Recent Land Use Changes in the United States

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The analysis of CARB indicates that between 0.16 and 0.28 million hectares (0.395 and 0.692 million acres) of U.S. land will be converted to cropland depending on the assumptions of the different scenarios. Averaging across scenarios, 0.21 million hectares of land could be brought into agricultural production. The results indicate that between 40% and 50% of the total expansion of cropland would occur by converting forestland (see Table 1). This short paper presents data on U.S. cropland changes in the last 15 years to see how well this model prediction accords with historical trends.

Table 1. Land Used Changes in CARB's Biodiesel Analysis

	A	B	C	D	E	F	G	Mean
U.S. land converted (million ha)	**0.24**	**0.16**	**0.28**	**0.28**	**0.16**	**0.2**	**0.18**	**0.21**
U.S. forest land (million ha)	0.11	0.06	0.13	0.12	0.08	0.09	0.08	0.1
U.S. pasture land (million ha)	0.13	0.1	0.14	0.16	0.08	0.11	0.11	0.12
% of forest on total converted	46%	38%	46%	43%	50%	45%	44%	48%

To put these estimated land use changes into perspective, Figure 1 shows the annual changes in U.S. crop acreage since 2000. The smallest change in acreage is the change from 2002 to 2003 at 0.6 million acres. Thus CARB's estimated changes are quite small relative to the acreage changes that we have actually observed in recent years.

It is useful to see if the changes in cropland shown in Figure 1 are associated with changes in pasture and forest land because CARB's GTAP analysis allocates land between crops, forests and pasture to maximize total returns. We do not have annual data on forest land, but we do have data on hayland (pasture) and CRP land. Figure 2 presents the annual changes in CRP and pasture land to the Figure 1 changes in cropland. Between 2000 and 2001 the sharp drop in cropland corresponds to an increase in pasture and CRP land. And the sharp increase in cropland in 2007 and 2008 corresponds to a decrease in CRP land in 2008 and 2009, although both CRP and crop acres decreased significantly in 2009. But what is notable about Figure 2 is the long-term stability of hayland. And CRP acres have been stable as well with the exception of the significant declines in 2008 and 2009, when increased crop prices led to farmers deciding not to renew their CRP contracts.

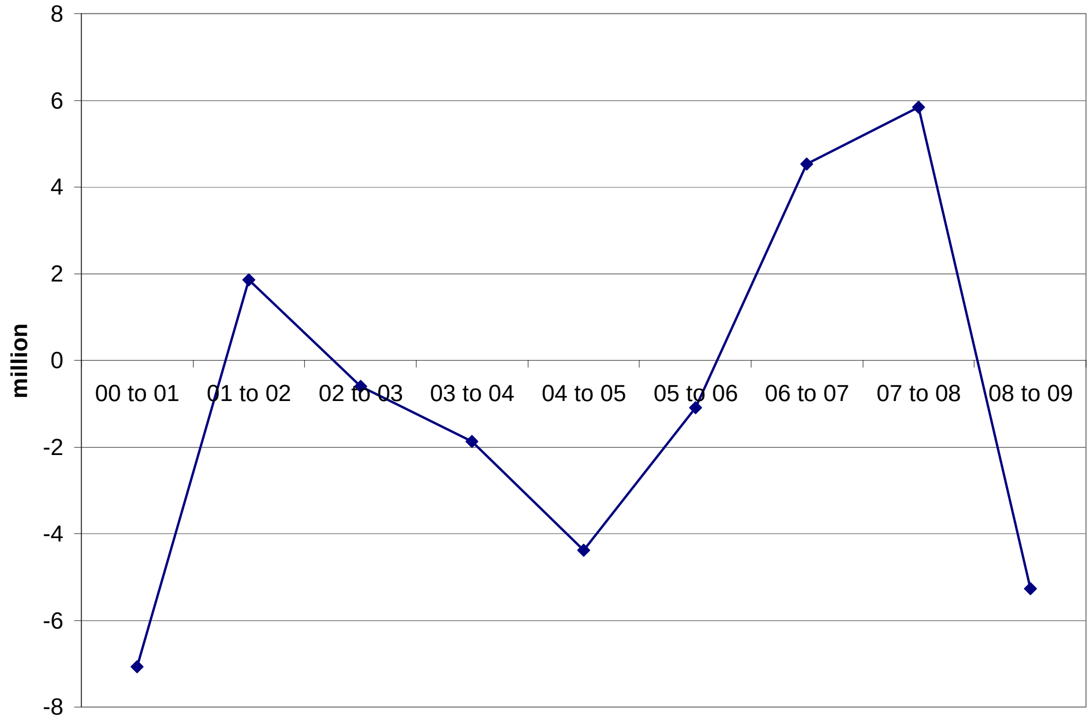

Figure 1. Annual Changes in U.S. Crop Acreage for the 13 Principle Field Crops
Source: FAPRI Agricultural Outlook

