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Recovery process of tree biomass after selective logging with moderate intensity in an Amazonian forest

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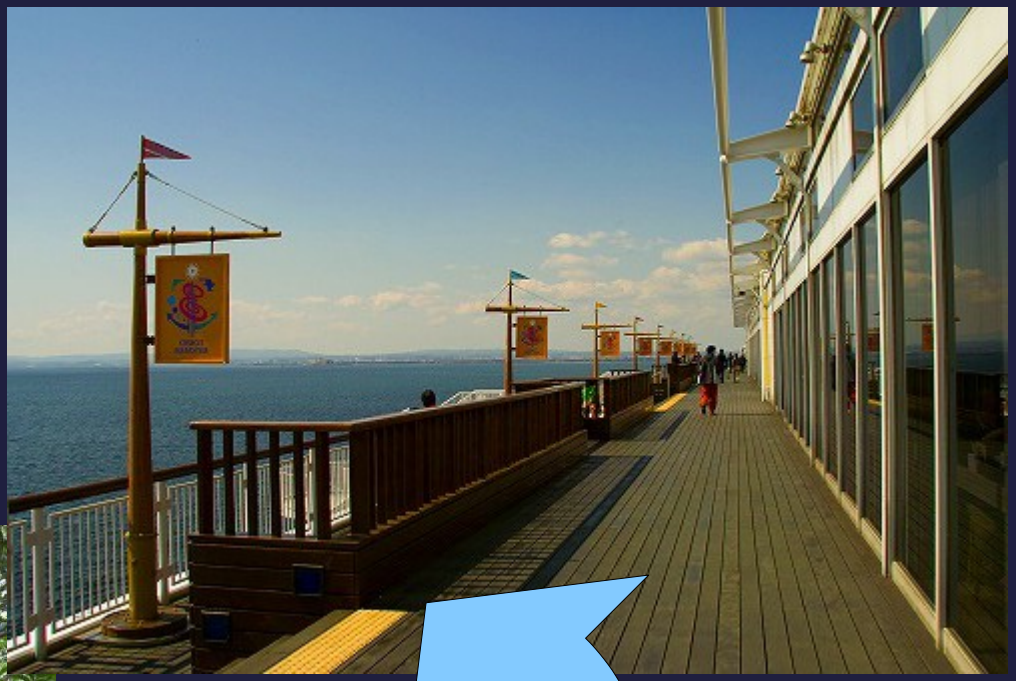
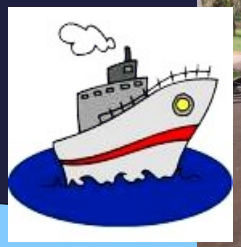
Logging in Amazon is not an issue in the other side of the world !!

(for Japanese)

Japan is still one of big consumers of tropical timber.

Lots of Amazon woods are used in public facilities, such as wood deck in waterfront. (Ipe, Itauba, Macaranduba etc.)





Selective logging vs Biomass, Carbon stock

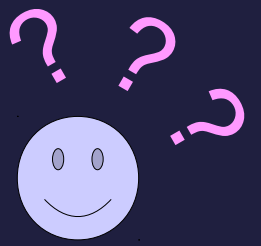
Management of natural forest by selective logging scheme is widely employed in tropical forests.

Serious concern about the global warming and REDD+

- Expansion of logged forests
- Their potential to regain carbon accumulation.

Estimation of the biomass and carbon stock dynamics in selectively logged forests in tropical areas is becoming an important issue.

