Global agricultural expansion: The sky isn't falling (yet)

This is an unformatted draft of a chapter/article that has been accepted for publication by Oxford University Press in the book "Effective Conservation Science: Data Not Dogma" edited by Peter Kareiva, Michelle Marvier, and Brian Silliman due for publication in October 2017 (this chapter is on pages 73-79): https://global.oup.com/academic/product/effective-conservation-science-9780198808985?cc=gb&lang=en&

Chapter 11

Global agricultural expansion:

The sky isn't falling (yet)

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11.1 How fast is agriculture expanding around the world?

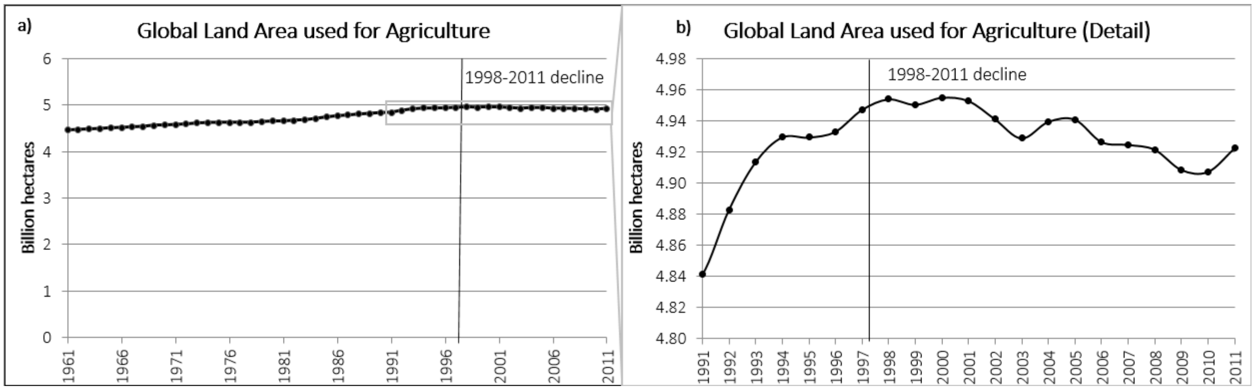
Agriculture is the largest land use on the planet (Foley et al., 2005), and accordingly conservation biologists have long been concerned about its impacts (Sala et al., 2000). Of the 8688 threatened or near-threatened species on the IUCN Red List, 5407 are placed at risk due to agricultural activities (Maxwell et al., 2016). The situation is expected to get worse, with a projected increase in demand for food that is sobering. We are expected to need between 26% and 110% more food by the year 2050 (Hunter et al., 2017; Tilman et al., 2011; FAO, 2011) due to an increasing population and a shift in the global diet toward greater meat consumption. In fact, if current trends continue, we will need around 1 billion ha of new rangeland and cropland

(Tilman et al., 2011), more than the entire land area of the United States or China.

These grim statistics, along with frequent reports of deforestation in places like Brazil and Indonesia, have led to a common belief that land is being cleared for agriculture at a rapid and increasing pace. While there are certainly published articles that discuss future land conversion due to agriculture (Lambin and Meyfroidt, 2011), for the most part it is a belief that conservationists seem to hold without having a specific reference or statistic to point to.

The prospect of further habitat loss due to crops and grazing has put agriculture on the agenda of most major conservation NGOs. Because there is a widespread perception that agricultural conversion is accelerating, a few years ago I wanted to know what the data tell us about the rate at which agriculture land is increasing. When I couldn't find a good reference in the published literature on the current rate of global land conversion due to agriculture (which surprised me), I turned to the best available global dataset on the subject (FAOSTAT, the statistics division of the Food and Agriculture Organization of the United Nations, FAO, 2013a). It was a simple exercise to simply graph the total global land area used for agriculture over time (combining annual row crops, pasture and rangeland for livestock, and permanent crops like orchards and vineyards). But, as shown in Figure 11.1, the result was shocking: the total land used globally for agriculture peaked in 1998, and has declined slightly since then. So not only was agricultural conversion not globally accelerating, it had been in decline for over a decade.