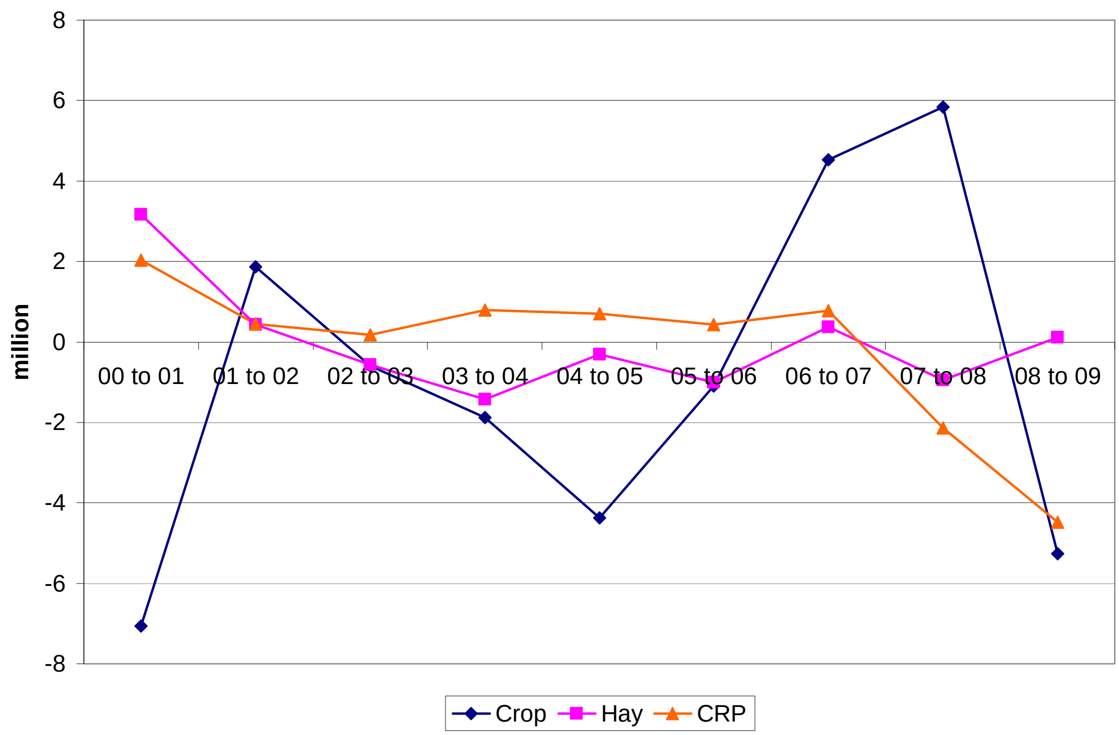

Figure 2. Annual Changes in U.S. Land Devoted to Crop, CRP and Hay

The data in Figure 2 suggests that there is some negative correlation between cropland and land enrolled in CRP and hayland, but the magnitude of the changes in cropland are much larger than the changes in either CRP or hayland. Because total land in the United States does not change, what land use category is changing along with cropland? Because CARB allocates acreage between crops, pasture, forest, and other (typically industrial land) the answer from CARB's modeling perspective is that one of these categories must be increasing or decreasing. From a data and accounting perspective, the first place to look is to account for changes in double-cropped acreage.

Figure 3 overlays the annual change in double cropped acres on the change in cropped acres. As shown, the large expansion of crop acres in 2007 and 2008 were partly accomplished by increasing double cropped acres. The correlation coefficient between the change in double cropped acres and the change in crop acres over this time period is 0.8. This suggests that the first adjustment that should be made in accounting for how the U.S. expands or contracts crop acreage is to subtract double cropped acreage from total crop acreage. Figure 3 shows that the annual change in crop acreage is significantly reduced by such a subtraction. The standard deviation of annual cropland changes from 2001 to 2009 drops from 4.37 to 3.32 million acres by this subtraction.

