

Spatial and Temporal patterns in Carbon Storage in Live and Dead biomass across the Tapajos National Forest and the BDFFP plots in Manaus.

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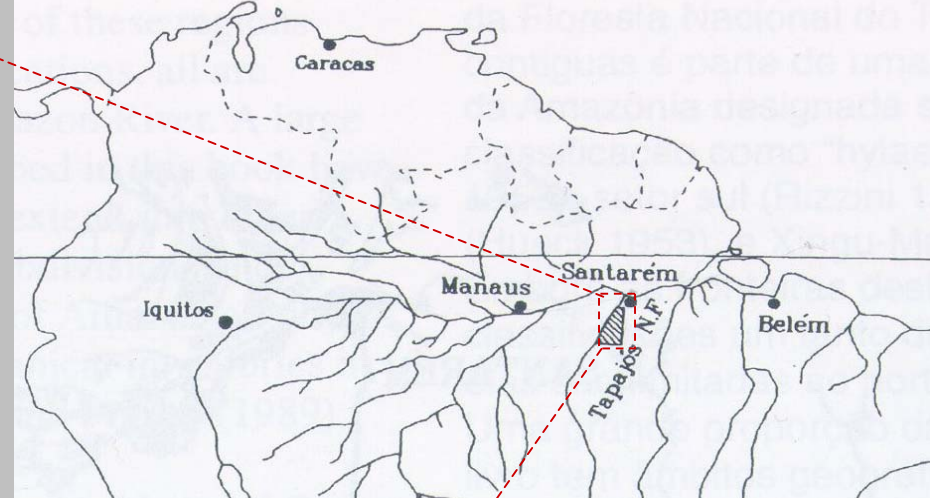
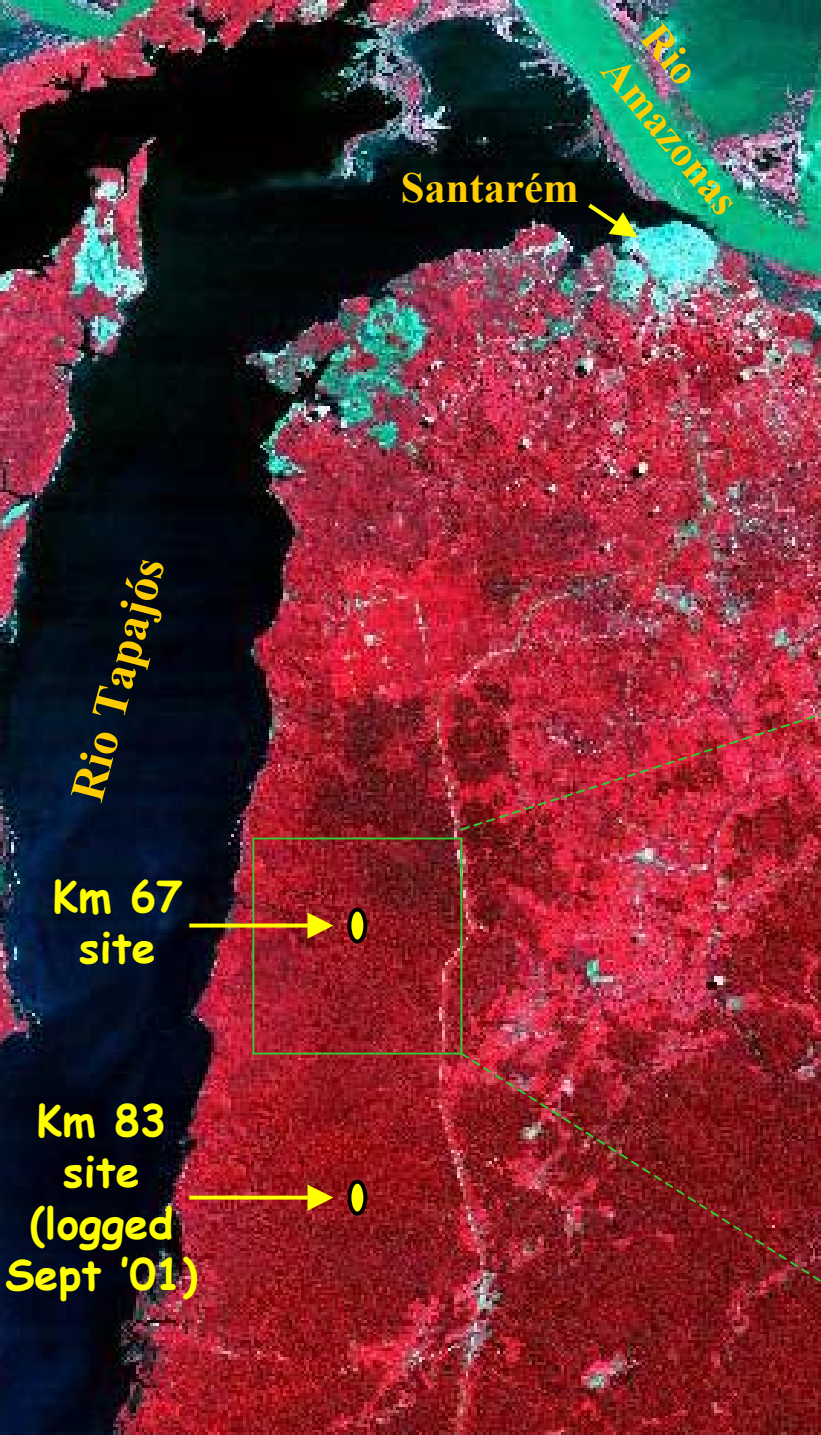
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(2) Biological Dynamics of Forest Fragment Project, Manaus, Brazil

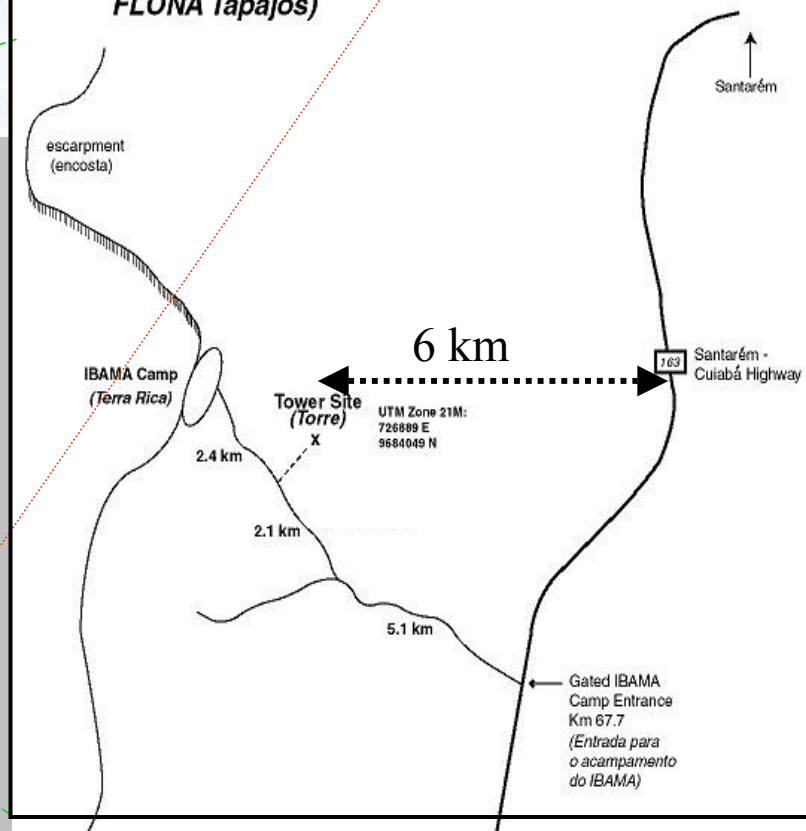
(3) Smithsonian Tropical Research Institute, Balboa, Panamá

(4) University of Sao Paulo, CENA, Piracicaba, Brazil.

(5) Universidade Federal do Pará, Santarém, PA, Brasil

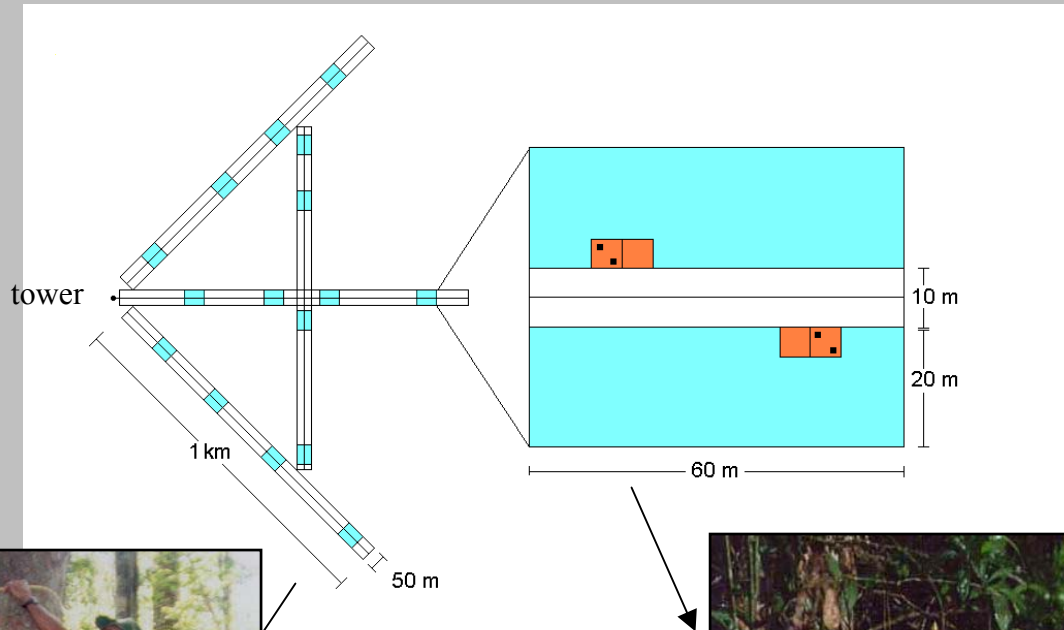


Primary Forest Site Location
(Localização da Torre Floresta Primária - FLONA Tapajós)

