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Review of implications of land use change on climate change mitigation & adaptation: Executive Summary

Debbie Fielding and Robin Matthews

The James Hutton Institute, Craigiebuckler, Aberdeen AB15 8QH.

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Enquirer: Zoe Kemp & Daniel Hinze

1. Background

In September 2014 the Scottish Government Land Use Strategy team commissioned CXC to undertake a review of the research evidence-base to inform the drafting of the revised Land Use Strategy. The work was undertaken by the James Hutton Institute, and the full report can be found on the ClimateXChange website.

We used the main land uses as defined by the International Panel on Climate Change (IPCC) which are croplands, forestlands, grasslands, wetlands, settlements and other (which includes water bodies, rocks, etc.). To make it more applicable to the Scottish context we also took into consideration the Joint Nature Conservation Committee (JNCC) broad habitat types which constitute each IPCC category.

2. Results

In broad terms, soil carbon stocks in these land uses are generally highest under grassland, followed by forestland, cropland and settlements when they are at equilibrium. However this depends on the category that bogs and peatlands are assigned to – currently grassland soil C stocks are high as bogs are included in this category. If peatlands and bogs are included under wetlands, then the ranking is wetland, forestland, grassland, cropland, settlements and other. For above ground carbon stocks in the vegetation, the ranking from highest to lowest was forestland, cropland, grassland, and then settlements. This assumes that each land use is at or near equilibrium in relation to carbon stocks.

Differences in these rankings are mainly due to differences in the balance between inputs and losses of carbon from each land use. For example, forestland accumulates high levels of carbon as the vegetation continues to grow year on year. Carbon inputs from the litter and roots is relatively high, and losses from the soil are relatively small if it is not disturbed.

In broad terms, greenhouse gas emissions (GHG) are highest from settlements, followed by cropland, wetland, grassland, and forests. Grassland and forestland are generally negative emitters of GHGs, i.e. they sequester carbon from the atmosphere. Settlements are high emitters because of the material used for buildings, human activity, and low carbon sequestration rates by the soil. Croplands are also high due to the application of fertilisers and disturbance of the soil by cultivation. A change from any of these land uses to another lower in the ranking will therefore result in loss of CO_2 to the atmosphere as the system moves to a new equilibrium with a new set of inputs and outputs and dynamics.

Woodland expansion generally leads to greater carbon sequestration, both in the soil and the biomass, and can therefore help to mitigate climate change by reducing net GHG emissions. However, the location of new woodland will greatly influence the climate change mitigation and adaptation potential – establishment of forestry on deep peat, as has occurred in the past, increases the potential to increase carbon loss by lowering the water table and increasing oxidation of the large carbon store in the peat. Woodland expansion may also lead to biodiversity loss due to the destruction of current habitats. On the other hand, careful choice of tree species and selection of planting sites to provide habitat networks could help to increase biodiversity. There may also be positive or negative implications of increased woodland planting for recreational interests.

Future climates are predicted to increase the amount of land in Scotland suitable for arable agriculture, so thought needs to be given to whether woodlands should be planted now where crops might be grown in the future. Clearance of existing woodlands for arable agriculture in these areas will reduce the amount of carbon stored in the landscape and will have implications for biodiversity due to the destruction of current habitats. Intensification of crop production on existing areas ("sustainable intensification") may reduce the pressure on existing woodlands in this way, but may also result in increased GHG emissions if this intensification is achieved by increased fertiliser use.

Conversion of existing arable land into grassland is likely to increase soil carbon stocks, but the overall net benefit in terms of global warming depends on the use to which grassland is put. If no livestock are present, then there is likely to be a reasonable benefit. However, if sheep or cattle are grazed, there is likely to be no to marginal benefit due to methane emissions from the livestock offsetting soil carbon gains, while the use of grassland for dairying is likely to create a large disbenefit in terms of GHG emissions.

Buffer strips of semi-natural grassland and/or trees in riparian areas alongside cropland have potential to increase the sequestration of carbon, improve biodiversity and prevent runoff of agricultural pollutants into watercourses.

Restoration of degraded peatland has the capacity to store large amounts of carbon from the atmosphere and contribute significantly to meeting GHG emission reduction targets. However, this depends on the extent of the existing degradation. If it occurred due to forest planting, then removal of the trees now may result in more carbon being removed, both in the harvested trees and from soil disturbance. Research is currently underway to determine the circumstances in which it might be beneficial in terms of GHG to leave existing forest on peatlands. Restoring peatlands by rewetting may also result in an initial production of methane, which will offset any potential carbon gains from restoration, again delaying the time to achieve net carbon benefits.

Despite windfarms producing renewable energy that can be used as a substitute for fossil fuels, siting of windfarms on existing land uses needs to be done carefully. Siting on deep peats can result in significant CO_2 losses resulting from soil disturbance and biodiversity loss due to habitat destruction. The loss of CO_2 can significantly affect the length of time before net carbon gains can be achieved. Siting on degraded peatland areas and areas with mineral soils is less likely to be as significant in this regard.

The effects of conversion of land to bioenergy crops largely depend on the previous land use. For example, conversion of forestland to bioenergy crops will result in a loss of both above (in the vegetation) and below-ground (in the soil) carbon, whereas conversion of cropland will result in higher above ground carbon and gradual accumulation of soil carbon. However, the latter land use change may also result in displacement of crop production and its associated GHG emissions elsewhere, either in Scotland or abroad, offsetting any net abatement potential. Impacts on biodiversity and hydrology will also depend on the land-use prior to conversion to bioenergy crops.

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