SI Appendix A: Do declines in cultivated areas for one crop precipitate increases in cultivated areas for other crops?

The significance of our findings hinges on the degree to which declines in cultivated areas in one crop lead either to land saving or to an increase in land used for another crop. As farmers, for example, decrease the number of fields in which they cultivate soy, do they increase the amount of land that they devote to barley? If so, then gains in productivity may reduce acreage in a particular crop, but acreage in other crops will climb. Under these circumstances he intensification – cultivated area decline dynamic would produce little land saving and investigations of the causes for intensification – cultivated area changes based on some but not all crops, like this study, would not be indicative of patterns in total crop area. For this reason, it is important to try and ascertain, to the extent possible given data limitations, the degree to which farmers shift between crops in large scale, asymmetrical ways. If they do make these shifts frequently from crops in our analysis to crops outside our analysis, it would undermine the validity of our work.

Three types of evidence allow us to estimate the extent of large scale, asymmetrical crop shifting. First, using FAO agro-ecological zone data for crops (1), we can calculate the degree of overlap between zones that are suitable for the ten crops in our analysis. A correlation matrix from these analyses reveals three agro-ecological clusters among the ten crops: wheat – potatoes, corn-soy-cotton, and sugarcane-coffee-bananas-cocoa. For example, we might expect to see farmers shift from growing cotton to growing soy because the extent of overlap in suitable zones is very high (.97), but we would not expect to see a farmer shift from wheat to rice because the extent of the overlap in suitable zones is quite low (.15). Seventy-four percent of the pairs of

crops in our analysis (coffee and cocoa excluded because of lack of data) showed less than 70% overlap. Because this analysis includes even minimally suitable sites for crops, it probably overestimates the possibilities for crop shifting. Farmers use much more fine grained criteria in their decision making about crops for particular fields than we have used here. In sum this analysis demonstrates that farmers' possibilities for crop shifting are substantially limited by agro-ecological conditions.

Second, the large scale, asymmetrical shifts from one crop to another crop could, depending on the crops involved, introduce error into our analyses. These crop to crop shifts in response to changing yields should, if they occur, leave markers in the aggregate data on crops. In particular we would expect to see inverse correlations between the two crops. To be sure, farmers will shift back and forth between crops, but it is only large scale, asymmetrical shifts from one crop to another that would threaten the validity of our analyses. To ascertain the frequency of these inverse associations, we cross-correlated changes in cultivated areas for all ten crops plus pasture for the 1990 to 2005 period (Table A1). Of the 55 correlations in the table, only one, between pasture and sugarcane, exhibits the inverse association we would expect to see if declines in the cultivated areas of one crop are precipitating increases in the cultivated area of another crop.

Of course the declines in the cultivated areas of one crop could produce a less conspicuous pattern of expansion in other crops in which the increases in cultivated areas spread across several other crops. If this pattern prevails, we would expect that the decline in the cultivated area for one crop would not extend to the cultivated areas of other crops in the country. There should, in fact, be a disjunction between the trends in the one crop and the national trends in cultivated areas if asymmetrical crop shifting occurs frequently between that

crop and other crops. Table A2 correlates the changes in cultivated areas for eleven crops (the ten crops plus pasture) with changes in the total agricultural land (pastures plus cropland) in nations. Seven of the eleven crops show significant (.10 > p.) positive associations between trends in the cultivated areas for the specific crop under study and trends in cultivated areas for all crops in a nation. We would not expect to see these positive associations between trends for individual crops and the aggregated cultivated areas for nations if the declines in cultivated areas of one crop were accompanied by increases in the cultivated areas of other crops. The prevalent pattern is that the changes in the cultivated areas for one crop seem to get repeated for other crops in a nation. Given that the cultivators are subject to a common set of political economic conditions, this finding should not seem surprising.

The preponderance of the evidence from these three analyses suggest that farmer decisions to curtail the cultivation of some crops did not, at least for the 1990-2005 period, induce a corresponding increase in the cultivation of other crops outside our analysis on the same lands. In this context it seems more likely that declines in cultivated land could have led to land sparing. By extension it seems worthwhile to pursue analyses of agricultural intensification and changes in cultivated areas.

References

1. Food and Agriculture Organization, Global Agro-Ecological Zones 2000, FAO. Rome. At: http://www.fao.org/ag/AGL/agll/ gaez/index.htm.

Table A1: Associations between Changes in Cultivated Areas for Crops across Nations, 1990-2005

	wheat	pasture	cotto	sugar	rice	potato	coffee	corn	soy	banana	cocoa
pasture	-.026 .822										
cotton	.044 .740	.002 .984									
sugar-cane	.025 .868	-.248* .024	.021 .867								
rice	-.018 .886	-.019 .856	.033 .781	.049 .671							
potato	-.012 .902	-.021 .830	-.019 .876	.217* .069	.210* .052						
coffee	.042 .824	.374* .002	.055 .719	.121 .353	-.111 .397	-.070 .621					
corn	.056 .605	-.049 .614	.035 .758	.044 .693	.047 .644	-.022 .815	.221* .077				
soy	-.006 .962	.194 .118	.261* .048	.173 .214	.264* .031	-.034 .771	-.100 .533	.056 .625			
banana	-.060 .684	.014 .895	.561* .000	.009 .941	.159 .172	.001 .991	-.012 .924	.197* .071	.115 .430		
cocoa	.394 .106	-.055 .700	.271 .140	.043 .784	.247 .102	.106 .540	-.102 .486	.426* .003	-.020 .918	.032 .828	

Notes: the top number is the Pearson correlation coefficient; the bottom number is the p value. *p<.10.

