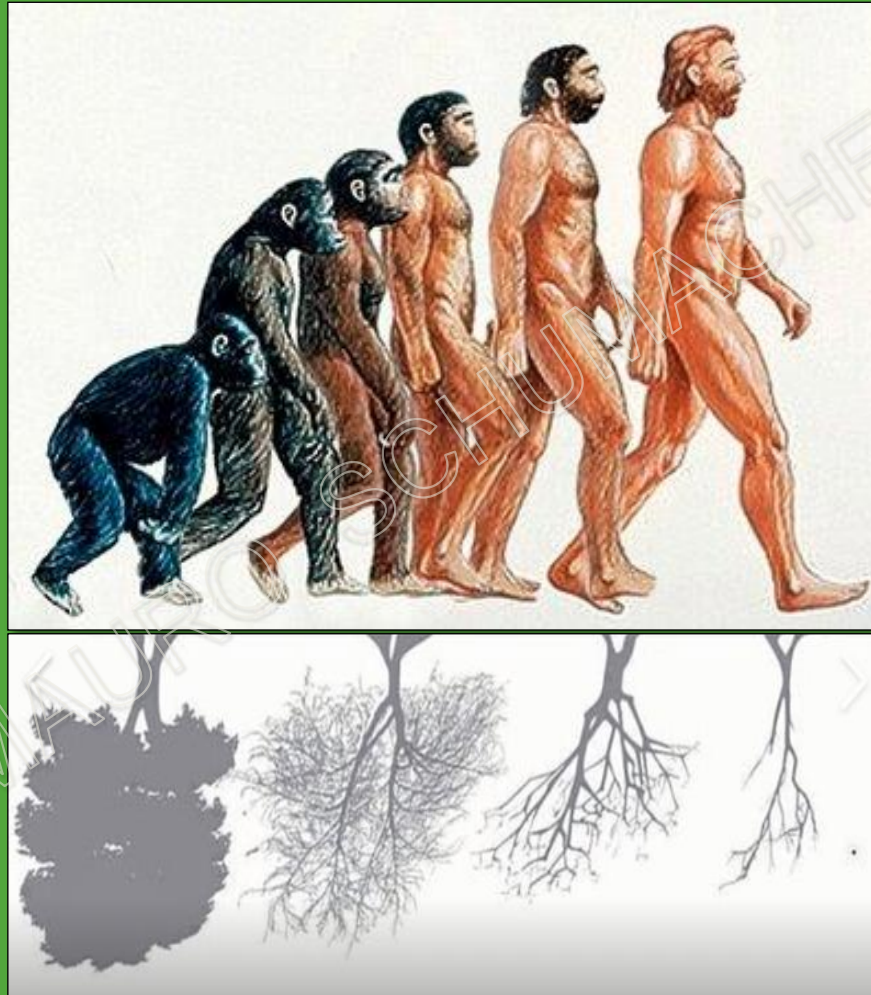


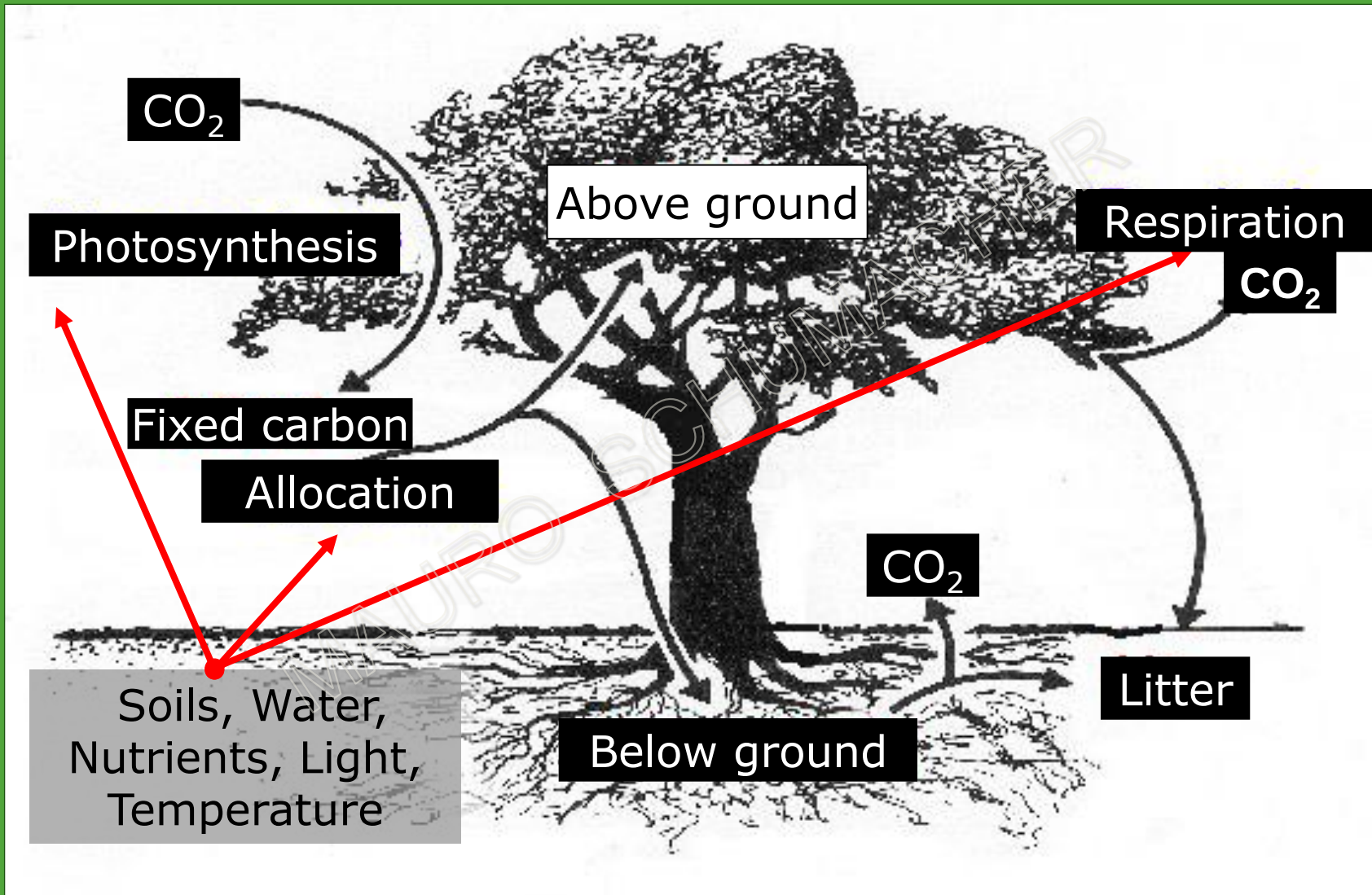
# *"Forest Environmental Monitoring"*

*Prof. Full Dr.nat.techn. Mauro V. Schumacher  
DCFI/CCR/UFSM  
Ecology and Forest nutrition  
mauro.schumacher@ufsm.br*

## *Evolution x Environment*

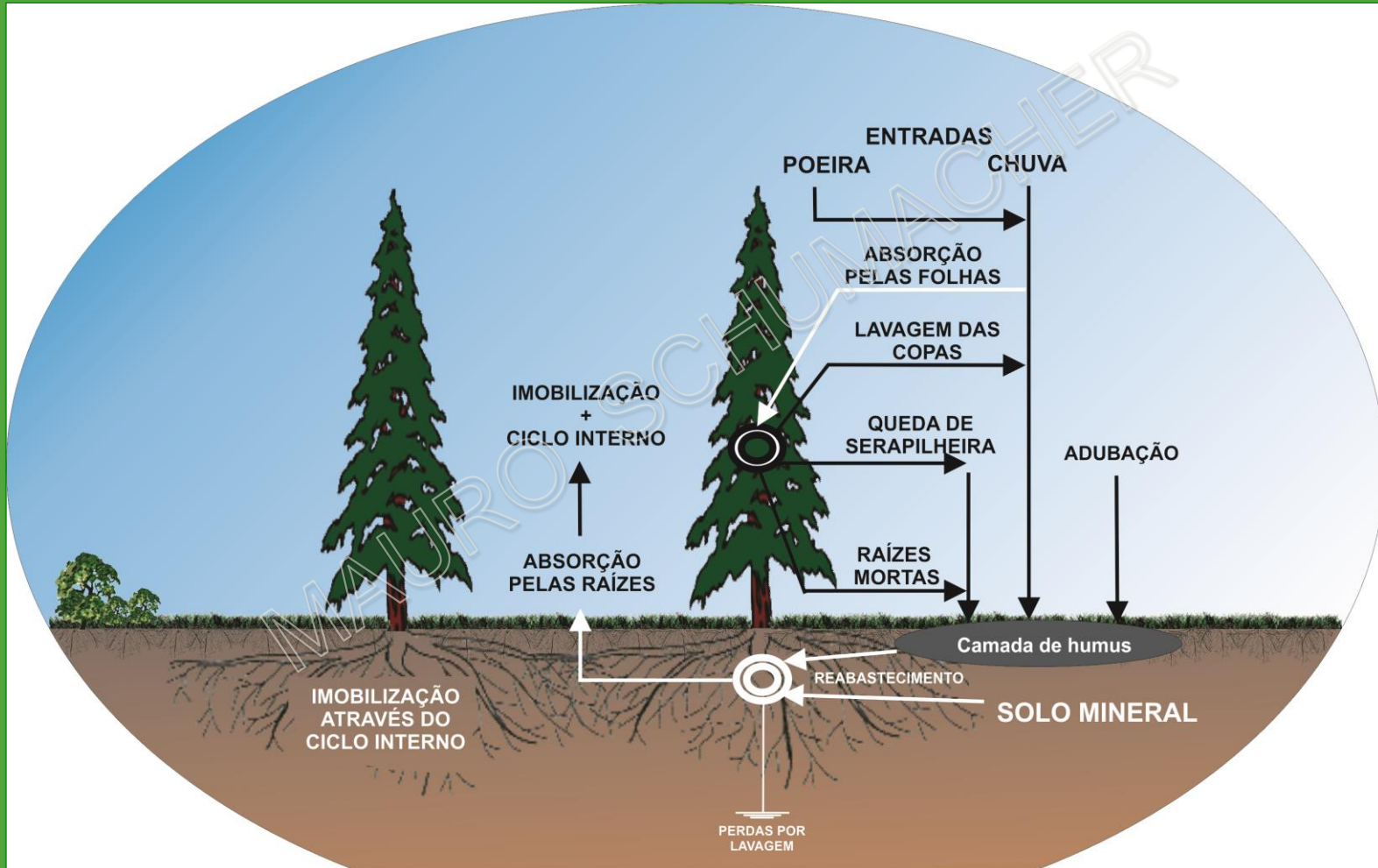


# Forest and plantation productivity



Source: Adapted from STAPE (2006)

# Nutrient cycling in Forest Ecosystems





## *Industrial emissions*



*Fog with "marine spray"*



*Burning "cleaning"*





## Connecting Sahara - Amazonas

### Tepui - Venezuela



Source: GEO (1995)



## *Dust Storm in the Sahara*



Source: GEO (1995)

*Sample of water and dust from the atmosphere*



Source: GEO (1995)

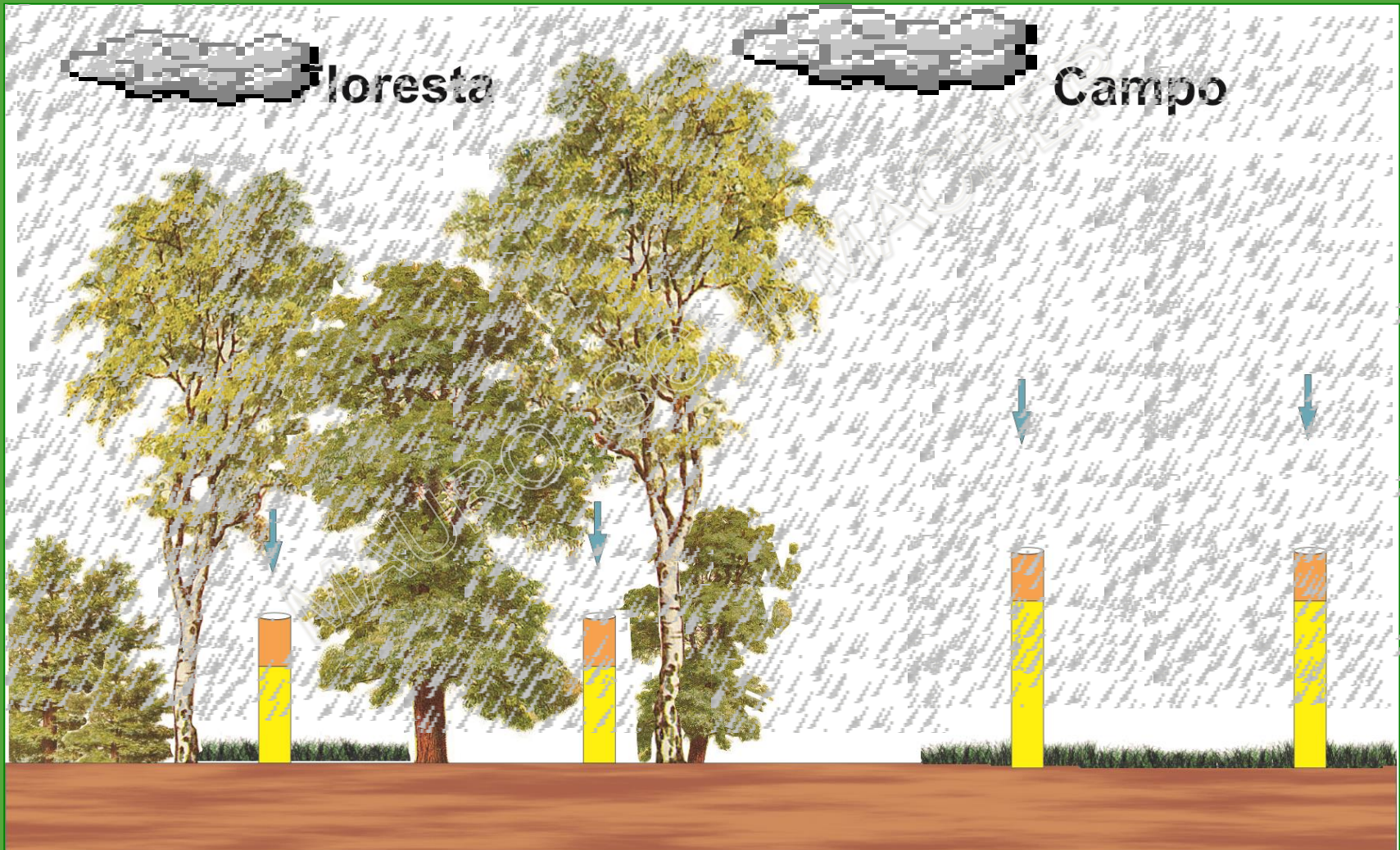
## Inputs of nutrients through atmospheric deposition

