Effects of Disturbance on Biomass, Structure and Carbon Balance in two Amazonian Forests

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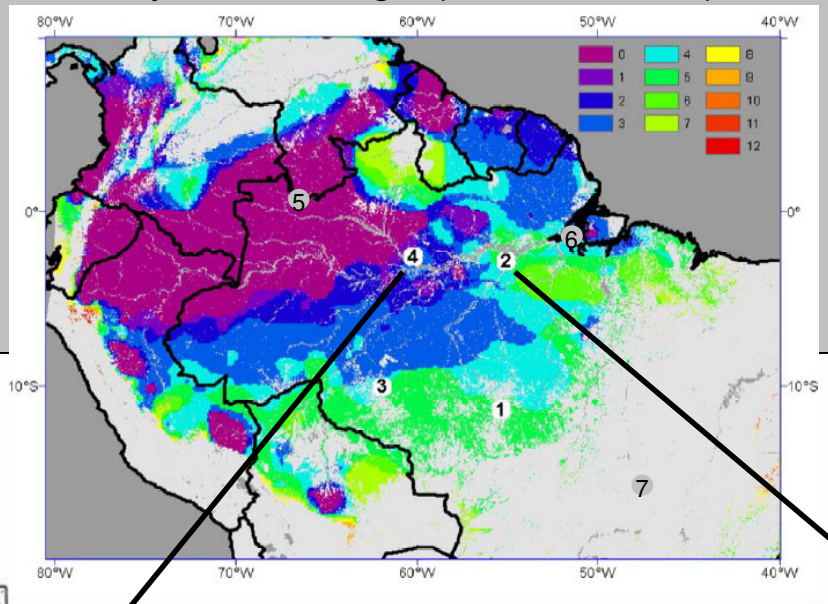
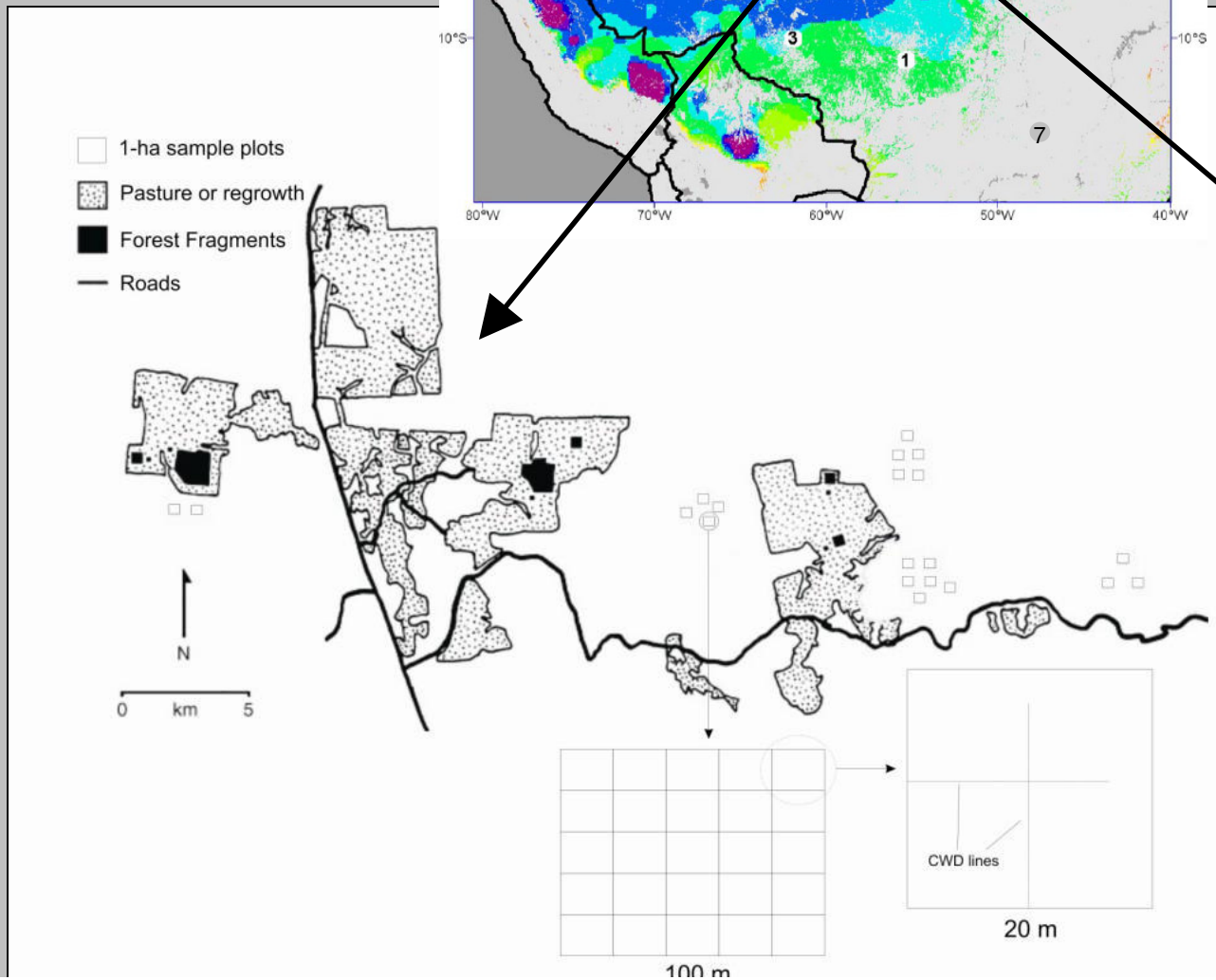
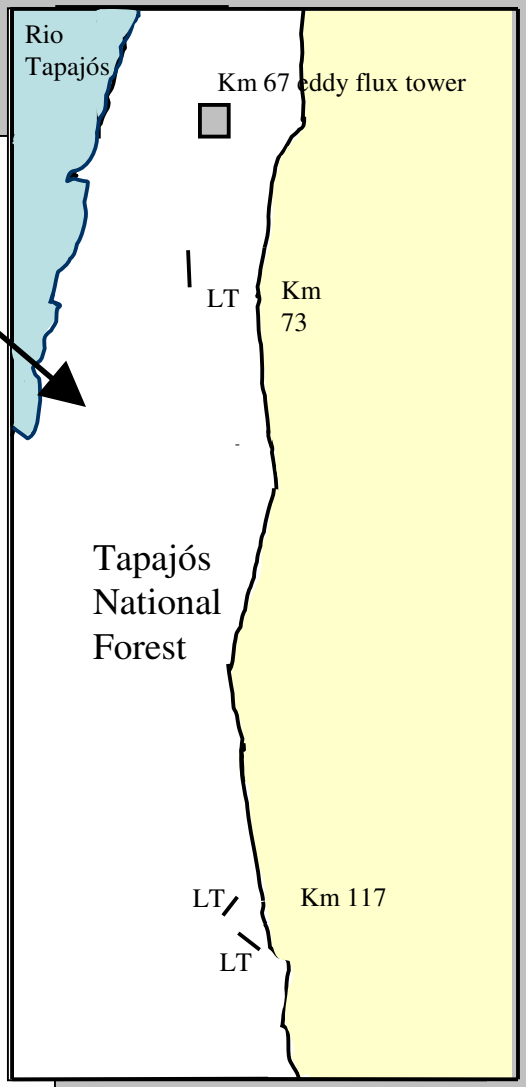
STUDY SITES

