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| Characterising Leaf Phenology of Tropical Forest Trees with repeated Drone Multispectral and LiDAR Surveys |
| Leaf phenology plays a crucial role in carbon and water cycling within tropical ecosystems, yet significant uncertainties persist regarding the timing of leaf cycling among tropical tree species and the underlying environmental and physiological mechanisms governing these patterns. The advent of drone-mounted sensors has substantially enhanced our ability to monitor biodiverse tropical forests with high spatiotemporal resolution.  In a study conducted in the tropical moist forests of French Guiana, we monitored the leafing phenology of 3000 tree crowns over two and a half years using lidar and photographic surveys conducted every three weeks. Through these surveys, we were able to track changes in Plant Area Density (PAD) and greenness (Green Leaf Index; GLI) of individual tree crowns over time, particularly focusing on variations in leaf quantity and quality in response to the short dry seasons prevalent in the region.  Our analysis involved calculating the periodicity, synchronicity, and regularity of phenological signals, as well as determining the seasonality and timing of leaf flushing and shedding for 100 dominant species. We observed distinct leaf phenology patterns among species, hypothesizing that these differences are related to species-specific resource acquisition strategies and local environmental heterogeneity.  The majority of tree species exhibited a leaf cycle period close to one year, with some displaying shorter-term cycles or cycles approaching two years. Approximately half of the species demonstrated statistically significant "seasonality" in leaf flushing and shedding. Most species tended to flush new leaves around the transition from wet to dry seasons. Interspecific variation in leaf phenology was strongly correlated with local topographic position (TPI) preference and tree height. Taller species tended to flush fresh leaves earlier relative to the dry season, particularly those associated with gully locations (low TPI). In contrast, species associated with ridges (high TPI) did not exhibit this pattern, suggesting a response to water stress.  The strength and synchronicity of leaf cycling signals were greater for species associated with ridges, indicating a heightened sensitivity to environmental cues among species in better-drained areas. Taller species generally displayed shorter leaf cycle periods, potentially reflecting a faster resource acquisition strategy required for canopy emergence.  Intraspecific variation in leaf phenology timing was linked to tree height, with taller trees tending to flush leaves earlier. Additionally, intraspecific variation in leaf cycle period was greatest at high TPI, suggesting a facultative exchange strategy.  Our findings suggest that leaf phenological traits are adaptable for opportunistic niche filling rather than being closely tied to evolutionary history. Incorporating additional leaf and wood traits into future studies would facilitate a more precise understanding of leaf phenology and its relationship to resource acquisition strategy. Furthermore, linking tree-level variations in leaf characteristics to observed fluxes can provide insights into how individual tree crowns contribute to seasonal patterns of forest productivity. |