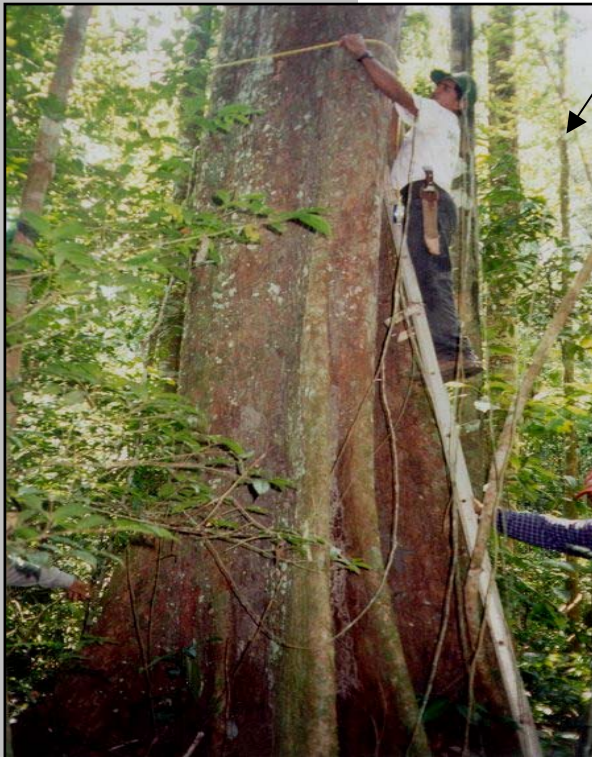


Part 1: Biometric Study of Tapajós Forest, km 67

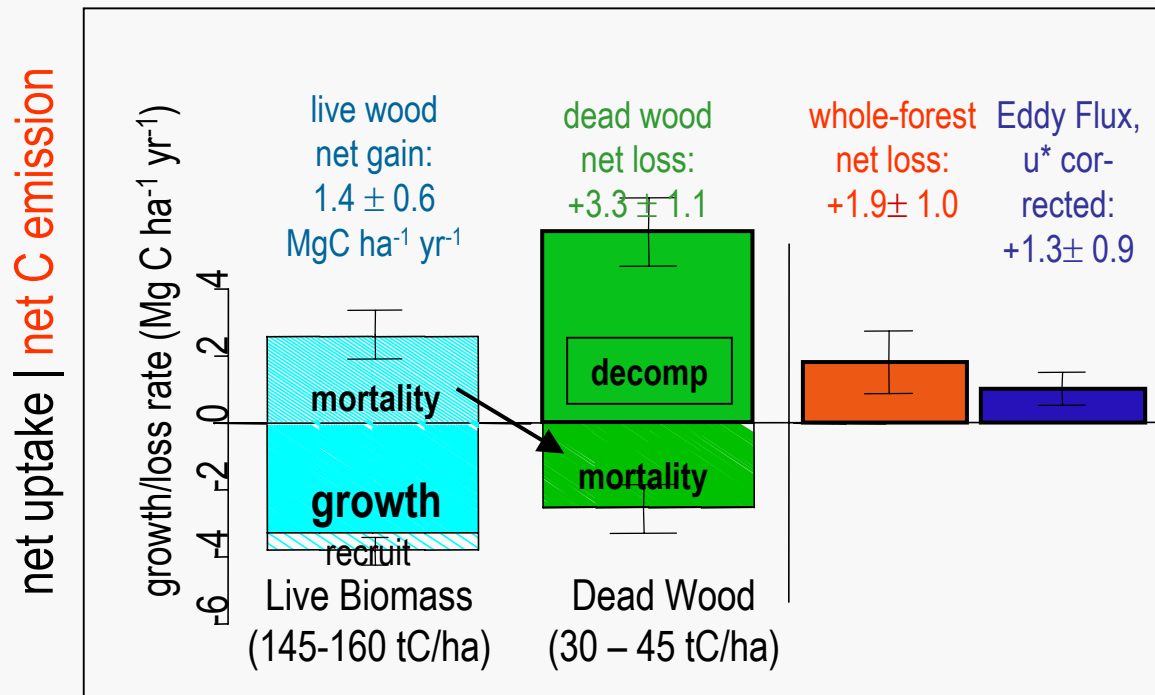
LIVE BIOMASS:
DBH measured in
50 by 1000m
transects in 1999.
~2800 trees
Remeasured in
2001, 2005.



DEAD
BIOMASS:
CWD measured
in subset of
transects in
nested plots in
2001.



Part 1. Biometry, 1999–2001: Disturbance Recovery



Uptake in Live Biomass:

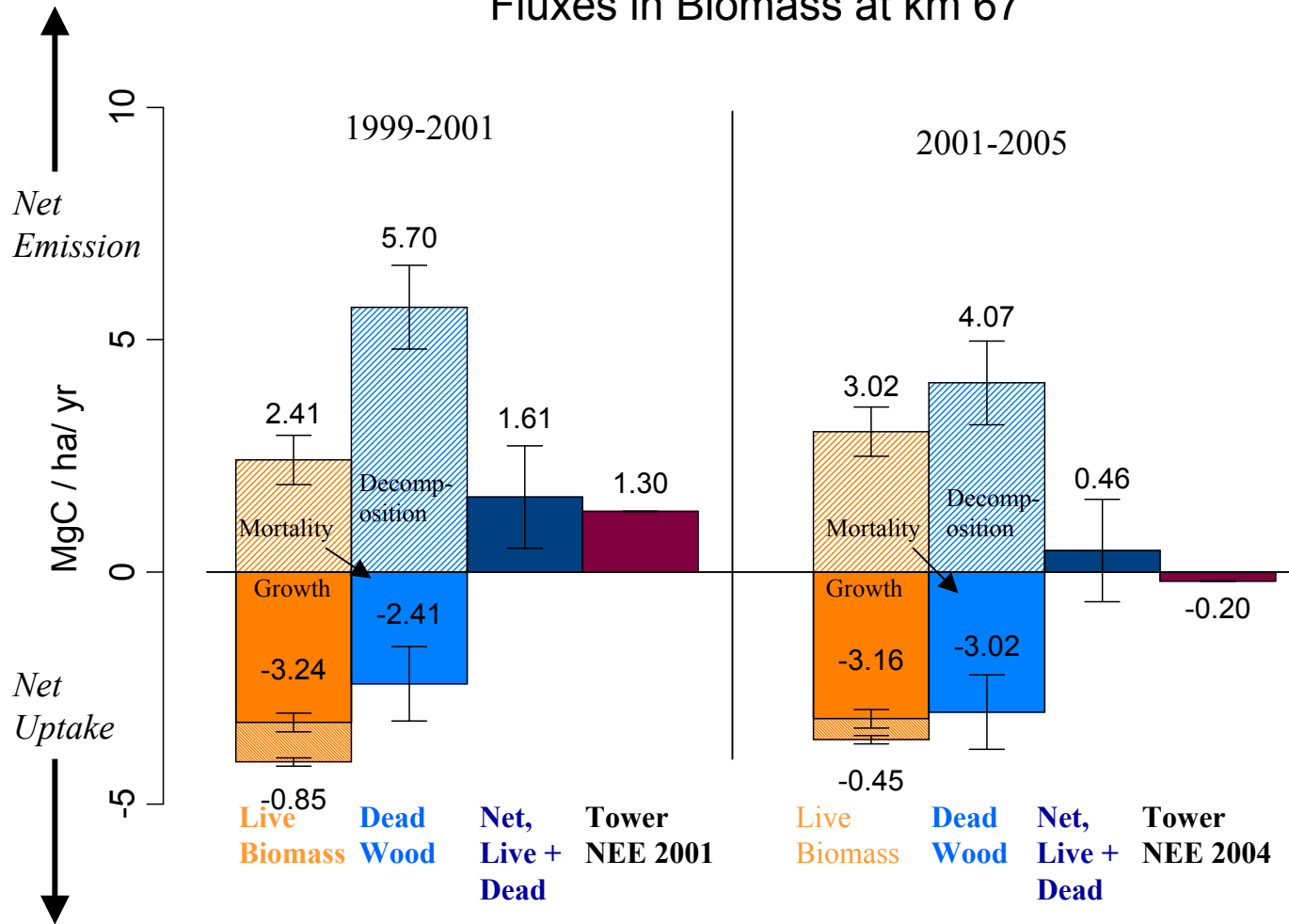
- High recruitment (4.8%) compared to "intact" Amazon forest (0.8% - 2.8%; Phillips&Gentry, 1994).
- Growth in live wood is high, above the 90%tile of a global tropical dataset (Phillips et al. 1998).

Large standing stock of **CWD**, with outflows (decomposition) outstripping inputs (mortality).

..... our hypothesis (Rice et al., 2004; Saleska et al., 2003) was that the forest responded to a significant disturbance event prior to beginning of the study in 1999.