Figure 11.1. a) Global land area used for agriculture (permanent crops, pasture / rangeland, and annual row crops) from 1961 to 2011. Figure b) shows a subset of the data from 1991-2011 to show greater detail. Figure adapted from Fisher and Kareiva 2018, in press. Data from FAO 2013a.

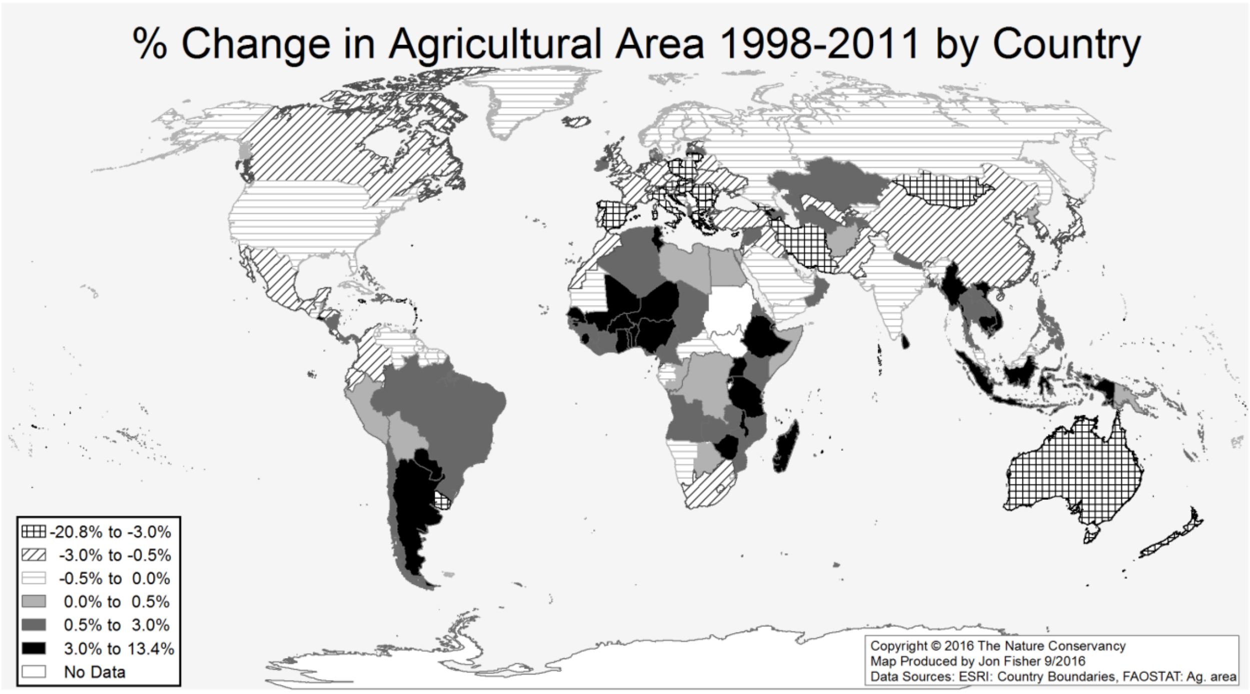


I was sure that couldn't be right, so I dug deeper into the data available at FAOSTAT. In trying to understand *how* agricultural land could be decreasing given the prevalence of the idea that the opposite was true, I split out the data by agricultural land use type. I found that while overall agricultural land area was down since 1998, this was due to a decline in pasture and rangeland (by 61 million ha, or 1.8% of 1998 area), and in fact during the same period there was an increase in permanent crops (23 million ha, 18% increase) and annual row crops (9.7 million ha, 0.7% increase, FAO, 2013a). Meanwhile global food supply per person has been generally increasing since 1991 (despite the decline in global agricultural land), and the most recent year with data (2011) showed the highest value ever (2868 kcal per capita, FAO, 2013b). But it wasn't until I split out the data by country that I understood the most likely source of the misconception around agricultural land area.

