Wood and soil surface CO_2 flux from the Tapajós National Forest

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SUMMARY

The exchange of carbon dioxide (CO_2) between tropical forests and the atmosphere is an important component of the global carbon cycle. A better understanding of controlling mechanisms and magnitude of CO_2 sources from tropical forests will improve our ability to understand the global carbon budget.

Stem CO_2 fluxes were measured using dynamic flux enclosures (Figure 3a and b). Annual averages at TNF averaged 1.7 μmol m^{-2} s^{-1}. Wood surface area was measured (4161 m^2 ha^{-1}) and wood CO_2 flux was extrapolated to ground area resulting in an annual flux of 259 gC m^{-2} yr^{-1}, corresponding to about 8% of the gross primary productivity.

Line sampling of soil-atmosphere CO_2 fluxes were made on randomly placed 30 m transects at TNF (Figure 3 a and c). Annually averaged fluxes were 4.7 $\pm$ 0.2 μmol m^{-2} s^{-1}. Average soil CO_2 flux during the wet season was higher (4.9 $\pm$ 0.3 μmol m^{-2} s^{-1}) than during the dry season (4.4 $\pm$ 0.2 μmol m^{-2} s^{-1}). Geostatistical analysis of grid sampling of soil CO_2 fluxes indicated that they were not spatially dependent down to 15 m separation distance (Figure 3d.). The estimated annual average of soil surface CO_2 flux for the TNF was 1780 gC m^{-2} yr^{-1}.

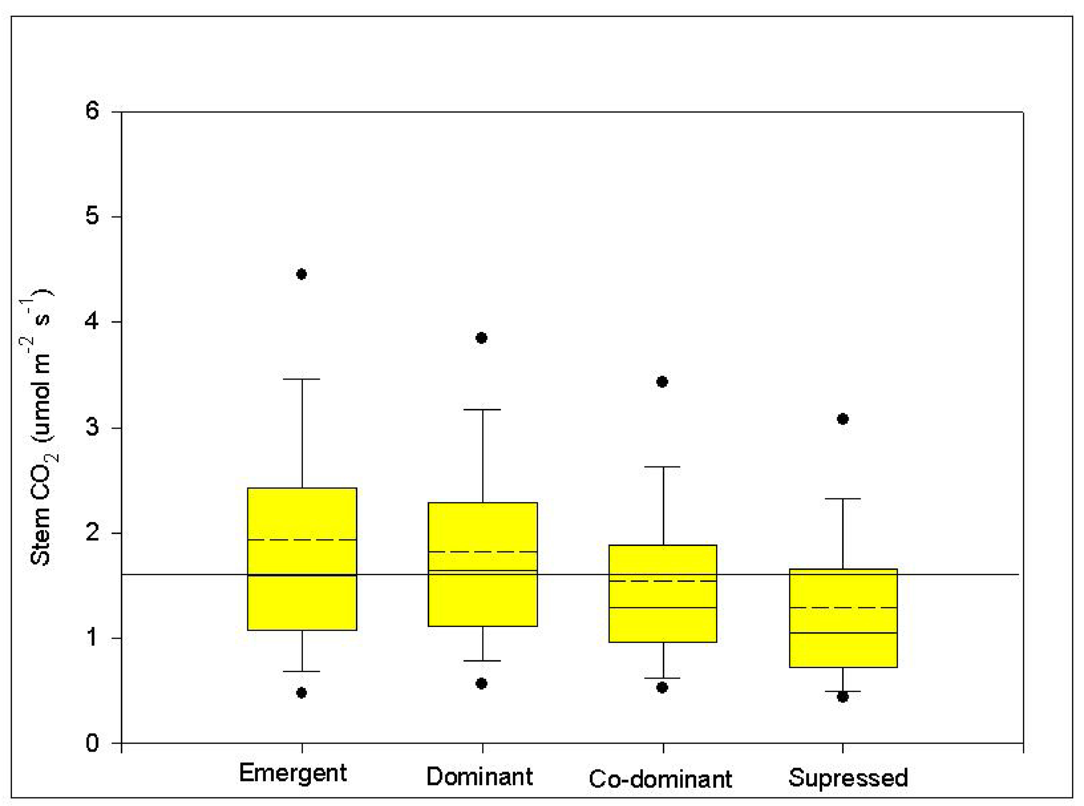


FIGURE 1 Stem CO_2 fluxes from trees grouped into four canopy positions. Trees located at the higher levels of the canopy (emergent and dominant) presented higher ($p<0.0001$) average stem CO_2 fluxes than trees located at lower levels of the canopy (co-dominant and suppressed).

