Tropical forests post-logging are a persistent net carbon source to the atmosphere

M. B. Mills, Y. Malhi, R. Ewers, K.L. Kho, Y.A. Teh, S. Both, D.F.R.P Burslem, N. Majalap, R. Nilus, W. Huaraca Huasco, R. Cruz, M. Montoya Pillco, E. Turner, G. Reynolds, T. Riutta

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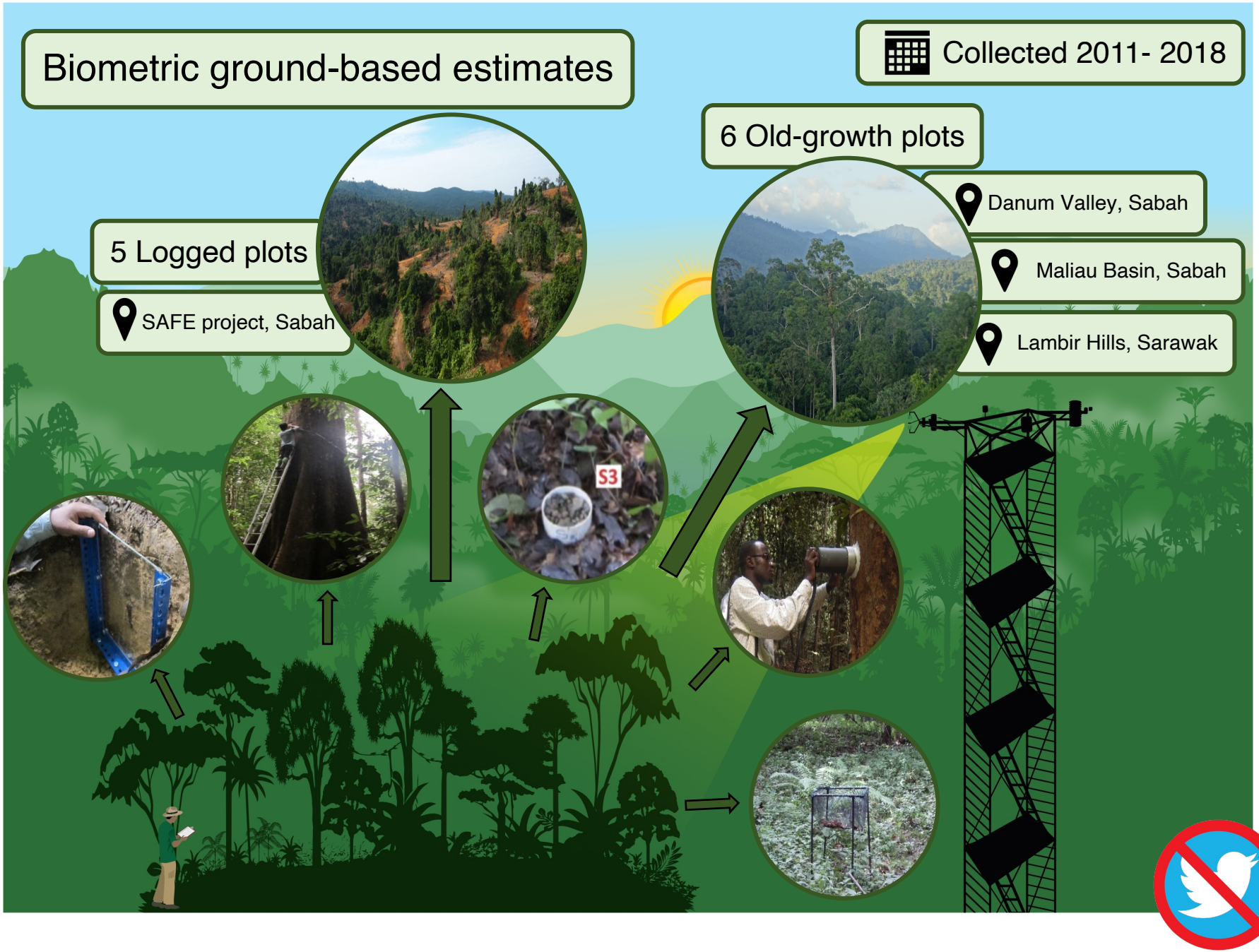
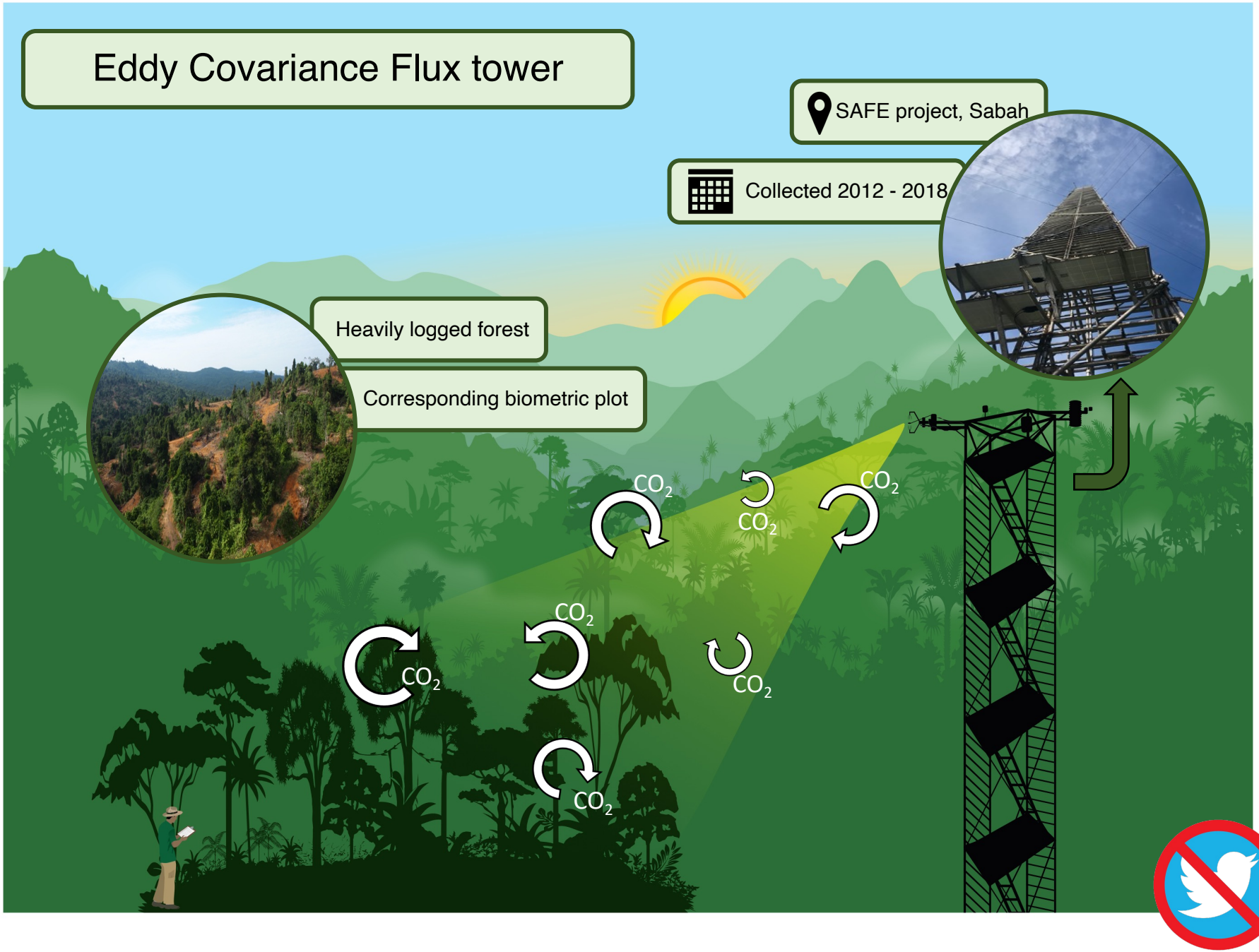
NERC SCIENCE OF THE ENVIRONMENT


