

UKCP09 Case Study on Land Use Capability

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Overall aim of the work:

The Land Capability for Agriculture (LCA) system classifies land in Scotland on the basis of climate, soils and topography and their interactions. Similar systems (Agricultural Land Classification) apply in England & Wales, and N Ireland. These systems act as an integral part of the planning system by providing an inventory of land use flexibility in the UK. The best land has the most options and is typically used for high-value produce through arable farming and horticulture (Table 1). Conversely, options are much more limited where there are major constraints on land use, particularly in marginal and upland areas. Climate is often a major factor, especially in Scotland due to cold and wetness (Figure 1).

We are developing Land Capability methods as adaptation tools to link climate change projections with spatial planning, and also to incorporate a wider range of ecosystem services than just agricultural production within land-use management systems. Previously we produced projections of potential future changes in LCA using the UKCIP02 scenarios and these were successful in raising awareness of both risks and opportunities. Now we are extending our work towards a more robust assessment that includes more information on climate change uncertainty.

The Scottish Government has a remit to produce a Land Use Strategy as part of the Scottish Climate Change Bill (2009), and one of our objectives is to provide accessible information on land use and the natural environment as part of this process. 'Prime agricultural land' has an element of protection in the planning system because of its importance for food production whereas the more marginal areas are important for other ecosystem benefits including semi-natural habitats, water quality, flood regulation and carbon storage.

<i>Class</i>	<i>Category</i>	<i>Climate Limitations</i>	<i>Land use</i>
Class 1	Prime	None or very minor	Very wide range of crops with consistently high yields
Class 2	Prime	Minor	Wide range of crops, except those harvested in winter
Class 3 ₁	Prime	Moderate	Moderate range of crops, with good yields for some (cereals and grass) and moderate yields for others (potatoes, field beans, other vegetables)
Class 3 ₂	Non-Prime	Moderate	Moderate range of crops, with average production, but potentially high yields of barley, oats and grass
Class 4 ₁	Non-Prime	Moderately-severe	Narrow range of crops, especially grass due to high yields but harvesting may be restricted
Class 4 ₂	Non-Prime	Moderately-severe	Narrow range of crops, especially grass due to high yields but harvesting may be severely restricted
Class 5	Non-Prime	Severe	Improved grassland, with mechanical intervention possible to allow seeding, rotavation or ploughing
Class 6	Non-Prime	Very Severe	Rough grazing pasture only
Class 7	Non-Prime	Extremely Severe	Very limited agricultural value

Table 1. Land Capability for Agriculture Classification System

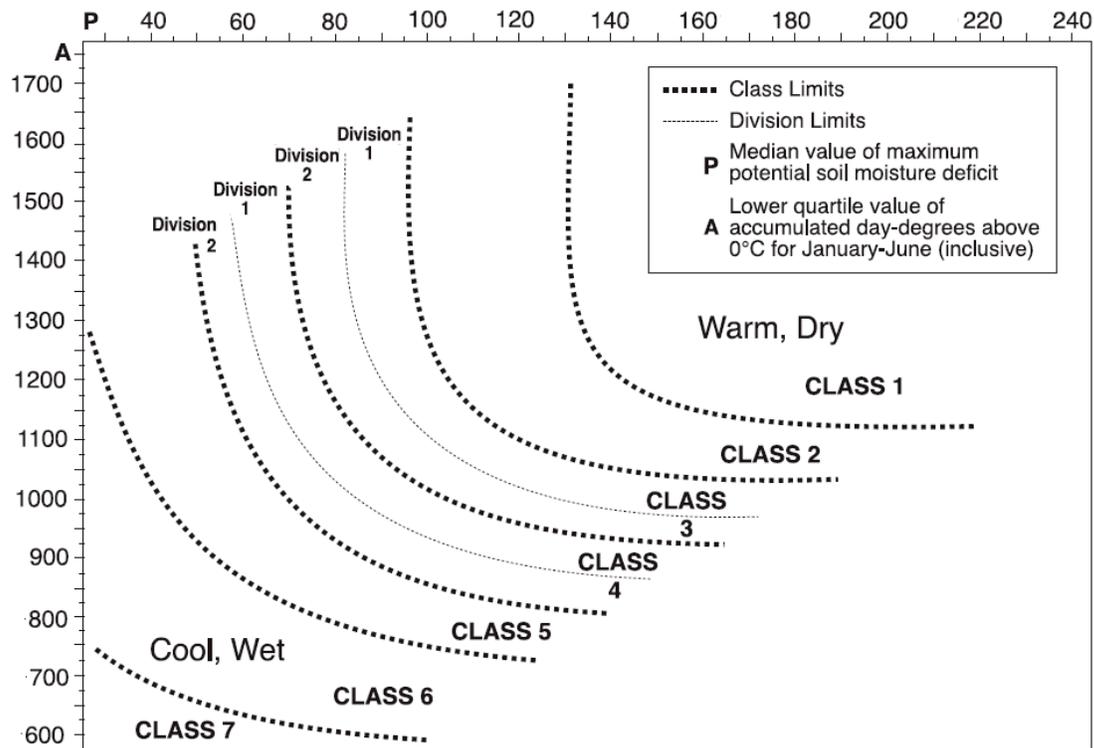


Figure 1 The main climate parameters used in the LCA system for Scotland.

