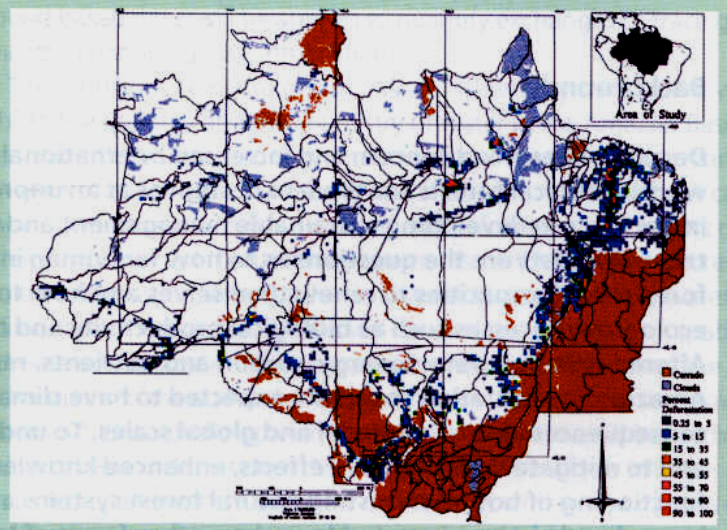
Carbon Dioxide Exchange of a Tropical Rainforest Before and After Selective Logging

UC IRVINE: SCOTT MILLER, MIKE GOULDEN, MARY MENTON, ED READ, ROB ELLIOT
USP: HUMBERTO DA ROCHA, MICHELA FIGUEIRA, ALBERT DA SOUSA, AGOSTO MEIA, HELBER FREITAS
HARVARD: STEVE WOFSY, SCOTT SALESKA



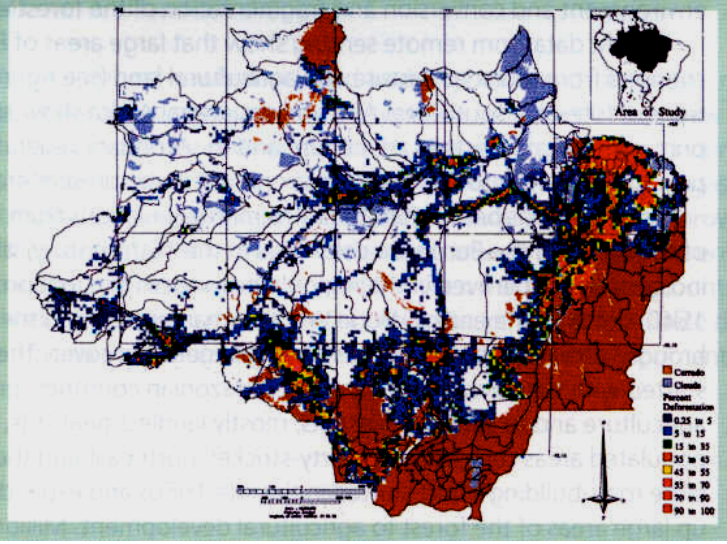
1978

Deforestation (confined to forest strata) in Brazilian Amazonia between 1978 (above) and 1
resolution LANDSAT satellite imagery, as reported by Skole and Tucker (Science 260, 1993)
1978 and 1988 from 78 000 km^2 to 230 000 km^2 . In the same study, the total area of a ha
increased from 208 000 km^2 in 1978 to 588 000 km^2 in 1988. Another estimate using a sli
forest shows a total deforestation of 430 000 km^2 , up to 1991. (Instituto Nacional de Pesq
Campos, Brazil, 1992).

Brazilian Amazon: 6 million km^2

Area Affected by Deforestation: 10% (1988)

Selective Logging: 10,000-15,000 km^{2}yr^{-1}



1988

Nepstad et al. 1999
Skole and Tucker 1997

Large inputs of slash/CWD

Canopy removal can of order 30% (vines).

Logging roads/skid trails impact soil

Gaps alter microclimate

Big Questions:

How does selective logging effect carbon exchange?

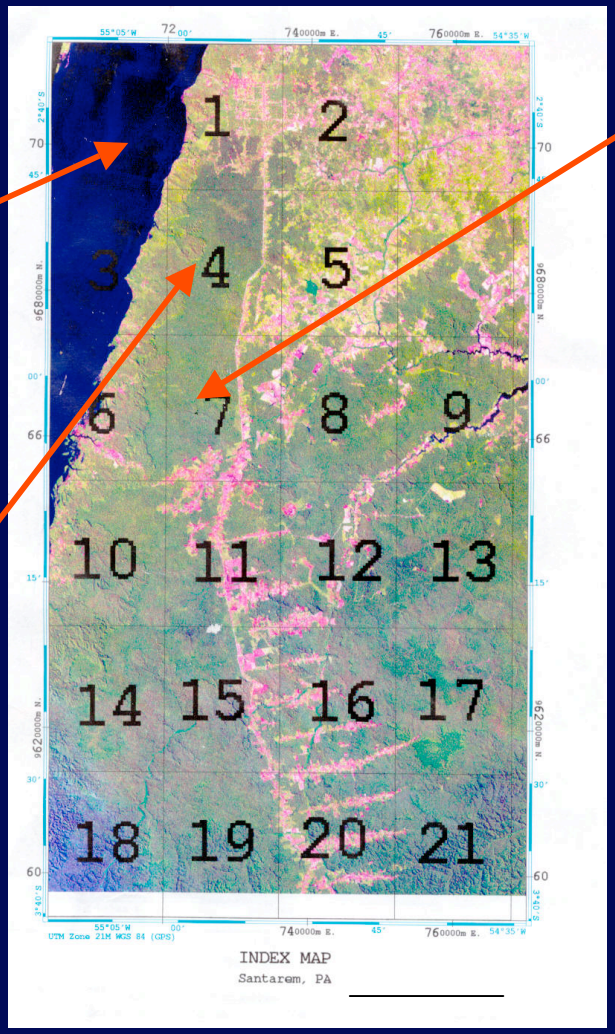
Do canopy gaps created by logging effect carbon exchange?