Questions

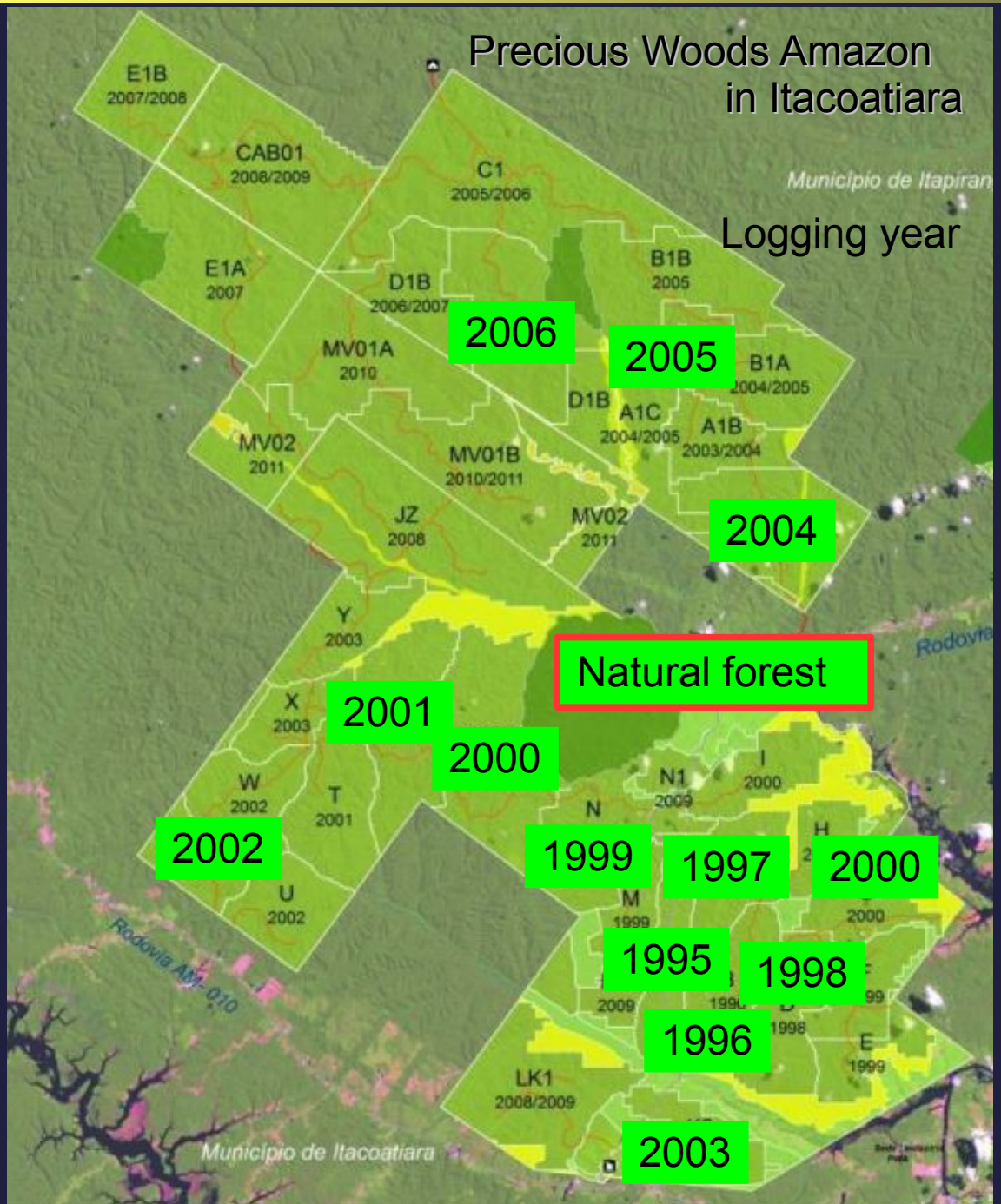


How can selectively logged forest recover exploited biomass?

Can selective logging with moderate intensity shorten the period of biomass recovery?

When biomass recovered from logging damage, are the other forest characteristics also restored to initial condition?

Comparison of biomass increment in forests with different logging history



In 2006
- 192 plots established
  (20m * 125m, 0.25ha)
- all trees > 10cm DBH measured

In 2010
- 119 plots established
  (20m * 125m, 0.25ha)
- all trees > 10cm DBH measured
- stumps in plots recorded

In 2013
- 54 plots re-censused
- stumps and skidder trails recorded

Biomass (AGB + BGB) estimation

Dry Biomass = 0.584 * 2.72 * DBH ^ 1.88

(Silva 2007)

Temporal changes in biomass after logging were examined.

