Stocks and dynamics of Coarse Woody Debris (CWD) in a lowland rainforest, Nanjenshan, southern Taiwan

Chia-Wen Chen, Chang-Fu Hsieh, Kuo-Jung Chao

2009.11.19.

Definition of Coarse woody debris (CWD)

- Types
  - Standing dead trees (Snags)
  - Downed boles (Logs)
  - Large branches
  - Coarse dead roots
- Sizes (Typical minimum diameters)
  - Above 2 cm
  - Above 10 cm in some tropical forests
  - 7.5-15 cm in western North American
  - 2.5-7.5 cm elsewhere

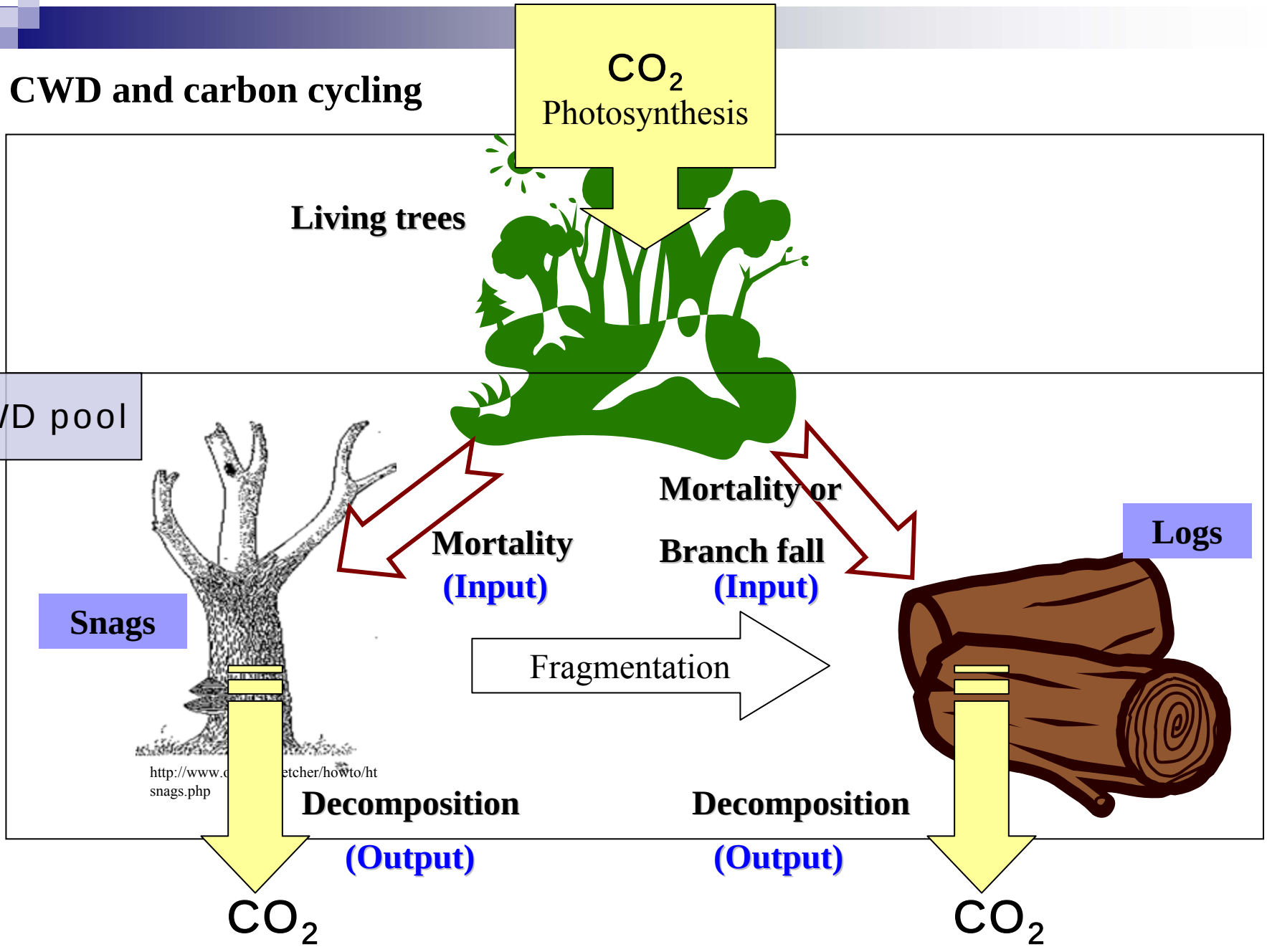
(Harmon et al., 1986)

Roles of CWD in forest ecosystem

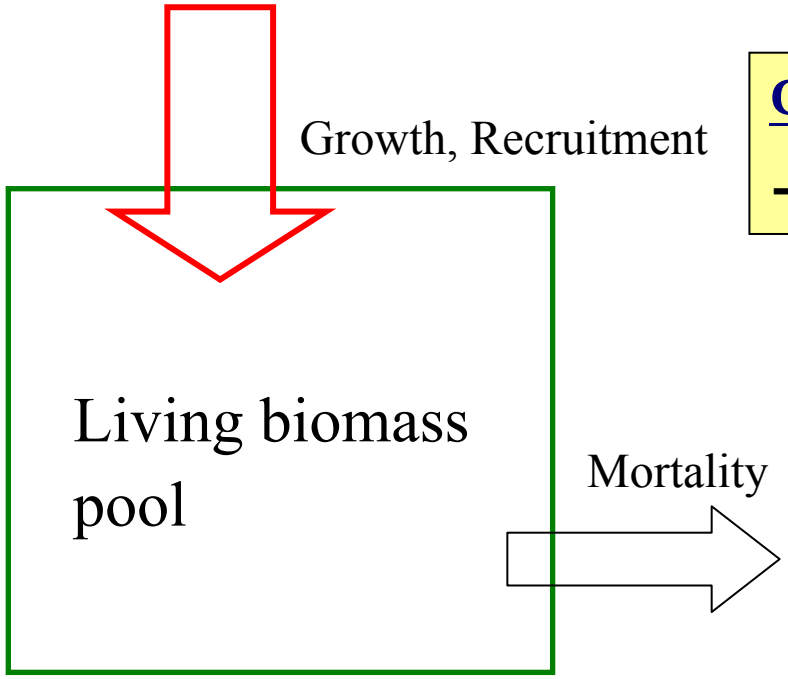
- Offering habitats for plants and animals
- Sources of nutrient cycle in forest
- **Carbon budget**

(Harmon et al., 1986)

CWD and carbon cycling



The importance of CWD in tropical forest carbon balance

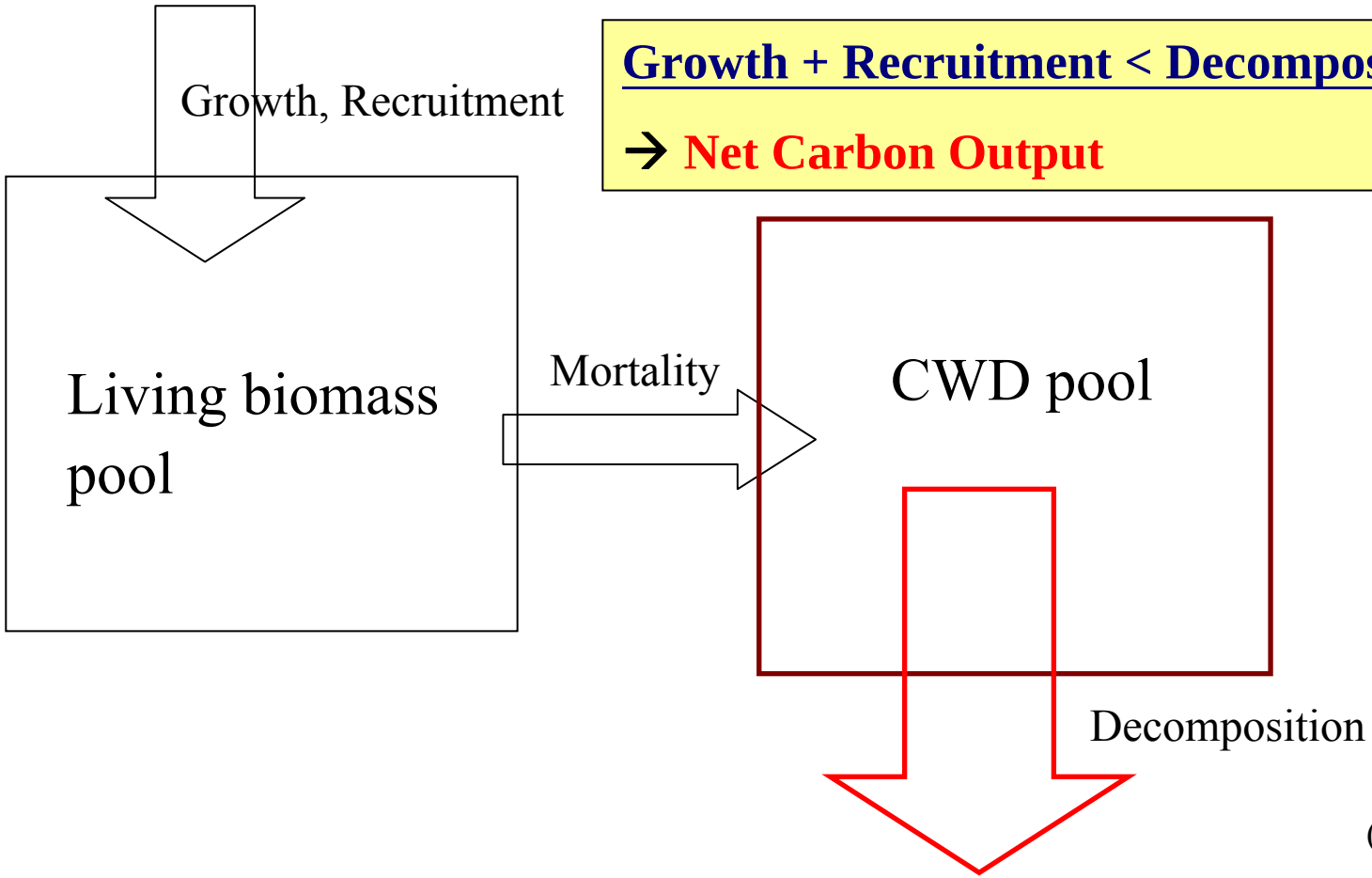


Growth + Recruitment > Mortality

→ **Net Carbon Uptake**

(Pyle, 2008)

The importance of CWD in tropical forest carbon balance



(Pyle, 2008)

Disturbances and CWD

- El Nino Southern Oscillation
  - Tropical forests in Amazon
  - CWD pool increase
  - Net carbon release

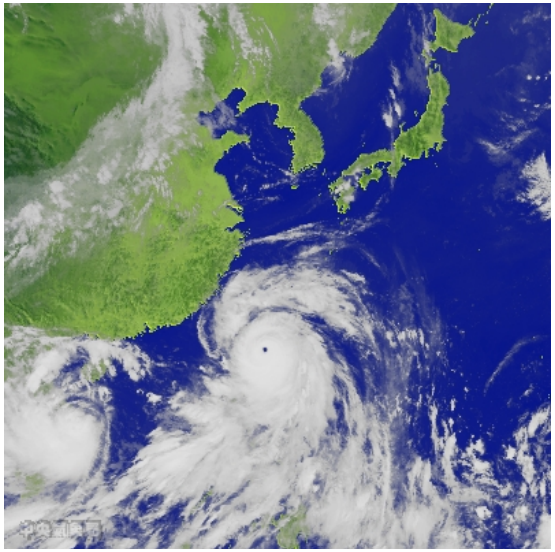
(Rice et al., 2004)

- Hurricanes
  - Mangrove forest in south Florida
  - Maximum CWD volume with the greatest wind speed

(Krauss et al., 2005)

Disturbances in Taiwan

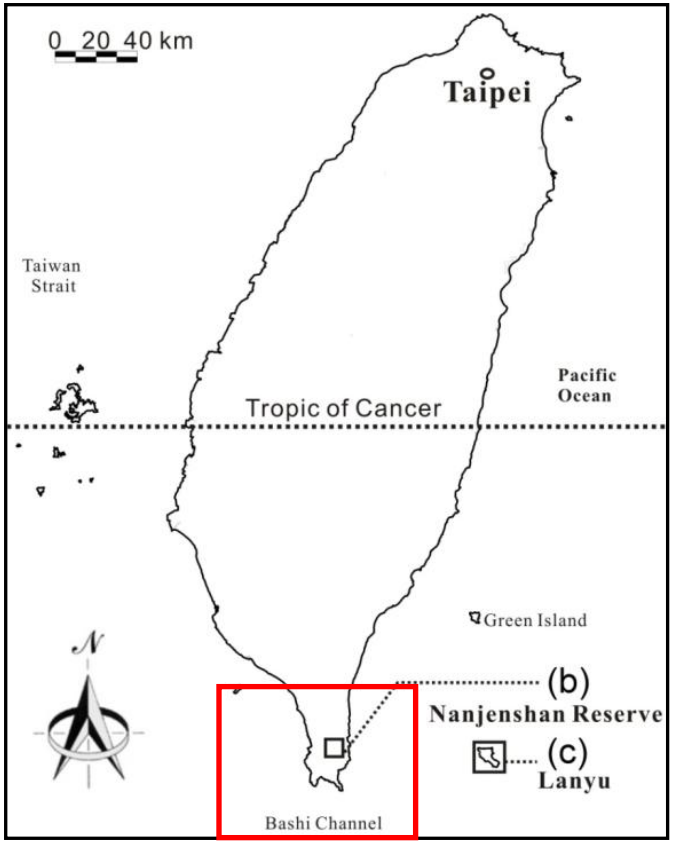
- Average 3.5 typhoons per year
- Influences of typhoon in forests
  - Litter fall increase
  - Crown damage



(莊, 2005)

Characteristics of Nanjenshan

- Lowland tropical forests
- Major disturbance
  - *Summer*: **typhoon**
- Temperature: 22.7 ˚C
- Precipitation: 3251.96 mm
- Area: 140 m × 150 m, 2.1 ha
- Latitude: 225-275 m



Objectives

- What are the stocks of CWD in Nanjenshan lowland forest?
  - What is the status of carbon balance in Nanjenshan by comparing the flux of CWD and living biomass?
- What is the seasonal input pattern of CWD?

