SECTION 5
Field measurements of carbon loss from soil following ploughing
Part 1: Flux measuring methods.

Loss of carbon from soil following ploughing.
Part 1: Field measurements of carbon fluxes.
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Objectives and Methods
The principal objective of this part of the contract is to establish (in conjunction with CEH Merlewood - see Chapter 3) 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, the method adopted for the previous DETR contract (EPG 1/1/39), and further details of the instrumental techniques may be found in Hargreaves *et al* (1998).
The method involves making near-continuous measurements of the surface exchange of carbon dioxide over a long-term pasture immediately prior to, during and after ploughing. It was originally intended to find a site where a mains power supply was available and to install a small building on the site. This proved to be very proscriptive when the time came to identify sites and it was decided instead to design and build a solar and wind-powered automatic flux station to allow installation wherever was convenient.
The flux station (Figures 1 and 2) is based around a Licor 6262 IRGA for measuring CO_2 and H_2O concentrations, an R.M. Young ultrasonic anemometer mounted at a height of 1.75 m, a PC-based software package for carrying out eddy covariance calculations and a Campbell 21X datalogger to manage flux station power and provide remote telemetry via the mobile telephone network. Supporting meteorological measurements include solar radiation, soil and air temperature, relative humidity and rainfall. Power is supplied by a Rutland model 910-3 Furlmatic wind turbine and four 60W solar panels with a total area of 2 m^2 charging an array of deep-cycle sealed lead-acid batteries with a total capacity of 700 Ah. The 21X datalogger controls power consumption by switching off sample pumps and the gas analyser when meteorological conditions are unsuitable for eddy covariance measurements.

Site selection, instrumentation and preliminary results
Initially, sites close to CEH Edinburgh were considered as site maintenance would be easier to manage. However, it rapidly became apparent that the permanent pasture areas between Edinburgh and the Southern Uplands were under intense grazing pressure and farmers were unwillingly to sacrifice the 4 ha of land required for the experiment. In addition, levels of soil carbon in this area were relatively low. Soil maps indicated that the next closest area with extensive permanent pasture was in south-west Scotland, specifically Nithsdale and Annandale. A search for sites in this area identified three possible locations with adequate micrometeorological conditions: 1) south-east of Moffat, 2) west of Lockerbie and 3) south-east of the forest of Ae. Site 1) was eventually chosen on the basis of good meteorological conditions, an appreciable organic layer indicative of a long-term permanent pasture and a cooperative farmer. The farm (Poldean) is a livestock enterprise with extensive permanent pasture receiving only fertiliser and manure inputs. The flux station is located at grid reference NT 111004 (N55:17:22, W3:24:08) at an altitude of 185 m. The general layout of the site is given in Figure 1 of Section 6.
Arrangements were made with a local contractor for the site to be fenced in the middle of November 2000. Despite regular contacts with the contractor throughout November and December during which CEH were repeatedly told the work had not been completed due to wet ground conditions, a conversation with the farmer in early

January revealed that it **had** in fact been fenced on 30 November. The flux station was therefore installed immediately and a 4 week test period started to establish the correct functioning of the equipment. Intermittent power problems were experienced initially and the test period extended to 20 February by which time the system was operating correctly.

Examples of preliminary data from the flux station are given in Figures 3 to 5 and represent the only day during the test period when the wind blew from the required (and normally prevailing) south-westerly direction. Sensible and latent heat fluxes (Figure 3) are as expected for a February day and it is clear that the detection limit for latent heat flux is less than 5 W m^{-2}. Carbon dioxide exchange (Figure 4) shows the expected diurnal cycle over grassland and a detection limit of around 0.1 :mol m^{-2} s^{-1} is easily attainable. Encouragingly, even over such a short time period a clear relationship between CO_2 flux and solar radiation is apparent (Figure 5) which gives great confidence that the system is functioning correctly.

