Nutrient Dynamics in *Acacia mangium* and *Eucalyptus pellita* Plantations in South Sumatra, Indonesia

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Introduction

- Fast wood plantation (FWP) have been expanded in Indonesia (ITTO, 2005)

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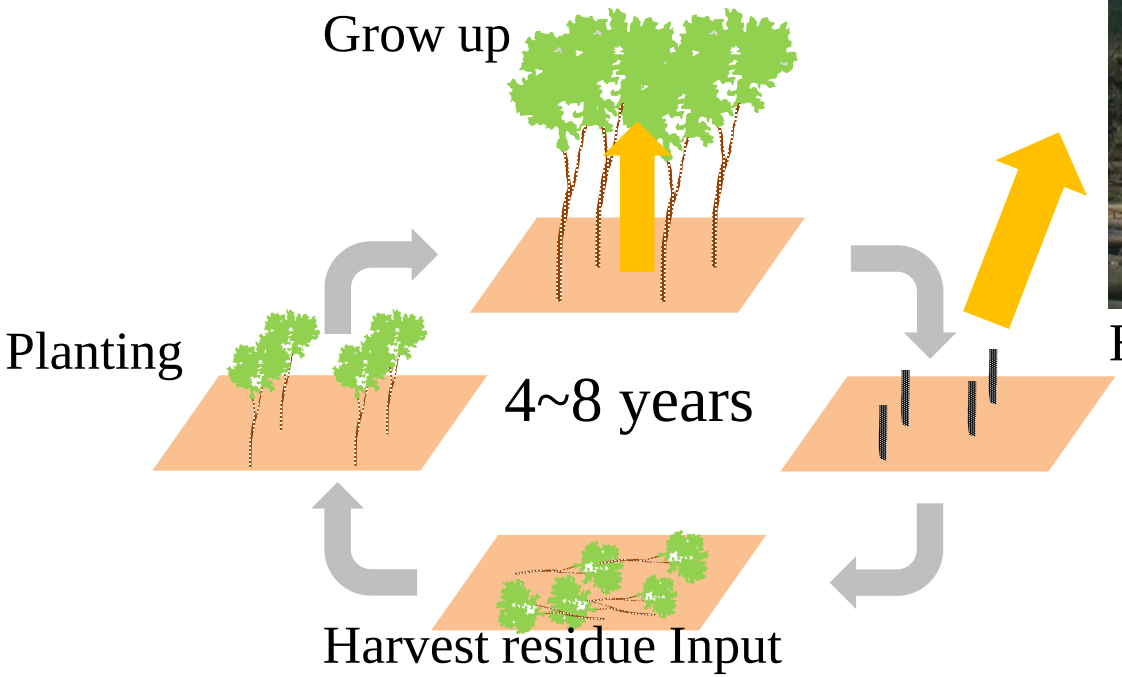
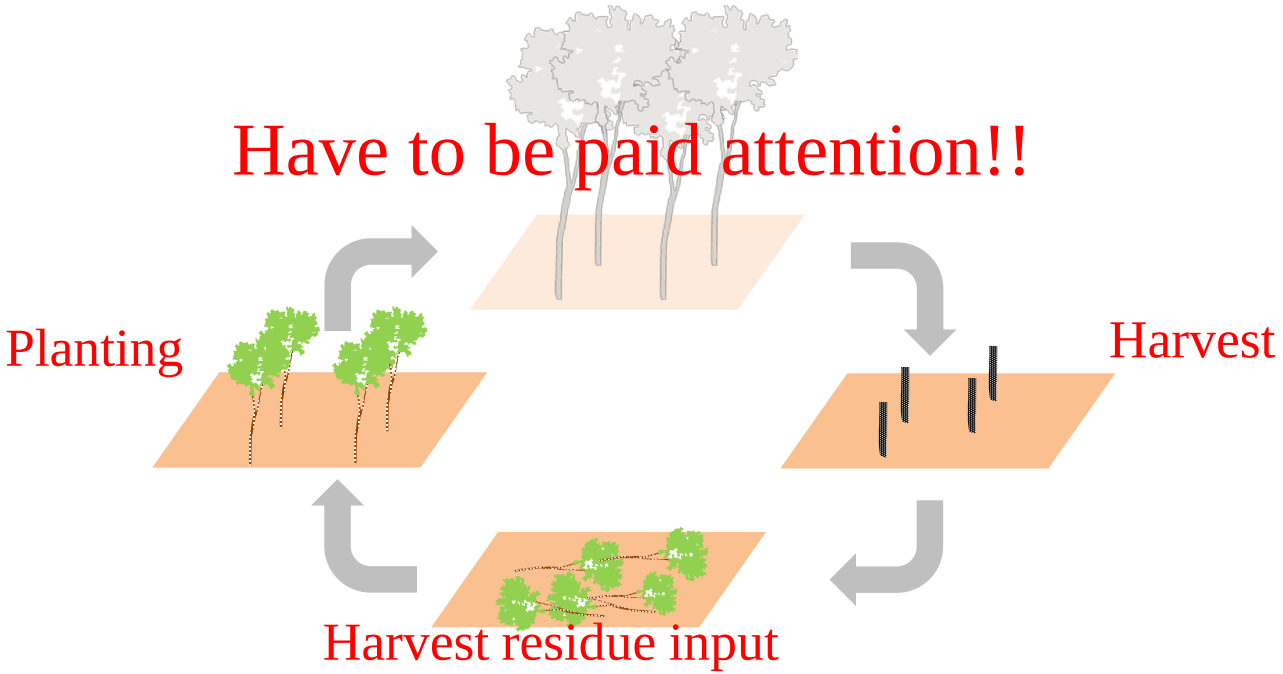
- FWP would lead depletion of available nutrients in the soil and have severe impact on the productivity and sustainability of forest stands (B du toit et al., 2004; Corbeels M, 2003)



Introduction

- Fast wood plantation (FWP) have been expanded in Indonesia (ITTO, 2005)
- FWP would lead depletion of available nutrients in the soil and have severe impact on the productivity and sustainability of forest stands (B du toit et al., 2004; Corbeels M, 2003)
- The greatest impact from management occurs during operations associated with harvesting and planting (A,Tiarks et al., 2004)



Introduction

- In Indonesia, *Acacia mangium* (1st) had largest parts in plantation.
- Reducing the risk of root rot of *Acacia mangium*, there is increasing introduction of *Eucalyptus pellita* (3rd) as plantation trees (Kurinobe., et al 2011)
- For sustainable nutrient management in Indonesia, information of nutrient dynamics of these two species is important.