Biometric ground-based estimates
Collected 2011- 2018
6 Old-growth plots
Danum Valley, Sabah
Maliau Basin, Sabah
Lambir Hills, Sarawak
5 Logged plots
SAFE project, Sabah
S3


Eddy Covariance Flux tower
SAFE project, Sabah
Collected 2012 - 2018
Heavily logged forest
Corresponding biometric plot
CO_2
CO_2
CO_2
CO_2
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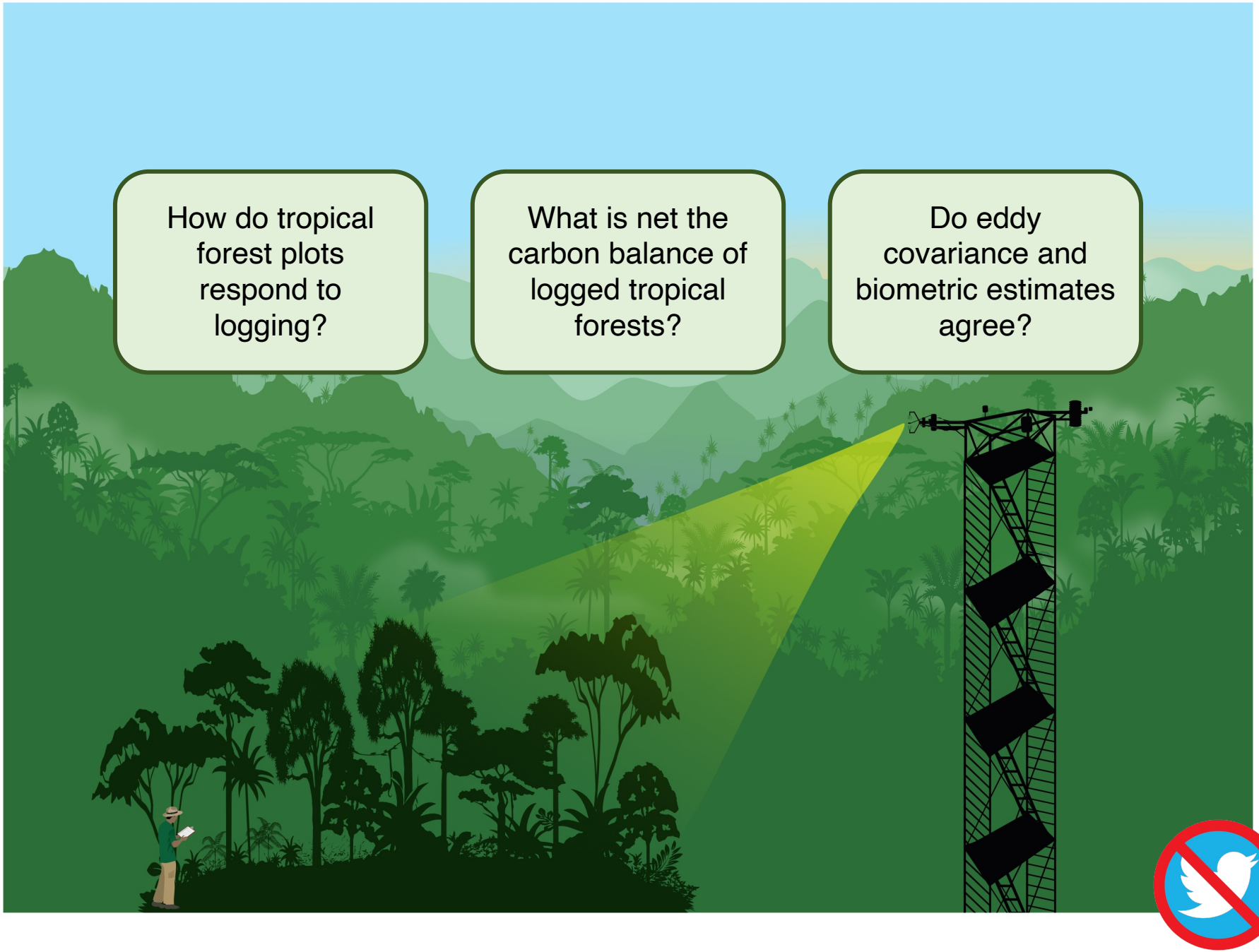
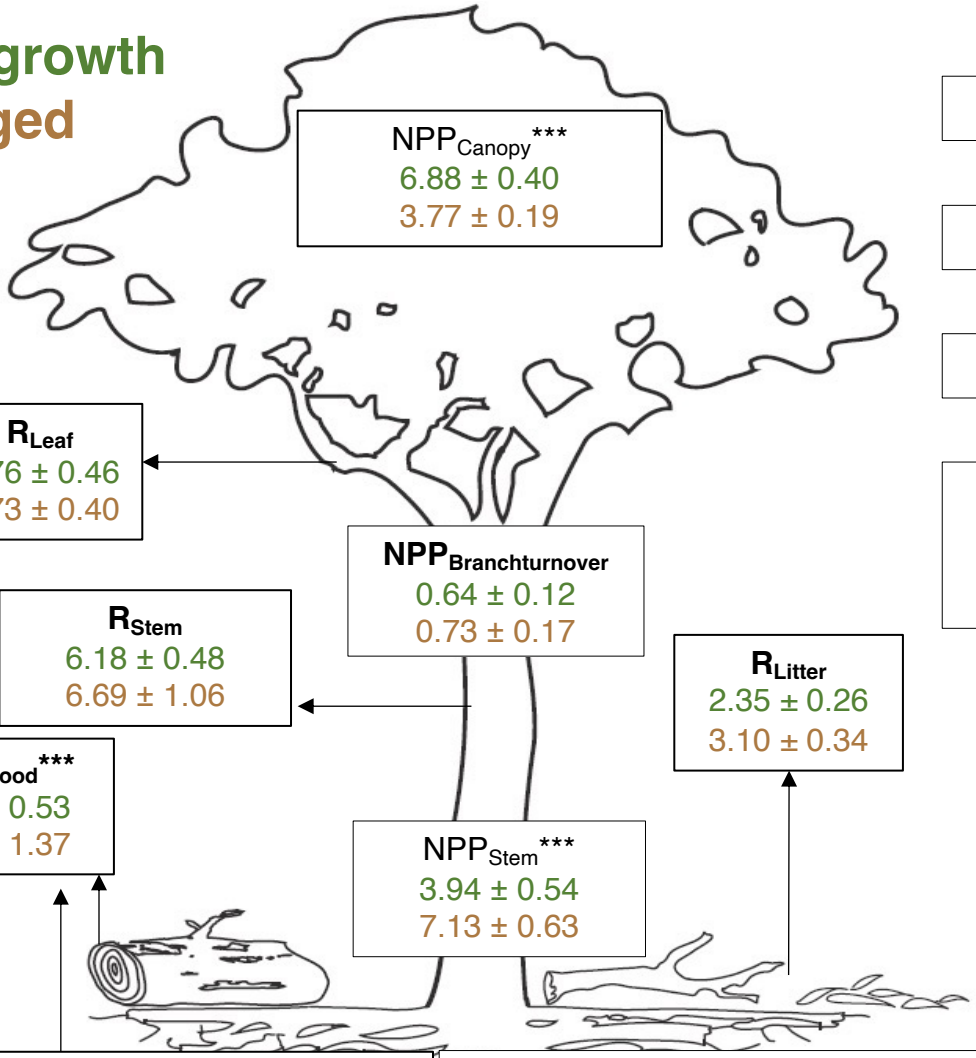
CO_2
CO_2


