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### Quantifying landscape degradation at a deforestation frontier in the Brazilian Amazon

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Forest landscape degradation from logging, forest fires and fragmentation can result in drastic losses of carbon and biodiversity and represents a major threat to the integrity of tropical forests worldwide. In the Amazon these anthropogenic pressures have already impacted an area larger than the total area of cleared land. Yet forest degradation and past deforestation trajectories are rarely accounted for in designing forest legislation, management and financial incentive schemes. Moreover, there is still a lack of clarity on optimal approaches to classifying and quantifying forest degradation. Recent developments in remote sensing, together with multi-decadal time-series of satellite images, provide opportunities for cost-effective, large-scale assessments of historical deforestation and forest degradation trajectories. Here we present a nested (site, catchment and region) assessment of deforestation and the frequency, timing and extent of pixel-scale anthropogenic degradation events during1988-2010 across two large (c. 1.5 million ha) study regions in the Brazilian Amazon (Paragominas and Santarém). We also use detailed field data to validate remote-sensing based estimates of forest degradation. We demonstrate that while deforestation trajectories at the catchment scale can help to explain spatial patterns of degradation, landscapes with similar levels of present-day forest cover still exhibit marked variability in forest condition and degradation profiles. Moreover, remote assessments of forest condition using only contemporary satellite images perform poorly in capturing the spatial heterogeneities in the frequency and timing of historical degradation events. We present new indices of forest degradation based on accumulated information regarding the extent and timing of historical impacts. These indices can inform a revised classification of forest degradation as well as a set of testable hypotheses concerning the loss of forest carbon stocks and biodiversity. These results contribute to integrate avoided degradation strategies into REDD+ programs, and to municipality scale ecological-economic zoning and conservation efforts in private lands.