Online Supplementary Appendix to the article titled "Changes in Cropland Area in the United States and the Role of CRP"

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A1 Comparison of Previous Literature Using Remote Sensing to Quantify Changes in Cropland Area

Table A1 lists the net change in cropland acreage reported from several recent studies. All of these studies, except the last row, use the CDL (Cropland Data Layer) as the raw data source. The last row in table A1 indicates estimates directly from the National Land Cover Database (NLCD). However, each paper uses a different definition of cropland conversions and analyzes different time periods for different regions. As a point of comparison, the last column in table A1 reports the change in cropland from the NRI (2007–2012) that we calculate for the same region as the respective study.

In a study by the Environmental Working Group, Faber, Rundquist, and Male (2012) estimated that 23.7 million acres of grassland, shrub land and wetlands were converted to cropland in the United States between 2008 and 2011. Clearly, this study dramatically overestimated the net change in cropland area because the NRI indicates only a 3.86 million acre increase in cropland over a longer period.

Wright and Wimberly (2013) attempt to reduce misclassification errors in the CDL and found that between 2006 and 2011 about 1.3 million acres were converted from grassland to corn or soybean production in the Western Corn Belt. The NRI indicates that between 2007 and 2012 there was a net increase in cropland of around 2.4 million acres. The estimate from Wright and Wimberly (2013) is certainly plausible given the different time period analyzed and Wright and Wimberly (2013) only analyze conversions of grassland to corn or soybean production. However, the estimates by Wright and Wimberly (2013) for Nebraska seem to underestimate cropland expansion—they estimate a 0.06 million acre increase in cropland and the NRI indicates a 0.41 million acre increase.

In 2013, the EWG revised their analysis to attempt to reduce errors in the CDL classifications (Cox and Rundquist 2013). The revised estimates indicate that 7.2 million acres of wetlands and highly erodible land were converted to cropland in the United States from 2008 to 2012 (Cox and Rundquist 2013)—a dramatically smaller estimate than Faber, Rundquist, and Male (2012). However, it is not clear from their results how much land was classified as

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converting from noncropland to cropland since they only report statistics for wetlands and highly erodible land.

Evans and Potts (2014) construct five broad land cover categories in the Midwest using the CDL. They estimate a net increase in primary crops of 11.0 million acres between 2006 and 2012 for 11 states in the Midwest. However, results in table 1 of Evans and Potts (2014) indicate that they find a net *decrease* of 0.2 million acres of cropland (primary crops and other crops). The NRI indicates that cropland increased 2.7 million acres in this same region from 2007 to 2012.

The most plausible estimate from recent studies is by Lark, Salmon, and Gibbs (2015) who propose a new method of removing misclassification errors in the CDL and estimate a 2.98 million acre net increase in cropland (2008-2012). This estimate is similar to the NRI that indicates a 3.86 million acre net increase between 2007 and 2012. The map of net conversions of cropland in figure 1 of Lark, Salmon, and Gibbs (2015) has a similar pattern as a map of NRI data that we show in our paper.

While all of the previous studies use annual data from the CDL, an alternative data source is the NLCD (National Land Cover Database). The NLCD is explicitly designed to monitor broad land use categories while the CDL is designed to monitor specific crop categories. Based on pixel counting for the entire United States, the NLCD indicates a mere 0.17 million acre net increase in cultivated cropland from 2006 to 2011 (Homer et al. 2015).

Table A1: Estimates of Net Cropland Conversions by Recent Studies using Remote Sensing

Study	Type of Conversion	Time Period	Region	Net Change in Acres (Millions)	NRI Net Change in Cropland Acres 2007–2012 (Millions)
Faber, Rundquist, and Male (2012)	Grassland, Shrub Land and Wetlands to Cropland	2008–2011	USA	23.682	3.86
Wright and Wimberly (2013)	Grassland to Corn or Soybeans	2006–2011	ND	0.220	0.713
			SD	0.451	0.546
			MN	0.196	0.234
			IA	0.376	0.494
			NE	0.062	0.410
			Total	1.306	2.397
Cox and Rundquist (2013)	Wetlands and Highly Erodible Land to Cropland	2008–2012	USA	7.200	3.86
Evans and Potts (2014)	Noncrop and Other Crop to Primary Crop	2006–2012	Midwest	10.996	2.714
	Noncrop to Primary and Other Crop	2006–2012	Midwest	-0.225	2.714
Lark, Salmon, and Gibbs (2015)	Noncropland to Cropland	2008–2012	USA	2.98	3.86
NLCD (Homer et al. 2015)	Any land use to Cultivated Cropland	2006–2011	USA	0.17	3.86

Note: Midwest in Evans & Potts (2014) represents IL, IN, IA, KS, NE, MN, MO, OH, OK, SD, and WI. The "Net Change in Acres" column reports the estimate from the respective study. The "Net Change in Cropland Acres 2007–2012" reports the estimate from the NRI for the same region as the study.