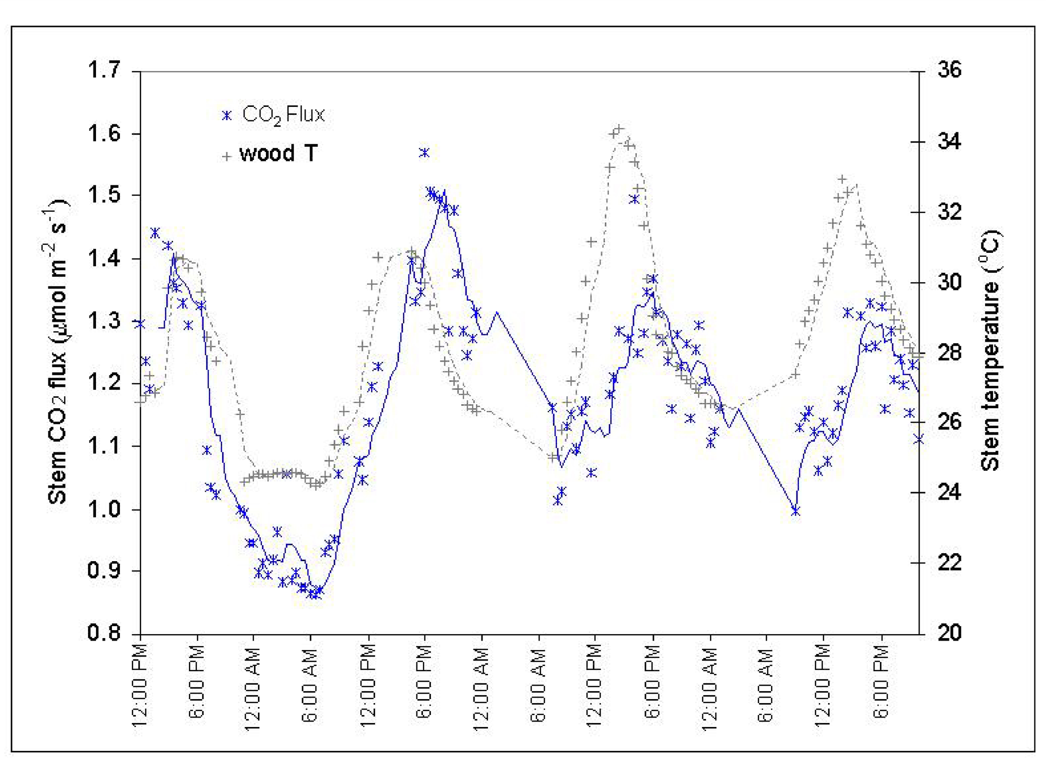


FIGURE 2 Example of continuous measurement of stem CO_2 flux and temperature. The Q_{10} values for five continuous measurement periods are summarized in Table 1. These values indicate that for an increase of 10ºC in temperature stem CO_2 flux increase between 1.2 and 3.4 times.

