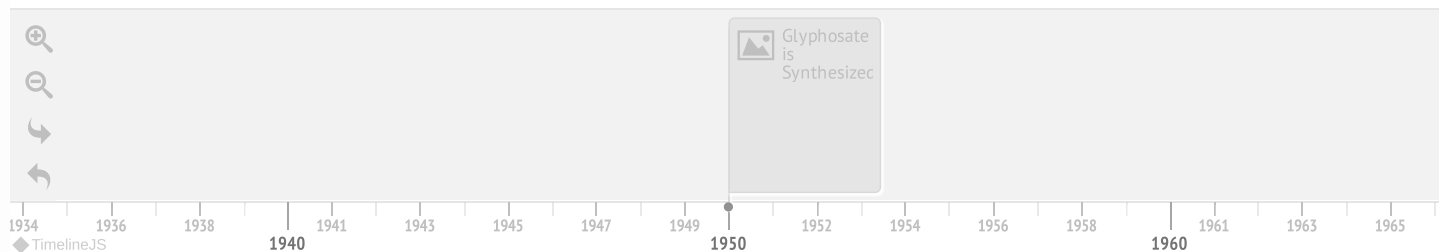
Such a massive increase in scale of soybean production aligns with the introduction of GM soybeans. A salient example is Bayer-Monsanto's Roundup Ready soybeans, which were approved in Argentina and the United States in 1996 on the merit of the "principle of substantial equivalence," claiming that "overall GM soybeans are similar to their non-GM equivalent, and thus represent no risk to the public health of the environment."⁴³ Since being launched in Argentina, Roundup Ready soybeans have had "practically a 100 per cent adoption rate."⁴⁴ By the 2000s, GM soybeans changed the Argentinian landscape, covering around 50 percent "of the country's arable land."⁴⁵ These GM plants are resistant to glyphosate, an herbicide used to kill weeds, allowing growers to spray the herbicide Roundup without killing the plant. In 2012, 80 Olympic-sized swimming pools worth of glyphosate—53 million gallons—"were sprayed across Argentina."⁴⁶

HISTORY OF GLYPHOSATE



Benjah-bmm27/Wikimedia Commons

➤
GLYPHOSATE IS
SYNTHESIZED



The GM explosion in Argentina has resulted in large agribusinesses taking land from Indigenous people, stripping them of their homes, and often imperiling their health.⁴⁷ One windy day in February 2003, farmers in Monte Azul woke up to the brutal realization that overnight, neighboring large-scale growers had sprayed their glyphosate-resistant soybeans with the herbicide 2,4D, and that glyphosate drifted over and killed their crop.⁴⁸ The farmers organized and hired a specialist to prove that their plants were killed by the herbicide. After analyzing the physiological effects that the spraying had on the farmers and the plants, the specialist advised the farmers to destroy their crops due to their toxicity, effectively decimating their harvest.⁴⁹ For the next few months, farmers demonstrated against the fumigation of soybean fields, blocking roads and slitting airplane tires with knives.⁵⁰ Eventually, a judge ordered that large-scale growers stop fumigating soybean fields. The ruling, however, came too late, as many of the local farmers had stopped investing in staple crops, terrified that their crops “could be destroyed by another agrochemical drift.”⁵¹ The “principle of substantial equivalence” was not as “equivalent” as it may have initially seemed. GM soybeans require toxic herbicides, which kill non-GM crops, and, over time, have detrimental effects on human health.⁵² Glyphosate has been linked to cancers, non-Hodgkin lymphoma, and other serious health issues.⁵³ The phrase “deforestation in the Amazon” means so much more than just cutting down the rainforest; in the case of soy, it signifies the erasure of lives and livelihoods.