Dry season Length (Xiao et al. 2006)



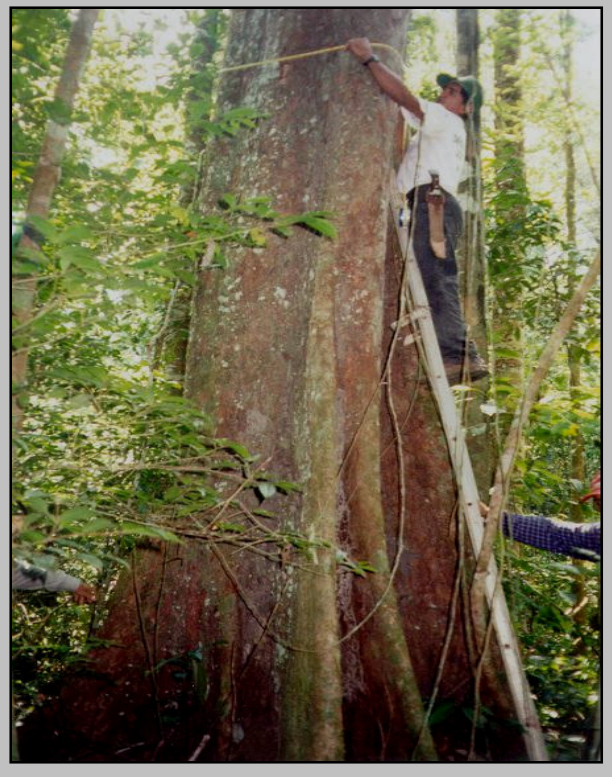


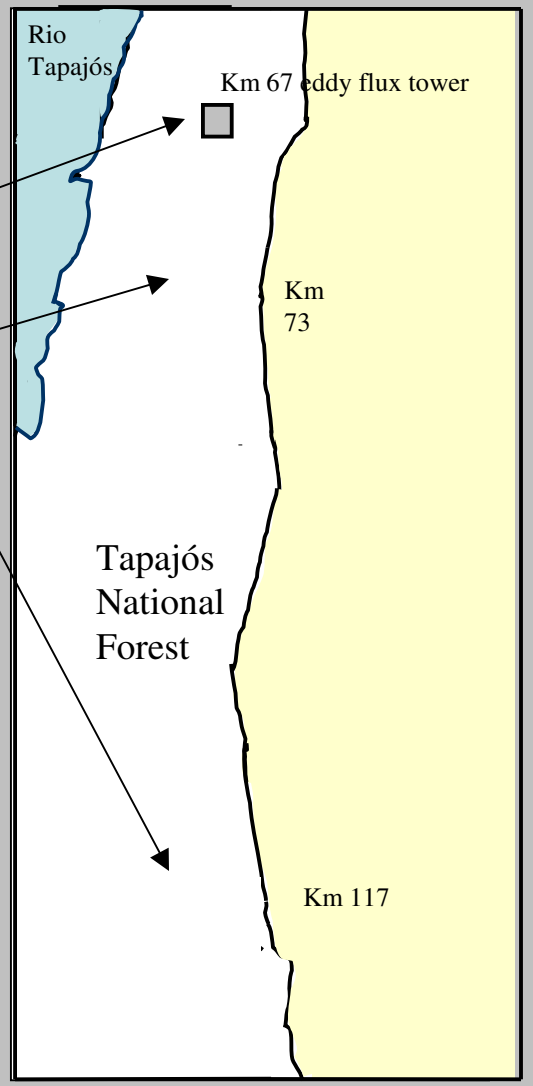


MEASUREMENTS:
TAPAJOS NATIONAL FOREST (TNF)

In 1999, 2001, 2005, ~ 20 ha live trees measured near eddy flux tower
CWD measured in nested subplots in 2001 for flux tower transects.

In 2003, 2005, ~30 ha live trees measured at km 117, and km 73
CWD measured in 2003 with line intercept methods for other transects.



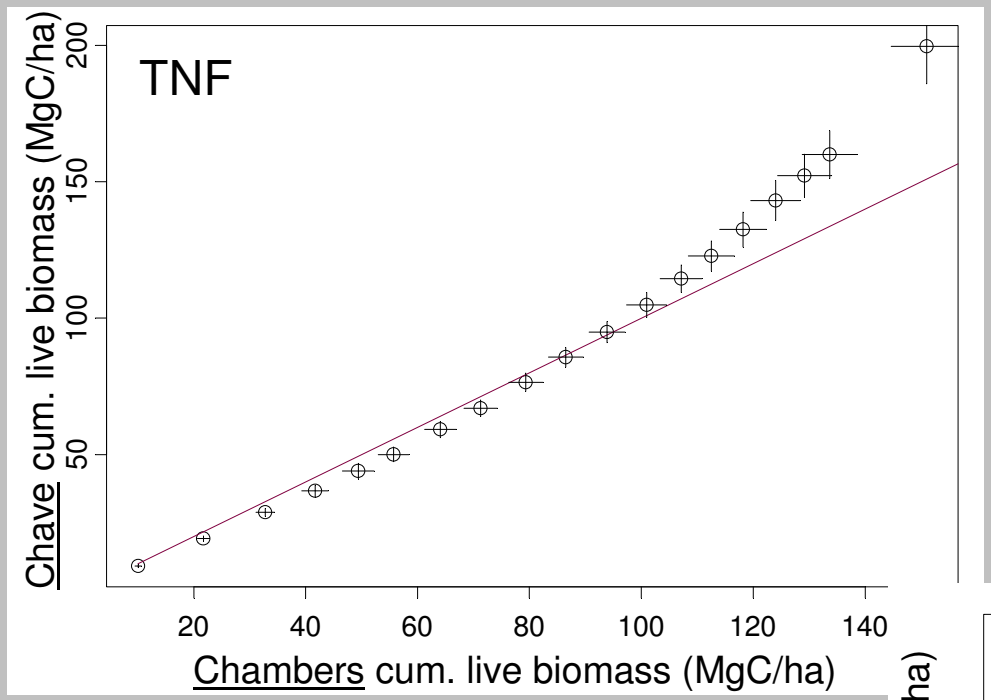


MEASUREMENTS:
BIOLOGICAL DYNAMICS OF FOREST FRAGMENTS (BDFFP)