- N-fixing species
- Use for pulp
- 100 million ha in Indonesia
- Risk of root rot

- non N-fixing species
- Use for pulp
- In these days increasing

Introduction

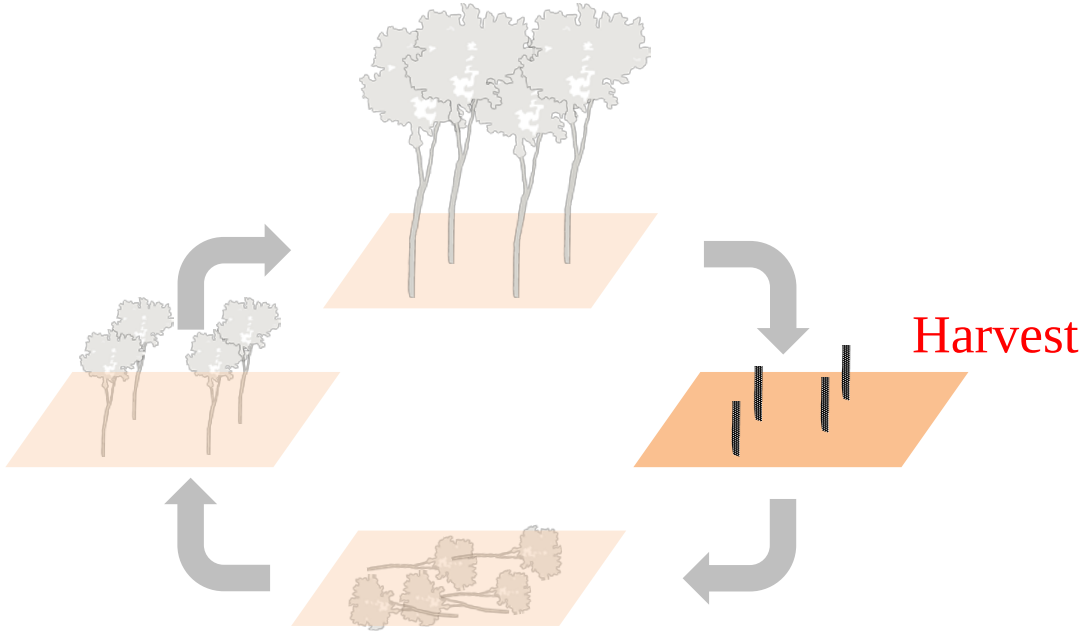
Objective

Understand the nutrient dynamics through harvesting of *Acacia mangium* and *Eucalyptus pellita* plantation

We focus on

Part Ⅰ -Takuya Sasaki

Impact of harvesting



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Understand the nutrient dynamics through harvesting of *Acacia mangium* and *Eucalyptus pellita* plantation

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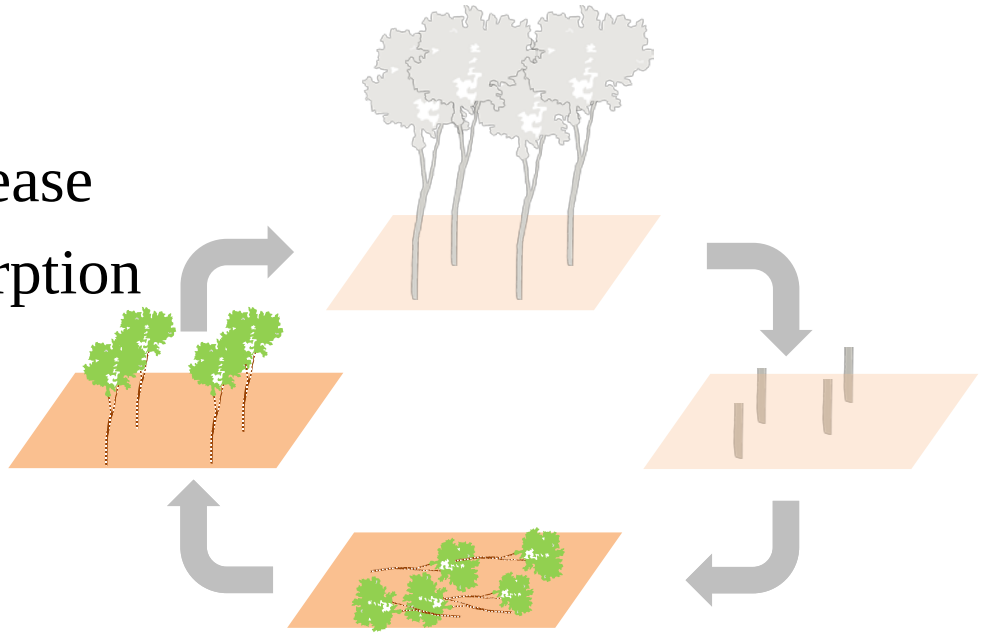
Part Ⅰ -Takuya Sasaki

Impact of harvesting

Part Ⅱ -Yukiko Sawa

Synchronization of nutrient release from harvest residues and absorption by subsequent plants