Ploughing and ongoing measurements

Arrangements were made for a site visit on 27 February to arrange ploughing to be carried out by a contractor that week, but the ban on livestock movements associated with the outbreak of foot and mouth disease (FMD) came into force on 23 February and the farmer requested that we postpone further visits for one week. On 1 March a farm at Lockerbie was confirmed with FMD and on 5 March the farm 300 m north-west of Poldean was also confirmed positive. Poldean succumbed to the disease on 13 March. At the time of writing (9 April 2001) a further eight cases in the immediate area had been dealt with, the last confirmed case being on 31 March. It is not yet certain when access to the farm will be possible again, but in the worst case we can expect the ploughing to take place in October 2001.

Conclusions

X A carbon dioxide and water eddy covariance flux-monitoring station suitable for operation at a site remote from mains power has been designed and built.

X A permanent, grazed, long-term pasture in south west Scotland has been fenced and the self-contained CO_2/H_2O flux monitoring station installed on site.

X Preliminary data from the undisturbed site confirm that the eddy covariance system is functioning correctly and with adequate sensitivity to measure the small respiration fluxes anticipated after ploughing.

X Following the foot and mouth disease outbreak the planned ploughing was delayed and the farm animals subsequently contracted FMD in early March 2001.

X Data is not currently being collected and there is no firm date yet available when the experiment can be restarted.

X

References

Hargreaves, K.J., Fowler, D. and Storeton-West, R.L. (1998). Long term changes in the carbon balance of afforested peatlands: Part 2. DETR Contract Report EPG 1/1/39, April 1998.

Acknowledgements

We acknowledge the cooperation and extensive practical assistance provided by Willy Davidson, Poldean Farm, Moffat.

Figure 1: General view looking north west of the CO2 flux monitoring station at Poldean

Figure 2: Interior of the flux monitoring station showing Licor IRGA, datalogger and eddy covariance computer