A2 Net Change in Land Use by Category from the Census

Figure A1 shows the change in area for different land use categories according to the Census. We calculate the acreage of the category "cropland used for crops" as the sum of cropland harvested, failed, and fallowed. We also supplement the Census data with acreage enrolled in the Conservation Reserve Program and subtract CRP acreage from idled cropland to create the category "other idle." The light blue bar shows the change in acreage from 2007 to 2012 and the dark red bar shows the change in acreage from 2002 to 2007.

Large reductions in cropland used for pasture are immediately evident from figure A1. However, the 2007 Census changed its methodology for categorizing cropland used for pasture causing a large shift of acreage to permanent pastureland from 2002 to 2007 (Nickerson et al. 2011). We assume that the large change in cropland used for pasture between 2007 and 2012 is also due primarily to a change in methodology of categorizing land uses. Changes in methodology make it especially difficult to estimate conversions of grassland to cropland used for crops from the Census data. Adding across all conversions indicates a net loss of land in farms. The only land use category that we omit from the Census is "land in farmsteads, building, etc.," which had an increase of about 0.8 million acres between 2007 and 2012. The Census reports the total land in farms as the sum across all categories. Total land in farms decreased by 7.6 million acres between 2007 and 2012.

Another observation from figure A1 is that the change in cropland used for crops is similar in magnitude to the change in CRP acreage. However, it is difficult to rule out that substantial amounts of pasture were converted to cropland given the change in land use definitions. It is also interesting to note that land categorized as "other idle" increased by 5.7 million acres from 2007 to 2012. The cause of the increase in other idled cropland is not clear. In summary, it is difficult—or impossible—to discern the source of new cropland using the Census data.