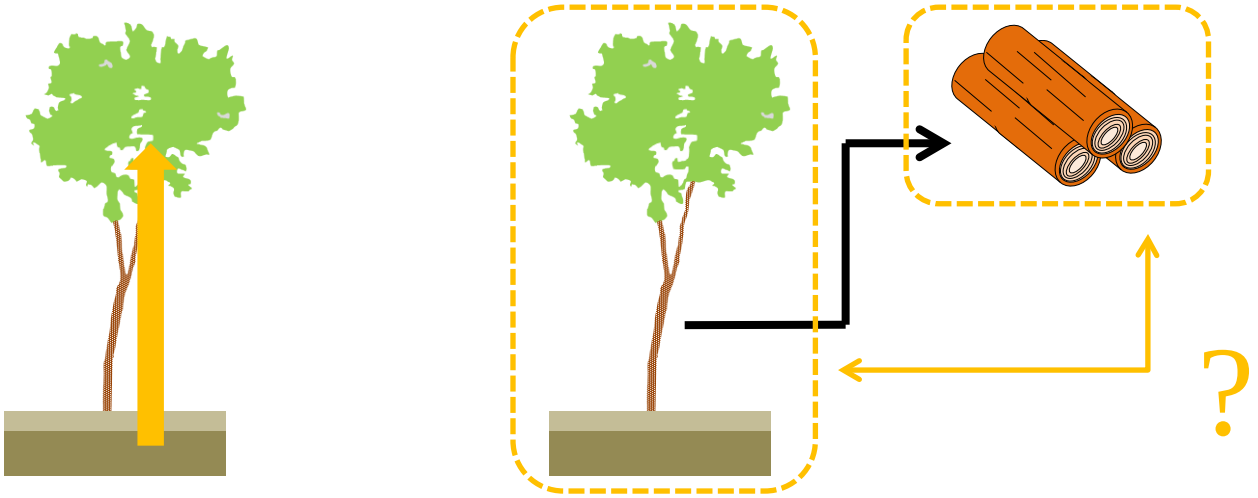


Part I
Impact of harvesting

Introduction

1 Estimate the nutrient accumulation into biomass

2 Compare removed nutrient through harvest with nutrient within tree-soil system



Experimental Design

Location

Industrial plantation of *Acacia mangium* and *Eucalyptus pellita* located in South sumatora Indonesia.

4-6 years harvesting rotation.

- Annual precipitation: 2000-3000 mm
- Mean annual temperature: 27.3 ºC
- No distinct dry and wet seasons
- Dryer season: From June to September
  Wetter season: From October to May

Experimetal term

Sep 2011

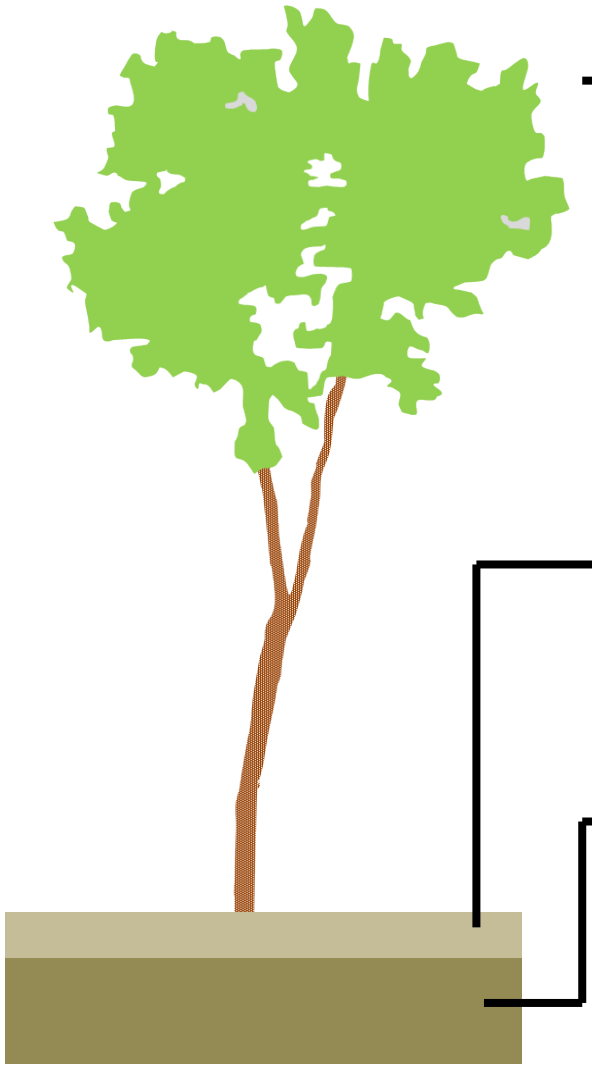
Site description

・4years neighboring plantation of *Acacia mangium* (Acacia*)* and *Eucalyptus pellita* (Eucalypt).

・Before establishing them, both sites were same old *Acacia mangium* plantation.

・Ini t ial soil condition are considered to be same between species.

Experimental Design



Accumulation into biomass

・Tree destructive sampling in both sites
→Allometry in both sites were made.
・T-K, T-P, T-N, T-Ca, T-Mg accumulation into biomass were estimated from allometry and DBH.

Estimated nutrient removal
Nutrient within stem
and stem bark which diamer < 6cm

Litter layer

Sampling with plastic ring (r = 21.5cm) in both sites (n=8).

T-P, K, N, Ca, Mg

Mineral Soil

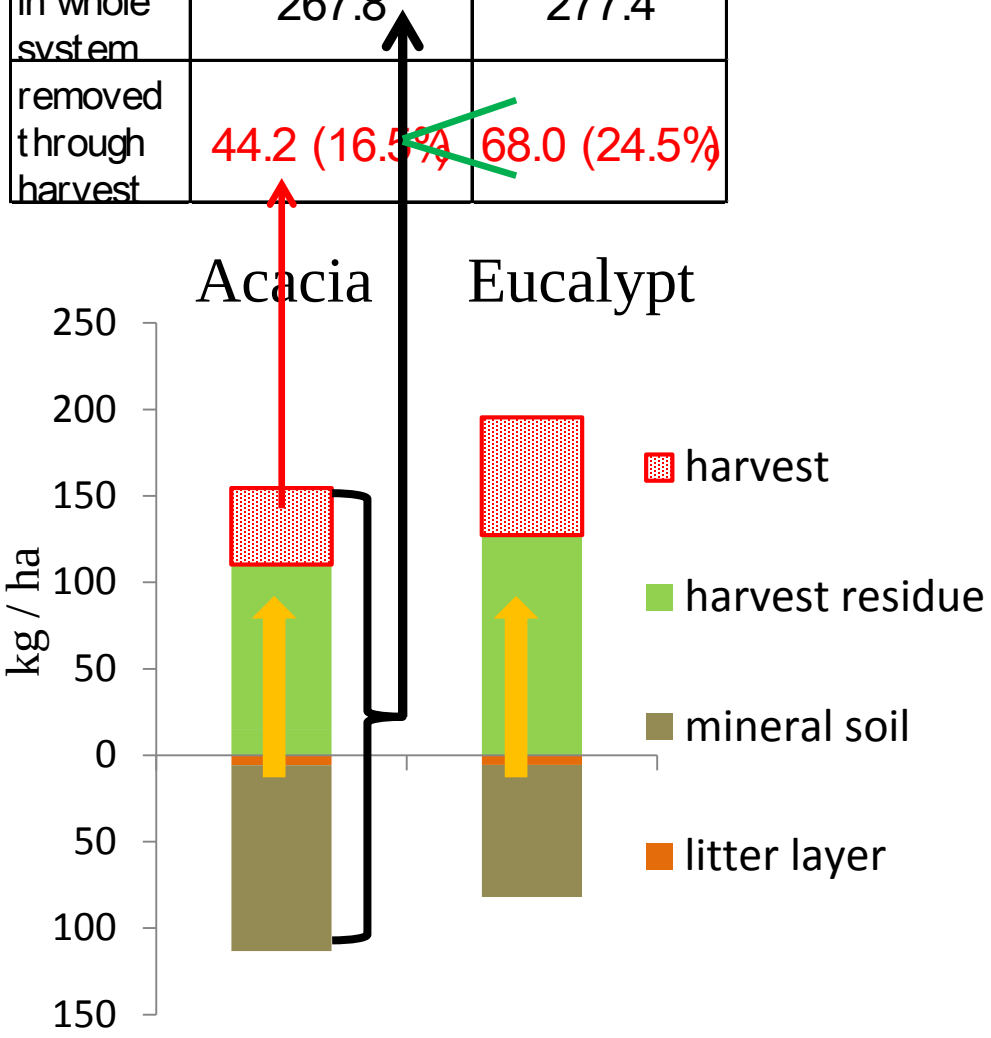
Multi sampling down to 30cm every 5cm interval with soil cylinder in both site (n=8)

