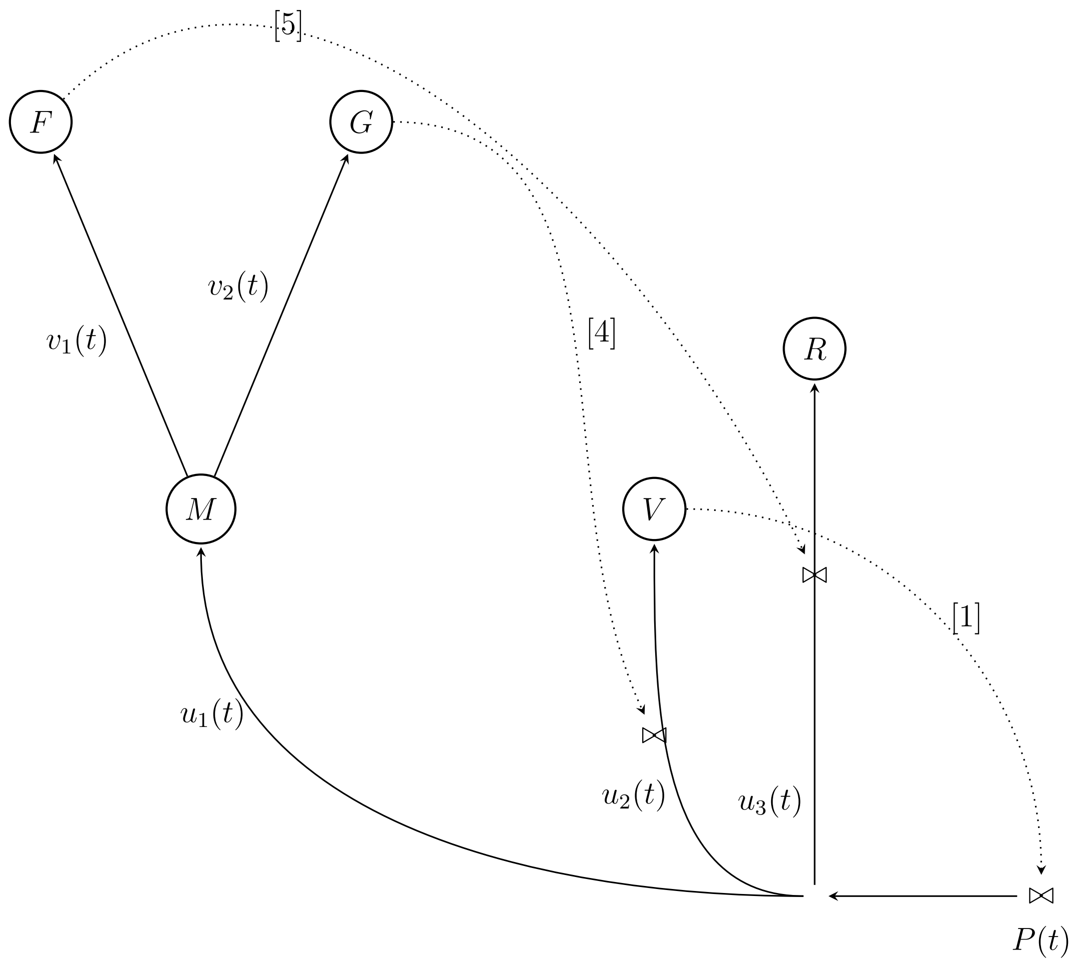
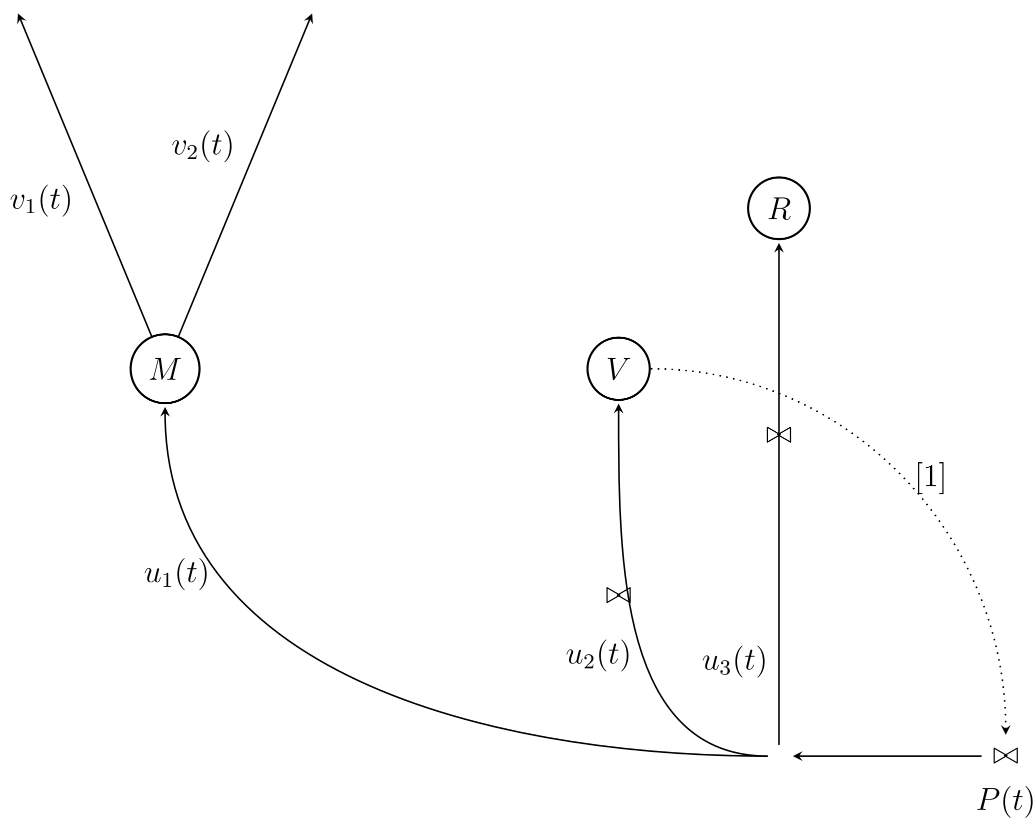
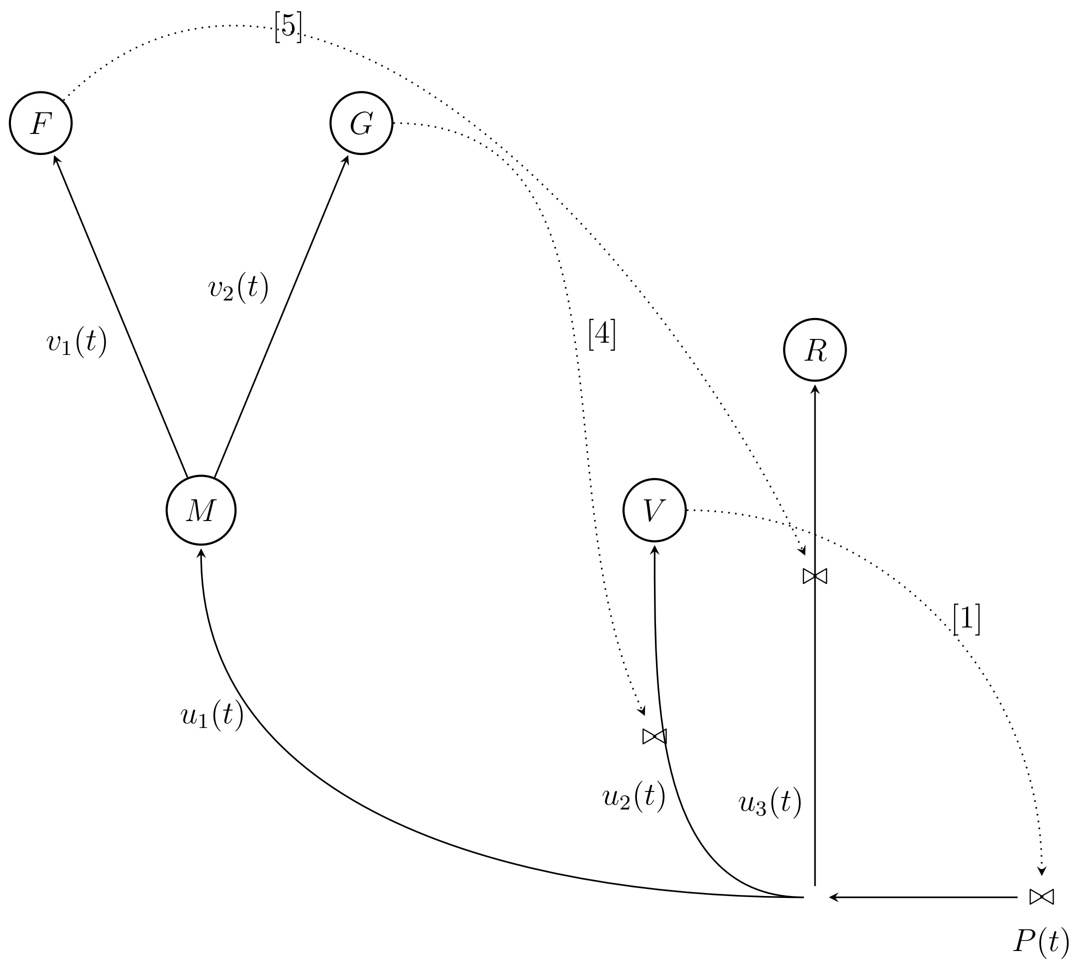
Full model: capacity for growth and reproduction is limited by meristem availability and rate of meristem commitment