Part1: *Stocks of CWD*

What are the stocks of CWD in Nanjenshan lowland forest?

Definition of CWD

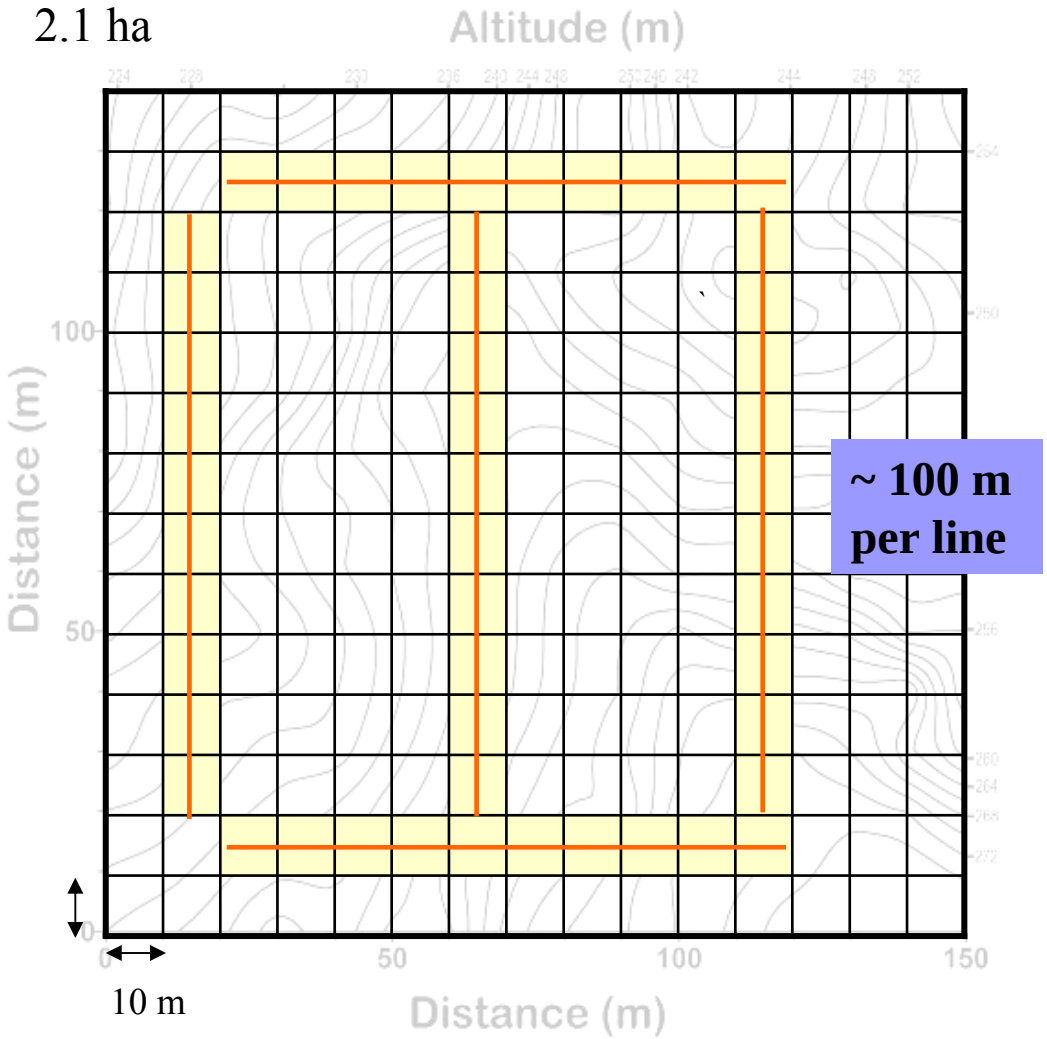
- Diameter
  - More than 1 cm
- Types of CWD
  - Fallen dead wood
  - Standing dead wood
  - Branches

Sampling for volume

- Types of CWD
  - Fallen dead wood & branches → ***Line intersect***
  - Standing dead wood → ***Strip plot sampling***

- ***Sampling methods***

Position of five transects



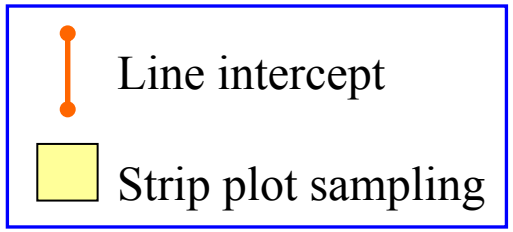
- Two directions
- Total about 500m
- Line transect
  - Fallen dead wood
- Strip plot sampling
  - Standing dead wood
- First surveying in January

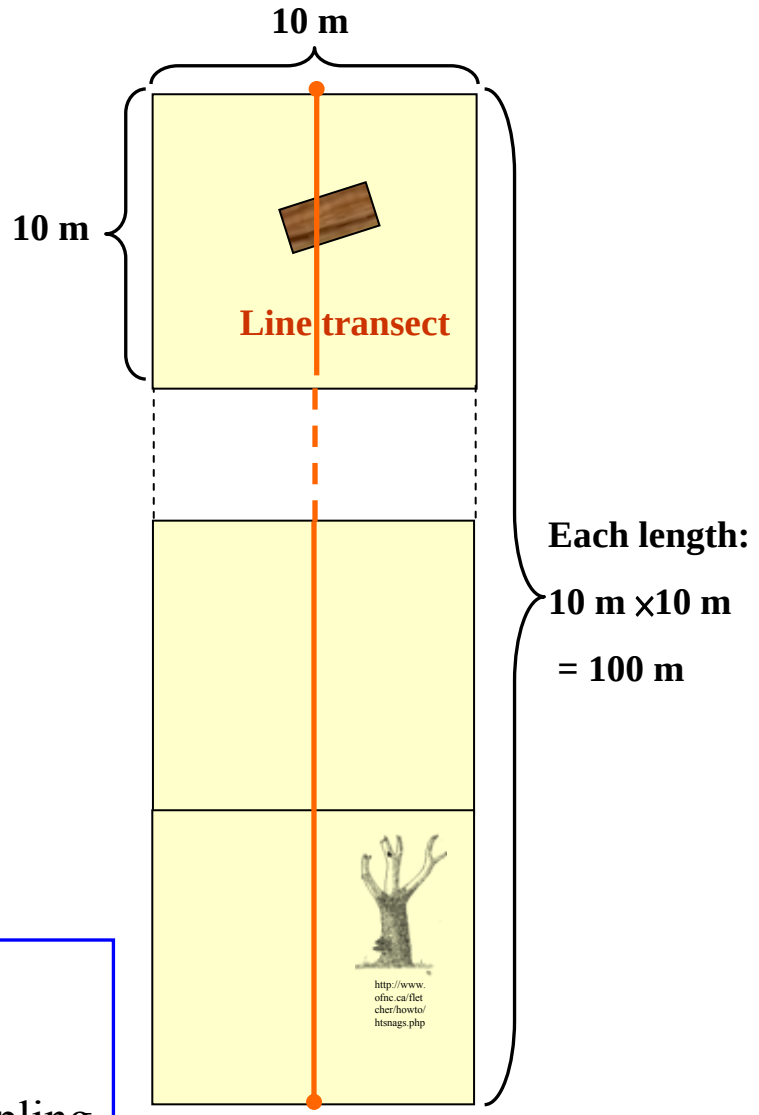
(van Wagner, 1968)

Sampling of CWD

- **Line transect**
  - Fallen dead wood
  - Recording diameters

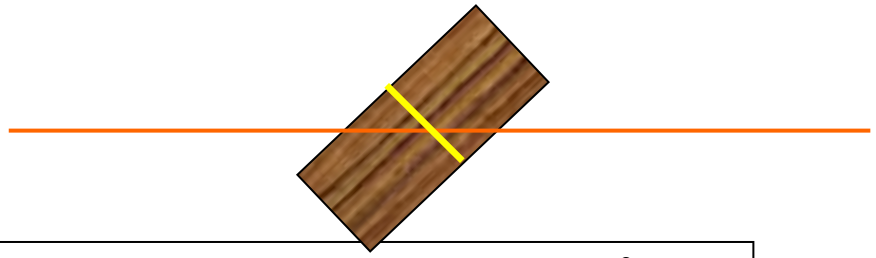
- **Strip plot sampling**
  - Standing dead wood (snag)
  - Width:10 m
  - Recording diameters and length of trunk and branch





Analysis of Volume

- **Fallen wood**
  - Recording diameter
  - Formula



$$V = \frac{\pi^2 \sum (d_i)^2}{(8 \times L)}$$

V: volume of wood per unit area (m^3/ha)
d_i : piece diameter (cm)
L: length of sample line (m)

(van Wagner, 1968)

- **Standing dead wood (snag)**
  - Diameter and length of trunk and branch
  - Formula

http://www.ofnc.ca/fletcher/howto/htsnags.php

$$V = L\left[\frac{\pi(D_1/2)^2 + \pi(D_2/2)^2}{2}\right]$$

L : the length of snag (m)
D : diameter, at either end (m)

Wood density

- **Decay level**

Level	Hardness	Feature
1	Hard, solid	Fresh, small branches attached
2	Hard, solid	Slightly decayed, some branches attached
3	Non-solid	Obviously decayed, bark not intake
4	Soft, loose	At least ½ biomass remaining
5	Soft, rotten	Easily collapsed

Wood density

- Wood samples collected near the plot margins
  - Classified by five decay levels
  - Classified by three diameter sizes
    - Small: 1-2 cm
    - Median: 2-10 cm
    - Large: ≧10 cm
- Bulk density
  - Measuring volume
  - Dried necromass

Necromass

- **Necromass**

$M\ (\text{Mg ha}^{-1}) =$ **Volume × wood density** ρ

V (m^3): external CWD volume

- The sampling standard error (E_N) of CWD by the line-intercept

$$E_N = E_\rho V_d + \rho_d E_v$$

ρ_d**:** density of each decay class
V_d: volume of each decay class
E_N: sampling standard error
E_ρ: standard errors in density
E_V: standard errors in volume

Wood density

- Wood densities (mean ± 1 SE, g · cm^{-3}) of coarse woody debris in Nanjenshan

Decay Level	Wood density	Sample size
1	0.40 (± 0.11)	32
2	0.35 (± 0.05)	52
3	0.27 (± 0.07)	89
4	0.19 (± 0.04)	55
5	0.15 (± 0.07)	11