The question then becomes whether changes in actual planted acreage adjusted for double cropping are accounted for by changes in pasture and CRP land. A scatter plot of the annual changes (with the annual change in crop acres shown on the horizontal axis) is shown in Figure 4. If there exists a strong negative relationship between pasture land and cropland, then most of the points should be in the southeast and northwest quadrants. However, only three of the nine points appear in this quadrant with the two most prominent changes occurring in 2008 and 2001.

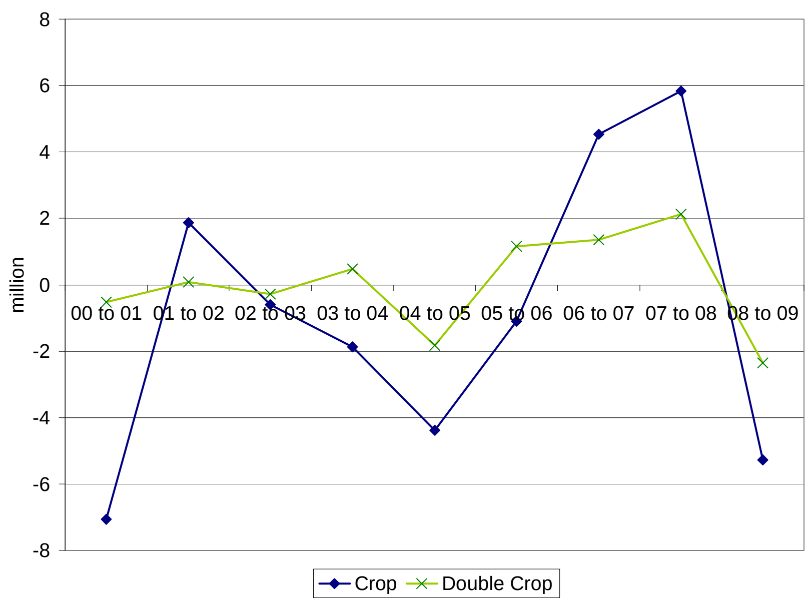

Figure 3. Accounting for Changes in Double Cropped Acres

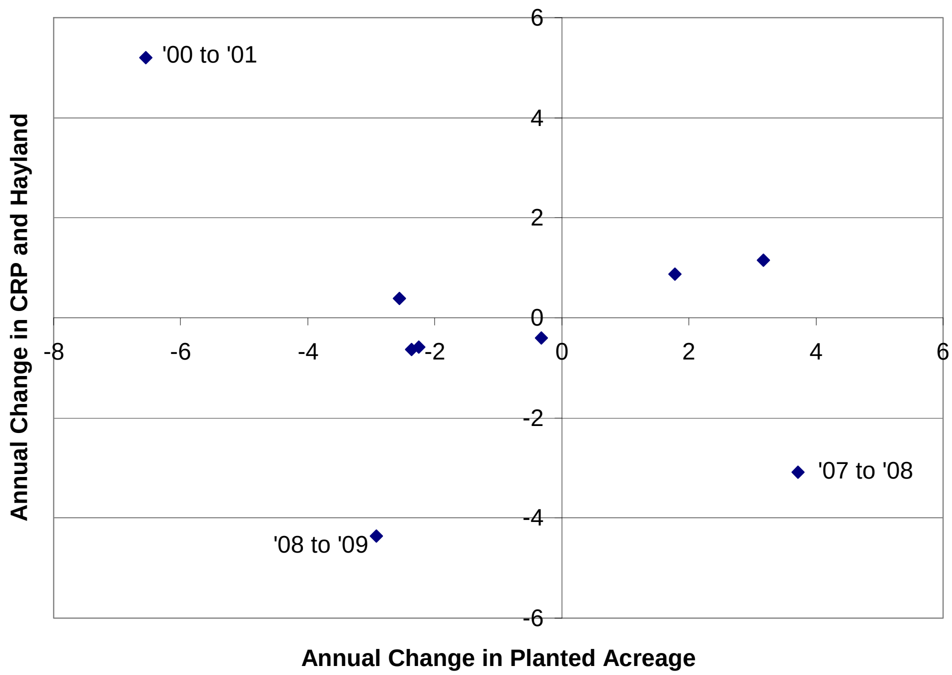

Figure 4. Relationship Between Cropland Changes and Pasture Changes

One conclusion that can be drawn from Figure 4 is that the annual fluctuations in crop acreage are not highly correlated with annual fluctuations in pasture land. What this suggests is that some other land use is absorbing the annual changes. This could be either changes in forest cover, urban land, or it could be that idle crop land moves in and out of production as economic conditions warrant.

