

From source to sink: Tracing the effects of natural disturbance on tropical forest carbon balance

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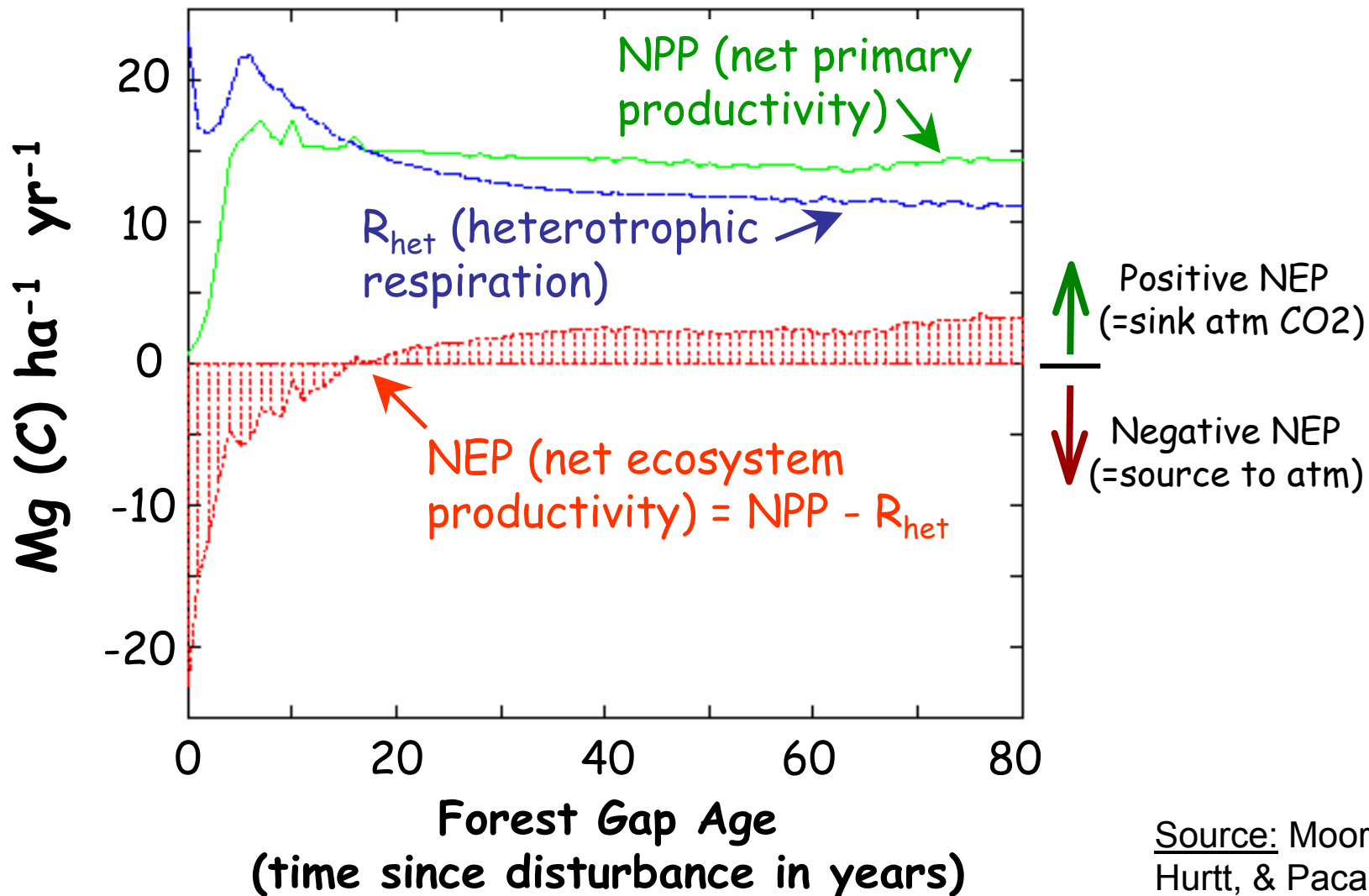
How do we estimate large-scale
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(given that disturbance is intrinsic
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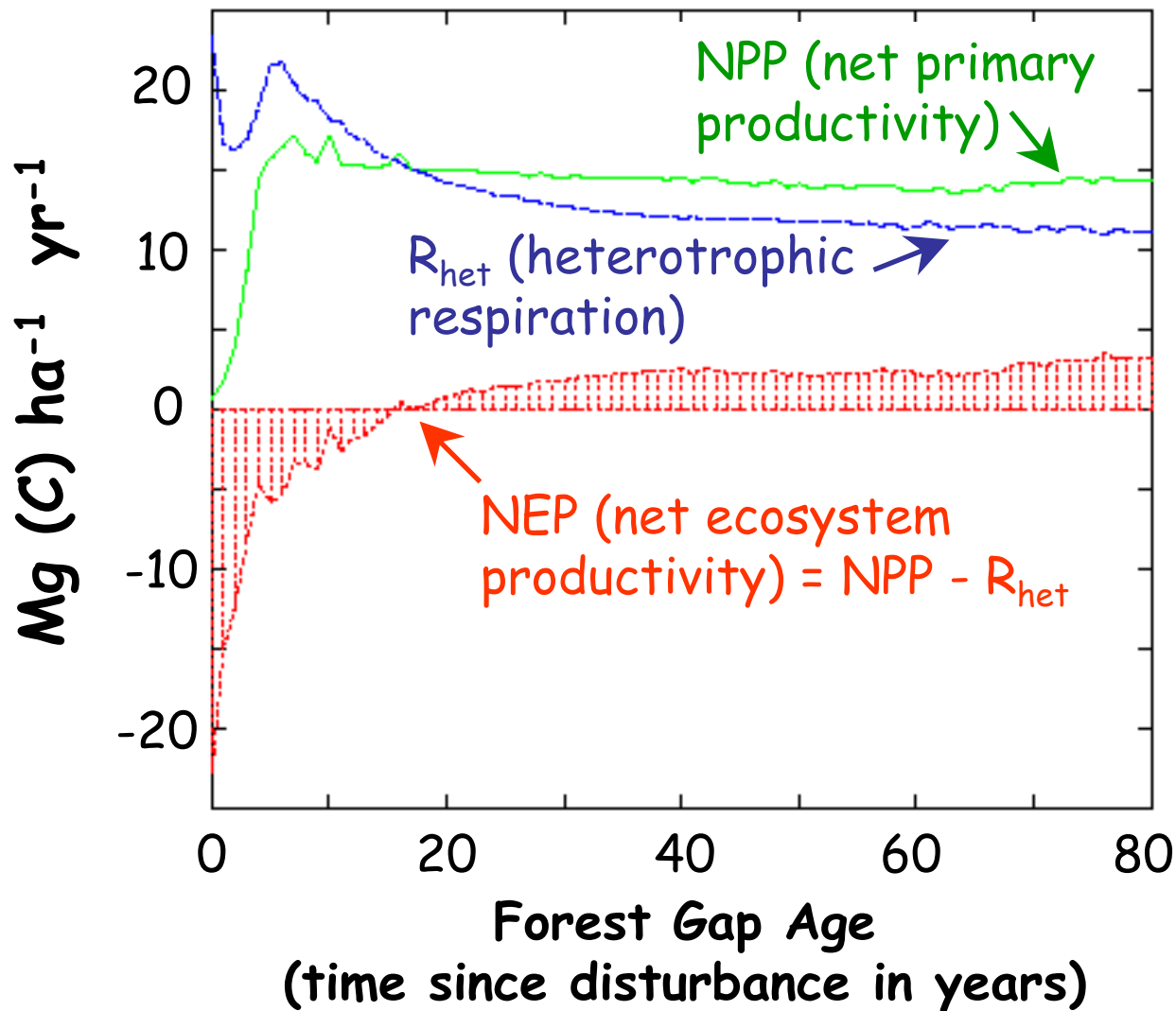
- I. Introduction: Two sub-questions
- II. Prior findings from an eddy flux study: disturbance-induced carbon loss in old-growth forest?
- III. A preliminary test of predictions from prior findings
- IV. Conclusion: Understanding disturbance

Introduction: Modeled carbon flux following disturbance in gap of "balanced-biosphere" Amazon rainforest



Source: Moorcroft,
Hurtt, & Pacala (2001)

Introduction: Modeled carbon flux following disturbance in gap of “balanced-biosphere” Amazon rainforest

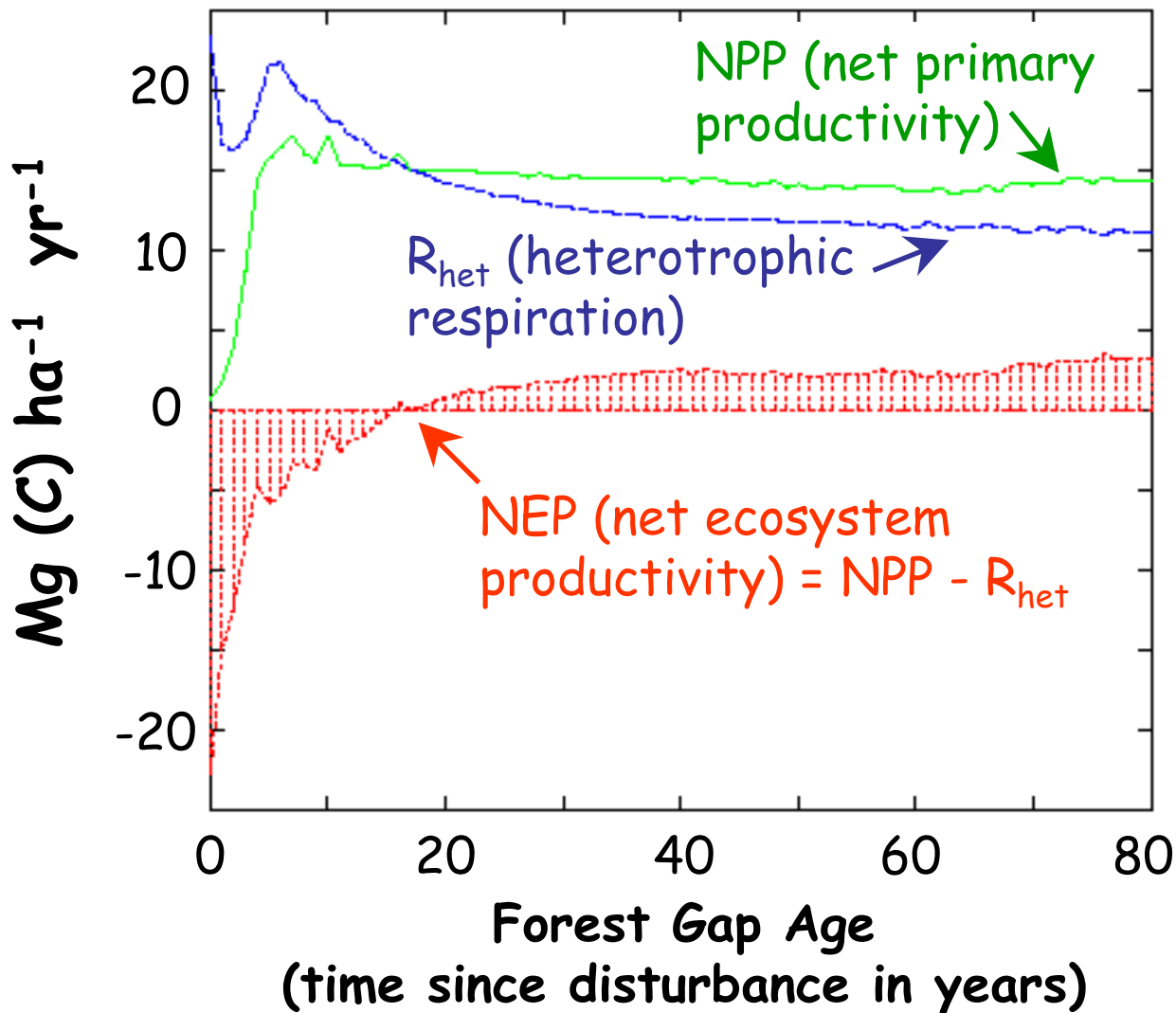


Key point:

- Landscape in carbon balance, but...
- Individual gaps may never be in carbon balance

What is large-scale Carbon balance?