How do tropical forest plots respond to logging?
What is net the carbon balance of logged tropical forests?
Do eddy covariance and biometric estimates agree?

Old-growth
Logged



NPP_{Canopy}***
6.88 ± 0.40
3.77 ± 0.19

R_{Leaf}
9.76 ± 0.46
9.73 ± 0.40

$NPP_{Branchturnover}$
0.64 ± 0.12
0.73 ± 0.17

R_{Stem}
6.18 ± 0.48
6.69 ± 1.06

R_{Litter}
2.35 ± 0.26
3.10 ± 0.34

$R_{Deadwood}$*
4.25 ± 0.53
8.01 ± 1.37

NPP_{Stem}***
3.94 ± 0.54
7.13 ± 0.63

$R_{Coarseroots}$* 0.88 ± 0.12, 1.72 ± 0.22

$R_{Fineroots}$ 2.61 ± 0.09, 2.58 ± 0.65

$NPP_{Coarseroots}$* 0.95 ± 0.26, 1.91 ± 0.14

$NPP_{Fineroots}$ 1.22 ± 0.20, 1.54 ± 0.32

$NPP_{Mycorrhiza}$ 1.4 ± 0.40, 0.85 ± 0.36

NEE* -0.71 ± 1.23, 3.85 ± 1.13**

GPP = 34.46 ± 1.12, 36.64 ± 2.22

NPP = 15.03 ± 0.75, 15.93 ± 1.28

R_{eco}* 33.75 ± 0.96, 40.49 ± 1.98**
R_h* 14.32 ± 0.64, 19.78 ± 1.51**
R_a 19.43 ± 0.52, 20.71 ± 1.15