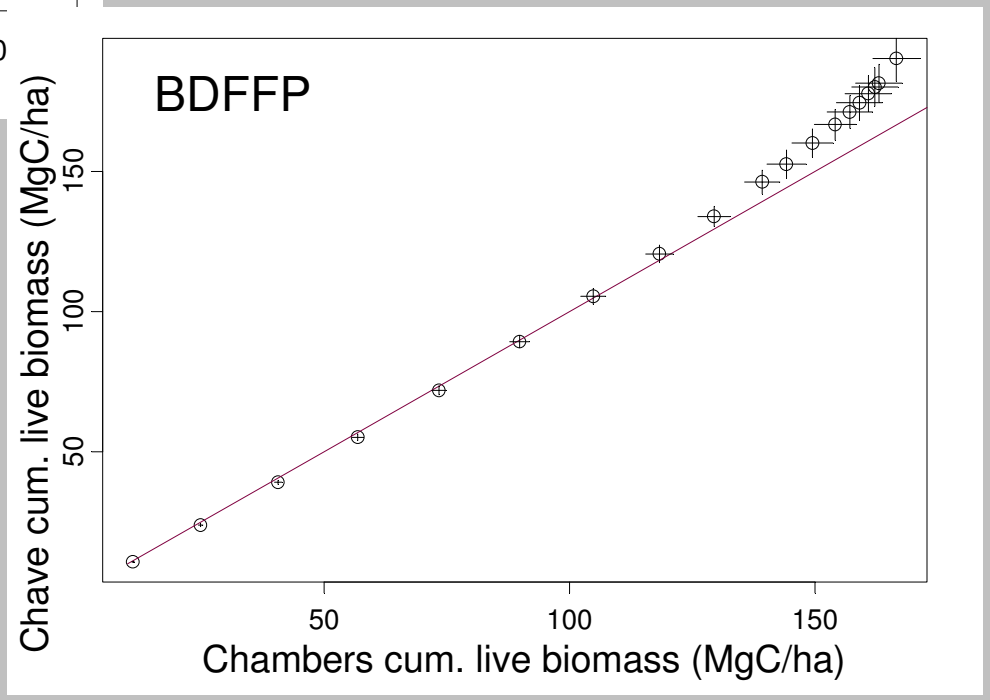
20 x 1 ha plots, live biomass measured in 1997-1999, and in 2002-2004.

CWD measured in each plot, ~750 m line intercept per plot.

SENSITIVITY OF BIOMASS TO ALLOMETRY?



Total Live Biomass:	
TNF, Chambers:	151 (±3.9)
TNF, Chave:	200 (±9.3)
BDFFP, Chambers:	169 (±4.0)
BDFFP, Chave:	194 (±5.7)



SENSITIVITY OF BIOMASS TO ALLOMETRY

	TNF (km 67)		BDFFP	
(MgC ha^{-1} yr^{-1})	Chave allometry	Chambers allometry	Chave allometry	Chambers allometry
Growth	3.81 (±0.24)	3.19 (±0.20)	3.08 (±0.18)	2.59 (±0.10)
Recruitment	0.38 (±0.04)	0.45 (±0.04)	0.24 (±0.01)	0.25 (±0.01)
Mortality	3.81 (±0.83)	3.02 (±0.42)	2.79 (±0.43)	2.55 (±0.33)
Net Flux	-1.23 (±0.61)	-1.79 (± 0.58)	0.67 (± 0.35)	0.18 (±0.29)

BIOMASS AND NECROMASS AT TWO SITES

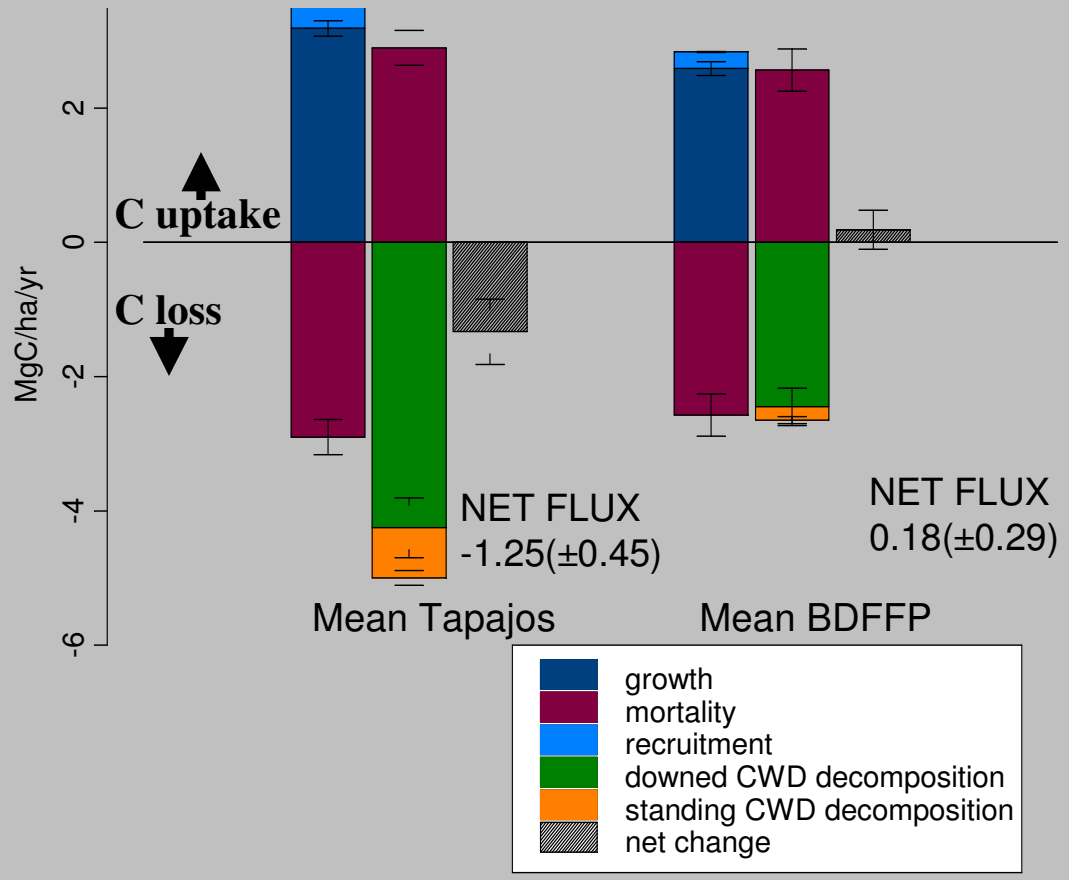
	Live Biomass (MgC ha^{-1})	Live Stems per ha	Fallen CWD (MgC ha^{-1})	Standing CWD (MgC ha^{-1})
Tapajós				
km 67(2001)	148(±6)	480 (±49)	35 (±4.8)	8.9 (±1.9)
km 72 (2003)	154 (±8)	428 (±33)	28.5 (±5.6)	12.7 (±2.8)
km 117 (2003)	150 (±7)	460 (±33)	37.43 (±18)	3.9 (±1.5)
km117 (2003)	144 (±7)	435 (±66)	35 (±14)	8.6 (±3.7)
mean	**148 (±3)**	**441(±43)**	**32 (±3.7)**	**8.7 (±1.3)**
BDFFP (2002)				
Gavião	150 (±9)	597 (±19)	12 (±2.2)	3.7 (±1.8)
Florestal	177 (±11)	634 (±22)	18 (±3.6)	1.7 (±0.6)
KM 41	172 (±14)	622 (±25)	11 (±2.3)	4.0 (±1.8)
Dimona	181 (±16)	688 (±43)	9.5 (±2.9)	4.9 (±2.8)
Cabo Frio	166 (±12)	608 (±52)	11.7 (±3.2)	2.8 (±2.1)
mean	**167 (±5)**	**621 (±39)**	**13 (±1.3)**	**3.2 (±0.8)**

