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Capability, Suitability and Climate Program

Applying ALC Data for Modelling Agricultural Flood Risk

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Capability, Suitability and Climate Programme

This project is led by Welsh Government Land, Nature and Forestry Division with partners Environment Systems Limited, RSK ADAS Limited and Cranfield University.

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Executive summary

This report describes the wider application of the Version 2 Predictive Agricultural Land Classification (ALC) dataset and supporting data, for modelling: agricultural flood risk; areas suitable for and requiring irrigation; and areas suitable for ecological restoration. The resulting models were created as 50 m resolution raster datasets, covering the whole of Wales.

This work forms part of a wider three-year project which is led by Welsh Government and includes Environment Systems, Cranfield University and ADAS. The project forms part of the Welsh Government climate change mitigation and adaptation plans (Welsh Government, 2019). Previous project reporting (Bell *et al.,* 2020) described the use of ALC data for modelling land suitability for 118 crops under present day conditions, and under nine projected climate change scenarios.

The first section of this report describes the outcomes of investigations into the use of Natural Resources Wales FRAW flood risk data for creating a spatial dataset to define areas of agricultural flood risk, graded according to ALC criteria. The dataset was successfully used to define the extent and distribution of Best and Most Versatile land in relation to both summer and winter flood risk. Data gaps prevented definition of the lowest ALC grade areas, subject to highest flood risk (grade 5 for winter flood risk, and grade 4 for summer flood risk). Partial definition was possible for land graded as 4 for winter flood risk, and 3b for summer flood risk.

The second section of the report describes investigations into the use of the Version 2 Predictive ALC data for modelling irrigation requirement for sensitive crops. The initial focus of the work was for modelling land suitability for irrigation. However, following a review of the outputs by soil and crop specialists, it was felt that the definition of suitability did not sufficiently distinguish between physical suitability of the land, and the level of derived benefits gained from irrigation. The level of derived benefits varies according to soil type, location, and crop. As a result, the rulebase was revised, and the final models focussed on irrigation requirement, using five specific crops; potato, sessile oak, Sitka spruce, strawberry, and wheat.

The revised models focused on ALC drought data, where each ALC grade was assessed in terms of likely irrigation need, for each of the crops. ALC slope data was then added to identify areas where slopes are too steep to enable irrigation. The resulting models showed areas with soils that currently do not generally require irrigation; areas where the crops may experience drought, and may therefore require irrigation; and areas that are highly likely to experience significant droughtiness, and will require irrigation. Areas likely to require irrigation have been divided into steep and shallow slopes, to identify places where irrigation may be physically possible.

The models show very limited areas requiring irrigation for the five sample crops, at the present time. However, drought is predicted to become a much more significant factor over large parts of Wales in the near future, due to climate change. Future work would benefit from repeating the analysis using future scenario data; this would reveal a greater area of soils at risk of droughtiness, and provide a rapid assessment of which of these areas could be irrigated to benefit target crops. Further such analyses would benefit from the availability of gridded monthly rainfall data.

The final section of this report describes investigations into the use of suitability scoring of ALC and supporting datasets to model ecological suitability for habitat restoration, with a focus on blanket bog habitat. The study used ALC, habitat, rainfall and soil data, all of which were classified into areas suitable, of limited suitability, and unsuitable for restoration of blanket bog. The study did not consider the appropriateness of restoring areas to blanket bog; merely whether biophysical conditions would facilitate this. The analysis was carried out for present day conditions, and predicted conditions in 2080, based on the UKCP18 2080M climate change scenario.

The resulting models showed a reduction in areas suitable for restoration to blanket bog between the present day and 2080. These changes were found to be driven by changes in climate, soil wetness, soil droughtiness, and annual average rainfall, with the upland fringe and parts of eastern Wales in particular becoming too dry to support blanket bog habitat.

The ecological suitability maps can be analysed in conjunction with habitat network connectivity data in order to identify areas where restoration could increase habitat resilience, through improving ecological connectivity. The methodology could also be applied to suitability modelling for other habitat types.