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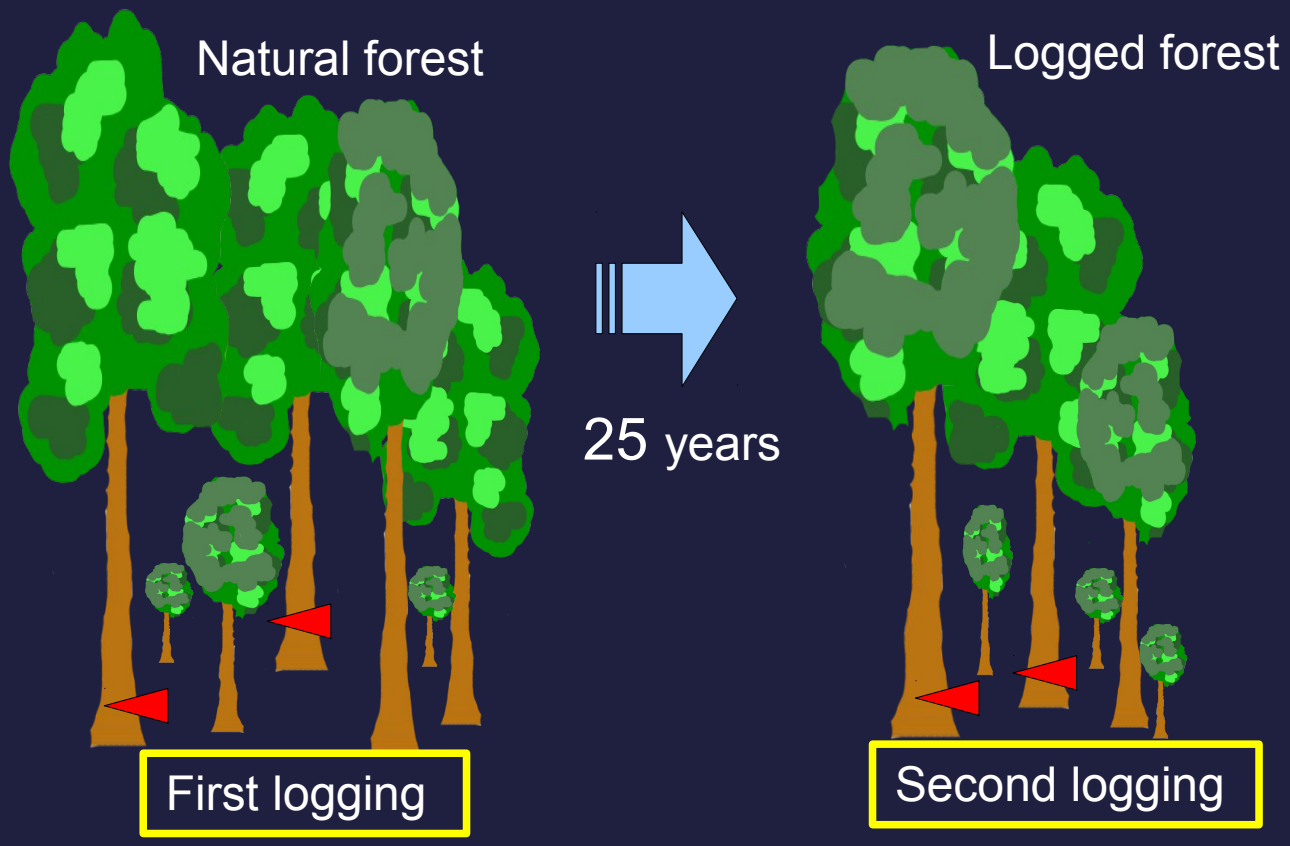