Biomass Similar at both sites.

Despite differences in stem density.

But…. CWD different.

FLUXES IN LIVE AND DEAD BIOMASS (1)



Net Flux

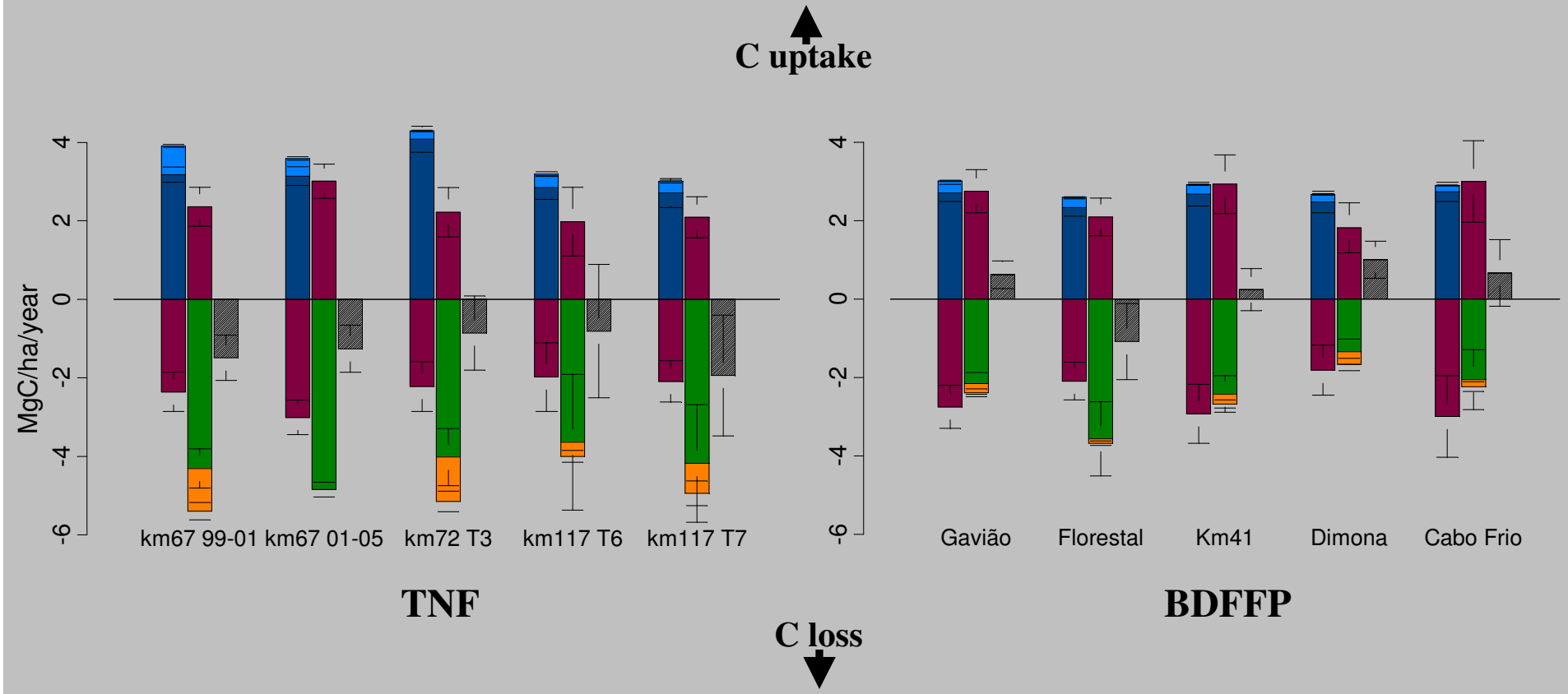
TNF Overall:
-1.25 Mg C ha^{-1} yr^{-1}
TNF without inclusion of CWD:
+ 0.8 Mg C ha^{-1} yr^{-1}
Eddy Flux: -0.89 ± 0.22 Mg C ha^{-1} yr^{-1}*

BDFFP overall:
+ 0.18 Mg C ha^{-1} yr^{-1}
BDFFP without inclusion of CWD:
+0.3 Mg C ha^{-1} yr^{-1}
Eddy Flux: 1-8 Mg C ha^{-1} yr^{-1}**