Insight into whether the land use changes that we have seen since 2000 are consistent with a stock of idle crop land can be obtained by looking at Figure 5, which shows the annual flux of cropland not accounted for by double cropped acres, CRP land, and hayland. A positive number means that land is flowing out of cropland and potentially into idle cropland. A negative number means a potential reduction in idle cropland. As shown, if Figure 5 does measure flux in idle cropland, then 2002, 2007 and 2008 reduced the stock of idle land, and the remaining years increased the stock. One question that is raised, in this limited time period, was there enough flow of land into the stock of idle cropland to offset the flows out of the stock? This question is answered by looking at the level of the stock of idle cropland, (Figure 6), which is simply the sum of the Figure 5 flux. As shown, the deficit in crop acres (not accounted for by changes in pasture, CRP, or double cropping) in 2002 and 2003 were greater than the reduction in crop acres in 2001. Thus, either the stock of idle cropland in 2000 was greater than zero, or some other category of land needed to be converted into cropland. The increase in crop acres in 2007 and 2008 could have been accommodated by the reduction in crop acres in 2004, 2005, and 2006. And the 2009 reduction in crop acres has seemingly rebuilt up the stock of potentially idle land. Whether the deficits in the stock of idle land in 2002 and 2003 could have been accommodated by an earlier buildup in idle land is revealed by Figure 6, which treats the stock of idle cropland as being zero in 1996, instead of in 2000. As shown, there was a large reduction in cropland in 1998 that could have created enough of a reserve of idle land to accommodate the 2002 and 2003 deficits.

