



Figure 6. Transitions to croplands detected with remote sensing from 2001 to 2006. The two primary cropland development paths analyzed in this paper (transitions of natural ecosystem directly to cropland or pasture to cropland) are illustrated for each of the natural ecosystems of origin. The net cropland is total increase in cropland area from either land-use trajectory. The total area is the cropland area in 2006 that came from either trajectory. Also, see Table 4 for annual transition rates.

growing agricultural regions in the world. This and previous studies in the Amazon frontier have documented rapid land-use change for pastures and croplands and point out the differing land-use trajectories within the region (Brown et al. 2007; Galford et al. 2008; Morton et al. 2006). Here, we show that remote sensing techniques track landscape-level processes of cropland extensification and double-cropping intensification with temporal and spatial detail not provided by census or agricultural surveys. We document that the average annual rate of agricultural extensification (0.47% increase each year) doubled from the 1990–96 annual rate (0.24%) reported in the agricultural census data (IBGE 2009). We estimate slightly higher rates of forest conversion to cropland (average $>1500 \text{ km}^2 \text{ yr}^{-1}$) as compared to previous studies (average $1350 \text{ km}^2 \text{ yr}^{-1}$; Morton et al. 2006). This could

Table 4. The relative importance of pasture-to-cropland transitions as a percentage of all transition in each of the three major biomes in Mato Grosso. The year of conversion is the year prior to the first crop harvest. For example, an area converted in 2005 would first be harvested in 2006, so only conversions between 2001 and 2006 are reported here. See Figure 4 for net (area) transitions along each land-use trajectory.

Year of conversion	Pasture-to-cropland transitions (percent of all cropland transitions)		
	Cerrado	Cerradão	Forest
Natural ecosystem of origin			
2002	60	67	64
2003	66	65	60
2004	82	78	68
2005	42	67	53
Annual avg	63	69	61
Std dev	17	6	6