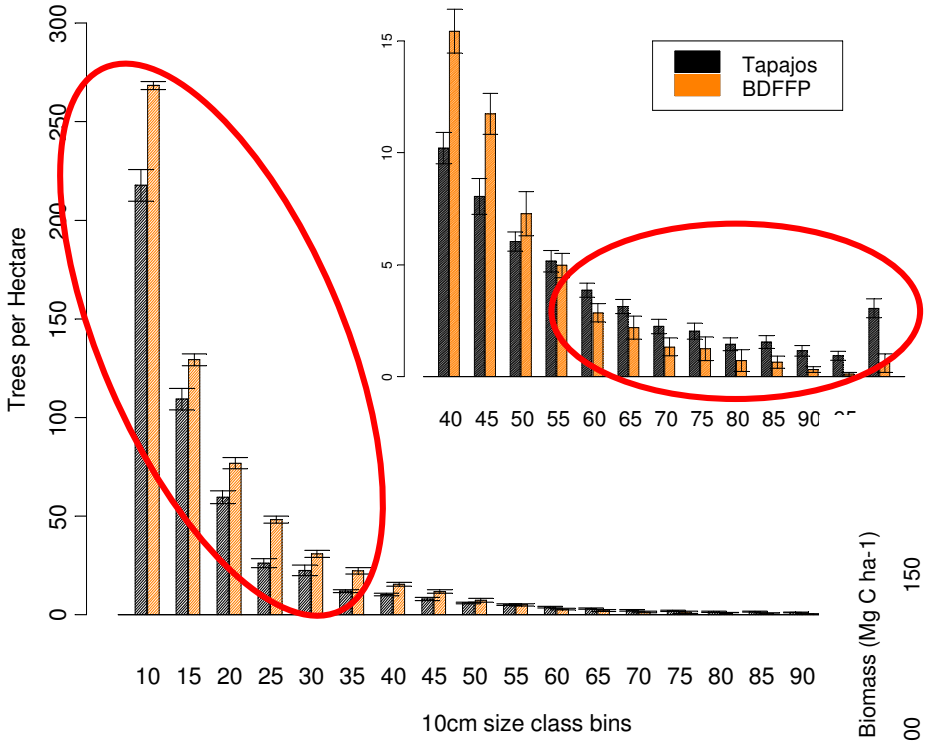
Residence time of CWD in the system is short, ~6-8 years, but variations in the CWD stocks and distribution have the potential to change the estimated C balance of site from sink to source.

* Hutyra et al. 2007
** Araujo et al. 2002

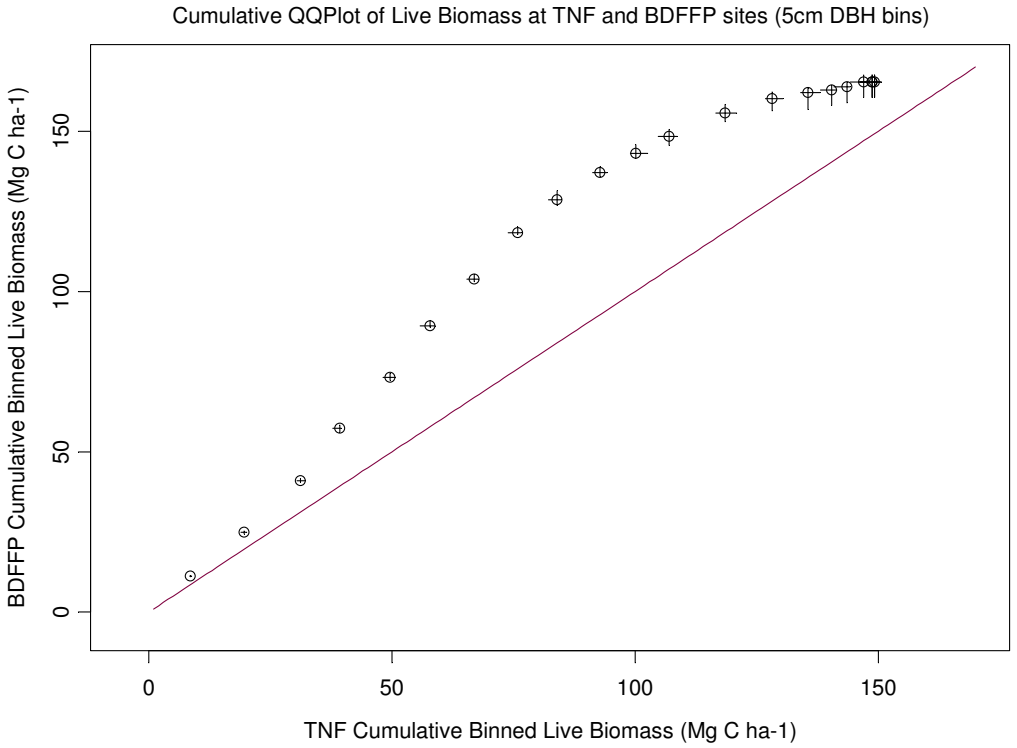
FLUXES IN LIVE AND DEAD BIOMASS (2)