Experimental Plan

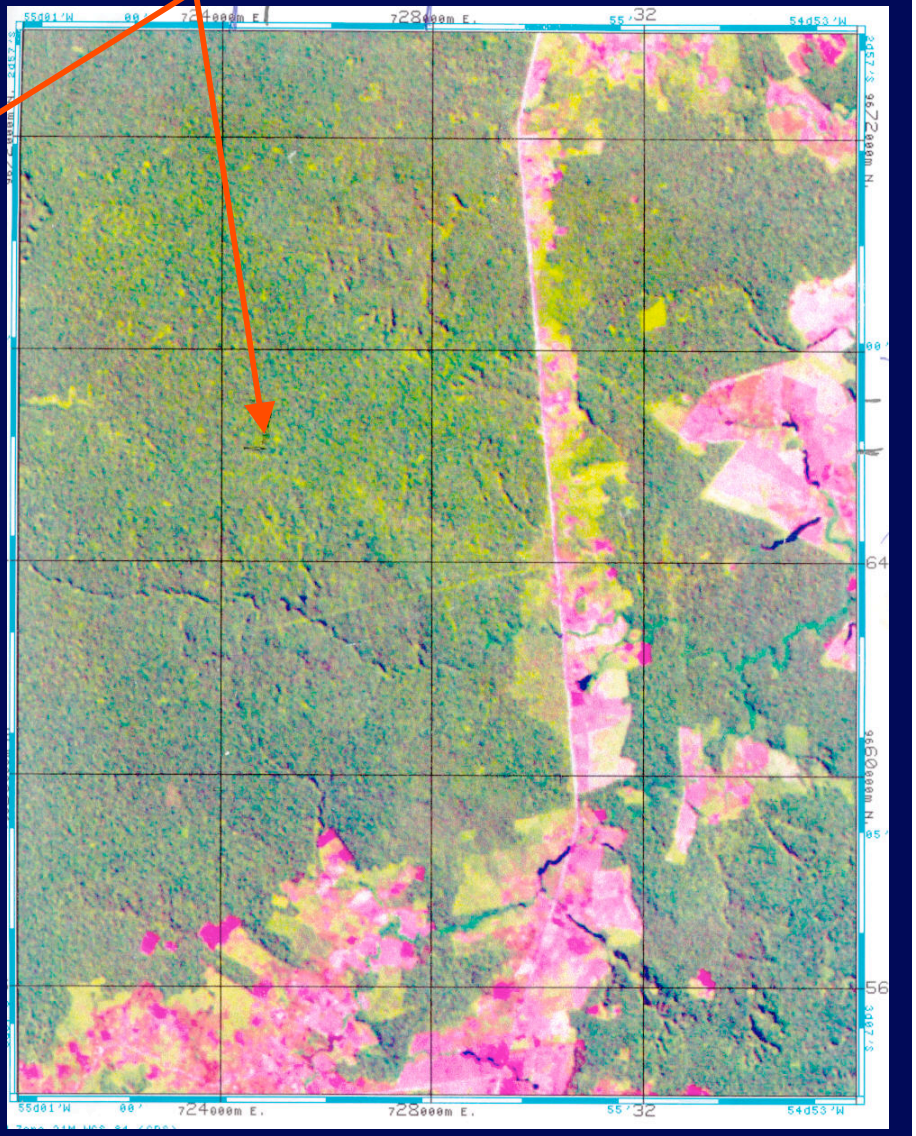
Logged Site

Tapajos River

Control Site

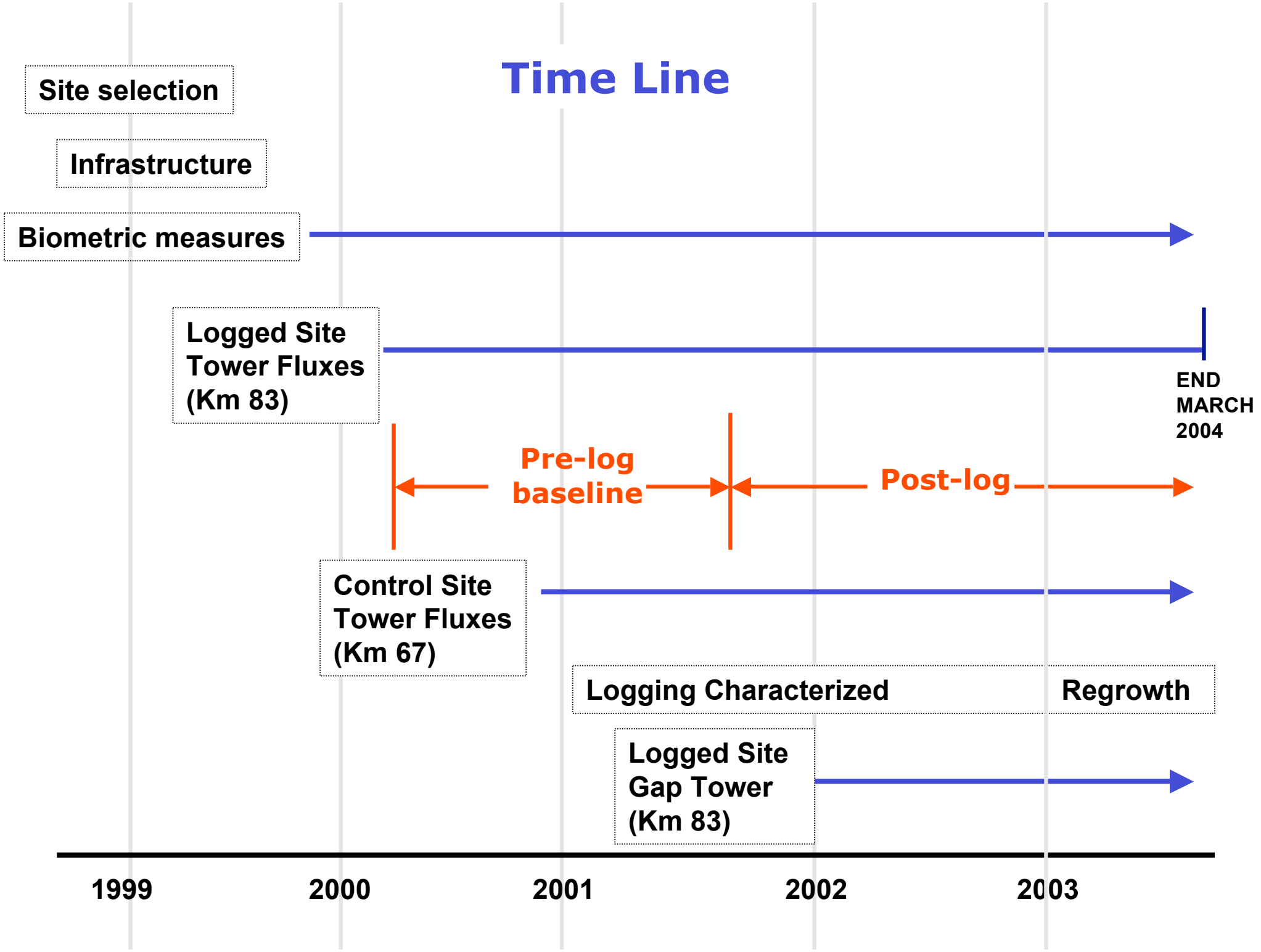


Wind dir



60 km

16 km


Time Line
Site selection
Infrastructure
Biometric measures
Logged Site Tower Fluxes (Km 83)
END MARCH 2004
Pre-log baseline
Post-log
Control Site Tower Fluxes (Km 67)
Logging Characterized
Regrowth
Logged Site Gap Tower (Km 83)
1999
2000
2001
2002
2003

Pre-logging Baseline

FOREST PHYSIOLOGY

Goulden et al. Physiological controls on tropical forest CO_2 exchange. Ecological Applications (2002) (2003) (2004?).

WATER/ENERGY BUDGET

da Rocha et al. Seasonality of water and heat fluxes over a tropical forest in eastern Amazonia. Ecological Applications (2002) (2003) (2004?).

CARBON BUDGET

Miller et al. Biometric and micrometeorological measurements of tropical forest carbon balance. Ecological Applications (2002) (2003) (2004?).

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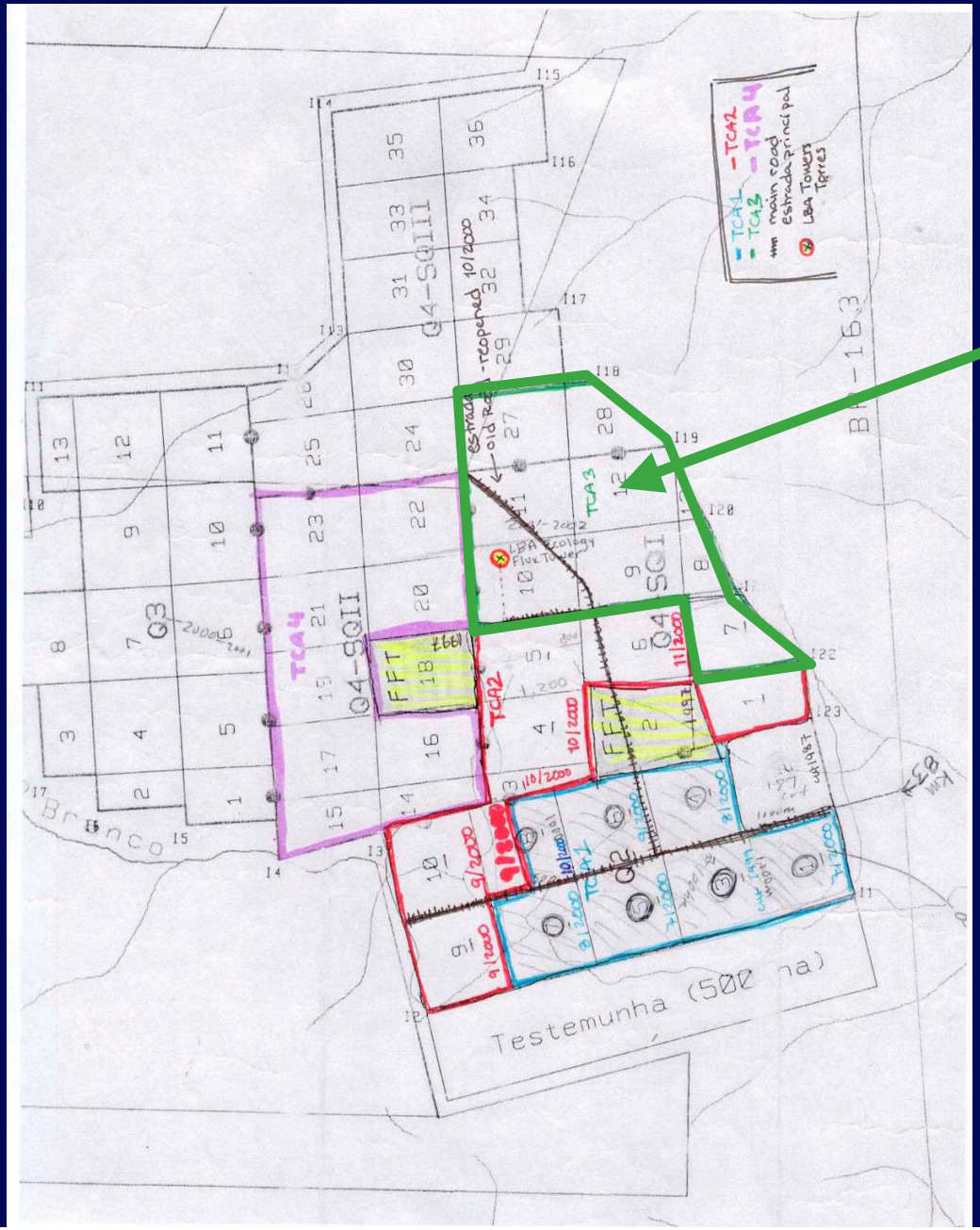
Username: cd04
Password: secure

