Moving the British cattle herd

SIR — One of the more extreme suggested solutions to the UK bovine spongiform encephalopathy (BSE) crisis is to move all cattle to new pasture after eradication of the disease. Although there may be little scientific basis for such an exercise, political pressure to take radical steps to restore public confidence in the British beef market continues to grow. Furthermore, with the suggested slaughter of a portion of the national herd, some UK grassland may be ploughed under and converted to arable land. We have attempted to quantify the possible impact on soil carbon (C) content and on nitrate leaching of the more extreme of these scenarios, moving all cattle in the United Kingdom to new pasture.

We estimate from statistics of the total number and age distribution of various classes of cattle in the United Kingdom[1] and the area of grassland required by individuals of each class[2] that the 11,833,500 cattle require at least 4.41×10^6 ha of grassland. The total UK area of permanent grassland[3] is 11.05×10^6 ha and the ratio of grassland more than five years old to that under five[1] is 3.72:1. Assuming that the use of grassland by cattle is distributed evenly between permanent and temporary grass, cattle are estimated to use 3.22×10^6 ha of permanent grassland, 29% of current permanent grassland would need to be ploughed under. This may be a conservative estimate as it assumes that cattle use the same fields every year. Using a mean figure for organic C content of grassland soils of 3.36% (derived from figures for six major soil types[4]) and a bulk density of 0.97 g cm^{-3} (from regression against organic C content[5]), the total organic C content of all UK permanent grassland to 30 cm can be calculated as 1077×10^6 t C ha^{-1}. The 29% of this used by cattle contains 312×10^6 t C ha^{-1}.

Long-term experiments in the United Kingdom show that converting permanent grassland to arable agriculture can result in a 20.3% loss of soil organic C over 15 years[6]. If a similar loss occurred when grassland was ploughed under, 63.4×10^6 t C would be lost from the terrestrial C pool over 15 years, equivalent to 6% of current C in grassland, or 0.3% of the total soil C stock of $21\,784 \times 10^6$ t C in Britain[5].

The loss would not be fully compensated for by the increase in soil C stock under new grassland converted from arable land. Long-term experiments show that organic matter increases much more slowly under reseeded grass than it is lost from ploughed-under grassland[7]. Arable soils contain less organic carbon than do grassland soils, so the predicted increase in organic C of 17% over 15 years[6] is less than that lost by ploughing-under grassland. Using similar calculations, assuming an average arable soil organic C content of 1.37% and a bulk density of 1.2 g cm^{-3}, the total increase in soil organic C for the 53% of current arable land[3] (6.08×10^6 ha) that would be required for new grassland is 27.5×10^6 t C, equivalent to 0.1% of total soil C stock for Britain.

The net change in total soil C content (decrease from ploughed-under grassland minus increase in reseeded arable land) is calculated as 36×10^6 t C over 15 years or 2.4 Tg yr^{-1}. This level of carbon loss from soils is equivalent to about 1.5% of the annual UK anthropogenic carbon dioxide-C production[8]. In the light of a commitment to stabilize or reduce carbon emissions to the atmosphere, such a loss of carbon from soil is not negligible and would push UK 1991 carbon dioxide emissions to a level not reached since 1980[8].

In addition to the implications for soil organic matter and loss of carbon to the atmosphere, the ploughing under of grassland would be likely to result in a significant increase in nitrate leaching. Ploughing-under permanent grassland can lead to increases in nitrate leaching of 4 t N ha^{-1} over 20 years[9], half of which can occur in the first 5.5 years. This is equivalent to 363 kg N ha^{-1} yr^{-1} during the first 5.5 years and could lead to concentrations in the water draining from fields in the first season[9] of up to 450 mg N l^{-1} depending on rainfall. This would almost certainly push the nitrate concentration in drinking water above the European Commission limit in some areas. Over the whole of Britain, the ploughing-under of the permanent grassland required to move all cattle could result in the leaching of an extra 4.4×10^6 t nitrate-N over 20 years.

The adverse environmental impact would also be partially realized if any shift in land-use from grassland to arable crops occurred as a result of selective cattle slaughter. Direct and indirect effects in other areas of environmental concern (for example, trace gas fluxes from the soil) are also likely.

Our preliminary calculations suggest that there would be significant and long-lasting adverse environmental effects associated with the ploughing under of grassland in response to the current BSE crisis. Our calculations suggest that in the absence of a sound scientific basis, the ploughing under of permanent grassland in order to move the national British cattle herd would be extremely unwise.

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Plateau reached

SIR — The letter from Olle Persson of Inforsk about data from the Institute for Scientific Information (ISI) relevant to trends in multinational collaboration (*Nature* **380**, 100; 1996) carried a particularly unfortunate title ("ISI miscount?").

Persson discusses whether the average number of (different) countries listed on research reports is rising or declining. He seems to recognize that the ISI data published in our newsletter *Science Watch* (**7** (1), 1; 1996) and picked up by your journal (*Nature* **379**, 287; 1996) deal with a different phenomenon: whether the percentage of internationally co-authored papers is markedly changing. (To clarify matters on this question, the *Science Watch* article found a "flattening out", elsewhere described as "a plateau". ISI found no evidence of a significant decline worldwide, or for any particular country, in percentage of international collaborations.) Thus, to characterize ISI's calculations as a miscount, when numbers collected and presented by Persson referred to a different question, is a mistake.

Furthermore, our analysis of Persson's question using a dataset larger than that used by Persson (22 OECD countries) — one incorporating all ISI-indexed journals in fact — does show the same flattening out in the average number of countries listed on research papers. The numbers ISI obtained, which are comparable to Persson's method of counting and are not limited to 22 OECD nations, are 1.124 for 1993 (938,482, the sum of countries on all papers, divided by 834,699, the number of papers) and 1.122 for 1994 (1,061,302 divided by 945,705). We would characterize this as a flattening out or a plateau.

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