

SUSTAIN :
a forest ecosystem model
incorporating hydraulic and
nutritional constraints on tree growth

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Goal : to understand and quantify the sustainable behaviour of forest plantations



Includes : plant-soil & C-N-H₂O interactions

Status : under development

Collaboration : F. Magnani (CNR, Italy)

Support : EC Program CARBO-AGE

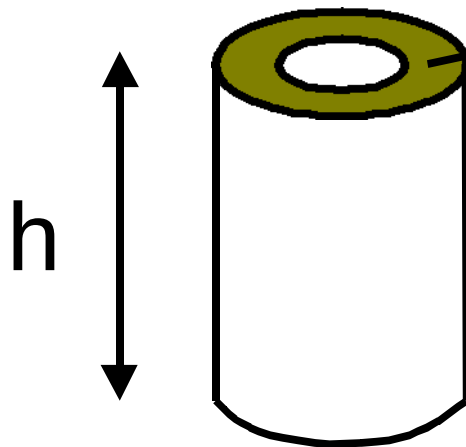


foliage (F)

Plant
sub-model

sapwood (W)

fine roots (R)



sapwood area (A)

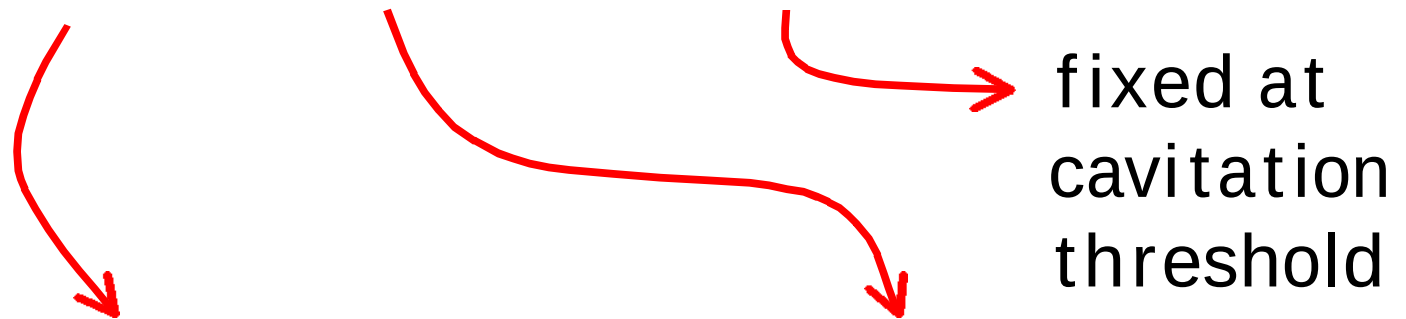
$$W = \rho_w A h$$

sapwood density

Cavitation hypothesis :

