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Feedbacks between phosphorus deposition and canopy cover: the emergence of multiple stable states in seasonally-dry tropical systems

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In old, phosphorus (P)-limited tropical systems, vegetation must be sustained by the maintenance of a dynamic equilibrium between small P-inputs and losses. Since accessible mineral-P is often depleted in these systems, losses of P (e.g. leaching, erosion, etc.) must be counter-balanced by atmospheric inputs in the form of rainfall, dust, or fog. Past research has shown that atmospheric deposition via dust and fog, both of which may be of critical importance to seasonally-dry systems, are dependent on vegetation biomass or density (e.g. LAI). Thus, the canopy may be seen as a "trap" for P, indirectly functioning as a source for this nutrient. This canopy function suggests that there may be a positive feedback between vegetation and P-supply (e.g. a denser canopy may increase deposited-P, which may increase the canopy) and changes in canopy cover may upset the balance between P-inputs and outputs. We developed a conceptual model to investigate how tropical vegetation may respond to reductions in P-deposition due to both gradual and catastrophic losses in canopy cover. The model suggests that under certain conditions losses in vegetation may lead to disproportionately large losses in P and, ultimately, to systems with insufficient P to recover naturally to the original vegetative state. Given the widespread conversion of tropical forests to agricultural systems and the plausible increase in natural disasters due to global climate change, a better understanding of the resiliency of tropical systems is necessary.