TABLE 1

Date	Q_{10}
01/21/03	1.9
01/22/03	1.2
01/23/03	1.5
08/11/03	3.1
08/12/03	3.4

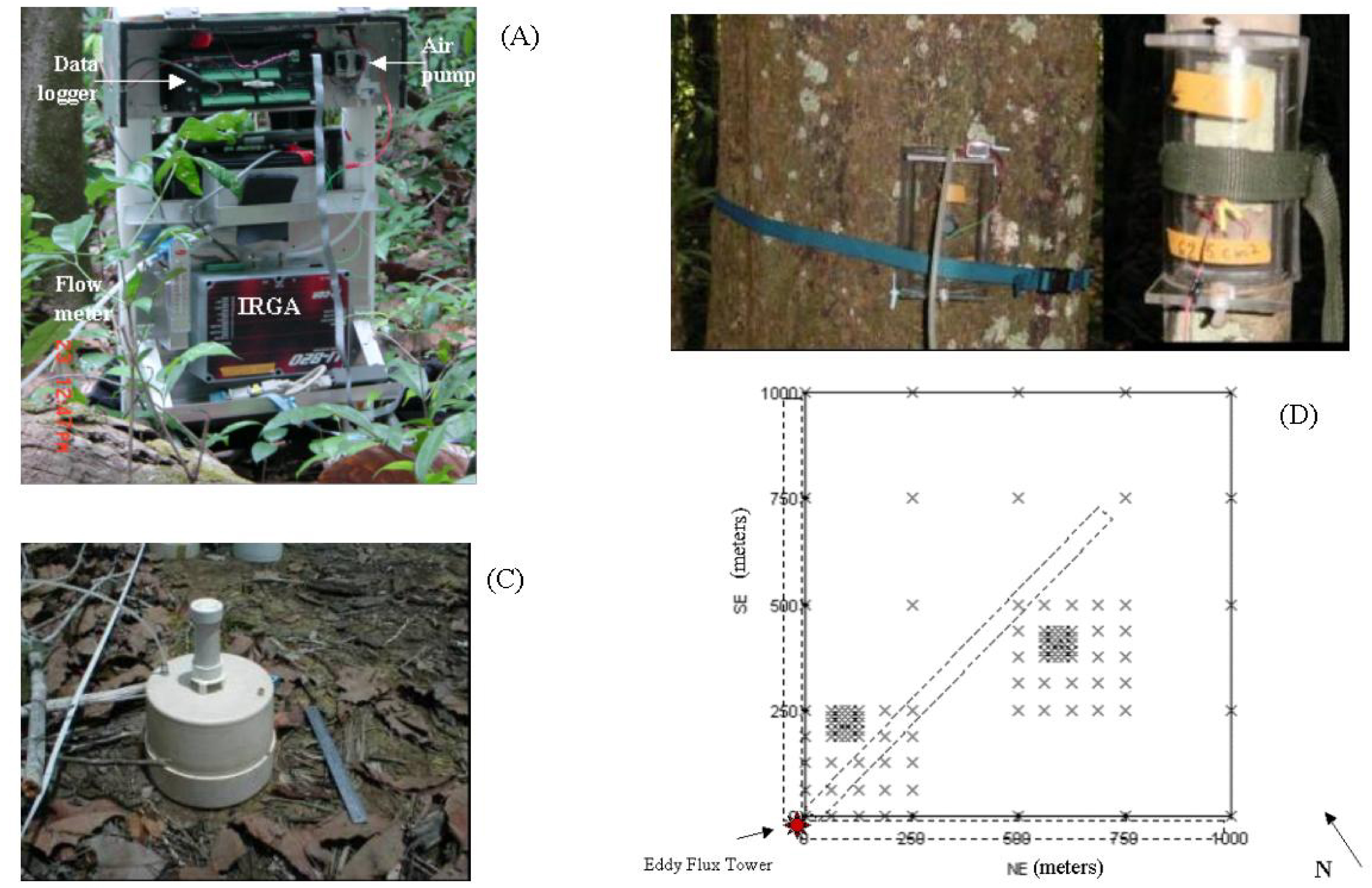
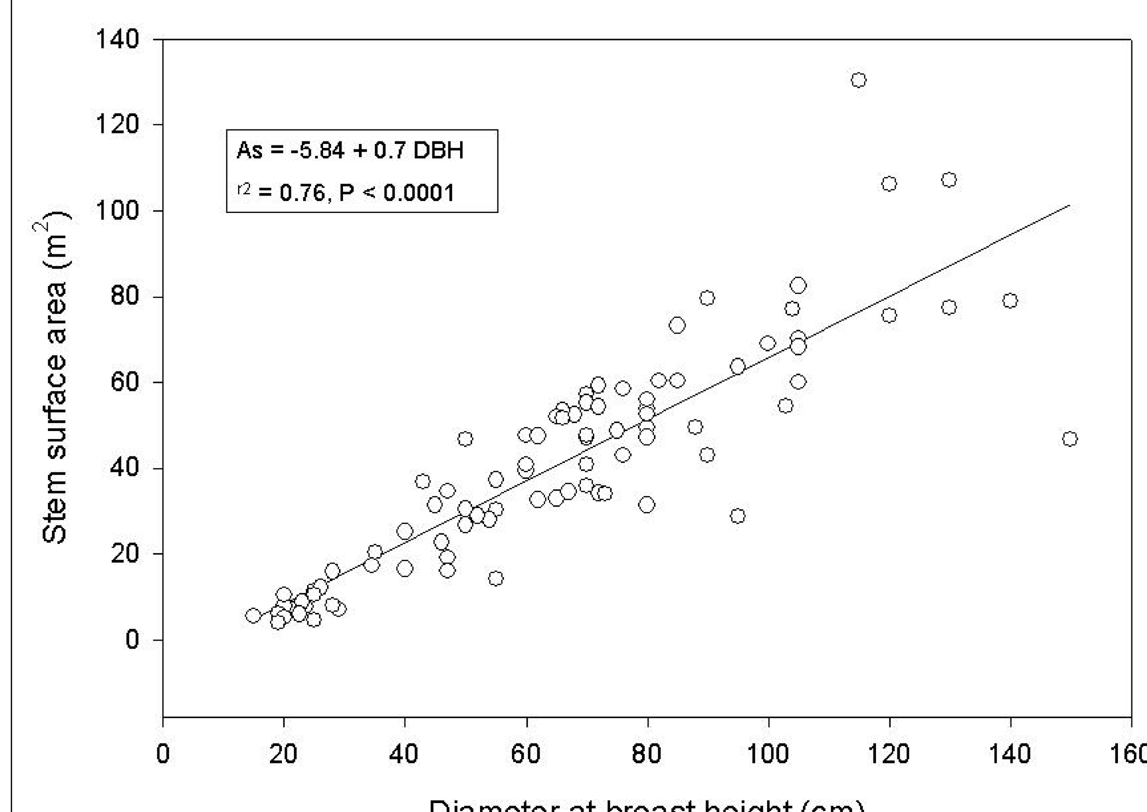