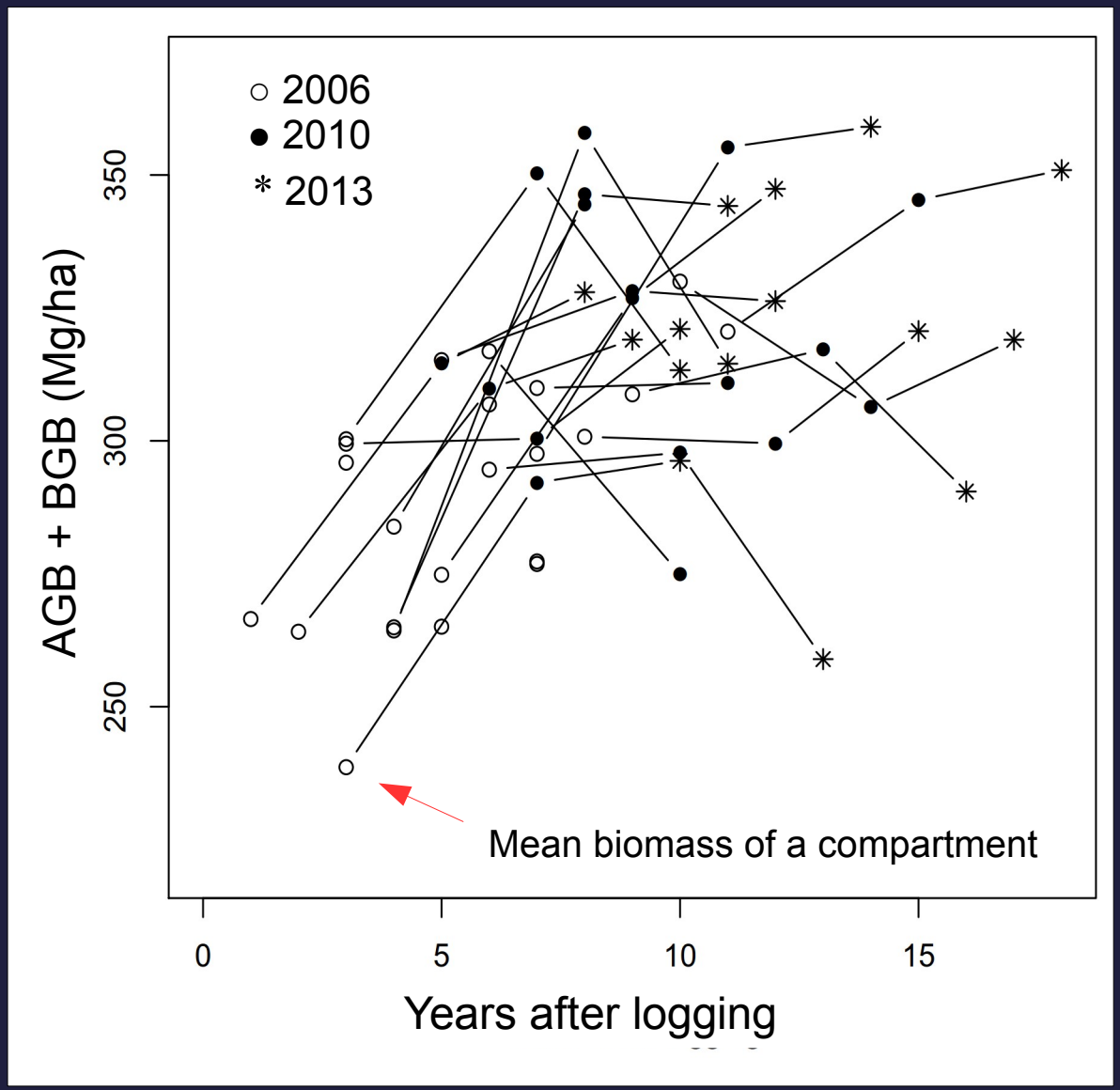
Selective logging by "Precious Woods Amazon"

