Workshop synthesis, future prospects

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Models for the sustainable management of temperate plantation forests

1. What is sustainable management ?
2. What are the main challenges for modellers ?
3. What have models achieved so far ?
4. Priorities for future research/collaboration ?

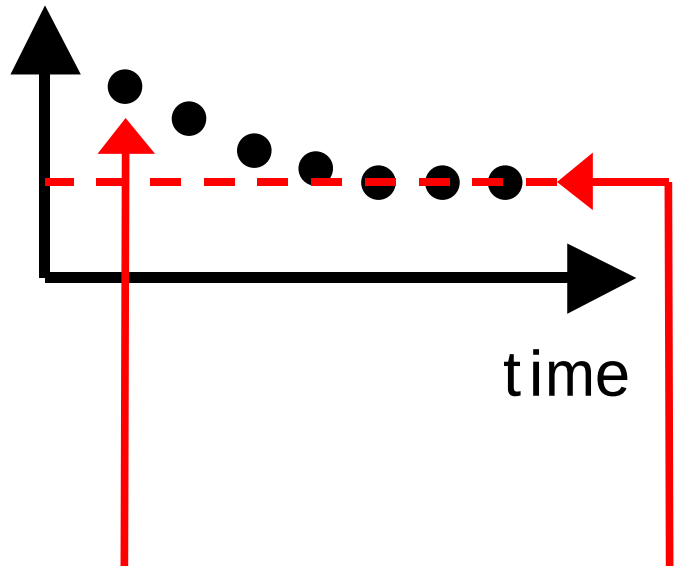
Models for the sustainable management of temperate plantation forests

1. What is sustainable management ?

Management regime (M) :

site preparation
fertilisation
irrigation
thinning
harvesting

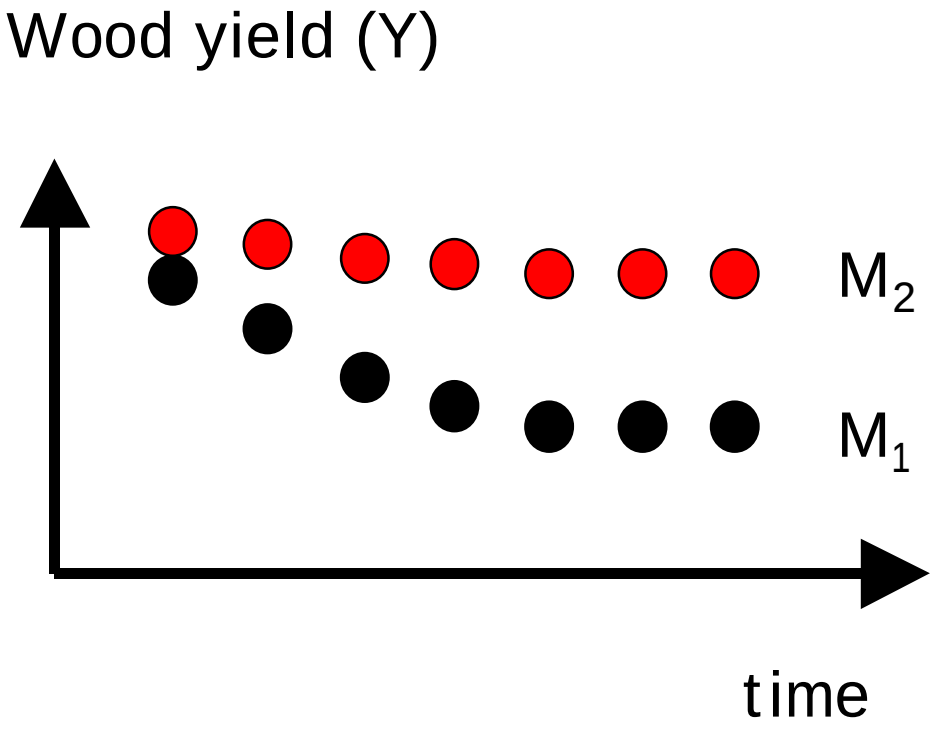
successive rotations



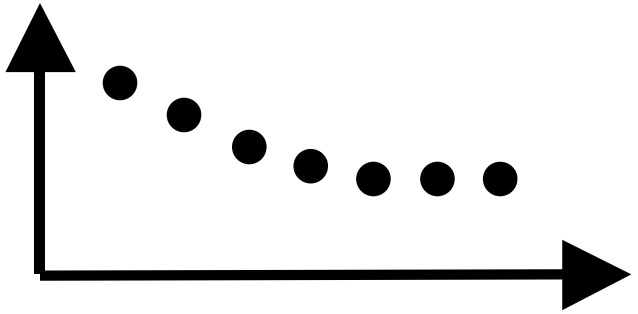
this Y is not sustainable under given M

sustainable Y under given M

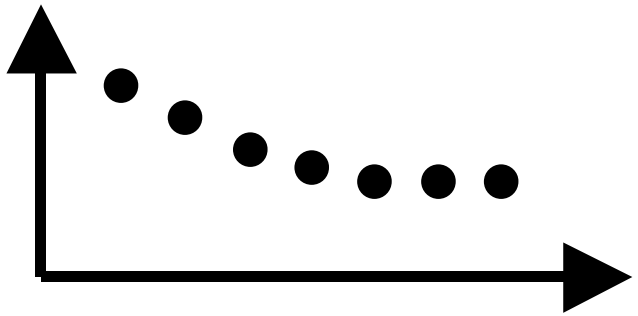
Different management regimes :



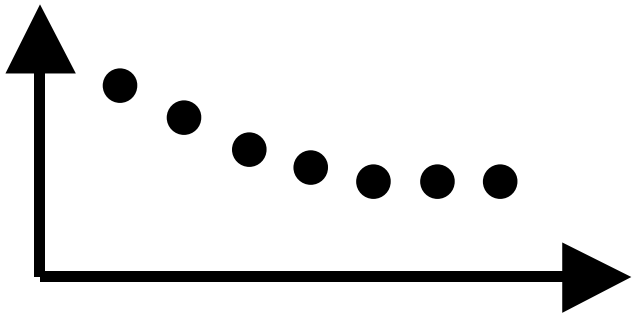
Wood yield (Y)



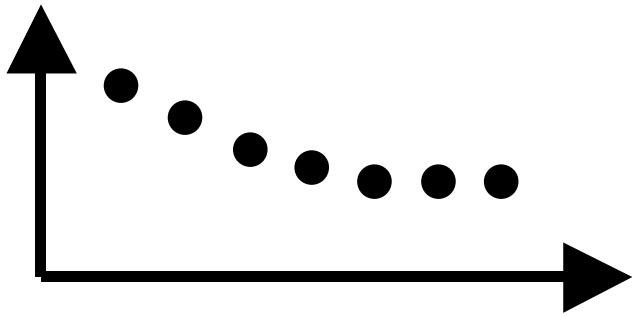
Nitrogen loss (N_{loss})