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1 Introduction

This report forms part of a wider three-year project which is led by Welsh Government and includes Environment Systems, Cranfield University and ADAS (Figure 1). The project forms part of the Welsh Government climate change mitigation and adaptation plans (Welsh Government, 2019). Previous project reporting (Bell *et al.*, 2020) described the use of Agricultural Land Classification (ALC) data for modelling land suitability for 118 crops under present day conditions, and under nine projected climate change scenarios.

Underpinning the crop suitability modelling was the Version 2 Predictive ALC dataset (Keay, 2020a), Natural Resources Wales Flood Risk Assessment Wales (FRAW) data (NRW, 2019), and additional models of frost, wind and salt spray risk, in order to consider the most important biophysical factors influencing suitability for growing crops. This report considers parallel work streams under the same project, to investigate other potential applications of these new and updated datasets; specifically relating to agricultural flood risk, irrigation suitability, and ecological suitability modelling.

The first section of this report describes the outcomes of investigations into use of FRAW data for creating a spatial dataset to define areas of agricultural flood risk, graded using ALC criteria, and to map the extent and distribution of the different land grades.

The second section of this report describes investigations into use of the Version 2 Predictive ALC data for modelling irrigation suitability.

The final section of this report describes investigations into the use of ALC and supporting datasets to model ecological suitability for habitat restoration, with a focus on blanket bog habitat.

All resulting models were created as 50 m resolution raster datasets, covering the whole of Wales.

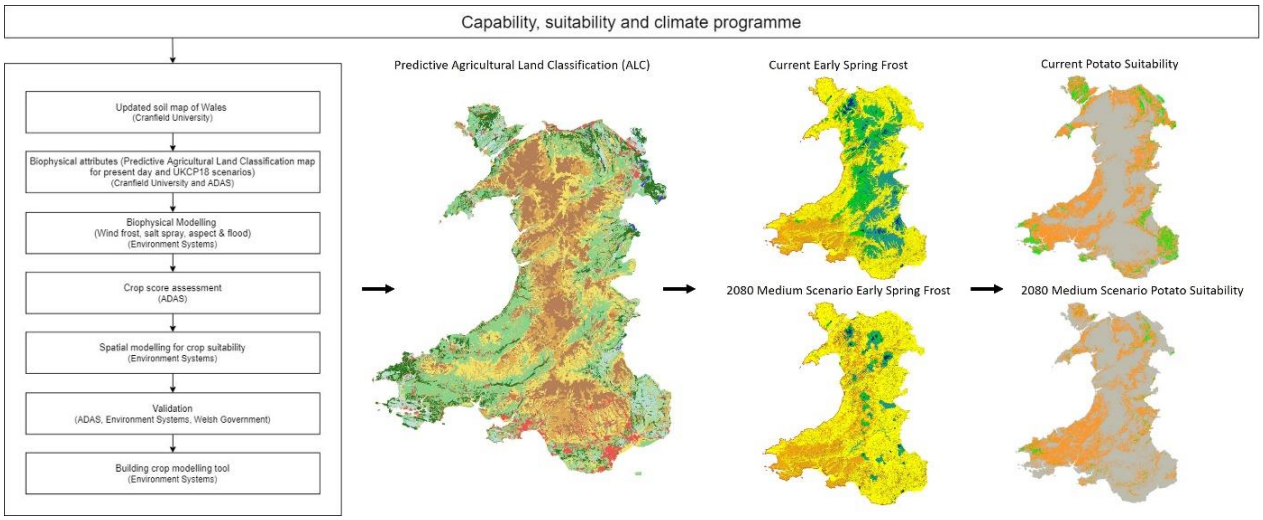


Figure 1: Stages of crop suitability modelling under the Capability, Suitability and Climate Programme

2 Agricultural flood risk

2.1 Background

Flooding is one of the factors limiting the overall ALC grade of agricultural land, as flooding has the potential to damage or destroy crops. How severely flooding impacts agricultural land depends both on the frequency and duration with which flooding occurs.

