SECTION 4

Field Measurements of Carbon Loss Due to Ploughing

Contents

Field measurements of carbon loss due to ploughing

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1 Introduction and Measurement Programme

The objective of this part of the contract is to establish (in conjunction with CEH Merlewood) an upper limit to the carbon loss from long-term pasture when it is disturbed by ploughing. The approach taken is that of eddy covariance, and further details of the instrumental techniques may be found in Hargreaves *et al* (1998) and Hargreaves *et al* (2001).

The site chosen for the study is at Poldean farm in south west Scotland. It is a livestock enterprise with extensive permanent pasture receiving fertiliser and manure inputs. The flux station is located at grid reference NT 111004 (N55:17:22, W3:24:08) at an altitude of 196 m. Further site details can be found in Hargreaves *et al*, 2001. Descriptions of the instrumentation employed may be found in Hargreaves *et al*, 2001 and Hargreaves *et al*, 2002.

2 Site treatment

At the time of the last report the site had still not been ploughed owing to delays caused by foot and mouth restrictions and poor weather. The site was eventually ploughed, with considerable difficulty, on 5 June 2002 and subsequently received two further treatments with glyphosate on 15 July 2002 and 18 September 2002 to prevent regrowth of the vegetation. In the latter case, the application was delayed for around two weeks owing to heavy rain during the first few days of September, and this allowed the field to begin to "green-up" slightly before the glyphosate became effective.

No further treatments are planned until March/April 2003 and at the time of writing the site is, with the exception of a vary low density of small seedlings, clear of vegetation.

3 Results and Discussion

On the day of ploughing (5 June 2002) micrometeorological measurements of CO_2 exchange were not possible as the wind was blowing from the north-east, thus carrying air over the ploughed area and away from the sensors. However, static chamber measurements were made over a period of 2 to 3 hours immediately following ploughing and although the spatial variability was large the mean emission rate of CO_2 was a fairly large 5.5 μmol m^{-2} s^{-1}. (Figure 1).

Gap filling for the month of June was undertaken by fitting a 4^{th} order polynomial to the measurements in order to indicate the magnitude of the CO_2 "pulse" immediately after ploughing. However, for subsequent months, this gap filling was performed by linear regression analysis of the dependence of CO_2 emission of soil temperature. An example of such a regression is given in Figure 2 for July 2002.

Although the intention was to produce such linear regression analyses for each calendar month, several problems led to very few fluxes being obtained over the ploughed field during August/September and November/December. In the former case this was primarily due to highly atypical weather in which the prevailing south-westerly winds required to make measurements over the ploughed site were very infrequent (Figure 3).