FIGURE 3 Portable system for CO_2 flux measurement for soil and wood. (A) Back-pack IRGA system; (B) plexiglass dynamic chambers for stems; (C) PVC and ABS plastic dynamic soil chamber; and (D) experiment grid for the spatial analysis of soil CO_2 flux at the km 67 site of the Tapajós National Forest.



$$As = p (R + r) [(h^2 + (R - r)^2]^{1/2}$$

FIGURE 4. Regression analysis between stem surface area and diameter at breast height for 90 harvested trees at the TNF. Stem surface area was calculated based on the approximation of a frustrum of cone (above).

TABLE 2

	Surface area (m^2 ha^{-1})
Stems	2391
Branches	1770
Total	4161

$$A_B = 4 m_b \ln (d_{max}/d_{min}) / [\rho (d_{max} - d_{min})]$$

FIGURE 5 Surface area of branches was calculated based on the pipe-model theory (Shinozaki et al., 1964). In equation 1m_b represents the mass of branches of a trees, d_{max} is the maximum diameter of branches, d_{min} is the minimum diameter of branches, ρ is the wood density. The sum of branches and stems equals the wood surface area. Surface area of stems and branches were calculated based on a sample of 20 hectares of forest from the km 67 TNF site (**TABLE 2**).

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FIGURE 6 Biweekly averages of stem CO_2 fluxes ($\pm$ SE) from undisturbed and selectively logged forest sites at the TNF. Fluxes measured at the undisturbed forest were not significantly different from those measured at the selectively logged site. There was no obvious seasonal variability.