The ALC methodology (MAFF, 1988) provides guidance on criteria for grading land according to agricultural flood risk (Figure 2), on the basis of how frequently land is flooded, how long the flooding lasts, and during which time of the year it occurs, using the definitions listed in Table 1. However, up to now flood risk has not been included in the Predictive ALC datasets, due to a lack of appropriate spatial data.

The aim of this task was to use the most recent and detailed flood risk datasets available at the Wales wide scale to create present day flood risk maps for summer and winter flooding, aligning as far as possible with the ALC land grades for flood risk. For individual sites, where flooding is a known issue, high resolution flood modelling using software such as ISIS / TUFLOW is occasionally carried out. As these types of software have very high data and processing requirements, this data does not exist for the whole of Wales, but instead provides spatially and temporally detailed information on sites where this is specifically required as complex biophysical settings render national scale data too error-prone to support site-specific decision making.

Table 1: ALC definition of flood frequency and duration categories used to grade the quality of land according to flood risk (MAFF, 1988).

Duration	Definition	Frequency	Definition
Short	Not more than 48 hrs	Very rare	Not more than once in 15 years
Medium	More than two but not more than four days	Rare	Once in 10 to once in 14 years
		Occasional	Once in three to once in nine years
Long	More than four days	Frequent	More than once in three years

Grade according to flood risk in summer

Grade/ Subgrade		Flood limits *frequency*	*duration*
1		very rare	short
2		rare	short
3a		very rare	medium or long
	or	rare	medium
	or	occasional	short
3b		rare	long
	or	occasional	medium
4		occasional	long
	or	frequent	short or medium
5		frequent	long

Grade according to flood risk in winter

Grade/ Subgrade		Flood limits *frequency*	*duration*
1		rare	short
2		rare	medium
	or	occasional	short
3a		rare	long
	or	occasional	medium
	or	frequent	short
3b		occasional	long
	or	frequent	medium
4		frequent	long

Figure 2: ALC land grade definitions according to flood risk in summer and winter (MAFF, 1988).

2.2 Methodology

The flood risk modelling utilised draft FRAW fluvial flood risk models for the present-day climate; climate change scenarios were not considered. The FRAW data represent winter flooding levels; a corresponding dataset representing summer flooding was not produced as the differences between flood levels during the different seasons was found to be marginal (David Tarrant, *pers. com.*).

The ALC criteria divides land quality into grades, depending on both the frequency and duration of flooding experienced (Figure 2: ALC land grade definitions according to flood risk in summer and winter (MAFF, 1988)., with grade 1 representing the best

quality agricultural land, and grade 5 the poorest. The available FRAW datasets were interpreted in the context of these grades, to determine which grades could be defined by the spatial data.

The FRAW dataset contained separate datasets relating to flood frequency and flood duration. The flood duration dataset allowed definition of all three duration classes defined within the ALC criteria: 'Short' (0-48 hrs), 'Medium' (49-96 hrs) and 'Long' (>96 hrs). However, only partial definition of the frequency classes was possible. Areas modelled as 1/30 year flood risk were classified as both 'Very Rare' and 'Rare' frequency of flooding. Areas modelled as 1/10 flood risk were classified as "Occasional" frequency of flooding. The 1/10 dataset is the most frequent FRAW flood event scenario, therefore it was not possible to classify areas of 'Frequent' flooding.

The definitions of flood frequency and duration were then combined in order to classify individual ALC grades, as shown in shown in Table 2 for winter flood risk, and Table 3 for summer flood risk.

Table 2: ALC winter flood risk criteria matched to their corresponding ALC grade and NRW FRAW winter flood duration model; two rows for the same Grade represent an 'or'-condition.

Grade	ALC Criteria (frequency)	ALC Criteria (duration)	Frequency data (years)	Duration (From)	Duration (To)
1	Rare	Short	1 in 30	0	48
2	Rare	Medium	1 in 30	49	96
	Occasional	Short	1 in 10	0	48
3a	Rare	Long	1 in 30	97	*
	Occasional	Medium	1 in 10	49	96
3b	Occasional	Long	1 in 10	97	*
	Frequent	Medium	No data: not modelled		
4	Frequent	Long	No data: not modelled		

Table 3: ALC summer flood risk criteria matched to their corresponding ALC grade and NRW FRAW winter flood duration model; two rows for the same Grade represent an 'or'-condition.