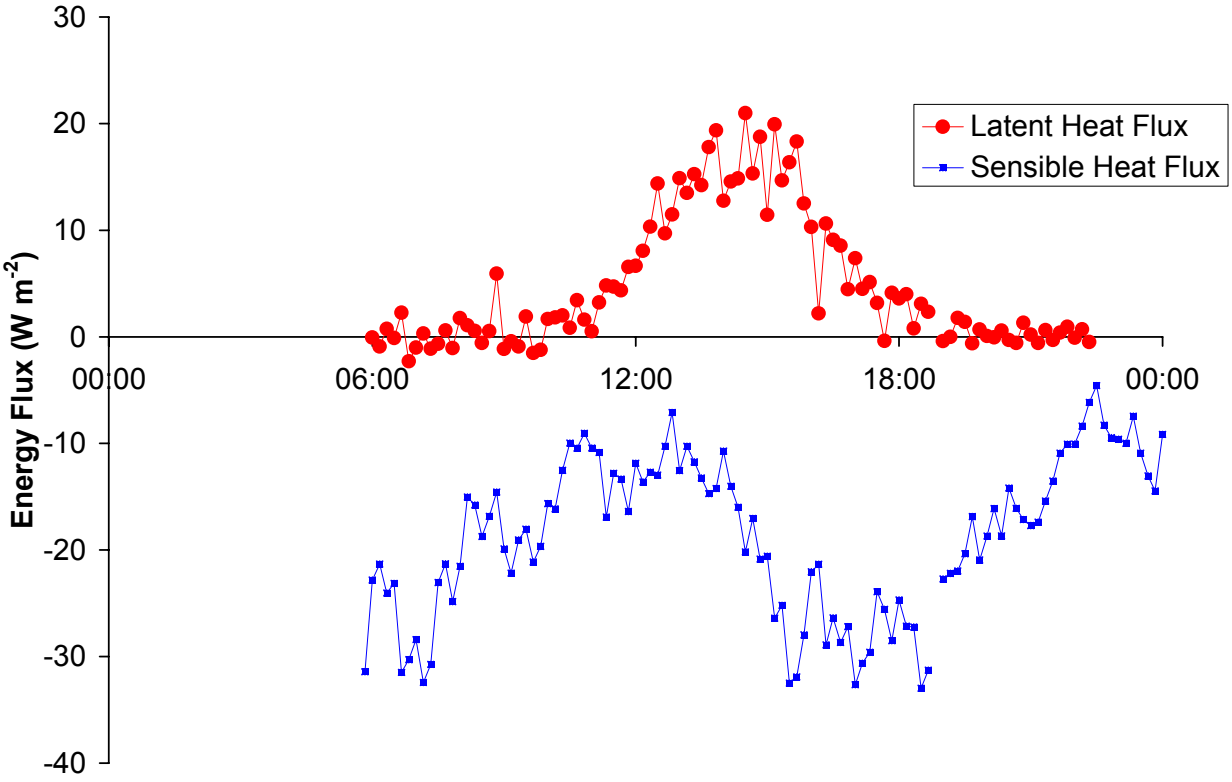

Figure 3: Sensible and Latent Heat Fluxes at Poldean, 14 February 2001.

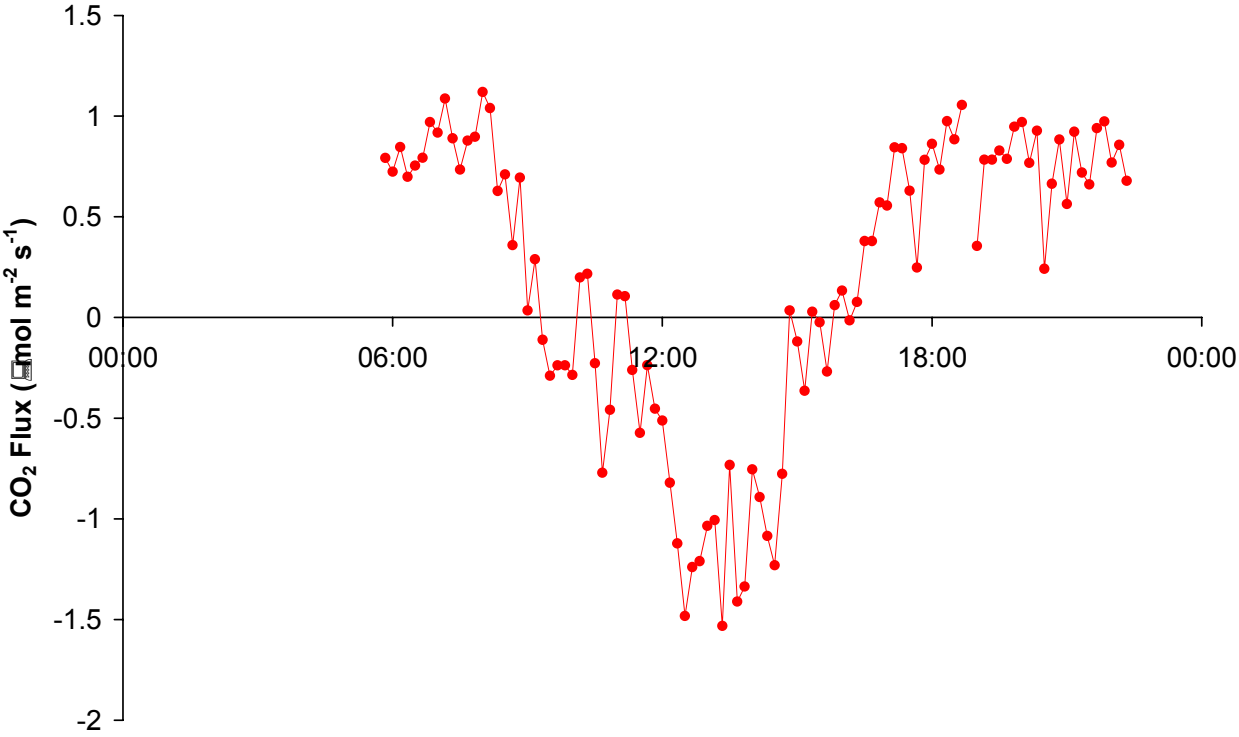

Figure 4: Carbon dioxide exchange over short grass at Poldean, 14 February 2001.