UKCP09 data sources used:

- (i) 1961-2006 Met Office Observed Climatology
- (ii) Hadley Centre regional climate model HadRM3 RCM (11-member ensemble)
- (iii) UKCP09 Weather generator
- (iv) UKCP09 Probabilistic projections

Why these outputs were used:

(i) Observed climate datasets from 1960 to the present have been used to produce maps investigating the influence of recent climate change on land-use capability. This work has shown land-use capability has often improved in parts of eastern Scotland in recent decades as it has become warmer and drier, but this has not happened in western Scotland. The result has been a subtle but significant increase in 'prime agricultural land', which mainly occurs in eastern Scotland. However, land capability does vary considerably from year to year due to inherent climate variability.

(ii) The HadRM3 RCM data (11-member ensemble) were used to produce 11 Scotland-wide maps showing future spatial variation of land-use capability. The combination of required climate parameters meant that we needed to manipulate the raw climate model data to produce the required metrics. For LCA the two primary climate metrics are *accumulated temperature* and *potential soil moisture deficit* (certain other parameters are also needed for the full LCA assessment which also includes risk due to drought, soil wetness and erosion).

(iii) The UKCP09 Weather Generator was used to more fully explore uncertainty at individual sites (5 km grid squares), by producing and analyzing the same combined agro-climate metrics with multiple simulations (100 runs of the baseline and for the 2050s (A1B medium emissions scenario)) for the typical soil profile at each site. It therefore complements the spatial data by providing a wider assessment of uncertainty but only based upon the selected locations.

(iv) The UKCP09 probabilistic data was used to gain an indication of the relative likelihood of future change.

How the outputs were used:

For the observed climatology and RCM data we calculate the climate metrics and then combine them with soils and topographic data using GIS procedures. The HadRM3 RCM data (present and future) is scaled to the observed data to remove biases and downscaled to a consistent 5km grid that we use to produce change maps (Figure 2). We have also added extra detail at 1km scale as local soil and topography are the dominant factor at this level. For the UKCP09 Weather Generator data we have established routines that can process the data from the UKCP09 User Interface and produce graphical outputs for particular sites (Figure 3).

Only the Medium Emissions scenario is available from the HadRM3 RCM. However, as we are mainly looking at future changes in the next 40 years or so, different emissions scenarios are less relevant than variations in climate sensitivity (our work with UKCP02 also showed this). We use the 100 runs available from the UKCP09 Weather Generator to explore the range of climate uncertainty at each of the sites of interest in more detail.

We are currently in the process of estimating changes in the complex soil-climate interactions that may also occur in the future, notably drought risk, wetness factors and erosion risk. These may substantially modify the initial results and example of which is shown in Figure 2, but this will also depend on the degree of adaptation included in the analysis (e.g. irrigation or new crops).

The final step in our approach is to link with the UKCP09 probabilistic data. Here we are particularly interested in joint probabilities relating to warmth and wetness. Although the LCA climate metrics are not currently available in this format, from UKCP09 we can analyse temperature-precipitation joint probabilities to provide preliminary information (Figure 4).