Necromass in Nanjenshan

Fallen dead wood

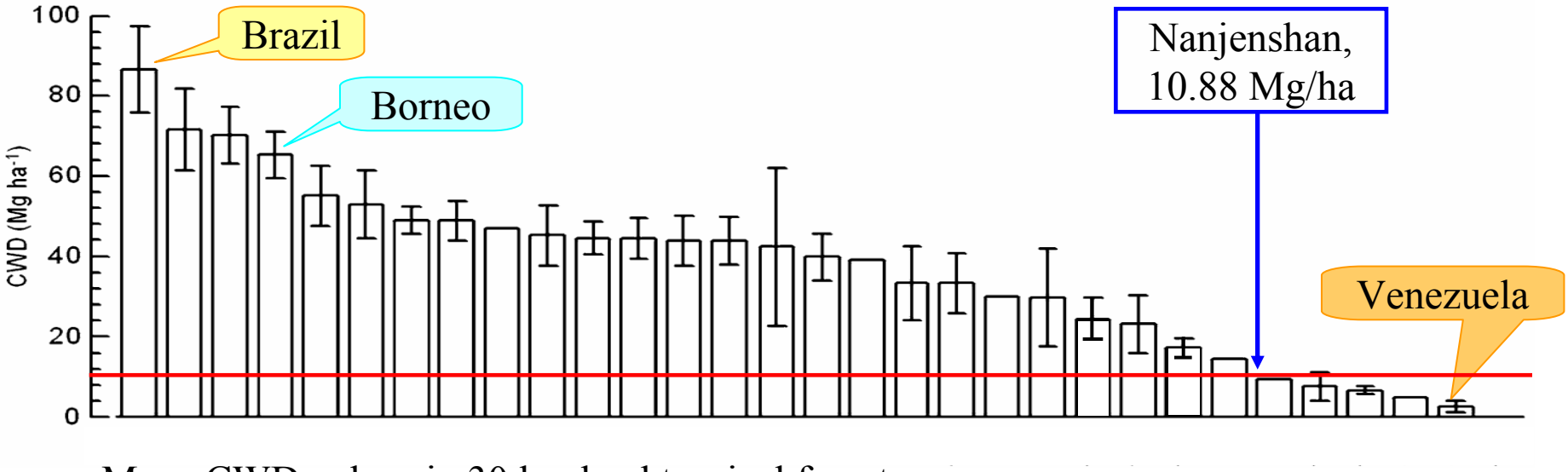
Decay level	Necromass ($Mg \cdot ha^{-1}$)
1	1.13 (± 0.35)
2	3.15 (± 0.52)
3	2.26 (± 0.64)
4	3.67 (± 1.17)
5	0.20 (± 0.11)
Total	**10.41**

Standing dead wood

Decay level	Necromass ($Mg \cdot ha^{-1}$)
1	0.15 (± 0.04)
2	0.15 (± 0.04)
3	0.13 (± 0.05)
4	0.03 (± 0.01)
5	0.01 (± 0.01)
Total	**0.47**

Comparing with other tropical forests

- Less than most of tropical forests



Mean CWD values in 30 lowland tropical forests

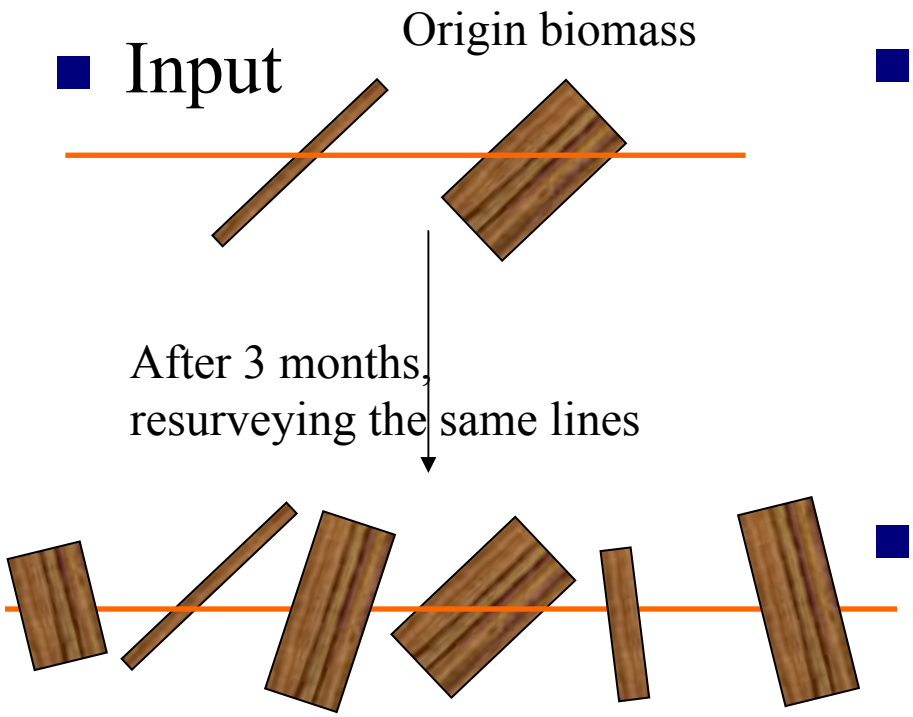
(Baker et al. 2007)

Part2: *Input pattern*

What is the seasonal input pattern of CWD?

Seasonal Input of CWD

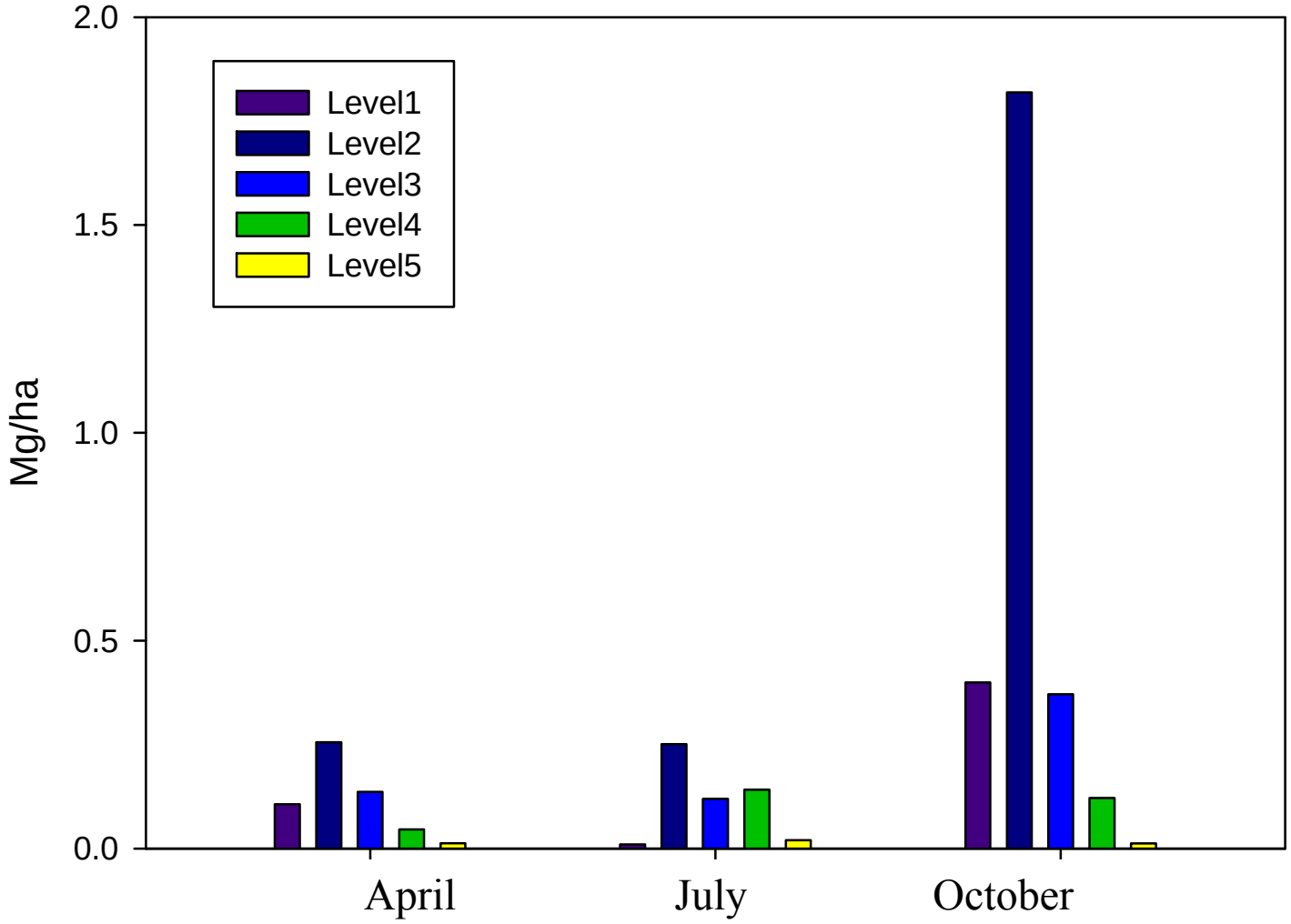
- Input



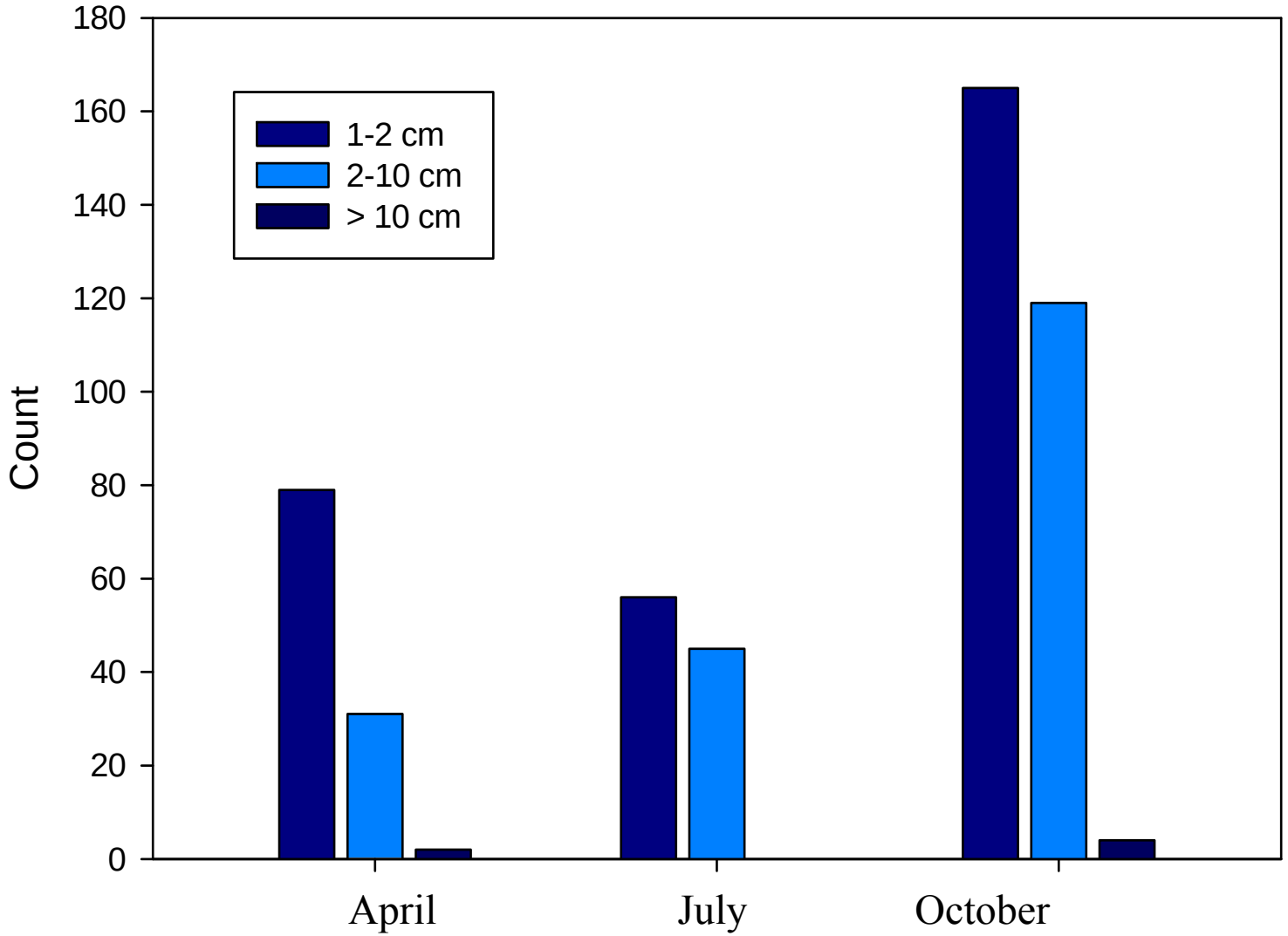
Recording the new wood input on the line