H₂O demand (E) = H₂O supply

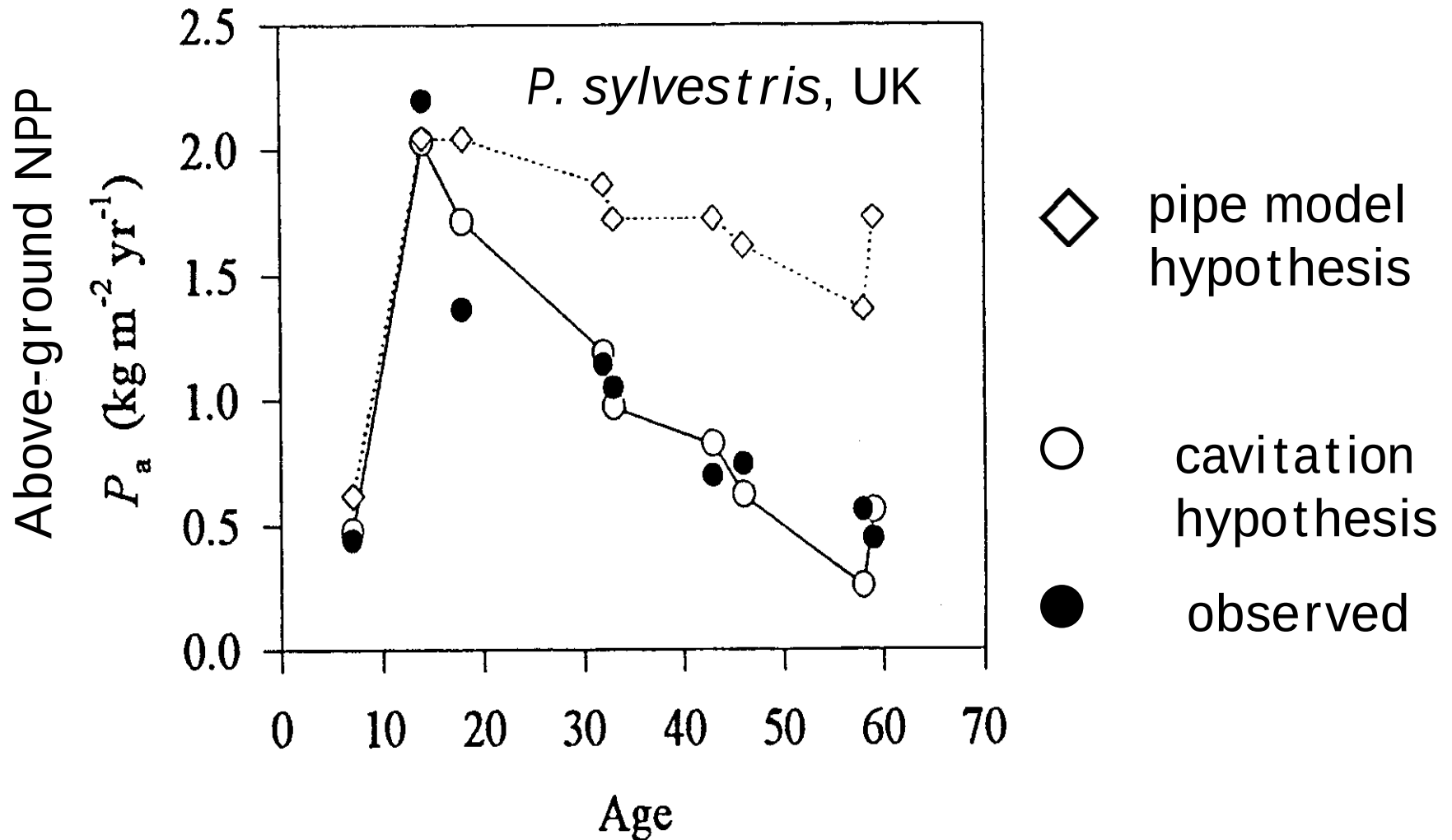
$$E = K_w (\psi_{\text{soil}} - \psi_{\text{foliage}})$$