Two sub-questions:

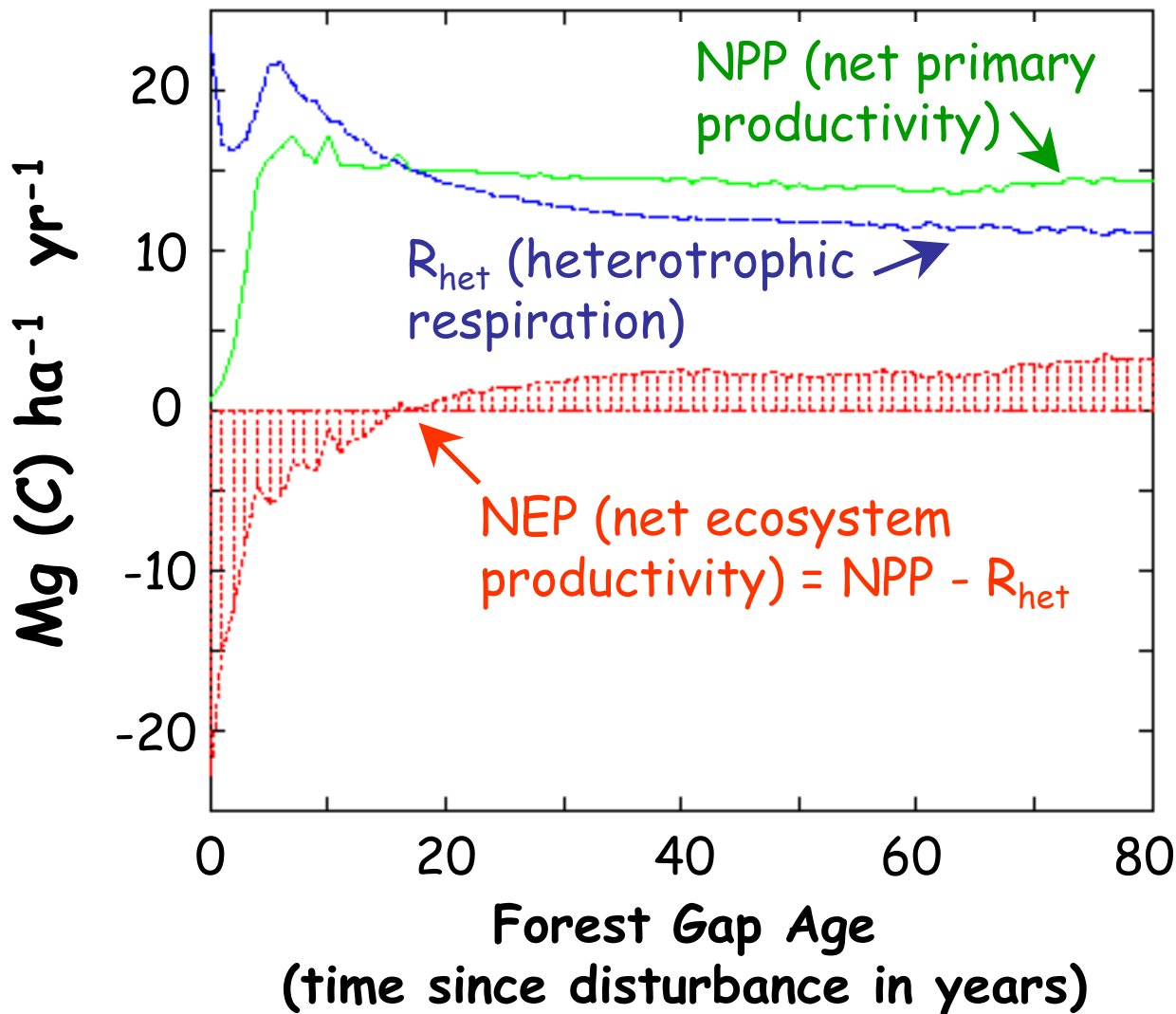


(1) What is the distribution of gap ages across the landscape?

(2) What are the detailed dynamics of forest response to disturbance?

What is large-scale Carbon balance?

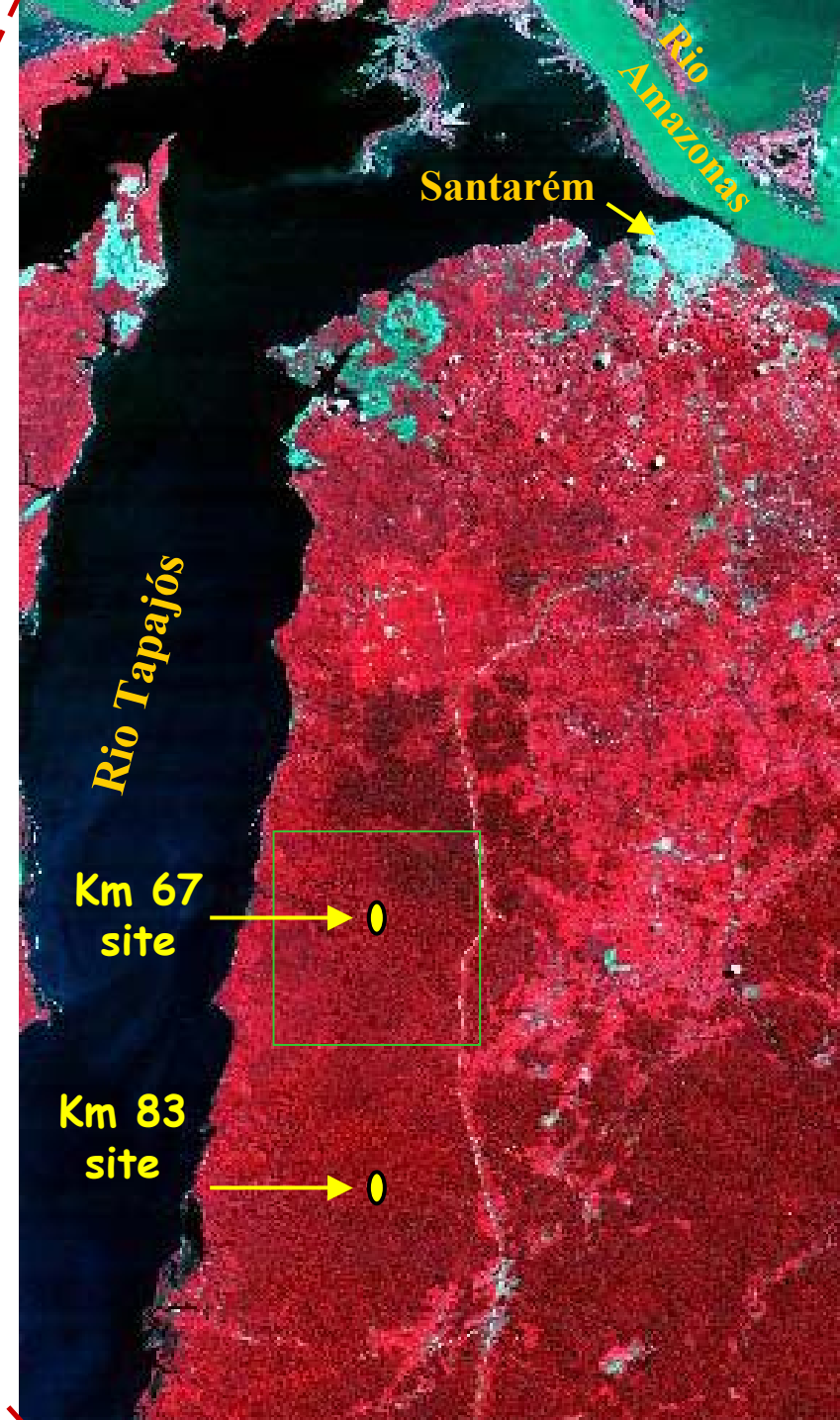
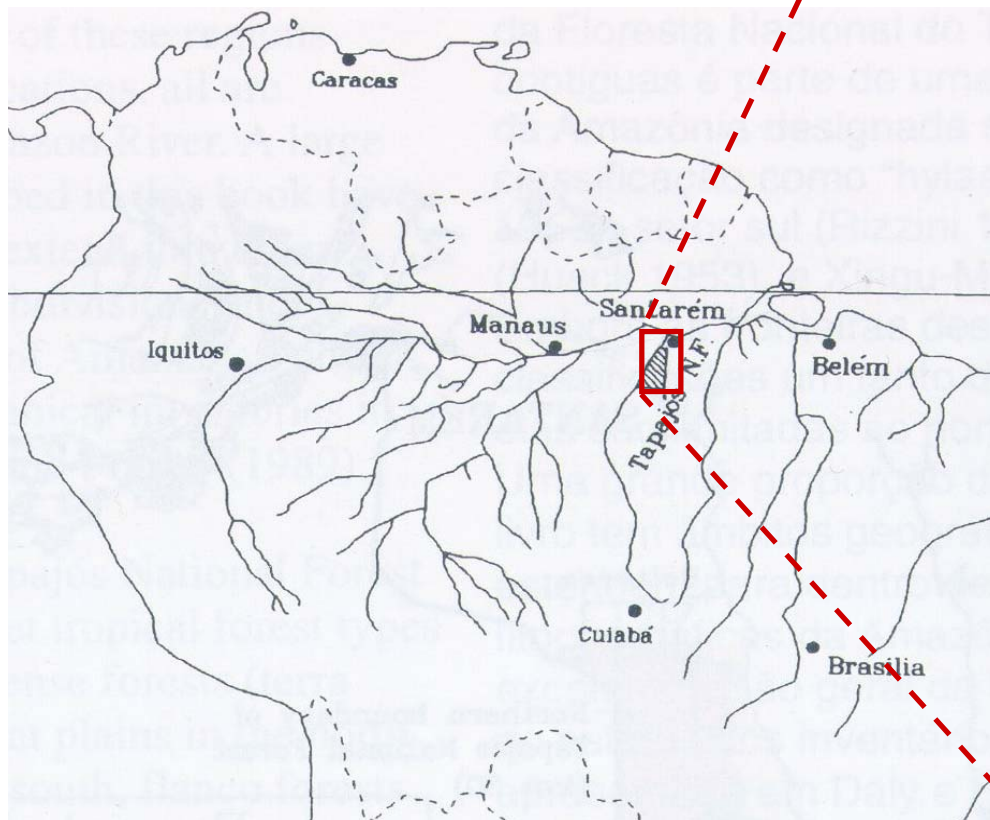
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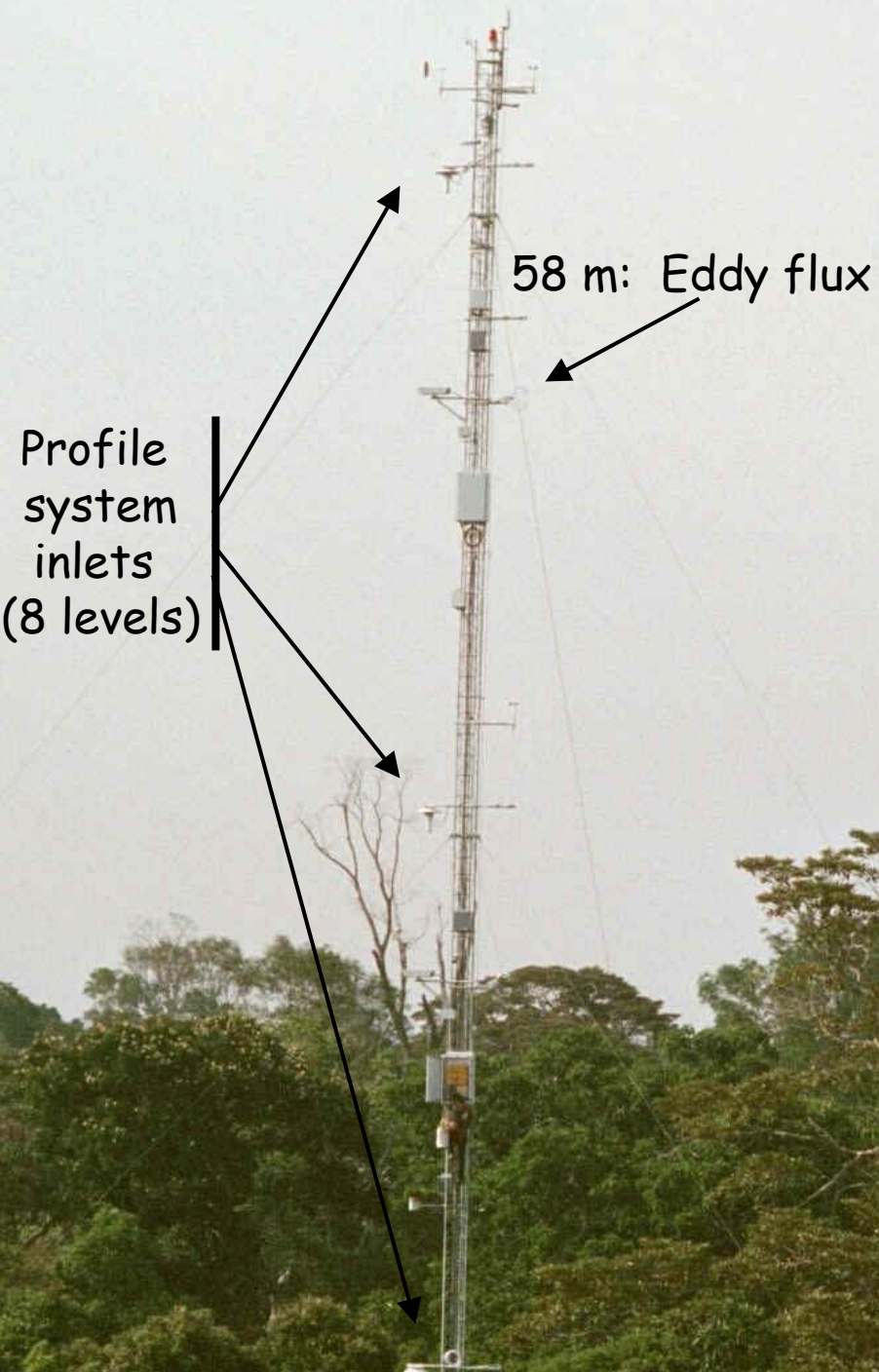
~~(1) What is the distribution of gap ages across the landscape?~~
(see Jeff Chambers talk coming up...)