- Resurveying every 3 months
  - April
  - July
  - October
  - Next January
- Recording the new wood on the line

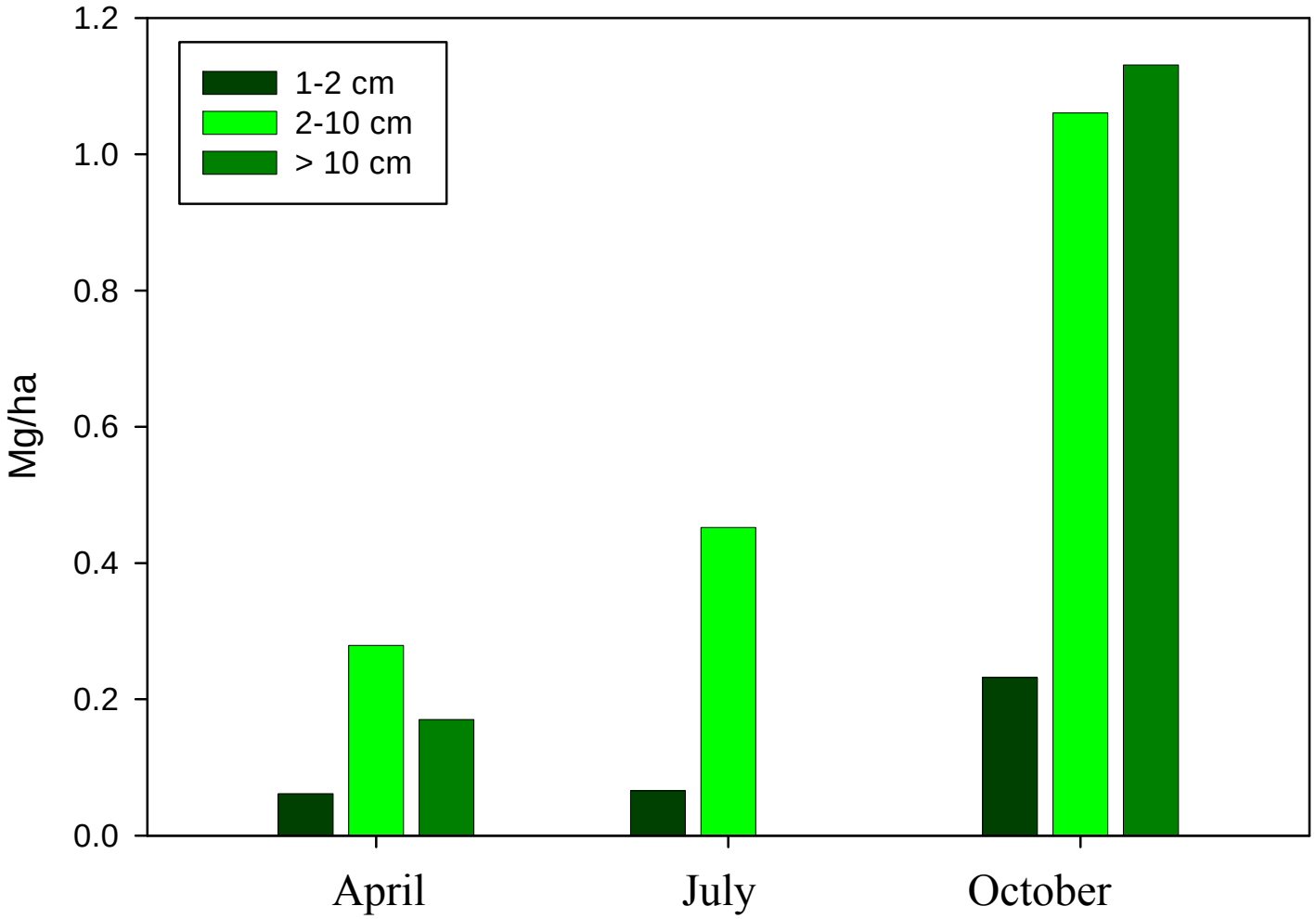
Decay Level vs. Input Necromass



Size Class vs. Numbers of CWD



Size Class vs. Seasonal Input Necromass



Discussion

- Two typhoons passed through Taiwan in summer.

Date	Typhoon	
2009.08.08.	莫拉克(MORAKOT)	中度
2009.10.05.	芭瑪(PARMA)	中度

- Does the northeast monsoon cause another peak necromass input in winter?

Conclusion

- Total necromass is 10.88Mg ha^{-1} in Nanjenshan, and less than other tropical forests.
  - And what is the status of carbon balance in Nanjenshan?
- Input necromass increased during July to October.

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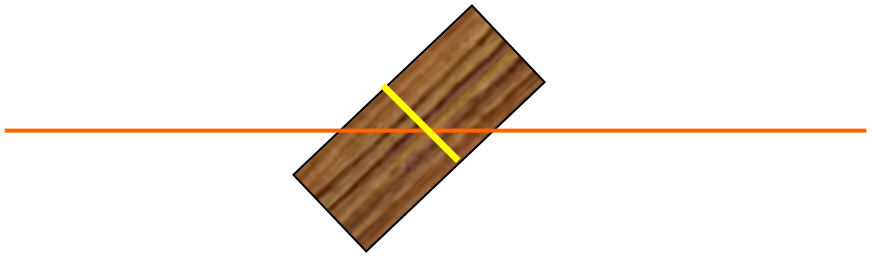
- 趙國容、趙偉村、陳凱眉，2008，台灣南仁山亞熱帶低地雨林森林動態與模式。行政院農業委員會林務局委託研究計畫 97-00-2-02。

Thanks for your listening.
敬請指教

Volume

- **Fallen wood**
  - Recording diameter
  - Formula



$$V = \frac{\pi^2 \sum (d_i)^2}{(8 \times L)}$$

V: volume of wood per unit area (m^3/ha)
d_i : piece diameter (cm)
L: length of sample line (m)

(Van Wagner,)

- **Standing dead wood (snag)**
  - Recording basal diameter、top diameter、length、the largest branch diameter and length
  - Formula

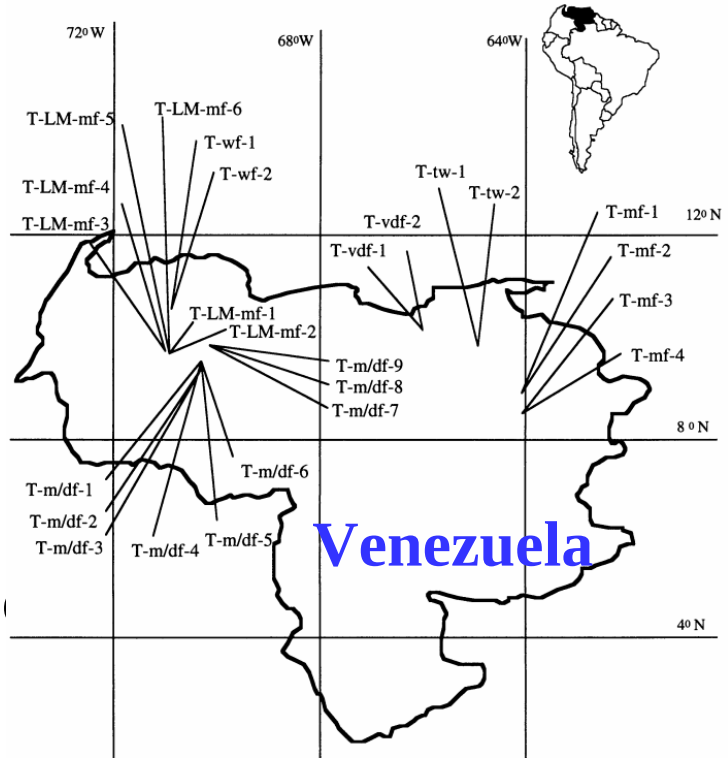
http://www.ofnc.ca/fletcher/howto/htsnags.php

$$V = L\left[\frac{\pi(D_1/2)^2 + \pi(D_2/2)^2}{2}\right]$$

L : the length of snag (m)
D : diameter, at either end (m)

The factors

- Environmental factors
  - Moisture (Delaney et al., 1998)
    - Moist forest – 42.33 Mg/ha
    - Dry-moist forest – 34.5 Mg/ha
    - Very dry forest – 2.43 Mg/ha
  - Topography and Soil nutri



The factors

- Forest dynamics (Chao et al., 2009)

West — East

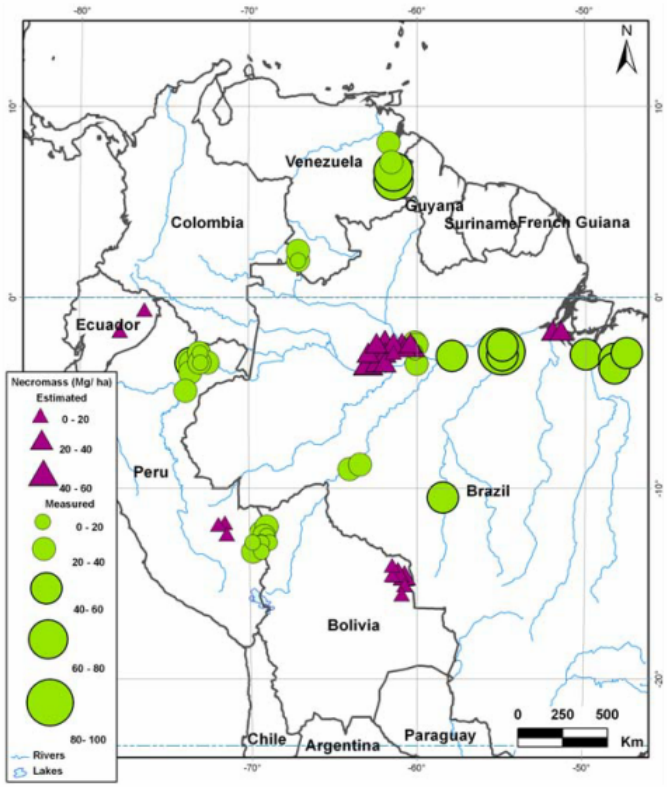
\- +

Mortality rate →

Biomass ←

Average wood density ←

Necromass →



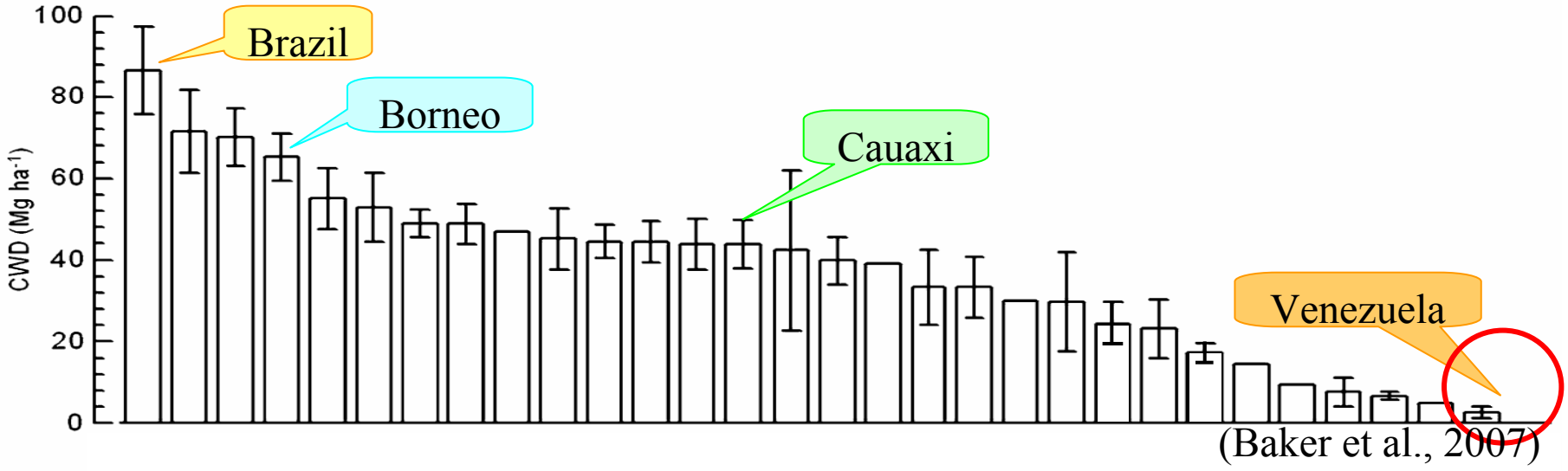
Necromass in *terra firma* Amazonian forests (Chao et al., 2009)

