

Globalization and Soybean Expansion into Semiarid Ecosystems of Argentina

Deforestation is the product of complex interaction among local idiosyncratic properties of natural and social systems and driving forces that commonly operate at large spatial scales (1). Social and economic globalization, particularly reduced communication and transportation barriers, has increased the relative importance of global drivers of environmental change (e.g. deforestation). For example, agriculture expansion is increasingly influenced by technological changes that are rapidly disseminated worldwide (2) and by changes in consumption patterns of a few countries that have a disproportionate influence on the global markets because of their large population (e.g. China) or high levels of consumption (e.g. USA, European Union).

The increased importance of soybean production in the global economy is an example of how local and global factors can interact and have large effects on natural systems. A number of characteristics of soybean have made it an attractive crop in the globalized context. Soybean has low water content, high nutritive value, and the capacity to yield a variety of products (e.g. human food, animal food, oil, and industrial derivatives) (3). These characteristics reduce vulnerability to market fluctuations, reduce storage and transportation costs, and have contributed to its rapid expansion. Furthermore, the increasing global demand for soybean products has resulted in large investments in research and development and the widespread use of transgenic cultivars that have increased yields, reduced costs by reducing herbicide use, and increased the range of appropriate planting environments (4).

A major factor influencing the growing demand for soybean has been a global increase in meat consumption (5), much of which is produced with soybean meal. Until 1993, China was a major exporter of soybeans, but the increasing demand for meat, particularly pork and chicken, associated with the socioeconomic changes during the last 10 y has converted China into the number one soybean importer in the world (6).

This increasing demand for soybeans is reflected in a doubling in planted area during the last 30 y (7). Globally, approximately 80 million ha are planted in soybean, and >70% is in the United States, Brazil, and Argentina. During

the last 10 y, production in the United States has been relatively stable, but South America has experienced a dramatic increase, much of which was established by deforesting extensive areas of tropical dry forest (3, 4, 8).

In this communication, we describe how increasing demand, technological advances, and climate change are driving soybean expansion in Argentina and seriously jeopardizing the integrity of extensive semiarid biomes.

ARGENTINA DRY ECOSYSTEMS AND SOYBEAN EXPANSION

Despite being one of the largest agricultural producers in the world, Argentina still has extensive wildlands. Argentina has the largest area of dry shrublands in the world (9) and a significant proportion of the Chaco forests, which is the second largest dry forest biome in South America (10). These areas are being transformed rapidly into soybean fields. The area planted in soybean in Argentina has increased from less than a million hectares in 1970 to more than 13 million ha in 2003 (5% of Argentina, an area larger Nicaragua; Fig. 1A). In part, this increase has occurred in areas that were previously used for other agricultural or grazing activities, but much of the increase in planting area has originated from the transformation of natural ecosystems. Deforestation for agricultural expansion has been particularly important in the northern provinces, which contain the largest areas of Chaco forest. For example, using Landsat TM images, we estimated that in the eastern part of Salta, 305 000 ha was deforested between 1984 and 2001. In only 4 y (1998–2002), 117 974 ha was deforested in the province of Chaco (11).

DRIVERS OF SOYBEAN EXPANSION

The major driver of deforestation for soybean expansion in Argentina has been the increase in global demand, but climate change, specifically rainfall, and technological advances have also played a major role. In subtropical Argentina where soybean production is expanding into semiarid wildlands, rainfall has increased by 20%–30% above levels during the first half of the 20th century (12; Fig. 1B) and has eliminated a major

environmental limitation for soybean growth over millions of hectares (13). This increase in precipitation is a consequence of increased continental circulation likely associated with global increase in greenhouse gases (14), and climate models predict that current levels of rainfall in this region are likely to persist or even increase during the coming decades (15).