(2) What are the detailed dynamics of forest response to disturbance?

LBA project near Santarém: Controls on Carbon Balance in the Tapajós National Forest, Brazil



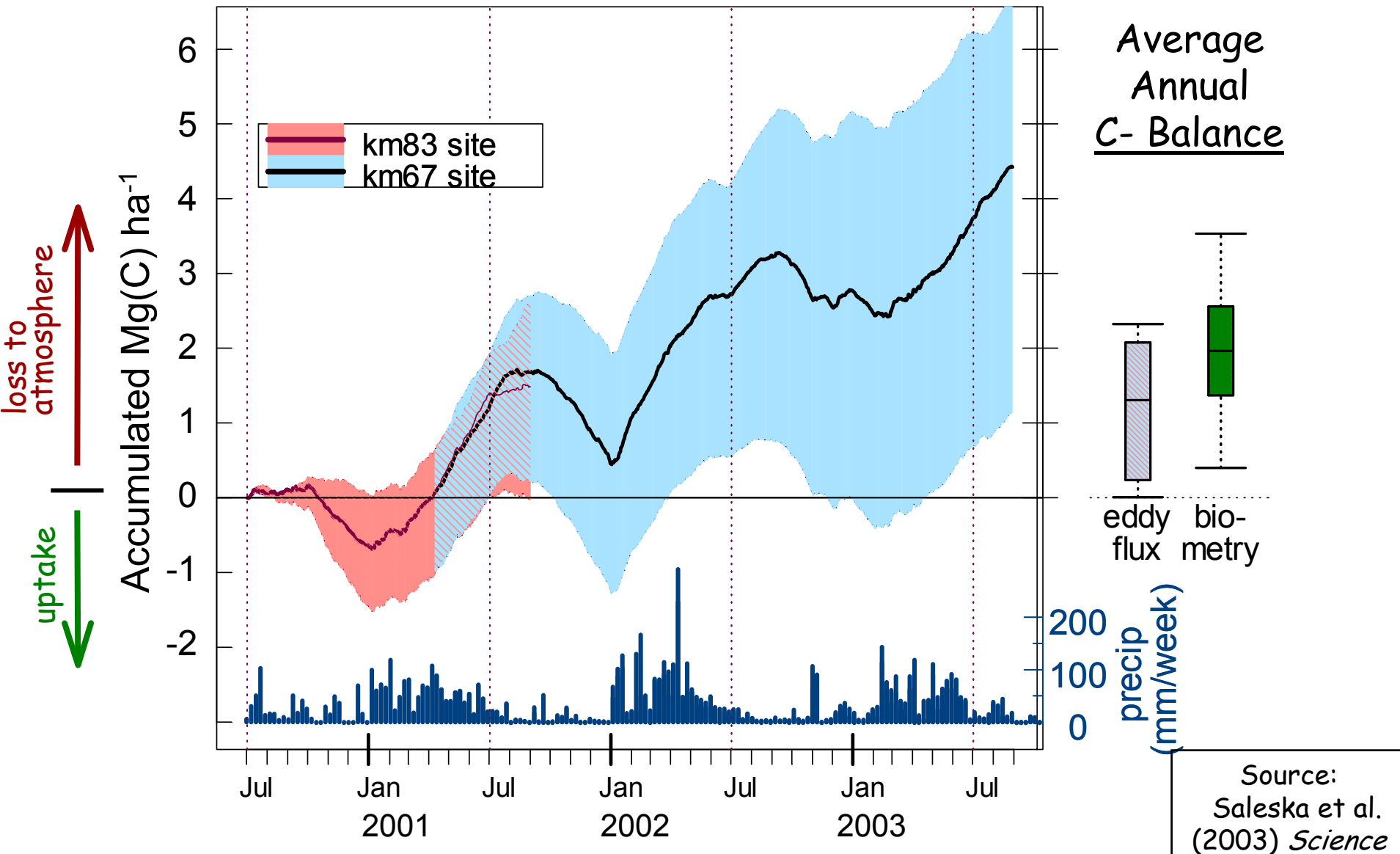
Methods



(1) Eddy Flux: 64m tall tower at Km67 in Tapajos forest

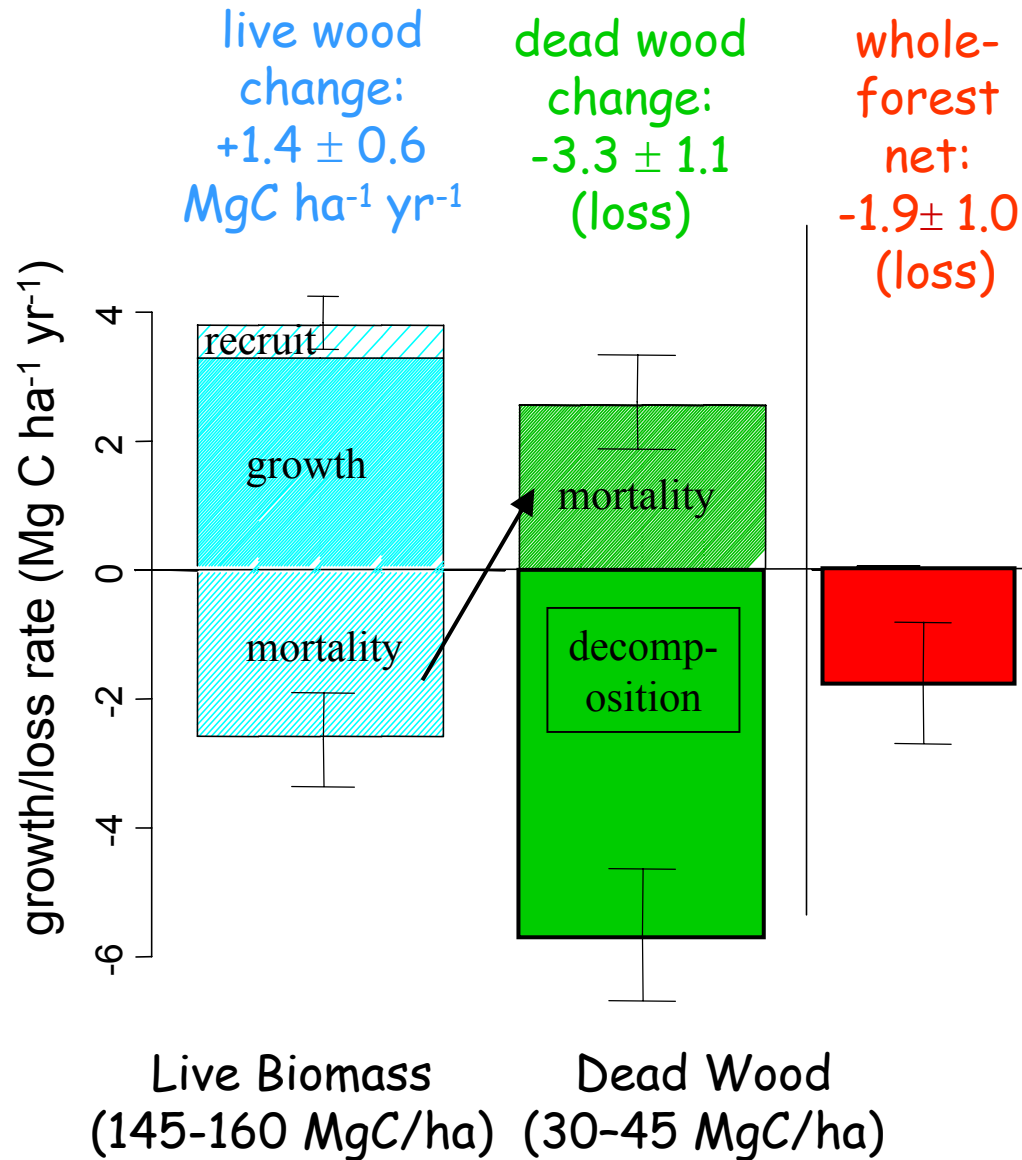
(2) Biometry: ~3000 trees and dead wood measured in 20 ha in footprint of eddy tower

Prior findings 1: eddy flux measurement show net loss of C in Tapajos National forest of Amazônia,



Prior findings 2: Carbon fluxes to biomass and dead wood → suggests C-loss is transient consequence of disturbance

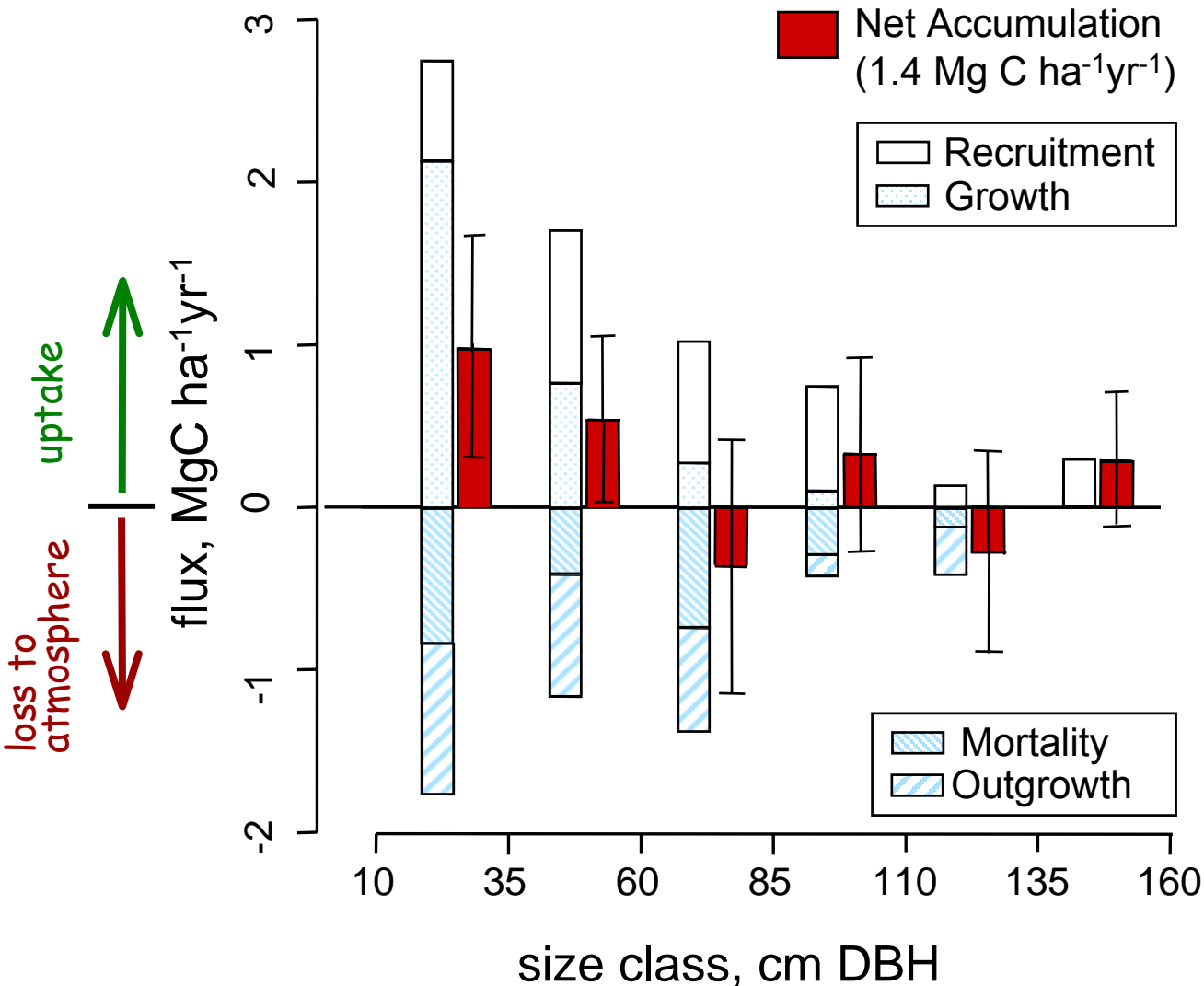
net C loss | net C uptake



Two observations suggest disturbance-recovery process:

(1) The balance for live wood and dead wood is in opposite directions

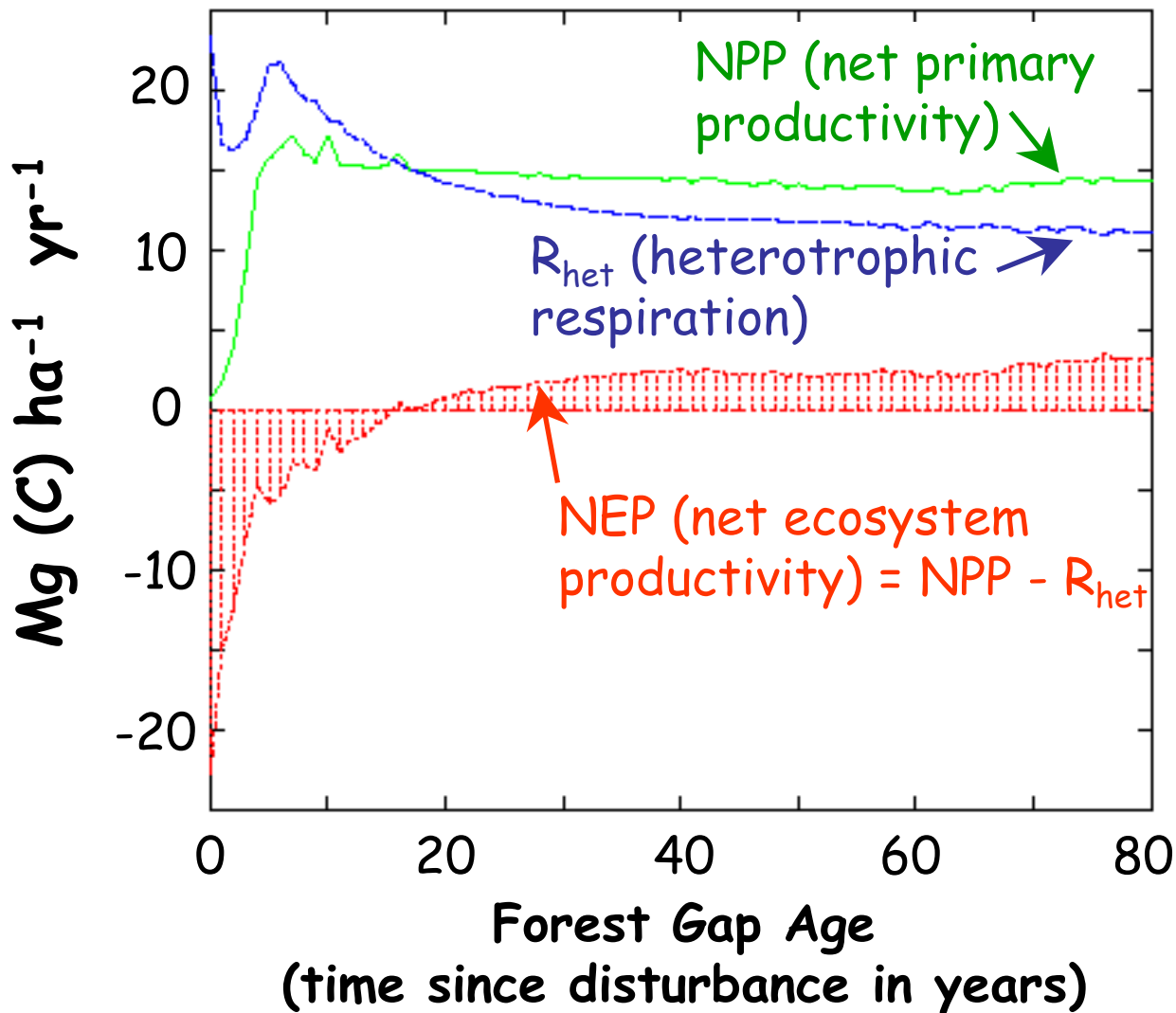
Prior findings 2: Carbon fluxes to biomass *by size-class*
→ suggests C-loss is transient consequence of disturbance



Observation 2:

Demographic shift:
The increase in flux
to biomass is
in the smaller size
classes

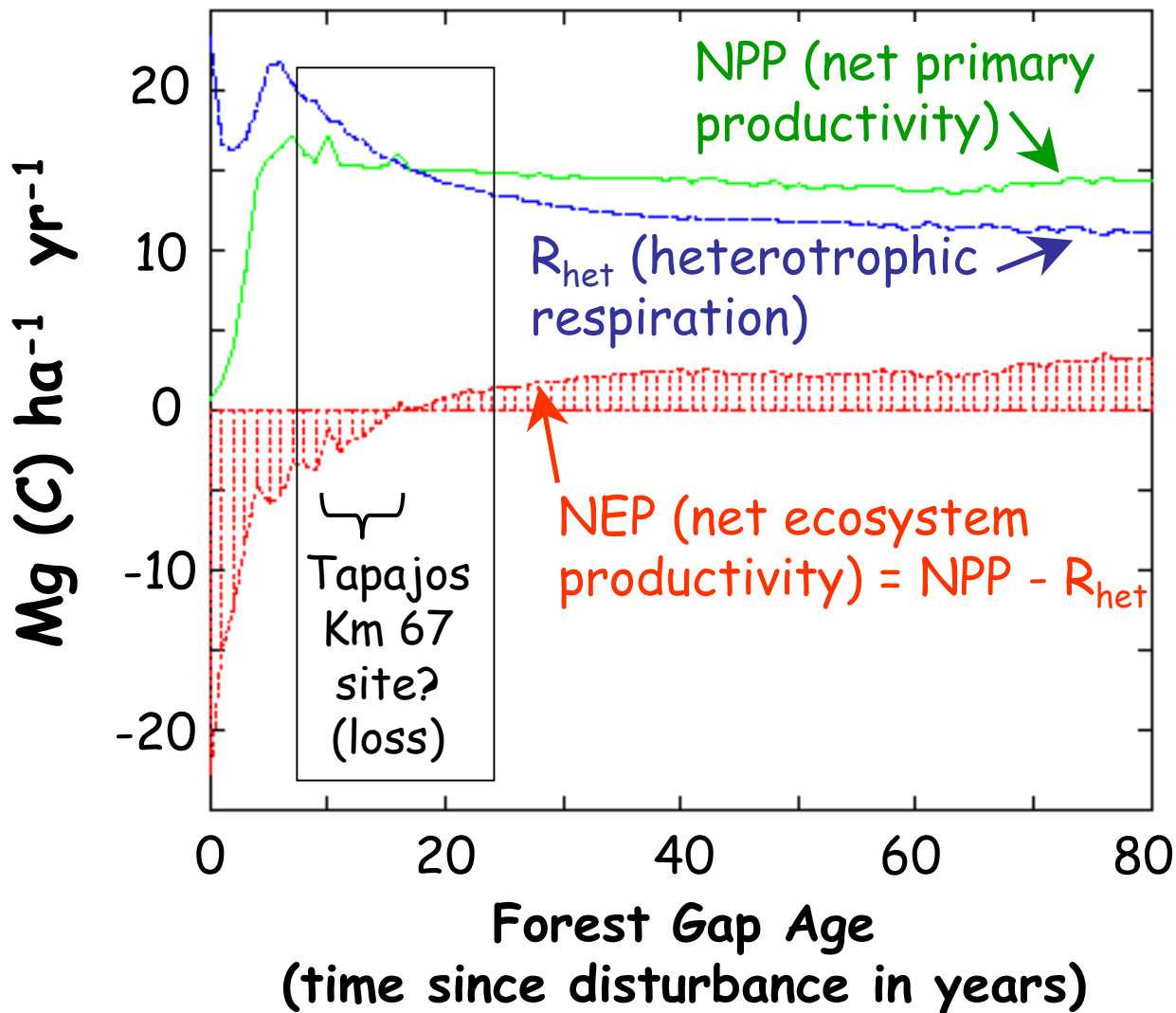
Predictions for continued observations following disturbance



~~(1) What is the distribution of gap ages across the landscape?~~

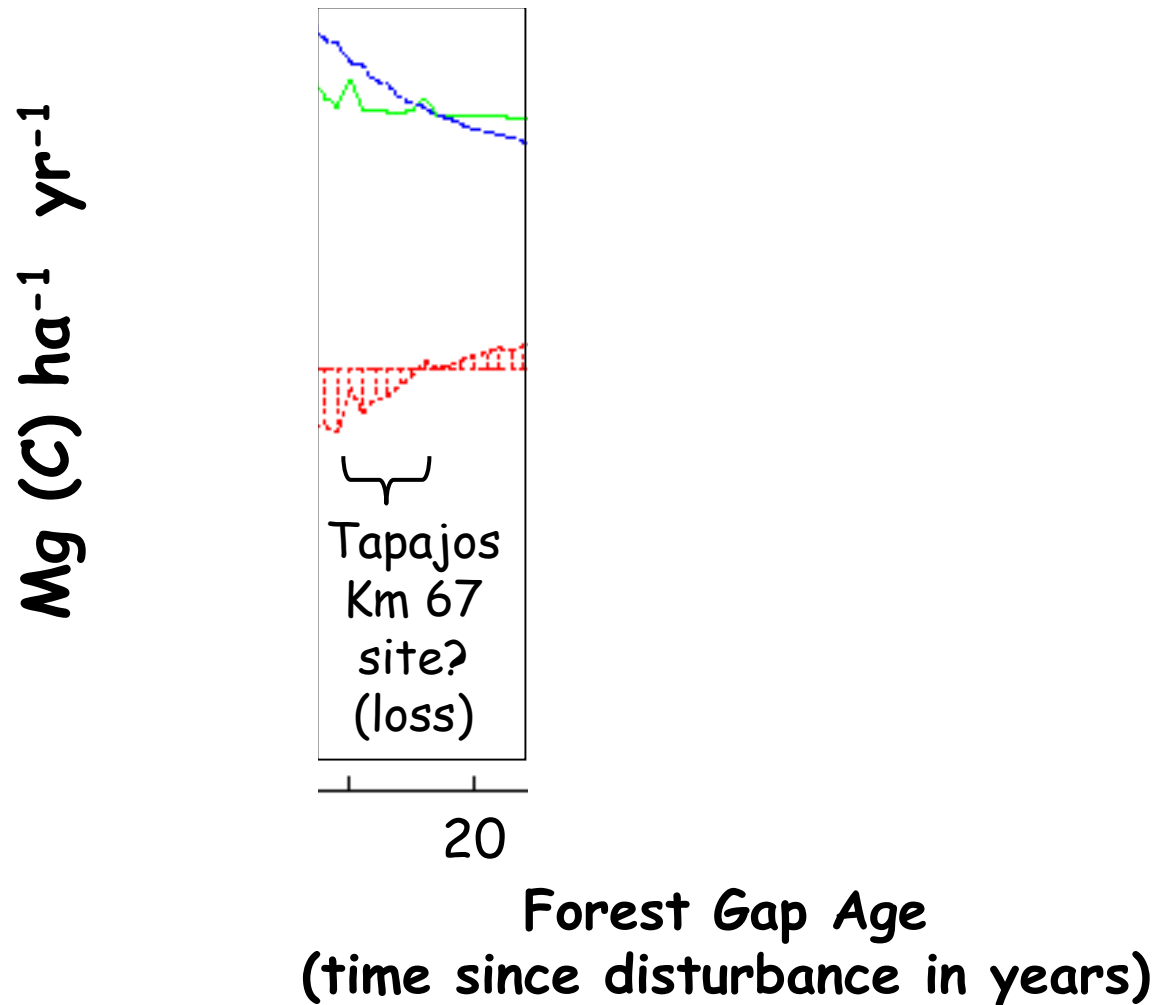
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Predictions for continued observations following disturbance