The factors

- Disturbance events
  - ENSO
  - Logging
  - Fire
  - Hurricane

Studies in Tropical Rainforests

- Variation
  - Mean stock from 0 Mg/ha to 80 Mg/ha
  - Range from 18% - 33% of aboveground live biomass (Palace et al., 2008)
  - Range from 2% - 40% of the aboveground carbon stock (Palace et al., 2008)



(Baker et al., 2007)

Peak branch fall in typhoon season

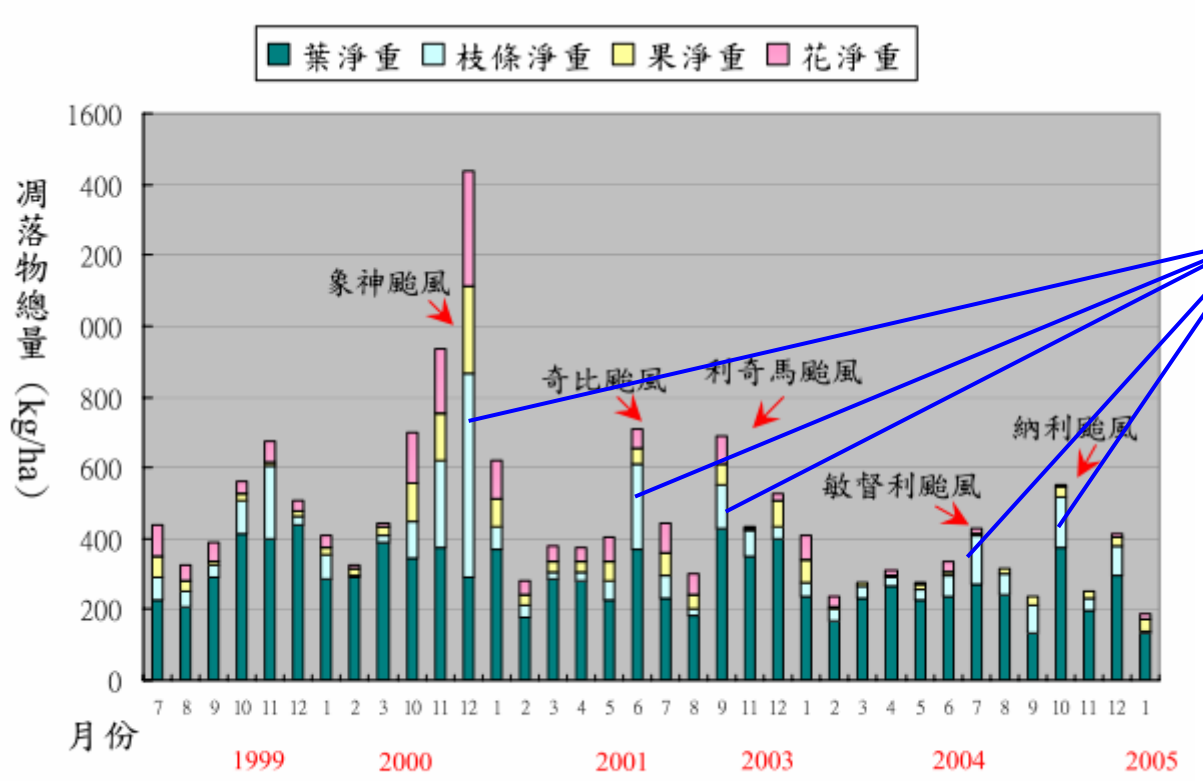


圖 26 南仁山森林生態系各月分凋落物組成長期變化圖

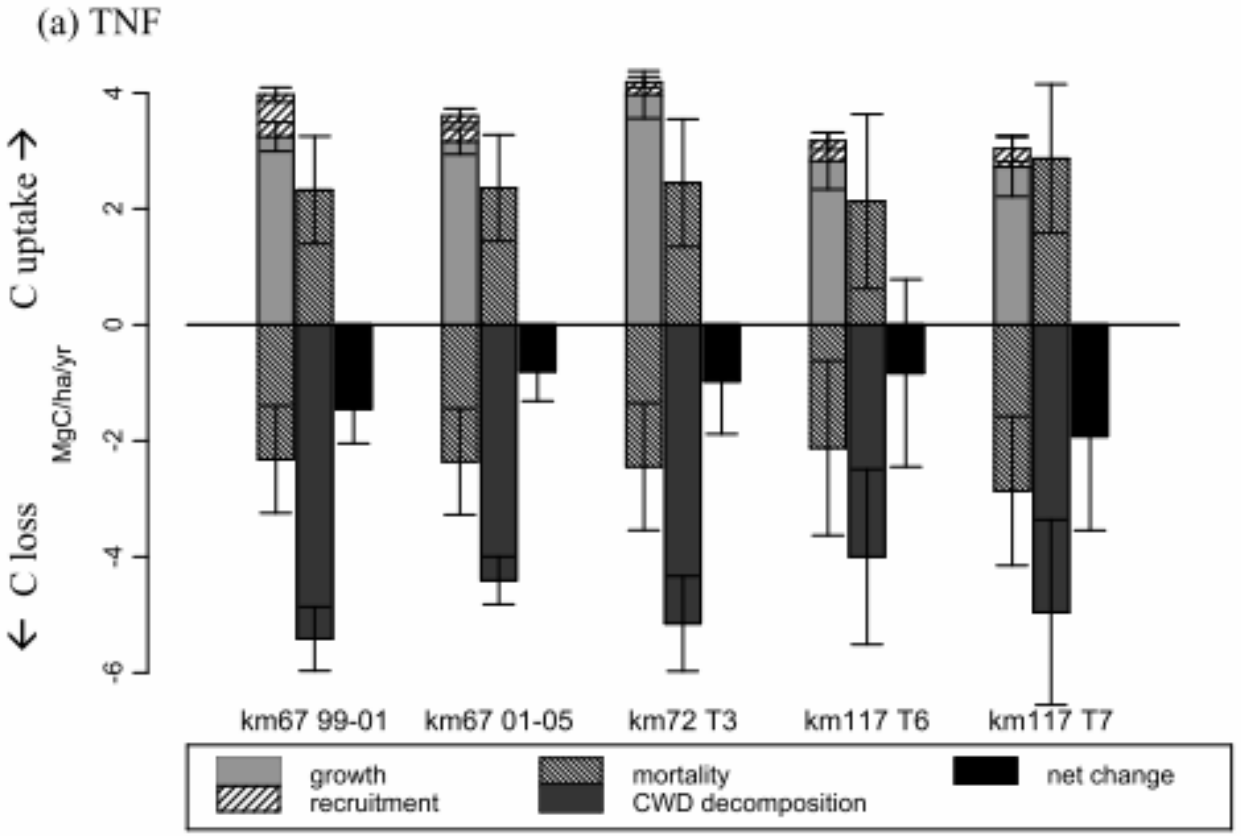
More branch fall

(莊, 2005)

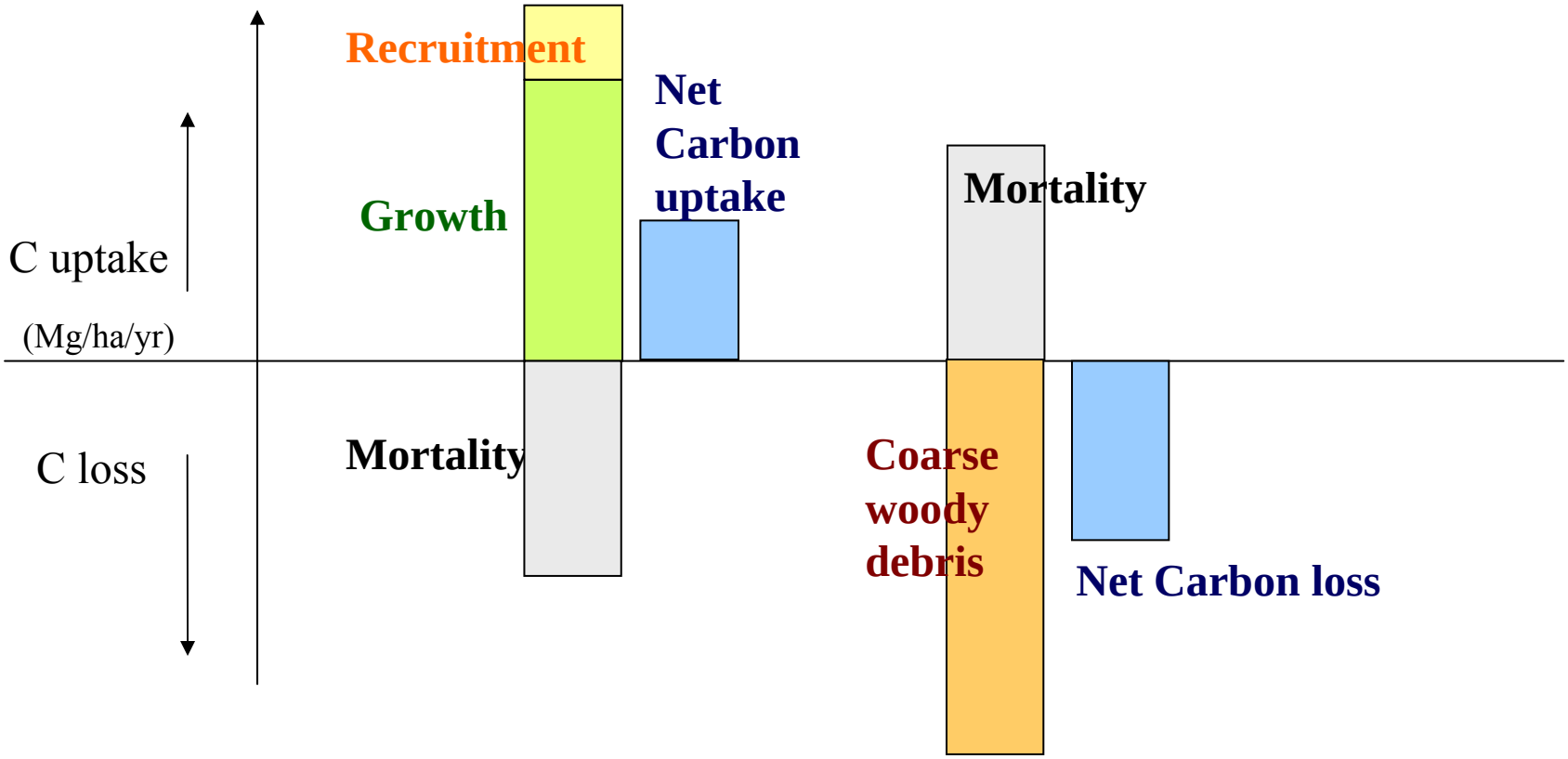
Temporal input patterns

- Long Term
  - Succession
- Annual

- Seasonal


(a) TNF
C uptake →
← C loss
MgC/ha/yr
4
2
0
-2
-4
-6
km67 99-01
km67 01-05
km72 T3
km117 T6
km117 T7
growth
recruitment
mortality
CWD decomposition
net change

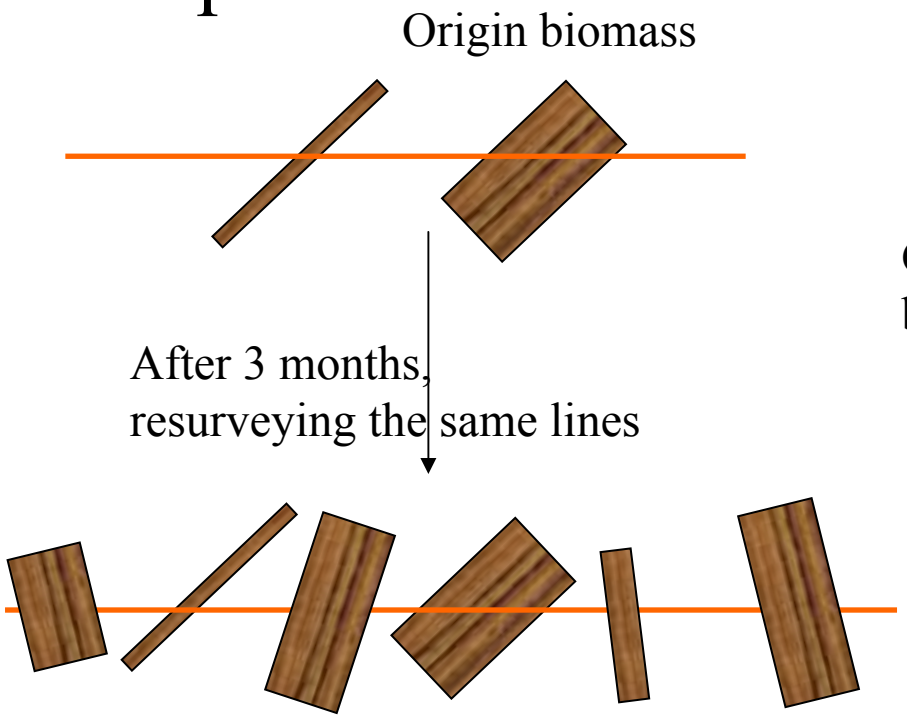
Importance for carbon balance



(Pyle, 2008)