| Nutrient ( $\text{kg ha}^{-1} \text{ year}^{-1}$ ) |      |     |      |      | Source |
|----------------------------------------------------|------|-----|------|------|--------|
| K                                                  | Ca   | Mg  | Na   | Cl   |        |
| 9,4                                                | 7,8  | 1,1 | 6,8  | -/-  | 1      |
| 17,1                                               | 23,3 | 2,9 | 15,8 | 23,3 | 2      |
| 1,9                                                | 4,1  | 0,7 | 3,9  | 7,7  | 3      |
| 7,2                                                | 9,7  | 1,7 | 33,3 | 40,3 | 4      |
| 3,6                                                | 9,3  | 1,5 | 4,8  | 14,0 | 5      |

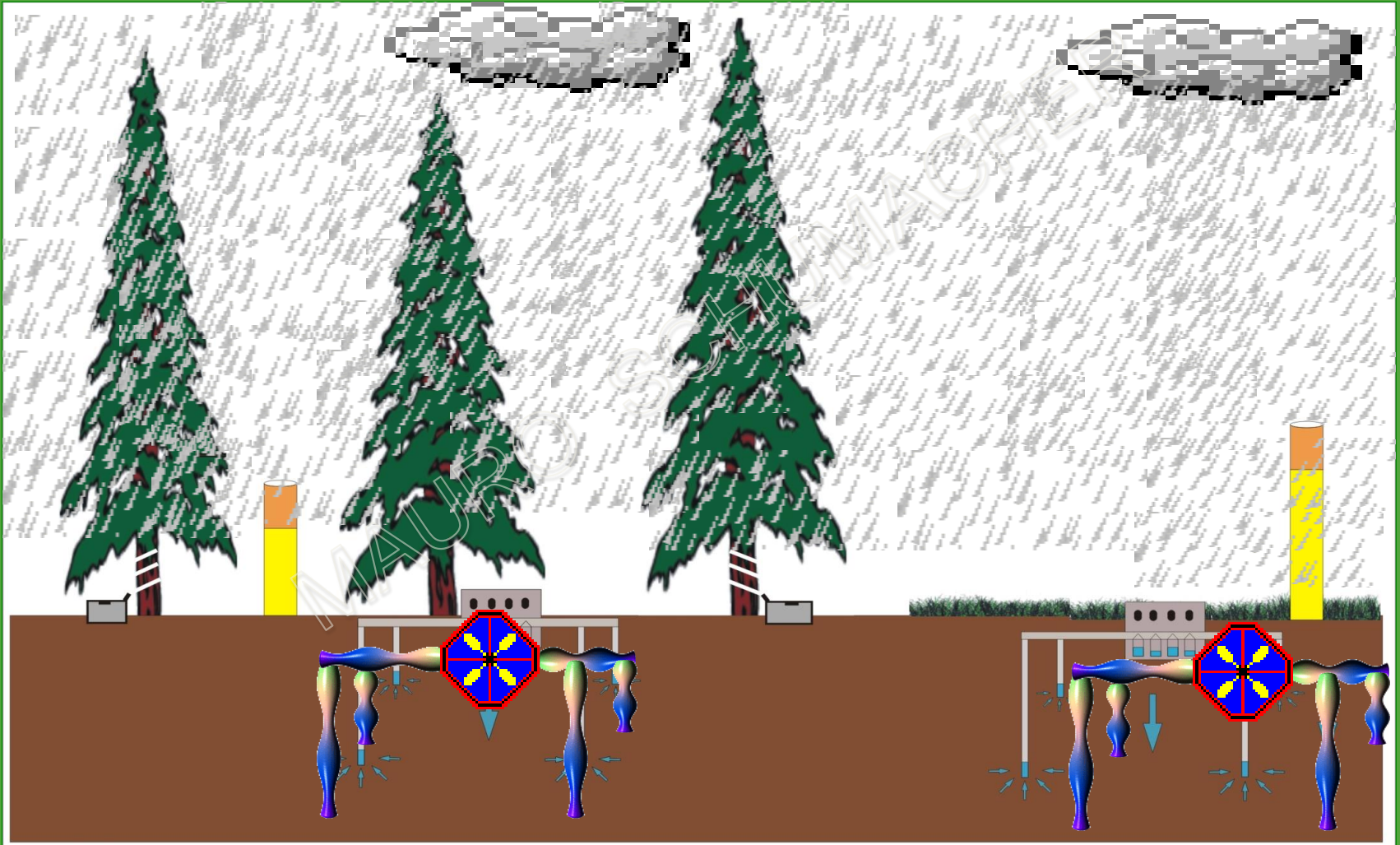
1 = Castro (1980) region of Viçosa where there are no industries;  
 2 = SIF (1986) in the Steel Valley;  
 3 = Armbruster et al. (1997) Germany;  
 4 = Schumacher et al. (2009) Cambará do Sul /RS;  
 5 = Laclau et al. (2010) Itatinga/SP.



## *Nutrient cycling in native forests*



## Nutrient cycling in plantations





## Atmospheric deposition



Source: © Schumacher (2008)



## Throughfall



Source: © Schumacher (2009)



## *Throughfall (Native forest)*



Source: © Schumacher (2003)

## Stemflow (*Pinus taeda*)



Source: © Schumacher (2008)



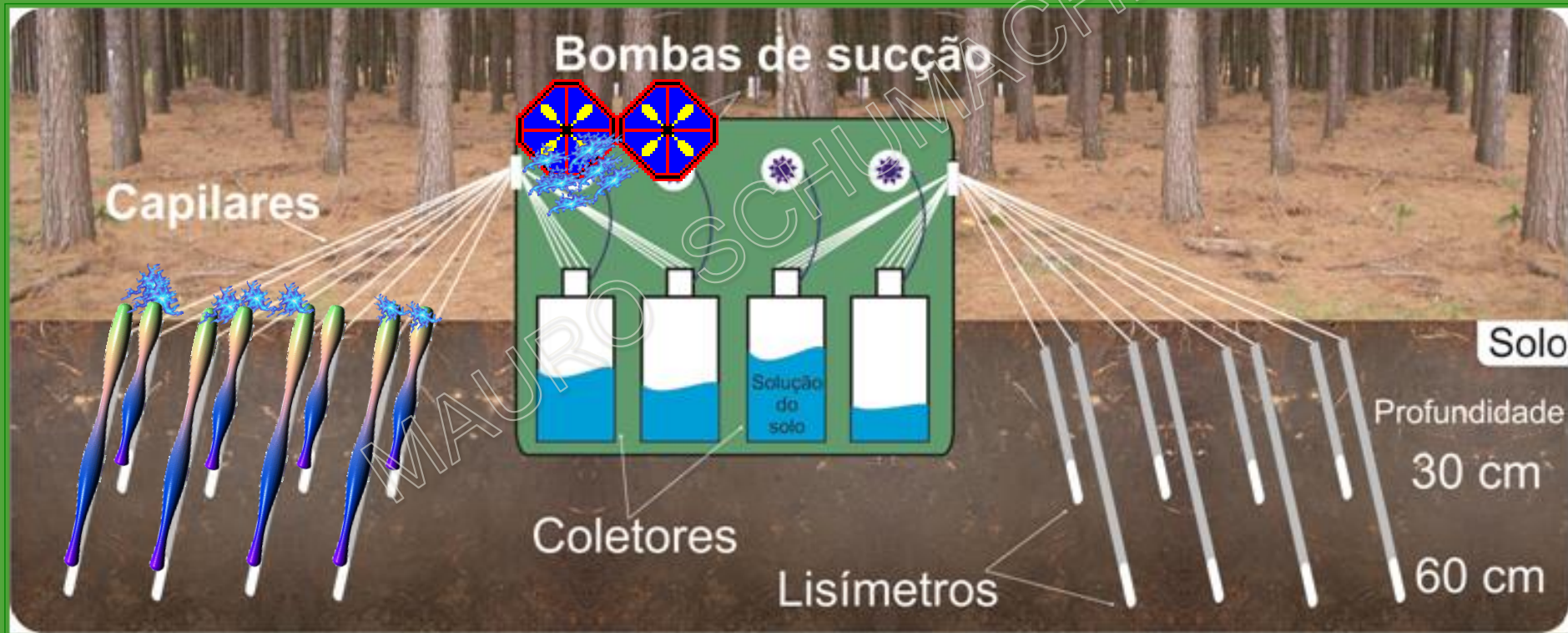
## Stemflow (*Eucalyptus globulus*)



Source: © Schumacher (2010)



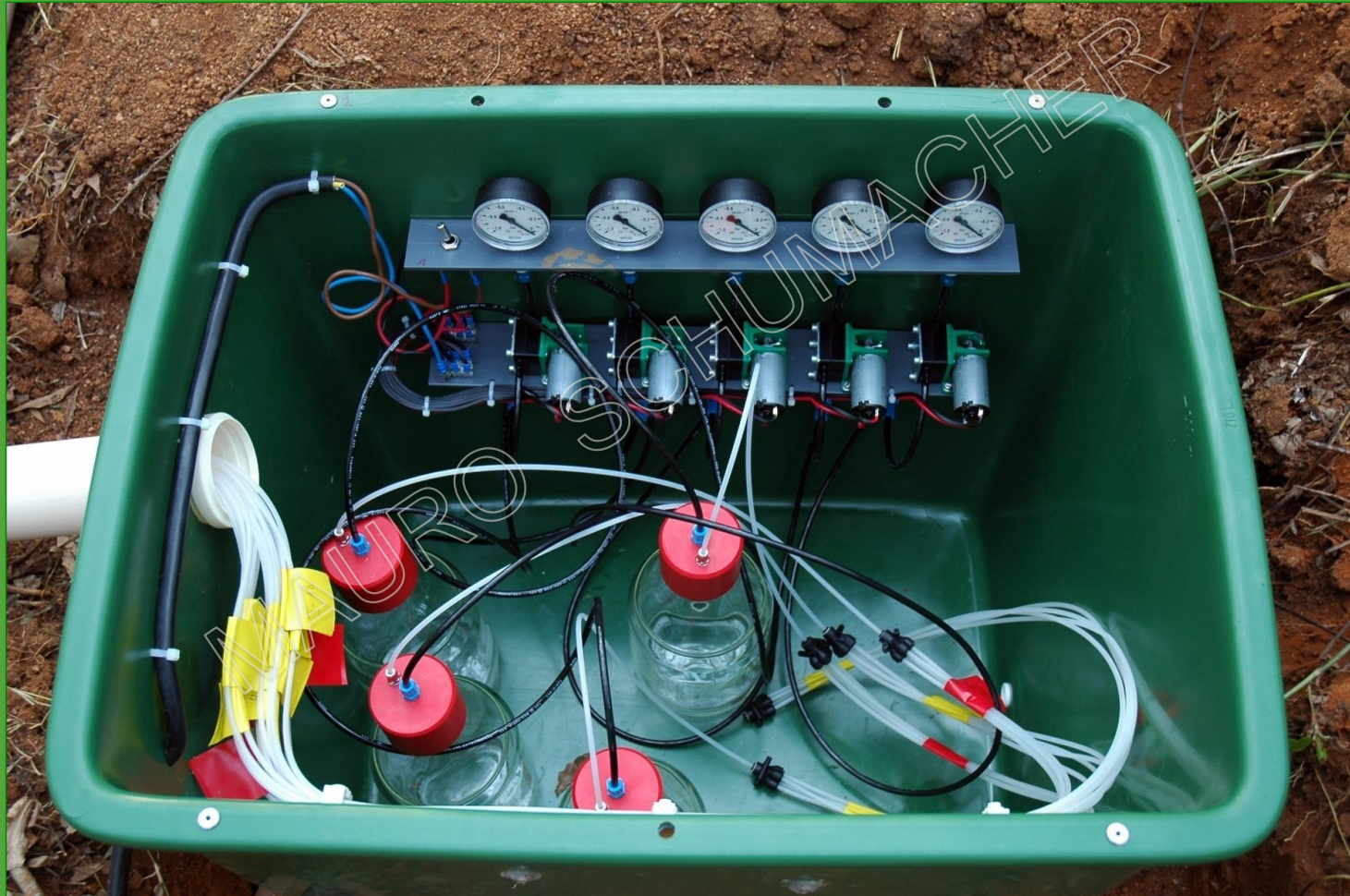
## Lysimeters pumping station



Source: © Lopes (2013)