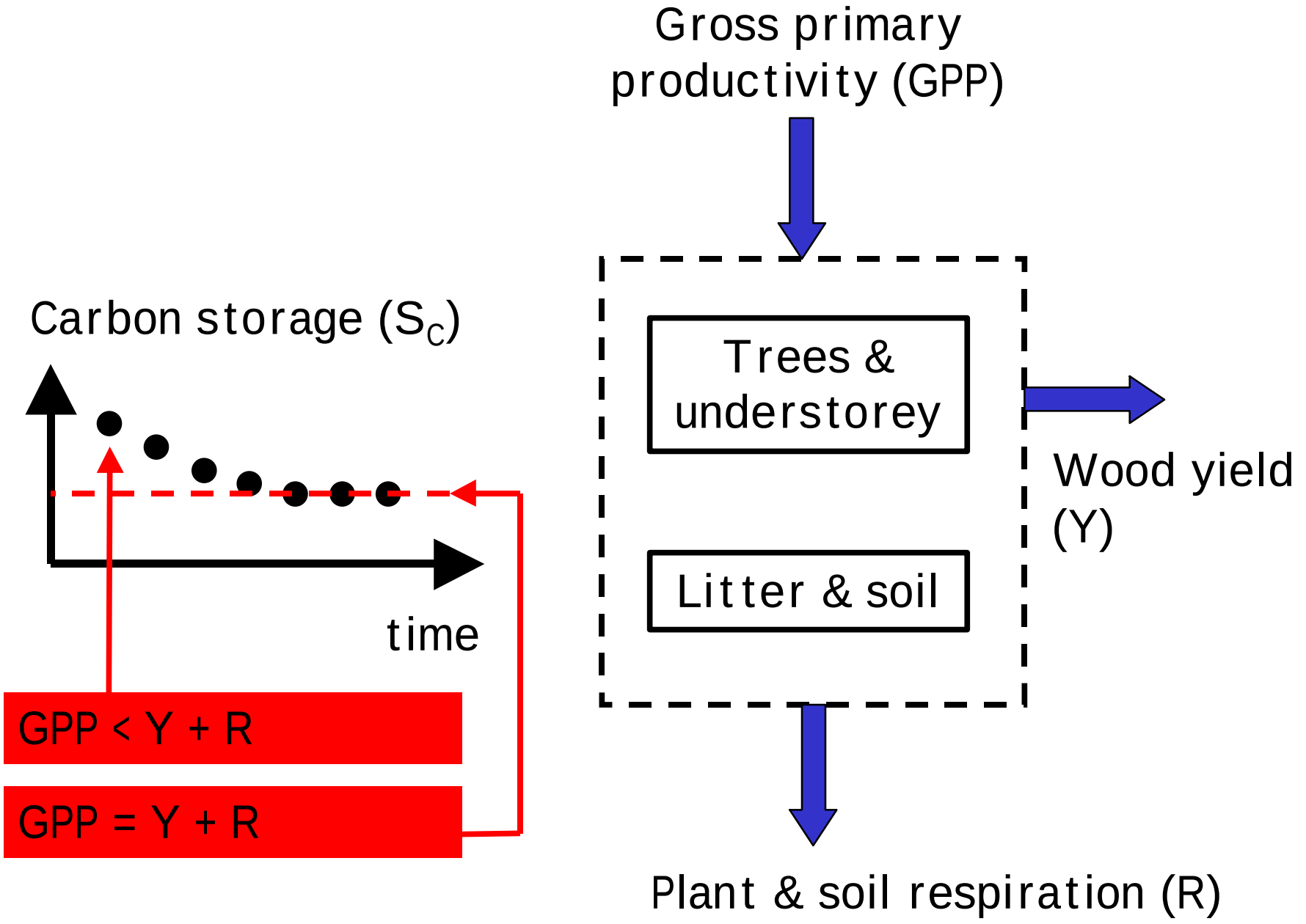


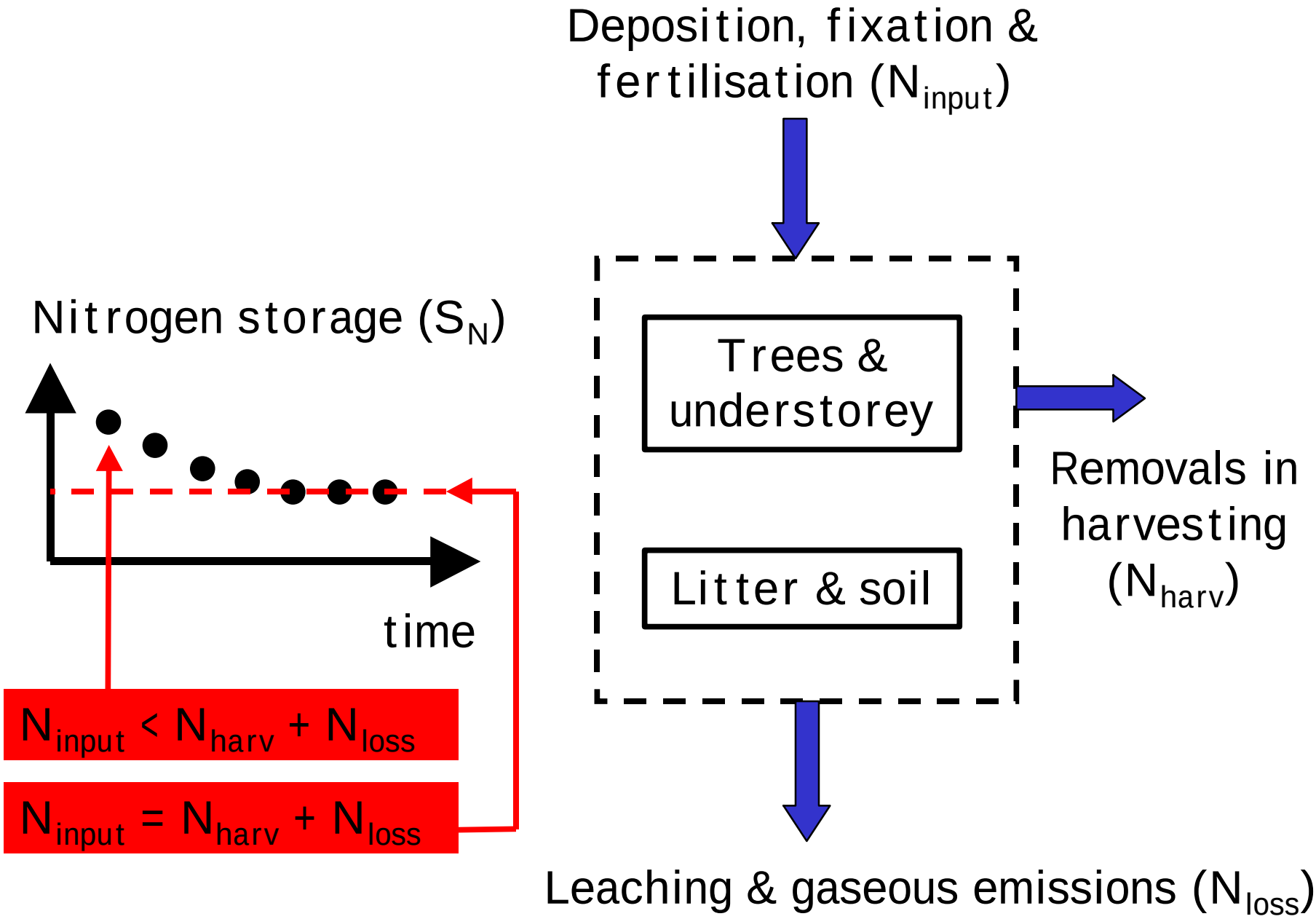
Carbon storage (S_C)



Nitrogen storage (S_N)




Gross primary productivity (GPP)
Carbon storage (S_C)
Trees & understorey
Wood yield (Y)
Litter & soil
time
GPP < Y + R
GPP = Y + R
Plant & soil respiration (R)


Deposition, fixation & fertilisation (N_{input})
Nitrogen storage (S_N)
Trees & understorey
Litter & soil
Removals in harvesting (N_{harv})
time
$N_{input} < N_{harv} + N_{loss}$
$N_{input} = N_{harv} + N_{loss}$
Leaching & gaseous emissions (N_{loss})

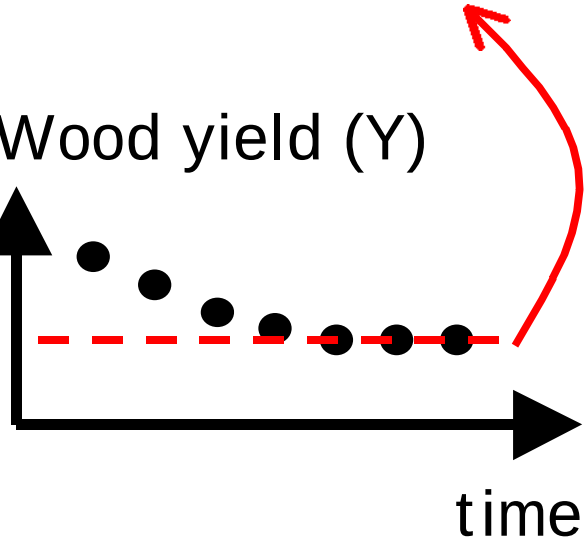
In a sustainably-managed (*i.e.* steady-state) plantation :

$$GPP = Y + R$$

$$N_{input} = N_{harv} + N_{loss}$$

$$Y = \frac{N_{input} - N_{loss}}{(N/C)_{wood}}$$

$$(N/C)_{wood} \times Y$$



1. What is sustainable management ?

Summary :

Steady-state ecosystem functioning

C & N inputs = C & N outputs
(averaged over a rotation or disturbance cycle)

What is the desired steady-state behaviour ?

What management regime best achieves this behaviour ?

Models for the sustainable management of temperate plantation forests

1. What is sustainable management ?

2. What are the main challenges for modellers ?

Growth trends (including age-related decline) and soil nutrient dynamics within a single rotation

Long-term growth and soil nutrient dynamics over successive rotations (up to steady state)