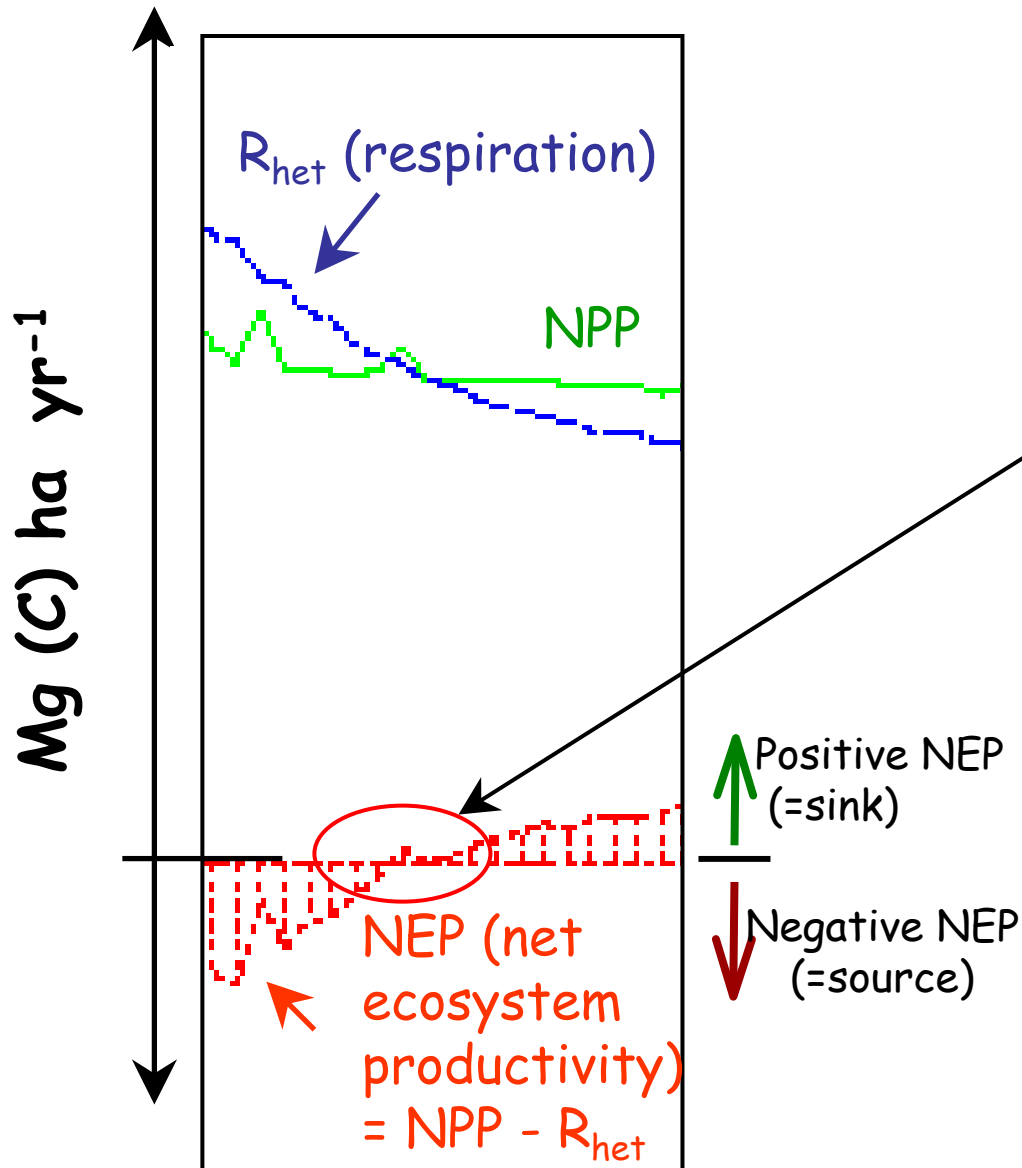


(2) What are the detailed dynamics of forest response to disturbance?

Predictions for continued observations following disturbance



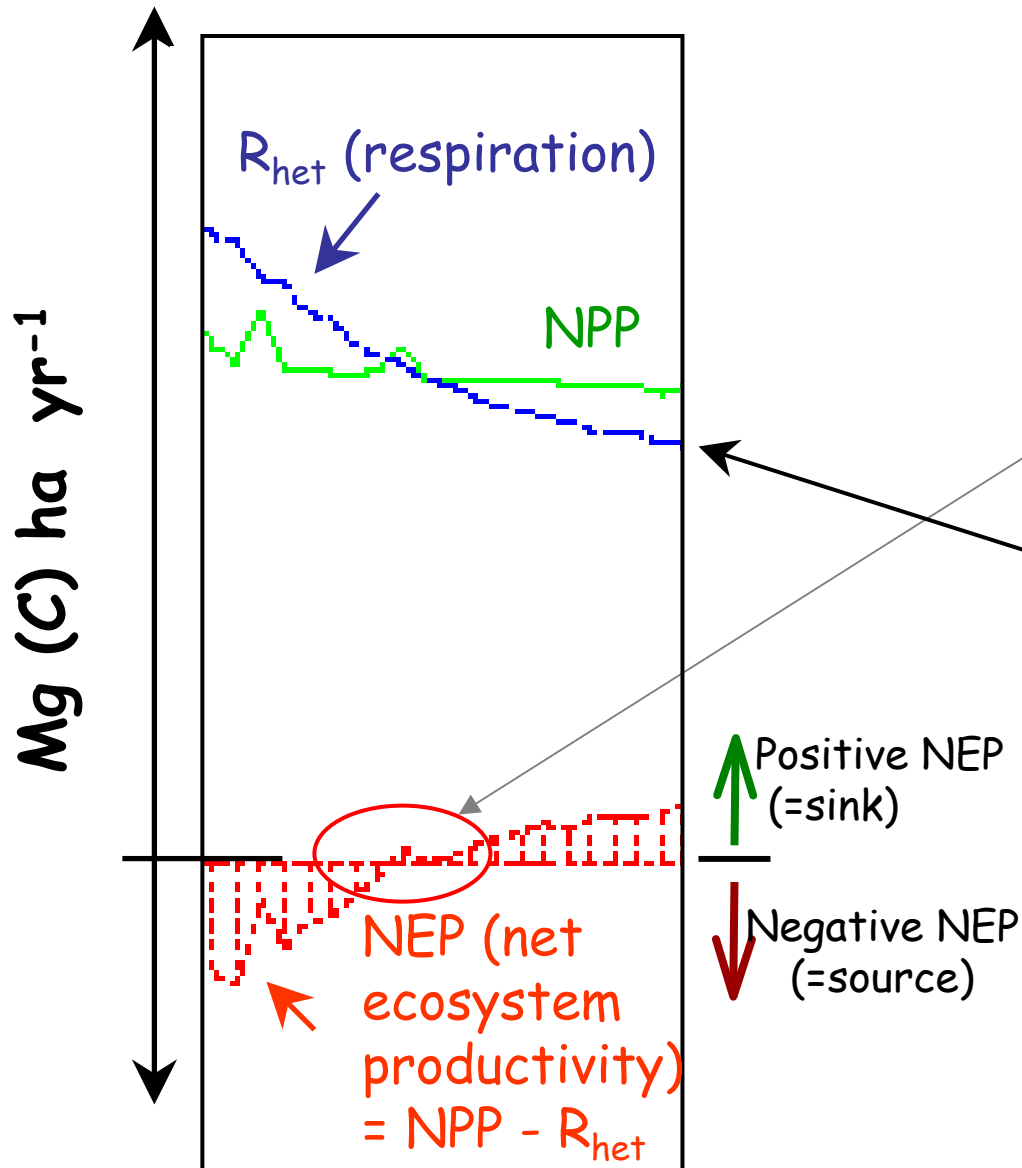
Predictions for continued observations following disturbance



(1) Whole-Ecosystem flux Predictions

(a) NEP should move from source to sink

Predictions for continued observations following disturbance



(1) Whole-Ecosystem flux Predictions

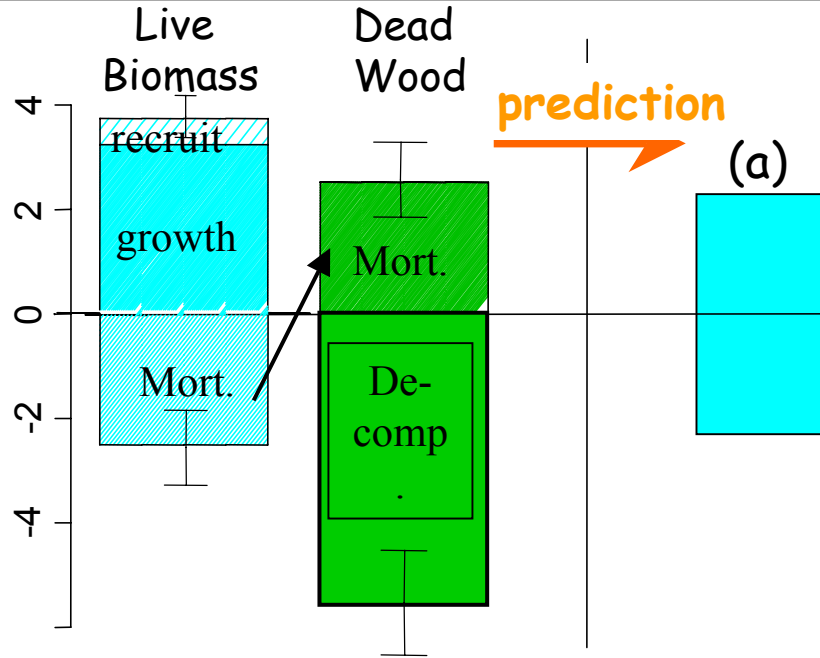
(a) NEP should move from source to sink

(b) Due to decline in respiration
(as deadwood substrate decays away)

Predictions for continued observations following disturbance

net C loss | net C uptake

growth/loss rate

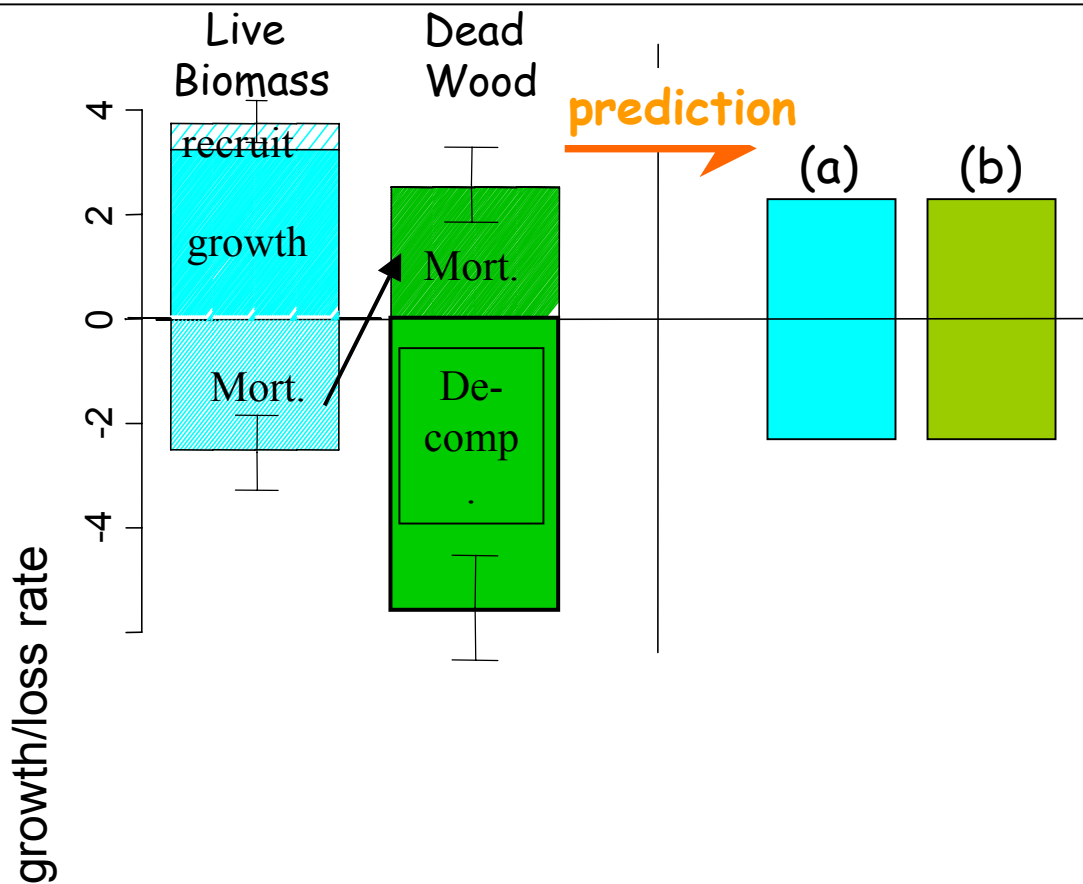


(2) Forest Demography Predictions

(a) Shift from uptake towards balance in live biomass (i.e. decrease in growth/ recruitment, increase in mortality)