## *Lysimeters pumping station*



Source: © Schumacher (2008)



## *Tension lysimeters*



Source: Schumacher (2008)



## *Water collection in watershed*



Source: © Schumacher (2008)



## *Litterfall sampling*



Source: © Schumacher (2010)



## *Sampling of thick branches*



Source: © Schumacher (2010)



## Fine Root Sampling



Source: © Lopes (2007)



## *Evaluation of the root system in forest ecosystems*



Source: © Schumacher (2007)



## *Scientific Research Results*



Source: © Schumacher (2016)

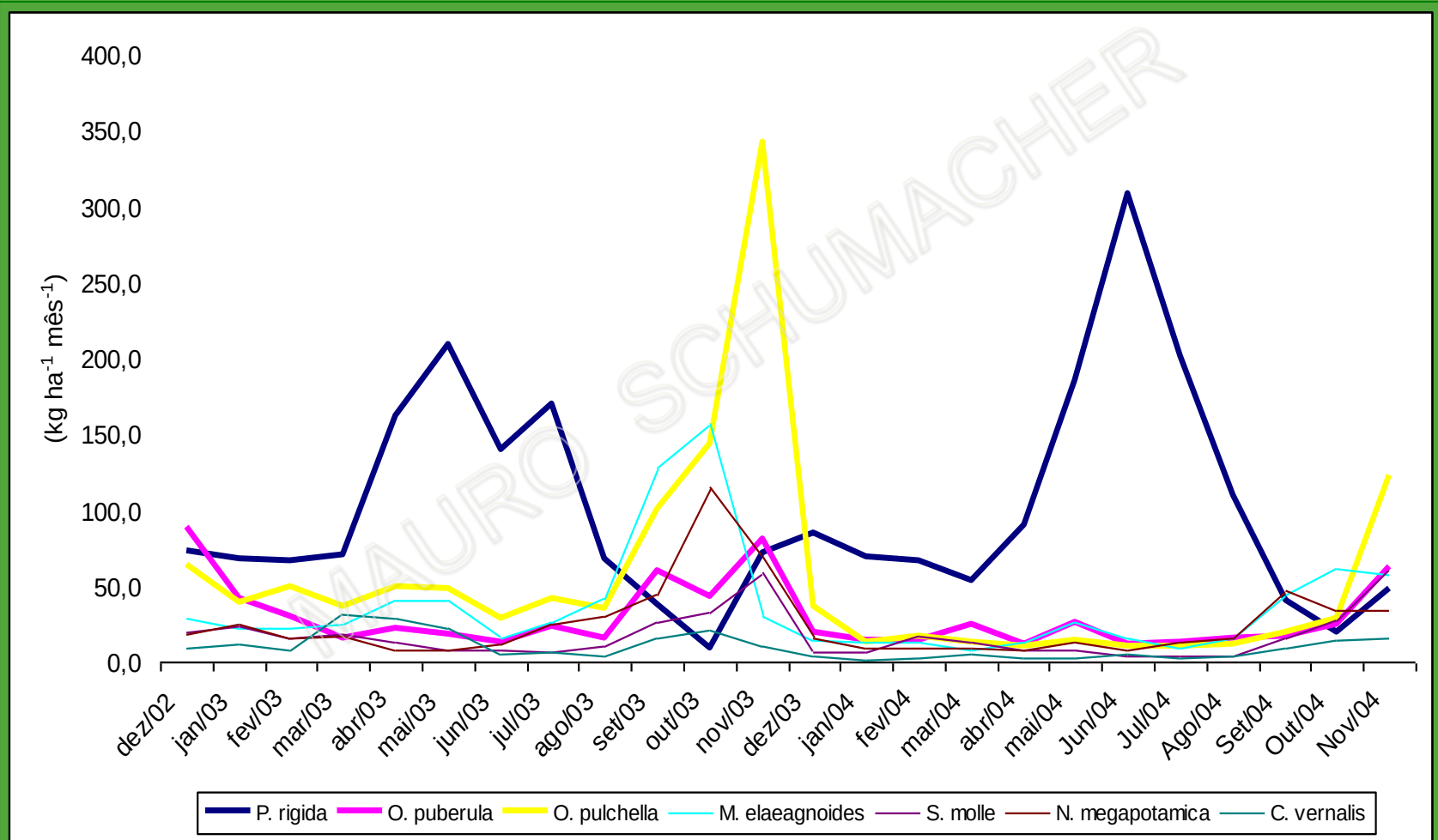


## *Native Forests*



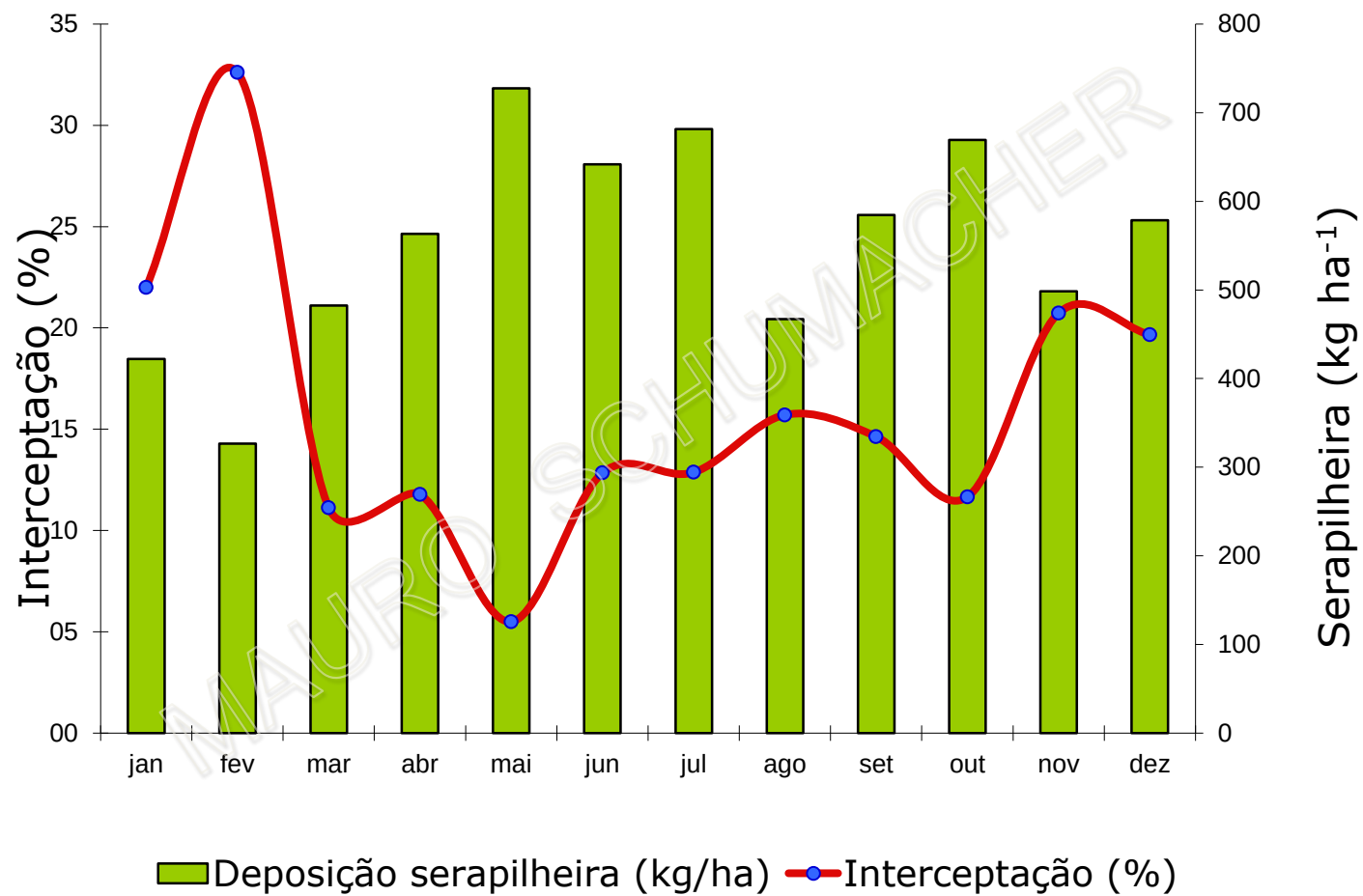
Source: © Schumacher (2009)

## Litterfall (leaves) in a Subtropical Seasonal Forest

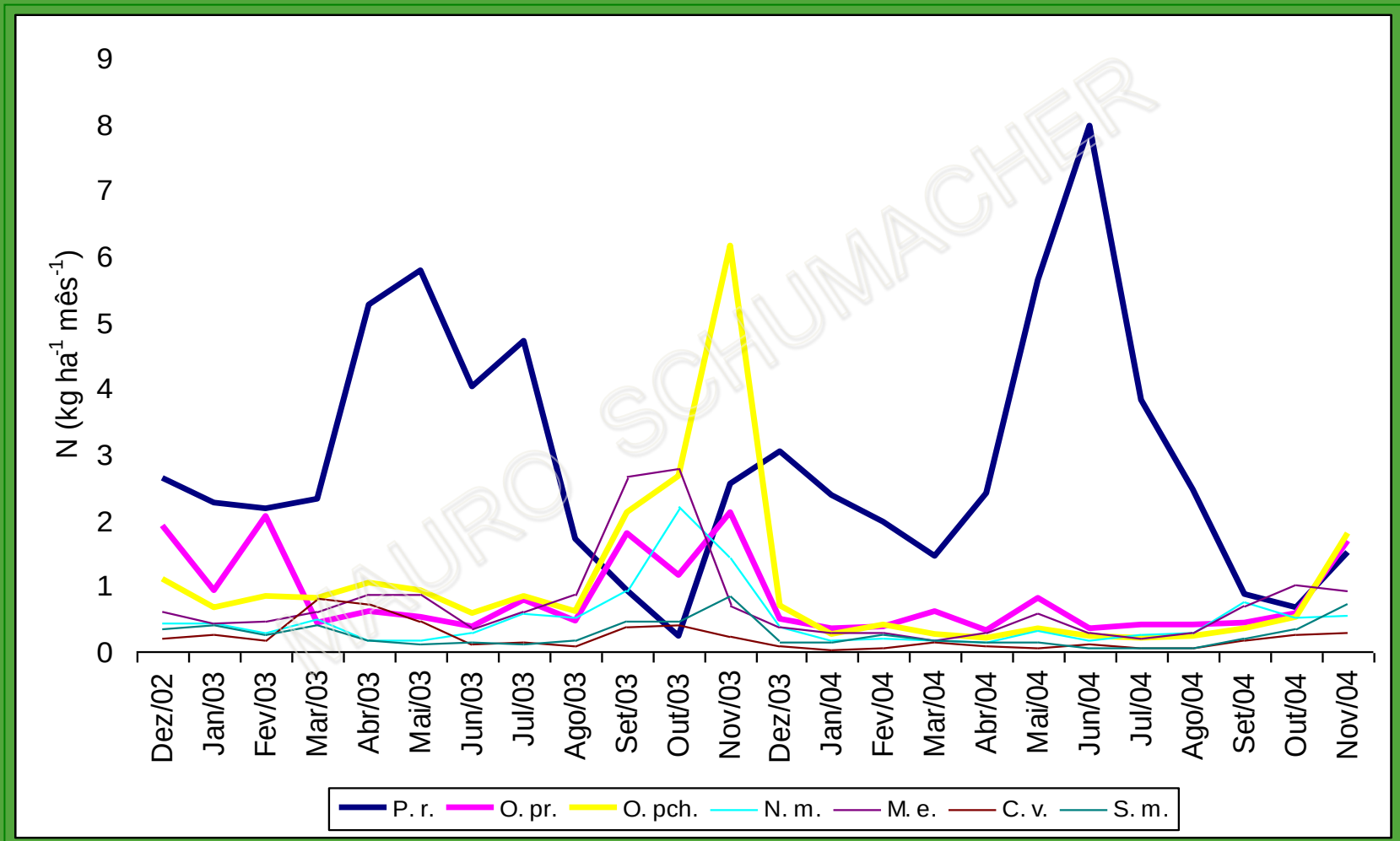


Source: Schumacher et al. (2009)