Part 1: After 2001: Biometric results also support disturbance recovery hypothesis at km 67 tower (25 ha, 4 km transects)

Fluxes in Biomass at km 67



Continued recovery from disturbance?

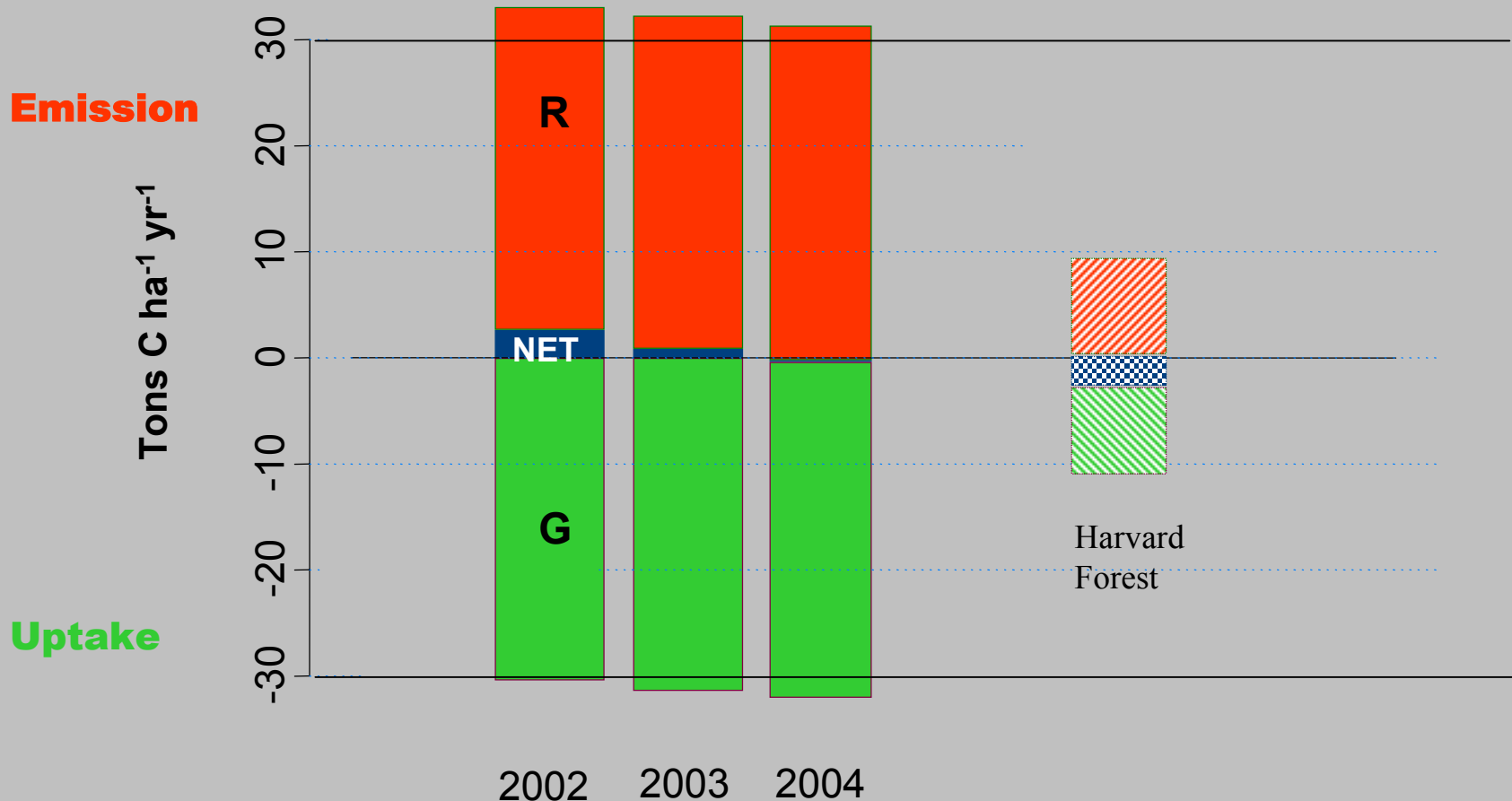
- (1) Accrual in live biomass remains high.
- (2) Mortality increased.
- (3) Recruitment decreased.
- (4) **But** Net flux in live+ dead, likely close to 0. (*Palace* decay rates)

.... Significant role for change in CWD; consistent with recovery from disturbance.

Net emission of CO₂ declined over 5 years to ~0
(change -1.15 (biometry) or -1.1 tonC/ha/yr from tower flux data.)

Part 1. Since 2001, eddy flux tower

Tapajós Annual Carbon Balance net: trend
from loss of C =>> ~0

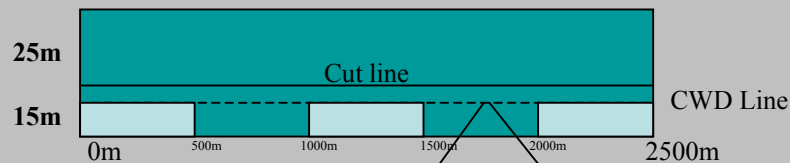


Part 2: Large Scale Biometric Study of Tapajós Forest

Is km 67 site representative of the region? The Amazon?

In 2003, 4 large transects distributed through out the TNF.

Transect Design:



DBH > 10cm
measured,
alive or dead.

■ DBH > 35cm

□ DBH > 10cm

0m 10m

CWD measured by

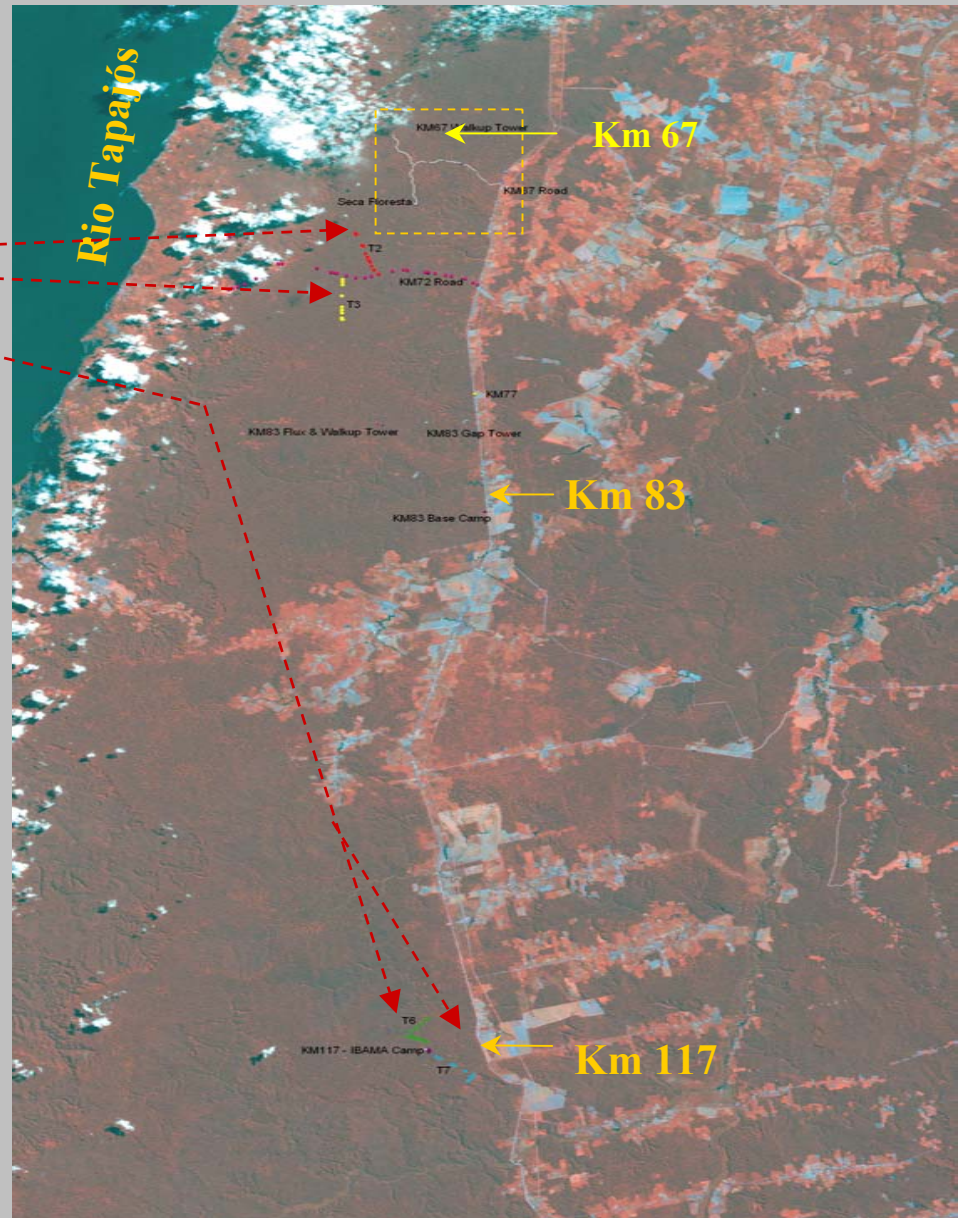
Line intercept method

10 m segments:

CWD \geq 7.5 cm DBH

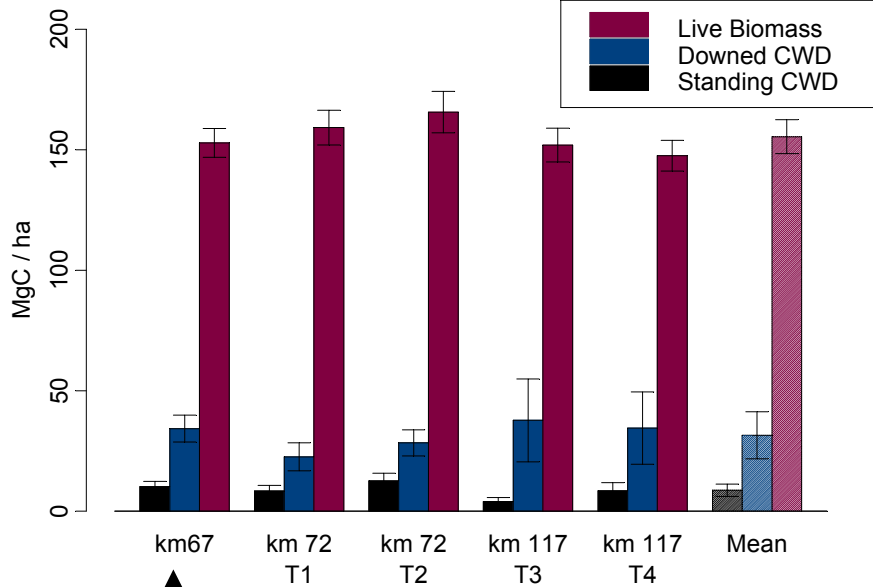
Every fifth segment:

CWD \geq 2cm dbh



The forest at km 67 is representative of CWD and live biomass across the TNF

Live Biomass and CWD by Transect

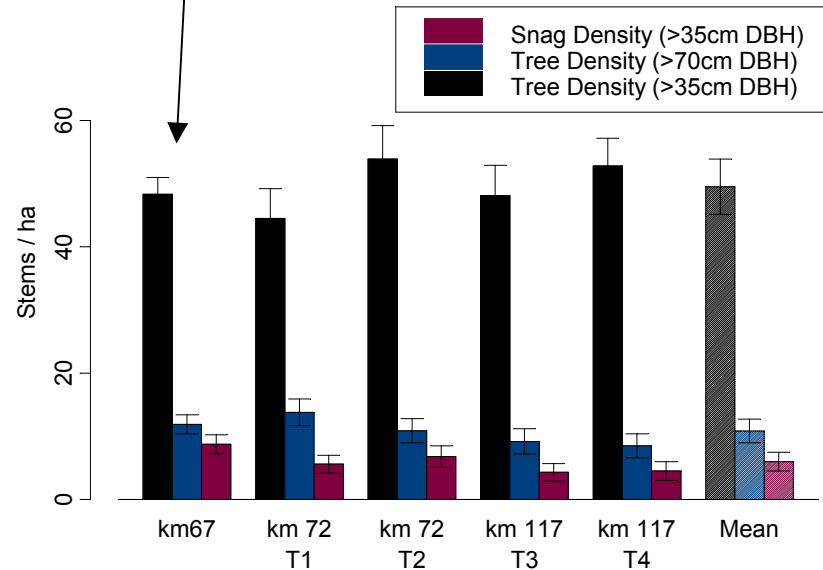


Km 67 values for standing dead, downed dead, and live biomass fall within range measured at the TNF.

Santoni (2004)

Km 67 values for stem density of both large (>35 cm) and very large (>70 cm DBH) are similar. Snags possibly higher?

Stem Density by Transect

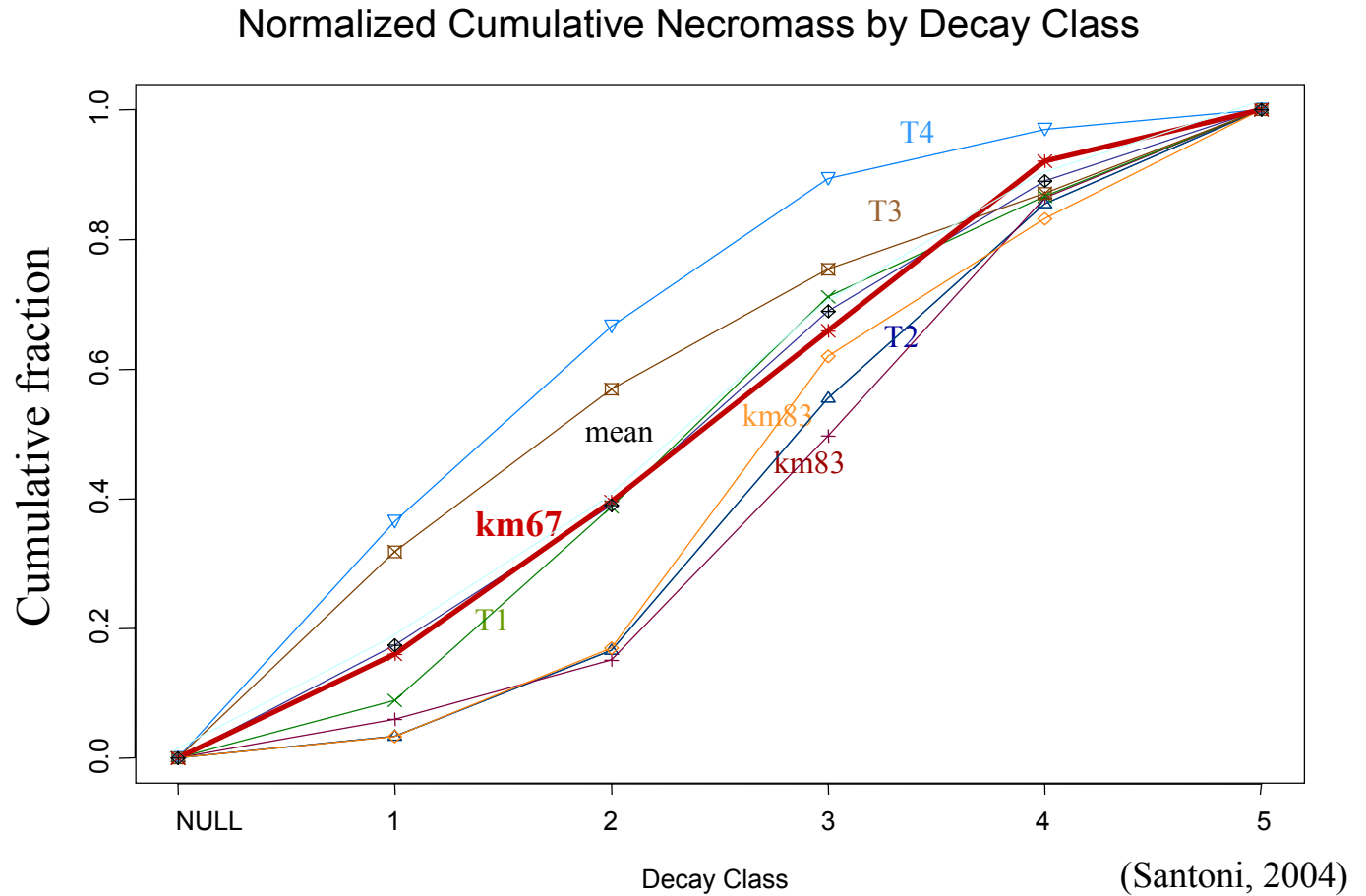


Variation in CWD patterns across the TNF

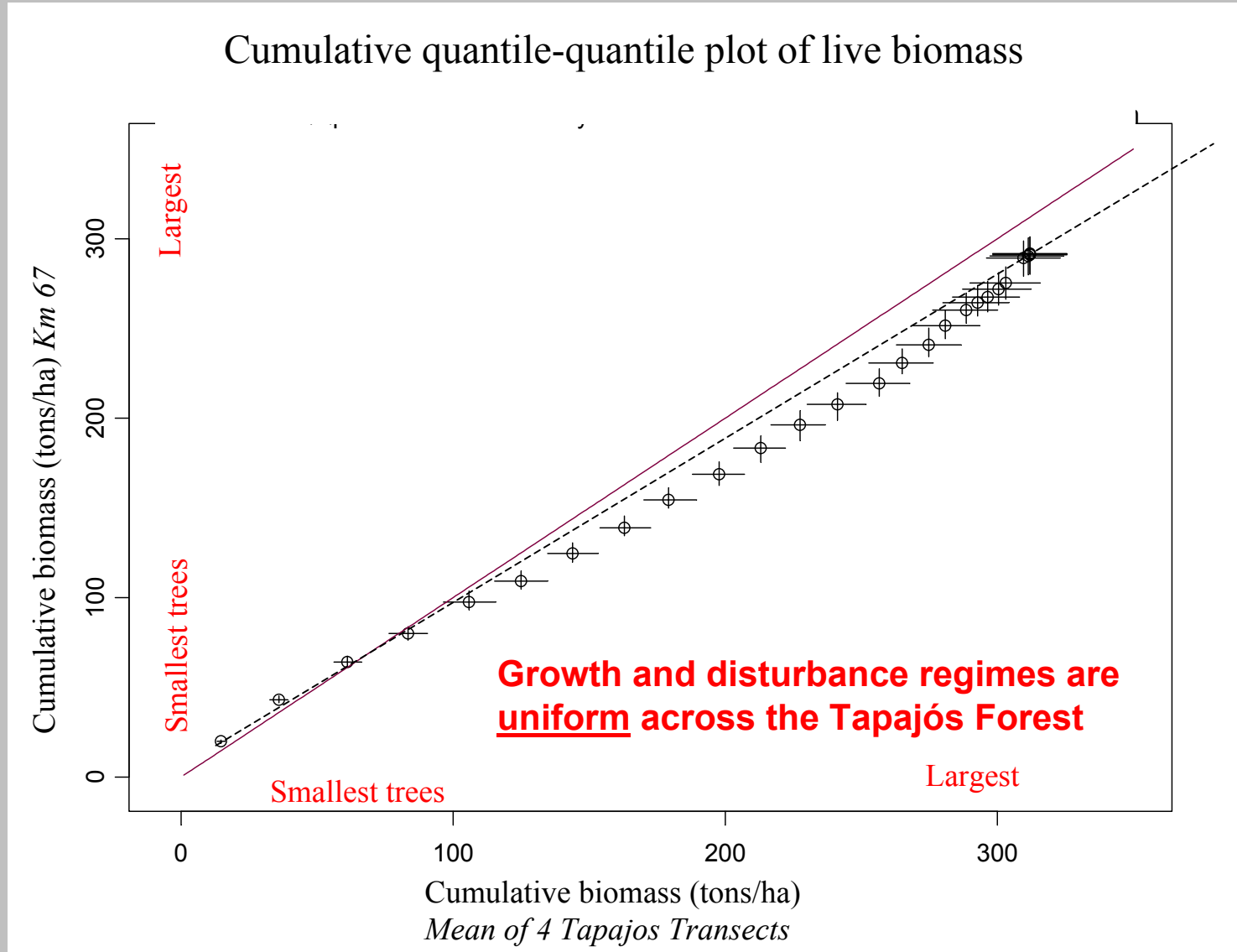
Some transects show signs of possible more recent disturbance:

Steeper slopes indicate more CWD in less decayed size classes.

Km 67 falls closest to the mean, indicating levels of disturbance typical for the TNF.



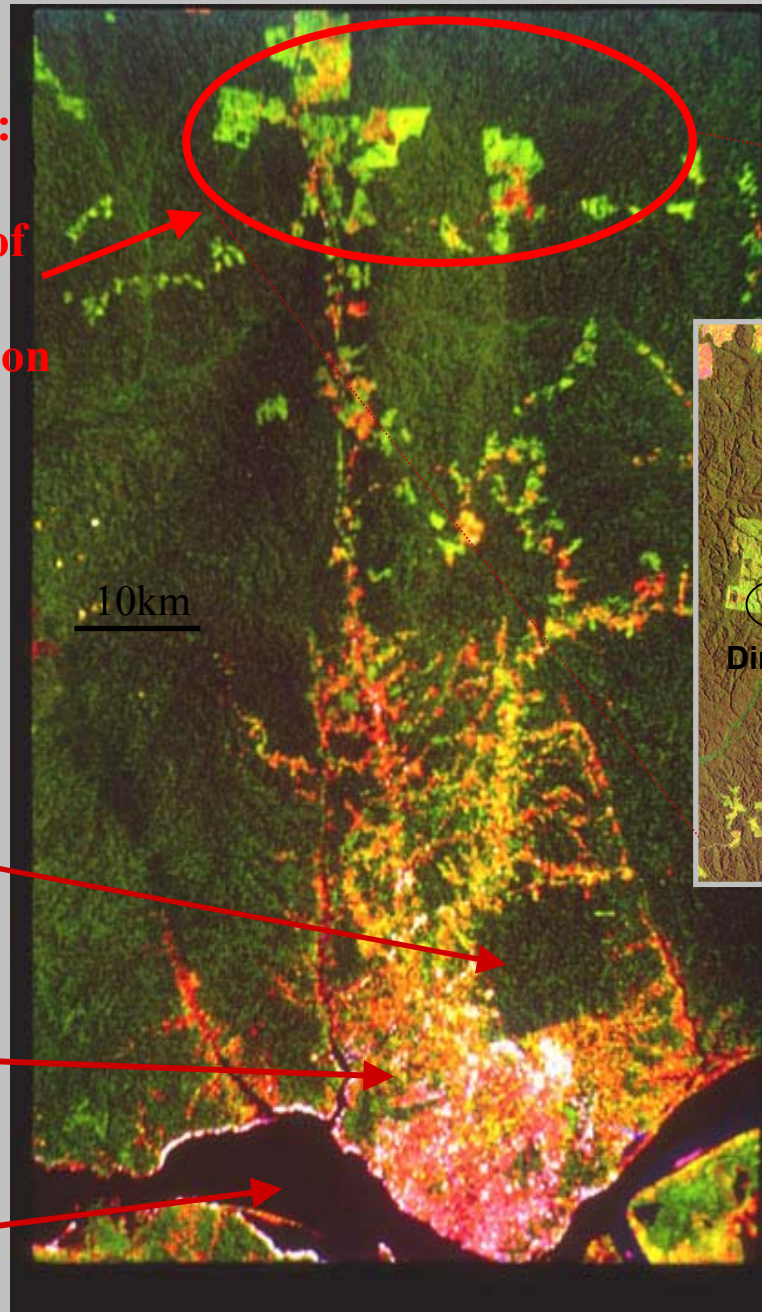
Distribution of Live biomass by size class at Km 67 appears equivalent to other Tapajos Transects.



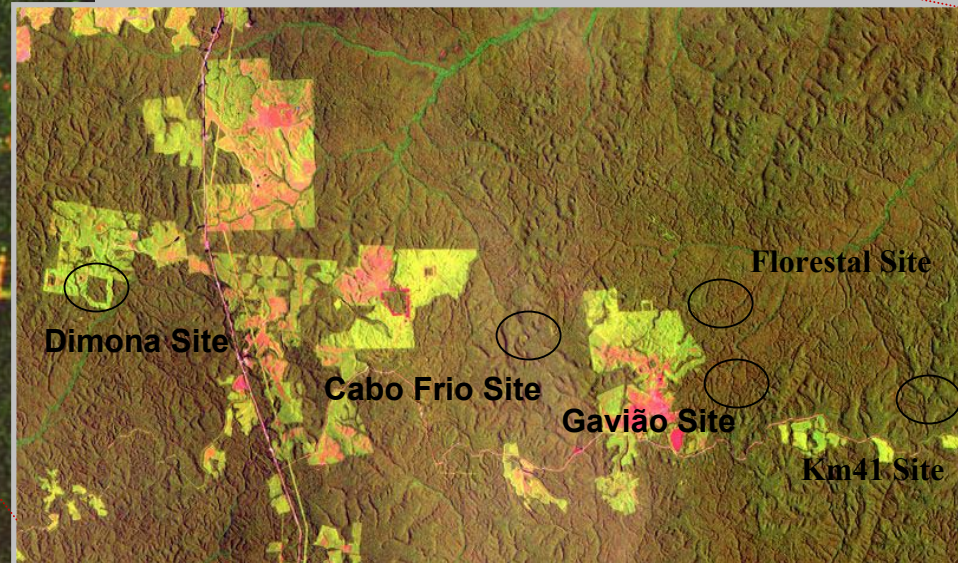
Part 3: Comparison with BDFFP plots, Manaus

Study area:

**Biological
Dynamics of
Forest
Fragmentation
Project
(BDFFP)**



**Plot Locations in the BDFFP
Experimental Landscape**



MEASUREMENTS:

20 x 1ha plots:
measured all trees >10cm DBH and snags

Each plot:
26 x 15m transects to measure fallen CWD

CWD: elevated at Tapajós vs. BDFFP, live biomass equal

by mass

	Standing CWD (MgC/ha)	Downed CWD (MgC/ha)	Live Biomass (MgC/ha)
TNF			
km67	10.2 (± 2.2)	34.3 (± 5.6)	152.8 (± 6.0) (95% CI)
T1 km72	8.4 (± 2.3)	22.6 (± 5.8)	159.2 (± 7.2)
T2 km72	12.6 (± 3.2)	28.4 (± 5.4)	165.6 (± 8.6)
T3 km117	4.0 (± 1.7)	37.7 (± 17.2)	151.9 (± 7.0)
T4 km117	8.5 (± 3.4)	34.5 (± 15.0)	147.5 (± 6.4)
mean	8.74 (± 2.6)	31.5 (± 9.8)	155.4 (± 7.0)
BDFF			
"Gavião"	2.77	12	149.5
"Florestal"	1.36	17.9	174.4
KM 41	3.09	10.9	172.3
Dimona	3.74	9.4	177.3
Cabo Frio	2.03	11.7	165.4
mean	2.598	12.38	167.78

Mean CWD volume (m³/ha)