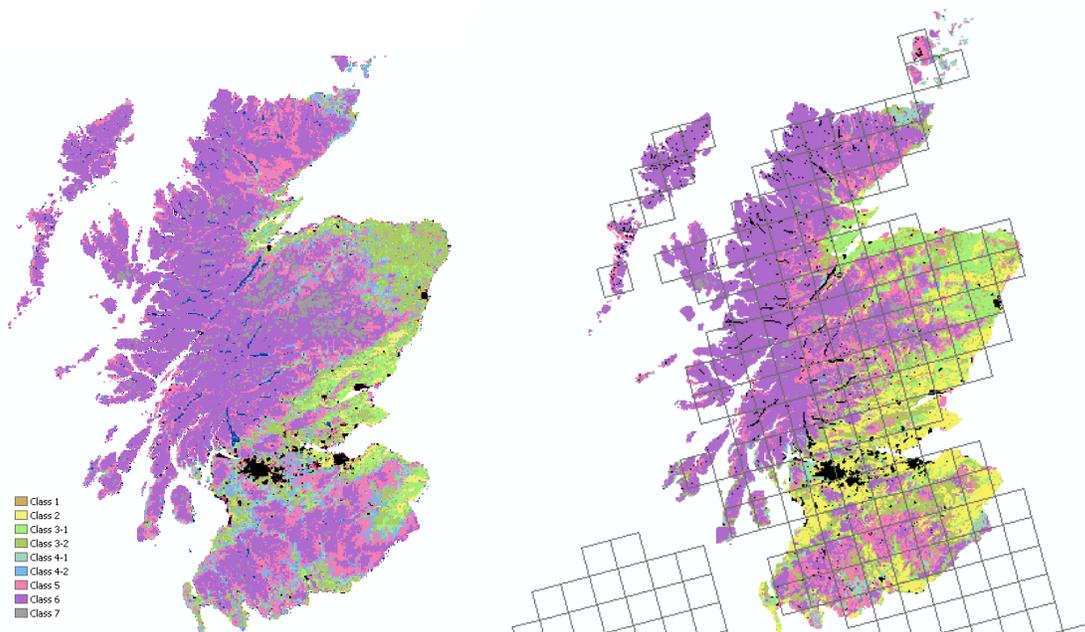


Figure 2. (Left) The official LCA map for Scotland (published in 1982 and based on 1958 to 1978 climate). (Right) A 2050s projection produced using one of the HadRM3 RCM simulations. The 2050s data shows a general increase in land capability for many areas but does not include soil-climate interactions (e.g. drought risk) that may limit these gains.

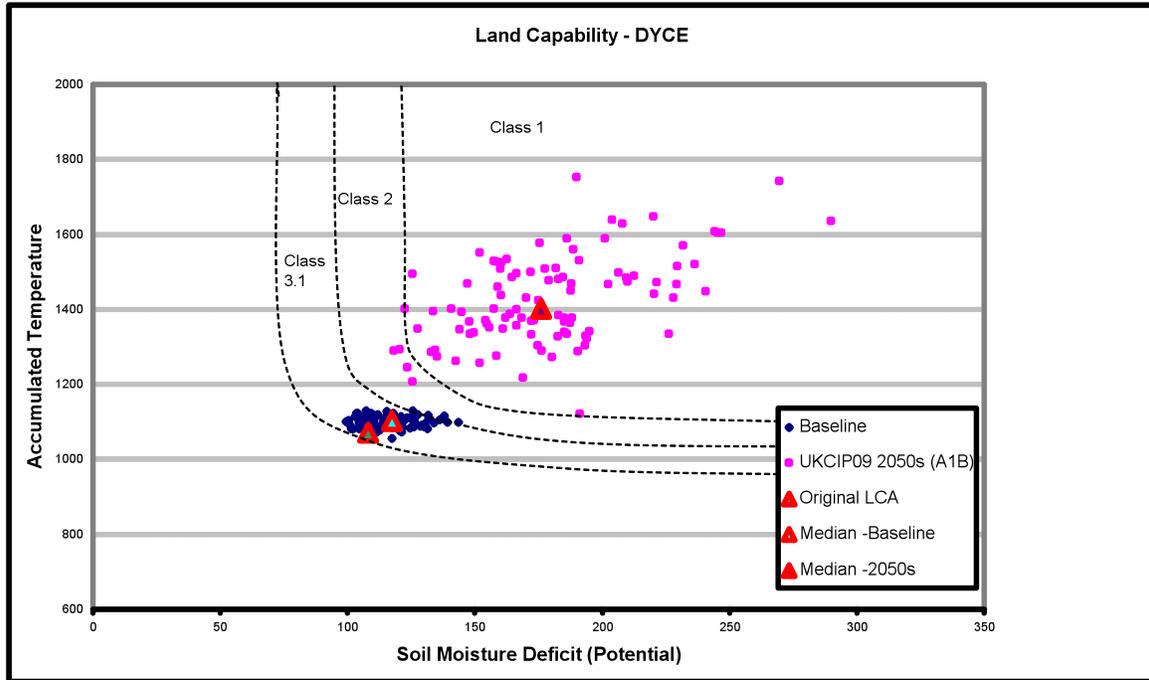


Figure 3. Climate metrics for Dyce (Aberdeen) based upon the same structure as Figure 1 using the metrics calculate from the 100 baseline simulations and the 100 further climate simulations (2050s A1B medium emissions scenario) provide by the UKCP09 Weather Generator. NB The metrics have been calculated based upon the climate parameters only and does not include soil, topography or soil-climate limitations which could reduce the final LCA class. Further work is exploring these issues using the Threshold Detector.