Grade	ALC Criteria (frequency)	ALC Criteria (duration)	Frequency dataset (years)	Duration (From)	Duration (To)
1	No flood risk	N/A	1 in 10, 1 in 30	N/A	N/A
2	Rare	Short	1 in 30	0	48
3a	Very rare	Medium	1 in 30	49	96
	Occasional	Short	1 in 10	0	48
3b	Rare	Long	1 in 30	97	*
	Occasional	Medium	1 in 10	49	96
4	Occasional	Long	1 in 10	97	*
	Frequent	Short or Medium	No data: not modelled		
5	Frequent	Long	No data: not modelled		

2.3 Results and discussion

The national model for ALC grade by winter flood risk is shown in Figure 3, which shows that the majority of Wales is classified as grade 1 (no flood risk), followed by grade 2. There are smaller areas of grade 3a and 3b land. In these models, these grades are determined based on flood risk considerations only.

Areas of highest flood risk (grade 3b) are located along the River Dee near Flint and Wrexham. Significant areas of grade 3a land are located along the River Dee near Wrexham, River Severn near Llandrinio, and along the lower reaches of the Western Cleddau. Other areas affected by flooding have been mapped as grade 2, which follow major watercourses across Wales. Areas unaffected by flooding are mapped as grade 1.

The national model for ALC grade by summer flood risk is shown in **Error! Reference source not found.**. The distribution of summer flood risk areas is very similar to the winter flood risk areas, but with most areas affected by flooding downgraded by at least one grade/sub-grade relative to winter; this is because summer flooding is generally more harmful to crops than winter flooding.

Assessed against flood risk only, in the summer flood risk model the majority of Wales is grade 1 land, with grade 3a land forming the second largest extent, following the paths of major watercourses throughout Wales. There are smaller areas of grade 3b and grade 4 land, but no grade 2 land.

As with the winter flood risk model, areas of highest flood risk (grade 4) are located near Flint and Wrexham. Significant areas of grade 3b land are also located near Wrexham, Welshpool, and Western Cleddau, as well as along lower reaches of the Clwyd and Teifi rivers. The remaining flood risk areas are grade 3a based on their flood risk assessment.