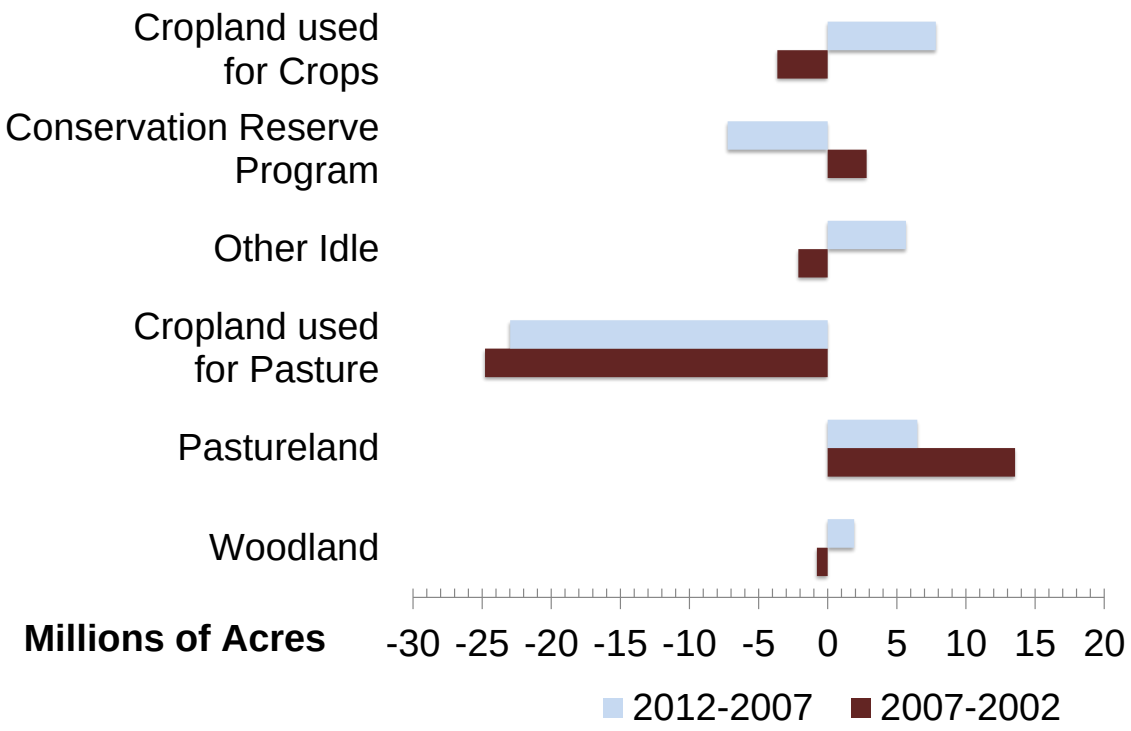

Figure A1: Change in Acreage of Census Land Use Categories.

