Supporting Information

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SI Text

Water. Water is an unlikely candidate as a sustained limiting factor at La Selva, where the frequency of occurrence of months receiving <0.1 m of rainfall is <0.1 (www.ots.ac.cr) and long-term mean rainfall exceeds 0.1 m in all months. Volumetric soil water content was measured periodically throughout the study and rarely dipped below 40% (Fig. S1).

Pest Damage. Severity of plant pest attacks was tracked throughout the study by recording a relative damage score and agent involved at the time of each plant inventory. There was no evidence that damage was ever severe enough to account for the growth declines observed in the deciduous tree species as they aged. Young Cedrela were subject to damage by larvae of shoot-boring moths, Hypsipyla grandella (Zeller) (Lepidoptera, Pyralidae), but attacks ceased once the trees were >5–7 m tall (about age 4 yr). Branch nodes of Cordia form domatia that are inhabited by any of several species of ants (2). Frequency of habitation by ants increases with tree age, and ant defense against herbivores is accordingly more effective in older trees (3). Young Cordia trees were subject to dry-season outbreaks of a phloem-feeding bug [Dictyla monotropidia (Stål) (Hemiptera, Tingidae)], but attacks were much less pronounced on older trees (>5 yr) than on young ones.

Soil Fertility. The high soil fertility was confirmed by annual measurements of exchangeable cations, pH, organic C, and extractable P (Fig. S2). The sum of base-forming cations (Ca + Mg + K) was 11–22 cmol/kg, whereas acid-forming cations (Al + H) were low (average ~0.2 cmol/kg). Consequently, the effective CEC (sum of positive charges) was only slightly greater than the sum of base cations. Values of CEC at pH buffered to 7 (25–45 cmol/kg) were almost double the values of effective CEC, suggesting a large amount of pH-dependent charge, a characteristic feature of volcanic soils (4, 5). Values of pH in water ranged from 5.5 to 7.0, whereas those in KCl were 1 pH unit lower, indicating net negative charge. Organic C was 2–4% at 0–10 cm and 0.9–2% at 10–25 cm; total N behaved similarly (0.28–0.38% and 0.10–0.20%). Most P concentrations in the surface soil were >10 mg/kg, a value often used to distinguish soils containing adequate P from those considered P-deficient (6, 7). High fertility extended throughout the profile: samples at 70–120 cm and 70–155 cm had ~12 cmol/kg of base cations, ~10 mg/kg of extractable P, and pH of 6.4.

Following the expected increase in soil fertility after vegetation felling and burning (8), most chemical properties (pH water, pH KCl, organic C, exchangeable Mg, Ca, and K) of the surface soil (0–10 and 10–25 cm) decreased significantly (P < 0.0001 in all cases) over time; nevertheless, even after 12 yr organic matter and cation availability remained high (Fig. S2). Extractable Ca and Mg accounted for 70–80% and 10–20% of base cations, respectively, and concentrations after 12 years were still high (8–10 cmol/kg Ca and 2–3 cmol/kg Mg). K decreased to relatively low concentrations (0.5–0.9 cmol/kg) but still higher than those reported for other young tropical volcanic soils (9).

The three tree species, and the monoculture or polyculture treatments, exerted measurable, and different, effects on soil P (Fig. S2). In Hyeronima and Cedrela monocultures soil P increased over time while remaining relatively constant (and lower) in Cordia monocultures and in all three polycultures. Different factors accounted for these results, reflecting differences among the three tree species. Cordia accrued large amounts of foliar N (means = 2.7–4.0%), and maintenance of its foliar N:P stoichiometry led to substantial consumption of soil P in both monoculture and polyculture. Monocultures of the other two tree species, which had much lower concentrations of foliar N, required less P to maintain N:P stoichiometry. As a result, P accumulated in the surface soil beneath these two species, presumably through returns in litterfall that exceeded uptake demand. In polycultures of Cedrela, growth of the P-limited Euterpe depleted soil P, whereas soil P under Hyeronima polycultures, where Euterpe did not grow vigorously until the latter half of the experiment, stayed relatively constant.

**Fig. S1.** Volumetric water content of soil under polycultures containing Cedrela odorata (A) and Cordia alliodora (B). Values are means ± SE from 3 blocks, each with 3 pairs of time domain reflectometry rods. Apparent dielectric constants were converted to volumetric water contents using equation developed on site (1).
Fig. S2. Time courses of soil properties. (A) Base cations (Ca + Mg + K). (B) pH in water. (C) Organic carbon. (D) Extractable phosphorus, where dotted line at 10 mg/kg indicates adequate level for plant growth (6, 7). Values are means of three blocks at 0–10 cm (red) and 10–25 cm (black), under monocultures (open symbols) and polycultures (filled symbols) containing *Heronima* (square), *Cedrela* (circle), or *Cordia* (triangle). Except in the case of phosphorus, only time contributed significantly ($P < 0.05$) to the model. There was a significant treatment $\times$ time interaction at depth 0–10 cm ($P = 0.001$) and a significant tree species $\times$ treatment $\times$ time interaction at depth 10–25 cm ($P = 0.003$).
Fig. S3. Foliar nutrient concentrations of the five species. Shown are foliar nitrogen (N) in tree species (A) and monocots (B), foliar phosphorus (P) in tree species (C) and monocots (D), and ratios of foliar N to P in tree species (E) and monocots (F). For tree species open bar is monoculture and filled bar is polyculture. For monocots open bar is when grown with *Heronima alchorneoides*, gray bar is with *Cedrela odorata*, and black bar is with *Cordia alliodora*. Values are means ± SE from 3 blocks across all years.