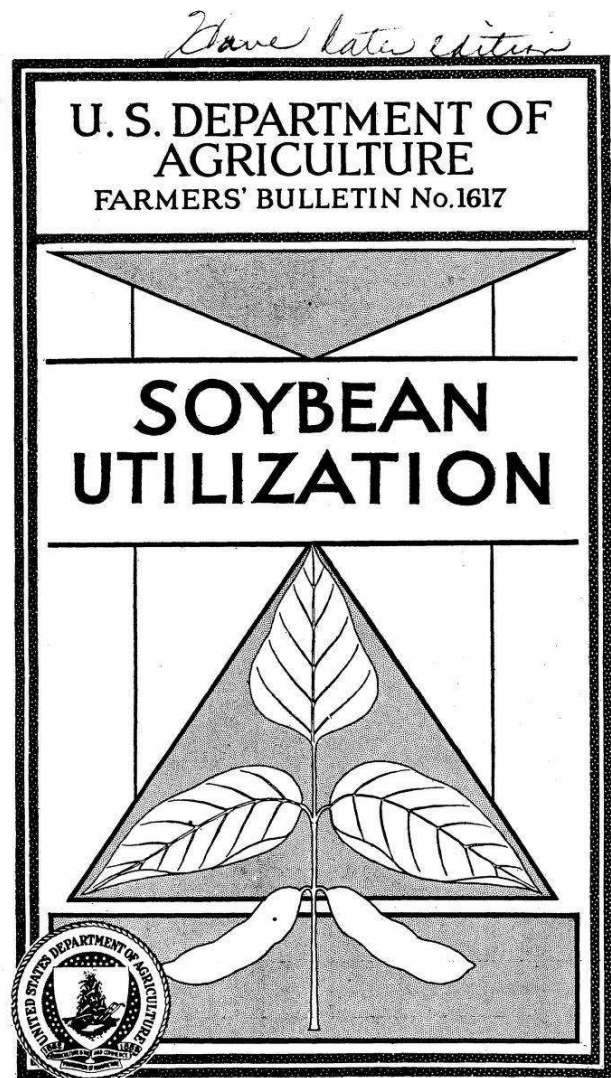


⋮ Trees 30 years after being sprayed with glyphosate ⋮

The Era of the Soy Moratorium

In April 2006, Greenpeace released a report stating that U.S. corporations “were responsible for 60 percent of the financing of Brazilian soybean agriculture.”⁵⁴ The report also detailed where soy from the Amazon ended up, including in animal feed for McDonalds’s chickens. McDonalds chicken nuggets, in other words, were produced from chickens fed with soybeans grown on deforested Amazonian land.⁵⁵ McDonalds responded to the report by pledging to “stop selling chicken fed on soybeans grown in newly deforested areas of the Amazon.”⁵⁶ The pressure from the Greenpeace report resulted in a “soy moratorium,” in Brazil, signed two months after the report’s release. The moratorium stipulated that, from that point on, companies would no longer buy soy from newly deforested areas.⁵⁷

In theory, the moratorium seemed to work, as there was evidence that the rate of deforestation for soybean production in the Amazon was slowing. In practice, however, soybean growers simply shifted where they planted: to cattle pastures. Cattle farmers pushed their operations deeper into the Amazon rainforest, and growers planted soybeans in the abandoned pastures. Paradoxically, it was cattle farmers, not soybean growers, who were accused of perpetuating deforestation.⁵⁸ Indeed, the soy moratorium applied to soy, not cattle, effectively creating a perfect loophole.⁵⁹ Some scholars argue that the soy moratorium had almost no effect on deforestation.⁶⁰



The Fragility of the “Soyacene”

Soybean, progressing from resiliency to versatility, chose humans; today, humans are overwhelmingly choosing soybeans. In 2022, an estimated 350 million metric tons of soy were produced worldwide.⁶¹ This large-scale production is unsustainable. Although it is nitrogen-fixing, when soy is continuously replanted, it depletes the soil. In Argentina, for example, “36 per cent of Argentine territory—roughly 100 million hectares—has become eroded over the past 25 years.”⁶² As for Roundup Ready and other GM products, they perpetuate cycles of destruction of their own. Only ten years after Roundup Ready soybeans was introduced into Argentina, glyphosate-resistant weeds began cropping up, too, causing growers to spray more toxic herbicides.⁶³

When certain crops are grown as a monoculture on a large scale, as in the case of soybeans, they lose nutritional value. This is due to the inverse yield nitrogen law that states “increased yields will be followed by a decrease in protein concentration.”⁶⁴ This pattern creates a dangerous cycle where growers need to produce more crops to meet the same protein concentrations that traders expect.⁶⁵



⋮ Roundup Herbicide



⋮ Pivot Irrigation on a Soybean Field



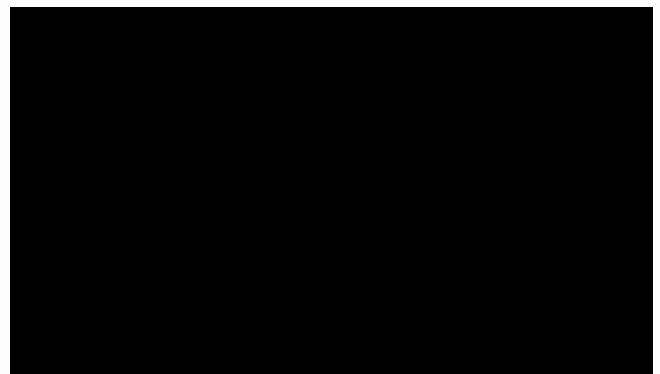
Consumers, who are indirectly complicit in the creation of the “ghost acres,” tend to take for granted the availability and cheapness of commodity crops like soybean. Even if consumers are not eating “direct” soy products like, for example, tofu or tempeh, they are likely consuming soy multiple times a day, whether by way of processed food or coating on fruits and vegetables. The rising global demand for soy has only been met through the destruction of multiple ecosystems. As journalists and authors Maurício Torres and Sue Branford wrote, “there is no such thing as empty land. Each tract of forest is used in some way, even if it isn’t inhabited.”⁶⁶



⋮ Aerial view of the Amazon Rainforest, near Manaus... 📷

Deforestation in the Amazon is moving at a slower rate in 2023 than in previous years, thanks to anti-deforestation policies implemented by Brazil’s president Luiz Inácio Lula da Silva.⁶⁷ However, rates of destruction are rising in the savannah-like cerrado, “an ecosystem that sits atop one of the world’s largest sweetwater aquifers.”⁶⁸ This land contains some of the oldest soil on earth, and to successfully grow soybeans requires more and more fertilizers; yet, the region is becoming a popular place for even American midwestern farmers to turn to in hopes of a more fruitful, GM-driven harvest.⁶⁹ With the global demand for soy rising, will soy overtake other landscapes, too? According to the United Nations, the world produces enough food to feed everyone and still have leftovers.⁷⁰ And yet, we are clearing land to make room for a commodity crop, which, at its core, is used as animal feed. Soybean has long been a source of prosperity for humans. Now, the replacement of the original ecosystems with soybean fields is one major factor in the acceleration of anthropogenic climate change. Although humans are still choosing soybeans, the question naturally arises: should we?⁷¹

[Agricultural land \(sq. km\)](#)



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