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Classifying Successional Forests Using Landsat Spectral Properties and Ecological Characteristics to Evaluate Recent Trends in Land Cover and Carbon Loss in Eastern Amazonia

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Secondary forests are becoming increasingly important as temporary reservoirs of genetic diversity, stocks of carbon and nutrients, and moderators of hydrologic cycles in the Amazon Basin as agricultural lands are abandoned and often later re-cleared for agriculture. We studied a municipality in northeastern Pará where numerous cycles of slash and burn agriculture have occurred during more than a century of settlement. Tree species were identified and heights and diameters were measured in chronosequences of secondary forests (3, 6, 10, 20, 40, 70 years) and in remnant mature forests. Land cover classes of young, intermediate, and advanced successional forests were identified using 1999 Landsat 7 TM imagery. Similar groupings were derived independently from analyses of species composition and from distributions of tree heights and diameters. Young forests have nearly uniform heights, whereas multiple height classes were present in the advanced successional forests, and their shadows affect spectral properties. Biomass accumulated more slowly in this chronosequence than has been reported elsewhere, which explains why these 70-year-old forests are still distinguishable from mature forests using spectral properties. Supervised classification of the imagery showed about 50% forest cover. Comparing Landsat images from 1995 and 1999, pastures and bare soil increased during the intervening 4 years at the expense of both secondary and mature forest areas, resulting in a net loss of $> 10^{11}$ g of carbon from the aboveground biomass of this 477-km^2 municipality. Although initial widespread deforestation occurred several decades ago, continued clearing of mostly secondary forests is causing a net carbon loss averaging at least 0.7 Mg C ha^{-1} yr^{-1}.