Bray2-P, Ex-Ca, Ex-Mg, Ex-K, T-N

Total K and Ex-K removal

Total K and Ex-K (kg/ha)

	Acacia	Eucalypt
total in whole system	267.8	277.4
removed through harvest	44.2 (16.5%)	68.0 (24.5%)



Accumulation into biomass

Acacia < Eucalypt

Especially branch and leaves had a higher accumulation in Eucalypt.

Removal from whole system

Acacia < Eucalypt

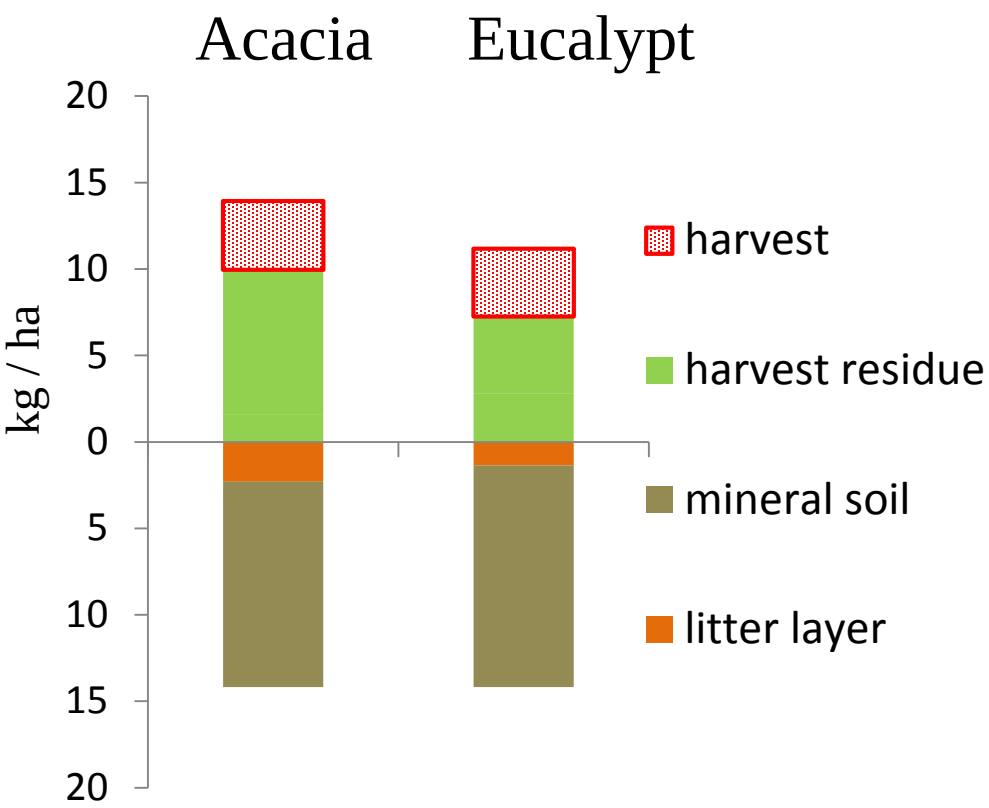
←Because of higher accumulation into log in Eucalypt

Difference in soil was because of difference in accumulation into biomass.

Total P and Bray2-P removal

Total P and Bray2-P (kg/ha)

	Acacia	Eucalypt
total in whole system	28.2	25.4
removed through harvest	3.97 (14.1%)	3.93 (15.5%)



Accumulation into biomass

Acacia > Eucalypt

Especially branch and leaves had a higher accumulation in Acacia.