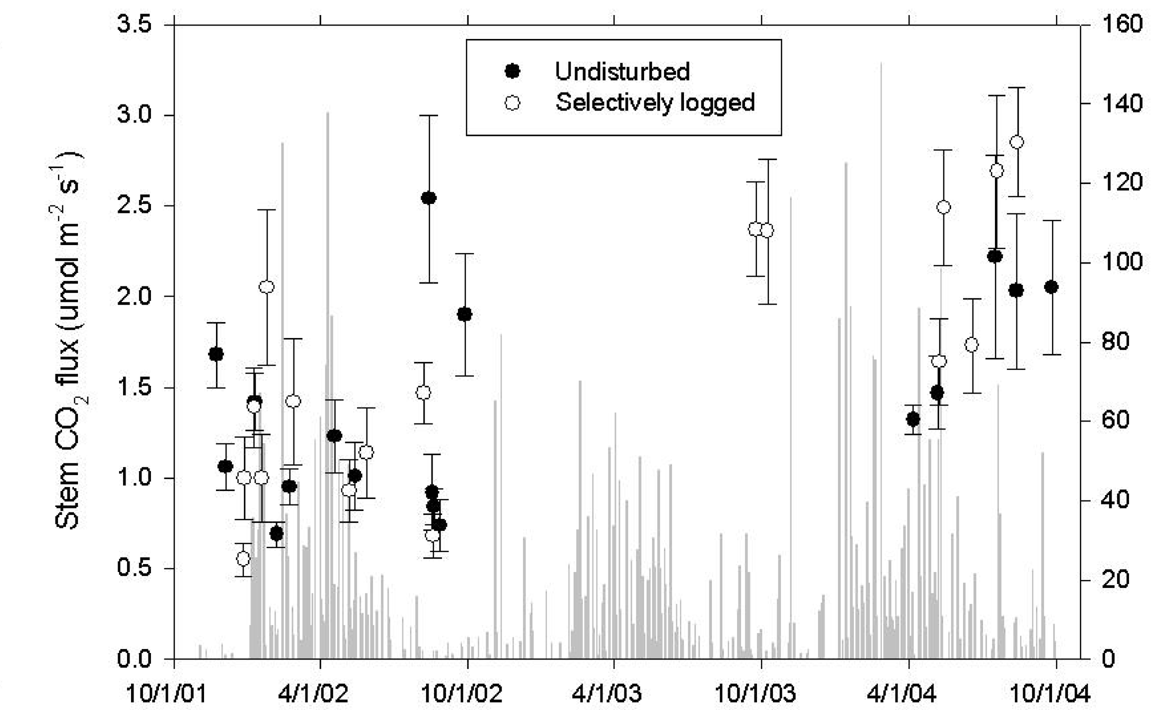

FIGURE 7 Stem CO_2 flux versus diameter at breast height (cm) for trees of undisturbed and selectively logged sites. A significant ($p<0.0001$) and weak ($r^2 = 0.2$) correlation was observed CO_2 flux and DBH for both sites combined.