- Trees > 50cm in DBH for logging
- Limit of total volume of timber, 30 m^3 / ha
- 40 and several species for timber (currently 19 species)
- GIS record for size and location of target trees

- 25 years logging cycle (no second logging yet)
- FSC certificated



Above- & below-ground biomass and passed years after logging



In 2006, 239 – 330 Mg/ha
In 2010, 275 – 358 Mg/ha
In 2013, 259 – 360 Mg/ha

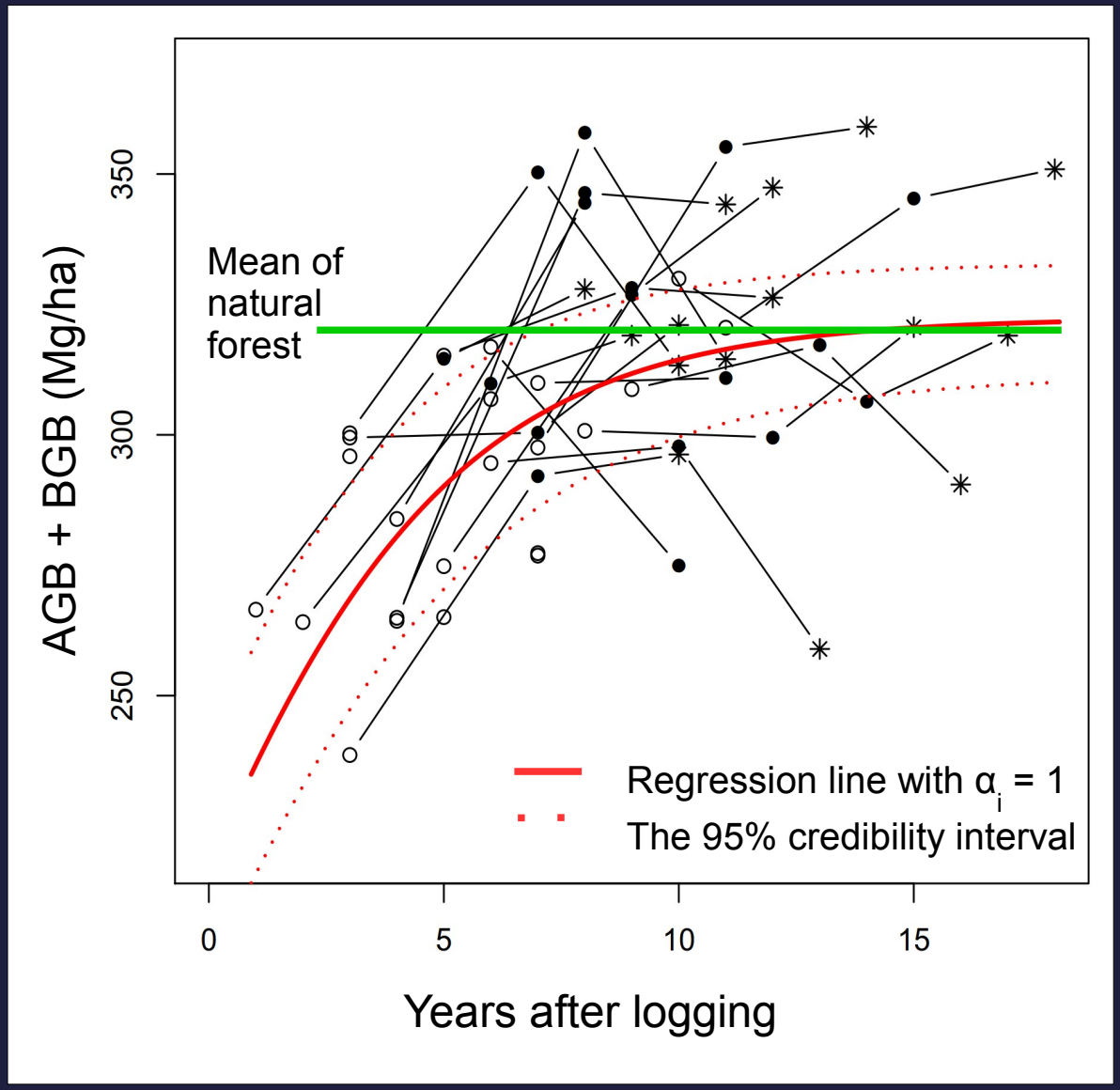
In 2006, a positive correlation between years after logging and biomass ($r = 0.63$, $p<0.01$, d.f.=21).