Conversion of results to practical tools for foresters and other end users

Models for the sustainable management of temperate plantation forests

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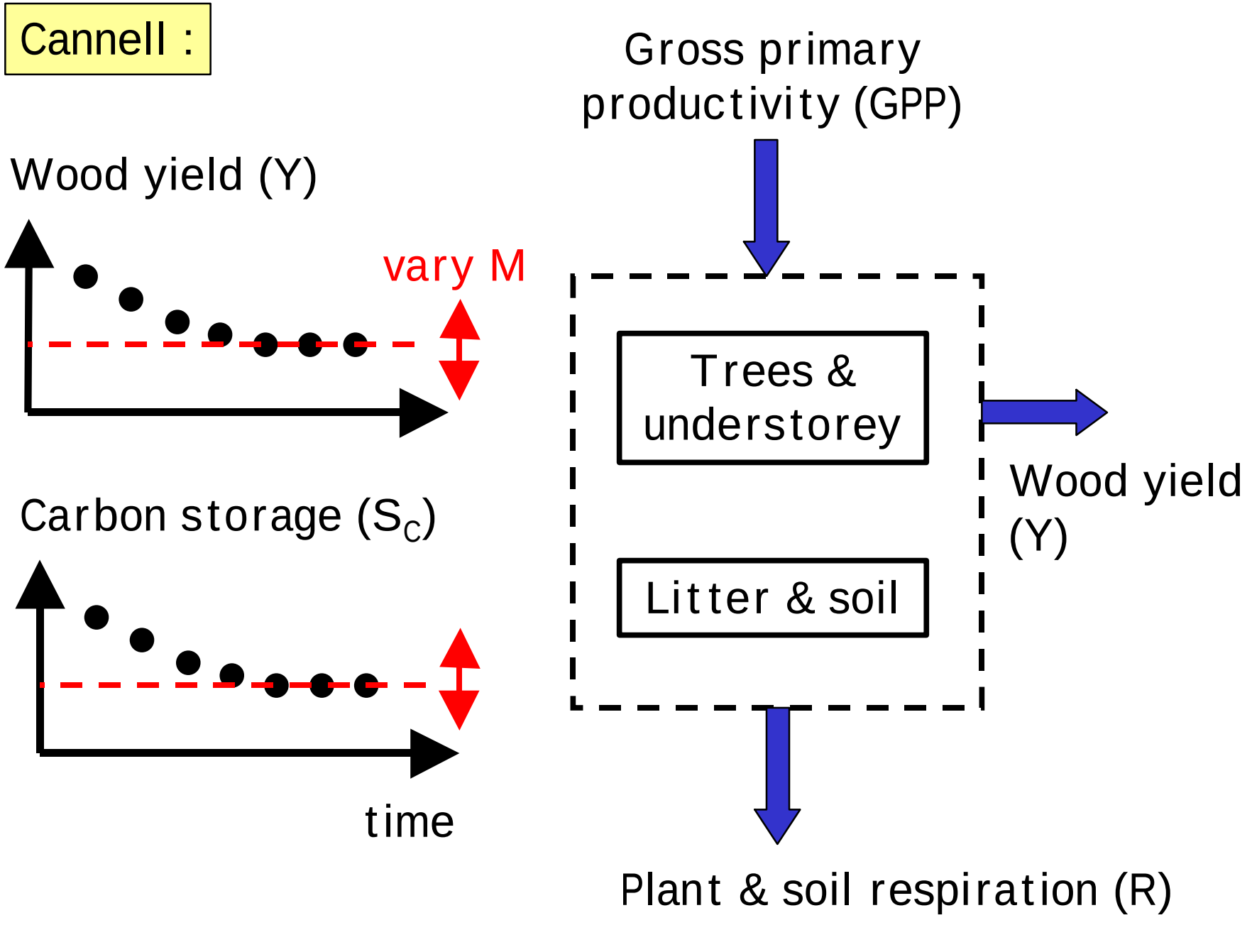
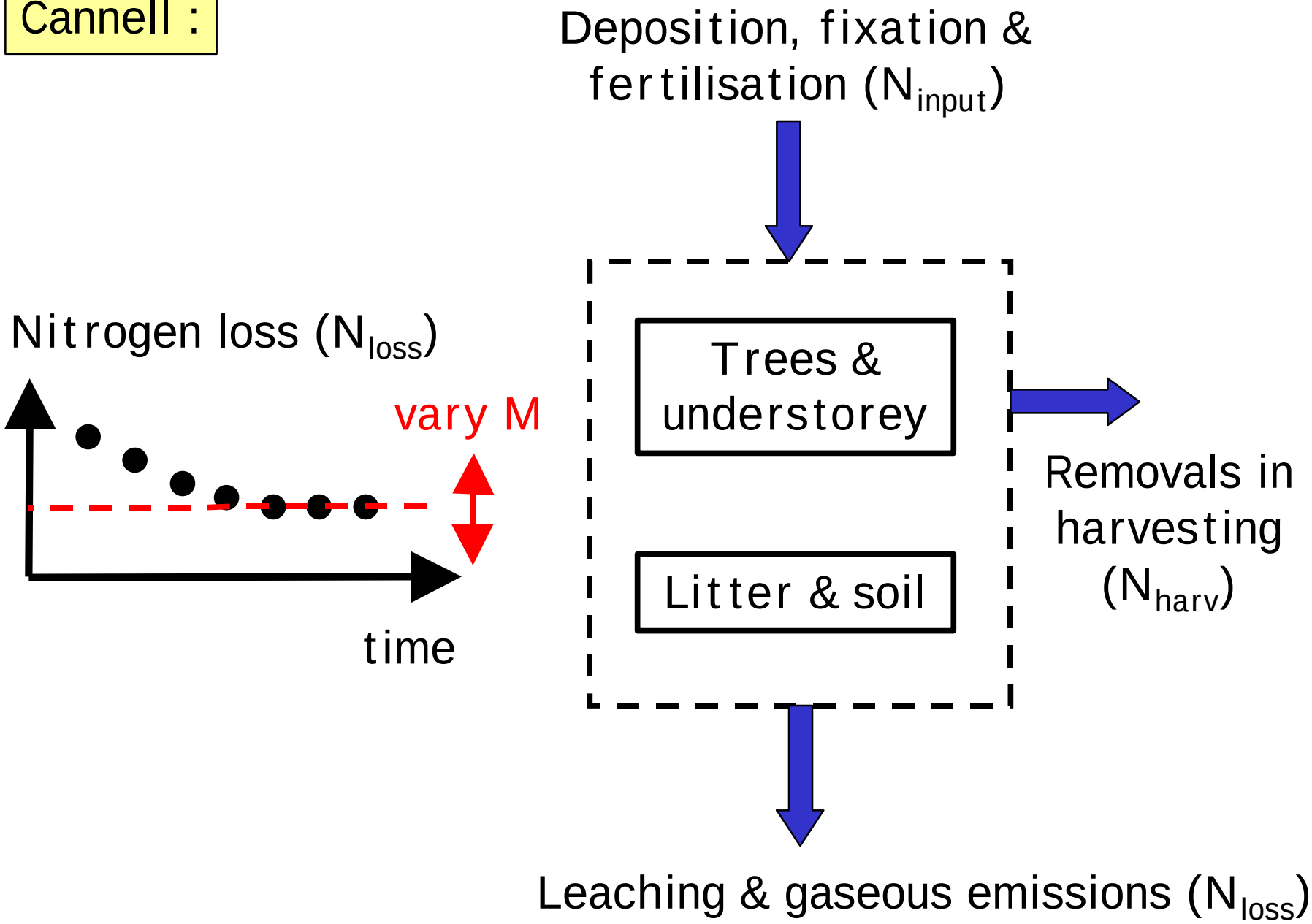
2. What are the main challenges for modellers ?
3. What have models achieved so far ?

Cannell :


Gross primary productivity (GPP)
Wood yield (Y)
vary M
Trees & understorey
Litter & soil
Wood yield (Y)
Carbon storage (S_C)
time
Plant & soil respiration (R)

Cannell :


Deposition, fixation & fertilisation (N_{input})
Trees & understorey
Litter & soil
Removals in harvesting (N_{harv})
Leaching & gaseous emissions (N_{loss})
Nitrogen loss (N_{loss})
vary M
time

Cannell :

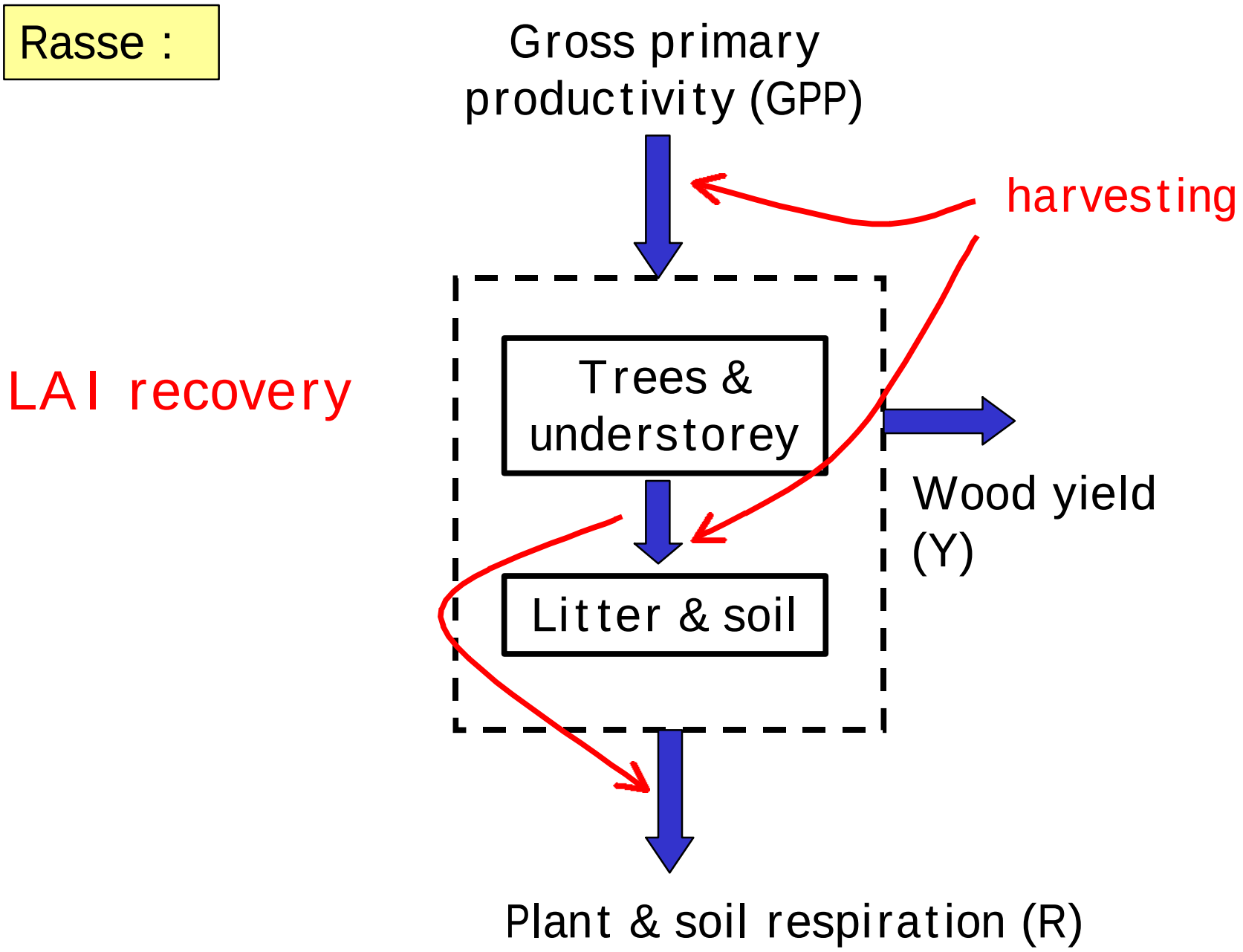
What is the optimal M which :