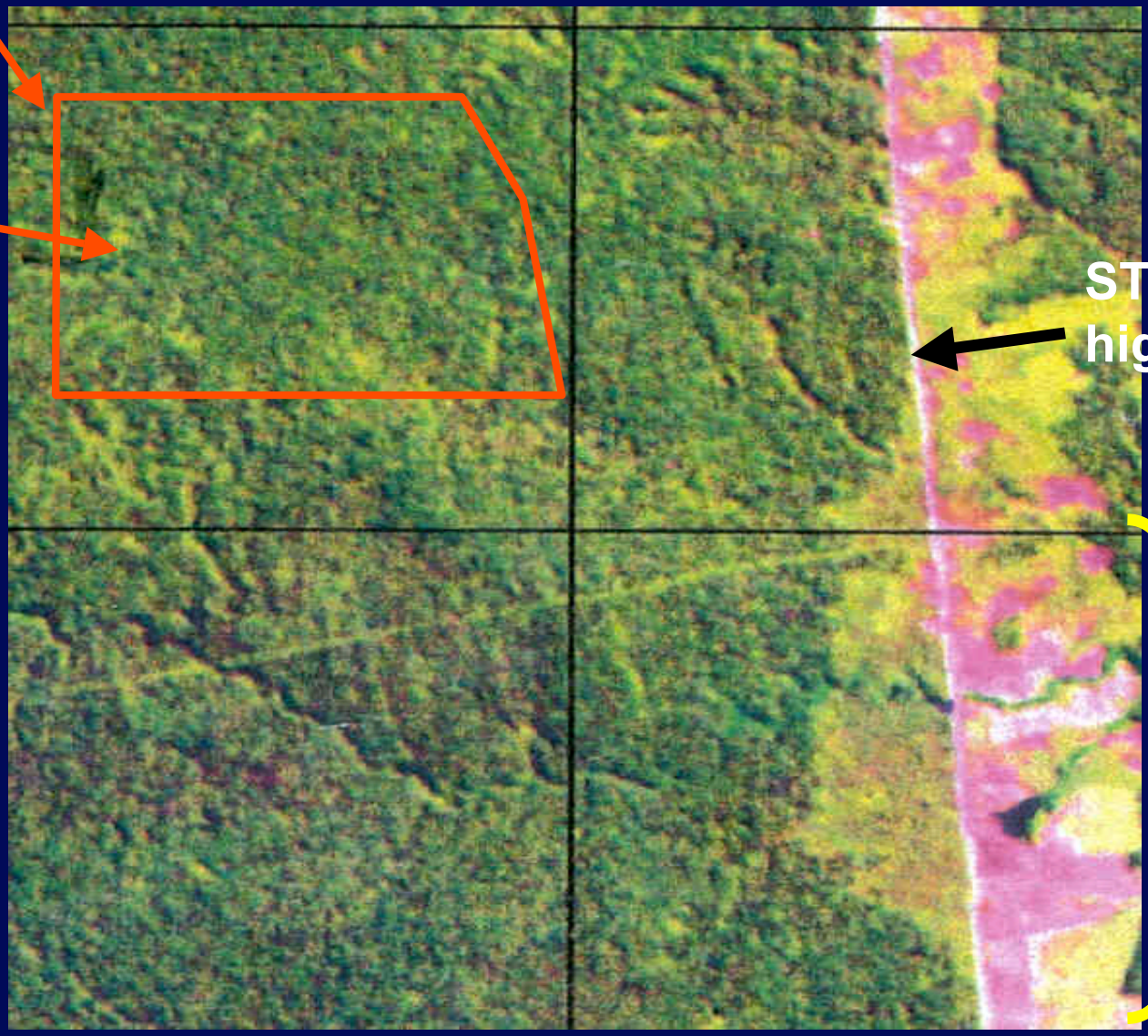
Logging Plan



2001 Logging Area

700 ha selectively logged in 2003

Tower



STM-Cuiaba highway

4km

Wind is East to west

Tower Measurements

METEOROLOGY

PAR (up/down)
Radiation (short and long wave, up and down)
Rain

PROFILES

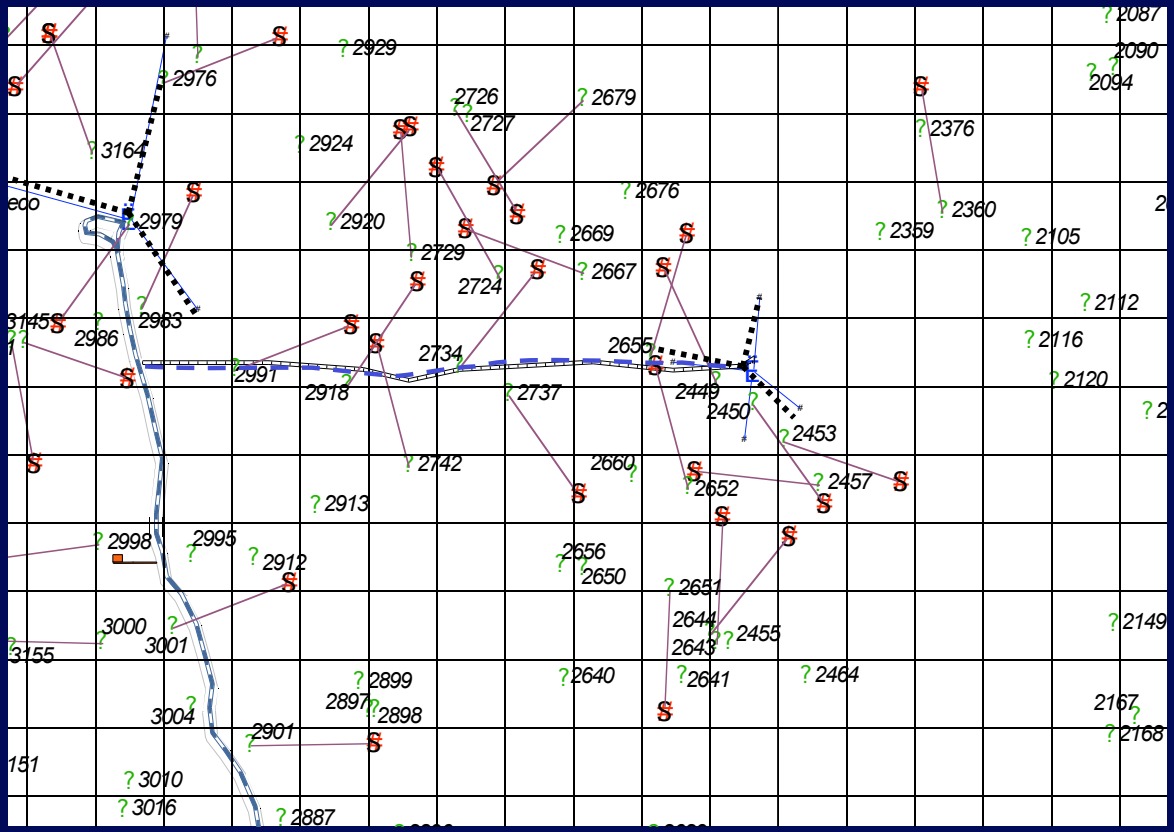
Wind (6 levels cups and 2D Sonics)
Temperature (6 levels)
CO_2/H_2O (12 levels)

FLUXES (64 meters)

Momentum/Heat	sonic anemometer
CO_2/H_2O	Infrared Gas Anayzer

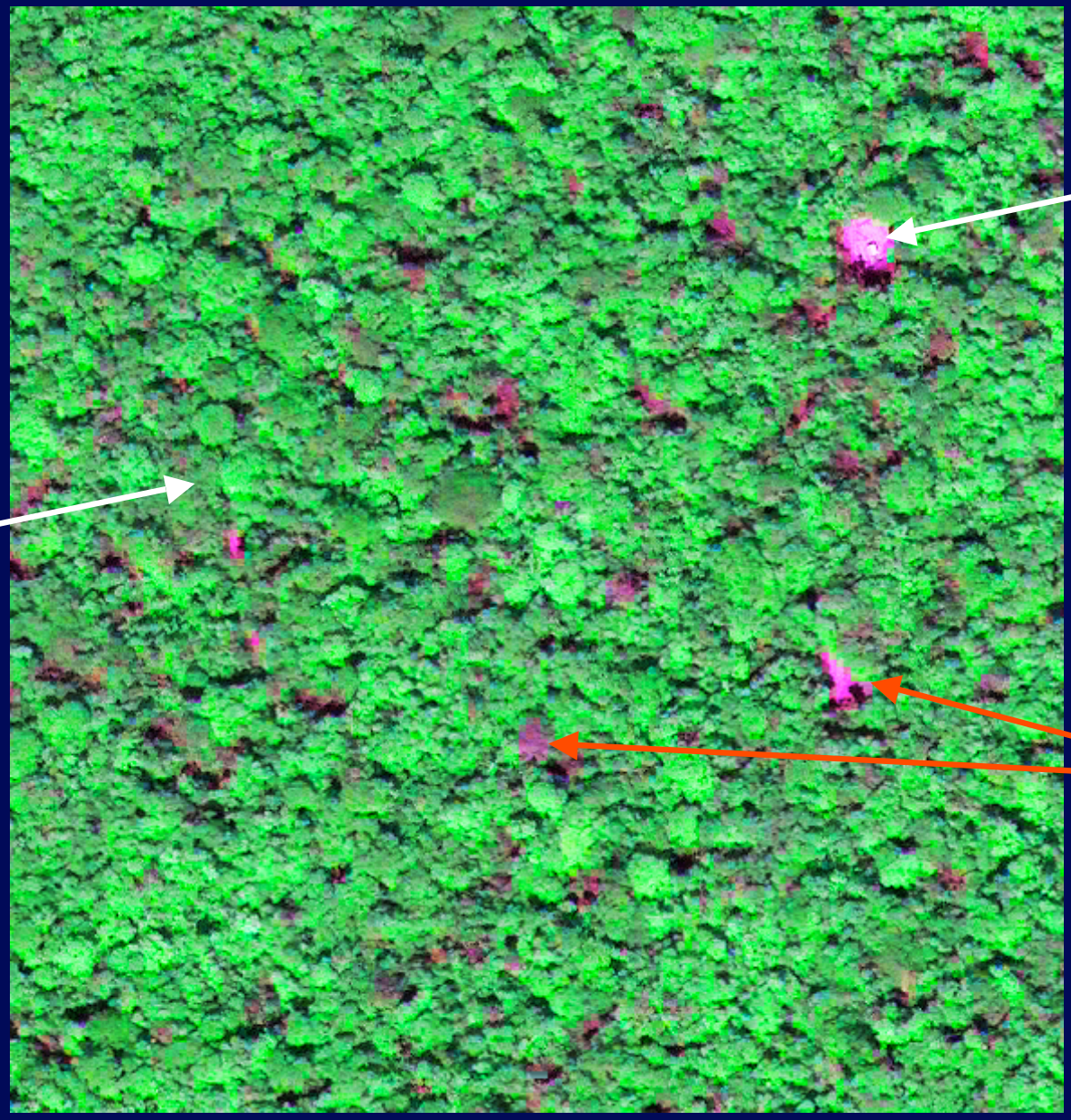
Reduced Impact Logging

- Forest inventories used to select trees
- Vines cut several months before logging
- Felling directions, skid trails, patios planned




