



Increasing use of land for crops in the United States negatively impacts wildlife while producing marginal benefits for farmers

In any competition, there are winners and losers. This is abundantly clear in sports, of course, when one team wins the championship and the other loses. But it's also true in normal life. For example, when natural habitat that supports wildlife is converted to cropland, wildlife loses that habitat while humans gain more land to produce food.

So, how is this scenario playing out in the United States? Are we losing habitat for wildlife as our desire to produce more food increases? If so, how extensive are the losses, and how does this impact wildlife such as pollinators? Conversely, how extensive are the gains in terms of agricultural production? In other words, are humans winning big and produc-

ing a lot more food while minimally impacting wildlife, or is the opposite true? These are the topics for our thirty-fifth Notes from the Lab, where we summarize **“Cropland expansion in the United States produces marginal yields at high costs to wildlife,”** written by Tyler Lark and colleagues and published in *Nature Communications* [11:4295].

For their study, Lark and colleagues first tracked changes in cropland throughout the United States during an eight-year period (2008-2016). Specifically, the authors used nationwide cropland maps from the USDA Cropland Data Layer (CDL) and National Land Cover Dataset (NLCD) to determine when non-cropland became cropland, and vice versa. Cropland was broadly defined as any area planted to cultivated row, closely grown, or horticultural crops, and included cultivated fallow and alfalfa. Their methods for determining shifts in land use improved upon previous work by identifying year-to-year changes at very high resolution (30 m spatial scale) while also keeping track of crop-specific changes.

Next, to evaluate productivity of new cropland compared to pre-existing cropland, the authors paired their change in land use results described above with crop-specific yield data for corn, soybean, and wheat fields. Yield data were obtained from 10 years (2008-17) of county-level crop yield

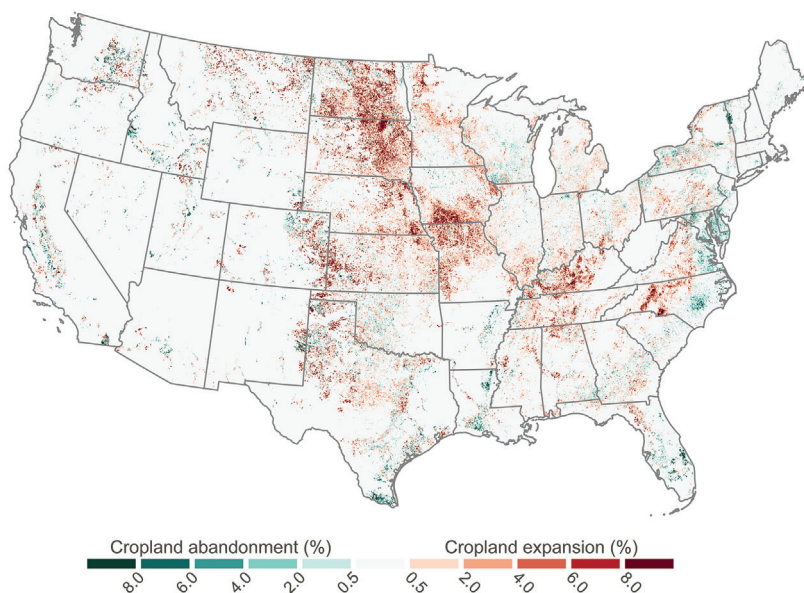


Fig. 1 Cropland in the U.S. expanded by about 6.5 million acres between 2008 and 2016. Rates of net conversion calculated as gross cropland expansion minus gross cropland abandonment and displayed as a percentage of total land area within non-overlapping 3 km x 3 km blocks. Net conversion was most concentrated in the eastern halves of North and South Dakota, southern Iowa, and western portions of Kansas, Kentucky, and North Carolina.