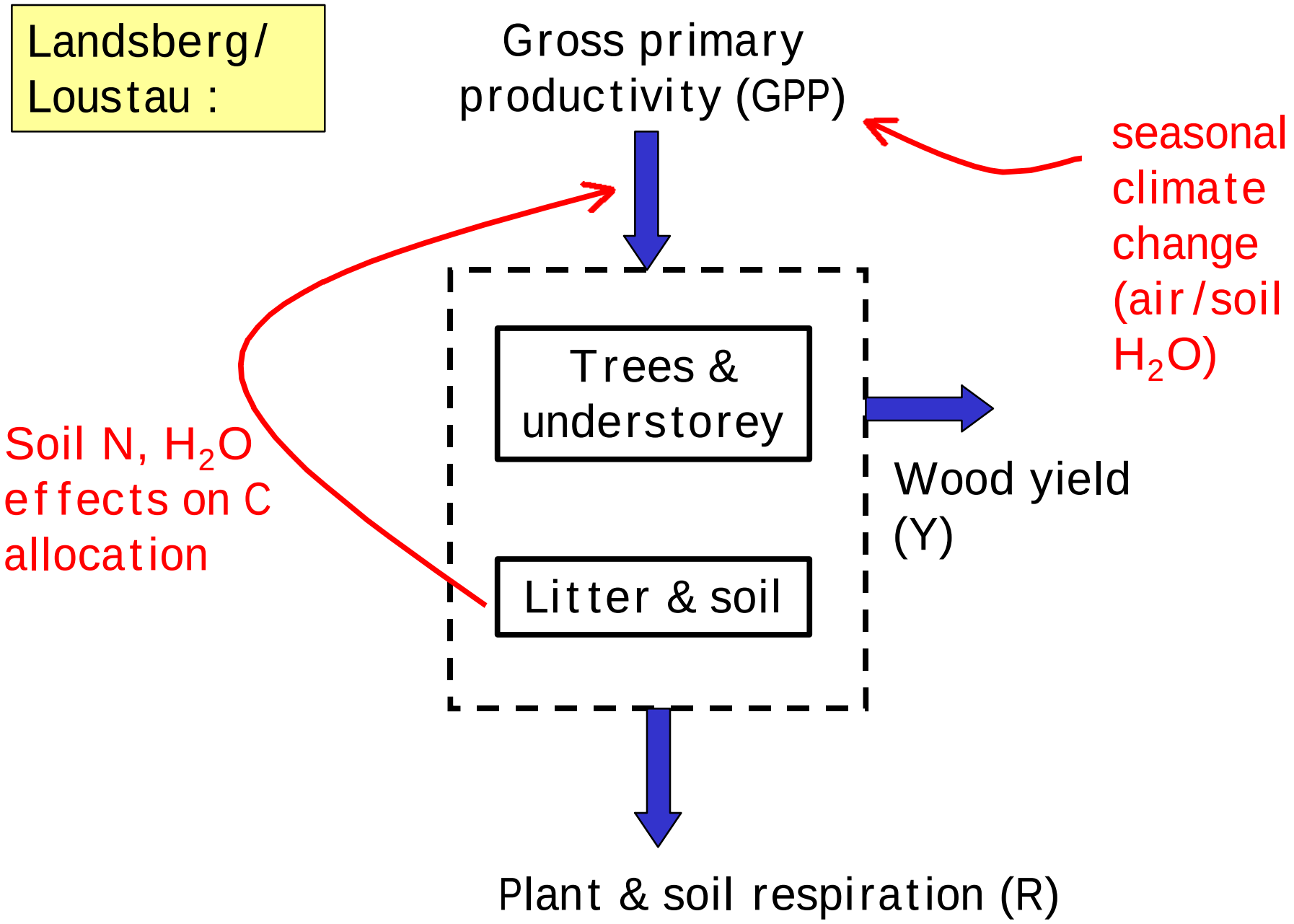
maximises yield and C storage ?

minimises N losses ?

Solution : optimal M ≈ 10-20% biomass removal per year

Rasse :


Gross primary productivity (GPP)
harvesting
LAI recovery
Trees & understorey
Litter & soil
Wood yield (Y)
Plant & soil respiration (R)

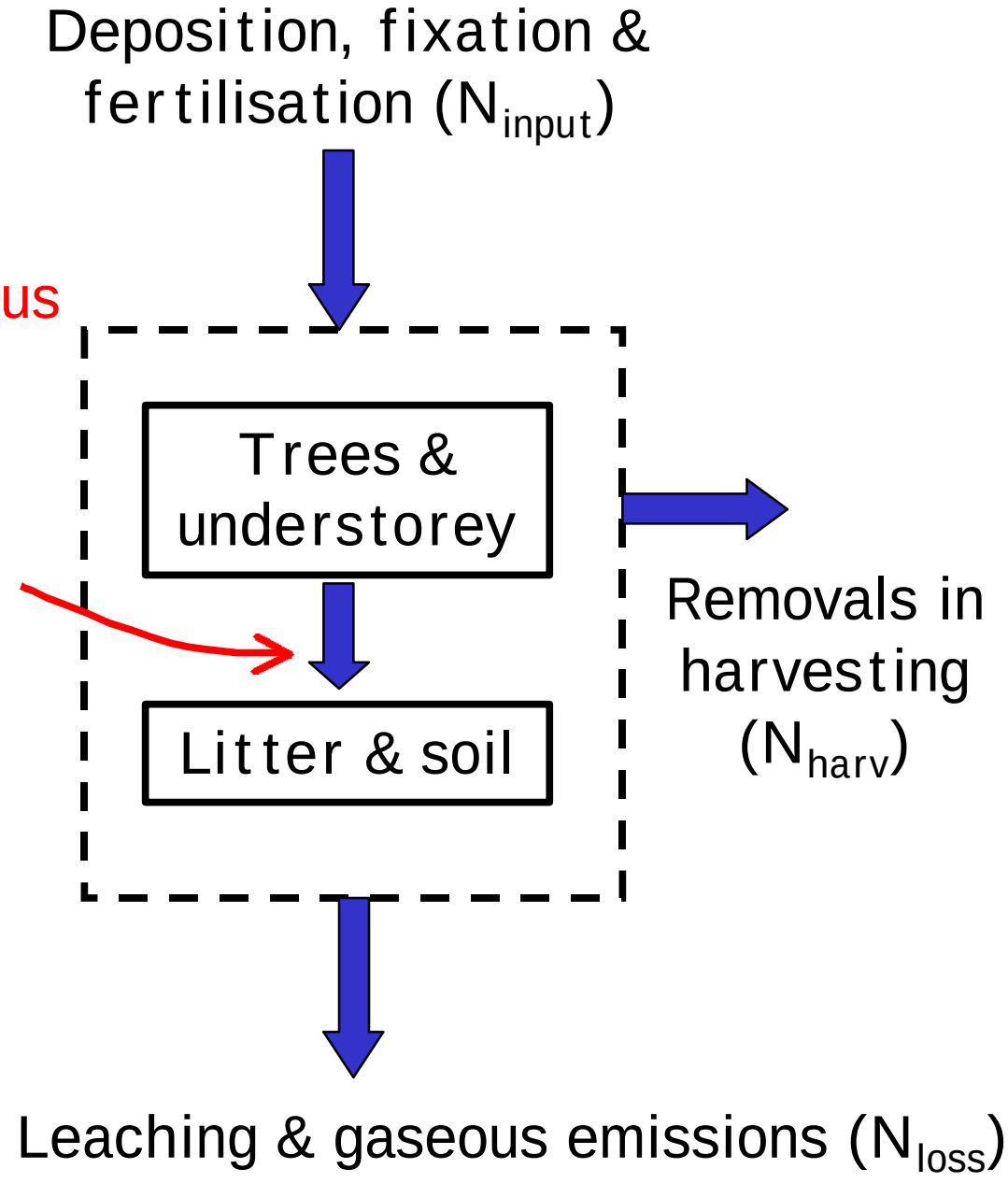

Landsberg/
Loustau :
Gross primary
productivity (GPP)
seasonal
climate
change
(air/soil
H_2O)
Trees &
understorey
Wood yield
(Y)
Soil N, H_2O
effects on C
allocation
Litter & soil
Plant & soil respiration (R)

McMurtrie/
Corbeels :

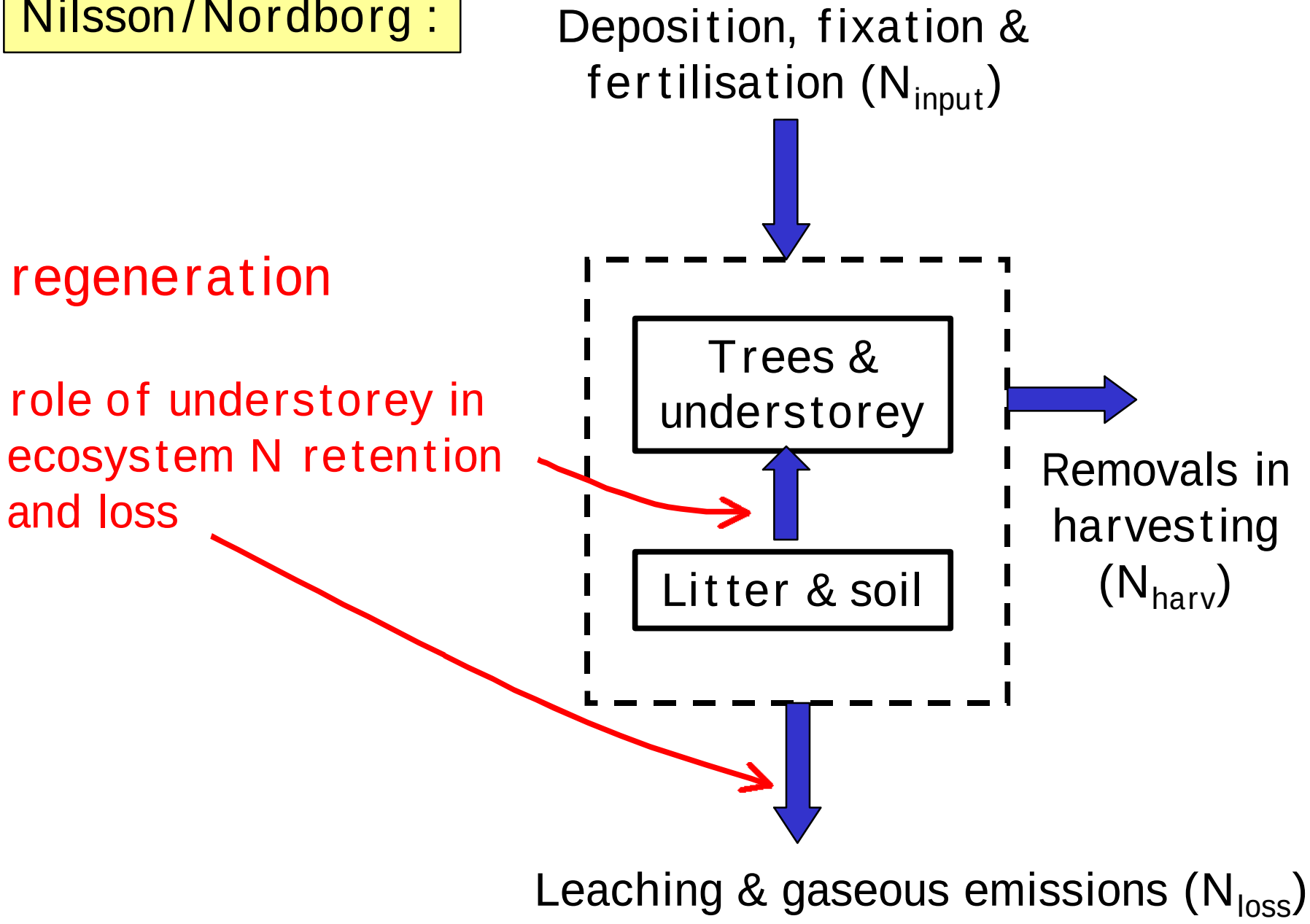
grassland → forest
short-rotation Eucalyptus