Removal from whole system

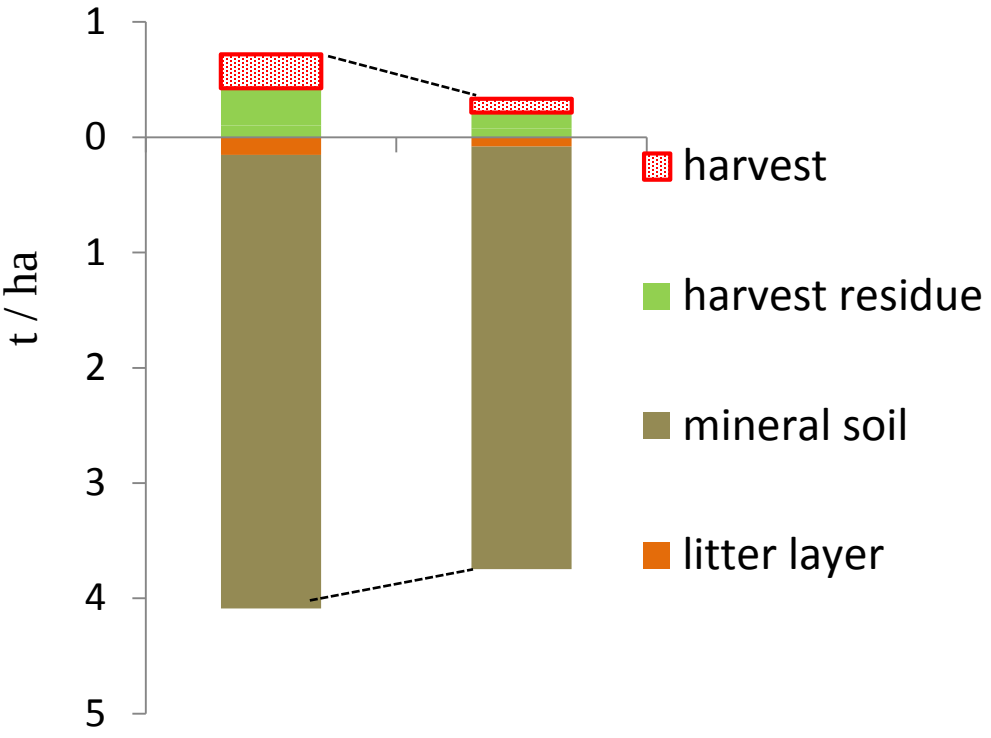
Acacia ≒ Eucalypt

Almost same amount of P were removed through harvest.

Total N

Total N (t/ha)

	Acacia	Eucalypt
total in whole system	4.9	4.1
removed through harvest	0.29 (6.11%)	0.12 (2.9%)



Accumulation into biomass

Acacia > Eucalypt

Because of N-fixing ability of Acacia

Removal from whole system

Acacia > Eucalypt

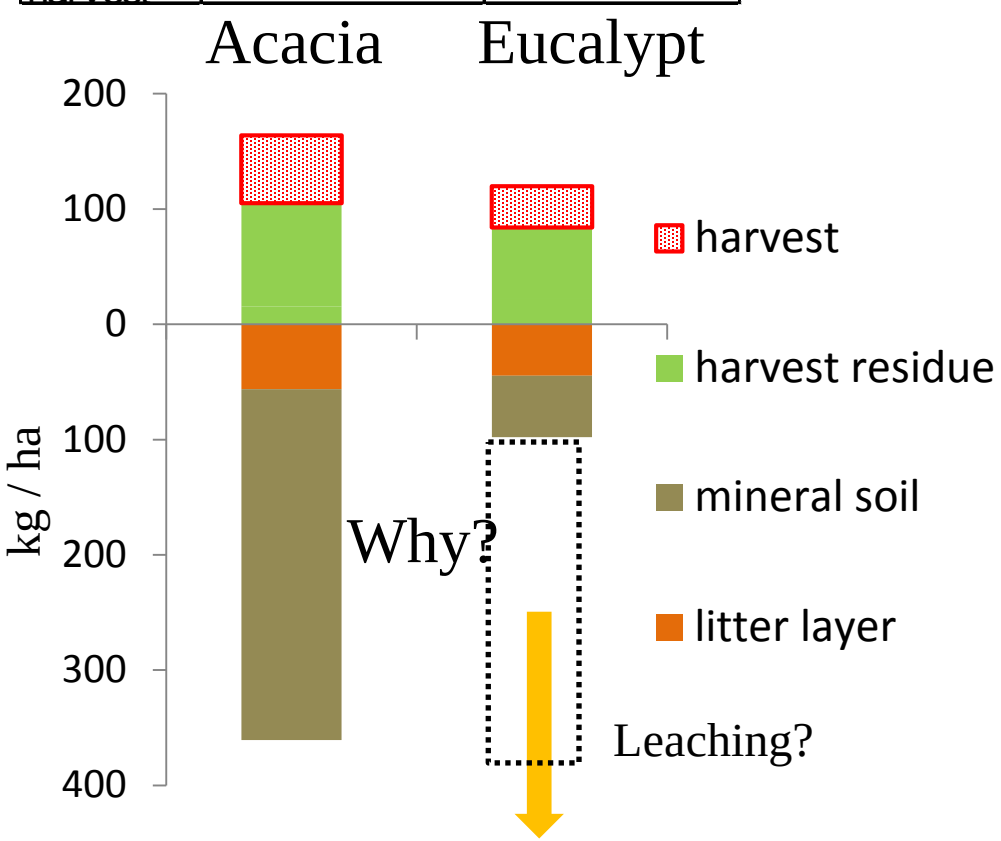
⇔removal N in harvest were small compared to soil N.

Acacia increase net N in whole system by N-fixing.

Total Ca and Ex-Ca removal

Total Ca and Ex-Ca (kg/ha)

	Acacia	Eucalypt
total in whole system	524.8	217.7
removed through harvest	58.8 (11.2%)	35.7 (16.4%)



Accumulation into biomass

Acacia > Eucalypt

Especially branch and leaves had a higher accumulation in Acacia.