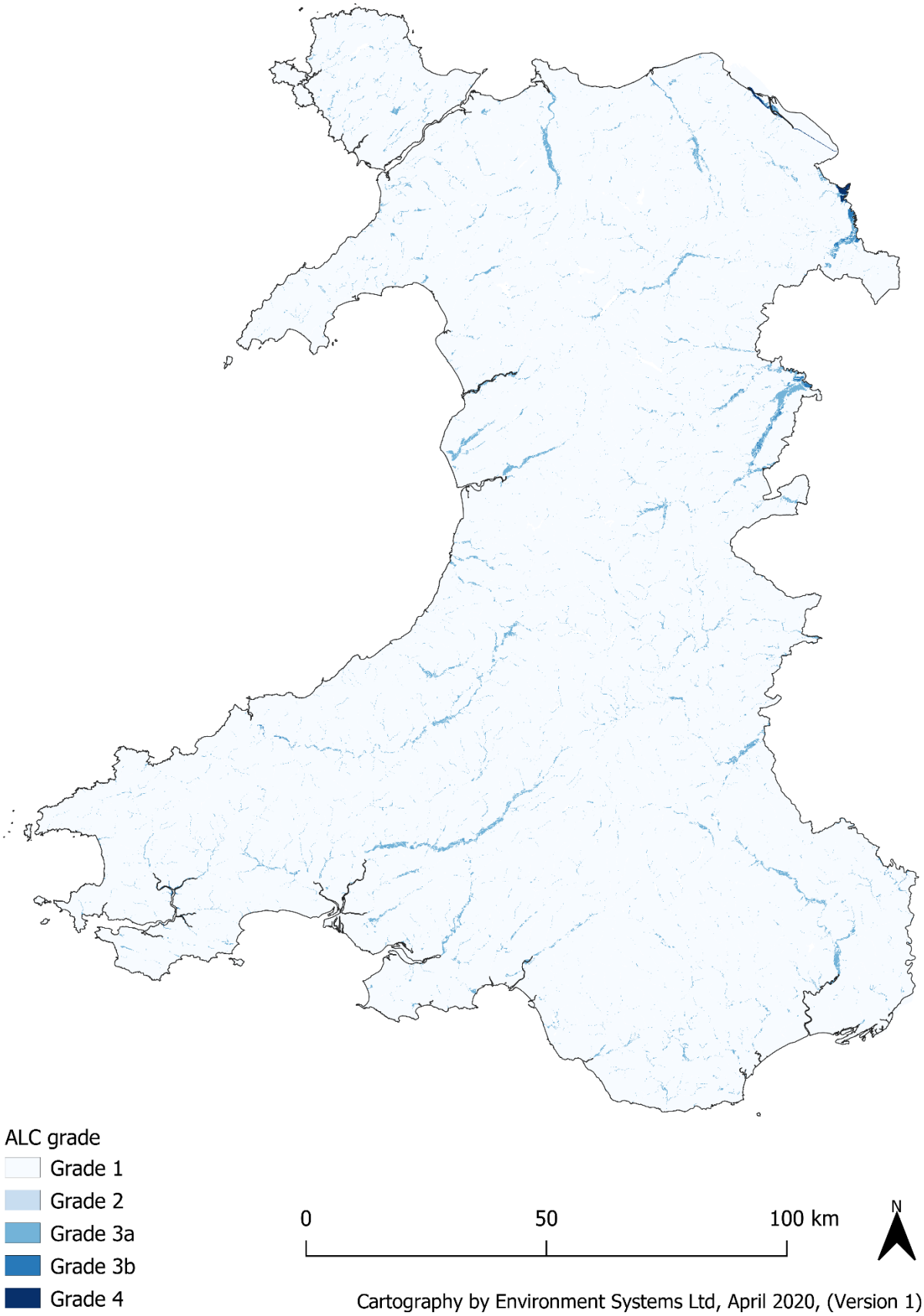
The available datasets enabled full modelling of grades 1-3a in the winter flood risk model, and grades 1-3b in the summer flood risk model. However, a lack of data for classification of areas subject to frequent flooding meant that some grades could only be partially modelled (grade 3b in the winter model, and grade 4 in the summer model), and the lowest quality land grades (grade 4 winter flood risk criteria, grade 5 summer flood risk criteria) could not be included in the models.

The 1 in 10 datasets were the best possible representation of 'occasional' flood risk, but as the ALC definition of 'occasional' is once in three to nine years, it is possible that this dataset over-estimates the extent of flooding in this category. Similarly, the 1 in 30 dataset was used to model 'rare' and 'very rare' flooding, as the closest-matching dataset to meet the ALC criteria of once in 10-15 years; it is therefore also possible that the 1 in 30 dataset overestimates the extent of flooding in the 'rare' and 'very rare' categories. However, the rapid changes in the frequency and extent of flooding experienced in Wales over recent years suggest that such potential overestimations could in fact be more representative of real flood risk.

The ALC flood risk criteria specifically relate to soils of good or moderate permeability; ALC guidance states that further downgrading may be justified in soils of poor permeability. Therefore, there is potential for future refinement of the models to include soil series data, in order to identify less permeable soil types within flood risk areas as candidates for downgrading. Long-term monitoring of flood events within areas mapped as different ALC flood risk grades, and particularly in areas with less permeable soil types, would provide useful validation data with which to assess model

accuracy and further refine the models. Alternatively, high risk sites could be targeted for site-based soil surveys, to analyse the interaction between high flood risk and soil type further.

Figure 3: ALC grades for winter flood risk


ALC grade
Grade 1
Grade 2
Grade 3a
Grade 3b
Grade 4
0
50
100 km
N
Cartography by Environment Systems Ltd, April 2020, (Version 1)

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