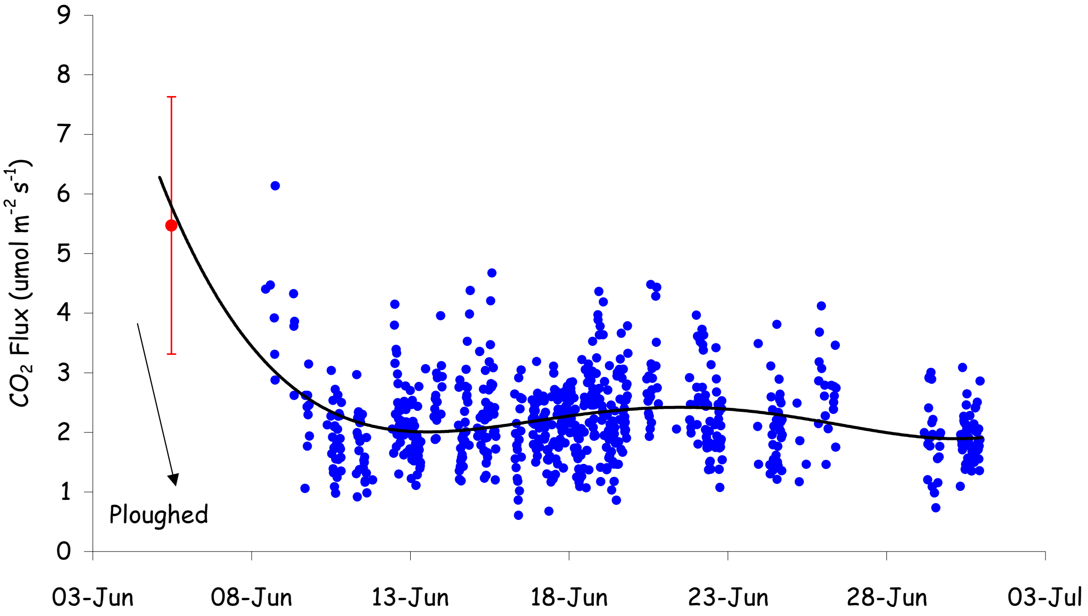

Figure 1: Carbon loss from the Poldean field immediately following ploughing. The single data point on 5 June denotes the mean ± 1 SD of chamber measurements of CO_2 release on the day of ploughing. The remainder of the data are from the eddy covariance system. The solid line is a 4th order polynomial fit to all the data.

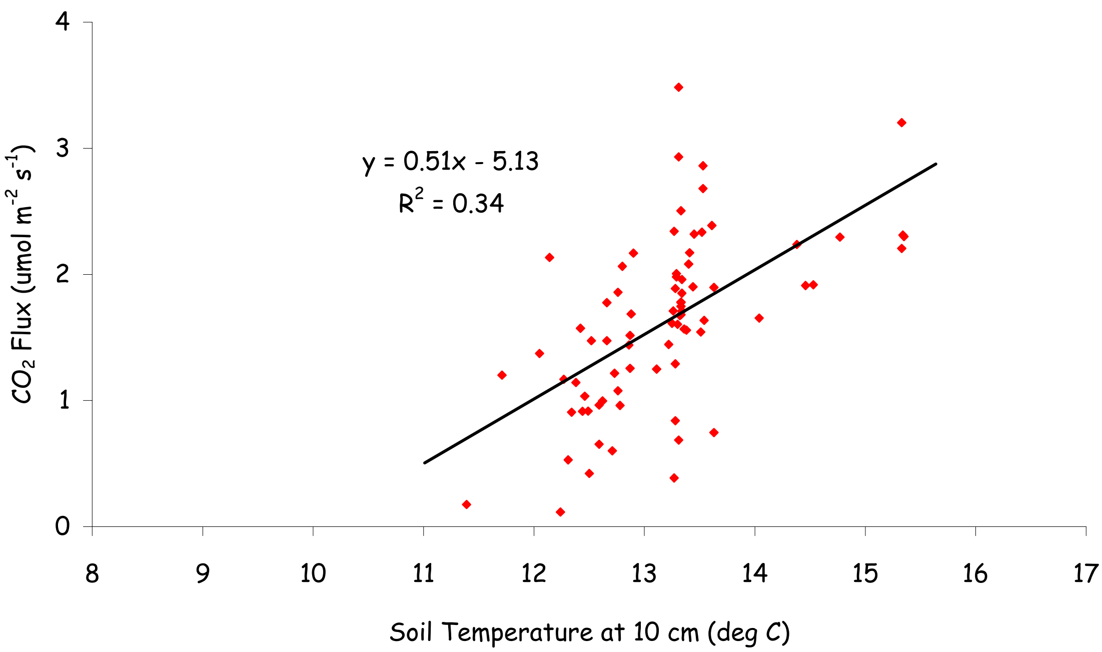

Figure 2: The dependence of CO_2 flux over the ploughed field at Poldean on soil temperature.

During November/December, although some data loss was due to poor wind directions, most of the loss was attributable to low battery voltage requiring the flux measuring equipment to be shut down to allow the batteries to recharge. As a result there were inadequate data available during those four months to produce reliable regression analyses so the regression analysis for July was applied to the August data, and that for October to the remaining three months. At present this permits a preliminary estimate of carbon loss up to the end of December 2002, but it is hoped that by the end of 2003 more data will be available to produce more reliable estimates of the temperature dependence of carbon loss. Since January 2003 data capture has improved, largely as a result of better weather conditions both in terms of wind direction and generally higher wind speeds. A prolonged period of fine weather during March 2003 has also improved data capture by providing a large amount of solar energy.