$$\frac{\text{LUE}}{\text{WUE}} \propto \text{APAR}(F) \propto \frac{A}{h}$$

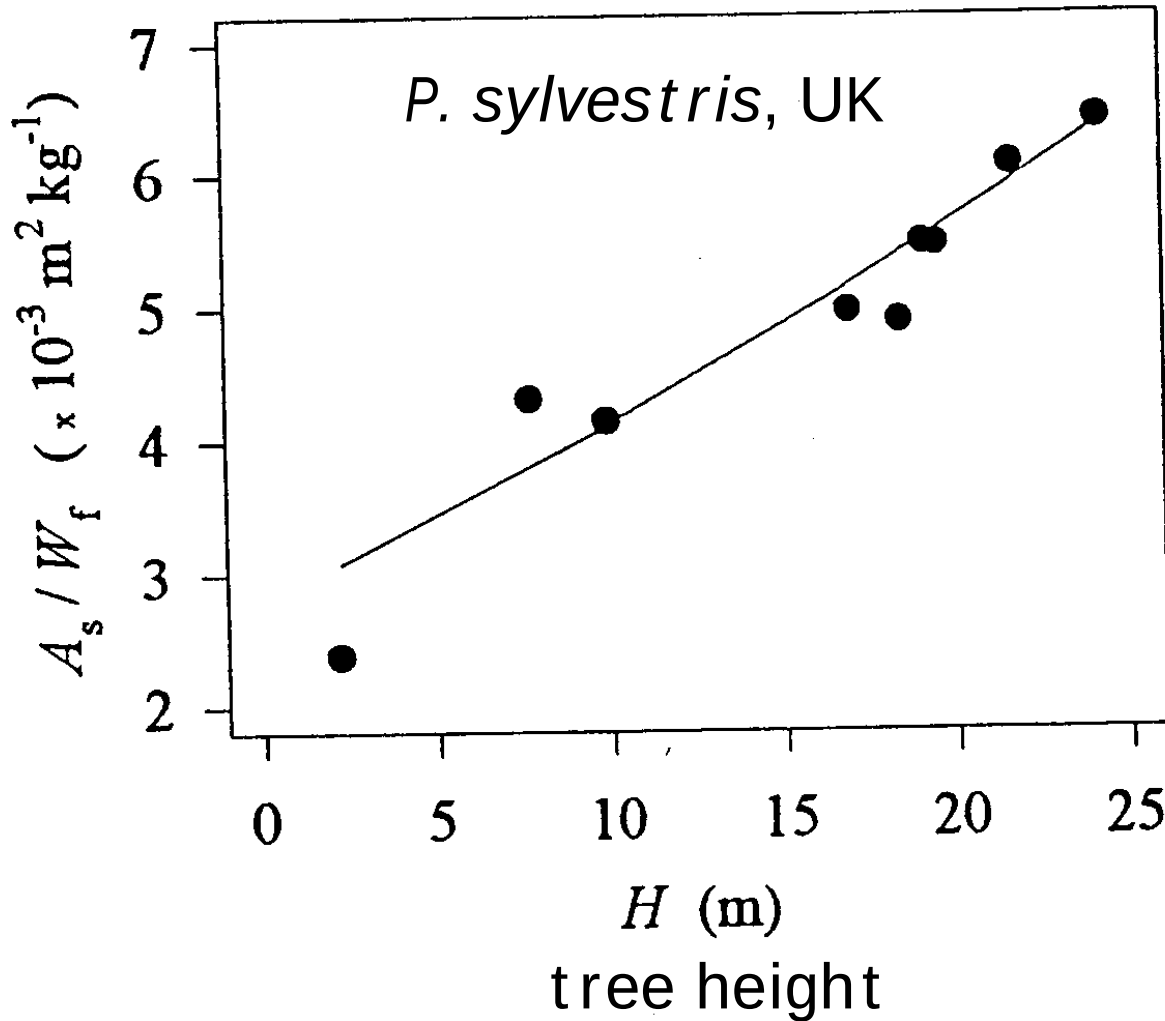
(cf. pipe model : $F \propto A$)

Magnani (PhD thesis, 1999) :



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sapwood area / foliage biomass

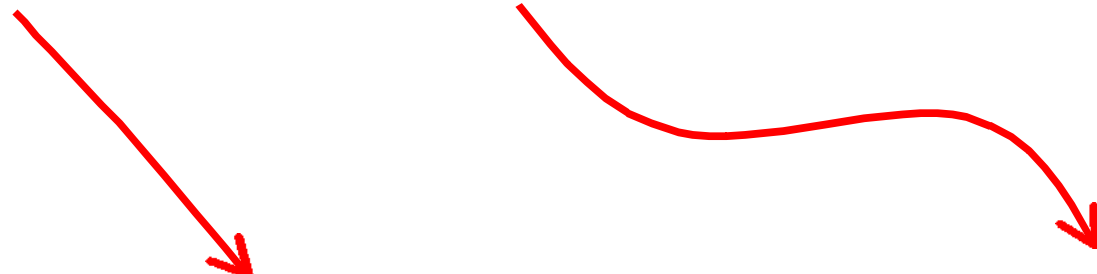


cavitation
hypothesis

observed

Functional balance :