AM 9:17
AUG.17 2001

IKONOS Post-Logging



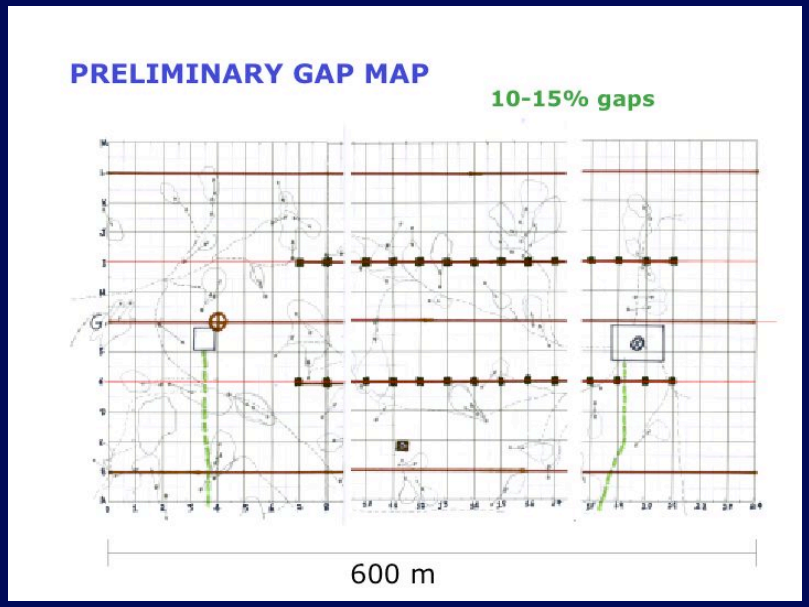
- 2-3 trees cut per hectare
- 5 T C ha^{-1}

~15 T C ha^{-1} slash left behind by logging

8% affected by roads and trails

Measured Effects of Logging

15% Overstory canopy lost during logging
15 T C ha^{-1} coarse woody debris
0.5 T C ha^{-1} leaf litter



Predicted Effects on CO2 Exchange

Photosynthesis: 15% Reduction

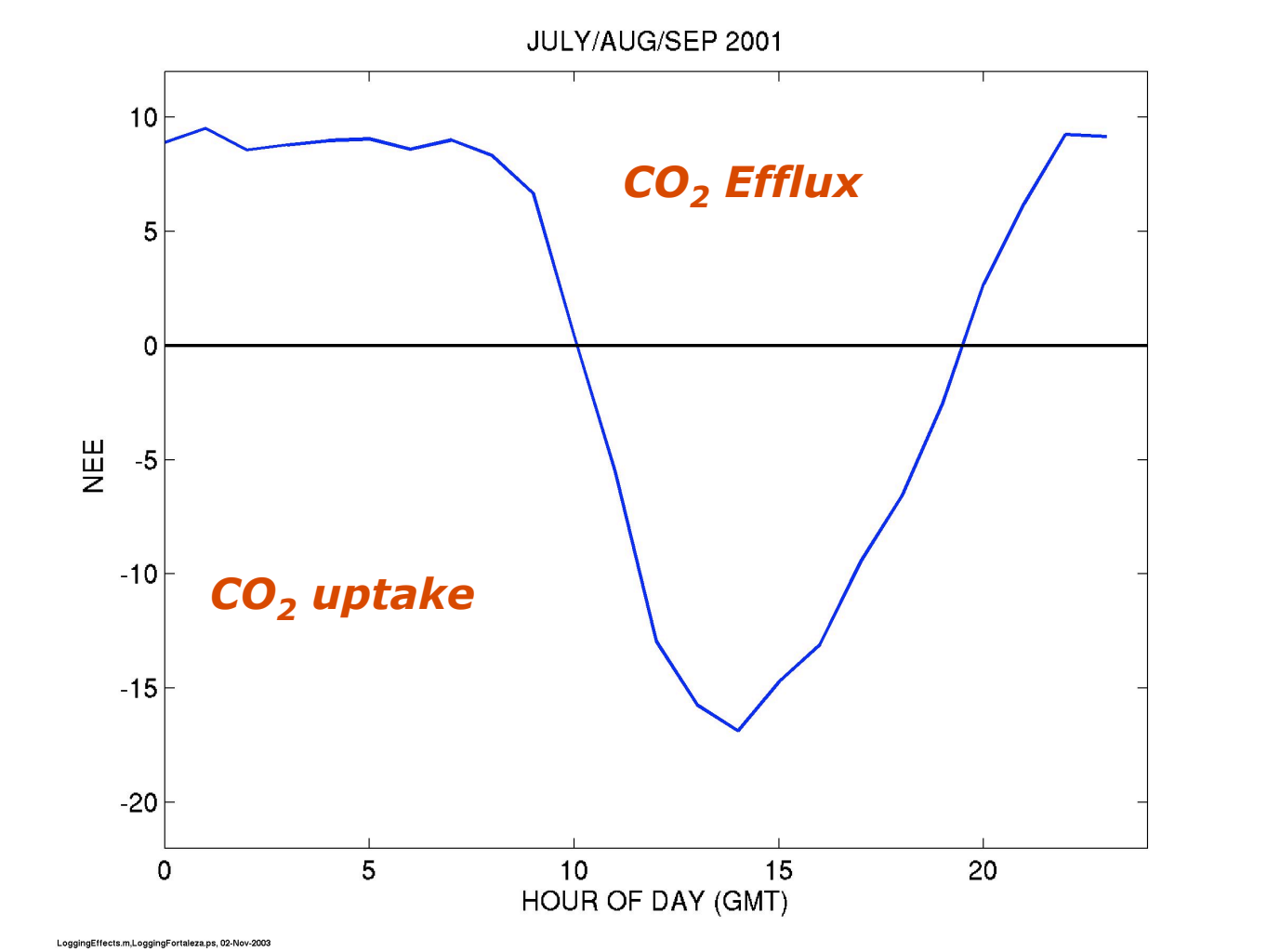
Autotrophic Respiration: 10% reduction

Decomposition: coarse woody debris takes 10 years to decay and leaves decay in 1 year

= Loss of ~1 T C ha^{-1} in first year

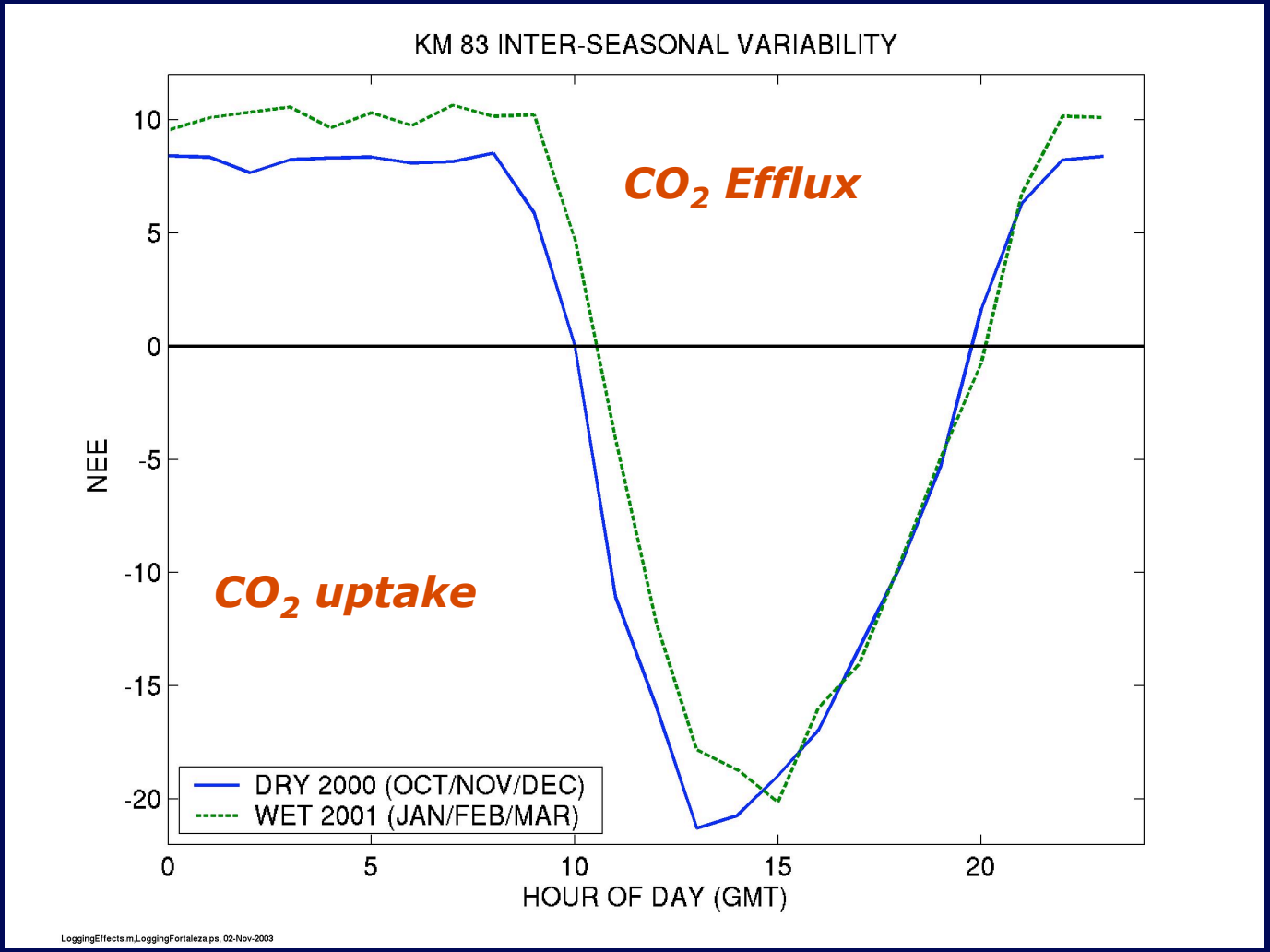
Resolving Logging Effects

Natural variability (Inter-Seasonal/Inter-Annual/Site-Site)