Plot Details:	
Data Source: Probabilistic Land	Temporal Average: JJA
Future Climate Change: True	Spatial Average: River
Variables: temp_dmean_tmean_abs, precip_dmean_tmean_perc	Location: North East Scotland
Emissions Scenario: Medium	Probability Data Type: samp_data
Time Period: 2040-2069	

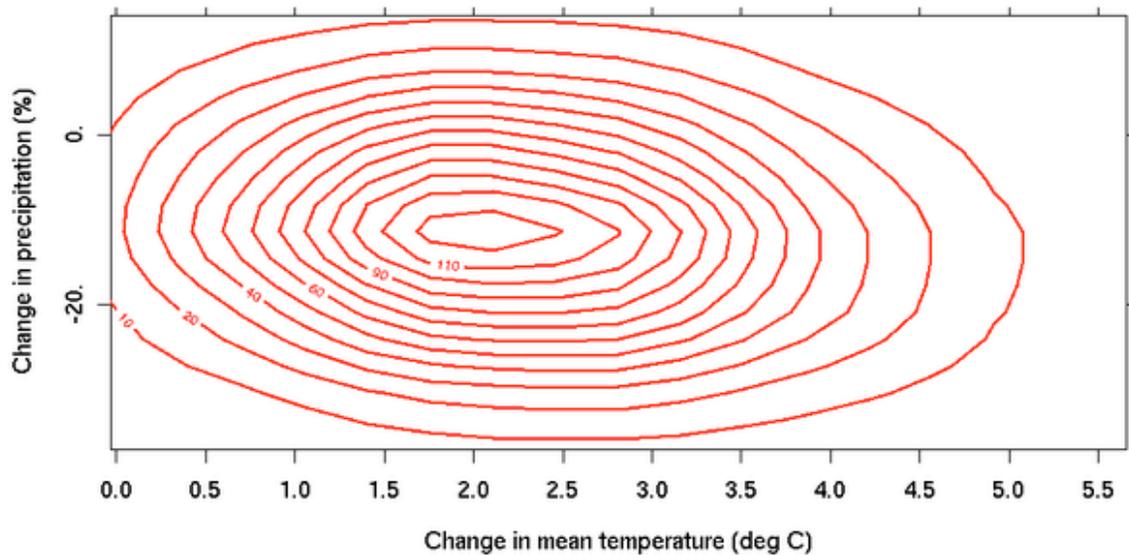


Figure 4. Joint probability assessment of summer change in temperature and precipitation (2050s). This would suggest an average shift to warmer drier conditions for NE Scotland. Probability contour values are x 1000.

Difficulties and limitations encountered:

- (i) The amount of data is huge and requires time to process.
- (ii) Soil moisture and evaporation data are the key for many adaptation assessments in the land and environment sectors but only limited data is made available.

Lessons learned regarding the use of UKCP09 information:

We now have a better idea of where our previous results calculate based on the UKCIP02 scenarios fit within the wider context provided by the HadRM3 and UKCP09 Weather Generator, together with a better impression of climate change uncertainty. Our concerns that the results from UKCP02 were at the extreme upper end of the range can now be shown in context, and that there are both higher and lower future projections. We can now consider the opportunities and risks for land use (especially agriculture) within a broad-based spatial framework that suggests increased land-use potential for many areas. However, dryness is likely to become an increasing problem for the drier areas of eastern Scotland and wetness will continue to be a problem for western Scotland. The full consequences of these changes will depend on the adaptation measures adopted.

Our analysis suggests that use of different UKCP09 tools can be used in a complementary way to assess both spatial variation and uncertainty, rather than just rely on one tool.

Communicating results to the target audience:

The existing LCA system is widely used and well-known amongst land managers, farmers and other stakeholders, so this provides an excellent reference framework for communicating climate change issues.

The biggest challenge (as ever) is communicating the uncertainty, but although there are important spatial variations (e.g. between east and west Scotland) the basic message of opportunity and risk linked to a warming climate provides a good starting dialogue.

The use of multiple data sources and graphical media (maps, graphs etc.) can be extremely useful to reinforce the message from different perspectives. We aim to combine the use of the maps with site-specific outputs from the Weather Generator to introduce risk and uncertainty through a structured process which progressively focuses on the key land-use issues as defined by different stakeholder perspectives.

Links to sources of more information:

Brown I et al (2008) The implications of climate change on Land Capability for Agriculture. Report to the Scottish Government. <http://www.programme3.net/rural/rural38climateLCLUSCCS.php>

Brown I et al (2008) Influence of climate change on agricultural land use potential: adapting and updating the land capability system for Scotland. Climate Research, 37, 43-57. <http://www.int-res.com/abstracts/cr/v37/n1/p43-57/>

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