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R_{SOM}* 6.32 ± 0.39, 7.82 ± 0.32**

Old-growth
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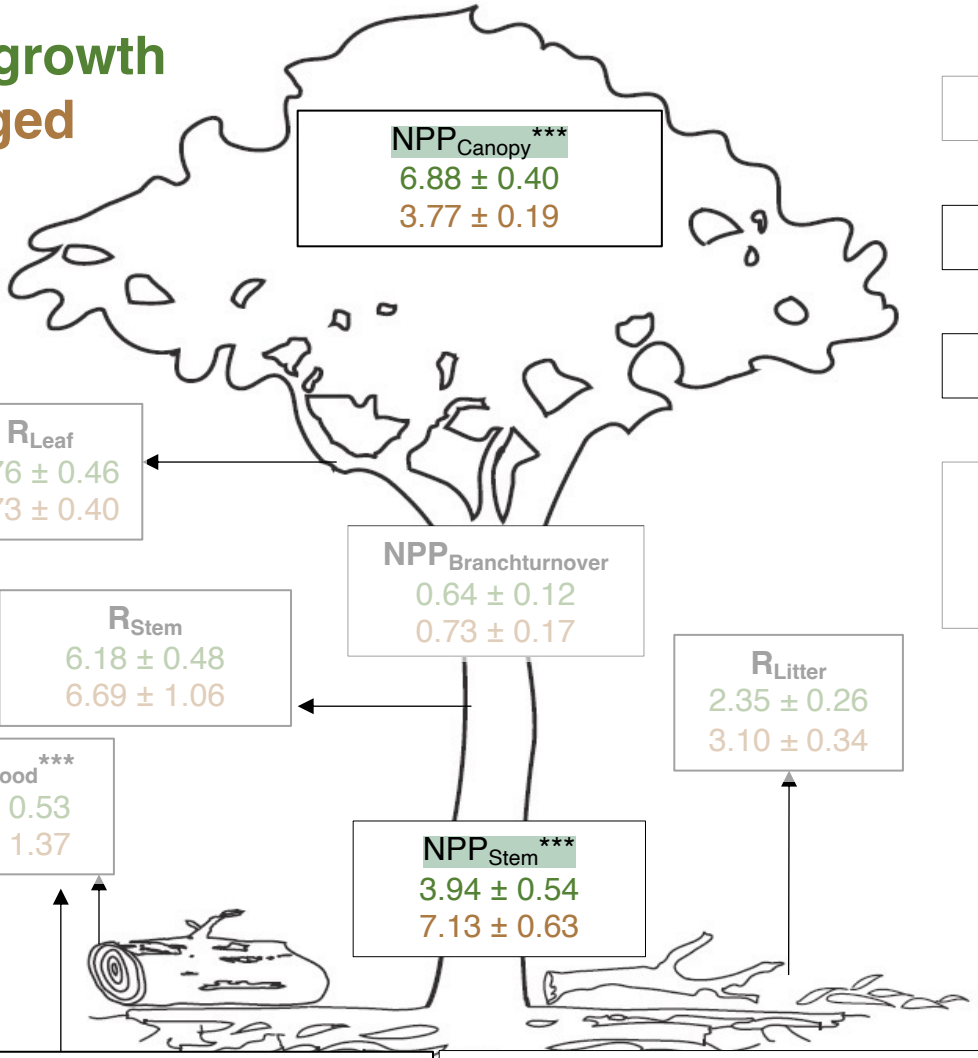