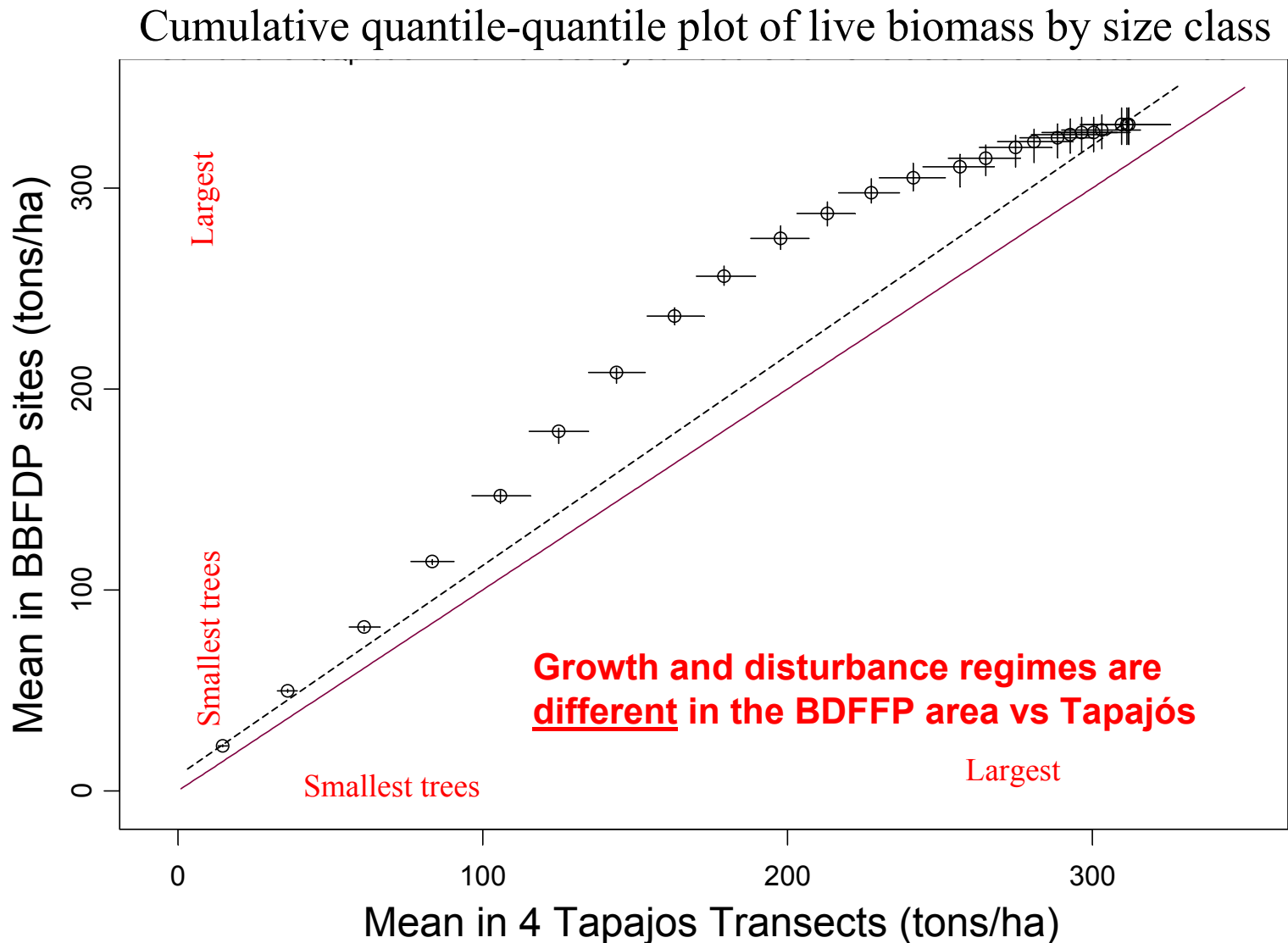
TNF	
T1 km72	86.6
T2 km72	118.71
T3 km117	129.03
T4 km117	132.4
Mean	116.685
BDFF	
"Gavião"	57.01
"Florestal"	89.27
KM 41	58.68
Dimona	39.32
Cabo Frio	56.36
Mean	60.128

by volume

Volume comparison, removes effects of CWD density used to scale CWD biomass.

CWD difference remains large.

Comparison of size class shows higher biomass at BDFP in middle size classes.



Conclusions

1. Intensive biometric and eddy flux measurements support the hypothesis that the carbon balance and structure of Tapajós Forest are strongly affected by recovery from regional—scale disturbance. *The results from measurements across the Tapajós Forest show that the eddy flux site at km 67 is regionally representative.*
2. Tapajós Forest has very high CWD and a live biomass distribution with more mass at the smallest and largest sizes, but similar total biomass, compared with BDFFP.

These results suggest a different disturbance history in the TNF, and possibly different forest dynamics , with strong effects on both carbon balance and on forest structure.

Acknowledgements

Bethany Reed, and STM support office

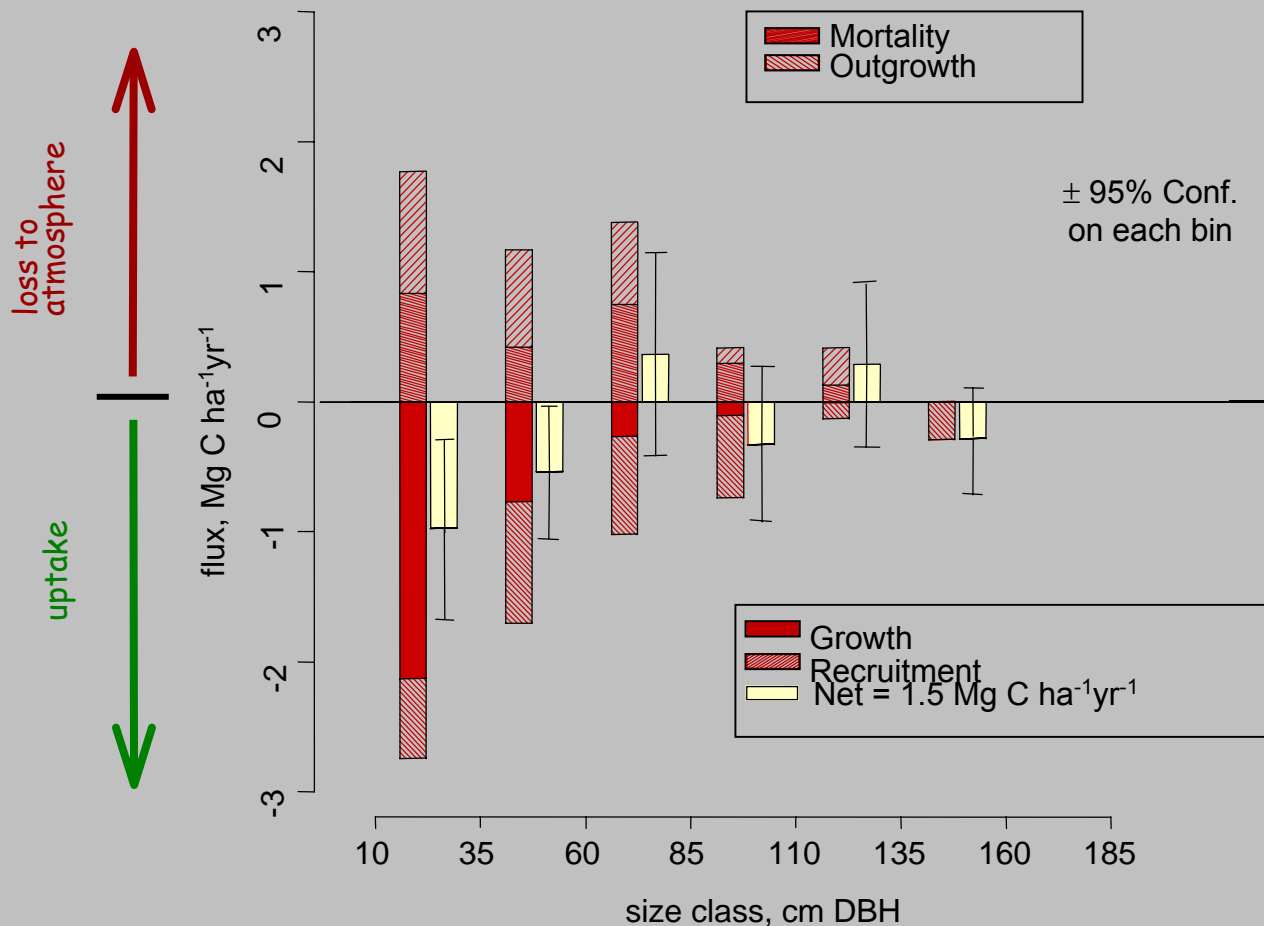
Nilson Rosa, Ehrly ???, other matieros

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Michael Keller

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Flux from Biomass & Changes in tree number density, by size class



Why is this forest not in carbon balance?

Demographic shift:

(a) The increase in flux to biomass is in the smaller size classes

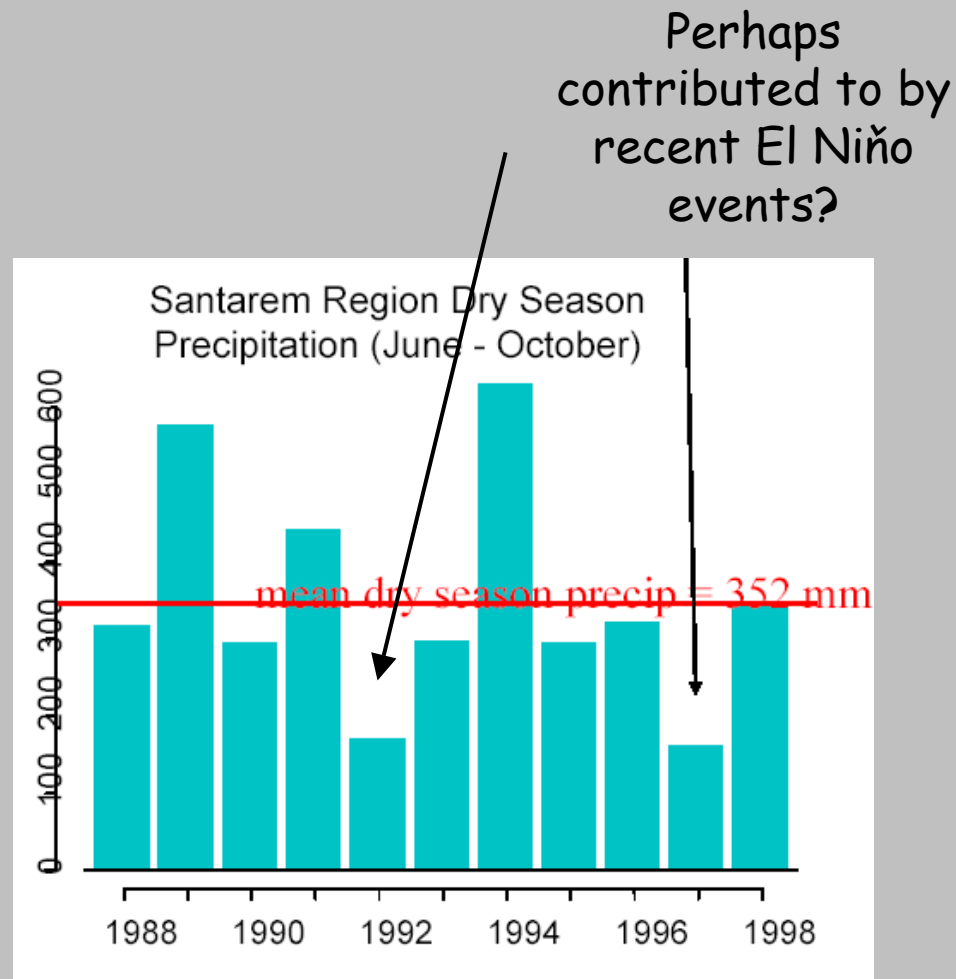
(b) Corresponding increase in density of tree stems in the smaller size classes

Why is this forest not in carbon balance?