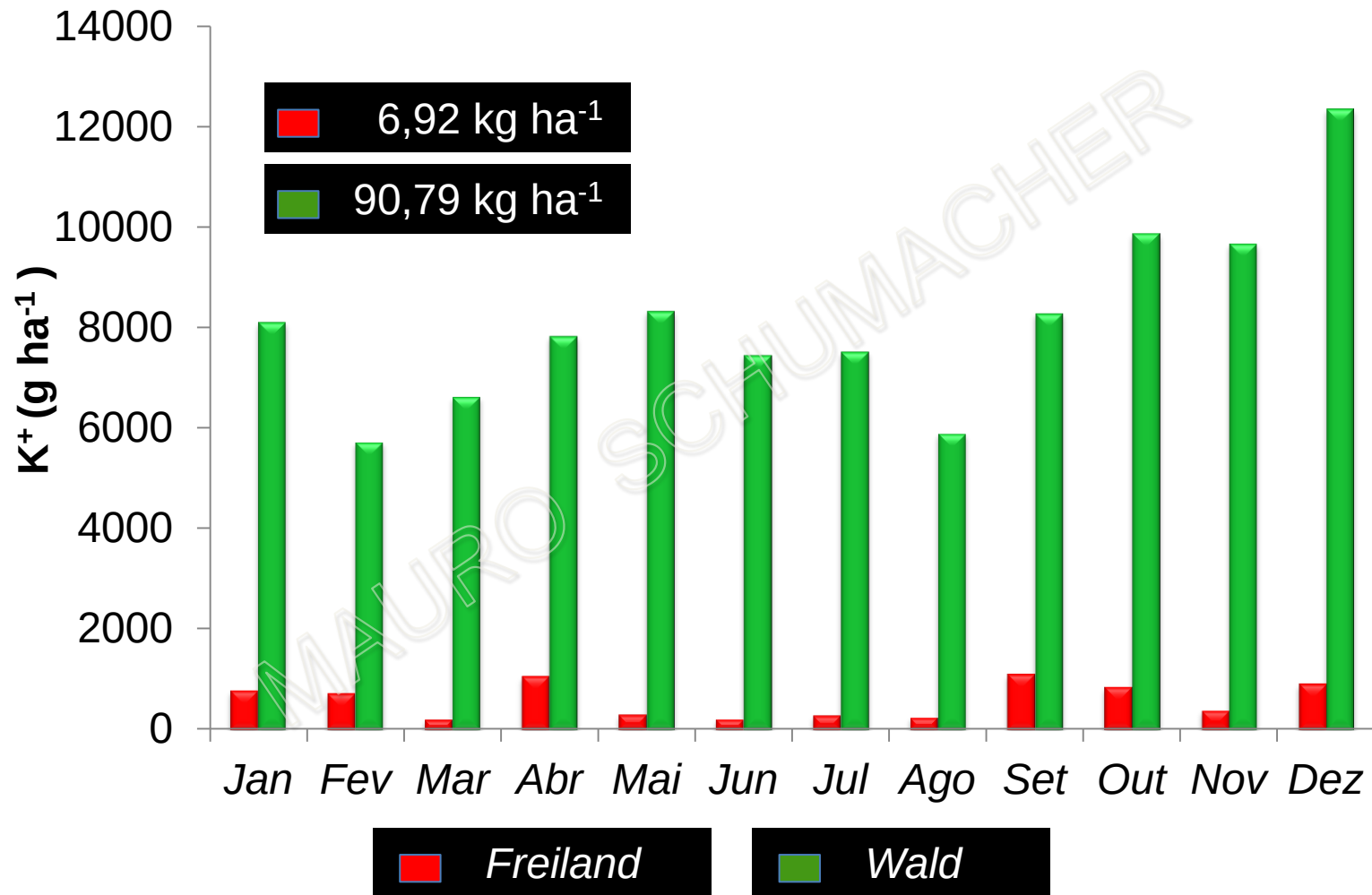
## Return of N by leaves in Subtropical Seasonal Forest



Source: Schumacher et al. (2009)

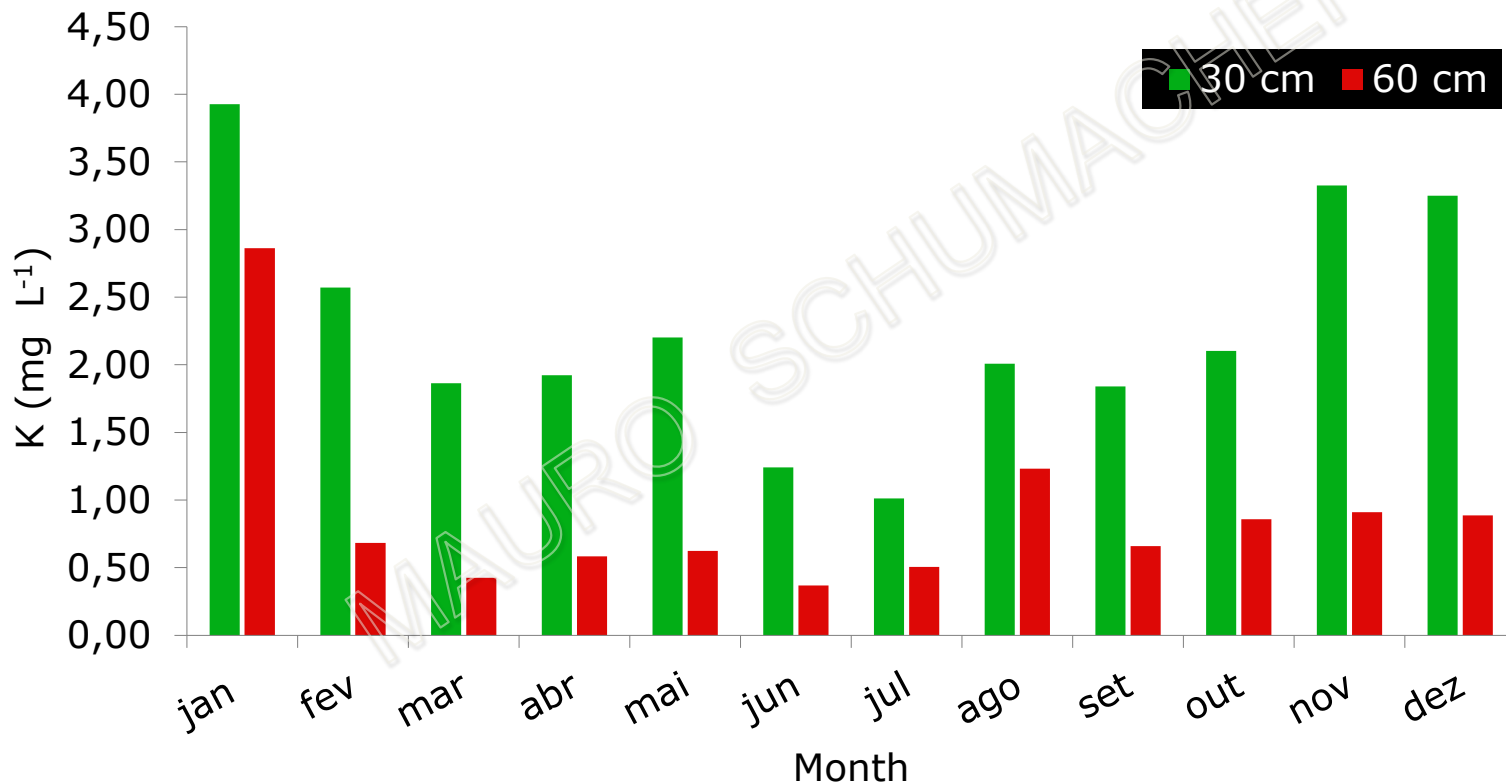


## Kalium Eintrag



Fonte: Schumacher et al. (2008)

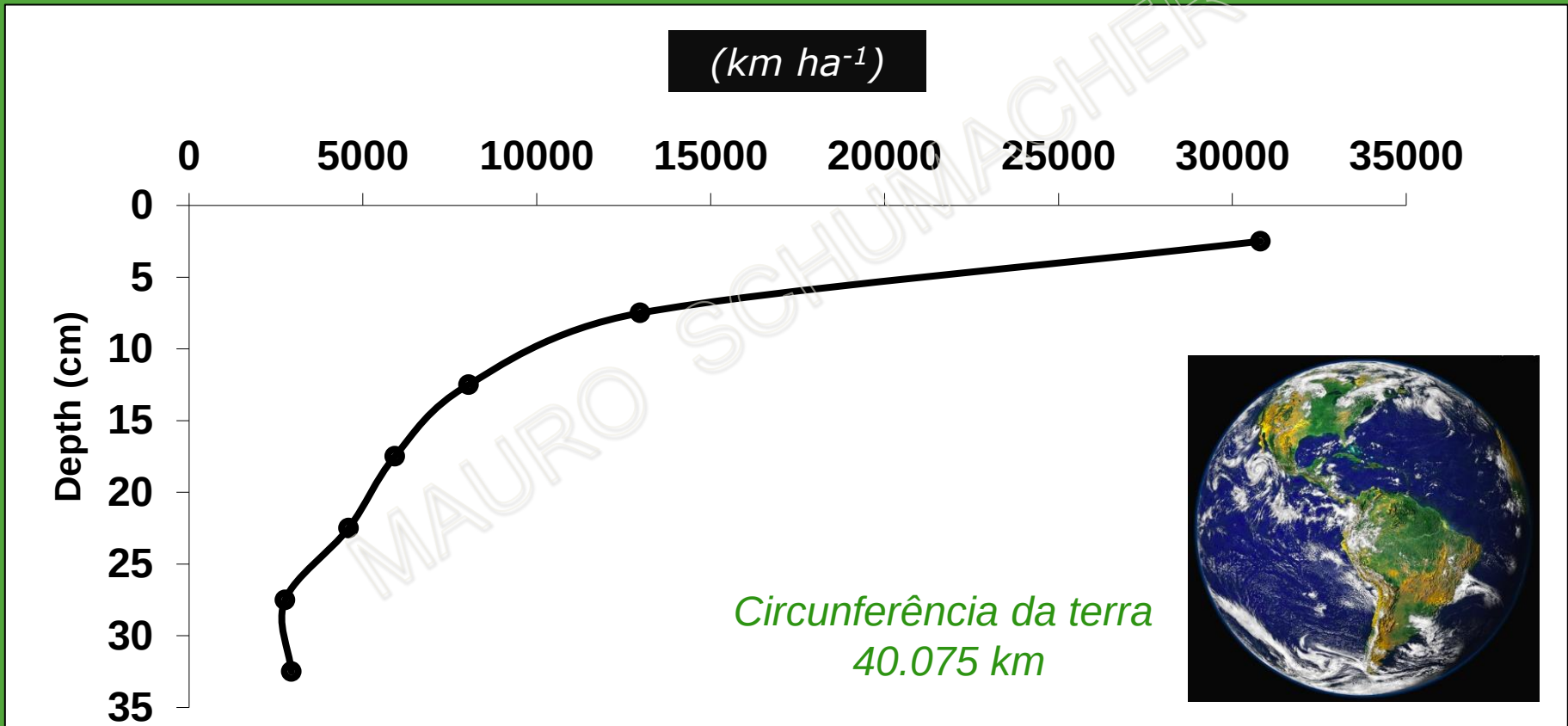
## Concentration of potassium in soil solution in Subtropical Seasonal Forest



Source: Schumacher et al. (2008)



*Length of fine roots (< 2,0 mm)  
in a Subtropical Seasonal Forest*



Source: Lopes et al. (2008)

## *Pinus plantations*



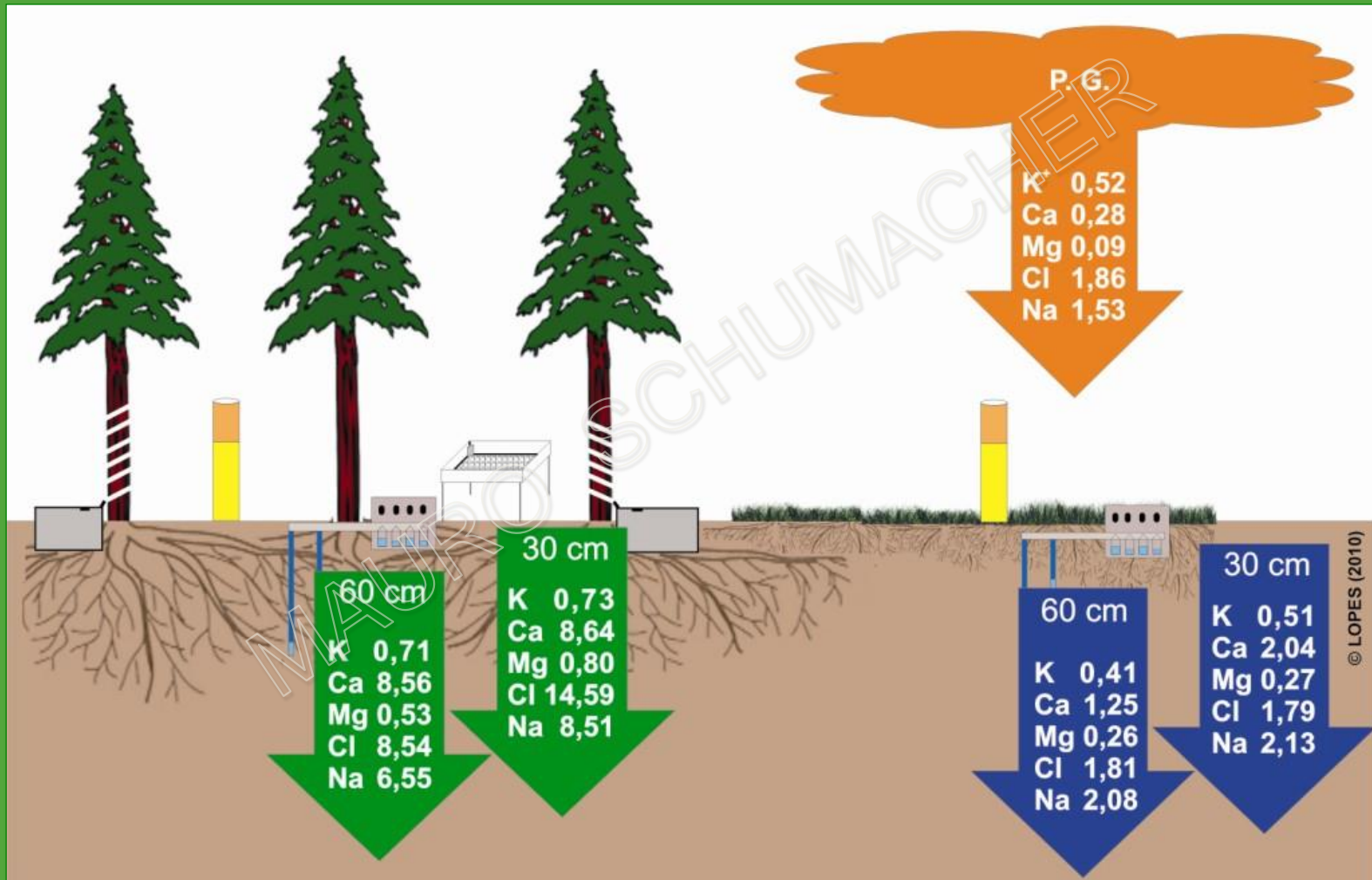


*Water balance in 11-year-old Pinus radiata plantation in New Zealand before and after thinning (Whitehead & Kelliher, 1991).*

| Component of BH             | Before         | After          |
|-----------------------------|----------------|----------------|
| Precipitation (P)           | 1623 mm (100%) | 1623 mm (100%) |
| Transpiration (Et)          | 636 mm (39%)   | 410 mm (25%)   |
| Interception (Ei)           | 268 mm (17%)   | 195 mm (12%)   |
| Direct Evap. of Soil (Eo)   | 93 mm (6%)     | 191 mm (12%)   |
| Effective Precipitation(PE) | 626 mm (38%)   | 827 mm (51%)   |