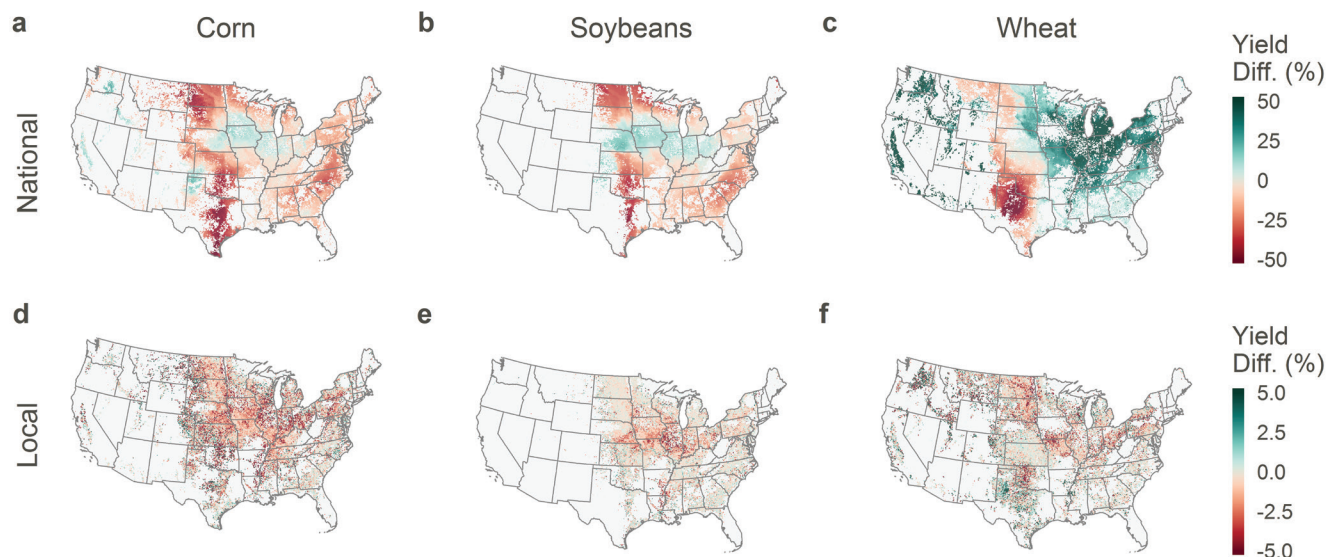


Fig. 2 Overall, 69.5% of new cropland areas produced yields below the national average, with a mean yield deficit of 6.5% on new croplands compared to existing croplands. Yield differential values represent the yields of new croplands relative to the yields of existing croplands nationwide (a-c) or within immediate 10 km x 10 km neighborhoods (d-f). Yields of new croplands planted to corn and soybeans were typically lower than the national average (a, b) and the nearby local average (d, e) of existing croplands for each crop. Yields of new croplands planted to wheat were generally higher than the corresponding national average (c) but lower than nearby existing croplands (f).

averages from the USDA's Agricultural Resource Management Surveys. Estimates of yield from new croplands were compared to pre-existing cropland yields in two ways: first, by comparing to the national average of pre-existing cropland yield for each crop, and second, by comparing to the local average in pre-existing cropland yield for each crop (within a 10 km x 10 km radius of the new field).

Finally, Lark and colleagues assessed the impacts of land use change on habitat suitable for the Monarch butterfly (*Danaus plexippus*), migratory game species (nesting waterfowl), and native plant communities (long-term grasslands). These taxa were selected for their familiarity to the public, representation of a broad range of wildlife types, and recognition as indicator species. To assess impacts on Monarch butterflies, the authors estimated loss of milkweed stem numbers while considering areas that were previously enrolled in the Conservation Reserve Program (CRP). To estimate impacts on duck breeding pair nesting accessibility, U.S. Fish and Wildlife Service habitat maps were used that account for spatial variation in habitat quality across multiple years and environmental conditions. To estimate impacts on long-term grasslands, locations which had never been classified as cropland or pasture/hay in any year of the NLCD were considered to be

long-term and thus approximated native prairie.