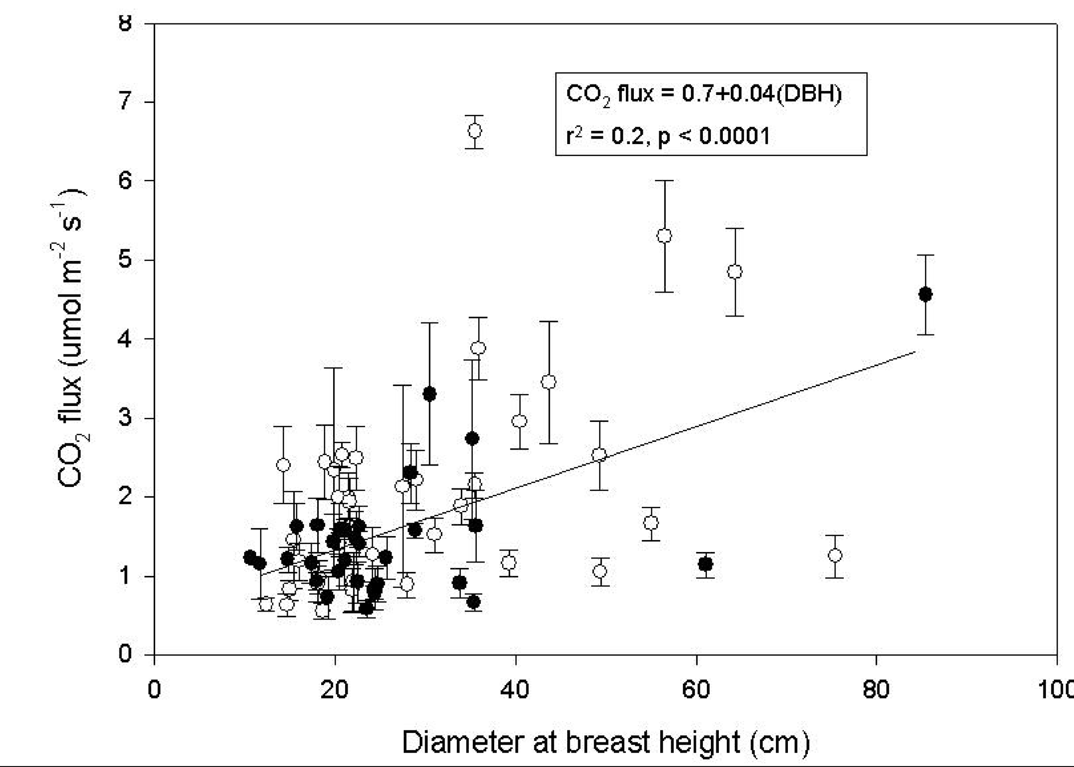

FIGURE 8 Monthly averages ($\pm$SE) of soil-atmosphere CO_2 flux and soil moisture from line sampling in 2001 through 2004 from an undisturbed forest site (km 67) at the TNF. The annual averages of soil CO_2 flux and soil moisture were 4.7 μmol m^{-2} s^{-1} and 44.1%, respectively.

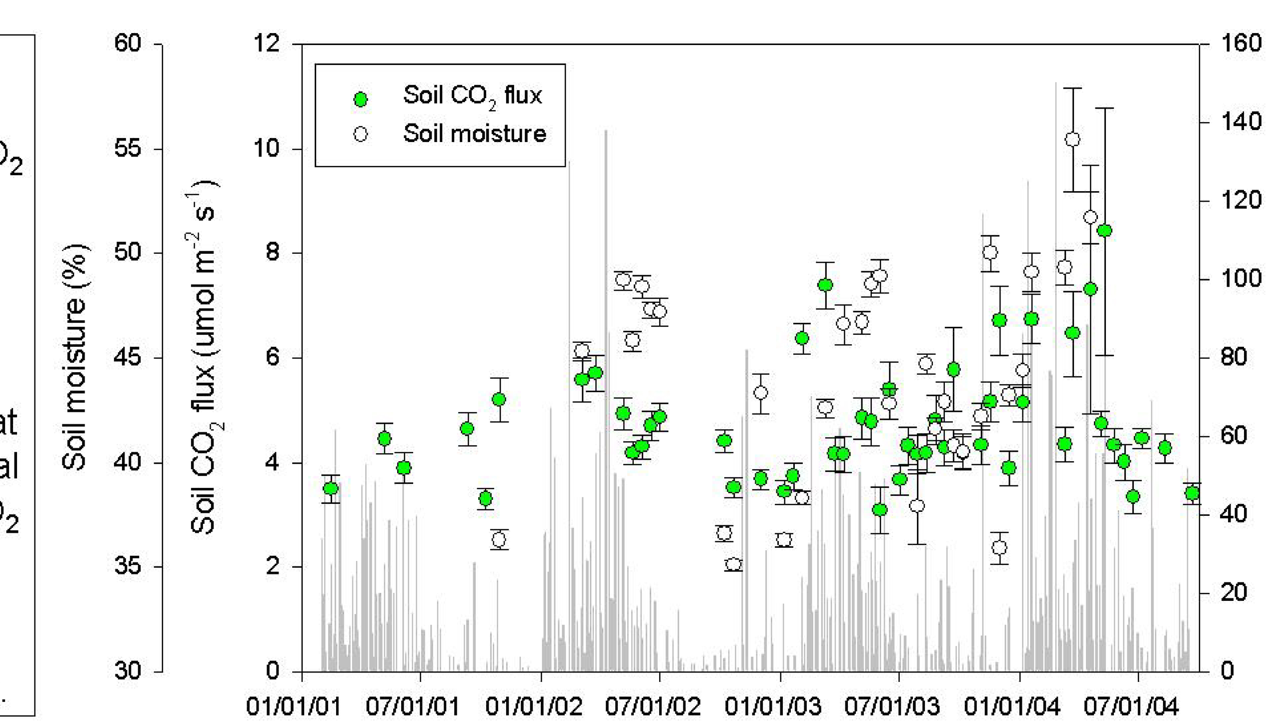

FIGURE 9 Semivariograms of soil CO_2 flux for wet and dry periods at the undisturbed forest site of the TNF. We observed no spatial dependency of soil-atmosphere CO_2 fluxes for separation distances greater than 15 m.