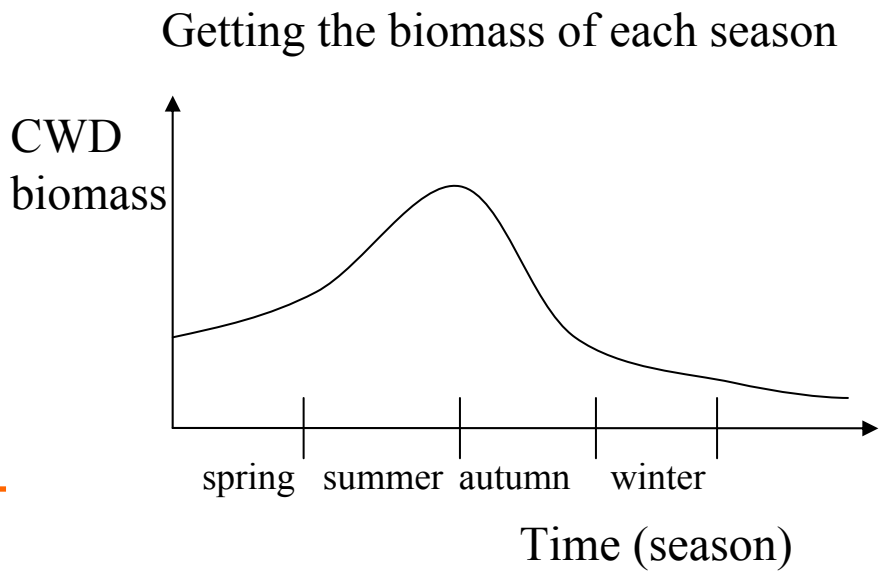
Seasonal Input of CWD

- Input



Recording the new wood input on the line

- Seasonal pattern



The Role of CWD in tropical rain forest carbon cycles

- Carbon stock

  Live tree biomass > **fallen CWD > standing CWD** > fine litter

- Annual inputs to forest floor

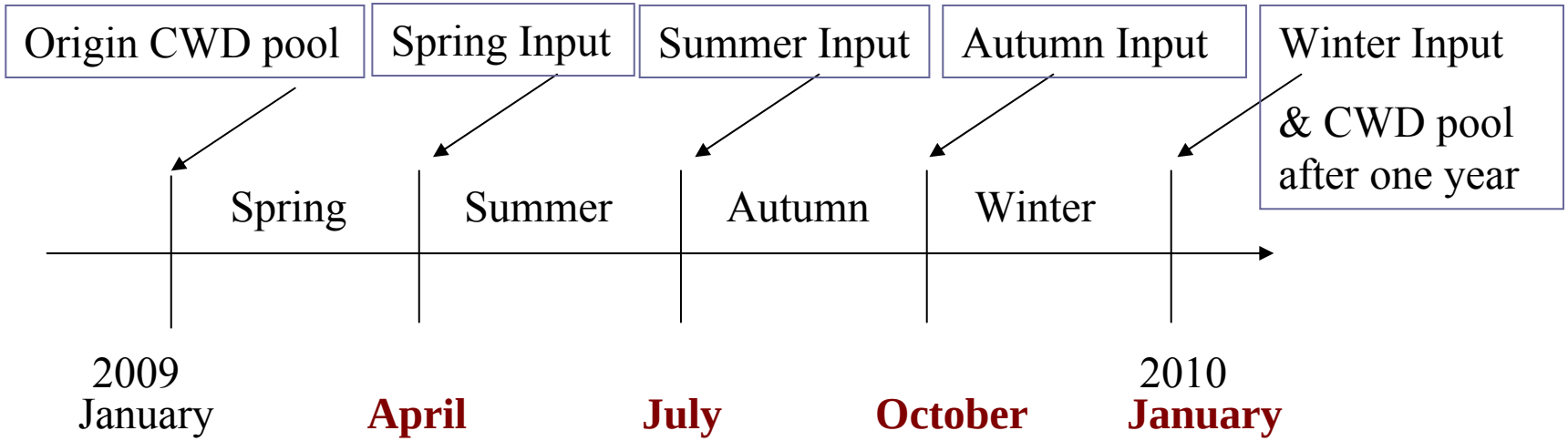
  Fine litter > **CWD**

- Turnover time

  Fine litter < **standing CWD** ≒ **fallen CWD** < live tree biomass

Seasonal Input of CWD

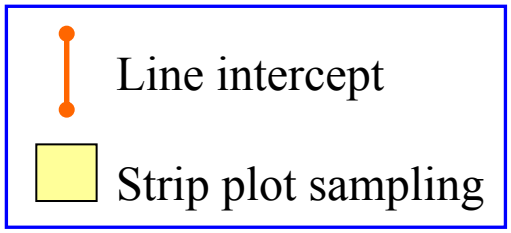
- Periods of surveying

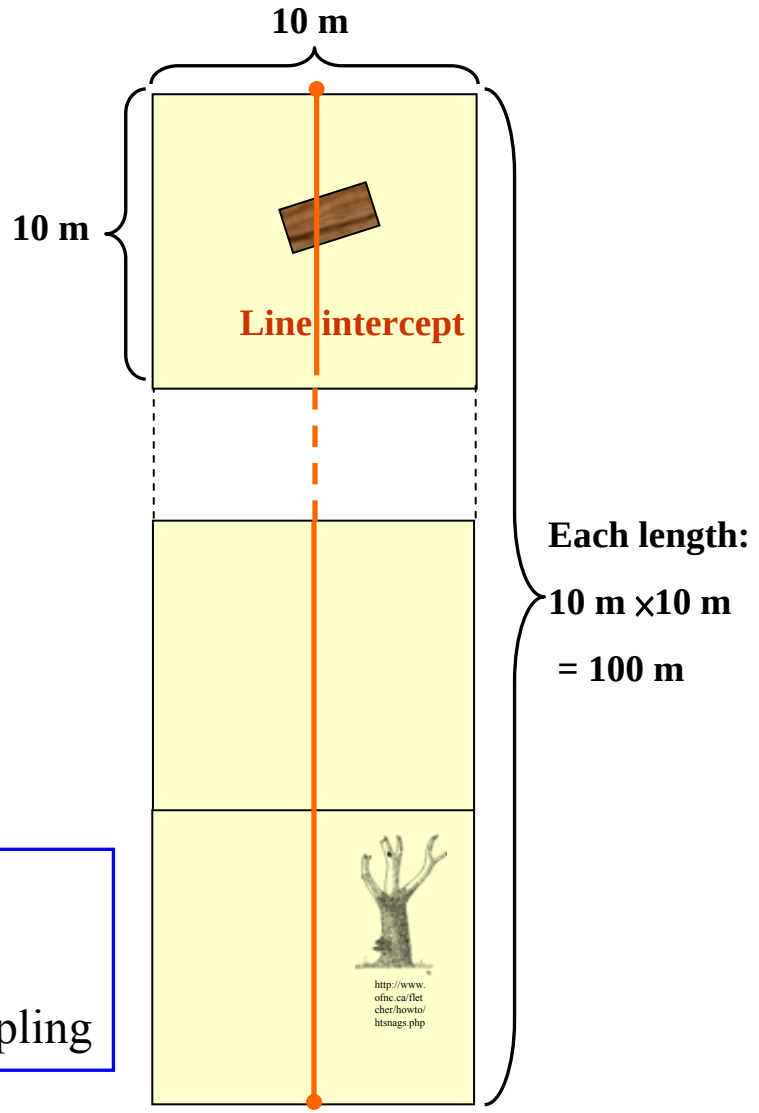


Volume

- **Fallen wood**

- **Strip plot sampling**
  - Standing dead wood (snag)
  - Width:10 m
  - Total length: 500 m
    (the same as Line intercept)





Volume

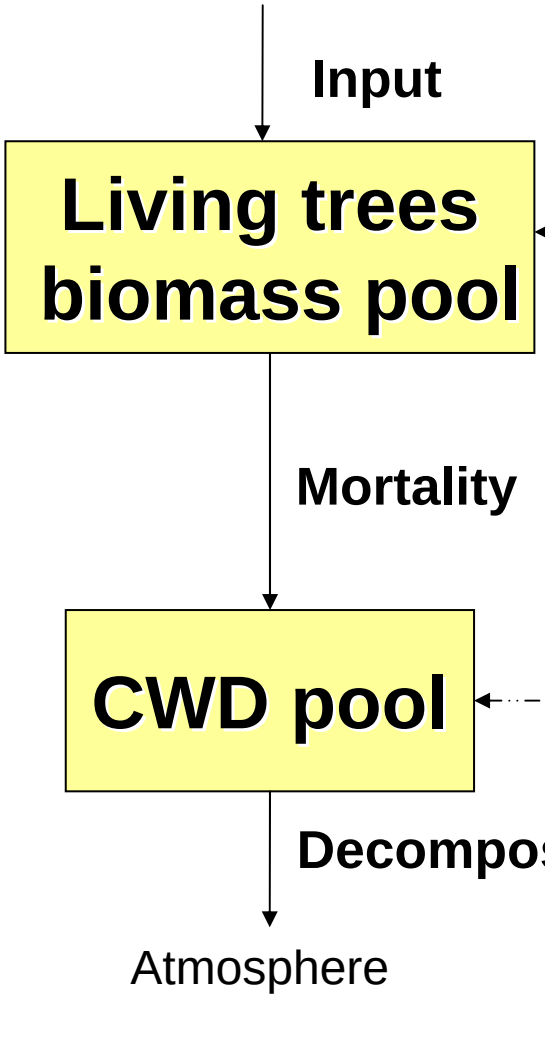
- **Standing dead wood (snag)**
  - Recording basal diameter、top diameter、length、the largest branch diameter and length
  - Formulae

$$V = L\left[\frac{\pi(D_1/2)^2 + \pi(D_2/2)^2}{2}\right]$$

L : the length of snag (m)
D : diameter, at either end (m)