When I mapped the percentage change in agricultural land by country (Figure 11.2), it became clear that in many places (concentrated in the tropics) agriculture *is* expanding. It's just that the declines in agricultural area in the rest of the world haven't been grabbing as many headlines, and when you combine the data around the world, globally there is a *net* decrease in agricultural area despite the expansion in some countries.

Figure 11.2. Percentage change in each country's agricultural land area between 1998 and 2011. Countries with darker solid colors indicate greater agricultural expansion, countries with denser line fills

indicate greater agricultural contraction. Figure adapted from Fisher and Kareiva In Press. Data from FAO 2013a.



While a net decrease in agricultural area sounds a lot better than rapid global expansion, there are some key caveats:

(1) the data do not tell us whether the intensification of agriculture is sustainable or due to high inputs of fertilizer and water that cannot continue;
(2) there could still be major losses of biodiversity driven by agriculture in important places *within* countries, even if those countries are experiencing a net decrease in agricultural area;
(3) much of the net agricultural expansion is taking place in countries with high biodiversity;
(4) lumping together relatively wildlife-friendly rangelands with more intensively managed row crops may mask important shifts in the amount of habitat available to wildlife; and
(5) the increasing demand for food will eventually lead to global net expansion reoccurring as the demand cannot all be met through intensification (Tilman et al., 2011).

So while this analysis upended the prevalent view of global agriculture as rapidly expanding, it also makes clear how aggregated global trends ("agriculture land use is declining") miss critical details and ecological constraints in exchange for a summary statistic for the whole world.

I originally did this analysis in the fall of 2013 for a book chapter (presented as just a few sentences within the introduction). I thought this was a timely enough finding that I didn't want to wait for publication, so I also wrote up this finding as a blog post (Fisher, 2014a). There was considerable internal concern within The Nature Conservancy that this article could be misinterpreted as saying that agriculture wasn't a threat, so I went through several rounds of internal review and edits with key internal stakeholders. After it finally went online, the initial response was fairly small, but started picking up as the blog was republished (e.g., by The Breakthrough Institute, Fisher, 2014b) and referenced across the internet. Within 6 months it was one of the most read posts on the blog it appeared in, garnering about 3700 page views, and within two years it had over 10 000 views (not counting other blogs where it was duplicated) and was beginning to be cited in scientific talks and publications.

To my surprise, my figures and text were used on conservative blogs and by commenters to "prove" that climate change was not real (since crop yields were going up as cropland area was going down, and climate change is often cited as threatening agriculture), and one blogger used some very colorful language to describe at length how stupid I was for saying this "*could* be read as good news" (my stupidity was established in his mind because I did not declare this to be unequivocally great news). On the other side, some dedicated conservationists dismissed the findings entirely either because they didn't trust the data or because they felt that the caveats made the core finding meaningless.

11.2 So what does this mean, and what else do we need to know?

There has been little formal discussion or debate about global trends regarding agricultural land use. As such, there are some urgent questions to be answered regarding the surprising discovery of no net gain in agricultural land over a time period (1998–2011) when over a billion people were added to the world's population (United Nations, 2015) and per capita food production rose by 168 kcal per person. First, it is important to determine if global agricultural area has continued to decline in recent years. The latest available year in the original analysis (2011) showed an apparent increase, and while the FAO has recently released data for 2012 and 2013 as well as slightly adjusting the figures for past years (FAO, 2016), the trend is still not entirely clear. Agricultural area increased again in 2012 to the highest level since 2005 (a 0.6% increase relative to global agricultural area in 2010 when it may have bottomed out), but in 2013 there was another modest decline (similar to what it was in 2006). Note that in the rest of this chapter the original FAO data through 2011 has been used rather than recreating all of the analysis.