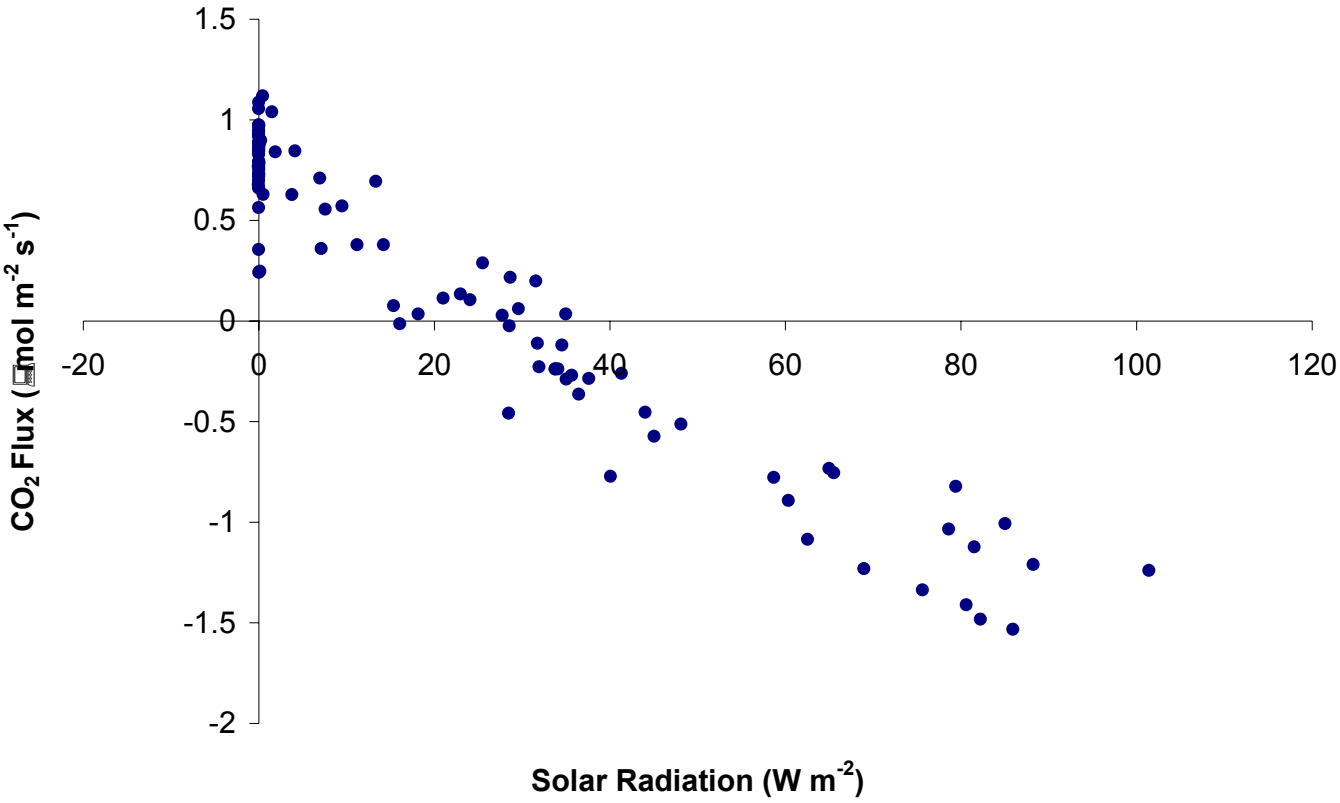

Figure 5: The response of CO2 flux over short grass to incident solar radiation. Poldean, 14 February 2001.