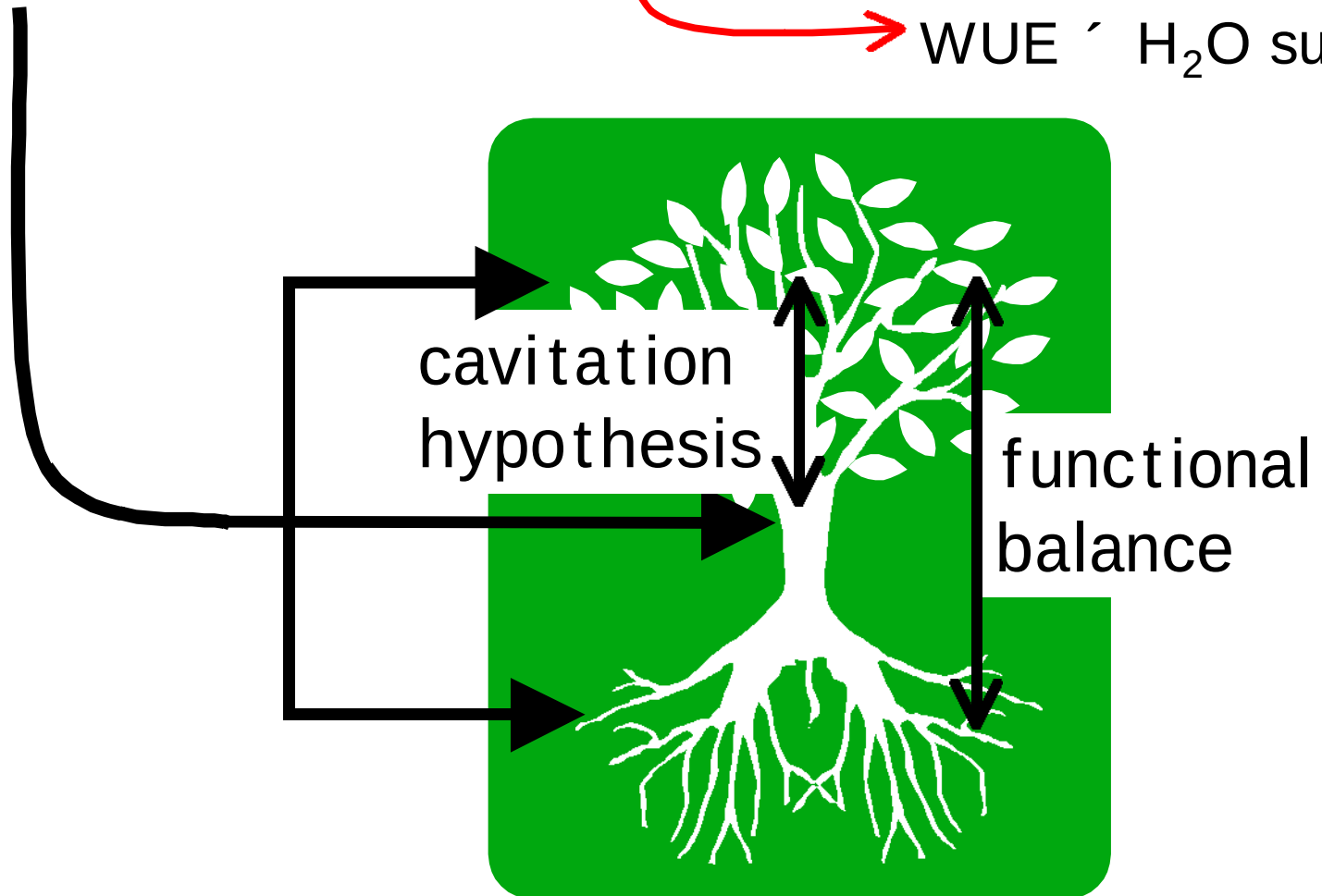
C uptake $\propto$ N uptake


$$\text{LUE} \propto \text{APAR}(F) \propto f(N_{\text{soil}}) \propto R$$

$$\text{GPP} = \min (G_{\text{light}}, G_{\text{water}})$$