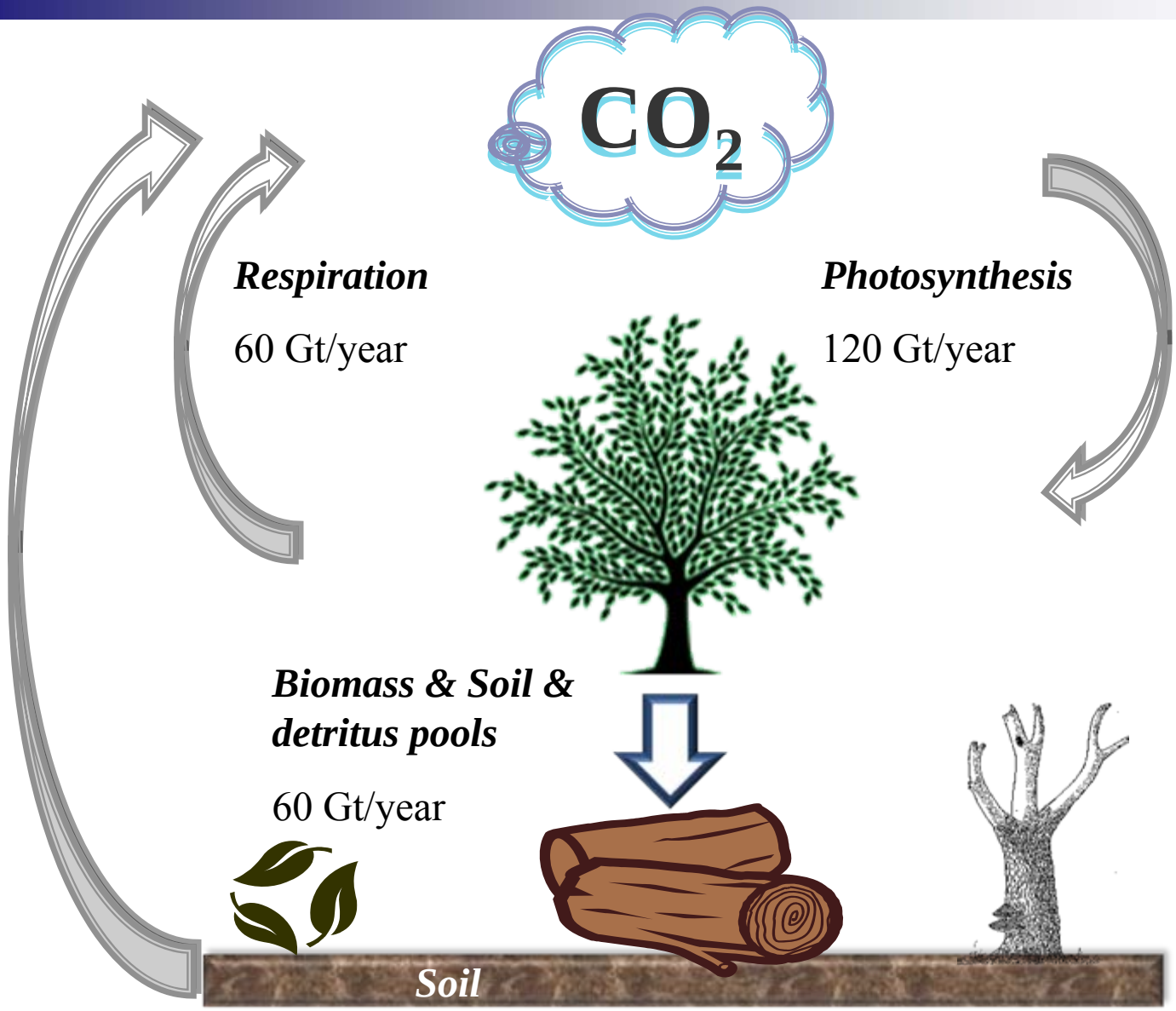
http://www.ofnc.ca/fletcher/howto/htsnags.php

Flow chart

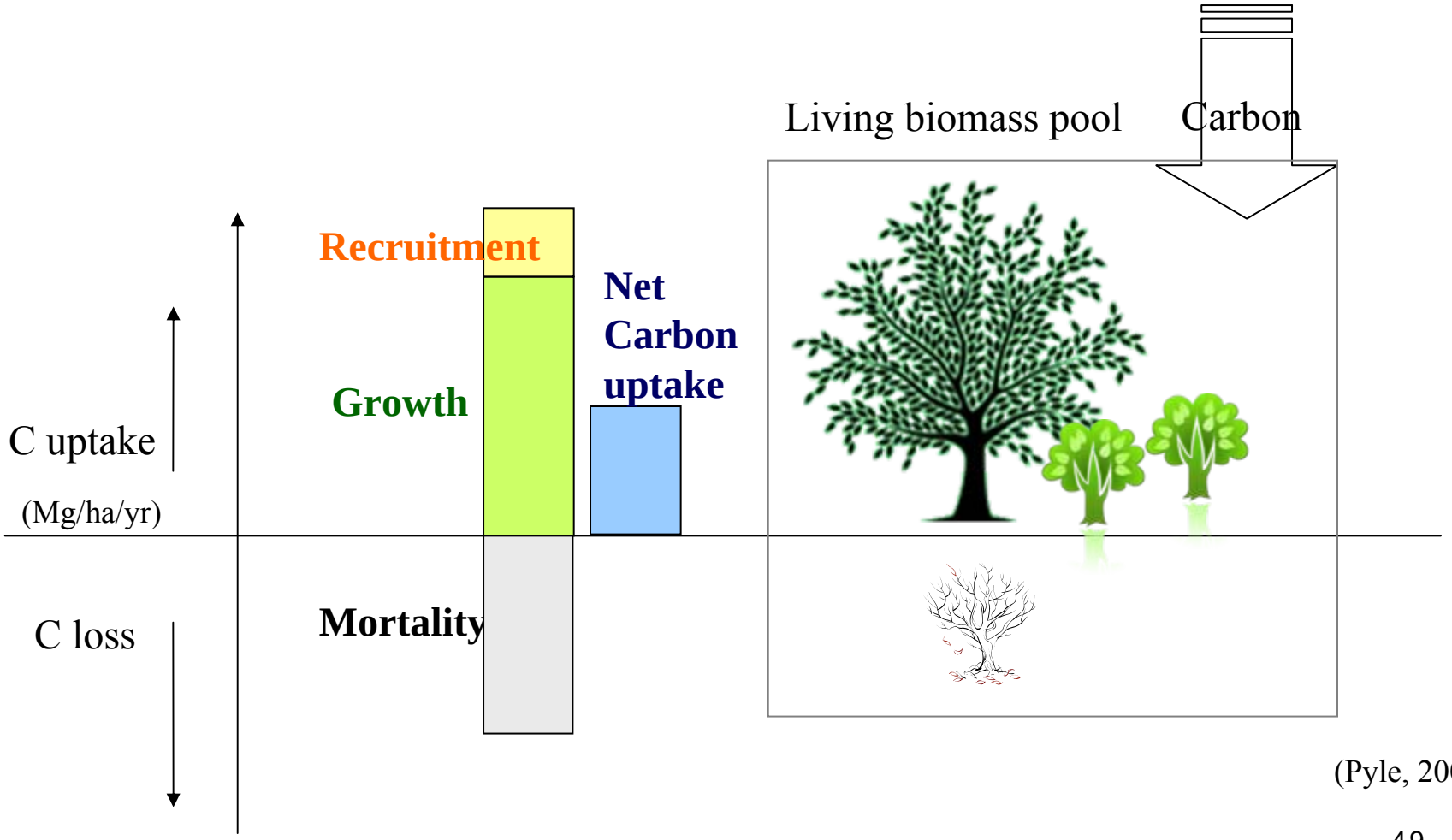


Method

1. Input rate from recensus data between 2000-2008
2. From 2008 living trees
3. Calculate the mortality rate from living trees biomass
4. Volume → Field measurement
5. Density → Literature survey
6. k value → Literature survey


CO_2
Respiration
60 Gt/year
Photosynthesis
120 Gt/year
Biomass & Soil & detritus pools
60 Gt/year
Soil

The importance of CWD in tropical forest carbon balance



(Pyle, 2008)

The importance of CWD in tropical forest carbon balance

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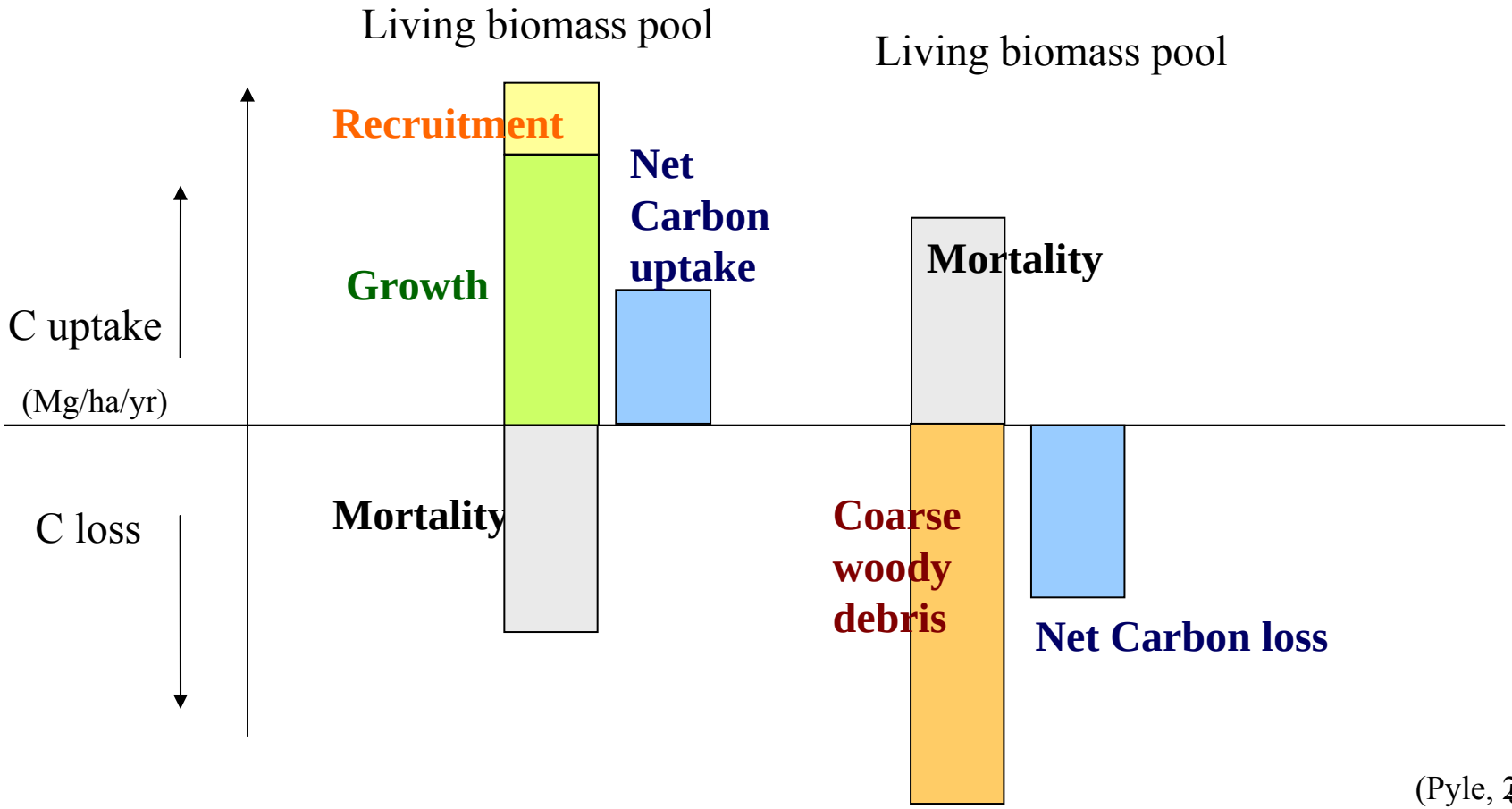
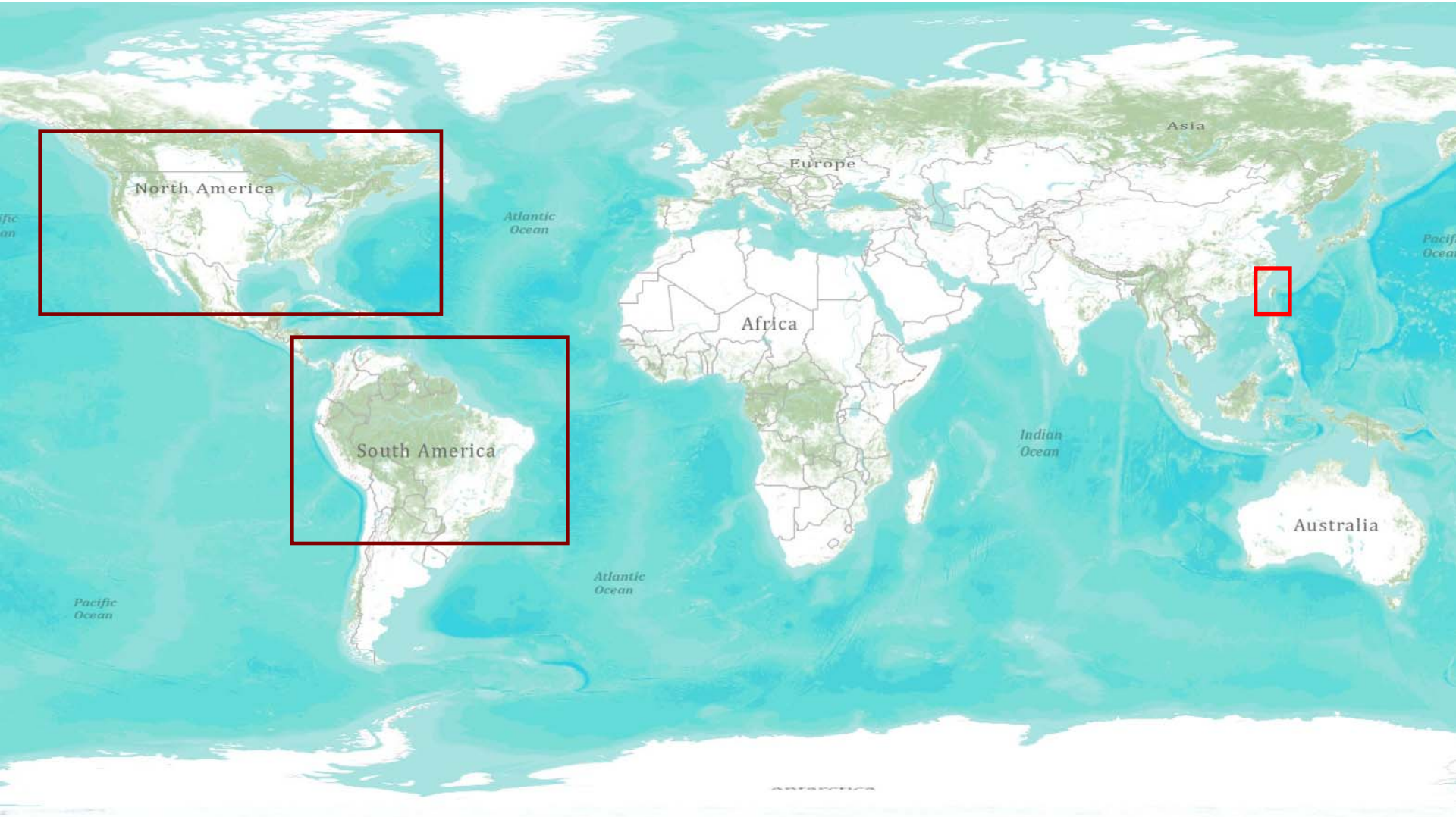