So, what did they find? Is cropland in the U.S. expanding? Yes. Overall, cropland in the U.S. expanded at a rate of over one million acres per year, for a total of 10 million acres added between 2008 and 2016. During the same period, only 3.5 million acres of cropland were abandoned or converted to non-agricultural use. In other words, the net increase in U.S. cropland was 6.5 million acres between 2008-2016, as shown in Figure 1.

(Editor's note: For context, USDA numbers show comparable cropland acreage to be stable overall for the 43 years prior to the study, while shifting between geographic regions: "... between 1964 and 2007, cropland used for crops ... increased by 11 million acres in the Corn Belt and decreased by a net 11 million acres in the remaining regions." Crop yields continue to rise due to advances in technology, but export markets and federal farm policy often affect crop production more than the need to feed Americans.)

Expansion of land used for farming occurred at the highest rates in Midwestern states such as Missouri, Iowa, Kansas, Nebraska, and North and South Dakota (red shading in Figure 1). However, cropland expansion occurred throughout the country, with major increases also observed in Kentucky, Tennessee, and North Carolina.

Grasslands, including those used for pasture and hay, constituted 88%

of land converted to crop production across the U.S. Other major land cover types that were converted included shrublands in the West, wetlands in the northern Plains, and forests in the Southeast.

What about productivity of the new cropland? Are we producing food at high rates on the new land? Unfortunately, no. And this is important. Overall, compared to pre-existing cropland, 69.5% of new cropland areas produced yields below the national average, with a mean yield deficit of 6.5% (Figure 2 panels a, b, and c). Yield deficits were less pronounced when new cropland was compared to pre-existing cropland at the local scale, but still negative (Figure 2 panels d, e, and f). These results indicate land that is suboptimal for growing crops in the U.S. is starting to be used for exactly that purpose.

Yield deficits were most pronounced for land converted to corn and soybean production, which together with wheat, represented 78% of the new land converted to crop production. Compared to the national average, yields of new corn plantings were 10.9% lower than corn yield on pre-existing cropland, 8.4% lower for soybeans, but 1.3% greater for wheat.

What about pollinators and other wildlife? Are they being impacted by the land conversion? Yes. And this is the second important point. Of all factors known to be driving

declines in pollinator populations and health, loss of habitat is perhaps the most important. Pollinators (and other wildlife) simply don't do well if you take away their habitat.

Specifically, Lark and colleagues estimate that ~220 million common milkweed stems were lost due to conversion of grasslands, wetlands, and shrublands to corn and soybean production across the Midwest between 2008 and 2016 (Figure 3). The largest reductions occurred in the Dakotas, Iowa, and Missouri. On average, natural land converted to cropland in these states contained an estimated 54 stems per acre prior to conversion, which is 3.4 times greater than the 16 stems per acre on all existing natural lands in the region (Figure 3). It's a small leap to assume this is having an impact on Monarch butterfly populations, at least when those butterflies are present in the Midwest. Furthermore, it's obviously not just Monarch forage that's being lost; floral resources for honey bees and other pollinators are also being lost, even though these broader reductions in floral resources were not explicitly quantified in this study.

A similar story is true for nesting waterfowl habitat and native plant communities. Overall, habitat estimated to provide 138,000 waterfowl nesting opportunities (2.8% of the total in the Prairie Pothole Region of Montana, the Dakotas, Minnesota, and Iowa) was converted to crop production. Similarly, 2.8 million acres of new cropland (28% of the total) came from longstanding habitat sites that had been undisturbed for at least a quarter century, of which 2.3 million acres (81%) were unimproved grasslands. These grasslands and longstanding sites often contain disproportionately high numbers of native plant species and undisturbed soils, both of which provide resources and habitat for bees, especially native stem- and ground-nesting bees.