$\xrightarrow{\text{red arrow}} \text{LUE} \propto \text{APAR}(F)$

$\xrightarrow{\text{red arrow}} \text{WUE} \propto \text{H}_2\text{O supply}$

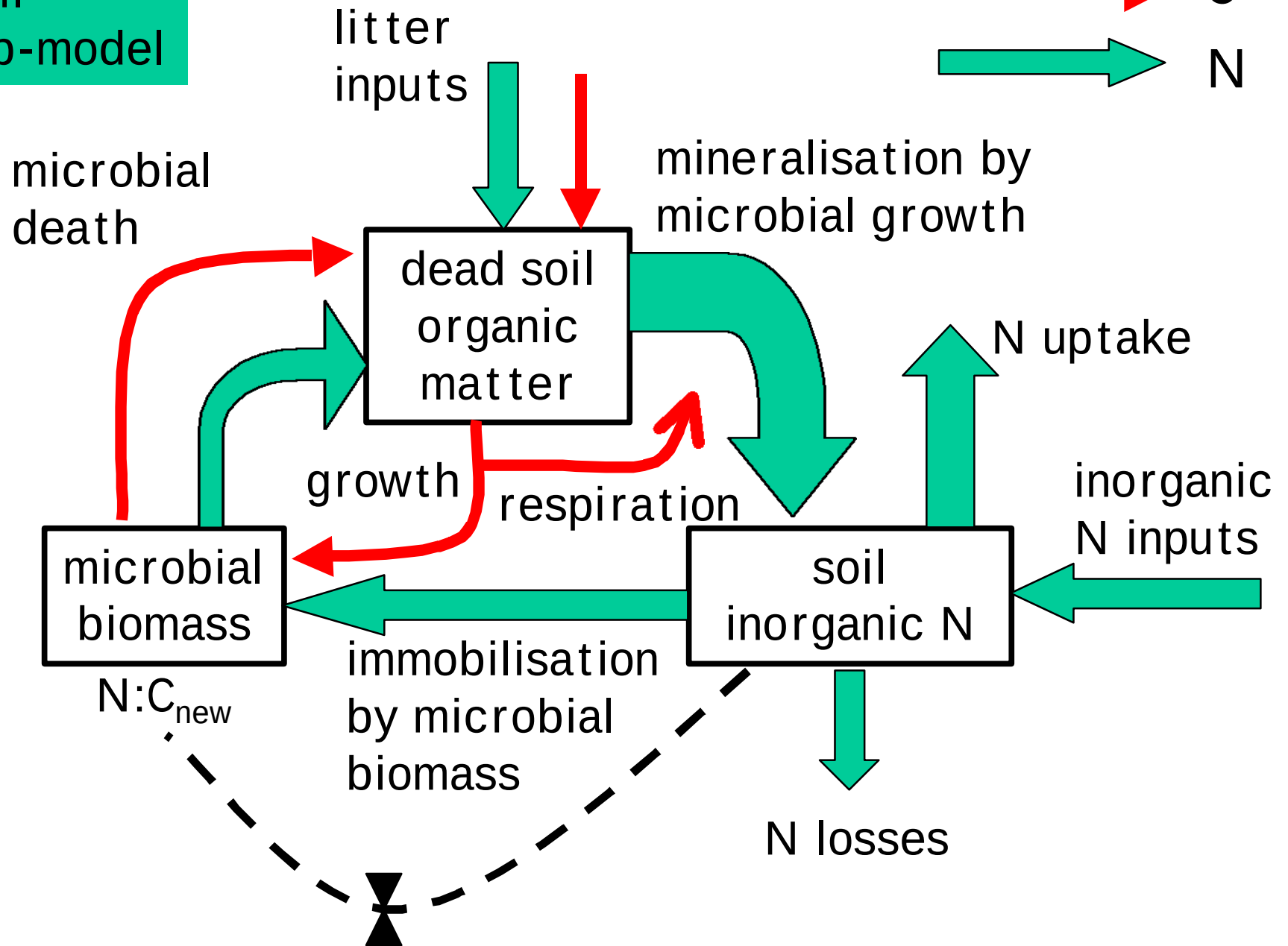
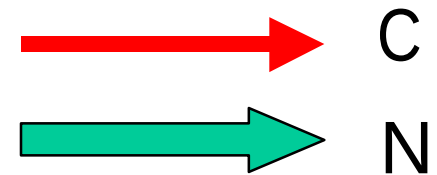


