A. Plant phosphorus demand for new growth

The total P demand for new growth is calculated using

$$F^{P}_{plant\_demand} = F^{C}_{avail\_alloc} \frac{P_{allom}}{C_{allom}} \qquad (0.1)$$

where $F^{C}_{avail\_alloc}$ is the potential available carbon for allocation assuming no nutrient limitation,

$$C_{allom} = \begin{cases} (1+g_1)(1+a_1+a_3(1+a_2)) & \text{for woody PFT} \\ 1+g_1+a_1(1+g_1) & \text{for non-woody PFT} \end{cases} \qquad (0.2)$$

$$P_{allom} = \begin{cases} \frac{1}{CP_{leaf}} + \frac{a_1}{CP_{fr}} + \frac{a_3 a_4 (1+a_2)}{CP_{lw}} + \frac{a_3(1-a_4)(1+a_2)}{CP_{dw}} & \text{for woody PFT} \\ \frac{1}{CP_{leaf}} + \frac{a_1}{CP_{fr}} & \text{for non-woody PFT.} \end{cases} \qquad (0.3)$$

The allometric parameters are defined as follows:

a_1 = ratio of new fine root : new leaf carbon allocation
a_2 = ratio of new coarse root : new stem carbon allocation
a_3 = ratio of new stem : new leaf carbon allocation
a_4 = ratio new live wood : new total wood allocation
g_1 = ratio of growth respiration carbon : new growth carbon.

Parameters a_1, a_2, and a_4 are defined as constants for a given PFT ((a_1 = 1, a_2 = 0.3, a_4 = 0.1 for tropical evergreen forest used in this study), while g_1 = 0.3 (unitless) is prescribed as a constant for all PFTs.

The model includes a dynamic allocation scheme that can be invoked for woody vegetation, in which case the ratio for carbon allocation between new stem and new leaf increases with increasing net primary production (NPP), as

$$a_3 = \max(0.2,\ 0.2 + 0.0025 NPP_{ann}) \qquad (0.4)$$

where NPP_{ann} is the annual sum of NPP from the previous year.

Carbon to phosphorus ratios are defined for different tissue types as follows:

$$CP_{leaf} = \text{C:P for leaf}$$
$$CP_{fr} = \text{C:P for fine root}$$
$$CP_{lw} = \text{C:P for live wood (in stem and coarse root)}$$
$$CP_{dw} = \text{C:P for dead wood (in stem and coarse root)}$$

where all C:P parameters are defined as constants.

B. Biological P mineralization and immobilization

P can be biologically mineralized (associated with the oxidation of carbon) or immobilized during decomposition of litter and soil organic matter (SOM). The potential P flux from an"upstream" pool (u) to a "downstream" pool (d) during decomposition is modeled following

$$F^{P}_{pot\_min,u\rightarrow d} = F^{C}_{pot,u} \frac{\left(1 - rf_u - \frac{CP_d}{CP_u}\right)}{CP_d} \quad (0.5)$$

Where $F^{C}_{pot,u}$ is the potential carbon flux out of the upstream pool, rf_u is the fraction of fluxes lost as respiration, CP_u and CP_d are the C:P ratios for upstream and downstream pools, respectively. If $F^{P}_{pot\_min,u\rightarrow d} < 0$, the decomposition step results in P mineralization and thus new inorganic P that enters solution P. If this is the case, decomposition is allowed to proceed at the potential rate. If $F^{P}_{pot\_min,u\rightarrow d} > 0$, P immobilization occurs as inorganic P is needed in order to maintain the C:P ratio of the downstream pool during decomposition. Microbial P demand ($F^{P}_{immob\_demand}$) is the sum of all immobilization P fluxes.

The actual P flux from an "upstream" pool (u) to a "downstream" pool (d) during decomposition is modeled following

$$F_{M,u\rightarrow d} = f_{immob} F^{P}_{pot\_min,u\rightarrow d} \quad (0.6)$$

where f_{immob} is the nutrient limitation factor on decomposition(see section 2.1.2). The CP ratios of the three litter pools are calculated based on the C and P fluxes from litter input. The C:P ratio of the product of decomposition(newly formed soil organic material) are fixed. However the C:P ratio of the four soil organic pools can change as P in SOMs can be “cleaved” by phosphotase enzymes(biochemical mineralization) without carbon oxidation.