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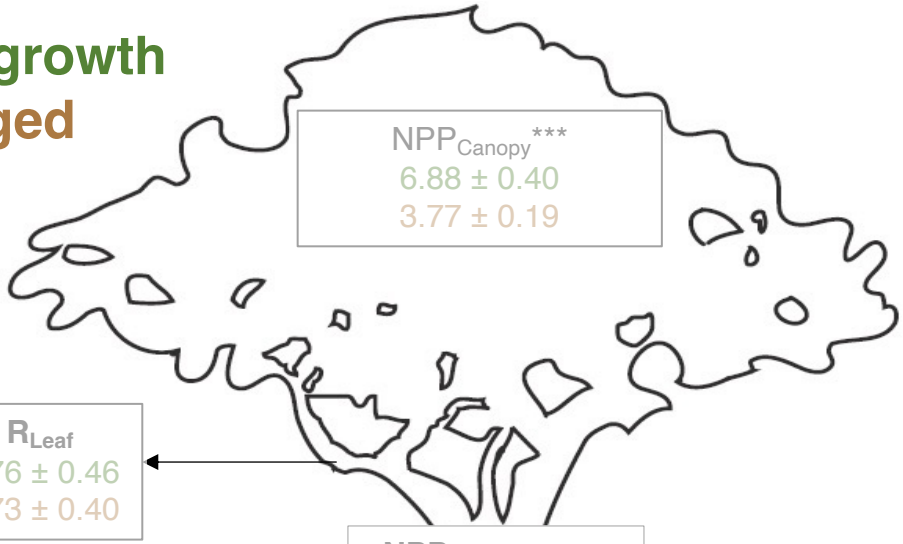