Removal from whole system

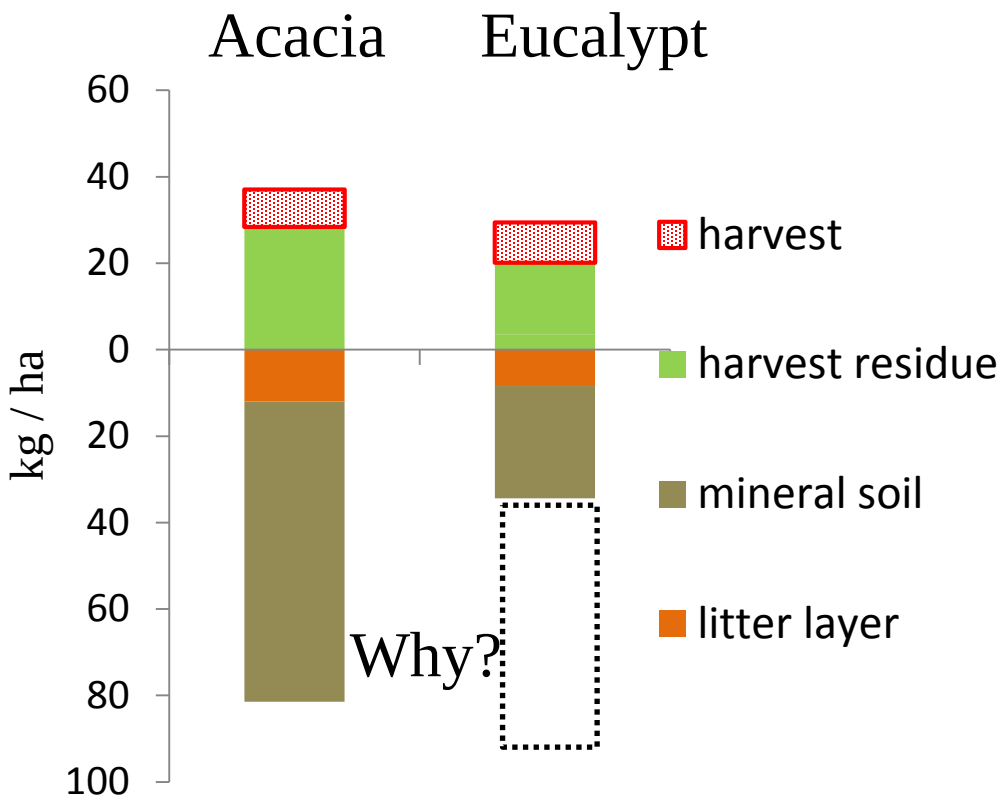
Acacia > Eucalypt

- Eucaly kept quite lower amount in whole system.
- Leaching down to deeper soil?
- This species specific effect more severe than harvest.

Total Mg and Ex-Mg removal

Total Mg and Ex-Mg (kg/ha)

	Acacia	Eucalypt
total in whole system	118.6	63.9
removed through harvest	8.7 (7.3%)	9.3 (14.6%)



Accumulation into biomass

Acacia > Eucalypt

Especially branch and leaves had a higher accumulation in Acacia.

Removal from whole system

Acacia > Eucalypt

・Eucaly kept quite lower amount in whole system.

・Same as Ca, this species specific effect more severe than harvest.

Summary

1 Nutrient removal through harvest.

- 2~24.5 % nutrient are removed through harvest
- Eucaly had potential to remove more K through harvest (24.5%).

  ←Higher accumulation of K into stem part in Eucaly.
- In both plantation, impact of P removal are almost same.
- N removal were not so big compared to soil stock (2~3%).

2 Loss of Ca and Mg in Eucalypt by other factor!!

- Eucalypt had lower amount of Ca and Mg than Acacia in whole system.

  ←Leaching down to soil layer?

Part Ⅱ

Nutrient release from decomposing harvest residues and litter on the forest floor, and its absorption by seedling and understory vegetation

Photo: Acacia plantation just after planting seedling

Introduction of part 2

Harvest residues and litter on the forest floor contain large amounts of nutrients (part 1)

- Investigate nutrient release rate, pattern, and amounts
- Evaluate if nutrient release is synchronized with its absorption by subsequent plants (seedling and understory vegetation)

Experimental term

From September, 2011 to September, 2012

Experimental plot

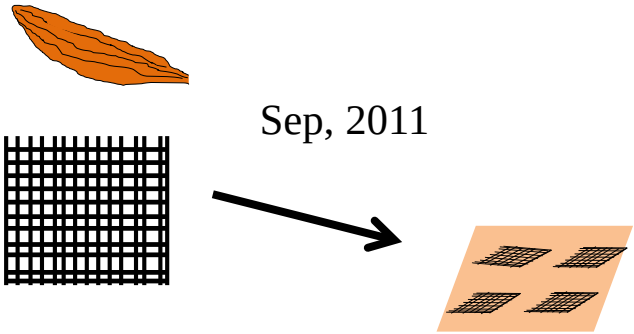
- Plot size: 21m ×27m (Acacia), 21m ×33m (Eucalypt)
- Cut all trees within the plot and stems were taken out
- Biomass of harvest residues and litter on the forest floor were calculated from allometry equation and sampling data of Part1

Nutrient release - litterbag method -

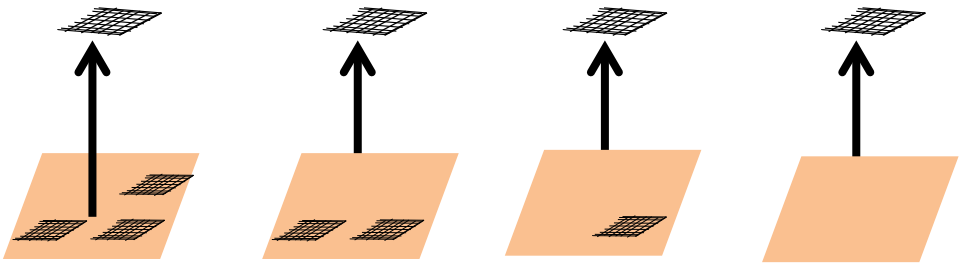
Harvest residues
- Leaves
- Branch (0-1, 1-3, 3- cm)
- Bark
- Root in litter layer
- Root in the mineral soil

(0-2, 2-5, 5-25, 25-50, 50-mm)

Litter from litter layer



3 month 6 month 9 month 12 month



(n=10) → Composited after weighing

Concentration of T-N, P, K, Ca and Mg in each component were analyzed. Amount of nutrient in each component was calculated same way as Part1

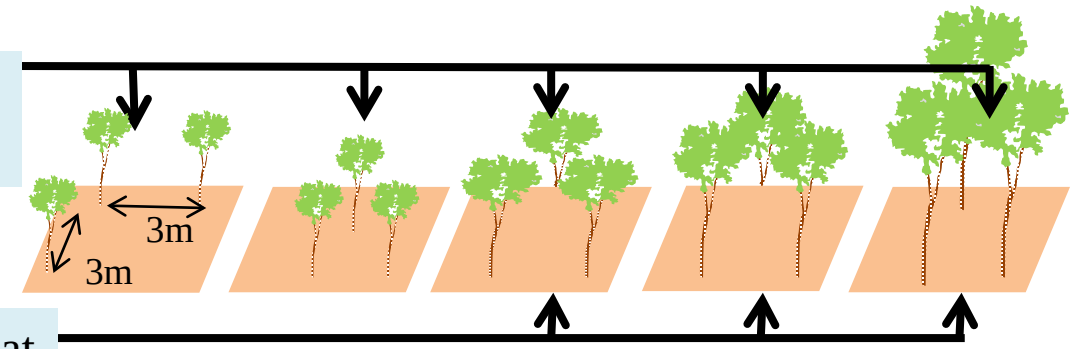
Nutrient absorption

Sampling seedling

Allometry equation by destructive sampling of 2-6 trees in each term

→ Biomass increment (kg/ha)