Rate model: capacity for growth and reproduction is limited by rate of meristem commitment



Meristem availability model: capacity for growth and reproduction is limited by meristem availability



Let un-allocated meristems, vegetative biomass, accumulated reproductive biomass, meristems committed to growth, and meristems committed to reproduction be represented as M, V, R, G, and F.

Growth in a season $(0 < t < T)$ is expressed as:

$$\frac{dM}{dt} = u_1(t)P(t) - v_1(t)M - v_2(t)M$$

$$\frac{dV}{dt} = u_2(t)P(t)$$

$$\frac{dR}{dt} = u_3(t)P(t)$$

$$\frac{dG}{dt} = v_1(t)M$$

$$\frac{dF}{dt} = v_2(t)M$$

with constraints $u_1(t) + u_2(t) + u_3(t) = 1$, $u_i(t) \geq 0$ $(i = 1, 2, 3)$, $v_1(t) + v_2(t) = 1$, and $R(0) = 0$. The assumptions here are that all energy produced by photosynthesis is allocated to meristem development, vegetative growth, or reproduction. Meristems are allocated to either growth or flowering; no meristems remain undifferentiated. Initial reproductive biomass is zero.

Daily photosynthesis is a function of vegetative biomass is represented as $g(V)$. The plant starts from initial size $g(V(0))$ set by seed resources. Following Iwasa (200), I assume that daily biomass production (photosynthesis production, respiration cost) daily net production, is an increasing, saturating function of the vegetative biomass:

$$[3] : g(V) = aV/(1 + hV).$$

Photosynthate is then allocated between meristem differentiation $(u_1(t))$, vegetative biomass $(u_2(t))$, and reproductive biomass $(u_3(t))$. The model jump starts photosynthesis by setting an initial seed size but [2] and [4] are mean to limit further production of vegetative biomass unless there is also allocation to meristems for growth. Plants are modular and meristem differentiation and subsequent determination are necessary to add vegetative modules (phytomers: internode+node with leaf+axillary meristem bud). The arrow from meristem state (M) to meristems for growth (G) corresponds to determination and growth of vegetative organs (e.g. leaf expansion) and requires energy that limits accumulation in V. When $v_2(t)$ is high (high rate of transition from undifferentiated meristems to meristems for growth), this inhibits the allocation of photosynthate to V.

$$[2] : \frac{1}{1 + bu_3(t)}$$

Many undifferentiated meristems (high M) also inhibits the transition to V:

$$[1] : \frac{1}{1 + cM}$$

Meristems committed to reproduction promote allocation to reproductive biomass. When there are no such meristems (F=0), allocation of photosynthate to reproductive biomass (R) follows $u_3(t)$. Increasing F linearly increases amount of reproductive biomass (R) per unit photosynthate:

$$[5] : 1 + dF$$