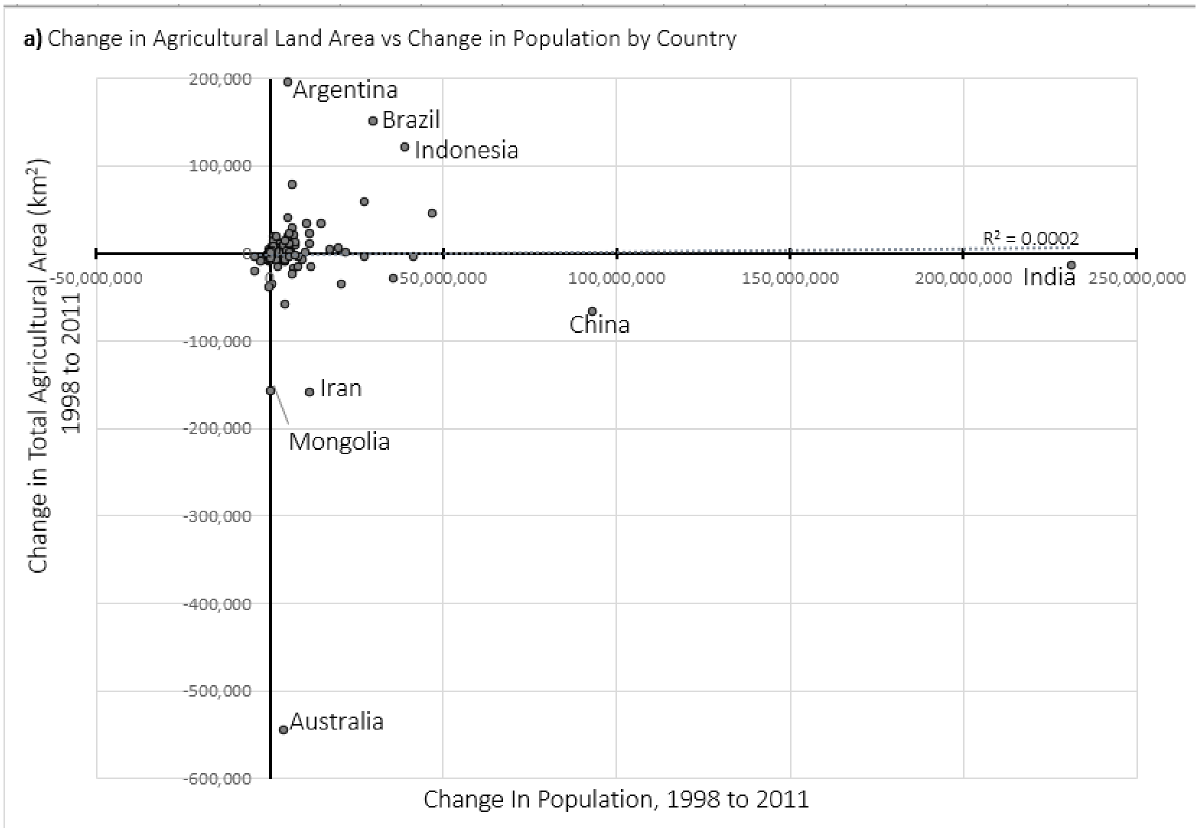
Second, we need to look at better data sources. For example, Lark et al. (2015) found that from 2008 to 2012 cropland in the United States increased by about 1.2 million ha (an increase of about 1%), while the FAO data for the USA show a 2008–2011 decrease of 0.7%. The methodology used by Lark et al. (2015) should be more reliable as it combines remote sensing with state-level datasets.