Resolving Logging Effects

- Inter-seasonal variability is about 15%



Resolving Logging Effects

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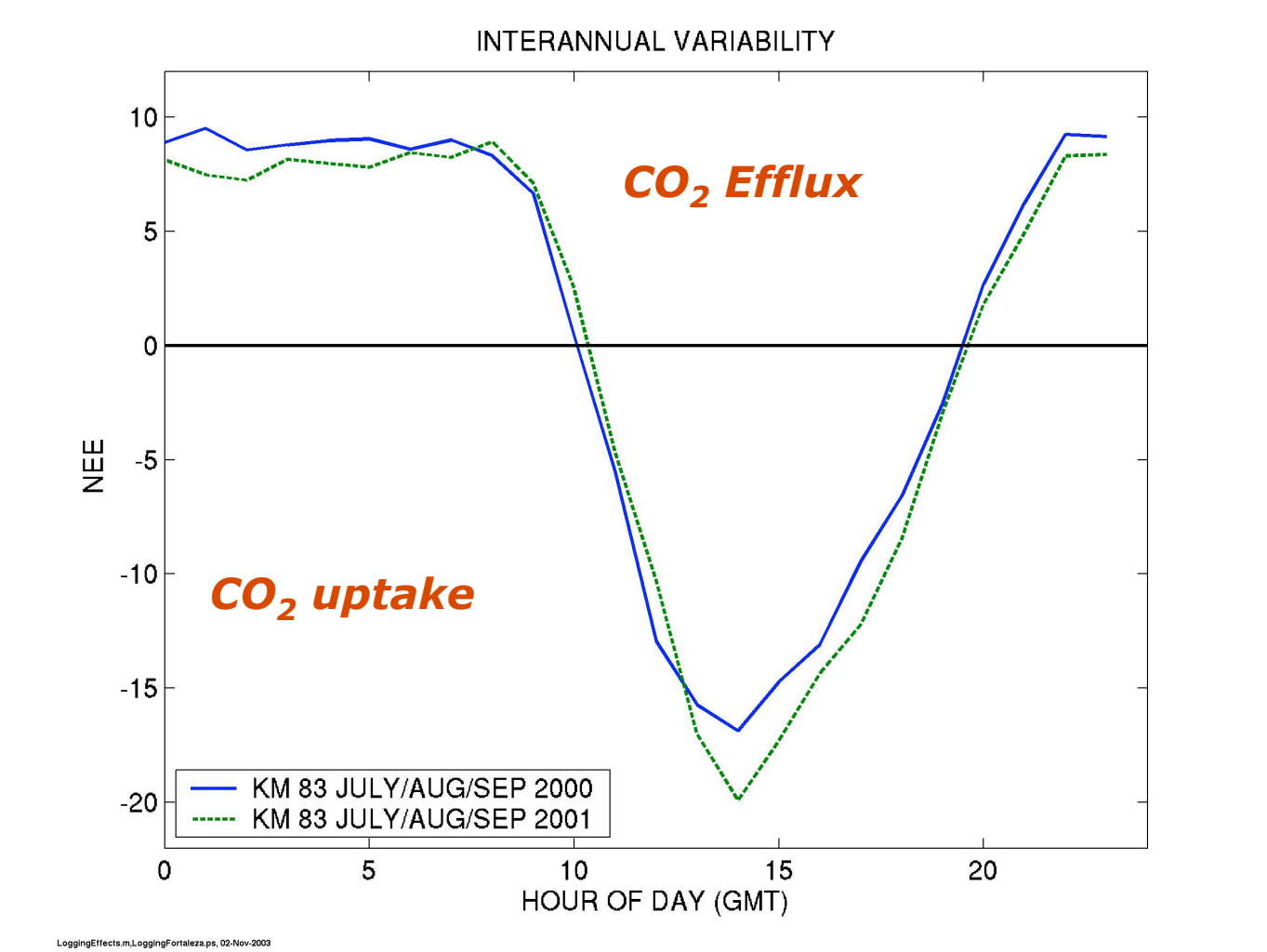
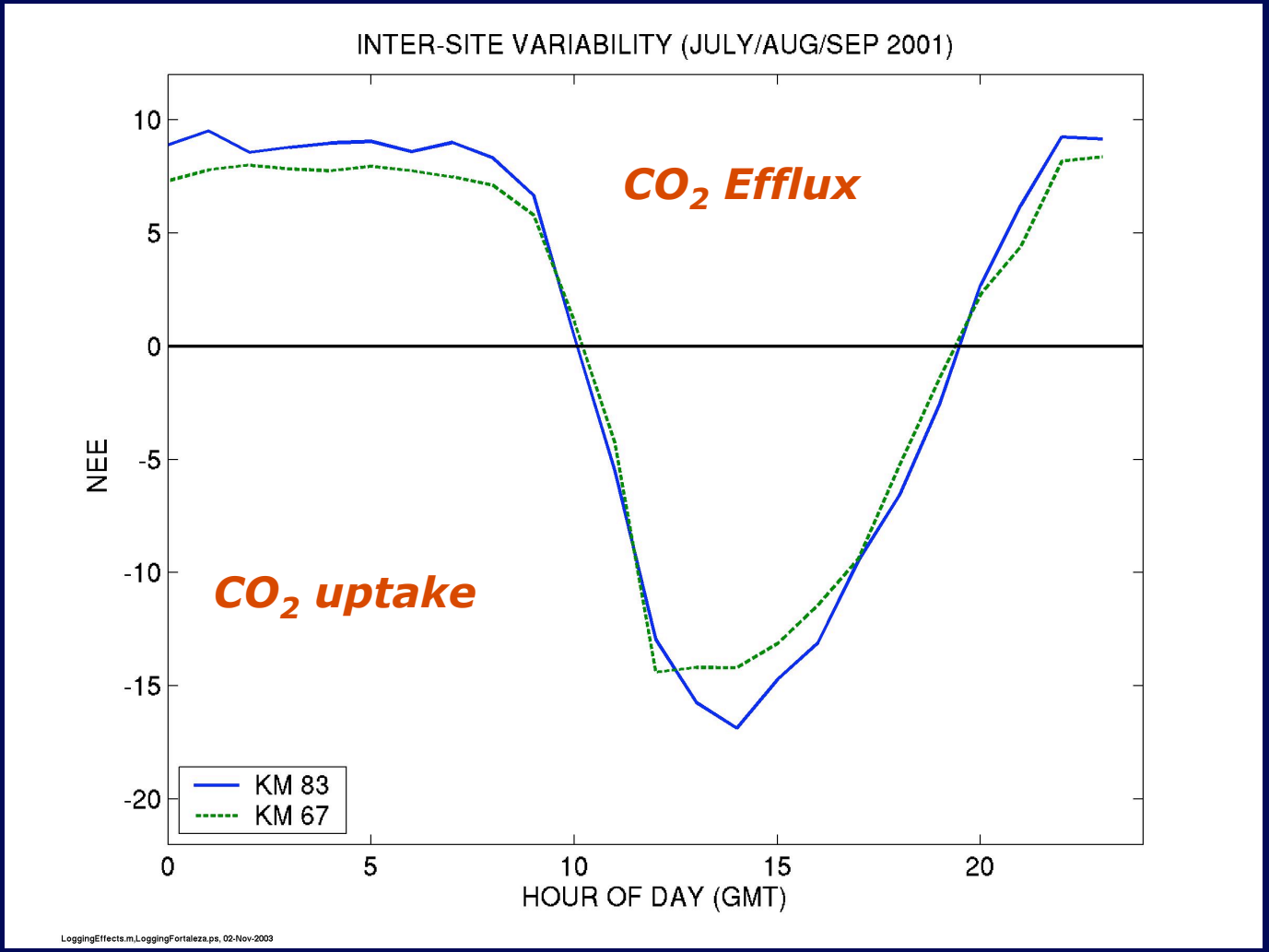


Resolving Logging Effects

Site-Site variability is about 15%



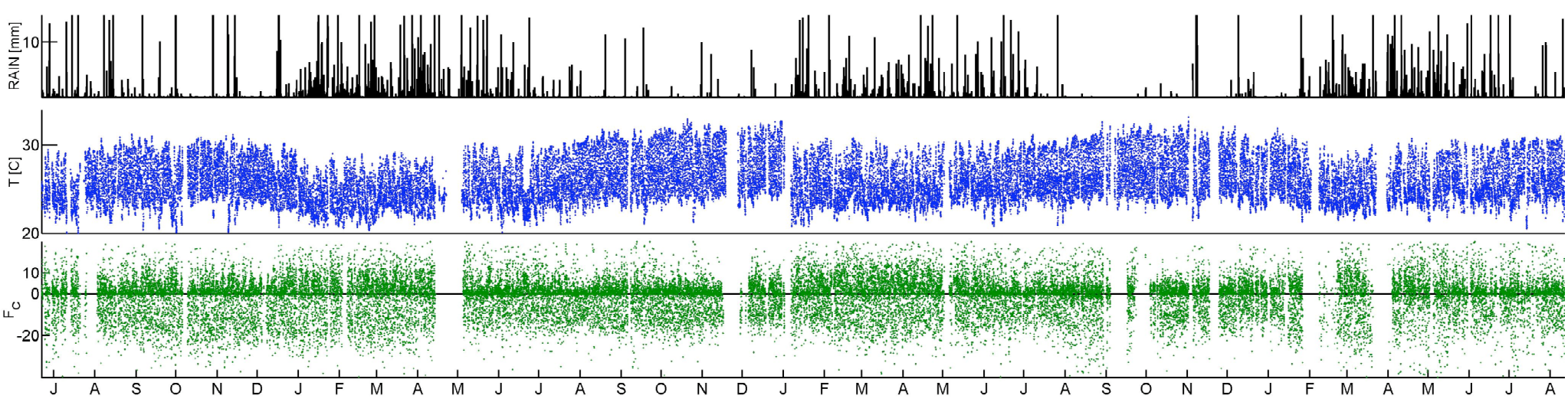
Resolving Logging Effects

Percentage of Canopy removed is similar to

- **Inter-seasonal variability**
- **Inter-annual variabiltiy**
- **Site-Site variability**

therefore, detection of a logging signal in the tower data is difficult, but we can take advantage of the high precision of eddy covariance.