Hypothesis:

Tapajós forest site is recovering from recent episode(s) of disturbance which:

- (1) Caused sharply elevated mortality preceeding onset of this study.
- (2) Caused a large increase in dead wood pool
(to the point where losses exceed inputs)
- (3) Opened canopy gaps causing significant new growth and recruitment into smaller size classes of live wood (making overall growth uptake exceptionally high)



Condit et al. (1995), Williamson et al. (2000) link El Niño to elevated tree mortality

November 2005

LBA km 67 2005 re-survey: CARBON BUDGETS

	Standing biomass	MgC/ha
1999	143.6	(n= 2612)
2001	148.9	(n= 2815)
2005	151.4	(n = 2867)

(2) Growth:		MgC/ha/yr
1999- 2001	3.24	(n = 2525)
2001- 2005	3.16	(n = 2559)

(3) Mortality:

2001	-2.41	(n = 87, 44 trees/yr)
2005	-3.02	(n = 259, 65 trees/yr)
(2001 - 2003)	-3.93	(n = 155, 78 trees/yr)
(2003 - 2005)	-2.20	(n = 104, 52 trees/yr)

(4) Recruitment :

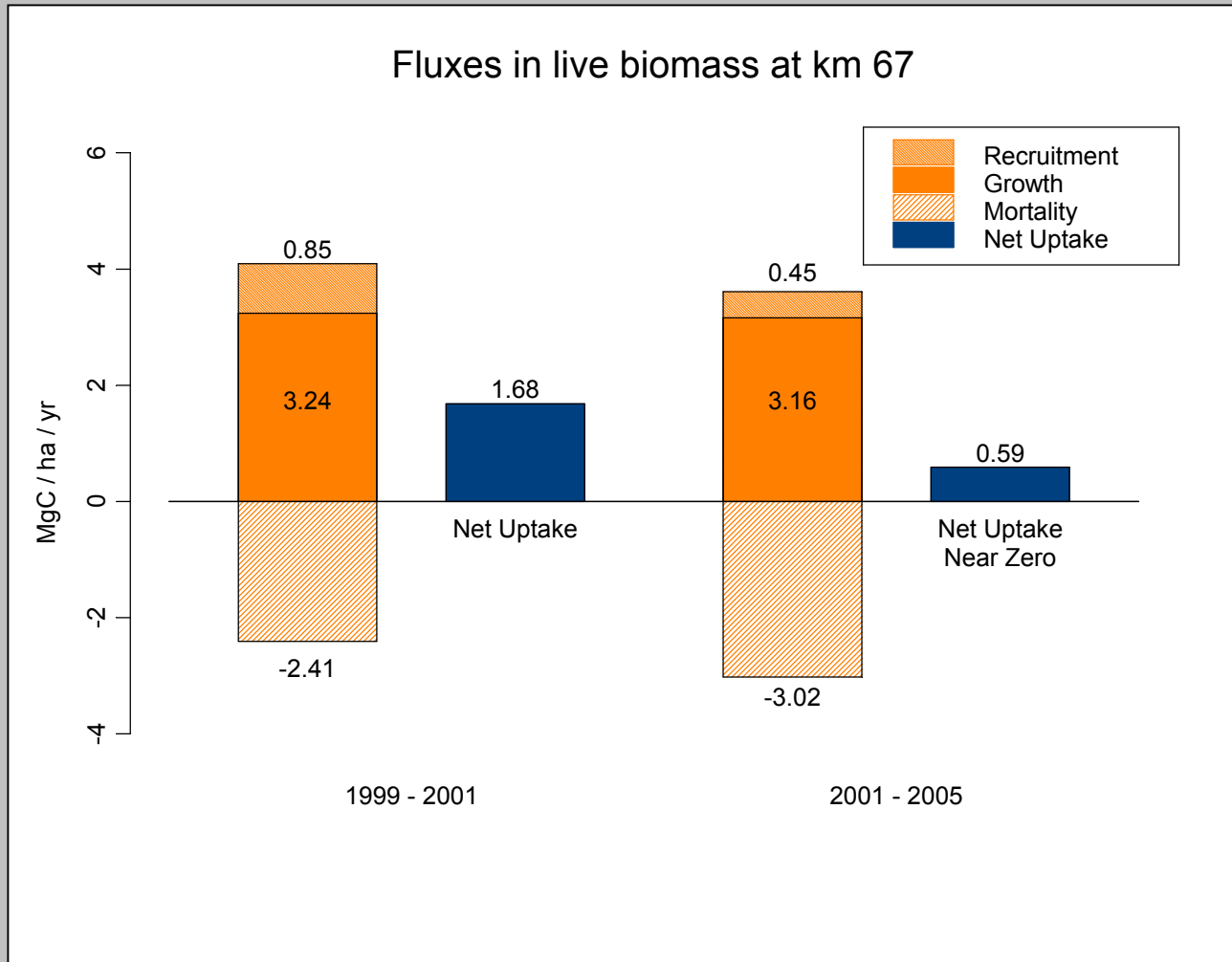
2001	0.85	(n =200, 100 trees/yr)
2005	0.45	(n = 189, 47 trees/yr)

FLUXES:

Net fluxes 2005	MgC/ha/yr	n
Recruitment	0.45	(189)
Growth	3.16	(2559)
Mortality	-3.02	(- 259)
Net change	0.59	per year

Biomass difference	MgC/yr	n
2001	148.9	(2815)
2005	151.4	(2882)
Net difference	1.25	<i>per year.</i>

Part 1: Preliminary results from re-survey 2005 support disturbance recovery hypothesis



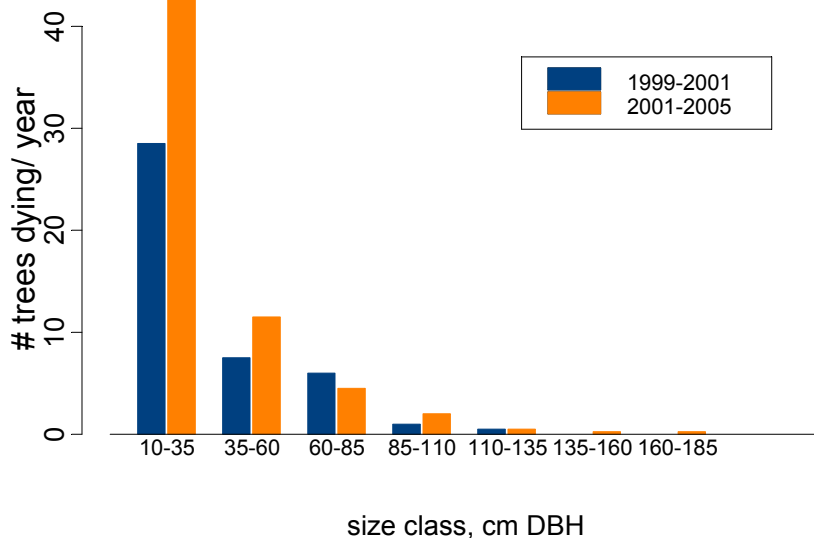
Still recovering from disturbance?

- (1) Accrual in live biomass remains high.
- (2) Mortality increased.
- (3) Recruitment decreased.

.... Consistent with further recovery from disturbance.

From 2001 to 2005, mortality increased in lower size classes.