A3 Net Change in Cropland Maps for Earlier Years

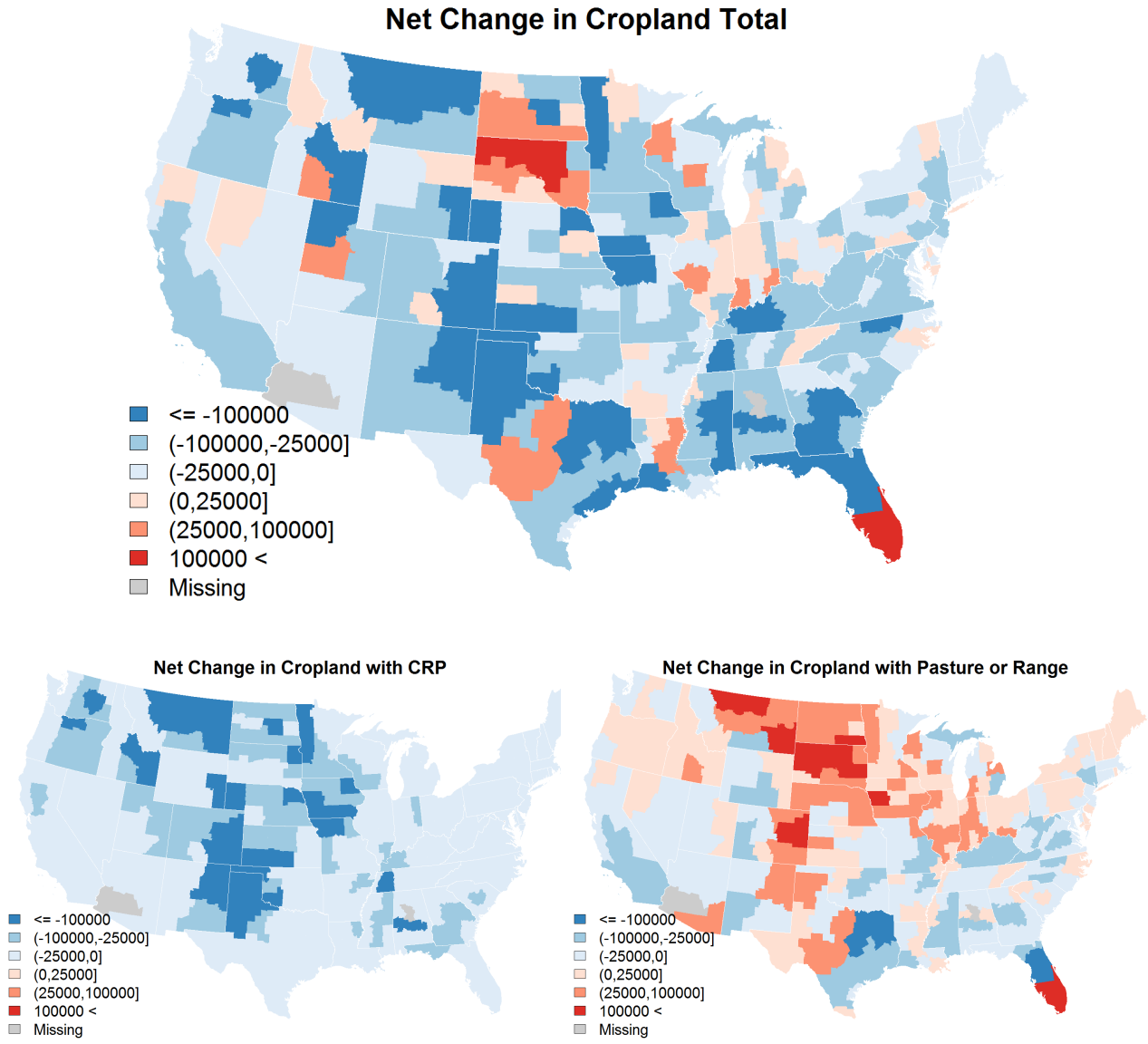

Figure A2: Net Change in Cropland Acres by Crop Reporting District 1982–1987

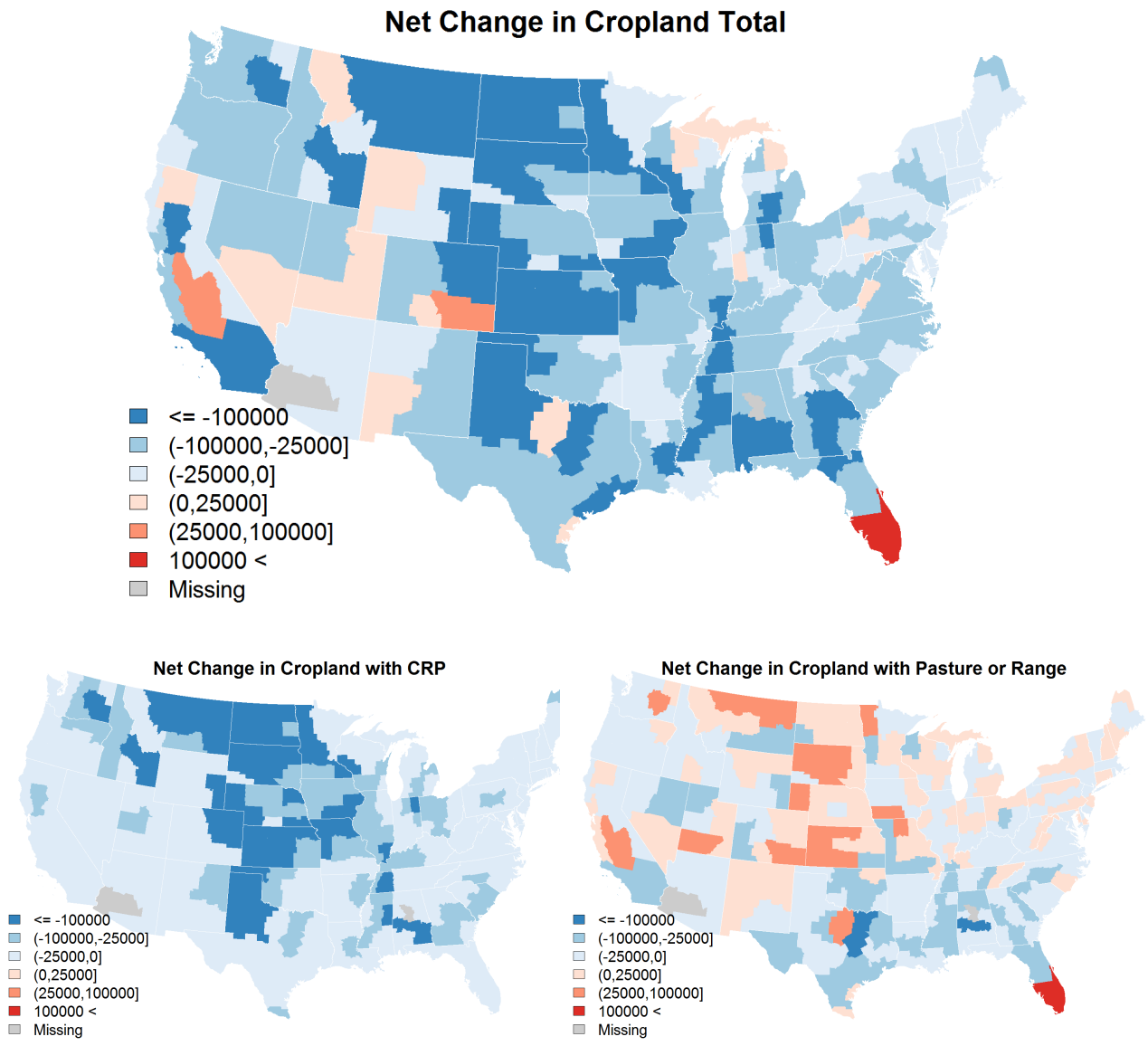

Figure A3: Net Change in Cropland Acres by Crop Reporting District 1987–1992

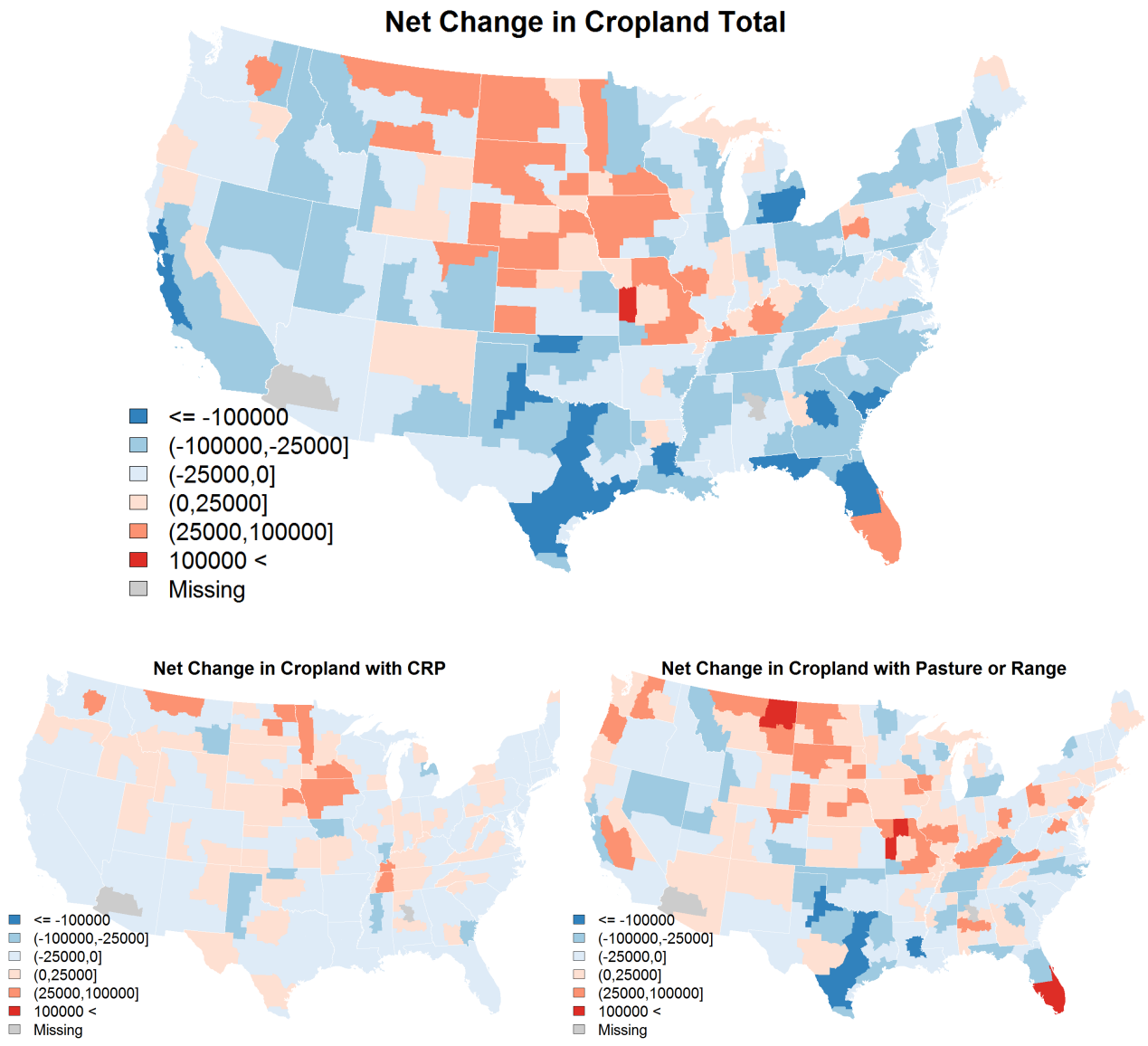

Figure A4: Net Change in Cropland Acres by Crop Reporting District 1992–1997

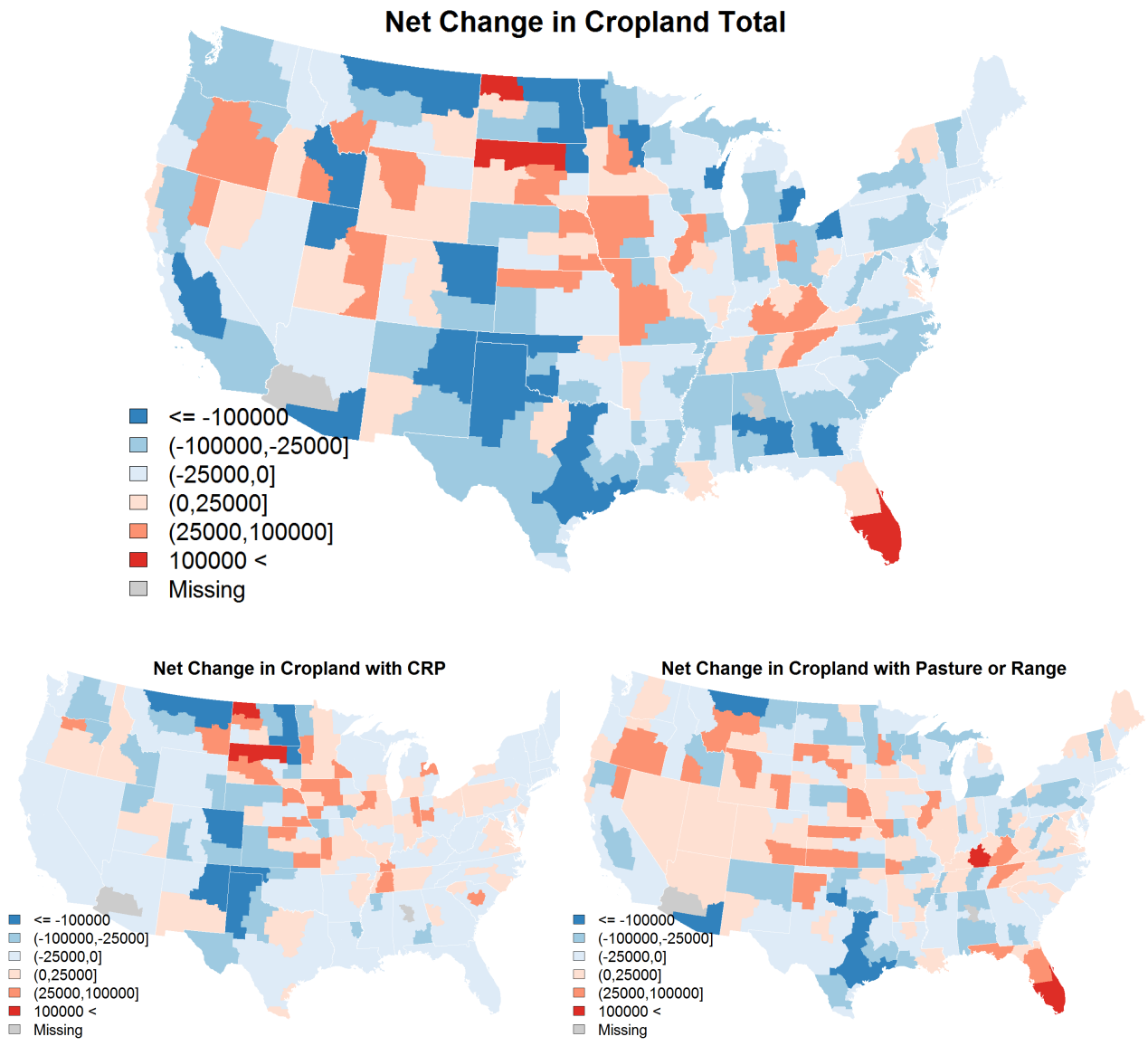

Figure A5: Net Change in Cropland Acres by Crop Reporting District 1997–2002

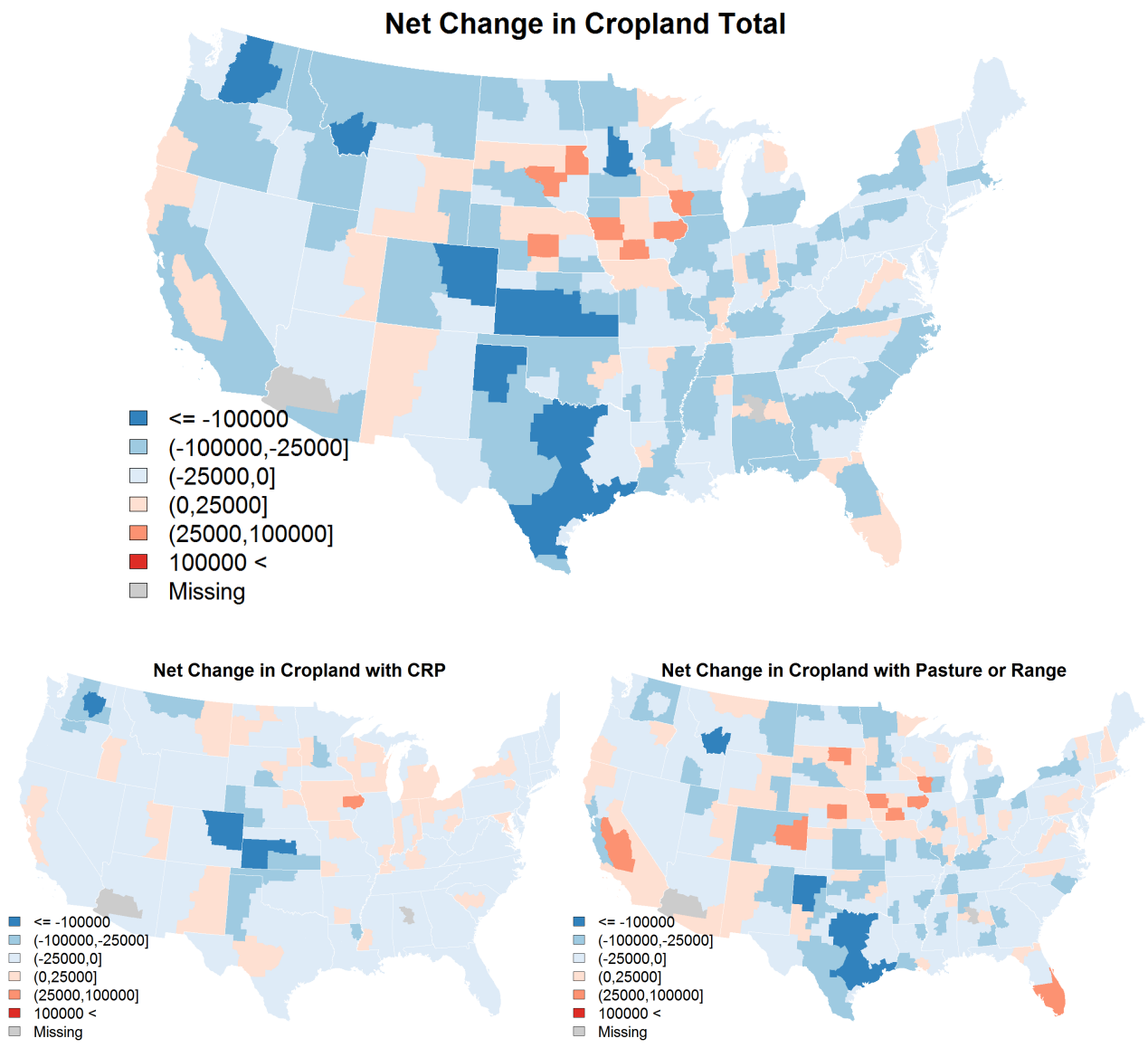