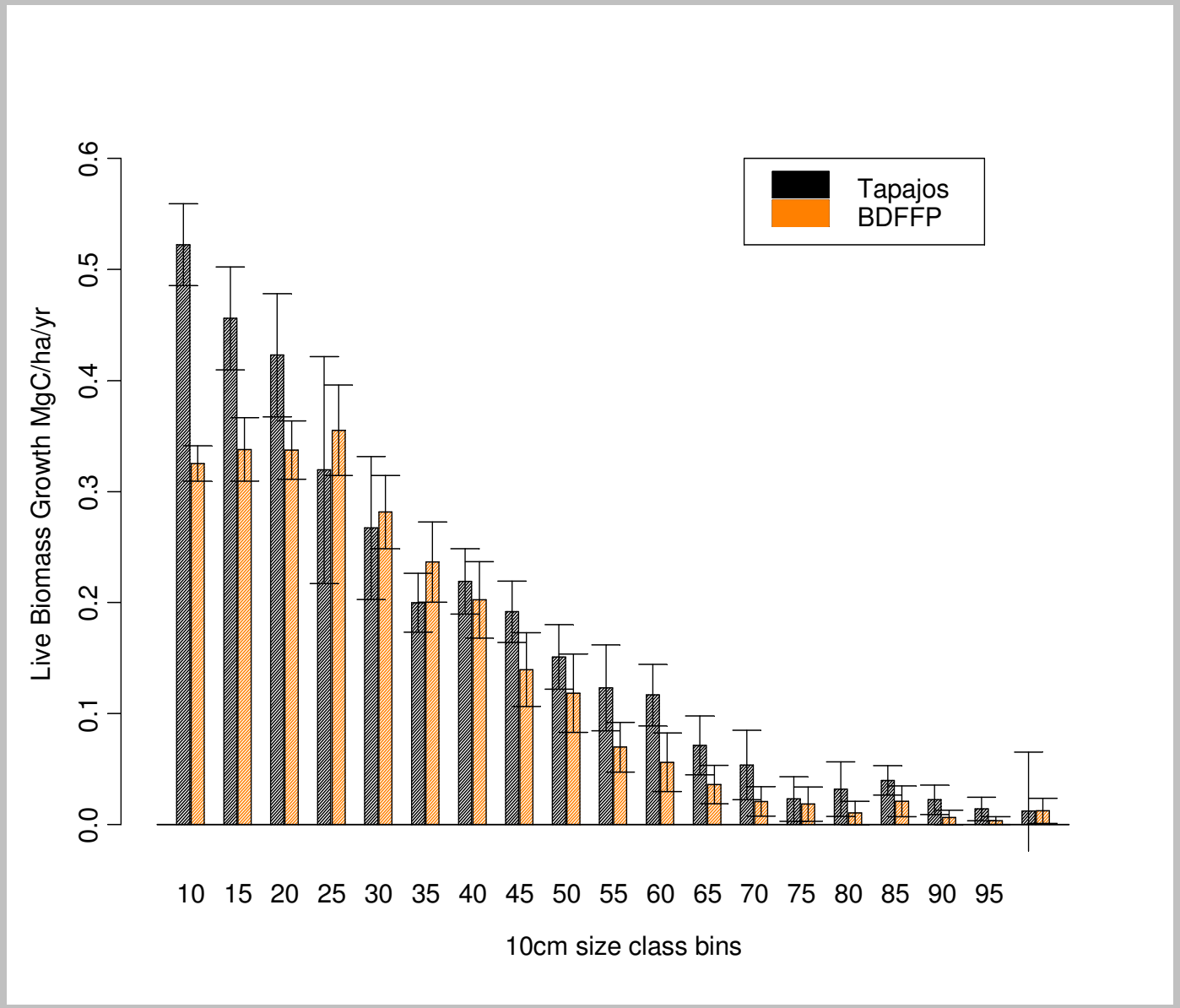
STRUCTURAL DIFFERENCES (1)



BDFFP shows more stems in the small and middle size classes, but the TNF showed higher growth rates in these size classes.

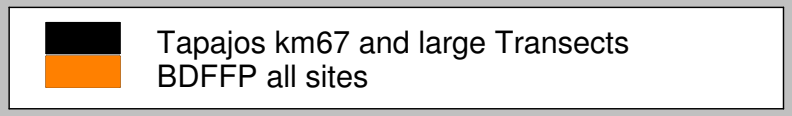


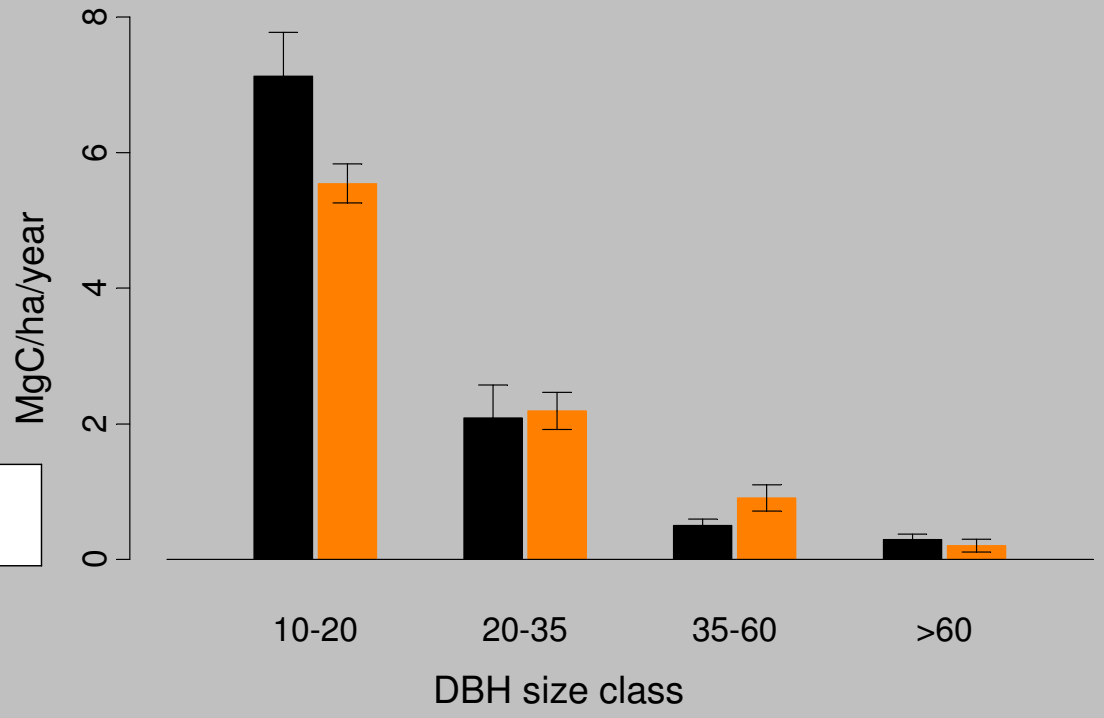
STRUCTURAL DIFFERENCES (2)