Predictions for continued observations following disturbance

net C loss | net C uptake



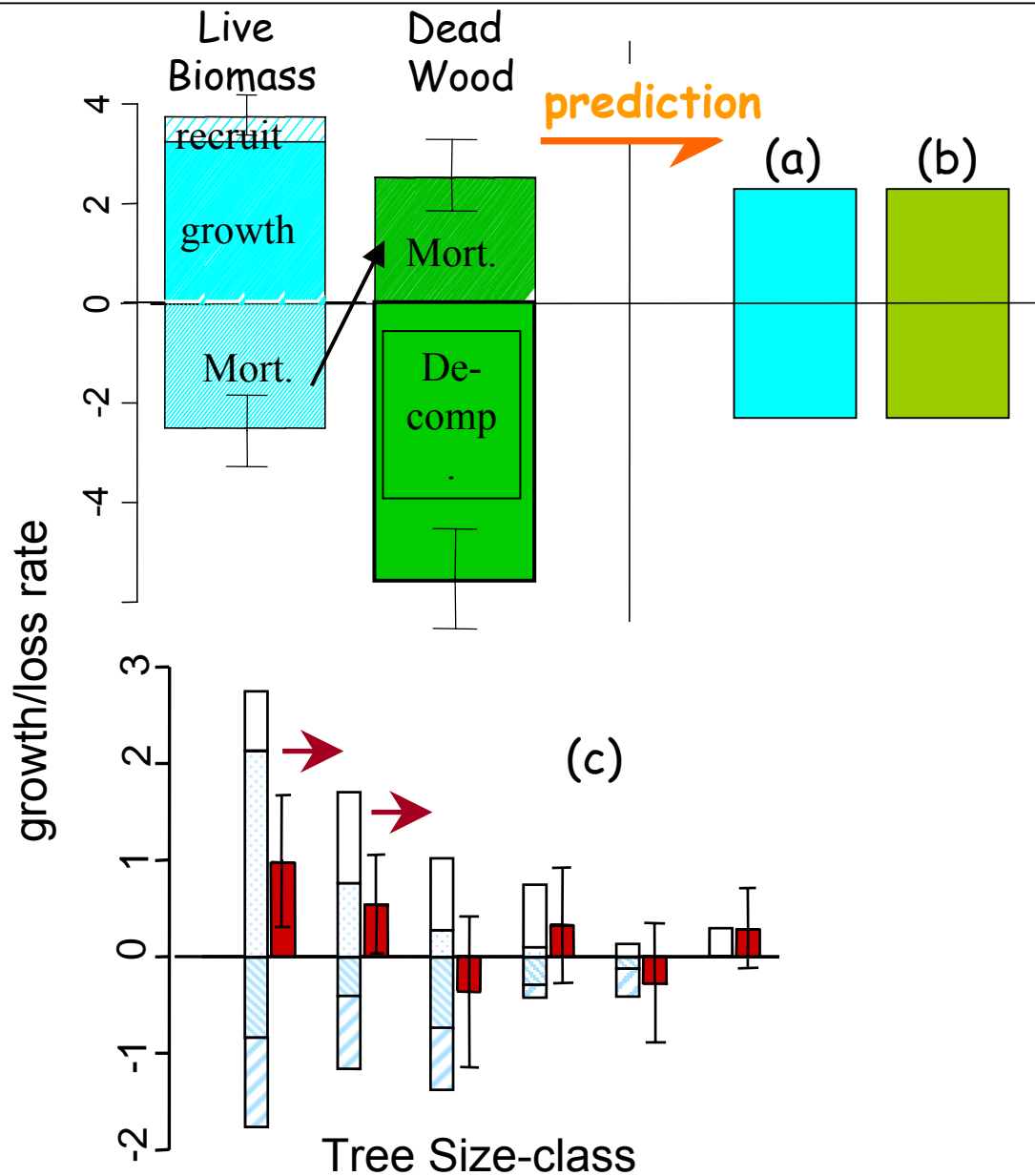
(2) Forest Demography Predictions

(a) Shift from uptake towards balance in live biomass (i.e. decrease in growth/ recruitment, increase in mortality)

(b) Shift from loss towards balance in dead wood

Predictions for continued observations following disturbance

net C loss | net C uptake



(2) Forest Demography Predictions

(a) Shift from uptake towards balance in live biomass (i.e. decrease in growth/ recruitment, increase in mortality)

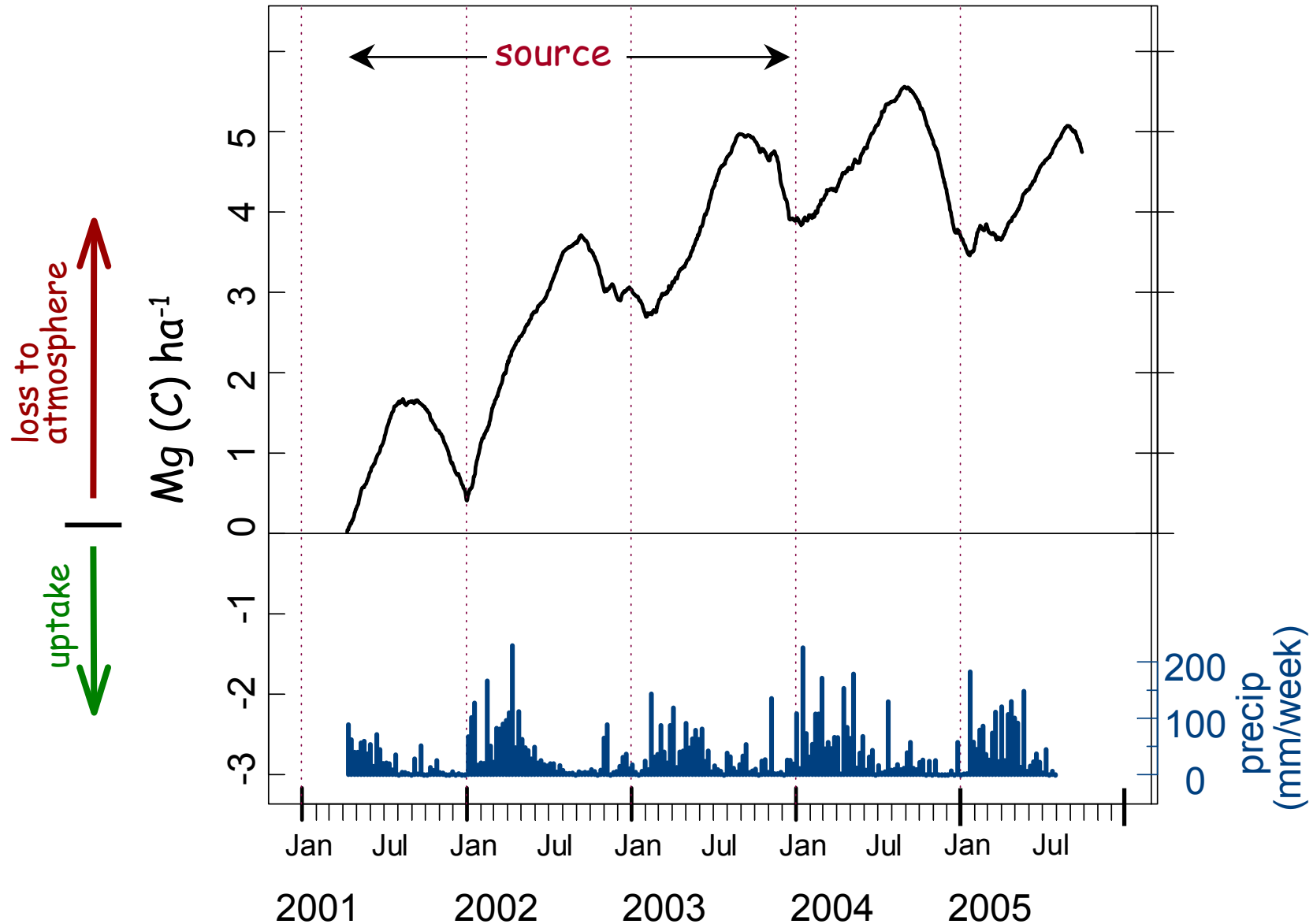
(b) Shift from loss towards balance in dead wood