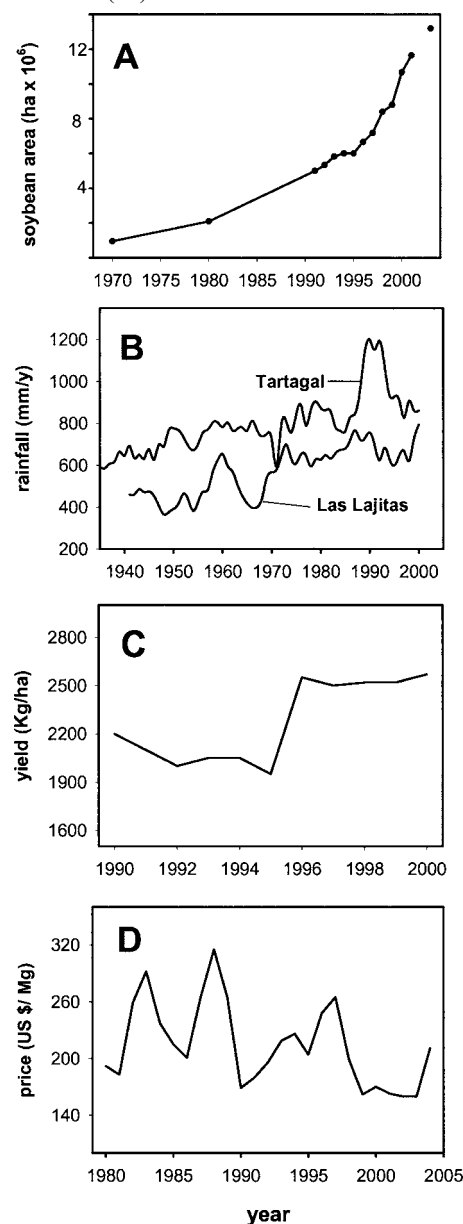


Figure 1. Time trends in A) area (ha) planted in soybean in Argentina; B) rainfall (mm y^{-1} , 5-y moving average) in two localities where soybean has expanded during the last 20 y (Tartagal and Las Lajitas, Province of Salta); C) average yield (kg ha^{-1}) of soybean between 1990 and 2000 in Argentina; and D) price of soybean ($\text{US\$ mg}^{-1}$).



Soybean expansion into seasonally dry forests in NW Argentina. Photo by T.M. Aide, 2002.

In addition to increasing rainfall, new varieties of soybean are expanding the environmental conditions appropriate for growth and increasing yield (4, 16). Yields increased more than 20% in 1997 with the introduction of transgenic cultivars (Fig. 1C). These cultivars also reduce herbicide use, lowering production costs (17). Although international soybean prices have dropped (Fig. 1D) following the introduction of the transgenic cultivars, profits are still high (17), and more dry forest is being transformed to soybean each year.

Between September 2003 and January 2004, the price of soybeans increased 50%. This increase is driven by a continued global increase in meat consumption, particularly in China, and a 12% decrease in the 2003 US soybean crop. The recent outbreak of mad cow disease in the United States should further increase soybean prices as demand for pork and poultry feed increases (18).

CONCLUSIONS

The trends in global drivers of soybean production (e.g. demand, technology, climate) strongly suggest that deforestation of tropical dry ecosystems will continue, despite changes in local conditions. Although the Argentina economy has fluctuated greatly during the last 10 y (e.g. gross domestic product annual change varied between +8% and -20%; 19), this local driver has had little or no effect compared with the global drivers. Moreover, other global factors, such as increased meat consumption in developing countries and mad cow disease in the

United States, will contribute to an increasing demand for soybean products.

Soybean exports have played an important role in the recovery of the Argentine economy following the 2002 financial crisis. Along with increased income for growers and associated industries, the government has benefited directly from a 20% export tax (*retenciones*). The 2003/2004 soybean crop is estimated to be approximately 13 million ha, with an average of 2.6 tons ha⁻¹. If the price continues above US\$200 ton⁻¹, 20% would represent more than US\$1 350 000 000 for the Argentine government. If current global factors do not change and the economy of Argentina continues to base its growth on soybean exports, millions of hectares of semiarid wildlands likely will disappear during the coming decades.

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- Acknowledgments: This work was financed primarily by grants from National Aeronautics and Space Administration (NASA, USA) and Comisión Nacional de Actividades Espaciales (CONAE, Argentina).

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