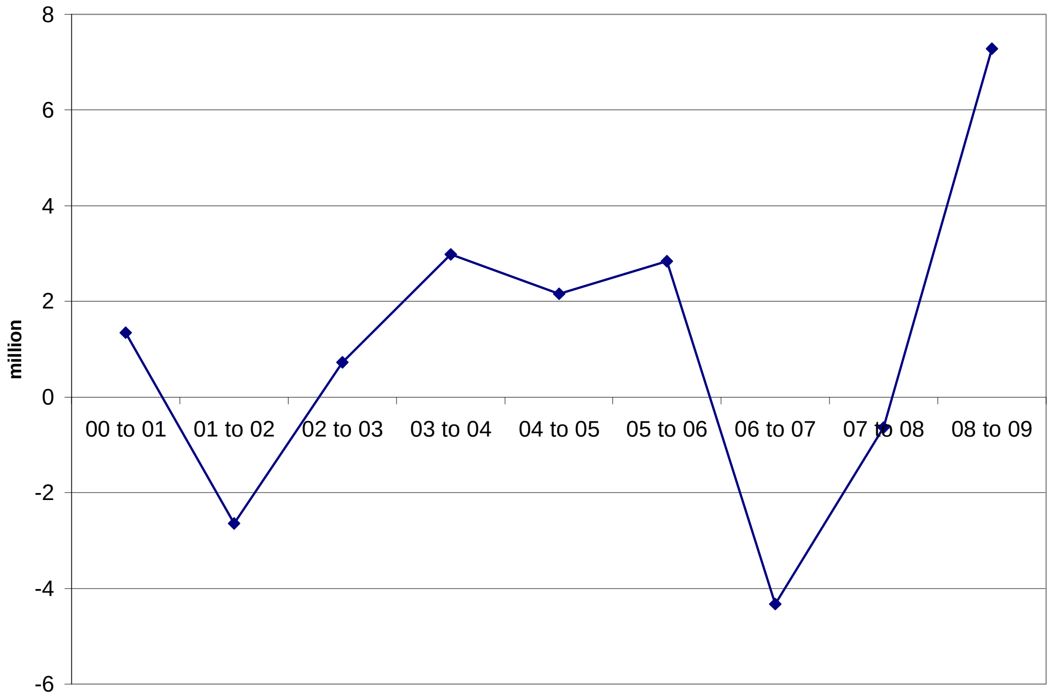

Figure 5. Potential Flux of Idle Cropland

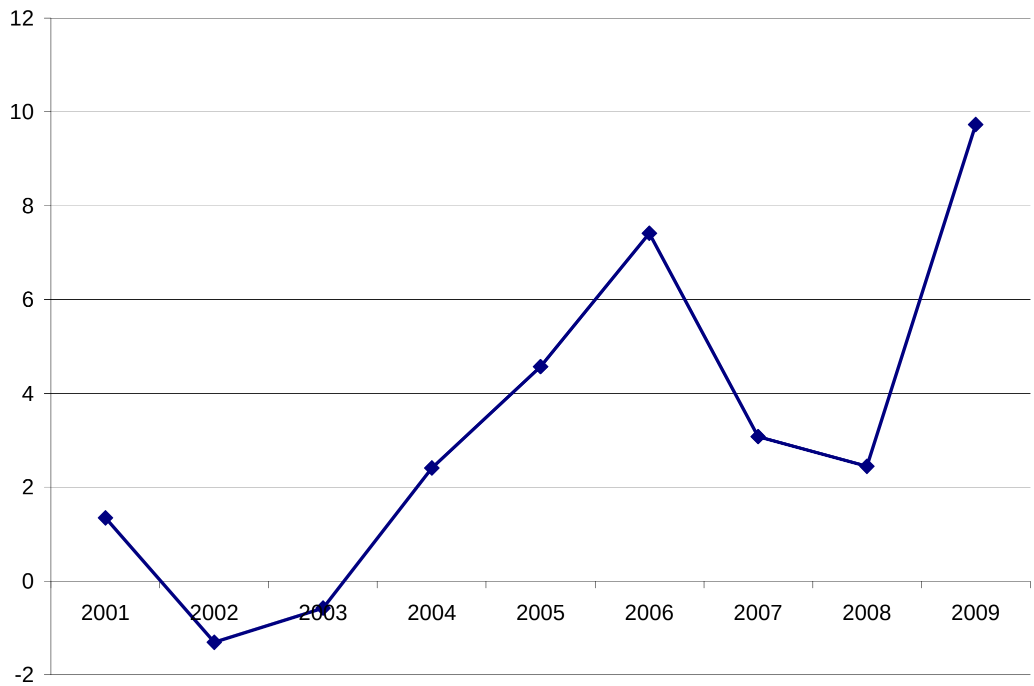

Figure 6. Potential Stock of Idle Cropland Assuming No Idle Land in 2000

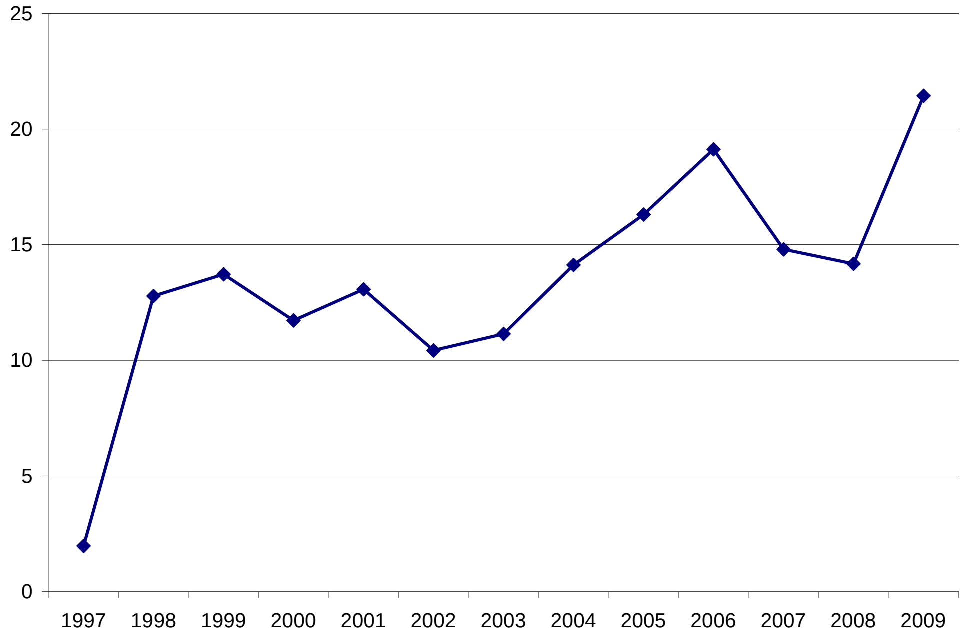

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Figure 7. Potential Stock of Idle Cropland Assuming No Idle Land in 1996

Figure 7 shows that it was possible to meet all demands for crop land out of land that was previously idled. Of course, this assumes that the land that moved out of crops (and that did not move into pasture or CRP) did not move to urban land or forests. If a large portion of the land attributed to idle cropland in Figure 7 became forest or if houses were built on it, then it would not have been available to meet the demands for cropland in 2007 and 2008.