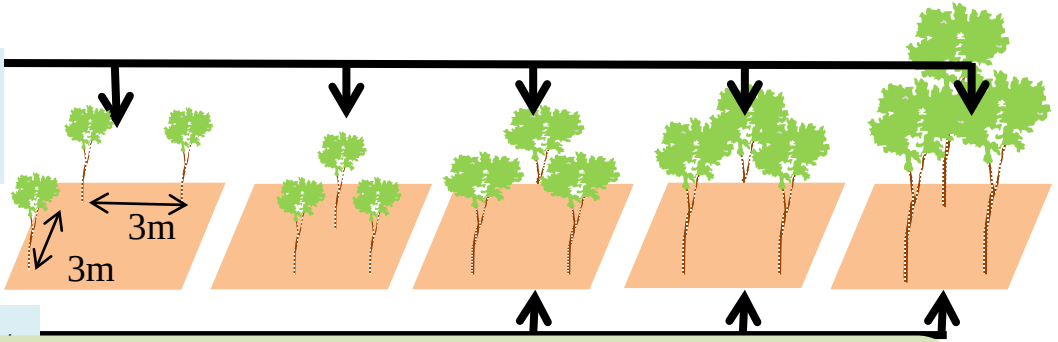
Measure diameter of every seedling at 10cm above the ground in each term



Nutrient absorption

Sampling seedling

Nov,2011 1 month 4 month 8 month 10 month



Allometry equation by destructive sampling of 2-6 trees in each term

→ Biomass increment (kg/ha)

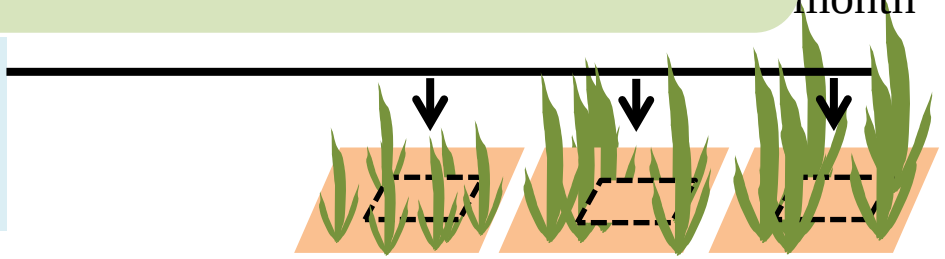
Measure diam… 10cm above t…

Concentration of T-N, P, K, Ca and Mg were analyzed.
Amount of was calculated same way as Part1

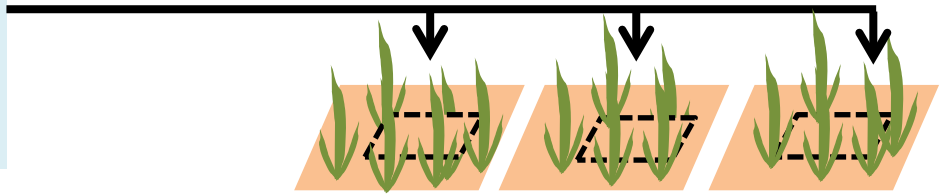
Sampling u…

month

Acacia plot
Cutting and weighing within subplot (1m×1m, n=5)



Eucalypt plot
Cut over in the plot, and then sampling and weighing within subplot (2m×3m, n=8)



Nutrient release

Amounts of nutrients released from harvest residues and litter, and release rate (their proportion to the amounts of initial contents of nutrients) in one year

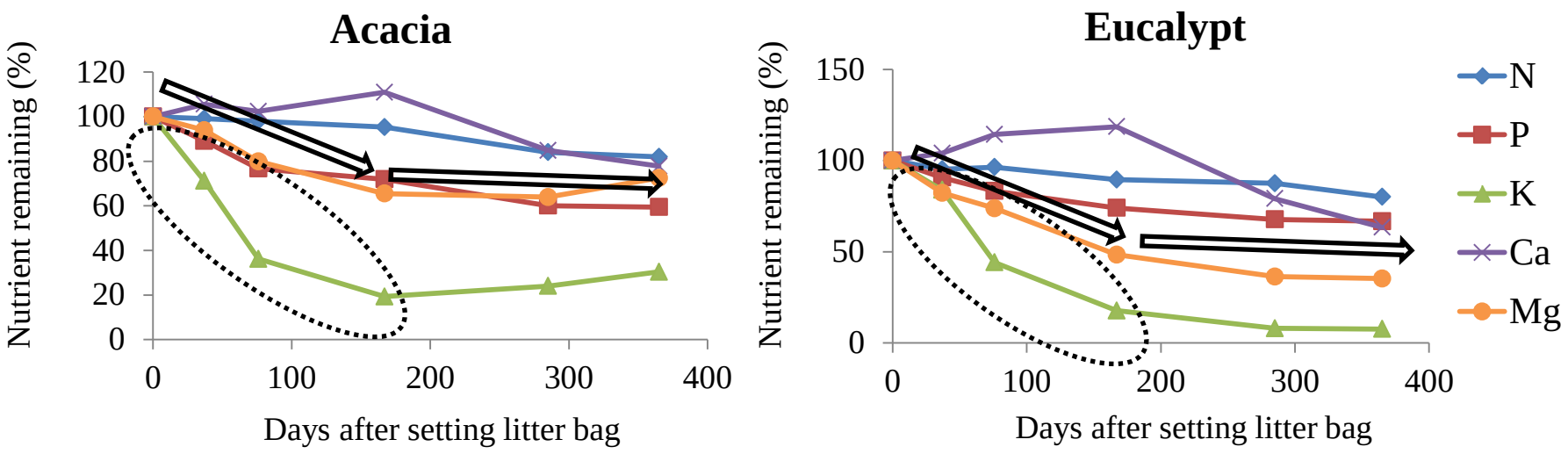
	Acacia		Eucalypt	
	Released amounts (kg ha^{-1})	Release rate (%)	Released amounts (kg ha^{-1})	Release rate (%)
N	143.3	18	58.2	20
P	6.6	39	2.6	32
K	147.8	68	113.6	90
Ca	42.7	21	49.7	36
Mg	11.9	24	27.0	64

- Most of K was released in one year in both species
- Release of N proceeded only below 20% in both species
- Release rates of K, Ca, and Mg were higher in Eucalypt

→ Eucalypt has less function as a source of nutrients in long-term

Release patterns of nutrients

Time courses of the nutrient content in decomposing harvest residues and litter



- Rapid release of K in first 6 months

  (173 and 101 kg ha^{-1} were released in first 6 months, which accounted 115 and 89 % of total released amounts in 1 year in Acacia and Eucalypt stand, respectively)