Figure A6: Net Change in Cropland Acres by Crop Reporting District 2002–2007

A4 Crop Prices and CRP Expenditures

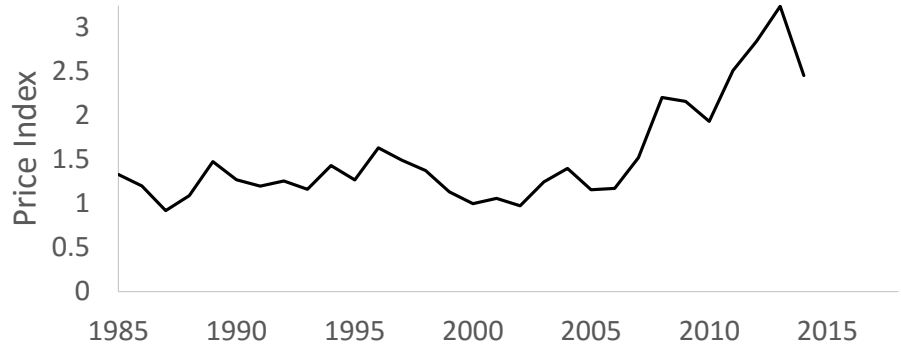

Figure A7: Crop prices over time. The price index is constructed as a Laspeyres index of corn, cotton, soybeans, and wheat marketing-year average prices from NASS.

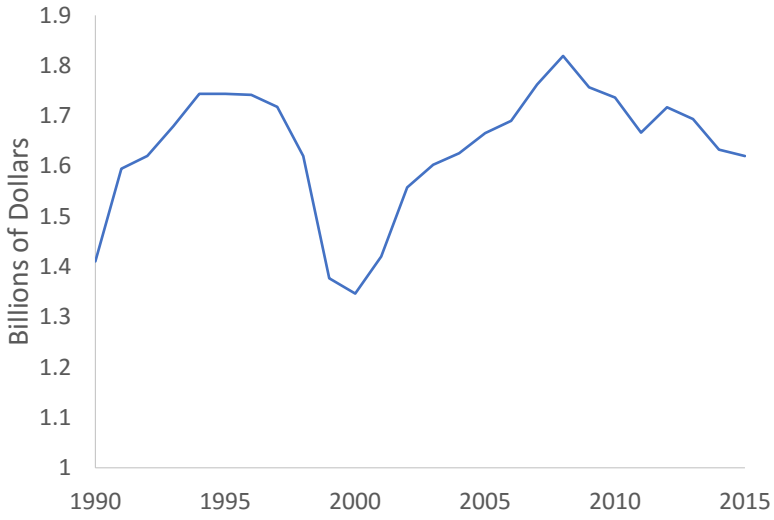

Figure A8: CRP expenditures over time. Data are obtained from the Farm Service Agency.

A5 Crop Planted for Exiting CRP

Table A2: Crop Planted in 2012 for Land that Transitioned from CRP in 2007 to Cropland in 2012