(c) Shift in tree growth from smaller to middle size classes

III. Test of predictions with new observations

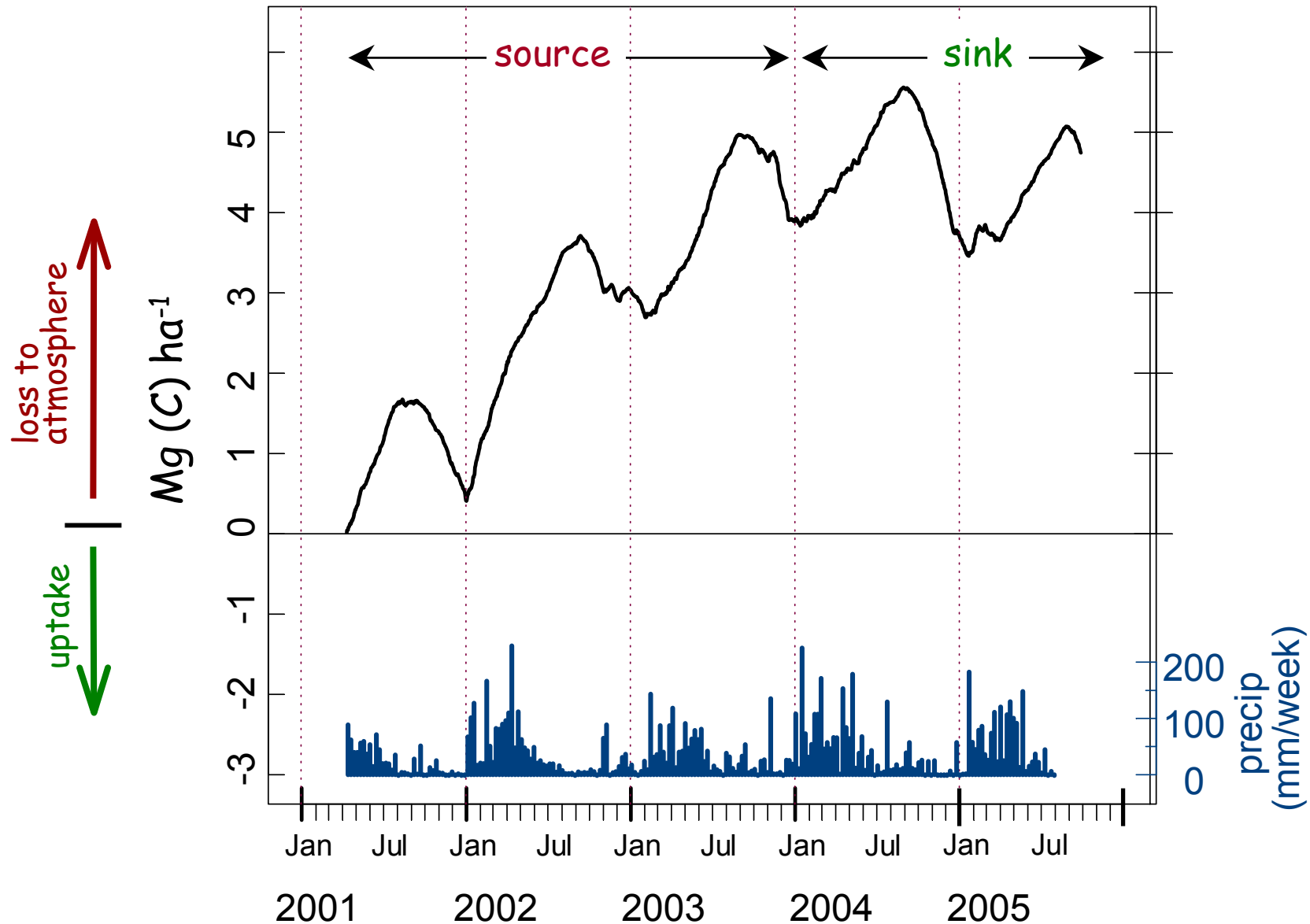
Test of predictions

Cumulative km67 Carbon Flux, 2001-2005



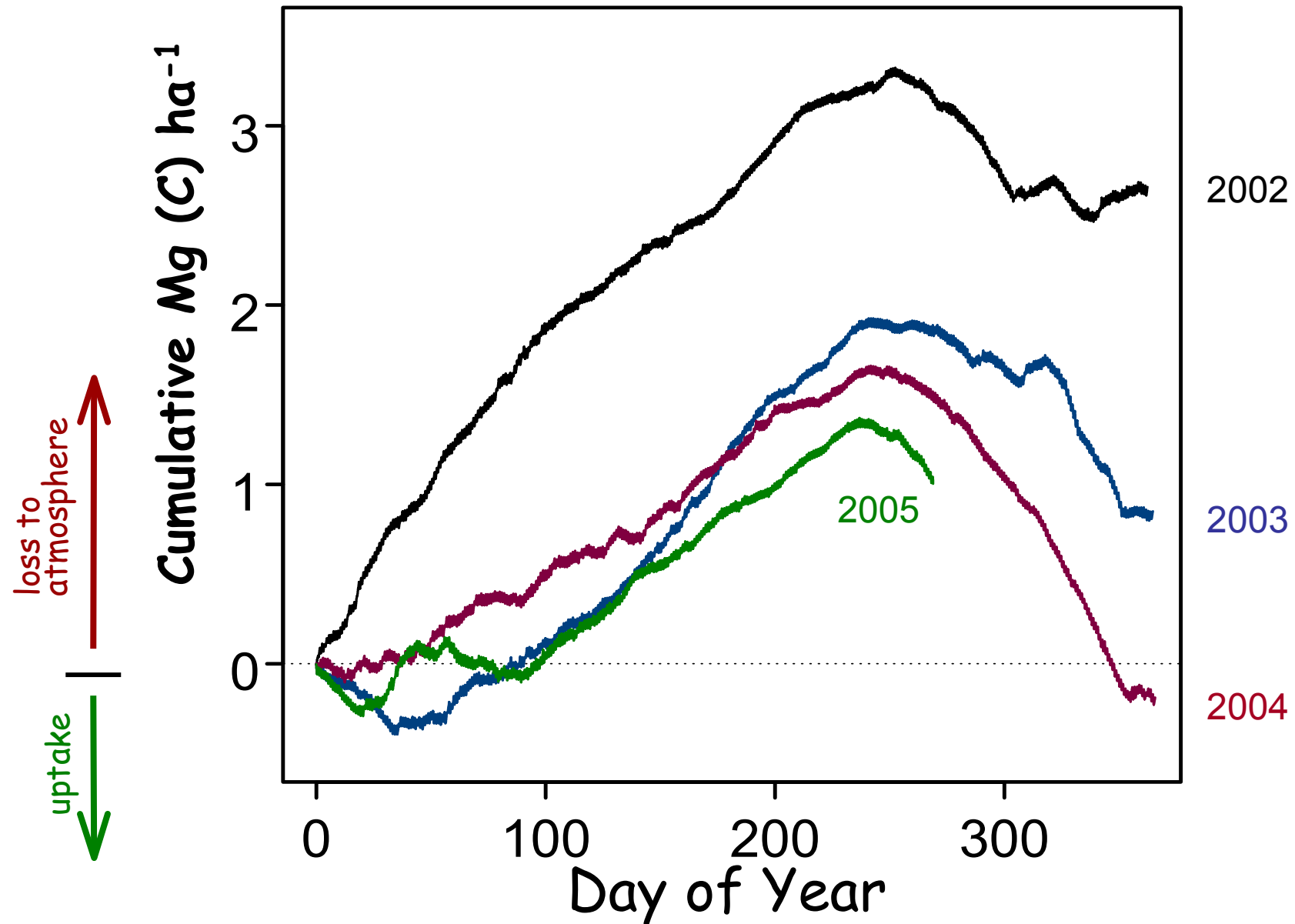
Test of predictions

Cumulative km67 Carbon Flux, 2001-2005



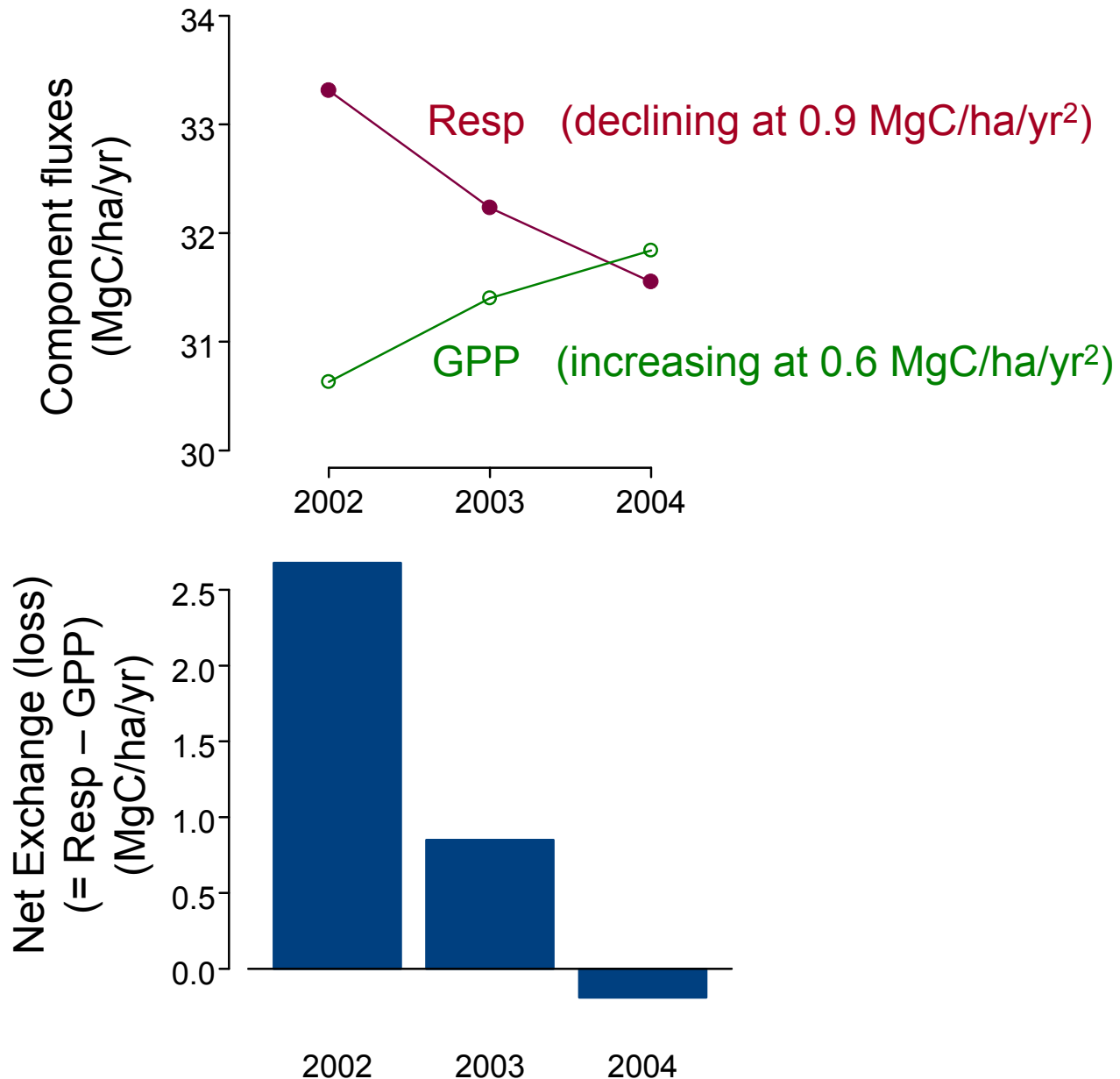
Test of predictions

Cumulative km67 Carbon Flux, 2001-2005



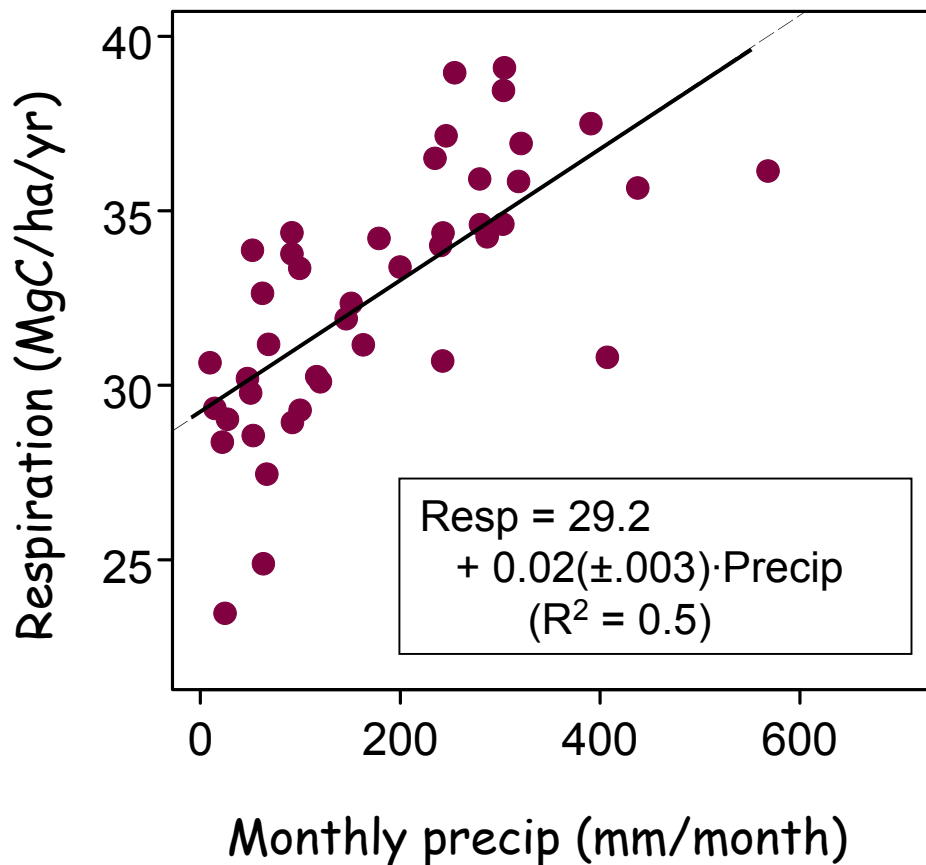
Test of predictions:

Trends in Annual sums of carbon flux

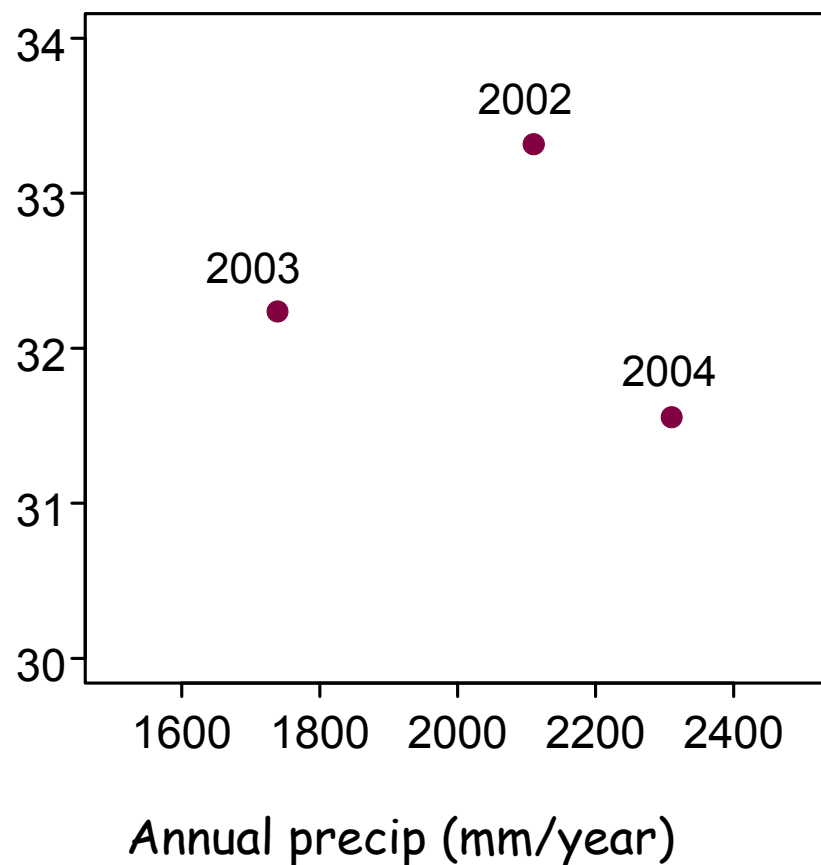


Precip controls short-term, but not long-term, integrated Resp flux

Monthly resp vs precip

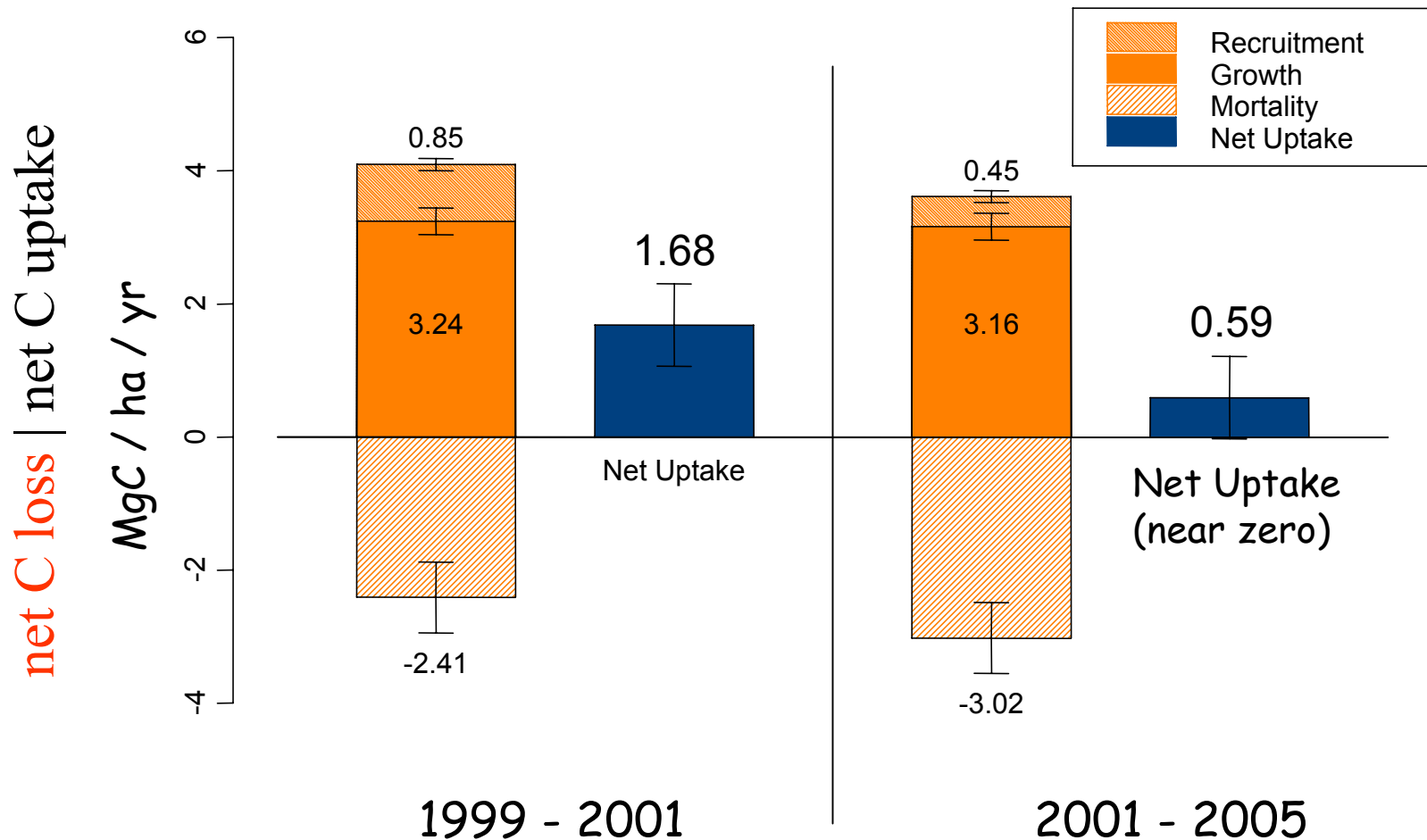


Annual resp vs precip

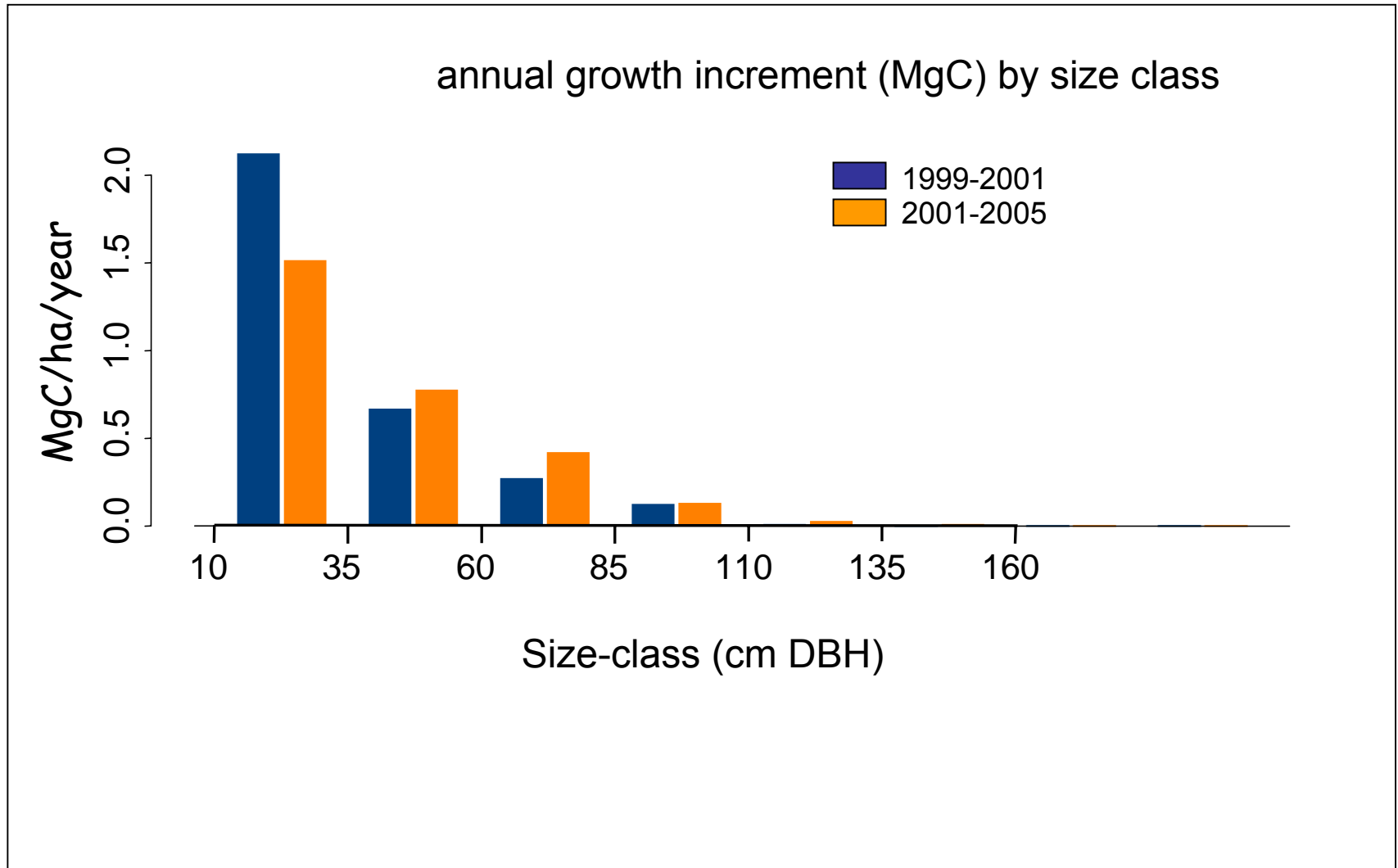


Test of predictions: Forest Demography (a): Live biomass pool shifts toward balance

Carbon fluxes to Live Biomass at km 67



Test of predictions: Forest Demography (c):
"Grow-in" shifts tree growth from
smaller to larger size-classes



Summary

Preliminary pattern confirms disturbance recovery hypothesis:

(1) for eddy flux predictions:

- Net ecosystem exchange shifts from source towards sink
- Due in part to decline in ecosystem respiration

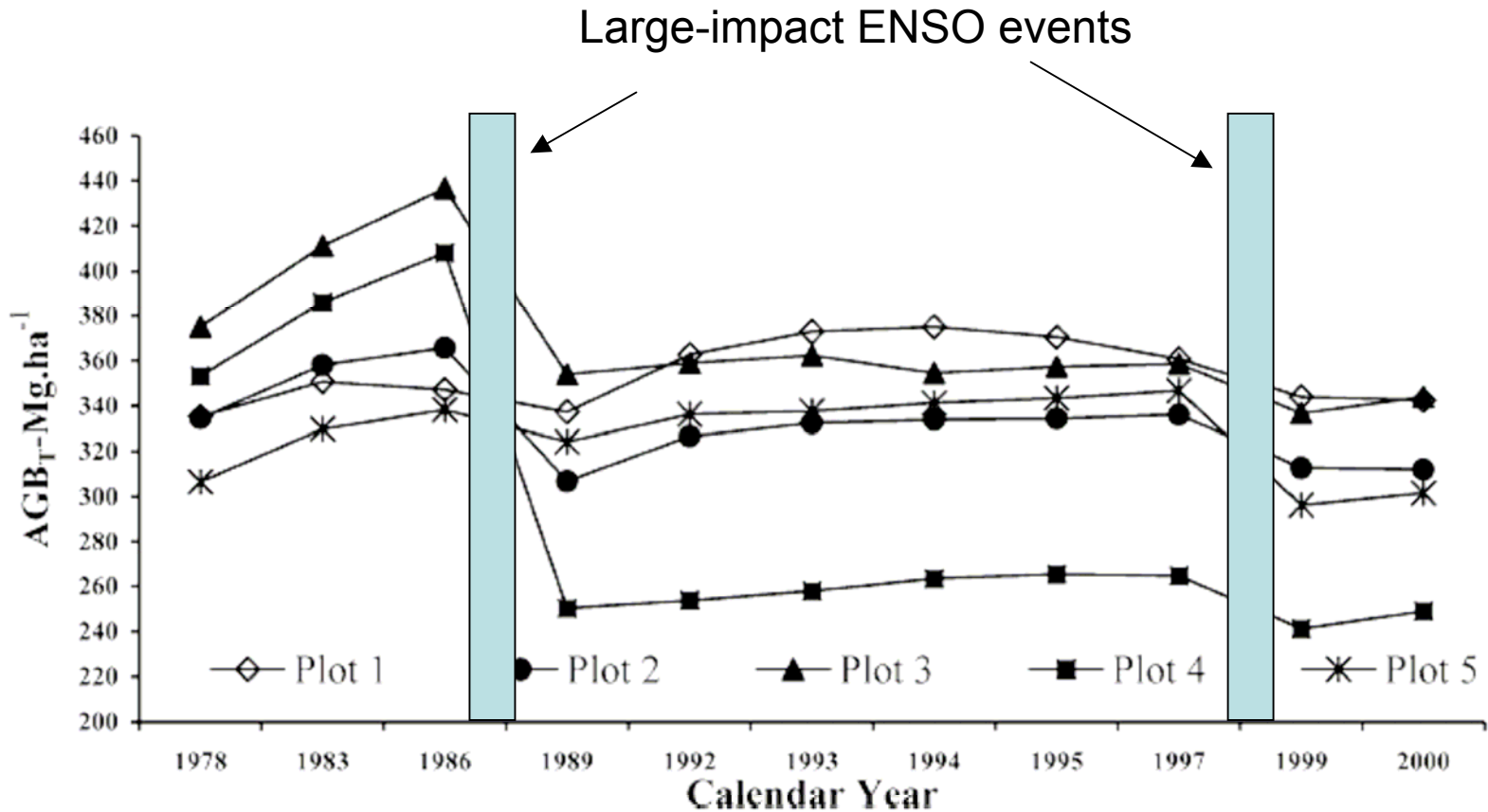
(2) for demographic predictions:

- Live biomass pool shifts towards balance
- Grow-in shifts growth fluxes towards larger size classes

IV. Conclusions

- (1) Multiple measures (demography, component fluxes, net C-balance) can be integrated to detect and track whole-forest response to disturbance
- (2) Detailed quantification of:
 - Flux magnitudes & Response times
 - demographic stateallows tests of models of important forest dynamics
- (3) We are making progress on understanding key factors for predicting large-scale forest carbon balance

Aboveground Biomass timeseries in 0.5-ha plots of Linhares Atlantic rainforest



Rolim et al. (2005)