So, what should we do about this loss of wildlife habitat that's producing suboptimal crop yields? Anything? The answer to this question obviously depends on which is valued more, wildlife habitat (including resources and habitat for bees), or food/profit for us as humans. Given that Lark and colleagues found the lost habitat had high value for wildlife but suboptimal value for crop production, this certainly should be considered in anyone's relative valuation.

But perhaps more importantly, the authors' findings suggest we need

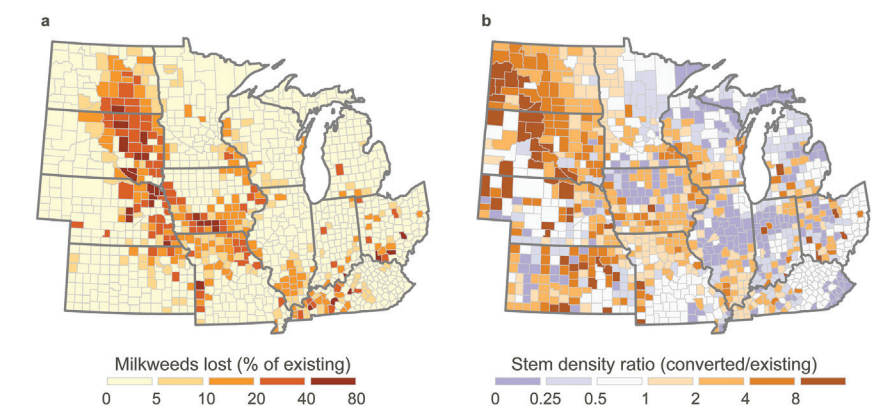


Fig. 3 Approximately 220 million common milkweed stems were lost due to conversion of land to corn and soy production in the Midwest between 2008 and 2016. The maps represent the number of milkweed stems lost as a proportion of those on all grasslands, shrublands, and wetlands in 2008 (a), and the density of milkweed stems on land subject to conversion relative to the density on existing lands in 2008 (b). Large losses of milkweed occurred in the region stretching from eastern North Dakota to northern Missouri — locations with high rates of cropland expansion and conversion from Conservation Reserve Program (CRP) lands, which harbor high densities of milkweed stems. Across the Midwest region, the average density of milkweed stems on land prior to conversion was over three times greater than that on average existing land. Milkweed stems provide the sole food source for Monarch butterfly larvae.

to think more critically about how we farm and use food. Specifically, should more land be used for farming, or should we use existing farmland more intensively? What about improving efficiency and reducing impacts of management, such as using cover crops and vegetation strips, as is currently implemented via the Prairie STRIPS program (see February 2020 Notes from the Lab: 160(2):199-201 and <https://www.nrem.iastate.edu/research/STRIPS/>)? And what about alternative solutions such as reducing food waste? Currently, it's estimated that 30-40% of food in the U.S. is wasted and never consumed. If we could cut this number down by only a few percent, less farmland would be needed and more habitat could be devoted to wildlife supporting Monarch butterflies, waterfowl, native plants, and bees.

Personally, I like this last solution, since it's like having your cake and eating it, too. Before the cake is wasted. But none of these solutions are going to happen on their own. We need more innovation in agriculture, more education about conservation strategies that work, and more action from people who care about the issues. Perhaps including you?

Until next time, bee well and do good work.

Scott McArt

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Scott McArt, an Assistant Professor of Pollinator Health, helps run the Dyce Lab for Honey Bee Studies at Cornell University in Ithaca, New York. He is particularly interested in scientific research that can inform management decisions by beekeepers, growers and the public.



Email: shm33@cornell.edu
 Lab website: blogs.cornell.edu/mcartlab
 Pollinator Network: pollinator.cals.cornell.edu
 Facebook: facebook.com/dycelab

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15642 Tiger Valley Road
 Danville, OH 43014
 740.599.7914
cwsimpson@embarqmail.com
www.simpsonsbessupply.com