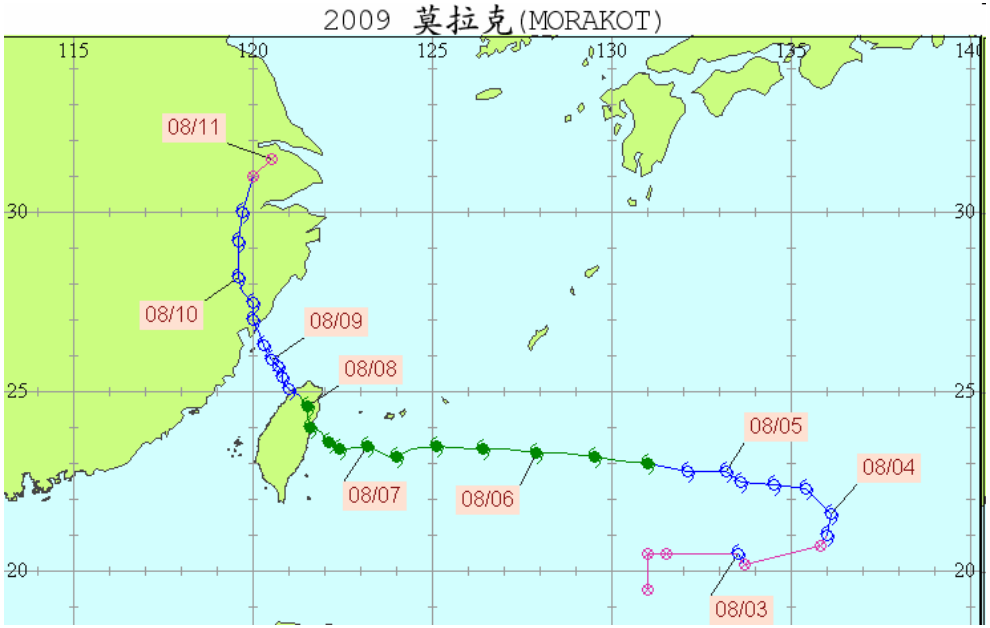
(Pyle, 2008)

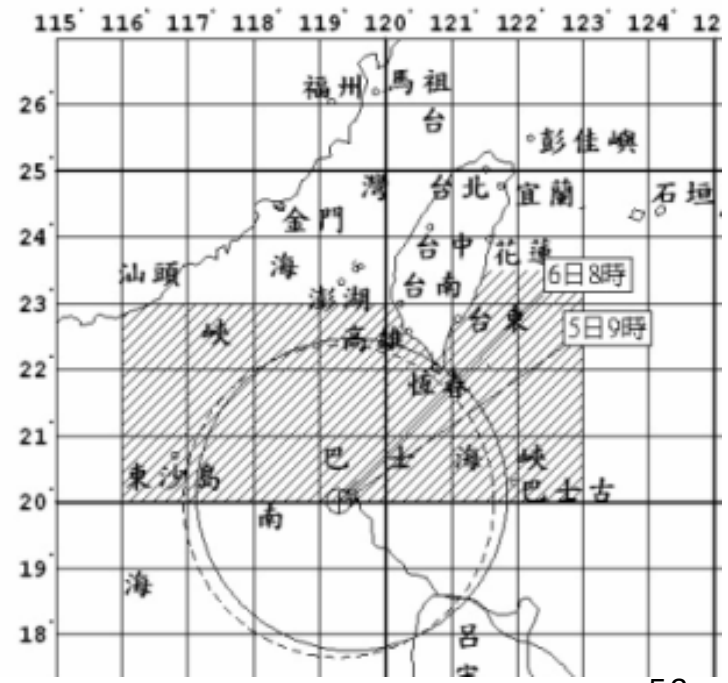
World


North America
South America
Europe
Asia
Africa
Australia
Atlantic Ocean
Pacific Ocean
Indian Ocean
Atlantic Ocean

Discussion

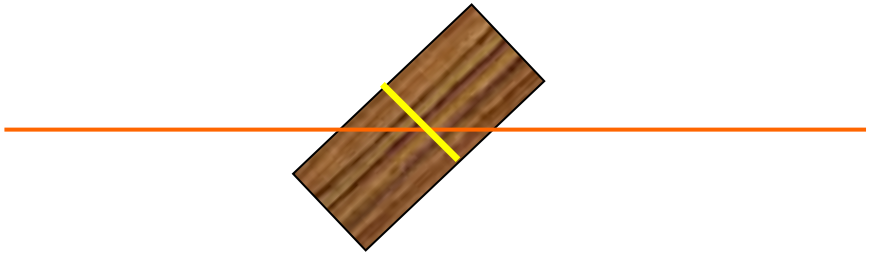
Date	Typhoon	
2009.08.08.	莫拉克(MORAKOT)	中度
2009.10.05.	芭瑪(PARMA)	中度





Fallen dead wood & branches

- Recording diameter of each wood

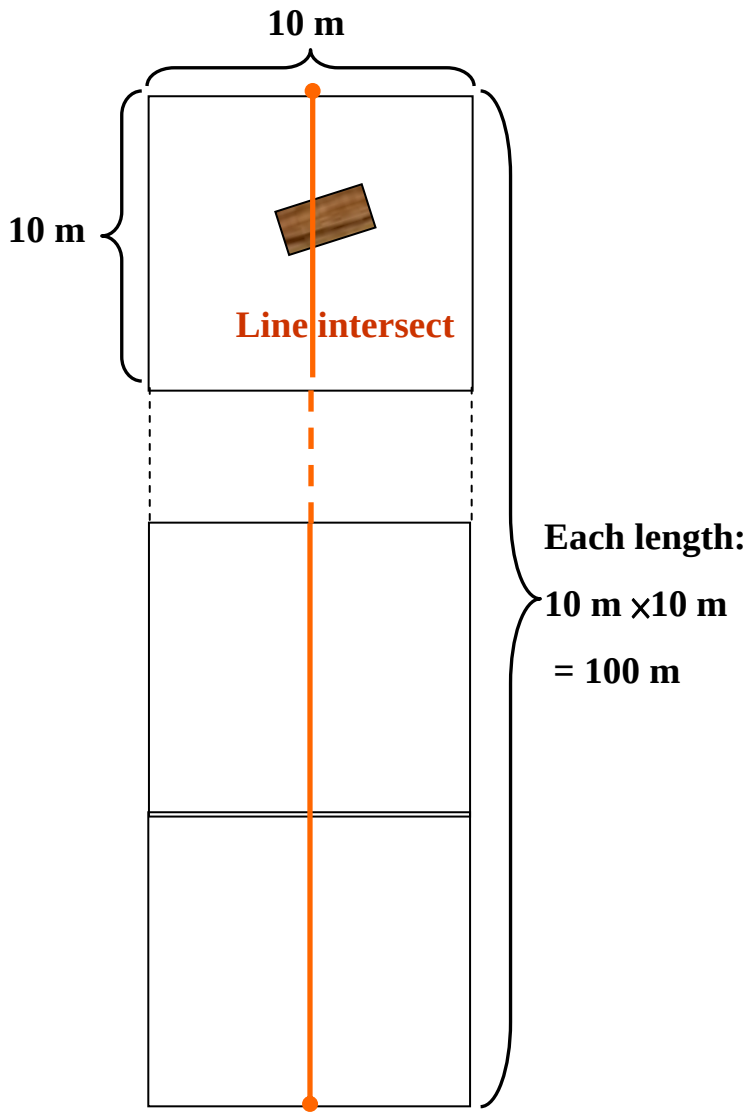


- Formulae (van Wagner, 1968)

$$V = \frac{\pi^2 \sum (d_i)^2}{(8 \times L)}$$

(van Wagner, 1968)

V: volume of wood per unit area (m^3/ha)
d_i : piece diameter (cm)
L: length of sample line (m)



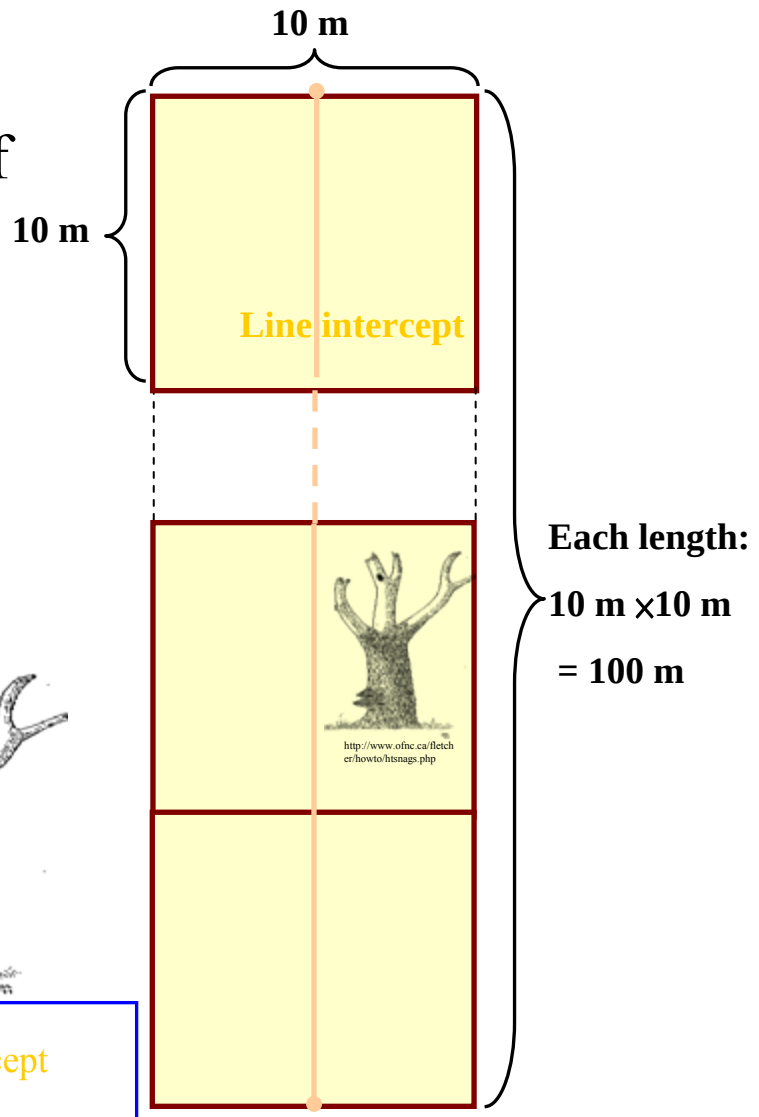
Standing dead wood

- Recording diameters and length of trunk and branches
- Smalian's formulae

(Phillip 1994, cited in Chao et al.,2008)

$$V = L\left[\frac{\pi(D_1/2)^2 + \pi(D_2/2)^2}{2}\right]$$

L : the length of snag (m)
D : diameter, at either end (m)



Fushan Subtropical Broadleaf Forest

Biomass and nutrient content of woody debris

(Lin at el. 2003)