In 2010 & 2013, no significant relationships.

$$Biomass = \frac{\alpha_i K}{1+\exp\left(\frac{a-Year}{b}\right)}$$

Baysian analysis with Markov Chain Monte Carlo (MCMC) algorithm
Random effect for compartment (Normal distribution, mean = 1)

Biomass recovery model after selective logging



$$Biomass = \frac{\alpha_i K}{1 + \exp\left(\frac{a - Year}{b}\right)}$$

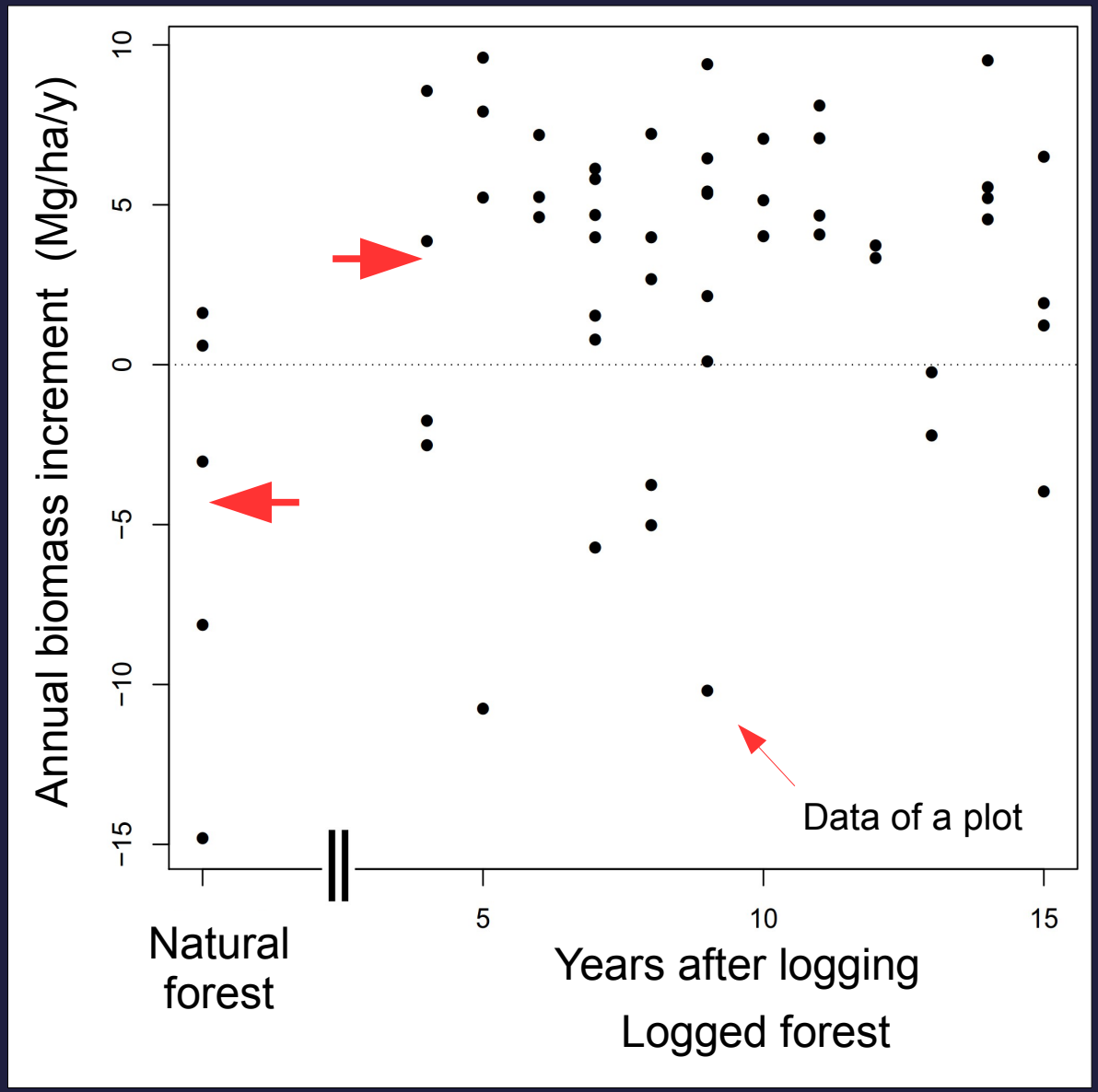
K = 322.4, a = -2.450,
b = 3.391
α_i = 0.912 – 1.100