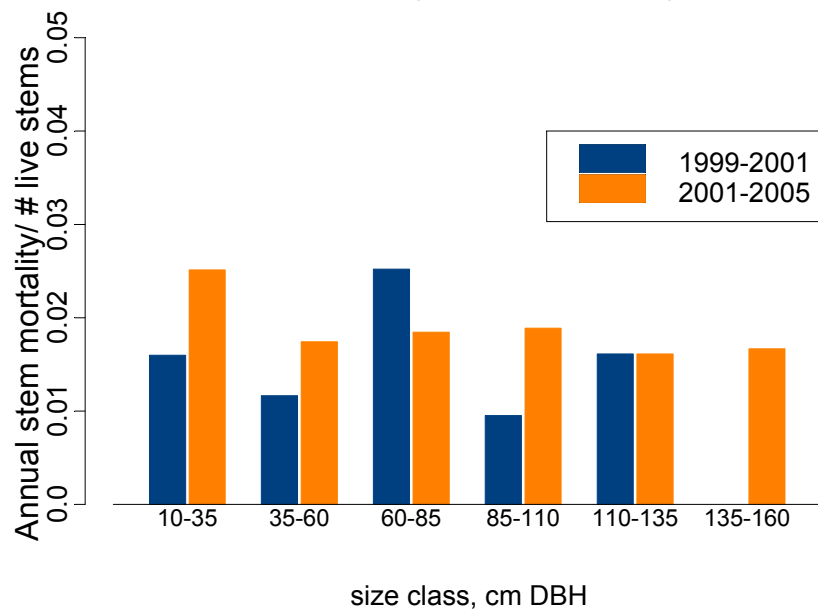
annual mortality by size class



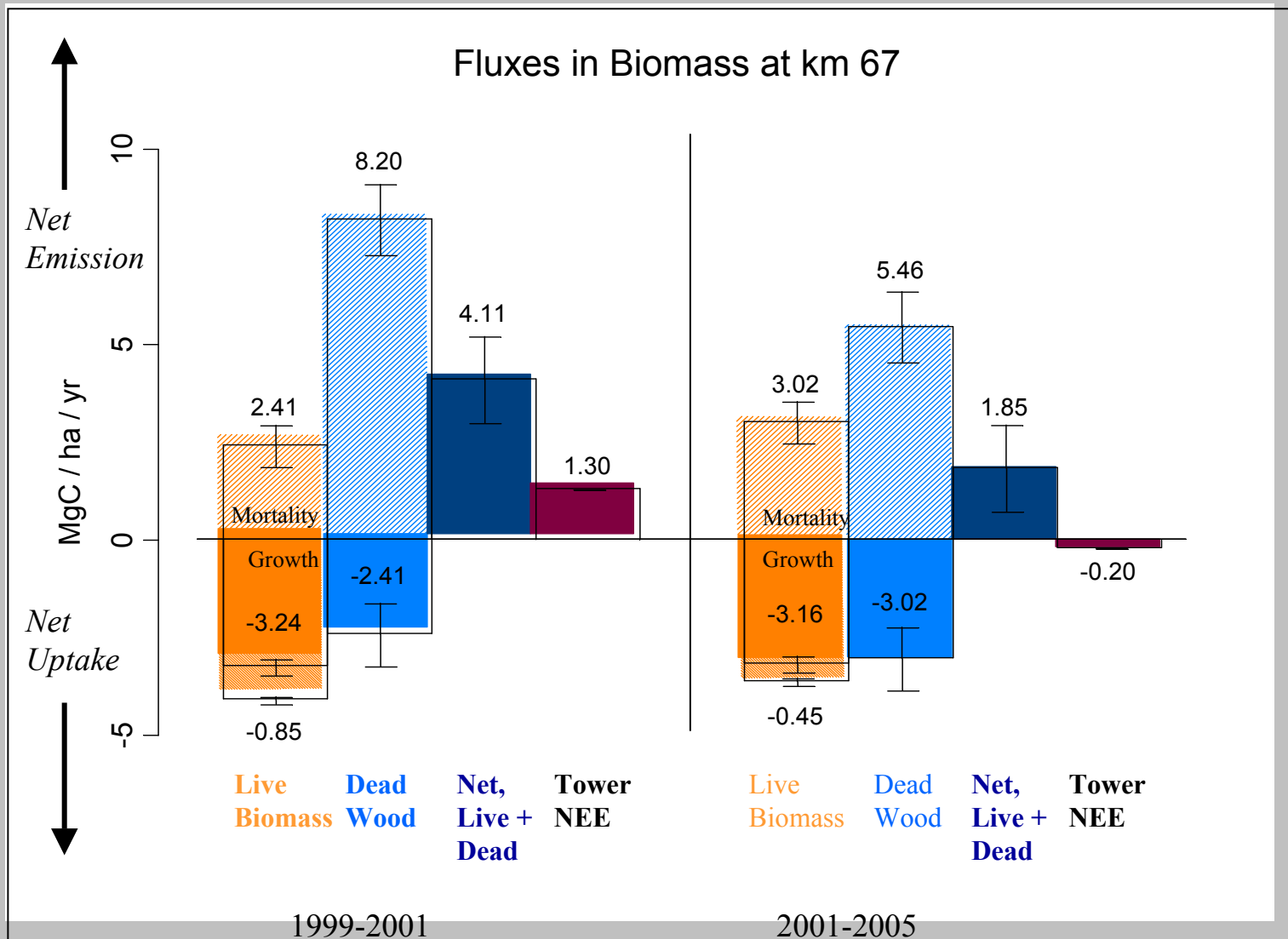
Increases in absolute mortality concentrated in smaller size classes.

Results from higher overall stem density in lower size classes.

Ratio of annual mortality to live trees by size class



Part 1: Preliminary results from re-survey 2005 support disturbance recovery hypothesis



*Still recovering
from
disturbance?*

- (1) Accrual in live biomass remains high.
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.... Consistent with further recovery from disturbance.

Estimating Flux in CWD 2001-2005

USED IN THIS TALK:

2001 CWD pool:	48.0 MgC/ha
05 mort	+3.02 MgC/ha/yr * 5yrs
01 decomp	<u>- 5.7 MgC/ha/yr * 5yrs</u>
est 2005 CWD pool:	34.26 MgC/ha

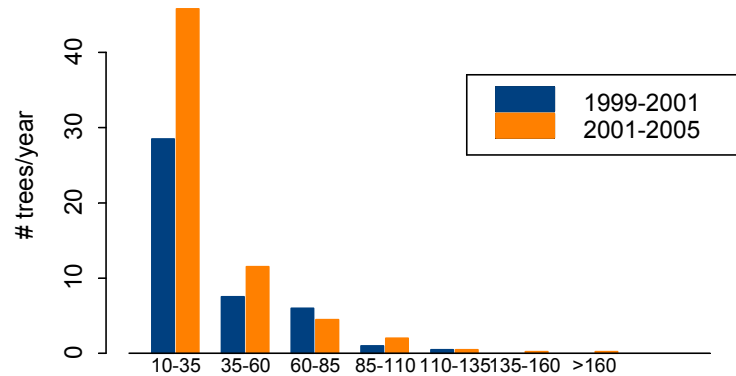
CWD pool declines $48 - 34.26 = 28.6\%$
 2005 estimated respiration rate should be : $5.7 - (0.286 * 5.7) = 4.07$ MgC/ha/yr

Alternative: USING JUST CHAMBERS DECOMP (appears in previous slide)

2001 CWD pool:	48.0 MgC/ha	
05 mort	+3.02	MgC/ha/yr
01 decomp	- 8.2	MgC/ha/yr
(Based on density-specific Keller et al. decay rates)		
est 2002 CWD pool:	42.82	MgC/ha
05 mort	+3.02	MgC/ha/yr
02 decomp	- 7.29	MgC/ha/yr
(based on Chambers k =0.17 applied to pool)		
est 2003 CWD pool:	38.55	MgC/ha
05 mort	+3.02	MgC/ha/yr
03 decomp	-6.55	MgC/ha/yr
est 2004 CWD pool:	35.02	MgC/ha
05 mort	+3.02	MgC/ha/yr
04 decomp	-5.95	MgC/ha/yr
est 2005 CWD pool:	32.09	MgC/ha
05 mort	+3.02	MgC/ha/yr
05 decomp	-5.46	MgC/ha/yr

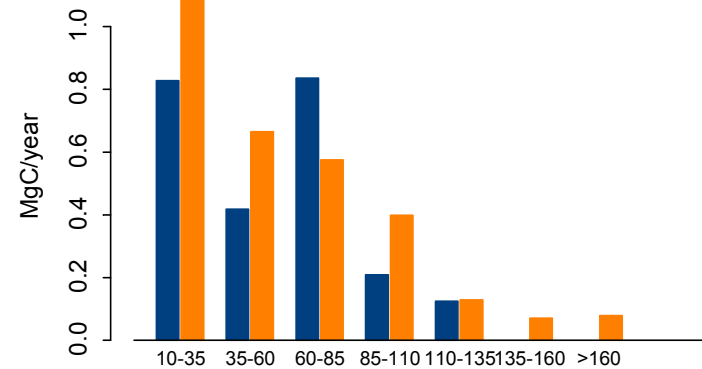
From 2001 to 2005, mortality increased in lower size classes.

annual mortality by size class



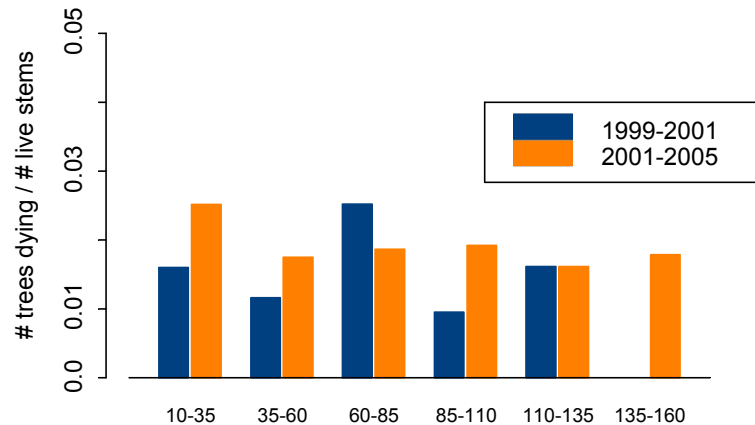
size class, cm DBH

annual mortality (MgC) by size class



size class, cm DBH

mortality/live biomass by size class



size class, cm DBH

Increases in mortality concentrated in smaller size classes.