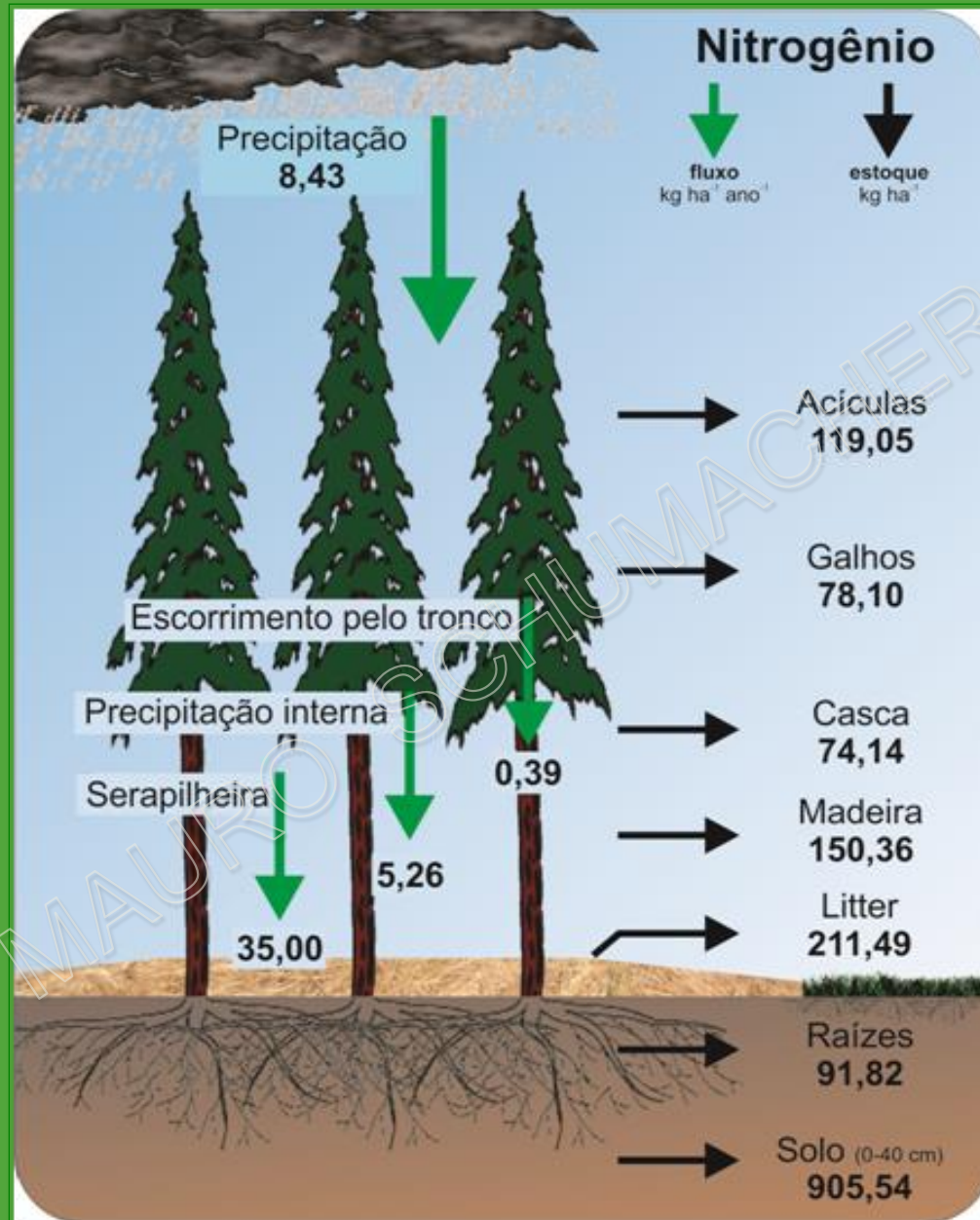
| Variable                             | Before thinning | After thinning |
|--------------------------------------|-----------------|----------------|
| Num. of trees ha <sup>-1</sup>       | 754             | 334            |
| Height (m)                           | 17,0            | 21,0           |
| LAI (m <sup>2</sup> m <sup>2</sup> ) | 15,5            | 9,0            |

*Ions ( $\text{mg L}^{-1}$ ) in the water of rainfall  
and in the solution of the soil.*

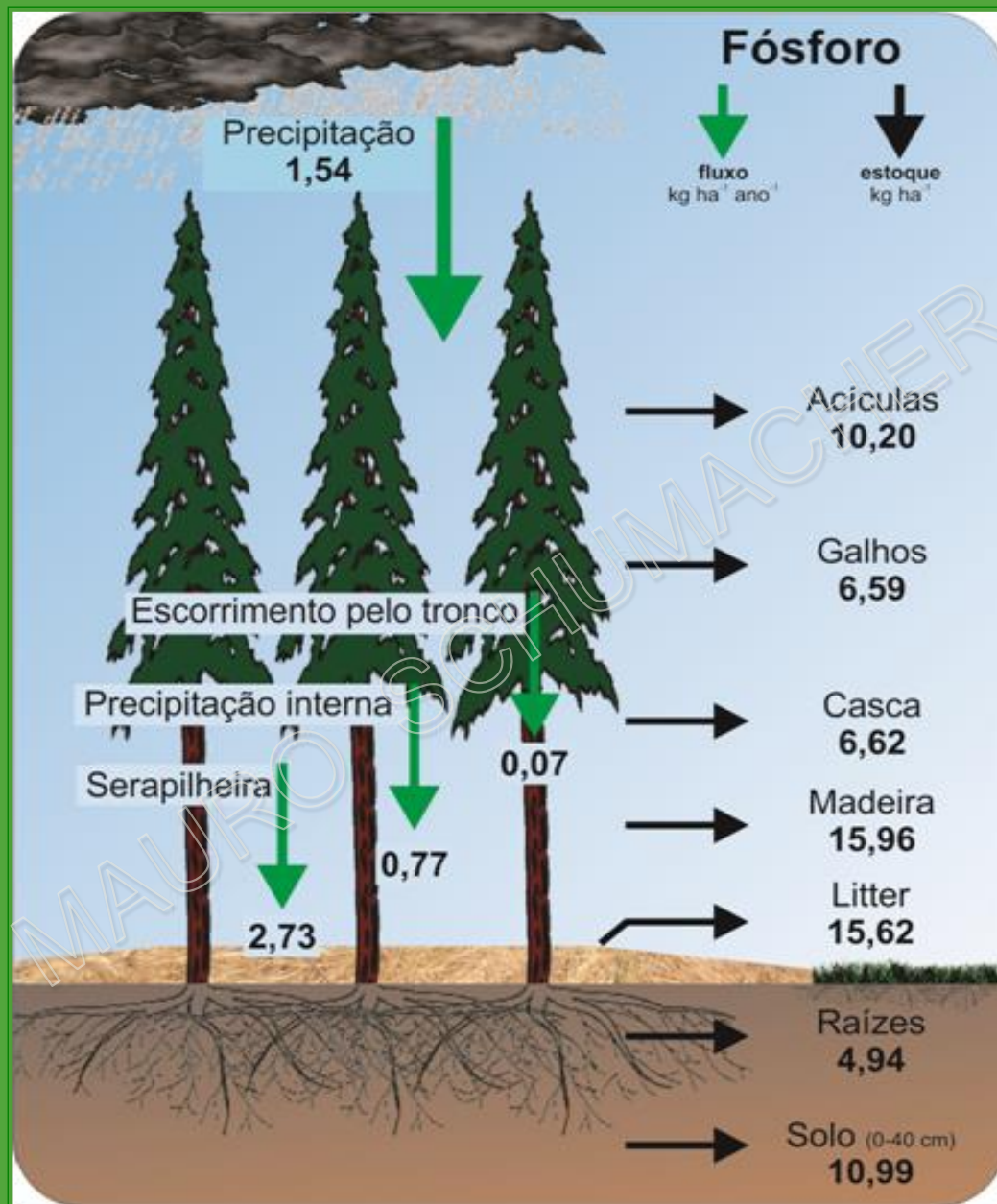


Source: Schumacher et al. (2009)



