or thaw frozen soil[15]. The EUROFLUX sites with almost neutral carbon balance are at high latitudes where significant warming has occurred, which may provoke loss of soil carbon at a rate comparable to plant biomass gains[15].

Unlike Grace and Rayment[3], we consider that the key to climatic sensitivity of soil carbon is not total ecosystem respiration but decomposition rates (carbon loss per unit of fractionated carbon pool). The high respiration rates at the northern EUROFLUX sites[14] are probably due to detritus accumulation under cool moist conditions, and not to temperature insensitivity of decomposition; even slow turnover of large stocks produces a lot of CO_2.

We agree with Giardina and Ryan that temperature effects on soil carbon dynamics may be overestimated in current biogeochemical models. However, feedback to global warming does not concern just temperature, but also includes its effect on soil water content and drainage, for example, and applies to all detrital carbon, whether on top of mineral soil or buried in peatlands and permafrost.

On the basis of the new results[2,14], Grace and Rayment[3] suggest that the doomsday view of runaway global warming now seems unlikely. We believe that, on the contrary, the evidence remains in favour of a strong climatic control over storage of detrital carbon in terrestrial ecosystems.

Eric A. Davidson*, Susan E. Trumbore†, ‡Ronald Amundson
**Woods Hole Research Center, Woods Hole, Massachusetts 02543, USA*
e-mail: edavidson@whrc.org
†Department of Earth System Science, University of California, Irvine, California 92697-3100, USA
‡Division of Ecosystem Sciences, University of California, Berkeley, California 94720, USA

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Giardina and Ryan reply — Davidson *et al.* question the validity of our conclusions on the grounds that differences in disturbance, high variability among sites, and the use of a single-pool model to estimate turnover time (TT) obscured the effect of temperature on the decomposition of soil carbon.

In our comparison of incubated soils, disturbance associated with sieving and mixing probably increased decomposition rates. However, soil processing was similar across sites, and the resulting increase in carbon availability should have accentuated an effect of temperature on TT. In our *in situ* comparison, most tropical sites were pastures and all of the temperate sites were cropped. But these differences did not obscure an effect of temperature on TT. First, a subset of tropical sites had been continuously cultivated with sugar cane, which involves biannual mechanized ploughing, burning and fertilization. For sites that had been similarly disturbed after conversion from forest — that is, under intensive cultivation — TT tended to increase with mean annual temperature (MAT; $R^2=0.14$, $P=0.07$, $n=25$). Second, tropical pastures are more severely disturbed than Davidson *et al.* suggest — bulldozers may be used to level a site and remove stumps, and mechanized disking is often used to control weeds[1,2]. Further, the effects of pasture conversion on carbon decomposition rates remain poorly understood[2].

There are two ways to test whether we missed significance because of high variability. First, how important is site-to-site variability? And second, given our sample size, how much variation must temperature explain in order to be significant? For the incubation comparison, variation in TT was low (coefficient of variation, 37%), and TT actually increased with temperature ($TT=0.09\times MAT+6.2$). For the *in situ* comparison, time since conversion explained 34% of the variance in per cent carbon mass loss, a measure that assumes no model or age distribution of carbon in soil. With a sample size of 44 sites for the *in situ* comparison, MAT need only explain 8% of the variance to be significant at the 0.05 level. Given that MAT explained less than 1% of this variance, more than 1,000 sites would be needed to establish that there is a global relationship between temperature and soil carbon turnover.

We examined whether a single-pool model could obscure a temperature effect, and concluded that this is unlikely because our methods were robust[1,3], the tests were independent and well replicated, and neither comparison showed the negative trends between TT and temperature that would be expected from modelled patterns of carbon mass loss across latitude[4]. We agree with Davidson *et al.* that only a small fraction of total soil carbon may be sensitive to temperature — this was our point.

Although the ^{14}C approach preferred by Davidson *et al.* is useful for examining carbon turnover in soil, it has some methodological problems. For example, the ^{14}C decay of interest begins at photosynthesis, not after incorporation into soil, as is now assumed[1,5]. In forests, this lag could affect estimates of soil-carbon TT that are based on ^{14}C because carbon can reside in living biomass and the litter layer for decades before being released to mineral soil. The ^{14}C approach is also sensitive to contamination[3] and has yielded much faster estimates of soil-carbon turnover than more direct methods[1].

Modelling terrestrial carbon storage depends on an accurate understanding of how temperature affects carbon TT in soil, but this effect cannot be inferred from large-scale relationships between soil-carbon content and MAT. Along gradients similar to those used by Jenny[6] and cited by Davidson *et al.*, plant primary production declines with increasing MAT, and it is this decline, not an increase in soil-carbon decomposition rate, that explains decreasing soil-carbon content with increasing temperature[7]. Similar findings have been reported[8] for MAT gradients in northern Europe, and the gradient study cited by Davidson *et al.* actually reports[9] longer carbon TT for tropical forest than for temperate forest. Despite the evidence against an exponential effect of temperature on soil carbon turnover, future *in situ* warming studies are needed to settle this issue.

Christian P. Giardina*, Michael G. Ryan†
**Department of Natural Resources and Environmental Management, University of Hawaii at Manoa, 1910 East-West Road, Honolulu, Hawaii 96822, USA*
e-mail: giardina@hawaii.edu
†United States Department of Agriculture Forest Service, Rocky Mountain Research Station, 240 West Prospect Street, Fort Collins, Colorado 80526, USA and Graduate Degree Program in Ecology, Colorado State University, Fort Collins, Colorado 80523, USA

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