plant model = ON, soil model = OFF*

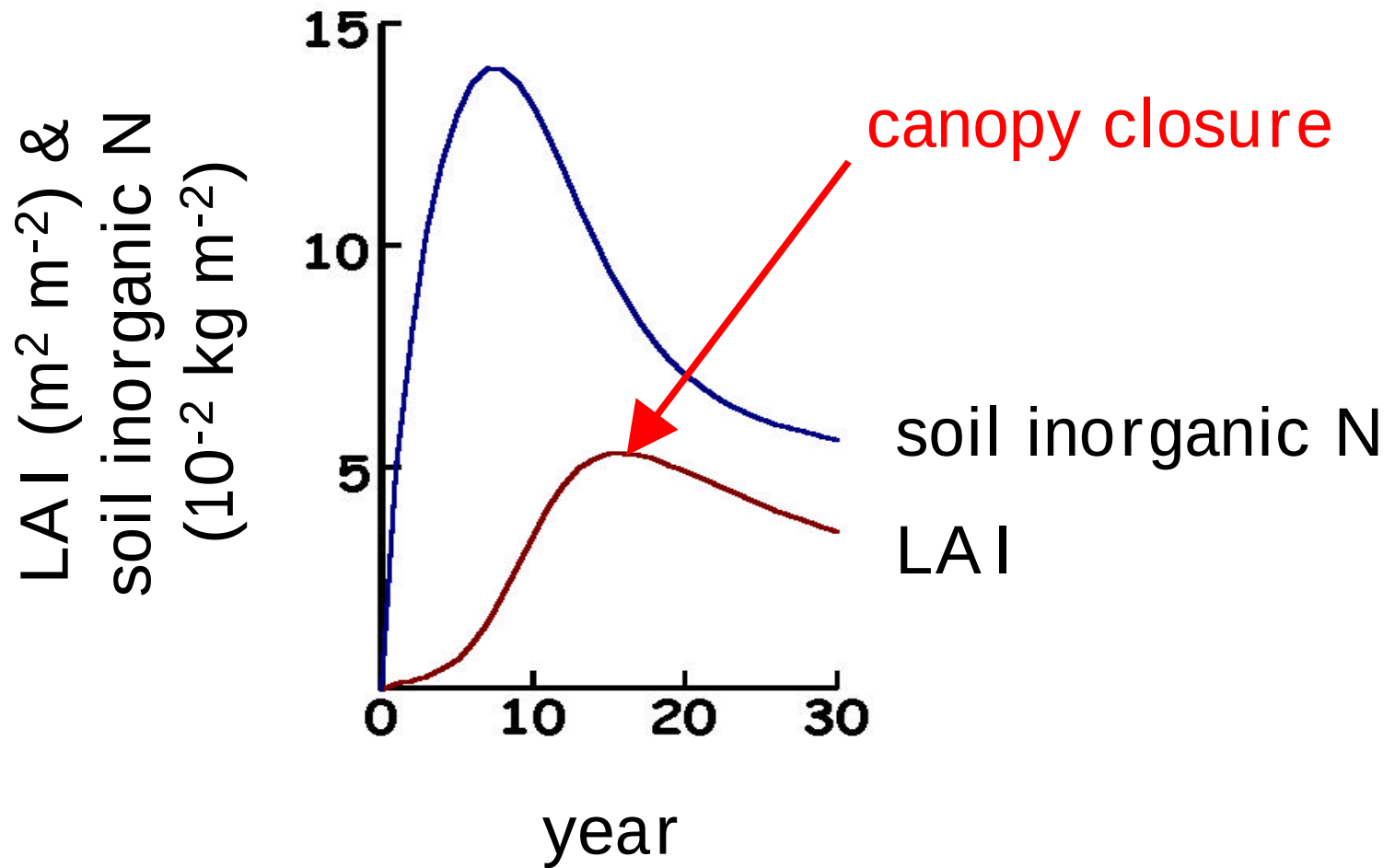
	t_{closure} (yr)	LAI_{max} ($\text{m}^2 \text{ m}^{-2}$)	h_{20} (m)	T_{rot} (yr)	MAI_{max} ($\text{m}^3 \text{ ha}^{-1} \text{ yr}^{-1}$)
base	11	5.6	13	52	13
$2 \times \text{N}_{\text{soil}}$	6	8.6	21	42	29
$2 \times \text{CO}_2$	10	7.9	19	65	18
$2 \times \text{VPD}$	10	4.2	10	41	12

* soil inorganic N held fixed

Soil
sub-model



plant model = ON, soil model = ON*



* soil inorganic N varies dynamically



Interim conclusions

Cavitation hypothesis + functional balance
gives simple, realistic allocation sub-model

Coupling to soil sub-model highlights risk of
leaching losses prior to canopy closure

What now ?

Evaluate soil sub-model

Incorporate management interventions

Explore long-term steady state