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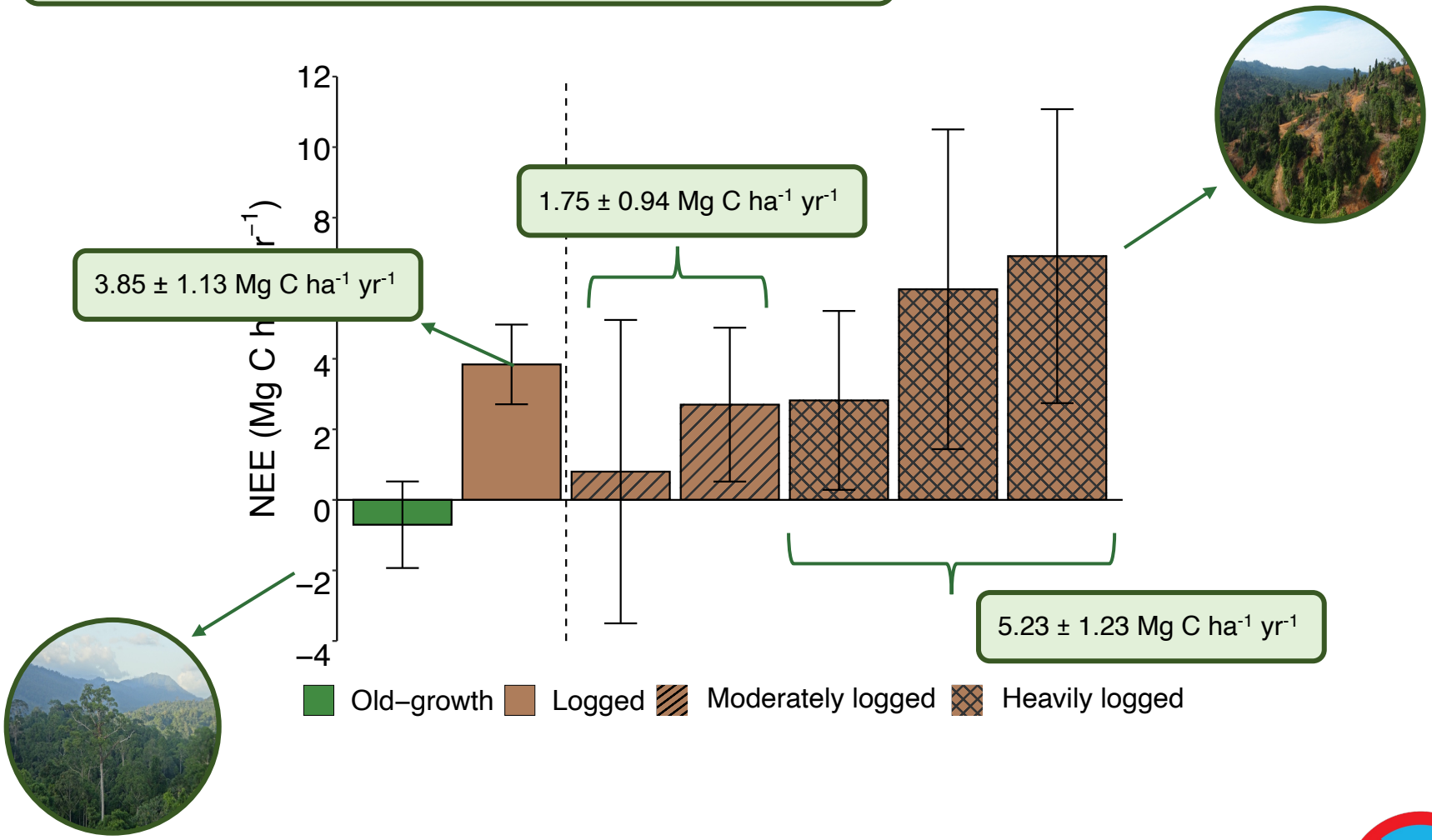
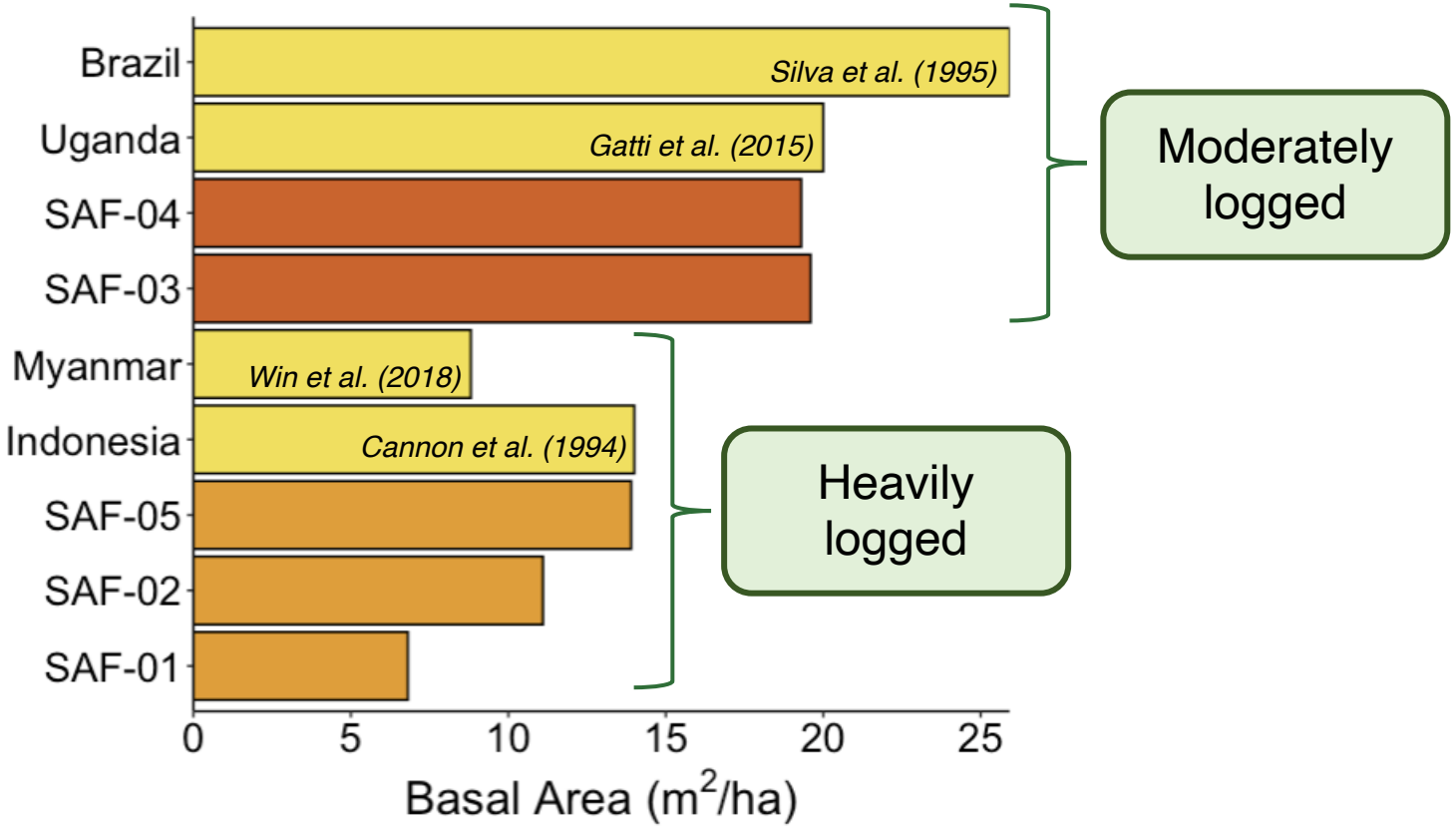
Carbon balance in logged forests