The time course of carbon loss from the site in the first seven months after ploughing is shown in Figure 4. There was an initial peak in emission (but measured on only one day) followed by a general trend of a high rate of carbon loss followed by a prolonged period where emissions were fairly stable at around 2 μmol m^{-2} s^{-1}. However, during October soil temperature reduced steadily to around 8 ^{o}C and emission rates declined appreciably to less than 1 μmol m^{-2} s^{-1} and remained at this low level for the remainder of the year. It is not yet possible to say whether this decline in emission is entirely a result of the reduction in soil temperature, or if some of the reduction in emission can be related to prior loss of the more labile fractions of soil carbon. If this is the case then as soil temperature increases in Spring 2003 the emission of carbon will be systematically lower than during 2002.

The cumulative carbon loss from the site (Figure 5) indicates a total loss over the first seven months after ploughing of 0.3 kg C m^{-2}. When compared to the soil C content in the 15 cm surface layer determined by CEH Merlewood (Jones *et al*, 2001) of 13.3 kg C m^{-2}) this represents a loss of 2.3% of the soil carbon stock. Figure 5 also illustrates the high loss rates associated with warm, relatively dry soils in summer and the small losses sustained during winter when the soil is cold and frequently waterlogged.

If similar rates of carbon loss are sustained during 2003 then by the time for the second round of soil sampling by CEH Merlewood in October 2003 we might expect in excess of 5% of the soil carbon to have been lost. This change may not be resolvable by the soil carbon analysis due to the spatial variability across the field. The resolution of detection of change by soil analysis is likely to lie in the 5-10% range. The comparison of the results from the two approaches will however be a useful test of their relative merits.