Annual increment of biomass

1 year → 18.4 Mg/ha/y
2 years → 15.7 Mg/ha/y
5 years → 8.5 Mg/ha/y
10 years → 2.3 Mg/ha/y

Logged forest needed 13.8 years, at least 7.0 years, to regain biomass to the equivalent level of natural forest.

Annual biomass increment from 2010 to 2013 – individual tree basis



No relationship between Years after logging and annual biomass increment

Mean annual increment of biomass

Logged forest
3.1 ± 4.7 Mg/ha/y (n=49)
95% c.i. → 1.8 – 4.5

Natural forest
-4.7 ± 6.8 Mg/ha/y (n=5)
95% c.i. → -13.1 – 3.7

Annual biomass increment of logged forest is almost equivalent to expected value by the regression model.
(Model expectation → 3.0 Mg/ha/y at 9.5 years after logging)

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Annual increment of biomass = Growth + Recruit - Mortality

	Overall	Growth	Recruit	Mortality
Natural forest	-4.7 ± 6.8	3.5 ± 1.3	1.5 ± 1.2	-9.8 ± 7.8
Logged forest	3.1 ± 4.7	5.8 ± 2.3	1.4 ± 1.2	-4.0 ± 3.7

Mean ± SD (Mg/ha/y)

Biomass increase due to growth and recruit
→ No difference between logged and natural forest

The negative value in overall annual biomass increment of natural forest was governed by decrease of biomass due to tree mortality.