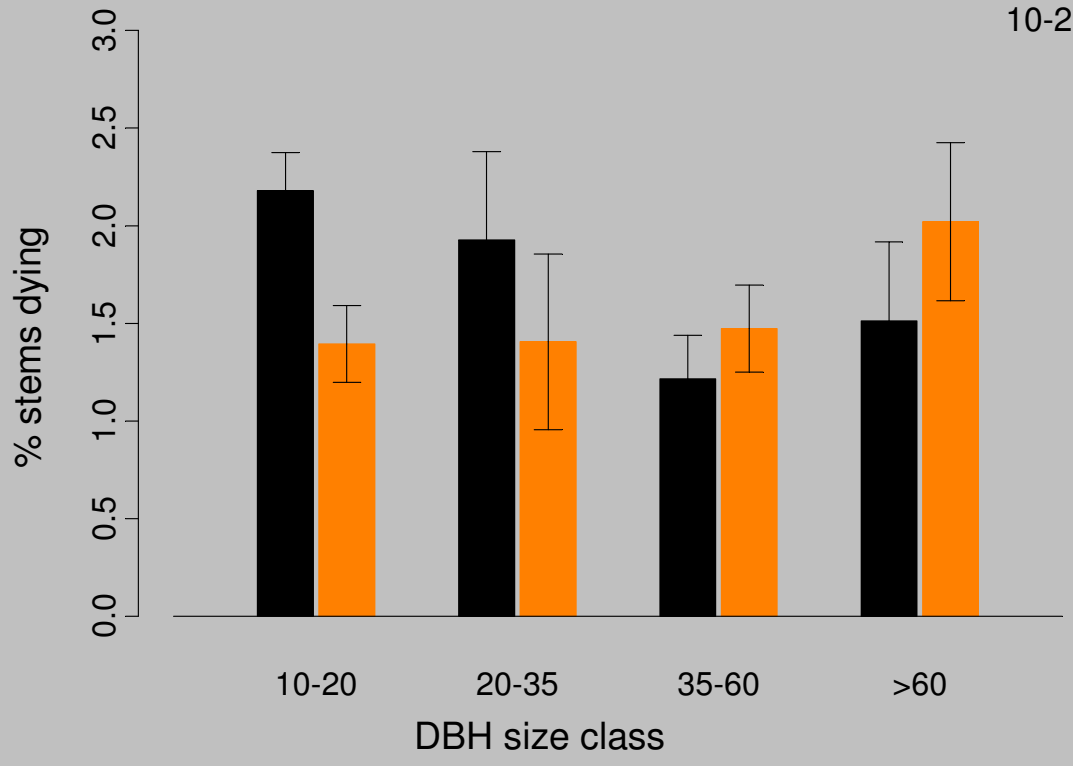


MORTALITY

Mortality (in MgC/ha/year) is greater in the smallest size classes in the TNF in terms of both carbon and % stem mortality







The mean mortality in the BDFFP plots was 1.6% vs. 2% in the TNF → 25% difference.

A DISTURBANCE HYPOTHESIS

Site differences suggest that TNF was subject to disturbance prior to the onset of the study

- CWD 2.5 times higher in TNF than in BDFFP
- Greater C loss from CWD respiration in TNF
- Higher growth rates in small trees in the TNF
- Lower stem densities in Small and Middle Size Classes in TNF
- Higher mortality in small trees in the TNF
- Overall, the TNF shows greater dynamism

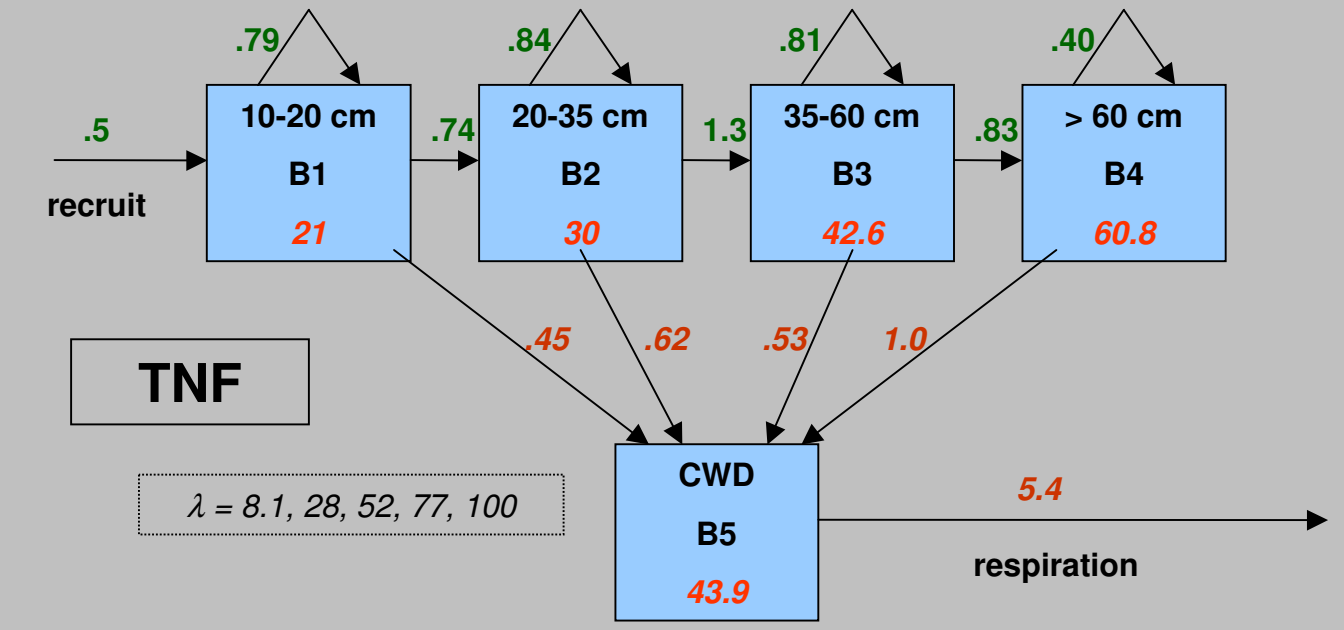
MODEL (SCHEMATIC)

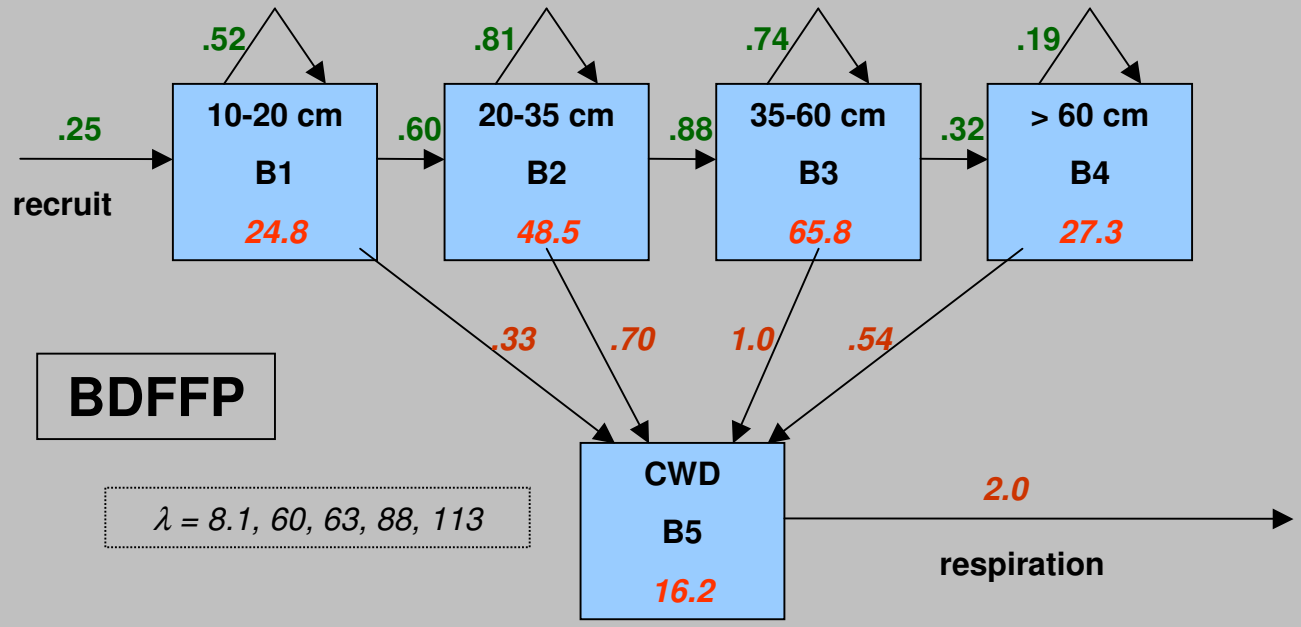
Simple Box Model of above ground woody biomass dynamics for assessing short term C dynamics. Each live box accumulates and transfers carbon based on observed rates at the two sites.