Data Summary



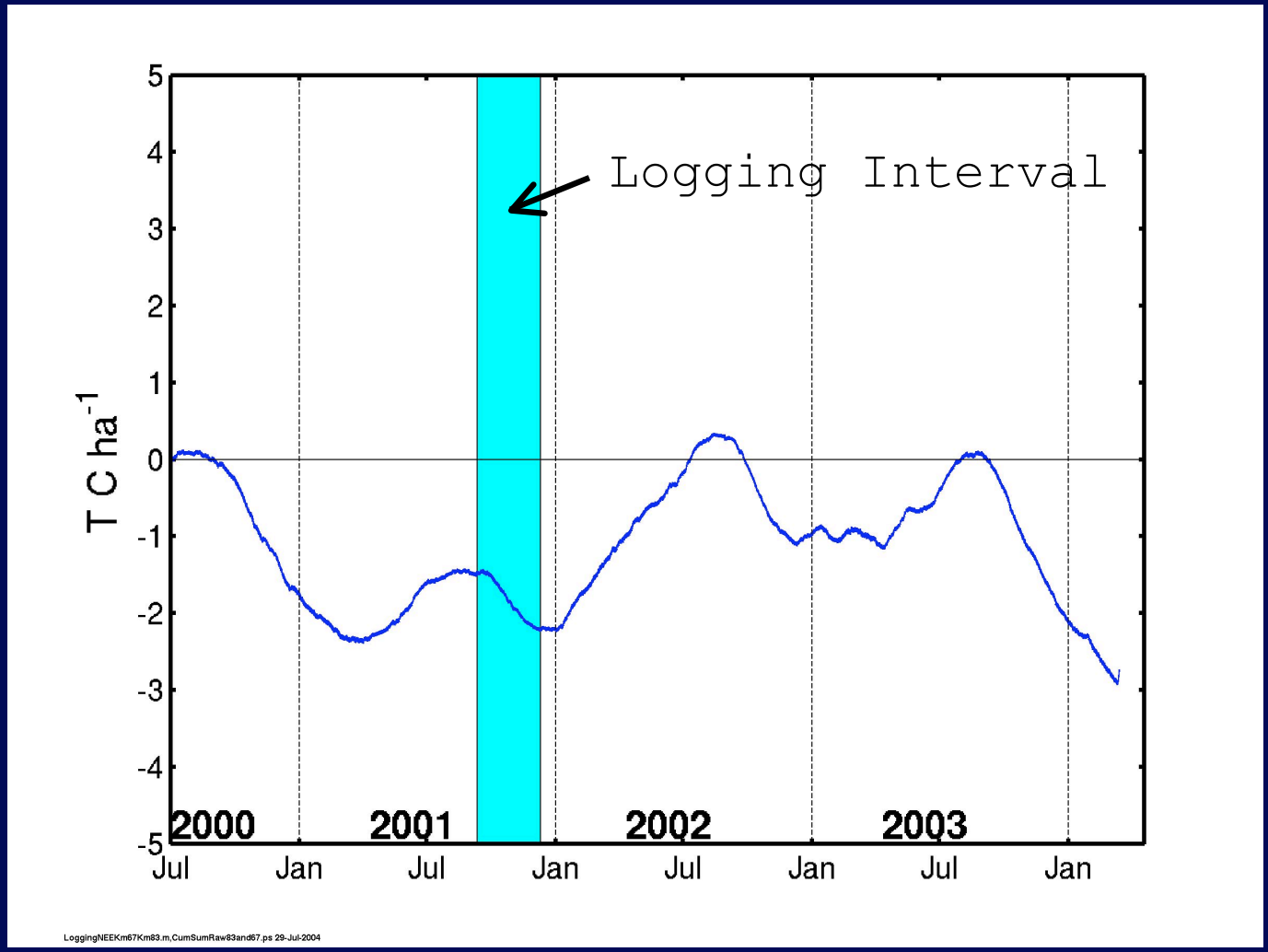
2000 2001 2002 2003

30-minute averaged co2 exchange (NEE) is integrated to determine net exchange over long periods