Recent trends for U.S. land use as measured by the National Resource Inventory (NRI) are shown in Table 2. The NRI provides nationally consistent data at several points in time for the 1982-2003 period. Total land covered in Table 2 is constant (at 1.938 billion acres) for all the NRI survey years, and thus the reallocation of land across uses can be assessed. The data indicates that forest and developed area have been consistently expanding over the 20 year period covered. At the same time, pasture and crop areas have declined over time. These observations have been made in the literature. According to Alig et al. (2004), while in recent decades forests have been the largest source of land converted to developed uses, these losses are more than offset by displacement of cropland and pastures (by forests). In this line, Alig et al. (2004) writes "*Movement of land between forestry and agriculture in the last two decades has resulted in net gains to forestry that have offset forest conversion to urban and developed uses in area terms*." (p 229).

Table 2. Total Surface Area by Land Cover/Use by Year

Year	Cropland	CRP Land	Pastureland	Rangeland	Forest Land	Other rural land	Developed land	Water areas	Federal land
	Million acres								
1982	419.9	0	131.1	415.5	402.4	48.2	72.9	48.6	399.1
1992	381.3	34	125.2	406.8	403.6	49.4	86.5	49.4	401.5
1997	376.4	32.7	119.5	404.9	404.7	50.4	97.6	49.9	401.7
2001	369.5	31.8	119.2	404.9	404.8	50.1	105.2	50.3	401.9
2003	367.9	31.5	117	405.1	405.6	50.2	108.1	50.4	401.9
Changes in consecutive reports									
1992-1982	-38.6	34	-5.9	-8.7	1.2	1.2	13.6	0.8	2.4
1997-1992	-4.9	-1.3	-5.7	-1.9	1.1	1	11.1	0.5	0.2
2001-1997	-6.9	-0.9	-0.3	0	0.1	-0.3	7.6	0.4	0.2
2003-2001	-1.6	-0.3	-2.2	0.2	0.8	0.1	2.9	0.1	0
Changes by year for different NRI intervals									
1992-1982	-3.86	3.40	-0.59	-0.87	0.12	0.12	1.36	0.08	0.24
1997-1992	-0.98	-0.26	-1.14	-0.38	0.22	0.20	2.22	0.10	0.04
2001-1997	-1.72	-0.23	-0.07	0.00	0.03	-0.07	1.90	0.10	0.05
2003-2001	-0.80	-0.15	-1.10	0.10	0.40	0.05	1.45	0.05	0.00
Average[a]	-1.17	-0.21	-0.77	-0.09	0.22	0.06	1.86	0.08	0.03

[a] Average is since 1992, to avoid confounding effect of CRP introduced in the first interval.
Source: Calculated by authors based on the 2003 Annual NRI report.
http://www.nrcs.usda.gov/technical/NRI/2003/national_landuse.html

Hence, history indicates forests advancing over cropland. This is suggestive suggests that at least some portion of the loss of cropland shown in Figure 7 could be accounted for by an increase in forest land. However, note that the increase in forest land seems to have decreased after 1997, so the magnitude of the change in cropland in Figure 7 does not seem like it could have been converted to forest. Note that the increase in urban land from 1997 to 2003 is about equal to the decrease in cropland over the same period, and that the NRI decrease in cropland is much less than the Figure 7 decrease in cropland. Thus it seems plausible at least that some portion of the Figure 7 cropland was urbanized and most of the remainder remained as cropland, as reported in the NRI, but was not planted.

This examination of land use changes shows that the abstraction used by the GTAP model which allocates land between pasture, forests should be altered to include a land category which better accounts for the likelihood that there is a relatively large amount of cropland that moves in an out of crops as economic conditions meet. This change would better reflect the reality of cropland changes since 1997 and it would result in a more accurate estimate of the greenhouse gas emissions from U.S. land use changes because conversion of idle cropland in active incurs few emissions. Of course, the data requirements of making such a change are not trivial, as this brief examination of the data suggests. The feasibility of implementing such a change in modeling structure outside the U.S. and perhaps Europe presents an even larger challenge. But this is the type of data that is needed to facilitate the type of analysis that is required to accurately estimate actual land use changes from expanded biofuels.