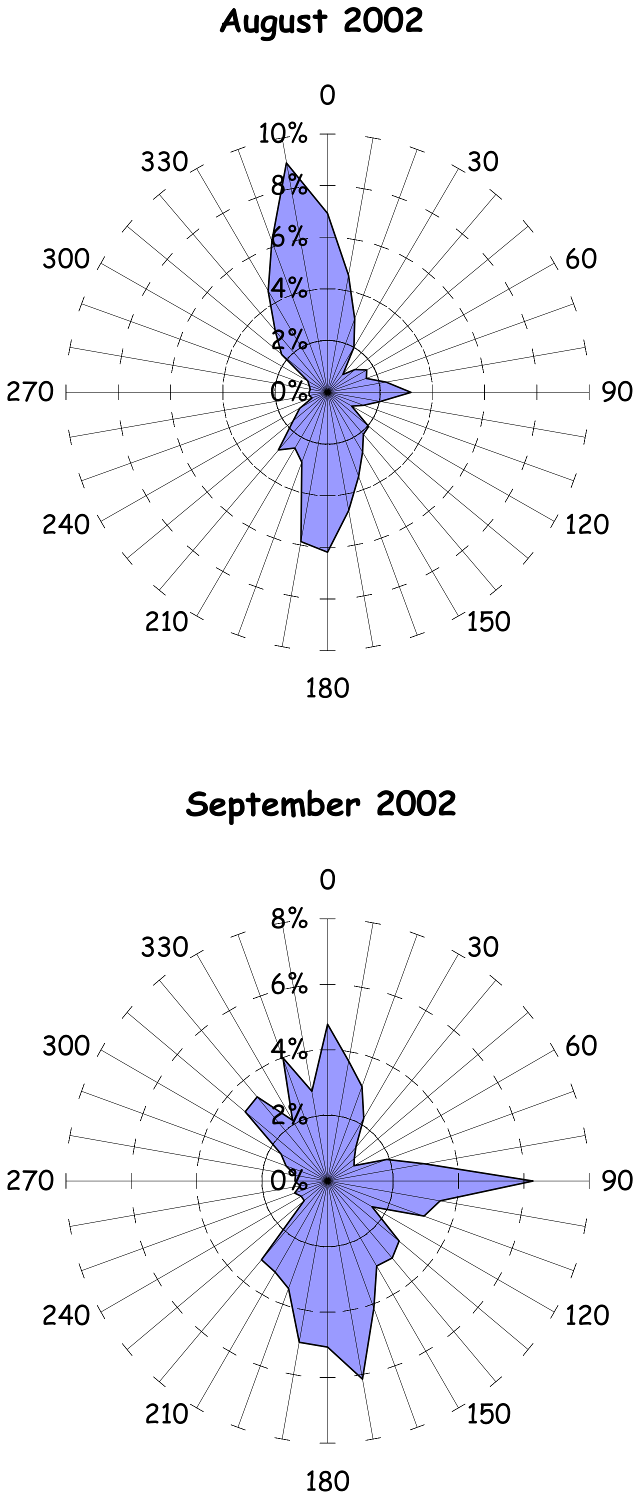

Figure 3 : Wind roses for August/September 2002 at Poldean. The radial axis denotes the percentage of time wind blew from a particular direction (circumferential axis, degrees from north).

Figure 4: The time course of carbon loss from the Poldean site. The first data points on the graph correspond to the ploughing date (5 June 2002).

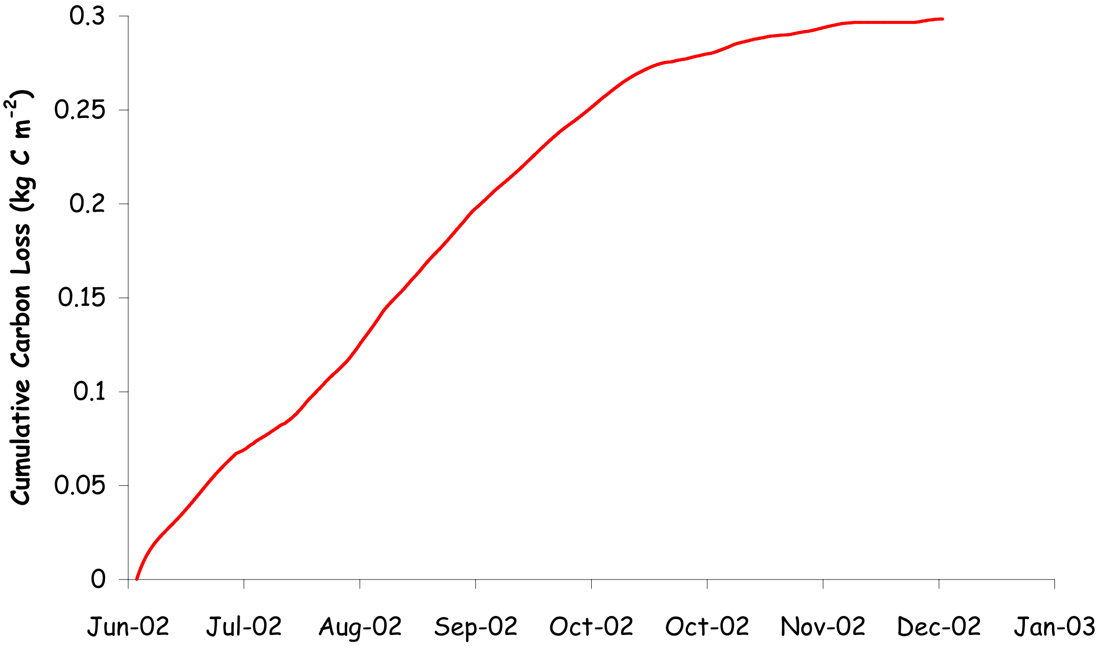

Figure 5: Cumulative carbon loss from the Poldean site since ploughing on 5 June 2002

4 Conclusions

A small "pulse" in respiration rate was observed immediately after ploughing, but this was sustained for less than 3 days and emissions declined to around 2 μmol m^{-2} s^{-1} within about a week of ploughing

Emission rates remained around 2 μmol m^{-2} s^{-1} until early October after which there was an abrupt decline in emissions, probably associated with a reduction in soil temperature.

Over the first seven months since ploughing, 0.30 kg C m^{-2} has been lost to the atmosphere by respiration. This represents 2.3% of the total soil carbon in the top 15 cm layer.

5 References

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6 Acknowledgements

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