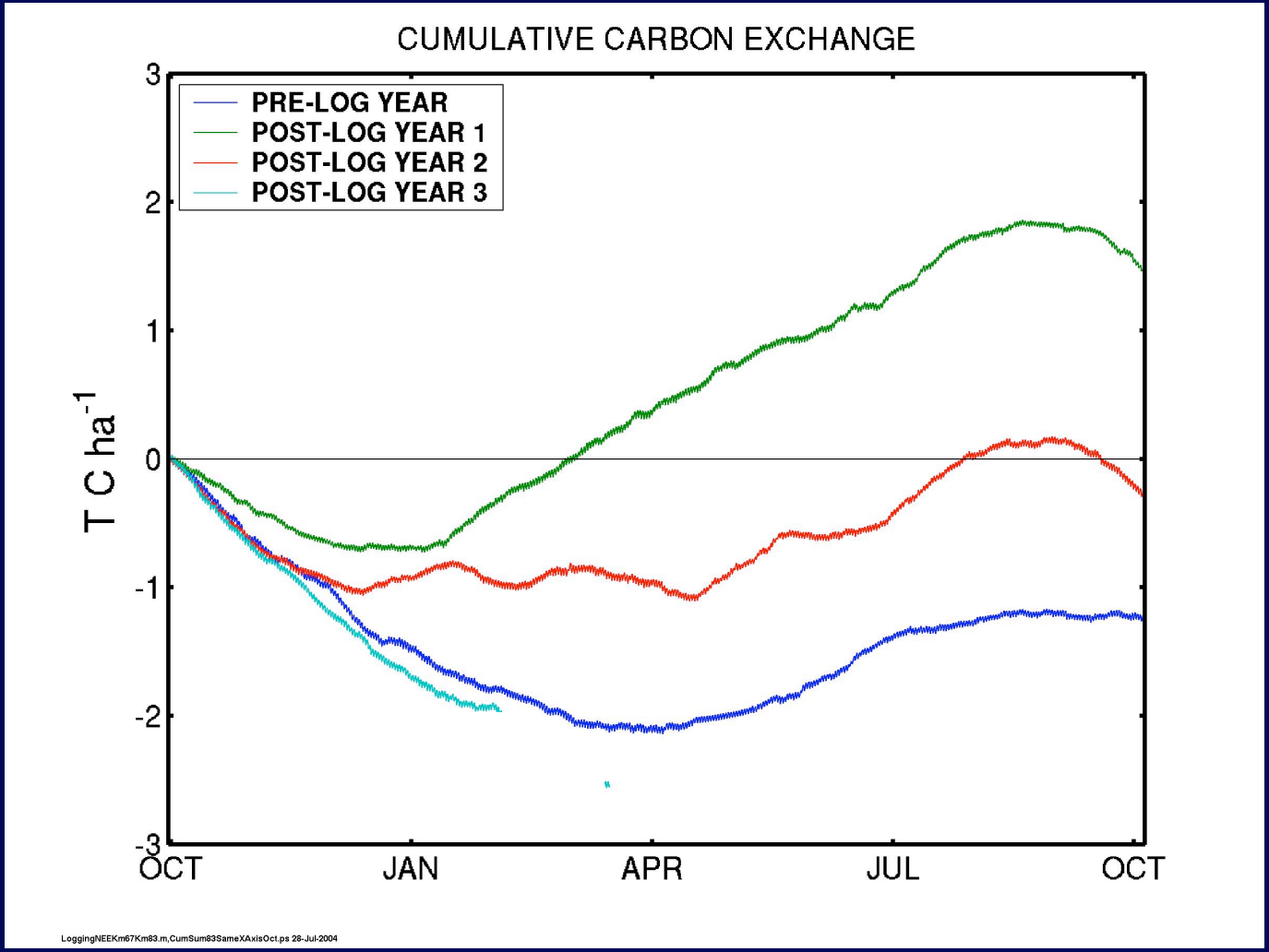
Cumulative Carbon Exchange Over 3 Years

Carbon source

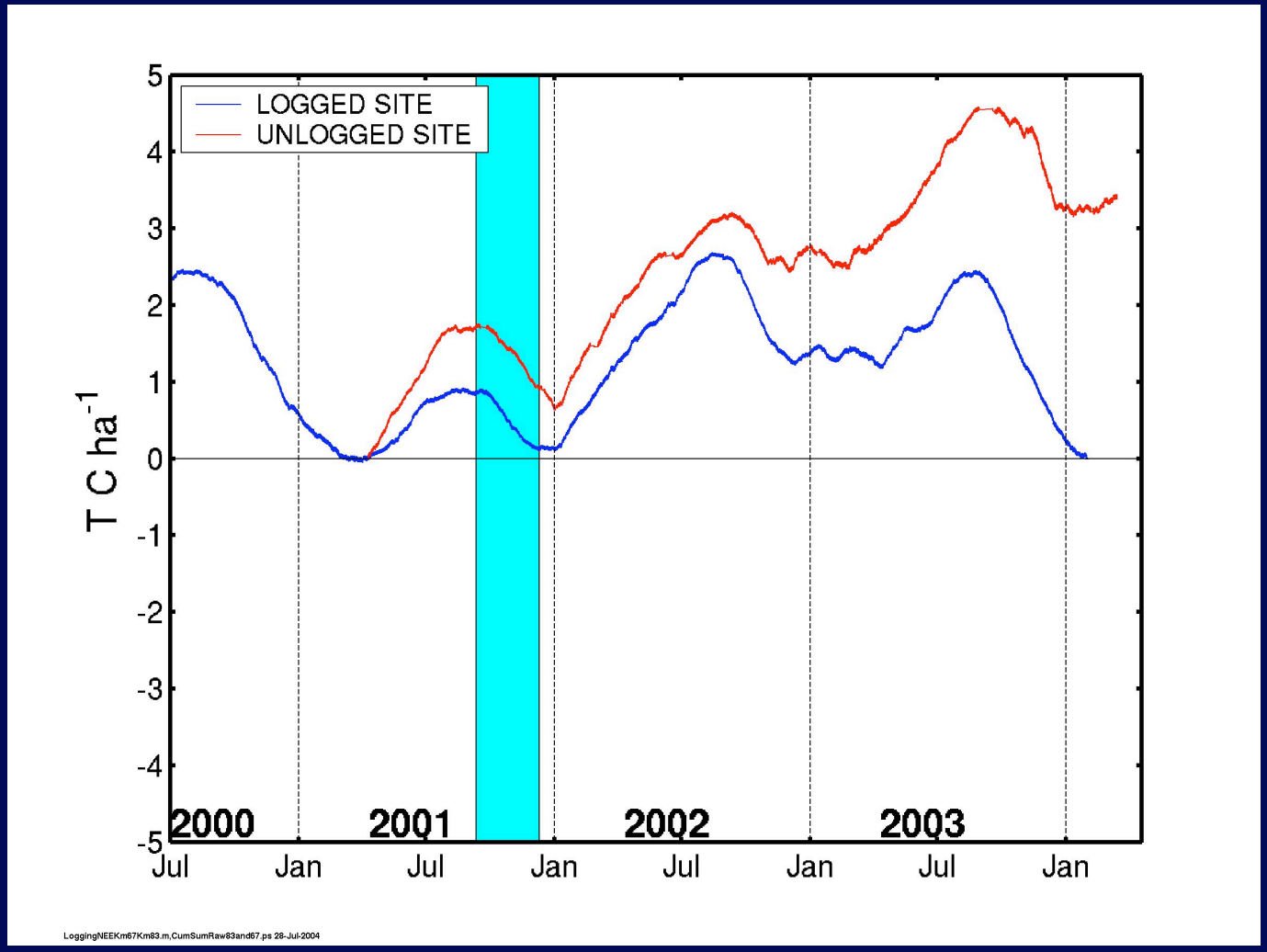
Carbon sink



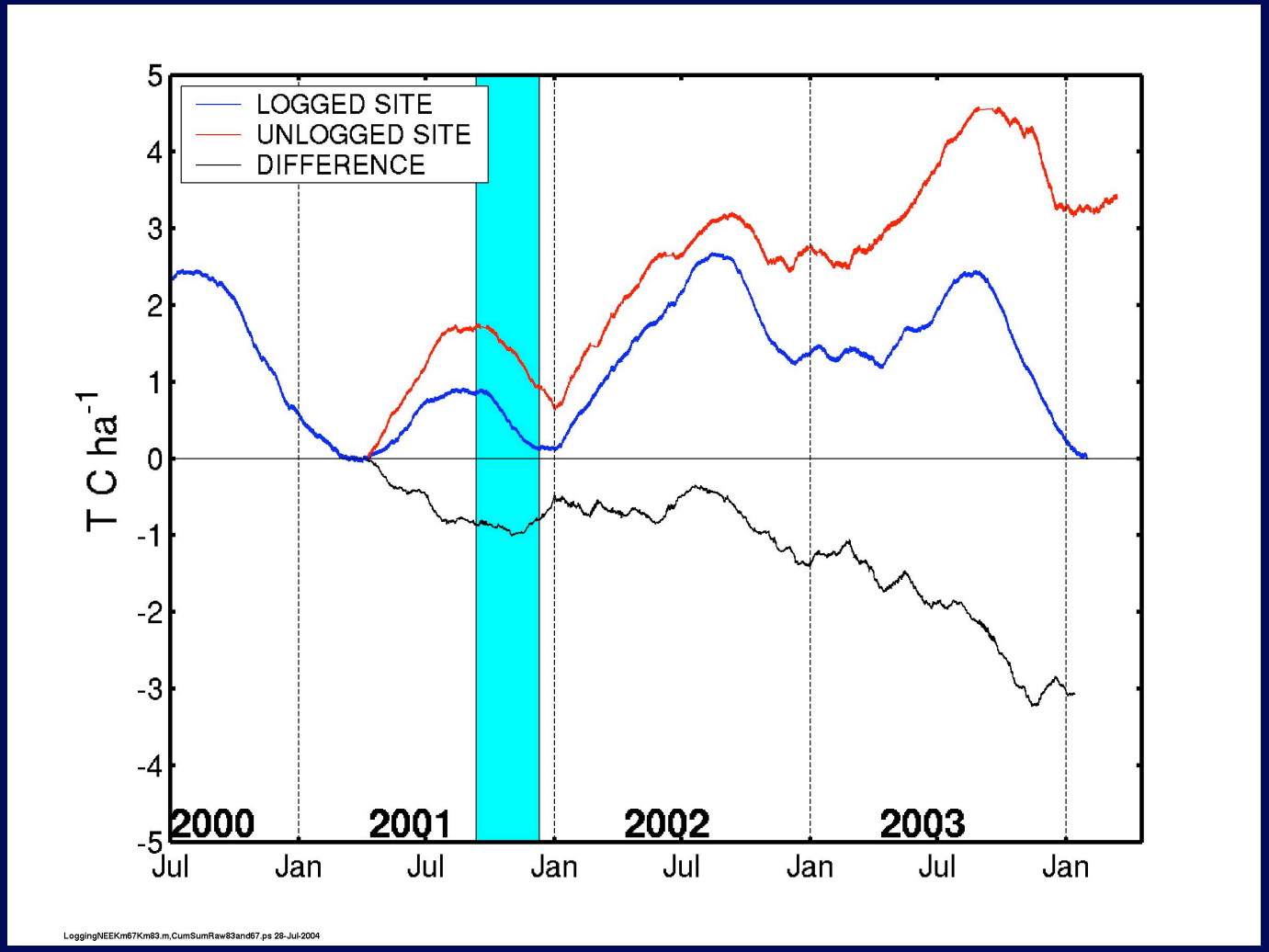
Comparison by year (logged site data only)



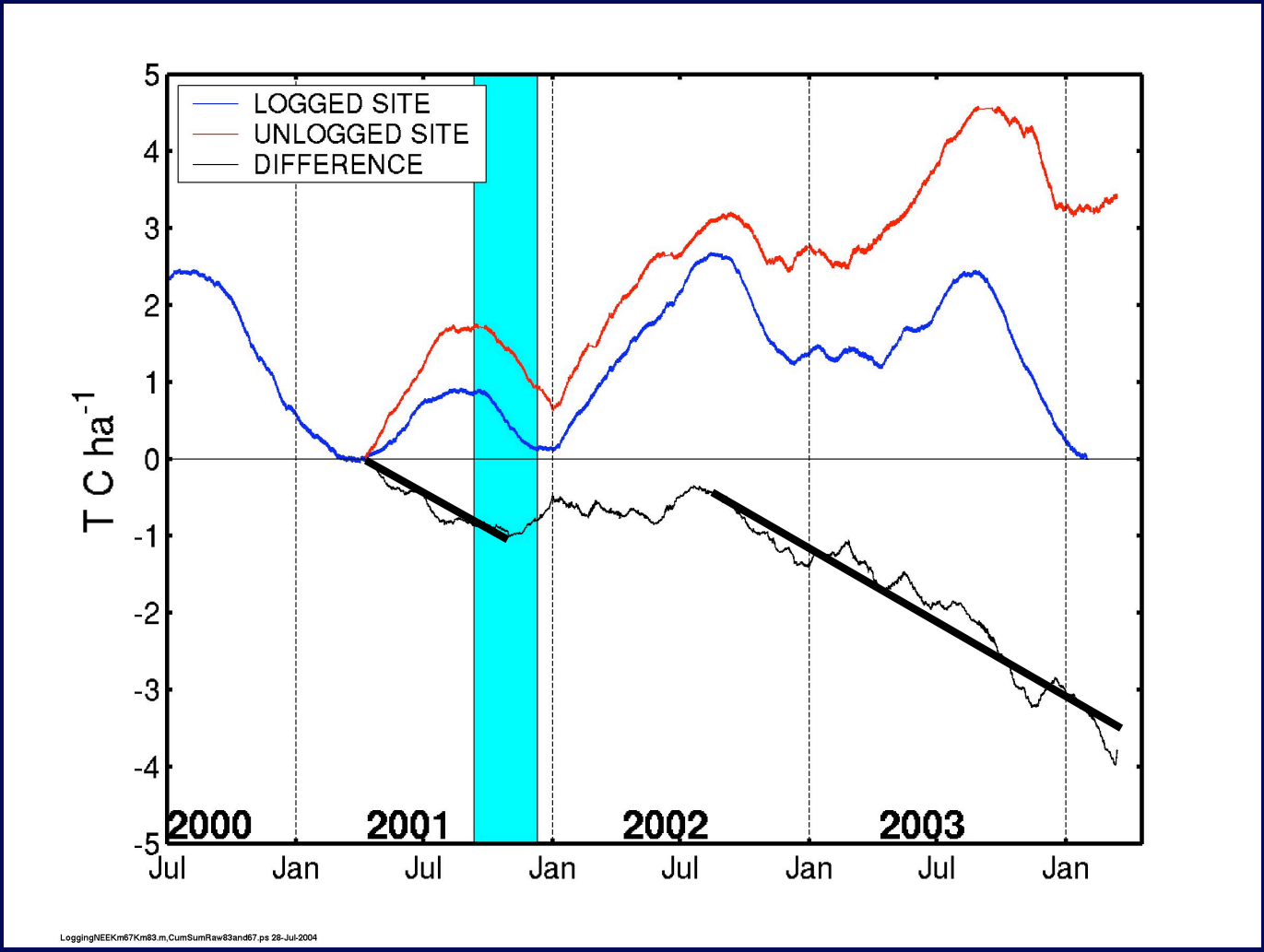
Comparison with Km 67



Comparison with Km 67



Removing interannual variability via the km 67 control site, in the year following logging the logged site emitted 1-2 TC ha^{-1}. The pre-logging relationship with the control site is then re-established.