- Release of P and Mg proceeded mostly in first 6 month (↔ Ca)

Nutrient absorption and release

Amounts of nutrients absorbed by seedling and understory vegetation in one year, and their proportion to the amounts of nutrients released from harvest residues and litter

	Acacia		Eucalypt	
	Absorbed amounts (kg ha^{-1})	Absorption / Release (%)	Absorbed amounts (kg ha^{-1})	Absorption / Release (%)
N	119.2	84	70.9	122
P	3.4	51	3.0	118
K	65.6	44	35.8	32
Ca	15.0	36	19.9	40
Mg	8.4	65	7.1	26

More than 50% of released K and Ca in both species and Mg in Eucaly were not absorbed by subsequent plants

→ If leaching occurred, substantial amounts of these nutrients might be lost from the tree - soil system, especially K

Nutrient absorption

Amounts of nutrients absorbed by seedling and understory vegetation in one year, and proportion of the amounts of nutrients absorbed by understory vegetation

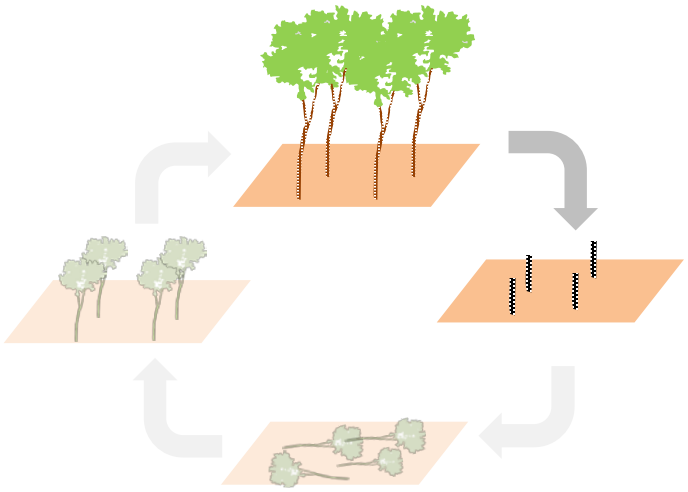
	Acacia		Eucalypt	
	Absorbed amounts (kg ha^{-1})	Contribution of understory vegetation (%)	Absorbed amounts (kg ha^{-1})	Contribution of understory vegetation (%)
N	119.2	51	70.9	87
P	3.4	53	3.0	85
K	65.6	55	35.8	82
Ca	15.0	36	19.9	89
Mg	8.4	60	7.1	83

Understory vegetation is major contributor to stock nutrients

If weeding is conducted, most released nutrients might be lost, especially in Eucalypt stand

(← Nutrients absorption by seedling: Eucalypt > Acacia)

Conclusion

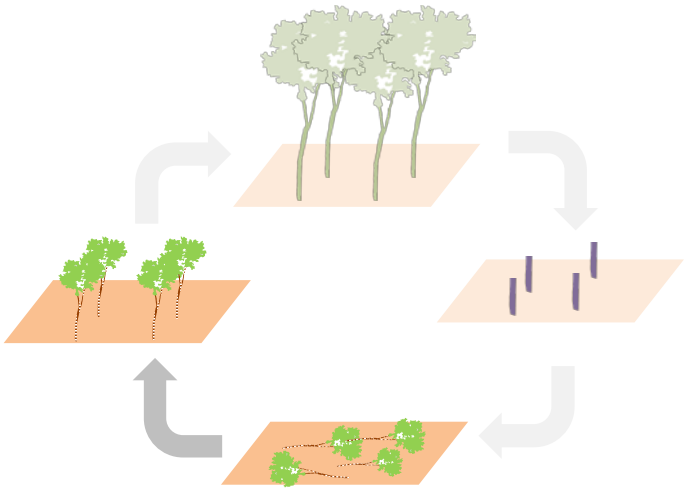


Harvest

K removal through harvest Eucalypt > Acacia

Ca and Mg lost by other factor Eucalypt > Acacia

Conclusion



Harvest

K removal through harvest Eucalypt > Acacia

Ca and Mg lost by other factor Eucalypt > Acacia

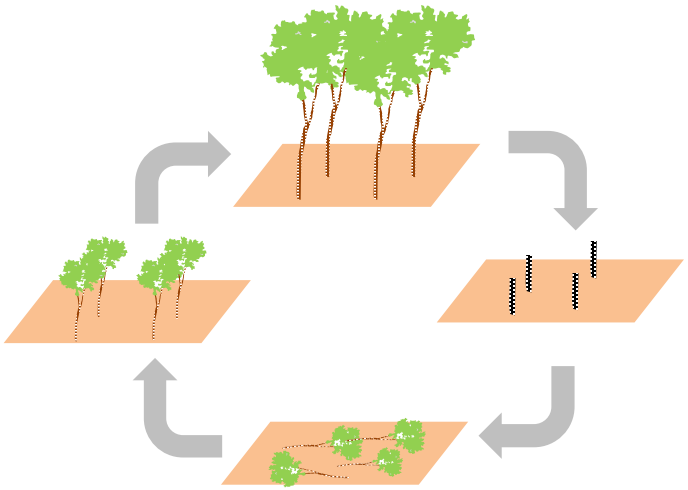
Decomposition of harvest residues

- Eucalypt has less function as a source of nutrients in long-term
- If leaching occurred, substantial amounts of nutrients might be lost from the tree - soil system, especially K

Planting

- Over 50 % of Ca and K were not absorbed in both species and Mg in Eucalypt stand
- Understory vegetation is important to stock nutrients
- If weeding is conducted, nutrients loss might be occurred especially in Eucalypt

Conclusion



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Decomposition of harvest residues

- Eucalypt has less function as a source of nutrients in long-term
- If leaching occurred, substantial amounts of nutrients might be lost from the tree - soil system

Through harvest and planting,

More nutrients, especially cation like Ca, Mg and K might be lost from tree – soil system in Eucalypt, than Acacia stand

nutrients

- If weeding is conducted, nutrients loss might be occurred especially in Eucalypt

Thank you for your attention

Acknowledgements

We thank for Mr. Arisman Hardjono, Maya Liony Lioe, and all staff members of Research of Development Division of PT. Mushi Hitan Persada for their help in our field work

Photo: Ninnaji temple in Kyoto (18/11/2012)