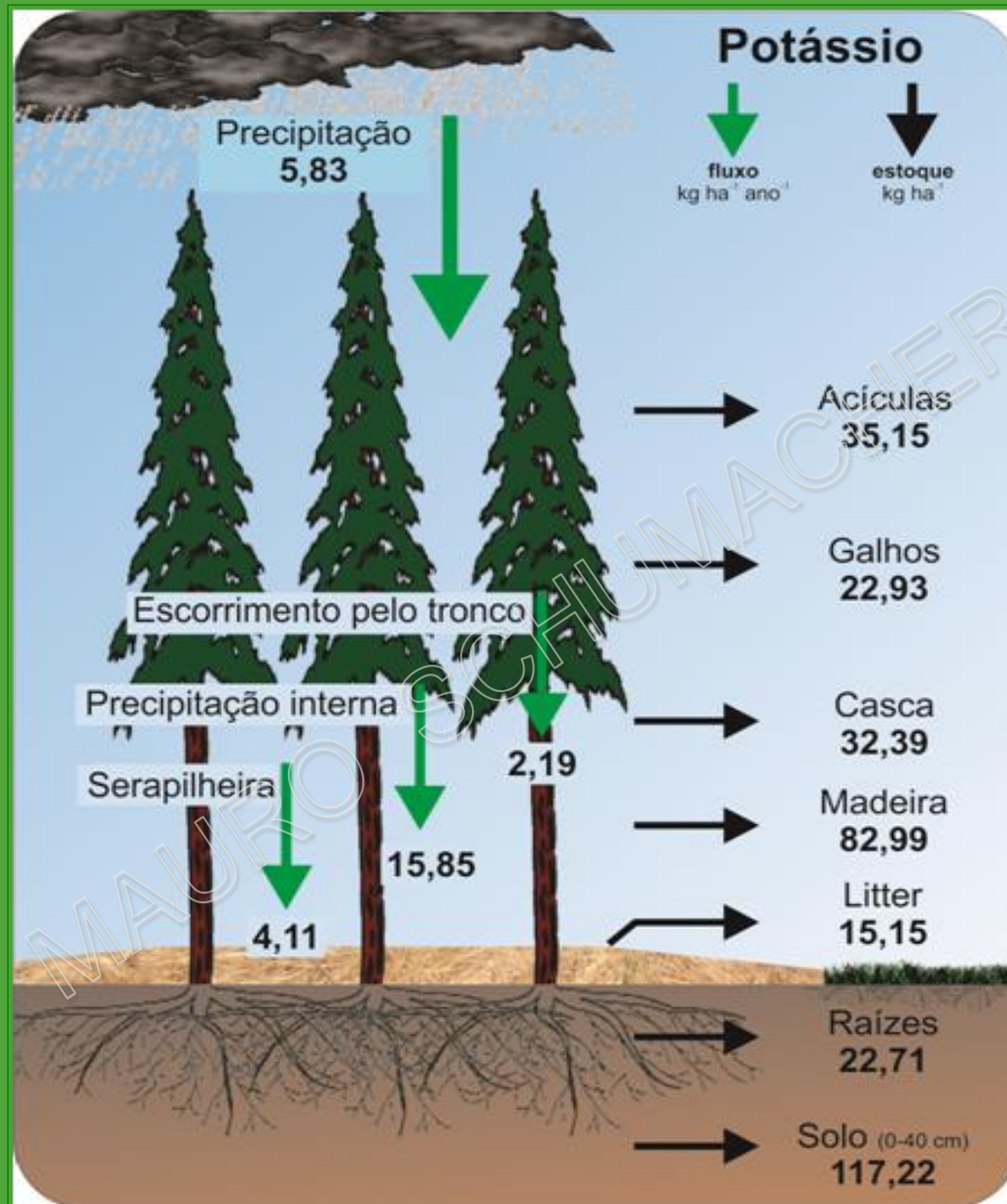


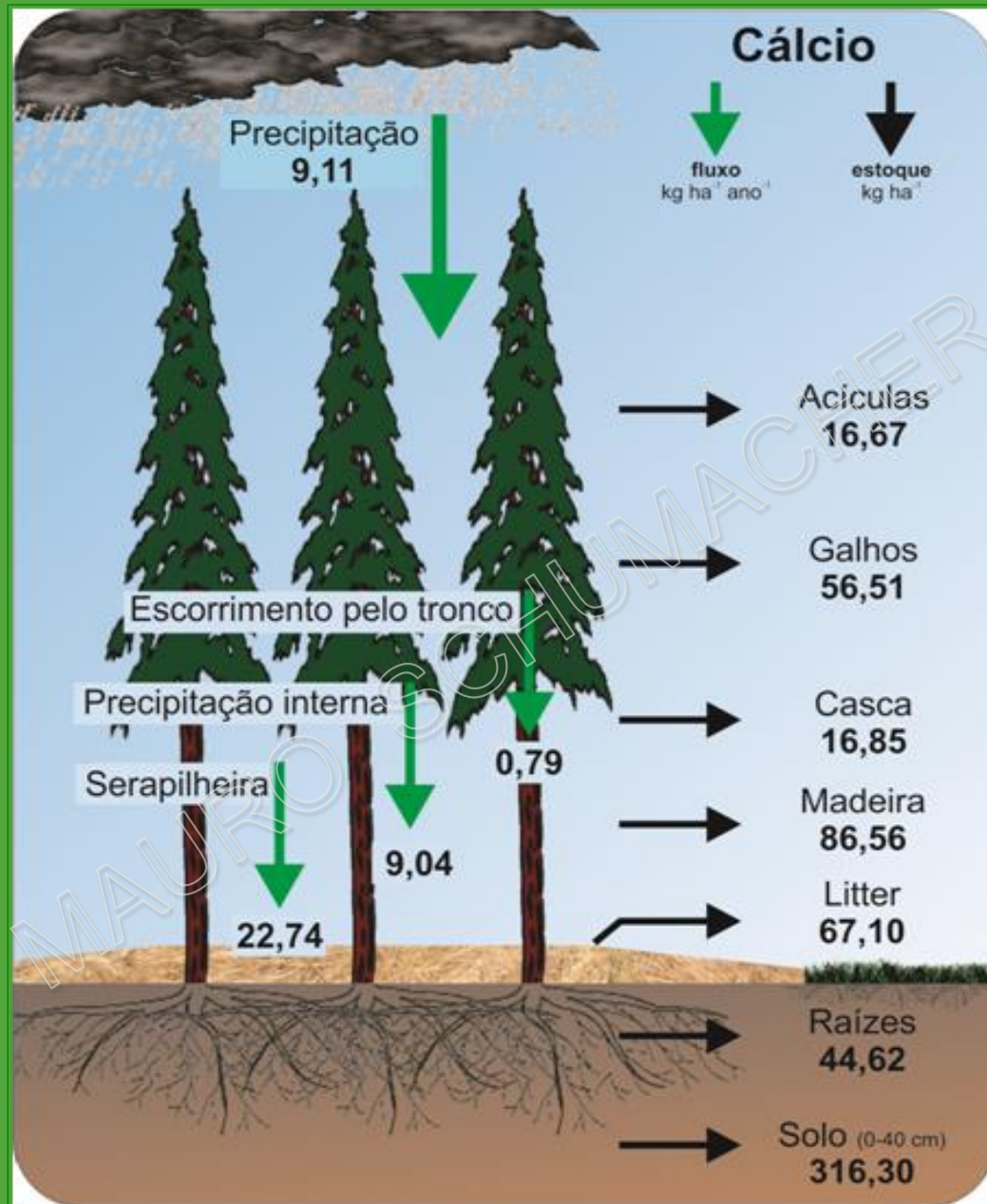
Source: Schumacher et al. (2009)



Source: Schumacher et al. (2009)

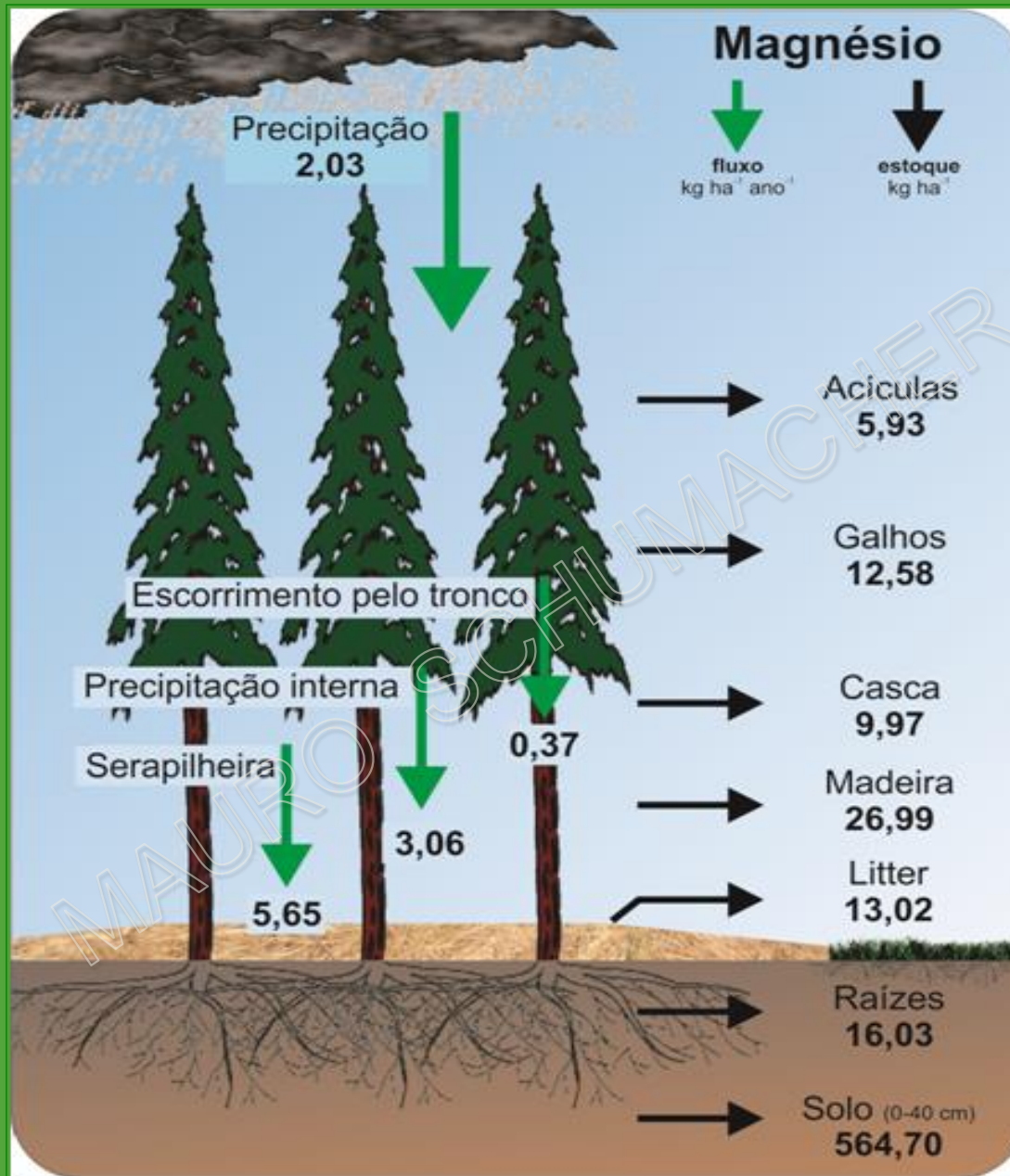






Source: Schumacher et al. (2009)





Source: Schumacher et al. (2009)

## *Harvesting of trees*



*Source: © Schumacher (2008)*



*Removal of nutrients through the harvest  
of a 27 year-old Pinus taeda stand*

| <i>Intensity of<br/>harvest</i> | <i>Total Removal<br/>(kg ha<sup>-1</sup>)</i> |          |          | <i>Average annual<br/>removal (kg ha<sup>-1</sup>)</i> |          |          |
|---------------------------------|-----------------------------------------------|----------|----------|--------------------------------------------------------|----------|----------|
|                                 | <i>N</i>                                      | <i>P</i> | <i>K</i> | <i>N</i>                                               | <i>P</i> | <i>K</i> |
| <i>Total biomass</i>            | 527,2                                         | 46,6     | 186,8    | 19,5                                                   | 1,72     | 6,29     |
| <i>wood + bark</i>              | 269,0                                         | 23,3     | 98,2     | 9,96                                                   | 0,86     | 3,63     |
| <i>Stemwood</i>                 | 210,8                                         | 18,8     | 79,5     | 7,8                                                    | 0,69     | 2,94     |

Source: Schumacher et al. (2007)

## *Removal of harvest residues.*



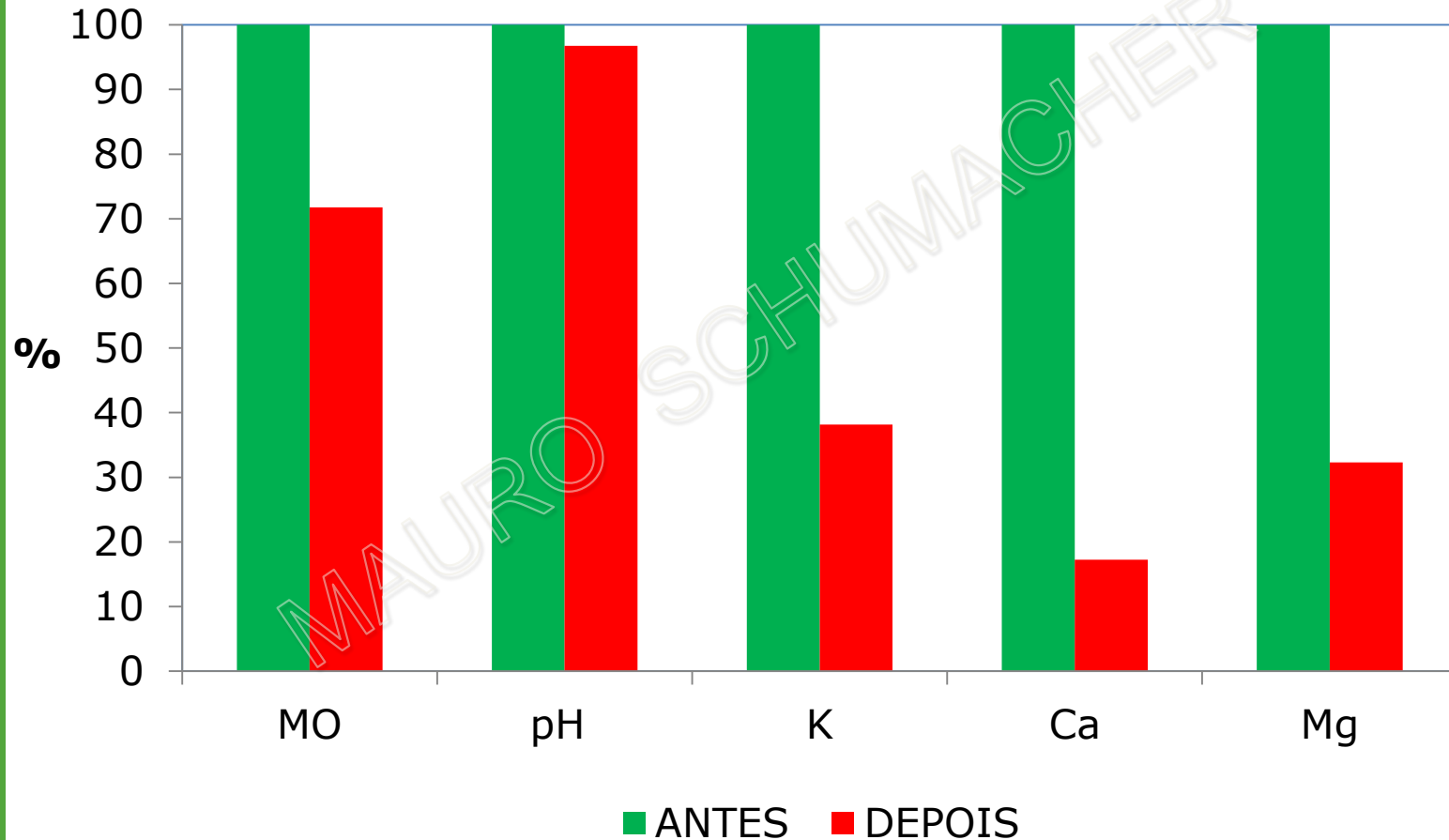
Source: © Falkenberg (2008)