Three estimates of logging effect are consistent:

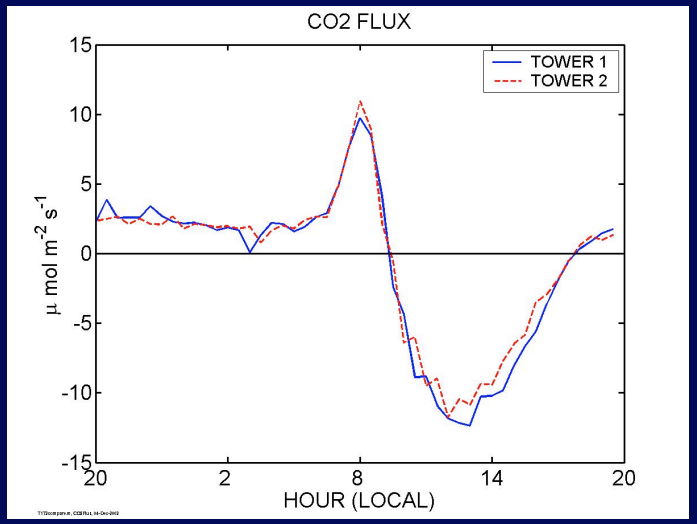
1. Biomass decomposition
2. Logged site tower before vs after
3. Comparison with control site

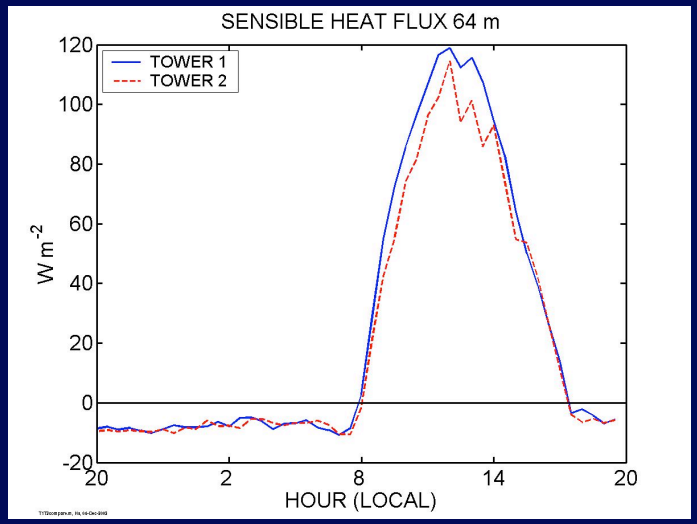
Vigorous understory growth likely contributes to the rapid return to the pre-logging levels of CO2 exchange.

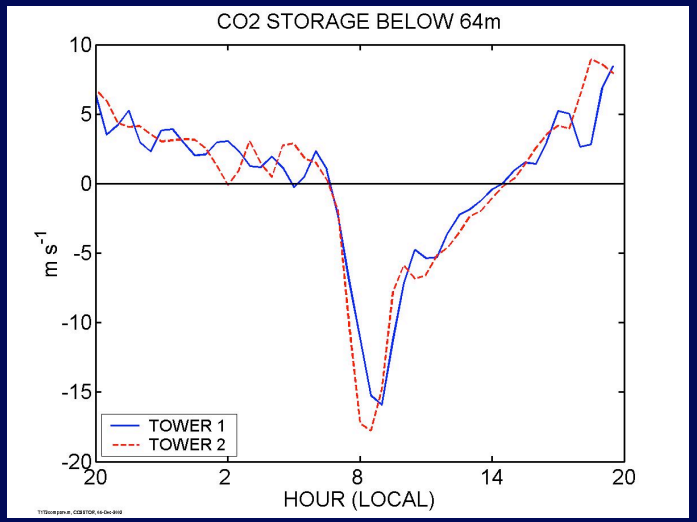
Gap tower

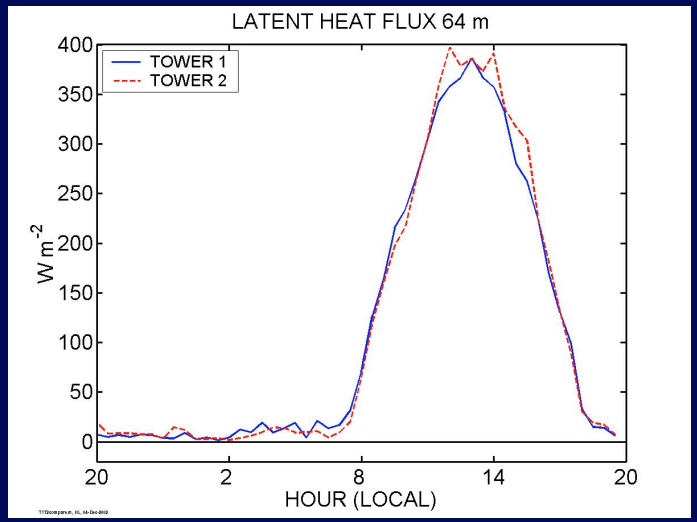
Comparison with Gap Tower Fluxes

- **Fluxes are similar**



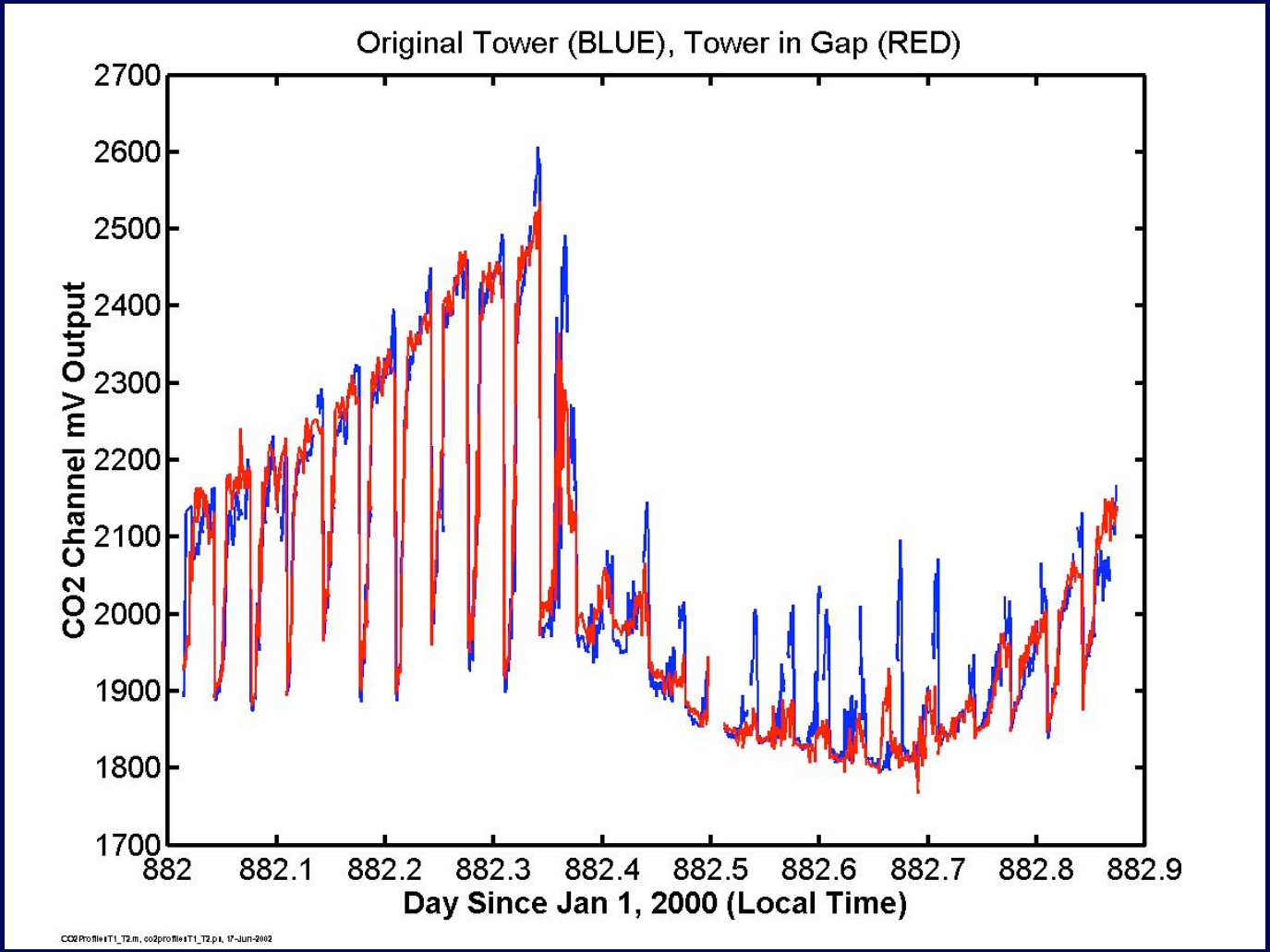






Comparison with Gap Tower Profiles

- Night CO2 Profile similar (air stratified across gaps)
- Day gap profile near ground more well-mixed



Conclusions

- Reduced impact selective logging did not have a major impact on net carbon exchange
- A transient moderate carbon release was observed, of order 1-2 T C ha^{-1}.
- Gaps are not showing signs that they are preferential vents for CO2
- With repsect to carbon exchange, the forest appears capable of rapid recovery (1-2 yrs) after reduced-impact selctive logging.

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