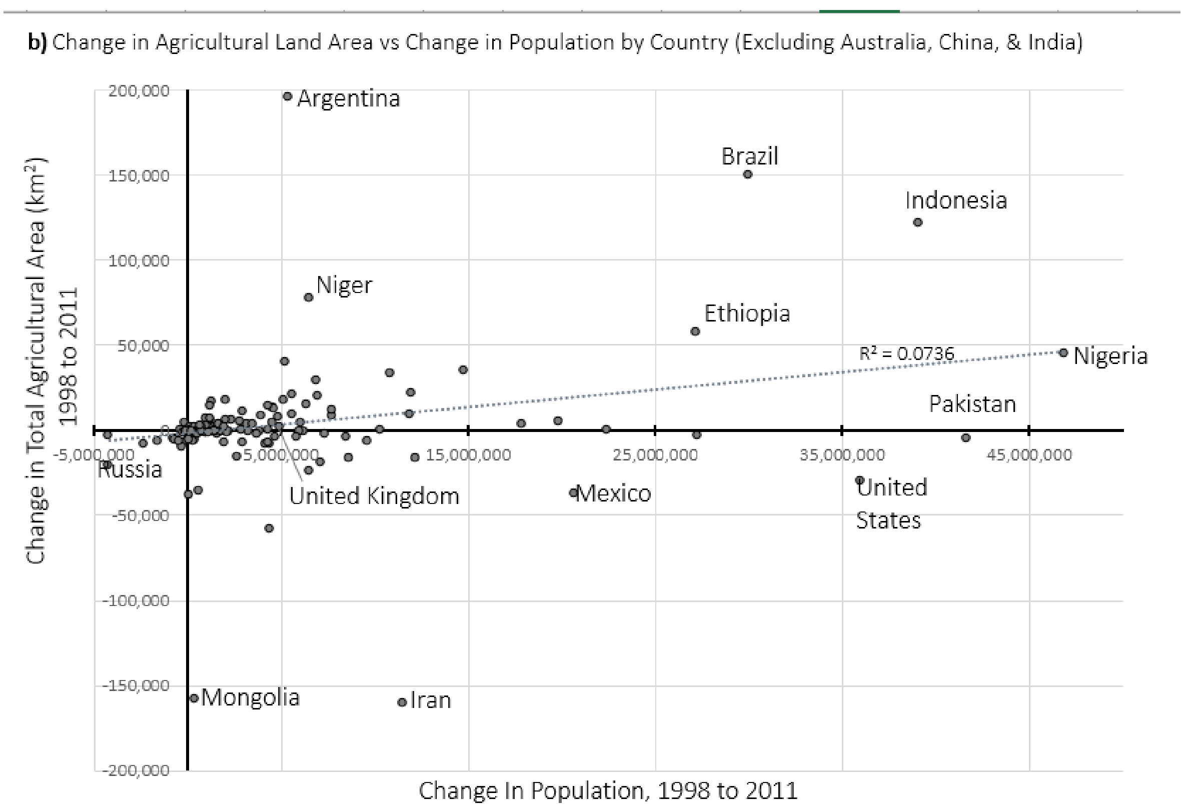
Third, to guide policy, we need to know (a) when and where agricultural expansion is taking place and (b) whether decreasing agricultural area in developed countries is resulting in unproductive lands returning to natural habitat, or productive lands being converted to urban areas, or something else. It would be preferable to intensify production on productive lands to limit expansion (especially if that intensification is done sustainably), rather than having extensive conversion both to and from agricultural land.

The common narrative surrounding agriculture and population is that as we add people we must convert more land to agriculture. The alternatives are that as we add people, we need to either intensify agriculture and increase yields on existing agricultural lands, reduce food waste (where significant room for improvement exists), or shift our diets toward plant foods (which require less area than animal products to produce the same amount of food).

Comparing the change in national population to the change in national agricultural land area from 1998 to 2011 shows only a weak relationship (Figure 11.3). For the 217 countries for which data exist for both population and agricultural land area in 1998 and 2011, 177 reported an increase in population during that time period: of these 177 nations with growing populations, a slight majority (93 nations) decreased in agricultural land, while the remaining 84 increased agricultural land. Accordingly, it does not appear population growth is the major driver of local (within the same nation) agricultural land expansion. Rather, the nations which had the most expansion (Argentina, Brazil, and Indonesia) produce crops such as beef, soy, and palm oil for which global demand has sharply increased.