Organic stocks (Mg C/ha, in red) fluxes (**growth**, in green, **mortality,** in brown, Mg C/ha/yr)

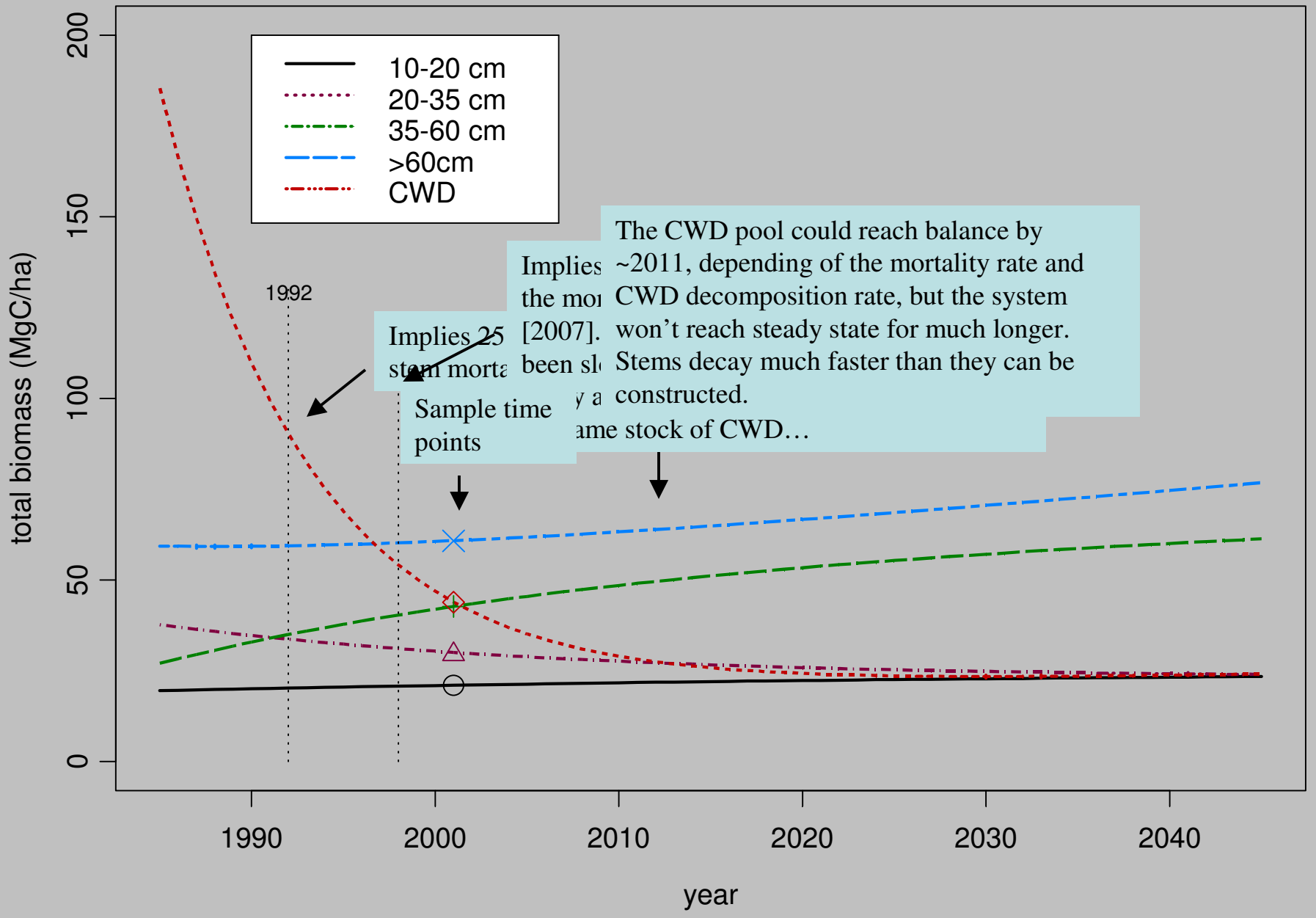
The *time constants* for the eigenmodes of the associated linearized model (λ) are given in yr.

In the TNF only the smallest size class approximated steady state. At the BDFFP was much closer to steady state.





MODEL (RESULTS)



SUMMARY

- These two eastern Amazonian sites differ significantly in their carbon dynamics, notwithstanding similar total live biomass.
- TNF shows larger gross fluxes in live and dead biomass, higher growth and mortality in smallest size classes, and an apparent shifting in live tree size class structure.
- In the TNF, the measurements appear to have captured the response of the ecosystem to a major mortality event, providing a unique opportunity to observe the legacies of disturbance and the dynamics of recovery.
- Major carbon pools were close to steady state at the BDFFP plots, with more biomass concentrated in middle size classes of live trees.

CONCLUSIONS

- The net loss of carbon from the TNF will likely last 10-15 years (controlled by the rate of decay of coarse woody debris), followed by uptake of carbon as the forest evens out imbalances in size class structure and composition.

- The data support the view that episodic disturbances create a patchwork of aggrading forests in Amazonia, interspersed with smaller areas that emit carbon to the atmosphere.

- Examining only these two site with such disparate carbon dynamics, we cannot guess at the net carbon balance of the entire Amazon Basin. While our two sites are internally consistent in carbon balance, the way they fit into the Basin as a whole remains unknown.

Acknowledgements

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