## Soil Characteristics in Area of *Pinus taeda* and Campo.

| Area               | Depth (cm) | O.M (%) | pH (H <sub>2</sub> O) | K mg dm <sup>-3</sup> | Ca                                 | Mg   |
|--------------------|------------|---------|-----------------------|-----------------------|------------------------------------|------|
|                    |            |         |                       |                       | cmol <sub>c</sub> dm <sup>-3</sup> |      |
| <i>Pinus taeda</i> | 0 – 10     | 4,8     | 4,5                   | 44,3                  | 0,14                               | 0,19 |
|                    | 10 – 20    | 5,1     | 4,5                   | 27,0                  | 0,06                               | 0,13 |
|                    | 20 – 30    | 5,1     | 4,6                   | 22,6                  | 0,04                               | 0,11 |
|                    | 30 – 40    | 3,2     | 4,6                   | 13,3                  | 0,05                               | 0,08 |
| Campo              | 0 – 10     | 7,7     | 4,6                   | 122,7                 | 0,83                               | 0,73 |
|                    | 10 – 20    | 6,1     | 4,7                   | 64,3                  | 0,33                               | 0,26 |
|                    | 20 – 30    | 4,5     | 4,8                   | 33,3                  | 0,20                               | 0,15 |
|                    | 30 – 40    | 3,2     | 4,8                   | 18,0                  | 0,18                               | 0,14 |

*Alteration of soil characteristics by cultivation of Pinus taeda after 15 years.*



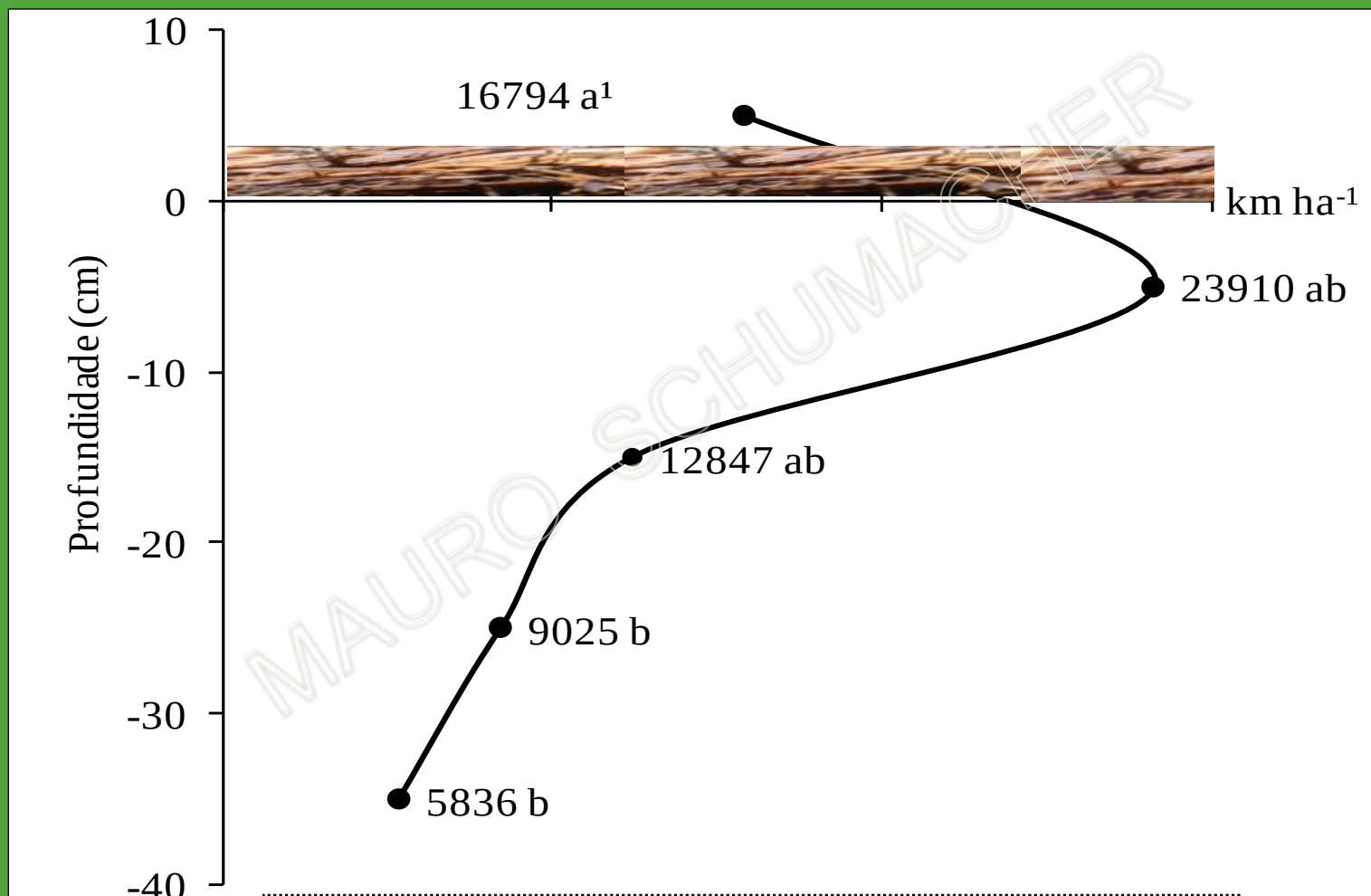


*Litter of Pinus taeda*



Source: © Schumacher (2008)

## Length of fine roots ( $\text{km ha}^{-1}$ )



Source: Lopes (2009)



## *Residues management of the forest harvest*



Source: © Schumacher (2005)

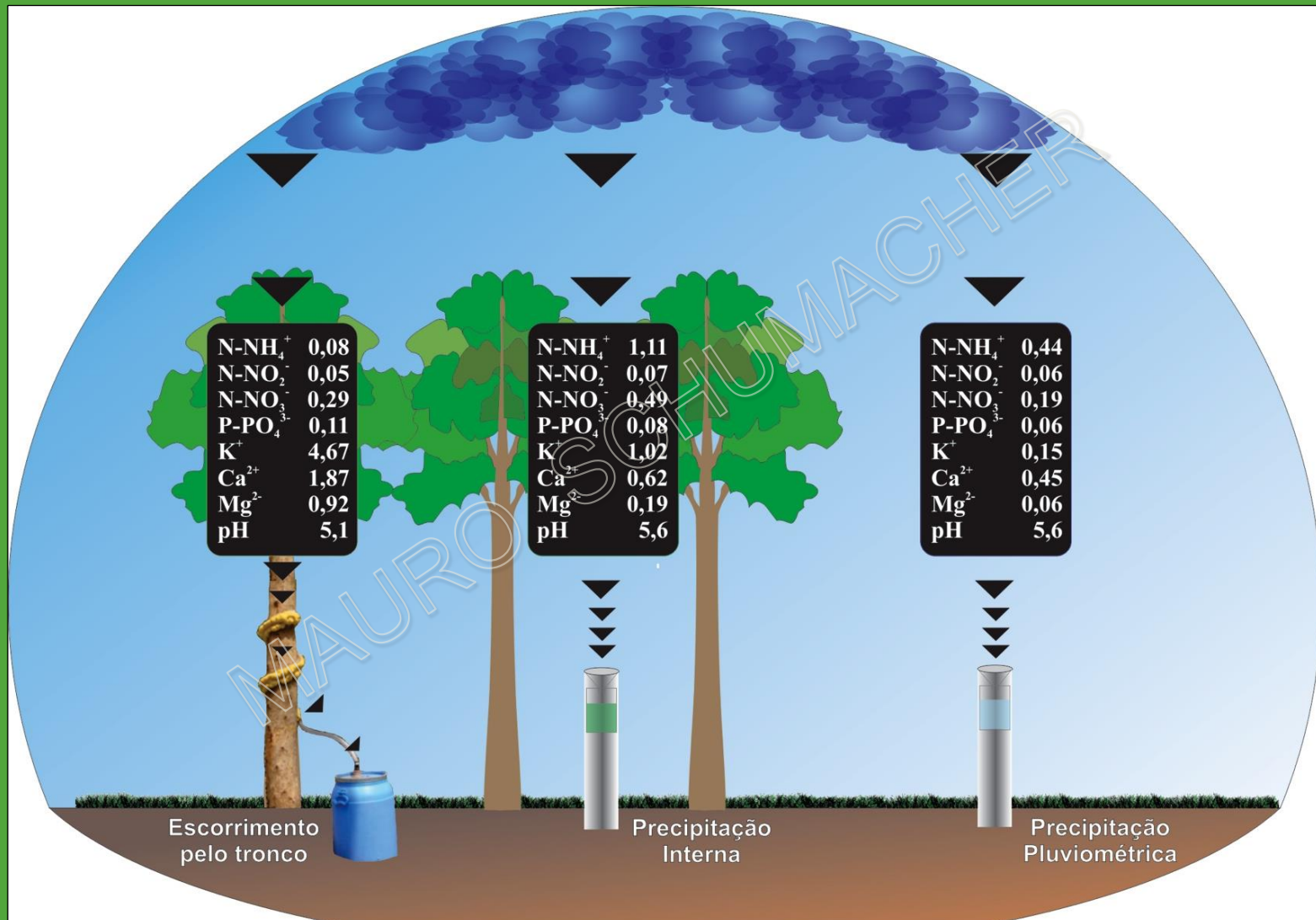


## *Eucalyptus stands*



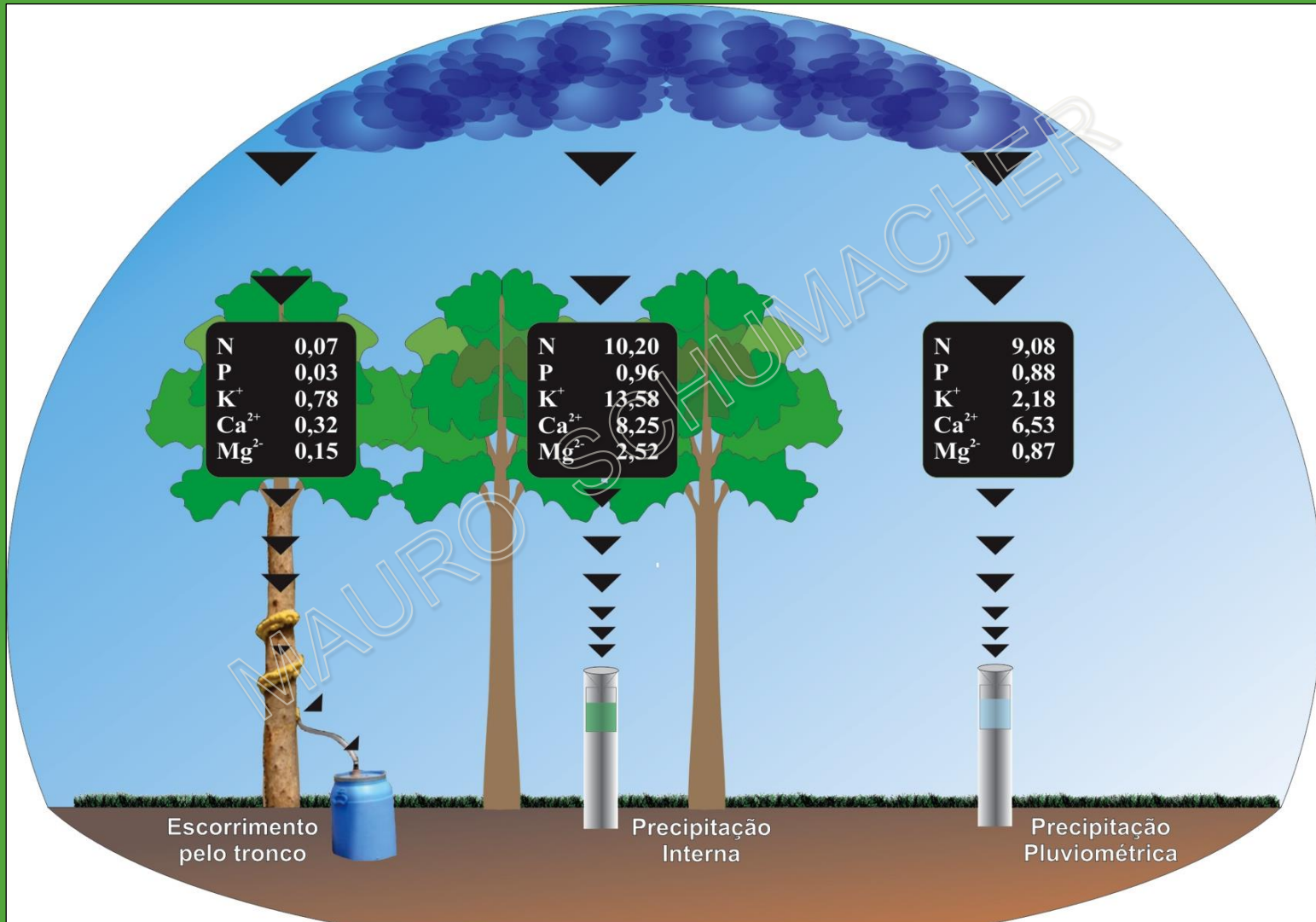


# Ions ( $\text{mg L}^{-1}$ ) in the water of P, Pi and Et in a 5 years-old *E. dunnii* stand



Source: Schumacher et al. (2012)

# Inputs ( $\text{kg ha}^{-1} \text{ year}^{-1}$ ) of nutrients in *E. dunnii* through $P$ , $P_i$ and $E_t$ .



Source: Schumacher et al. (2012)