Figure 11.3. Agricultural land area by country vs. population change by country, between 1998 and 2011. The figure above (3a) includes data from all countries; the figure below (3b) has the three extreme outliers in the data (Australia, China, and India) removed. Data from UN 2015 and FAO 2013a.


a) Change in Agricultural Land Area vs Change in Population by Country
Change in Total Agricultural Area (km²) 1998 to 2011
Change In Population, 1998 to 2011
200,000
100,000
0
-100,000
-200,000
-300,000
-400,000
-500,000
-600,000
-50,000,000
50,000,000
100,000,000
150,000,000
200,000,000
250,000,000
Argentina
Brazil
Indonesia
India
China
Iran
Mongolia
Australia
R² = 0.0002


b) Change in Agricultural Land Area vs Change in Population by Country (Excluding Australia, China, & India)
Change in Total Agricultural Area (km²) 1998 to 2011
Change In Population, 1998 to 2011
200,000
150,000
100,000
50,000
0
-50,000
-100,000
-150,000
-200,000
-5,000,000
5,000,000
15,000,000
25,000,000
35,000,000
45,000,000
Argentina
Brazil
Indonesia
Niger
Ethiopia
Nigeria
Pakistan
Russia
United Kingdom
Mexico
United States
Mongolia
Iran
R² = 0.0736

Given the impact of agriculture on biodiversity, it is important to understand what drives massive agricultural expansion in countries such as Argentina, Brazil, and Indonesia. Their numerical dominance is partly due to the overall size of these countries (they are the eighth, fifth, and fifteenth largest countries by land area, respectively). Given their large sizes, there is simply more land to potentially convert to agriculture.

Agricultural expansion in Brazil and Argentina has been driven largely by growth in export commodities, such as soybeans and corn, to satisfy the growing global demand for meat (Lee et al., 2016). For example from 1998 to 2011, China went from producing almost enough soybeans to meet its demand to importing over 50 million metric tons, with much of those imports coming from Brazil and Argentina (along with the United States and Australia, Gale et al., 2015). During that time the area of Brazilian soybean fields almost doubled (an 80% increase) and in Argentina they almost tripled (a 170% increase, FAO, 2013a). Together, Argentina and Brazil account for 46% of world soybean exports, and 31% of corn exports (with the United States supplying about 42% of each, USDA ERS, 2016). New tools such as Trase allow increased transparency about imports and exports by country, commodity, and company for a limited selection of commodities and geographies (Trase, 2016).

In Indonesia, the majority of the expansion is due to palm oil, for which national production and area planted both more than tripled between 2000 and 2011 (FAO, 2013a; USDA ESMIS, 2016). The high productivity per area of palm oil, its low cost, and bans on artificial trans-fatty acids (Hendry et al, 2015) have driven increasing demand both as food (palm has overtaken soy as the most prevalent vegetable oil) and biofuel (Carter et al., 2007).

11.3 Global data opens conversations, finer data enables action

The key lesson I drew from my analyses of global trends in agricultural lands is that global trends are not necessarily very informative. To truly understand what is going on, one needs to break the data into national trends and perhaps even finer scales. For communication purposes we are drawn to global trends when describing everything from forest cover to population growth to water consumption, but in most cases the problems are best examined regionally and locally. That being said, global trends can provide a benchmark by which to gauge national patterns (e.g., global food demand and prices driving national crop production) and identify issues of emerging concern (e.g., the impact of increased water scarcity on future food production).

Through improved agricultural planning, we can achieve better human and conservation outcomes. For example, it is possible to focus agricultural expansion in productive areas while concentrating habitat restoration elsewhere (with benefits to both humans and conservation, Kennedy et al., 2016). While we have a temporary reprieve from the global expansion of cropland, we should be thinking hard about how to meet global food demand as sustainably as possible, and how to motivate the relevant actors (farmers, governments, consumers, and agricultural companies) to embrace conservation along with food production. The key is to pay as much attention to the subtleties of data as to the power of a compelling narrative such as the global expansion of agricultural lands.

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