litter quality & quantity
effects on soil N
availability & C storage

harvest residues



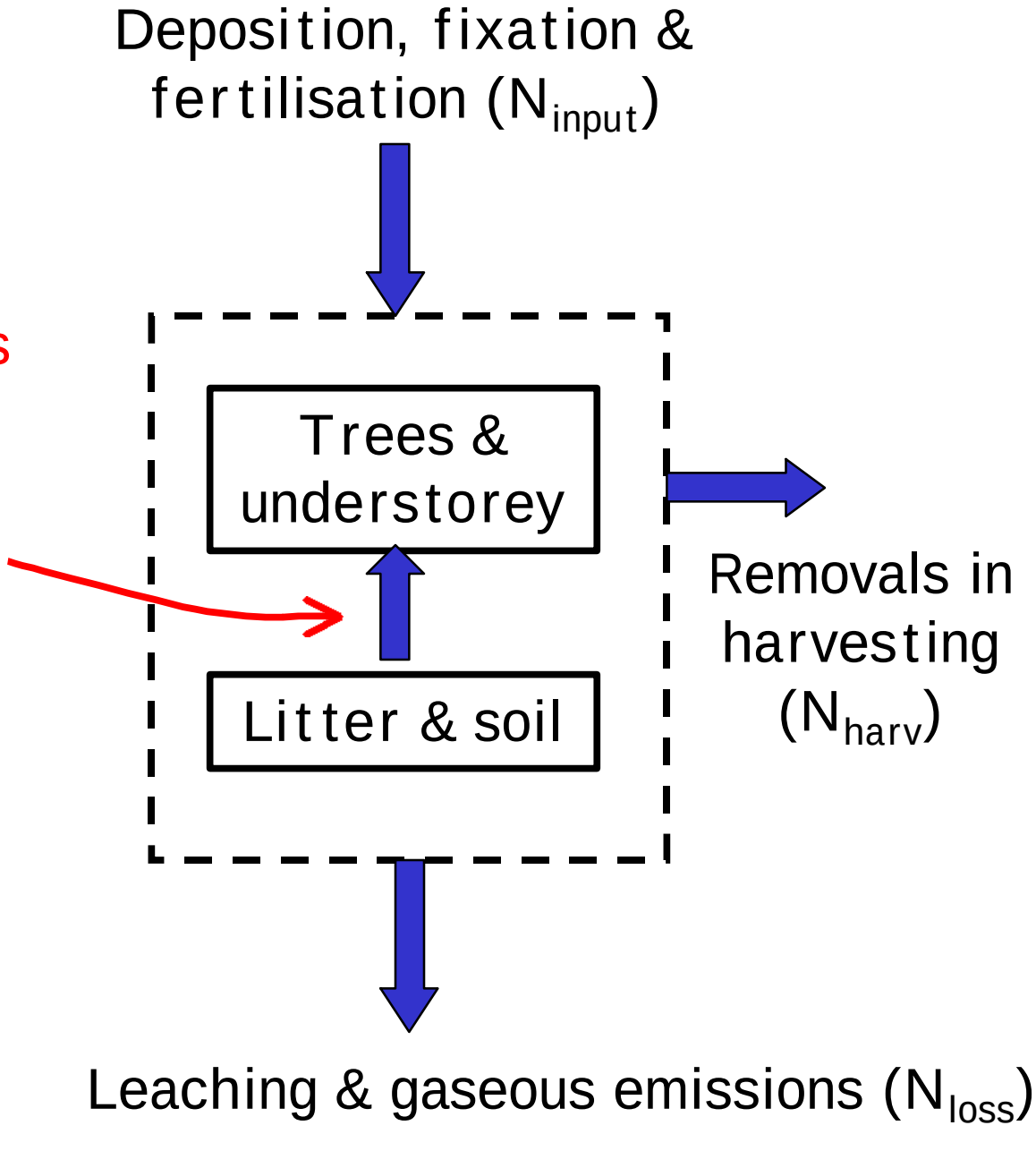
Nilsson/Nordborg :



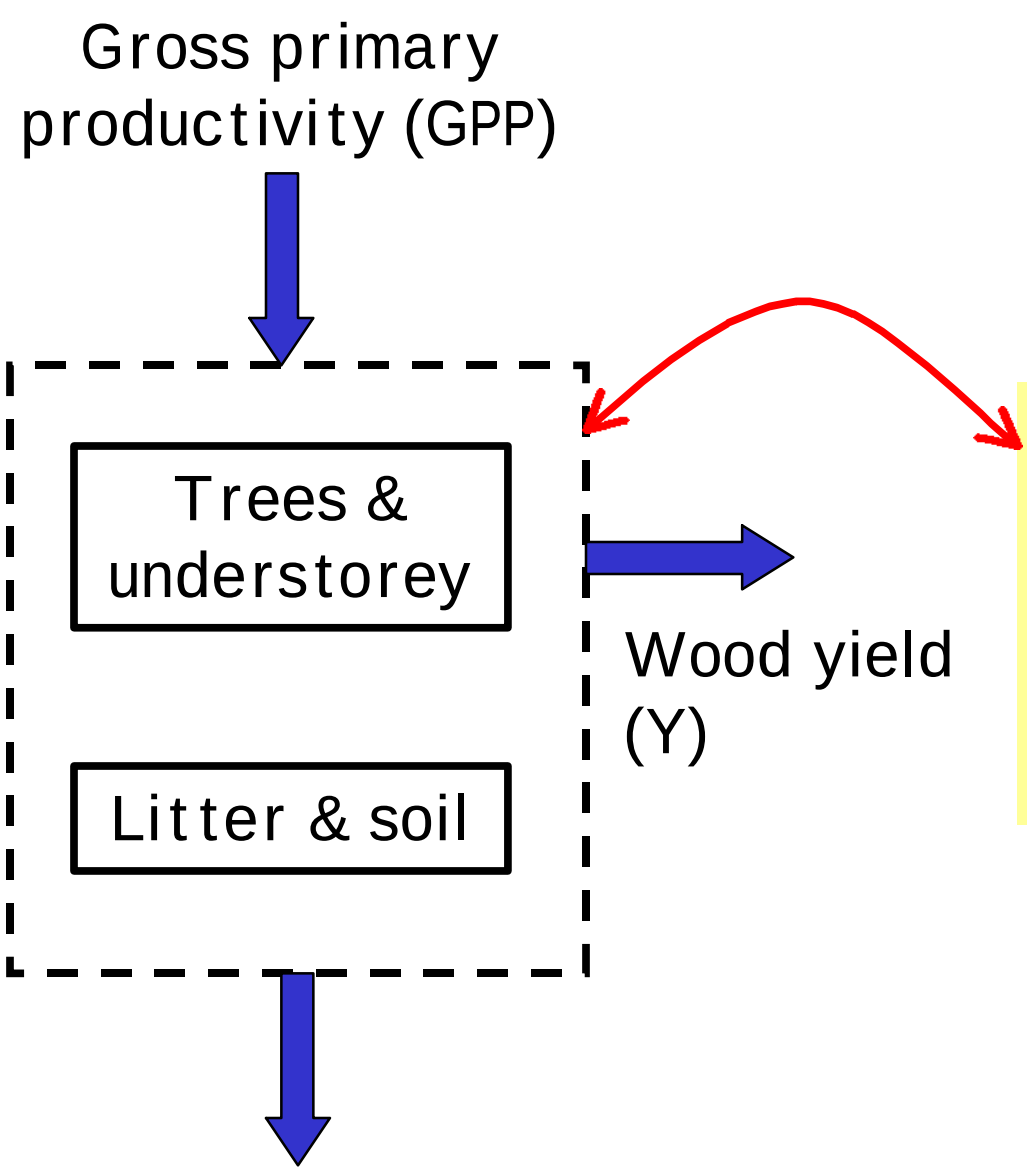
Allen :

Semi-empirical tools for foresters:

N uptake *vs.* soil N, soil drainage & texture classes



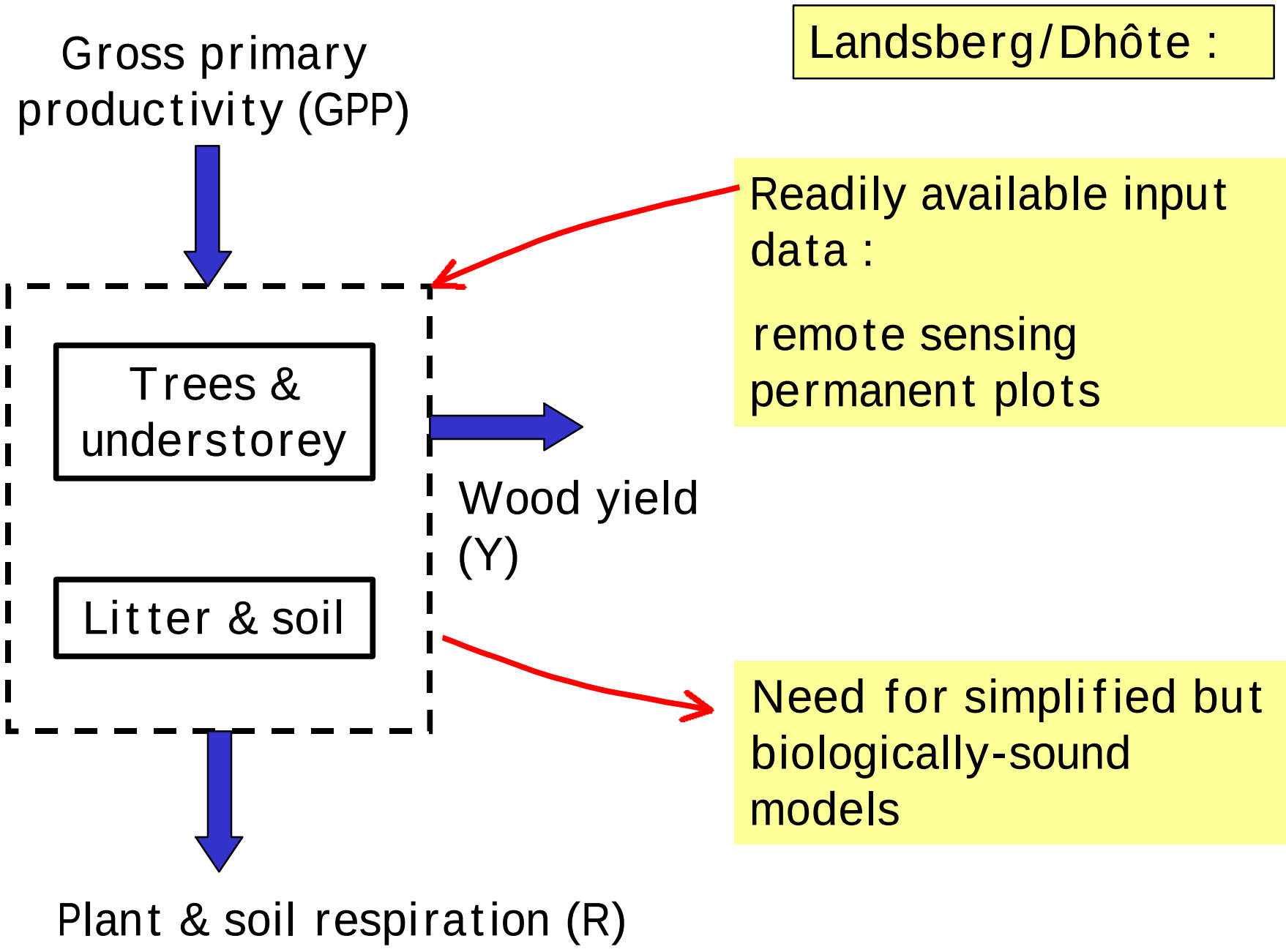
Tomé/Pinto :



Decision support systems to assess :

pulpwood sustainability

labour costs vs. stability


Landsberg/Dhôte :
Gross primary productivity (GPP)
Readily available input data :
remote sensing
permanent plots
Trees & understorey
Wood yield (Y)
Litter & soil
Need for simplified but biologically-sound models
Plant & soil respiration (R)

Fourcaud :

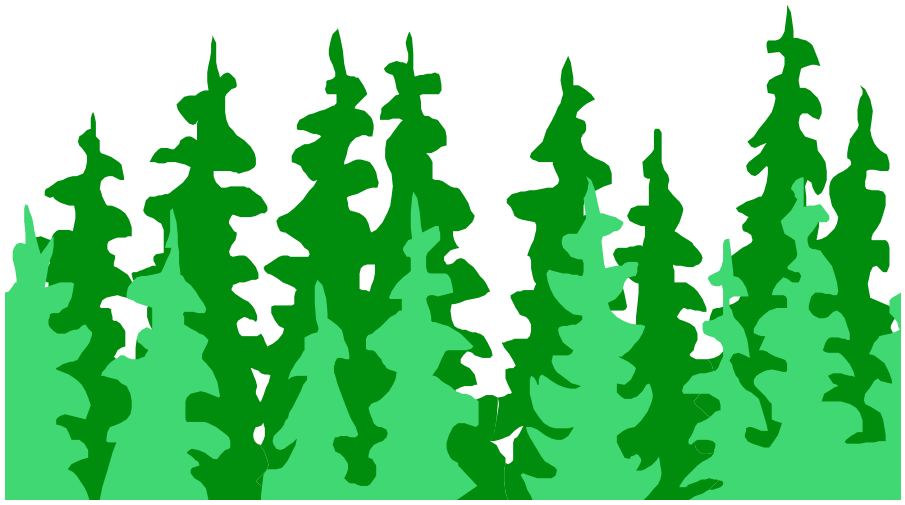
Growth & form

↓

Stem stress distribution

↓

Tree & stand stability



3. What have models achieved so far?

Summary :

Predictions of sustainable yield, C storage, etc. as function of management and climate, based on plant-soil & C-N-H_2O interactions

Coupling of simplified plant models to decision making tools

Growth ® stress ® wind-throw hasard

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4. Priorities for future research/collaboration ?

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C balance
N balance
biomechanics
end users

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C balance

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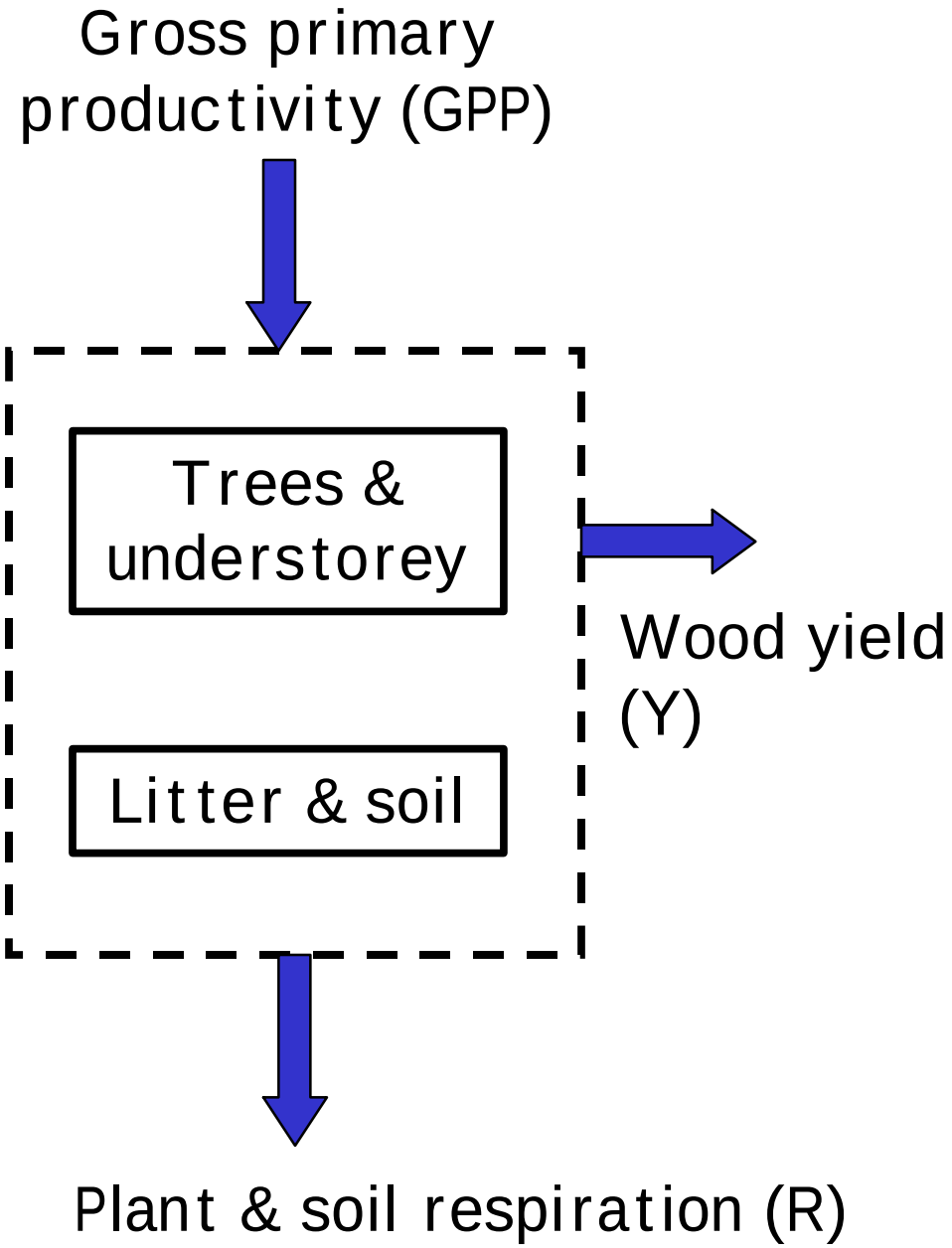
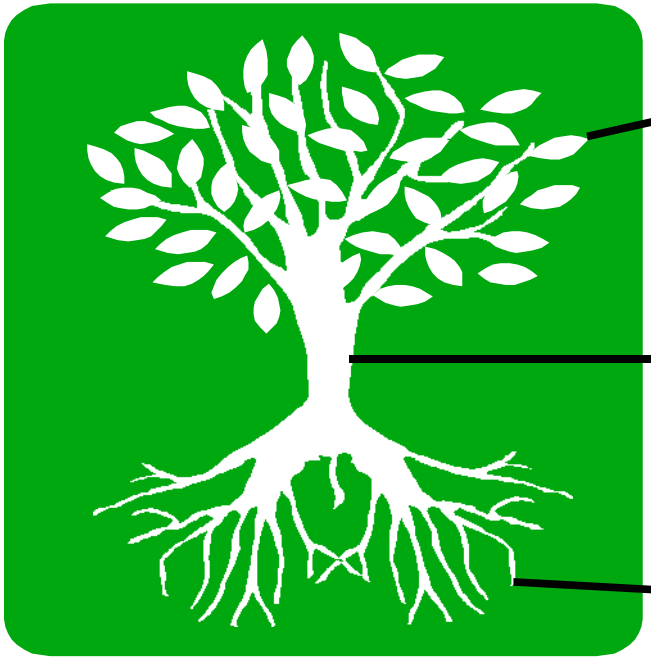