Crop	Percent of Land
Corn	23.0%
Soybeans	20.4%
Wheat	18.4%
Hay	18.0%
Idle	8.4%
Other Crop	11.7%

Source: National Resources Inventory point-level data.

References

Cox, C., and S. Rundquist. 2013. "Going, Going, Gone! Millions of Acres of Wetlands and Fragile Land Go Under the Plow." *Environmental Working Group Report*, Available at: `http://static.ewg.org/pdf/going_gone_cropland_hotspots_final.pdf?_ga=1.257630027.1555155239.1412819990`.

Evans, S., and M. Potts. 2014. "Effect of Agricultural Commodity Prices on Species Abundance of US Grassland Birds." *Environmental and Resource Economics*, pp. 1–17.

Faber, S., S. Rundquist, and T. Male. 2012. "Plowed Under: How Crop Subsidies Contribute to Massive Habitat Losses." *Environmental Working Group Report*, Available at: `http://static.ewg.org/pdf/plowed_under.pdf`.

Homer, C., J. Dewitz, L. Yang, S. Jin, P. Danielson, G. Xian, J. Coulston, N. Herold, J. Wickham, and K. Megown. 2015. "Completion of the 2011 National Land Cover Database for the Conterminous United States - Representing a Decade of Land Cover Change Information." *Photogrammetric Engineering and Remote Sensing* 81:345–354.

Lark, T.J., J.M. Salmon, and H.K. Gibbs. 2015. "Cropland Expansion Outpaces Agricultural and Biofuel Policies in the United States." *Environmental Research Letters* 10:044003.

Nickerson, C., R. Ebel, A. Borchers, and F. Carriazo. 2011. *Major Uses of Land in the United States, 2007*. US Department of Agriculture, Economic Research Service.

Wright, C.K., and M.C. Wimberly. 2013. "Recent Land Use Change in the Western Corn Belt Threatens Grasslands and Wetlands." *Proceedings of the National Academy of Sciences* 110:4134 – 4139.