*Biomasse in Eucalyptus saligna mit verschiedenen Altersstufen, in Guaíba, RS, Brasilien*

| Alter<br>(Jahre) | Blätter                | Äste | Rinde | Holz  | Wurzeln | Gesamt |
|------------------|------------------------|------|-------|-------|---------|--------|
|                  | (Mg ha <sup>-1</sup> ) |      |       |       |         |        |
| 2                | 6,4                    | 6,4  | 3,4   | 21,6  | 12,9    | 50,8   |
| 3                | 7,1                    | 8,8  | 6,2   | 55,3  | 21,4    | 98,8   |
| 4                | 6,8                    | 11,2 | 8,9   | 88,2  | 28,9    | 144,1  |
| 5                | 5,7                    | 8,4  | 10,3  | 115,3 | 40,4    | 180,2  |
| 6                | 4,8                    | 7,6  | 13,2  | 153,9 | 43,1    | 222,6  |
| 7                | 4,6                    | 8,9  | 15,2  | 178,7 | 32,5    | 240,0  |
| 8                | 4,1                    | 9,6  | 17,3  | 200,4 | 45,6    | 277,1  |

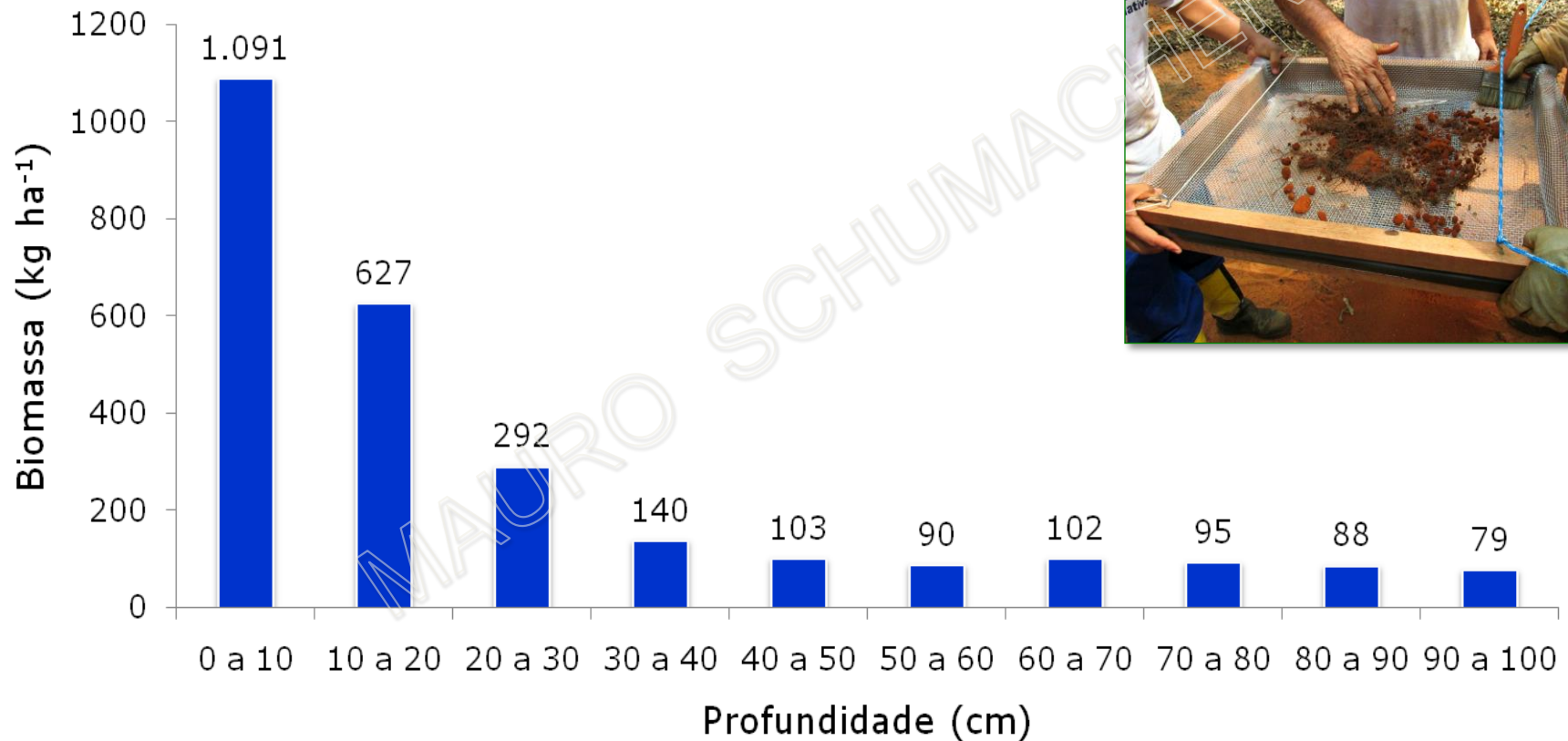
*Biomasse von Eucalyptus saligna-Schlagabraumes,  
in Guaíba, RS, Brasilien*

| Alter<br>(Jahre) | Blätter                | Äste       | Rinde       | Gesamt |
|------------------|------------------------|------------|-------------|--------|
|                  | (Mg ha <sup>-1</sup> ) |            |             |        |
| 5                | 5,7 (23,3)             | 8,4 (34,4) | 10,3 (42,3) | 24,4   |
| 6                | 4,8 (18,7)             | 7,6 (29,6) | 13,2 (51,5) | 25,6   |
| 7                | 4,6 (16,0)             | 8,9 (31,0) | 15,2 (52,9) | 28,7   |
| 8                | 4,1 (13,2)             | 9,6 (30,9) | 17,3 (55,8) | 31,0   |

Quelle: Witschoreck (2014)

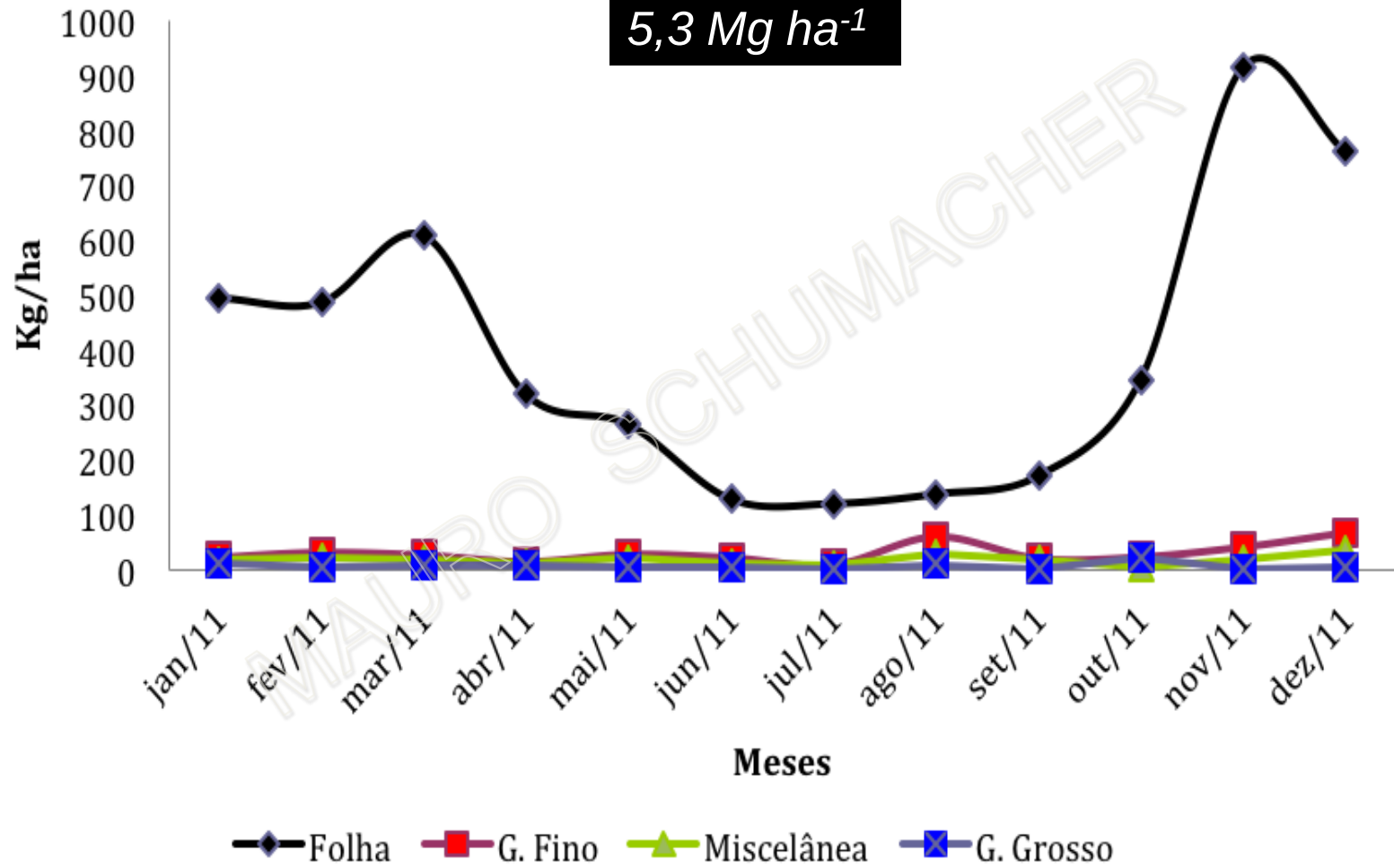


## Feinwurzelbiomasse ( $< 2,0$ mm) in *E. urograndis*



Quelle: Frantz et al. (2015)

## Streufall in ein 5-Jährige *E. dunnii* bestand



Quelle: Schumacher et al. (2012)

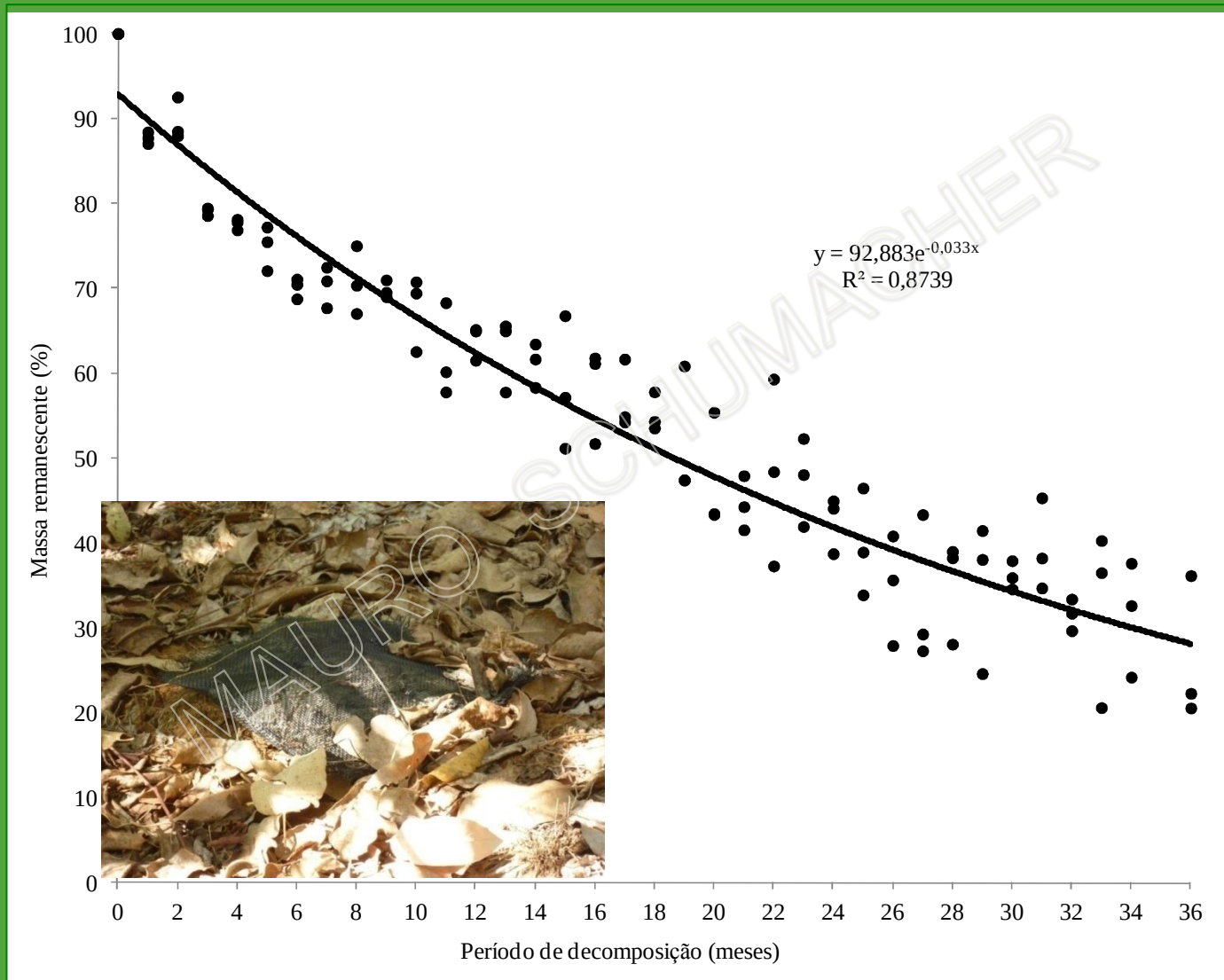


## *Residue of eucalyptus harvest*



Source: © Schumacher (2018)

# Mass remaining in litterbags in *E. urophylla* x *E. globulus*.





***Save the planet's biodiversity***