Key fluxes :
GPP & Y

Key controls :

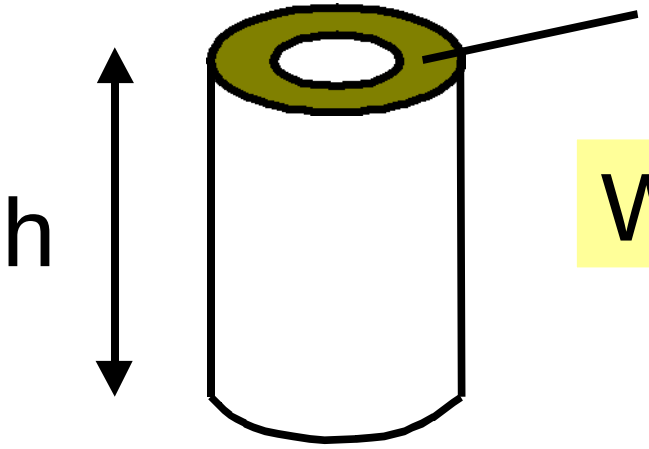
Carbon allocation to foliage, wood & fine roots as function of soil N, H_20



foliage (F)

sapwood (W)

fine roots (R)



sapwood area (A)

$W = \rho_w A h$

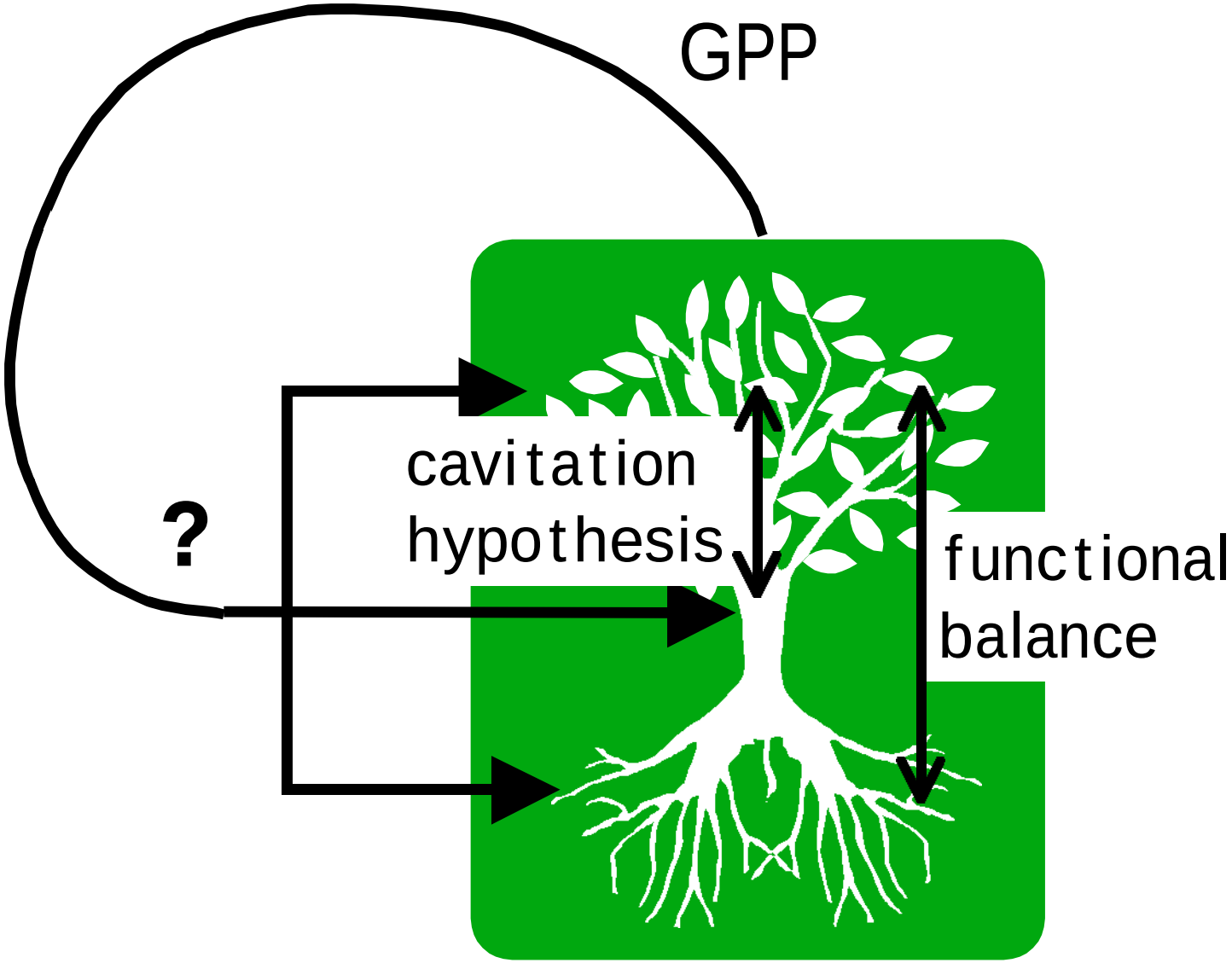
sapwood density

SUSTAIN (Dewar, poster)

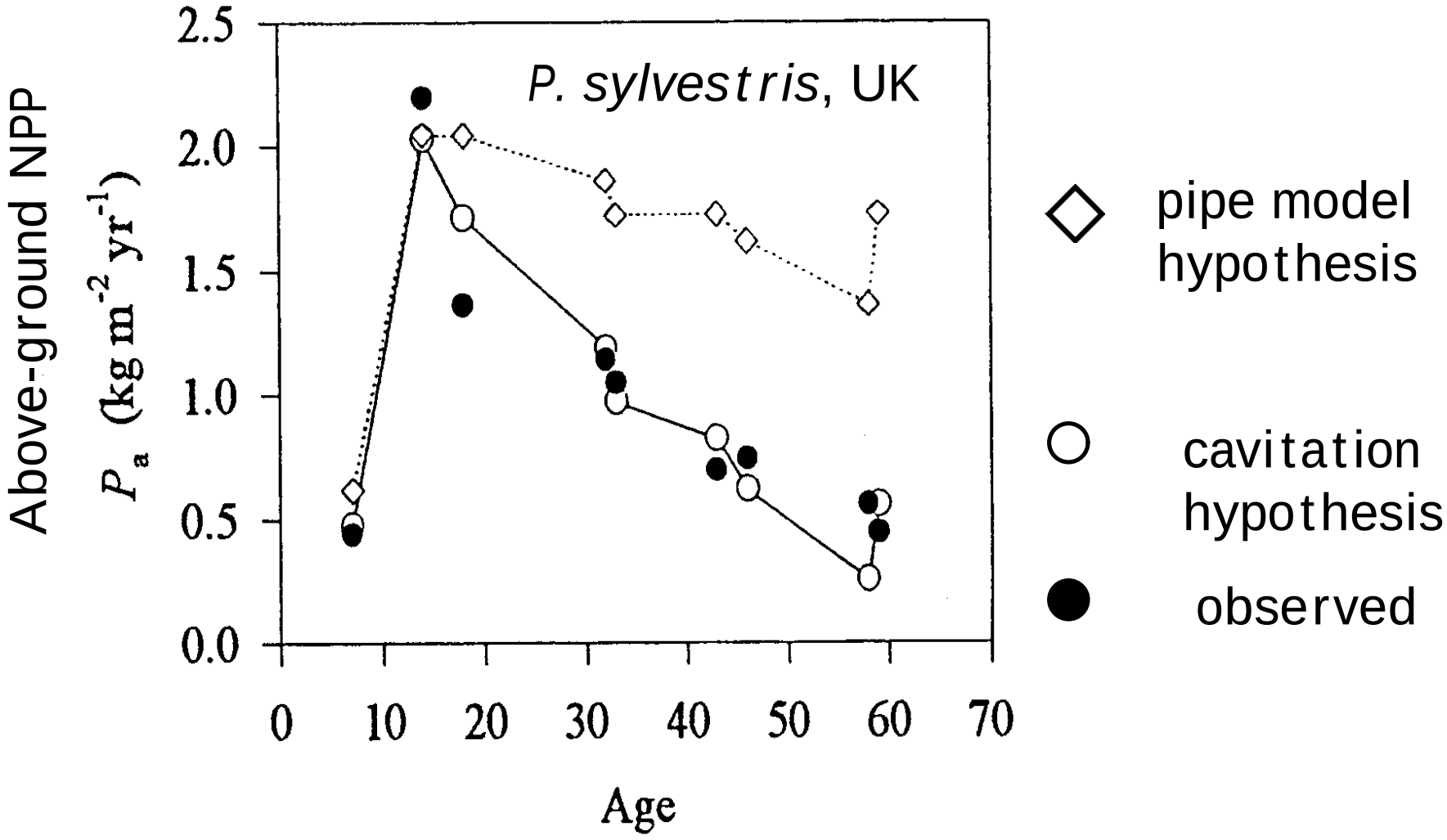
On an annual timescale:

Foliage, sapwood and stem height growth maintains ψ_{leaf} above cavitation threshold

Foliage and fine root growth maintains a balance between C and N uptake


GPP
cavitation
hypothesis
?
functional
balance

Magnani (PhD thesis, 1999) :



Sensitivity analysis :

	$t_{closure}$ (yr)	LAI_{max} ($m^2\ m^{-2}$)	h_{20} (m)	T_{rot} (yr)	MAI_{max} ($m^3\ ha^{-1}\ yr^{-1}$)
base	11	5.6	13	52	13
$2\times N_{soil}$	6	8.6	21	42	29
$2\times CO_2$	10	7.9	19	65	18
2×VPD	10	4.2	10	41	12

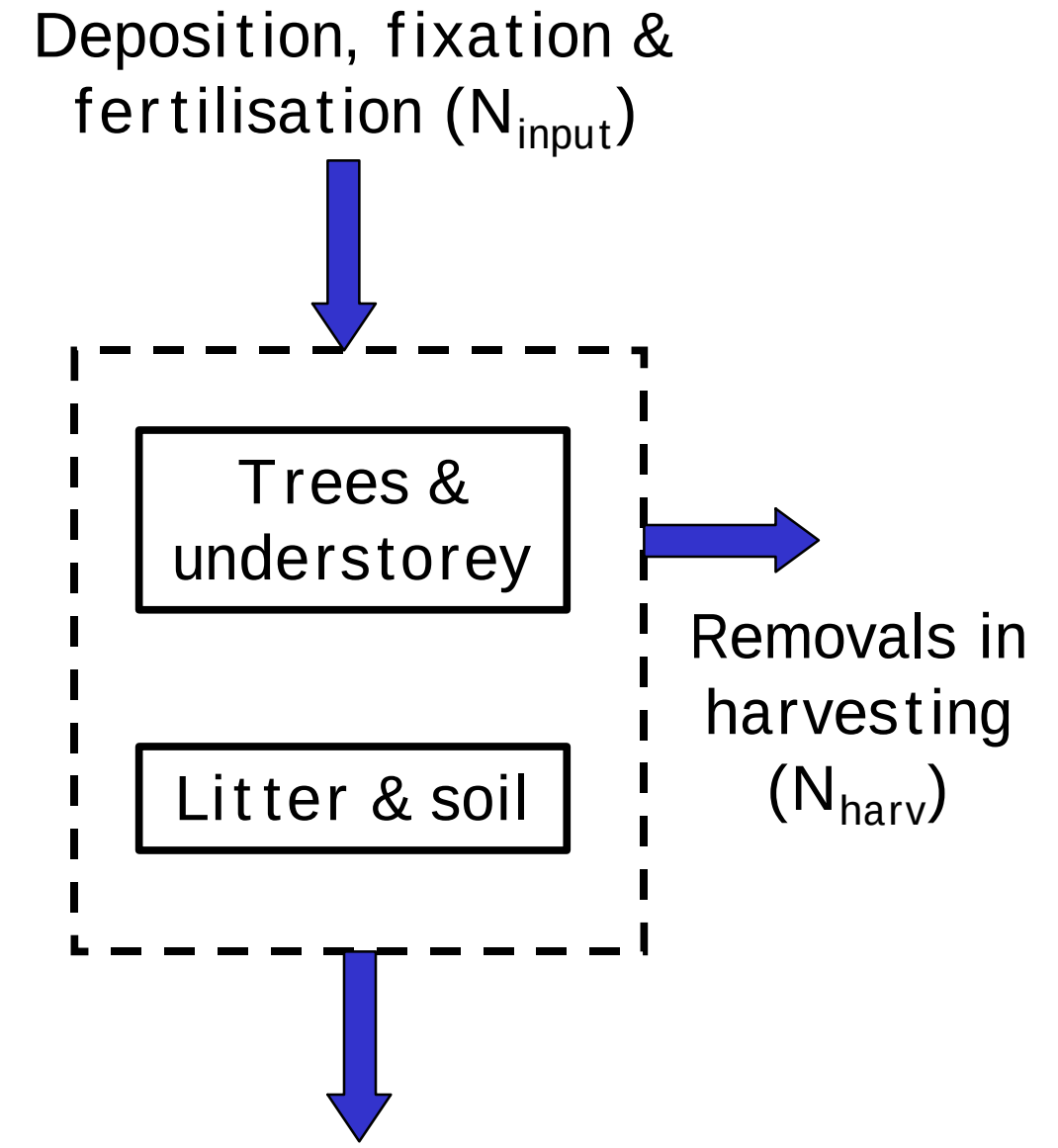
4. Priorities for future research/collaboration ?

C balance

N balance

biomechanics

end users

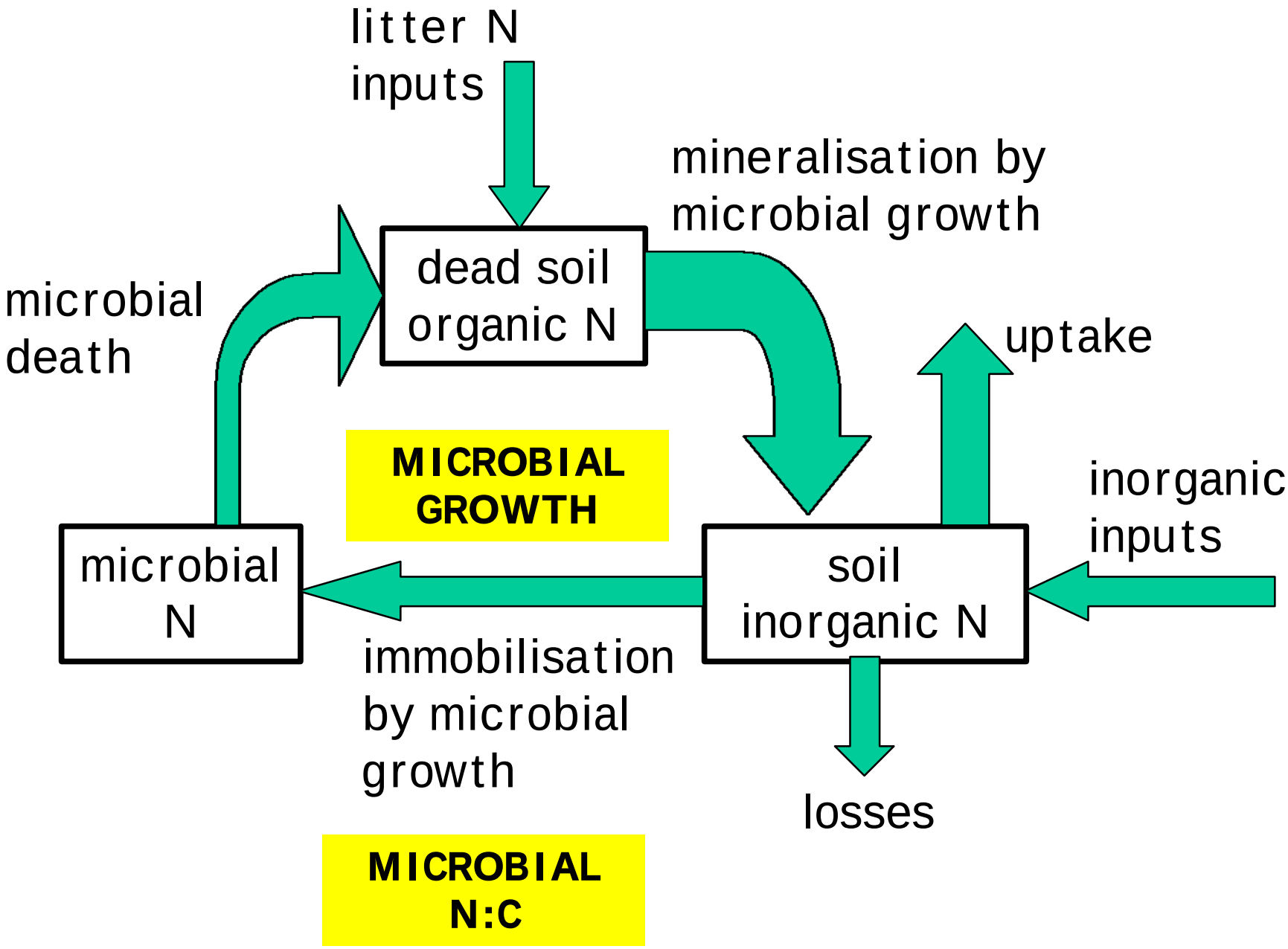


Key flux :
N_{loss}

Key pool : soil inorganic N

Key controls :

Microbial growth
Microbial N:C
N uptake


litter N inputs
mineralisation by microbial growth
dead soil organic N
microbial death
uptake
MICROBIAL GROWTH
inorganic inputs
microbial N
soil inorganic N
immobilisation by microbial growth
losses
MICROBIAL N:C

4. Priorities for future research/collaboration ?

C balance
N balance
biomechanics
end users

1. Stress → growth → constant stress distribution along stem ?

2. Effect of given wind-throw damage (intensity, freq.) on sustainable behaviour ?

4. Priorities for future research/collaboration ?

C balance
N balance
biomechanics
end users

What do end-users really want ?

Coupling of simplified ecosystem models to decision-making systems ?

Robust (parameter-insensitive) predictions from more mechanistic models $\rightarrow$ practical guidelines

4. Priorities for future research/ collaboration?

Summary :

Stand growth decline after canopy closure

Regulation of microbial growth and N:C

Role of understorey in N retention during canopy closure

Impact of wind damage on ecosystem C & N balance

Simple ecosystem models and/or generic predictions

Conclusion :

Models : We have a good ‘terroir’

People : We have some good vintages

Let the wine flow !