Table A2: Changes in Areas in Specific Crops and in all Agriculture Land, 1990-2005, across Nations

	Chnge in Past.	Chnge in Wheat	Chnge in Cotton	Chnge in Sugarca	Chnge in Rice	Chnge in Potato	Chnge in Coffee	Chnge in Corn	Chnge in Soy	Chnge in Banana	Chnge in Cocoa
Chnge in all Ag. Lands	.262* .002	-.035 .732	.242* .028	.181* .096	.207* .037	.231* .009	.335* .006	-.037 .678	.193* .087	-.024 .823	.065 .649

Notes: the top number is the Pearson correlation coefficient; the bottom number is the p value. *p<.10.

Appendix B: Countries by Region:

Sub-Saharan Africa: Angola, Benin, Burundi, Cameroon, Cape Verde, Congo - Dem Rep., Congo - Rep., Cote D'Ivoire, Djibouti, Ethiopia, Gabon, Gambia, Ghana, Guinea-Bissau, Guinea, Kenya, Liberia, Madagascar, Malawi, Mali, Mauritania, Mauritius, Mozambique, Niger, Nigeria, Rwanda, Sao Tome and Principe, Senegal, Seychelles, South Africa, Sudan, Tanzania, Togo, Uganda, Zambia, Zimbabwe.

Near East and North Africa: Algeria, Egypt, Iran, Israel, Jordan, Lebanon, Libya, Morocco, Saudi Arabia, Syria, Tunisia, Turkey. UAE, Yemen

Europe: Albania, Austria, Belarus, Belgium, Luxembourg, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Macedonia, Malta, Moldova, Netherlands, Norway, Poland, Portugal, Romania, Serbia and Montenegro, Slovakia, Slovenia, Spain, Sweden, Switzerland, United Kingdom

East and South Asia: Bangladesh, Brunei-Darussalam, Cambodia, India, Indonesia

China, Comoros, Japan, Korea - Dem. Rep., Korea-Rep., Laos, Malaysia, Maldives, Myanmar, Nepal, Pakistan, Philippines, Sri Lanka, Thailand, Timor-Leste, Viet Nam

Central Asia: Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Mongolia, Russian Federation, Turkmenistan, Uzbekistan

Oceania: Australia, Fiji, French Polynesia, Kiribati, New Zealand, Samoa, Solomon Islands, Vanuatu,

Anglo-America: Bermuda, Canada, United States

Middle America: Antigua and Barbuda, Bahamas, Barbados, Belize, Costa Rica, Cuba, Dominica, Dominican Republic, El Salvador, Grenada, Guatemala, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Saint Lucia, Trinidad & Tobago,

South America: Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Guyana, Paraguay, Peru, Suriname, Uruguay, Venezuela

Appendix C: the Land Sparing Effects of Intensification: Determinants by Crop (Source: FAOSTAT)

	All	Corn	Rice	Soy	Wheat	Potatoes	Bananas	Cocoa	Coffee	Sugarcane	Cotton
Cons.Res. Program	.09** (.03)	-.4*** (.10)	.10* (.05)		.21** (.06)						
Production, 1990						-66** (18)			.18* (.08)		
Irrigated Land, 1990			.02 (.02)	-.07 (.07)			-.05 (.04)				
Cereal Imp.	.02* .01			.17*** (.03)			.86* (.41)	.13*** (.02)			
Prop. Land Cultivated	43** (14)	289* (130)	.73 (.54)		-292** (85)	1553*** (196)			2360*** (578)		
GDP, 1990		.12* (.06)							-.23** (.07)	-.33* (.14)	
Prop. Econ. Active Ag			42** (.12)			-1.9*** (.15)				-.70* (.29)	
SubSaharan Africa	.15* (.06)										
South America				-.58*** (.12)	.27** (.13)				.99*** (.27)	-.16* (.09)	.78*** (.17)
Cntl. Asia					-.36*** (.08)						
Adj r2	.020	.172	.099	.468	.525	.693	.066	.480	.368	.044	.203
N of Cases	927	130	102	81	101	127	85	45	63	78	80

Appendix D: Countries with Conservation Set Aside Programs during the 1990s: A list with information sources.

Countries

Austria	Italy
Belgium	Luxembourg
Canada	Netherlands
China	Portugal
Denmark	Spain
Finland	Sweden
France	Switzerland
Germany	United Kingdom
Greece	United States
Ireland	

Sources: For Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom (Common Agricultural Policy at a glance – at: http://www.epha.org/a/495); for Canada, in some provinces (Agriculture Canada – at http://www4.agr.gc.ca/AAFC-AAC/display-afficher.do?id=1204137480722&lang=eng#e); for China (Xu et al., 2006, World Dev. 34:130-48); for Switzerland (Muller, Grether, 2001, Long run effects of the common agricultural policy for Switzerland – at: http://www.unige.ch/ses/metri/mueller/cahier0201.pdf); for United States (Osborn, 1997, Wheat and the Conservation Reserve Program, USDA, Washington, DC).