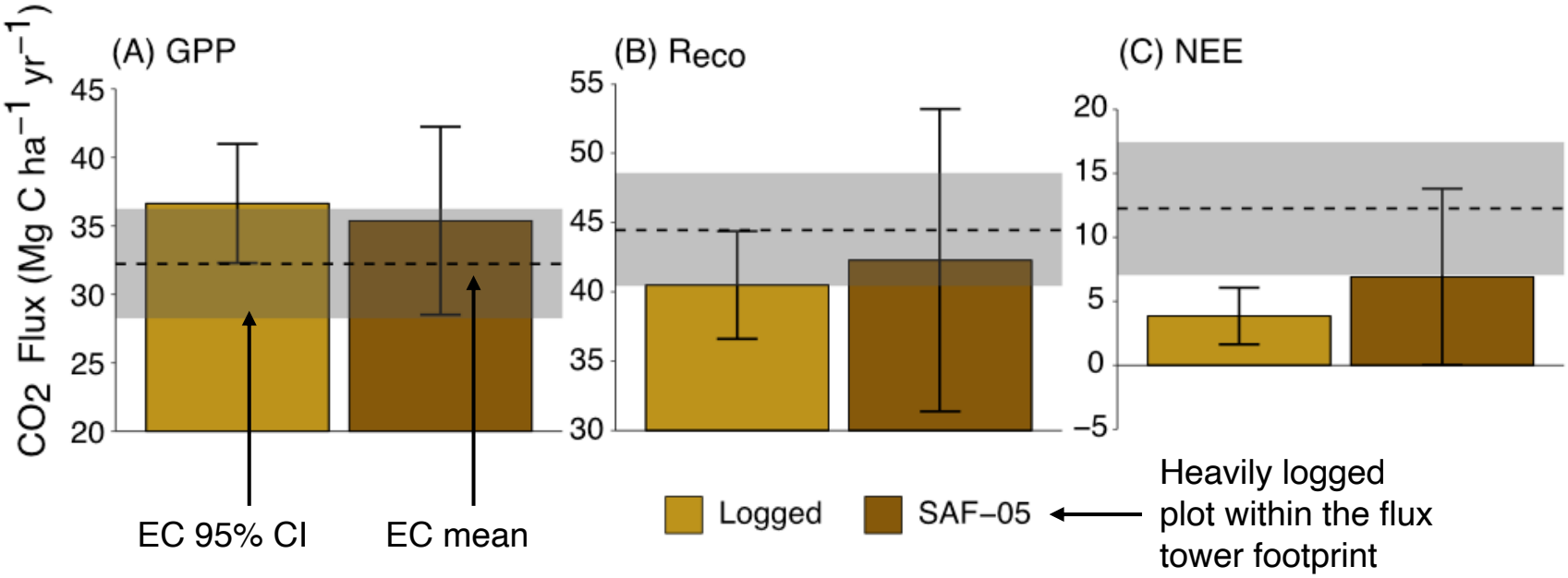


Is this landscape representative?



Silva, J. N. M. et al. (1995) Forest Ecology and Management 71, 267–274
Gatti, C. R. et al. (2015) Ecological Research, 30, 119– 132
Win, Z. C. et al. (2018) Journal of Forest Planning 23, 1–8
Cannon, C. H. et al. (1994). Forest Ecology and Management 67, 49–68

Eddy Covariance and Biometric



"EC and BM provide different estimates of NEE, but comparable ecosystem respiration and gross primary production for forest ecosystems globally" Campioli et al (2016)

Summary of findings

1. Logged forests are as productive as old-growth forests, but…
2. Logged are a persistent net source of carbon due to losses from R_h
3. EC and biometric estimates have good agreement for GPP and R_{eco} but less so for NEE, as expected

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