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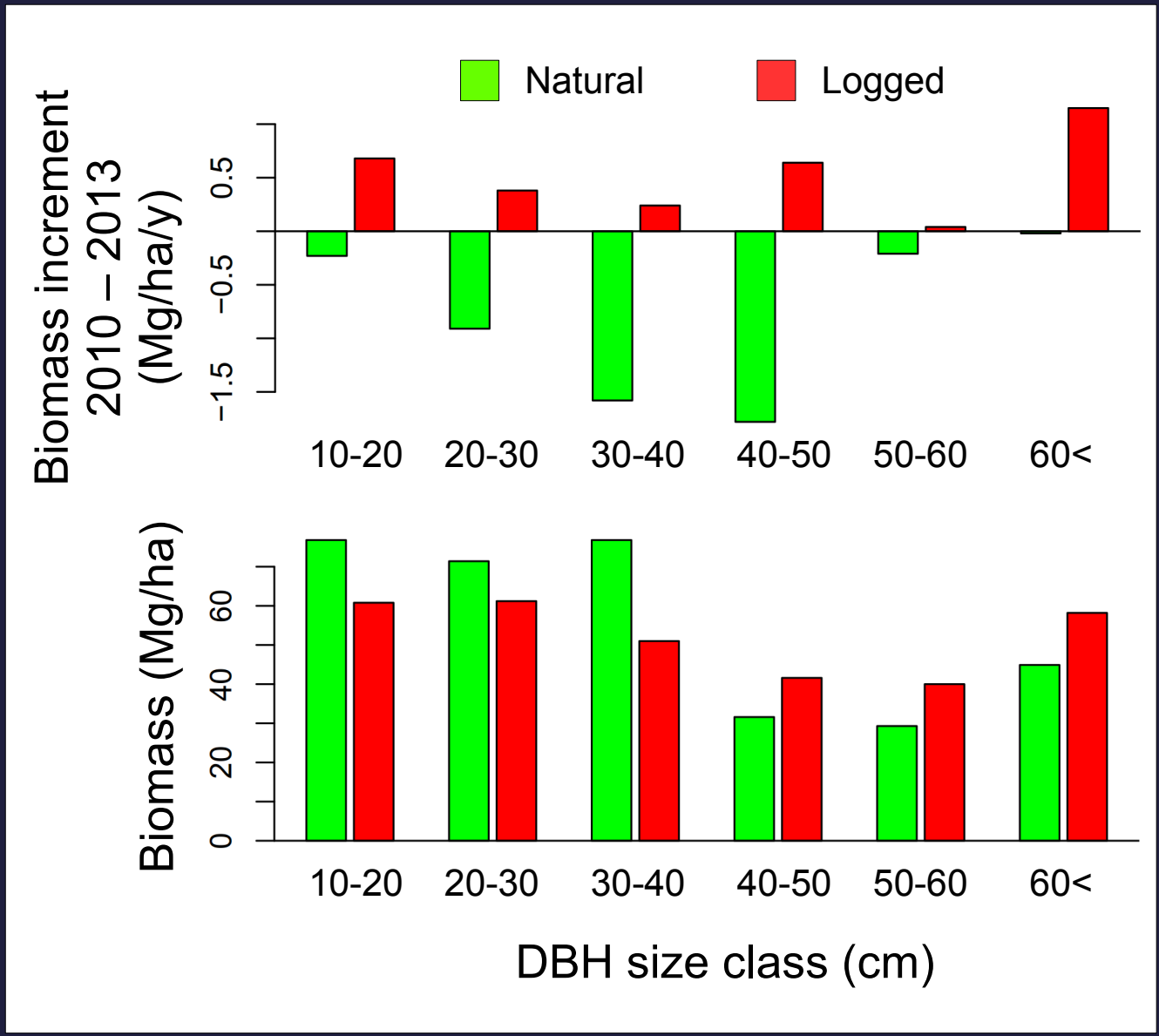
Current biomass & Biomass increment in DBH size class

Decrease of biomass due to mortality of medium sized-trees in natural forest.

Higher proportion of biomass of small- and medium-sized trees in natural forest.

Good performance of large-sized trees in logged forest.



Logging intensity vs Biomass recovery period

Record of stumps in plots

1.9 stumps /ha with diameter 61 ± 19cm

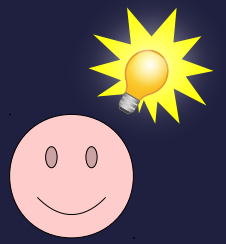
Biomass recovery 13.8 years

Paragominas, east Amazon	4.5 trees / ha → 16 years	West et al. (2014)
Paragominas, east Amazon	3 trees / ha → 15 years 6 trees / ha → 51 years 9 trees / ha → 88 years	Mazzei et al. (2010)
Para, northern Amazon	6 trees / ha → 49 years 8 trees / ha → 87 years	Sist et al. (2012)

Logging intensity should be regulated less than 3 - 4 trees /ha for sustainable use.

Longer monitoring and evaluation for bio-diversity are also required.

Conclusions



The logistic regression model showed that the logged forest with moderate harvesting intensity (<2 trees/ha) took 13.8 years to recover exploited biomass.

Even though the total amount of tree biomass has been regained after logging, biomass dynamics and structure would not be restored yet.

Logging intensity should be regulated less than several trees /ha to achieve sustainable use of forest from the view point of tree biomass.

Acknowledgments

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