Appendix 7 - Environmental Assessment Technical Paper

Environmental Report

Renewable & Low Carbon Energy Supplementary Guidance

June 2017

PERTH & KINROSS COUNCIL

in partnership with

The James Hutton Institute

Acknowledgements

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List of Tables and Figures

Glossary of Terms

Degree of tranquillity	The extent to which we experience calmness, remoteness and/or peacefulness within a landscape.
Digital Elevation Model (DEM)	A digital model, or 3D representation of a terrain's surface, commonly for a planet (including Earth), created from terrain elevation data. A DEM can be represented as a raster or as a vector-based triangular irregular network (TIN). TIN is a digital data surface used in GIS for the representation of a surface.
Ecosystem Services	The benefits provided by ecosystem services that contribute to making human life both possible and worth living. Examples of ecosystem services include products such as food and water, regulation of floods, soil erosion and disease outbreaks, and non-material benefits such as recreational and spiritual benefits in natural areas (UK NEA).
Environmental Impact Assessment (EIA)	This is a way of drawing together, in a systematic way, an assessment of the likely significant environmental effects arising from a proposed development. Developments falling within a description in Schedule 1 to the 2011 EIA Regulations always require EIA. Development of a type listed under Schedule 2 of the Regulations will require EIA if it is likely to have a significant effect on the environment, by virtue of factors such as its size, nature or location. The requirement for EIA comes from European Directive 2011/92/EU and has been transposed into Scottish law through a number of Scottish Statutory Instruments.
Geographical Information System (GIS)	A GIS is a system designed to capture, store, manipulate, analyse, manage and present spatial or geographic data.
Grid Cell(s)	A grid cell is the area between grid coordinates.
Landscape Character	The distinct and recognisable pattern of elements that occurs consistently in a particular type of landscape. (The Countryside Agency and Scottish Natural Heritage, 2002).
Landscape Sensitivity	The degree to which the character and qualities of the landscape are affected by specific types of development and land-use change. Sensitivity depends upon the type, nature and magnitude of the proposed change, as well as the characteristics of the host landscape. High sensitivity indicates landscapes are vulnerable to the change; low sensitivity that they are more able to accommodate the change and that the key characteristics of that landscape will essentially remain unaltered. (SNH)
Perceived Naturalness	Defined as a high degree of perceived naturalness in the setting, especially in its vegetation cover and wildlife, and in the natural processes affecting the land, and with little evidence of contemporary human use of the land. (SNH, 2002)
Pixel	In a data model pixels or picture elements are used as building blocks for

	creating points, lines, areas, networks and surfaces. Pixels can be triangles, hexagons, squares, or even octagons. The majority of available GIS data are built on a square pixel. In a raster model the area covered by each pixel determines the spatial resolution of the raster model from which it is derived. A raster model with pixels representing 10 metres by 10 metres (or 100 square metres) in the real world would be said to have a spatial resolution of 10 metres.
Quartiles	Statistical measures that divide a set of data into four equal parts.
Rasterised	The conversion of an image (stored as an outline) into pixels that can be displayed on a screen or printed.
Sinuosity	A curve, bend or turn.
Strategic Environmental Assessment (SEA)	A process used to assess, consult upon and monitor the likely significant effects (both positive and negative) of implementing a qualifying public plan, programme or strategy (PPS) on the environment. A list of qualifying PPS and the legislative requirements for SEA are set out in the Environmental Assessment (Scotland) Act 2005.
Viewshed(s)	A geographical area that is visible from a location. It includes all surrounding points that are in line of sight with that location, and excludes points that are beyond the horizon or obstructed by terrain or other features. Conversely, it can also refer to an area from which an object can be seen. Viewsheds are commonly used in terrain analysis. In Town and Country Planning, viewsheds are often calculated for areas of particular scenic or historic value that are considered to be worthy of preservation from development or other change.
Watershed(s)	An area of land that captures rainfall and other precipitation and funnels it to a lake or stream or wetland.

1. Introduction

1.1. This report has been produced as a technical appendix to Perth & Kinross Council's Strategic Environmental Assessment (SEA) for its Draft Renewable Energy and Low Carbon Supplementary Guidance (SG). It aims to set out how the Council, in partnership with The James Hutton Institute (JHI), carried out the environmental assessment, including the landscape sensitivity analysis element of that SEA. It has been put together using background papers [1&2]supplied by JHI following the completion of their work on the development of a Strategic Land Use Capacity Map (SLUC) and Framework.

1.2. The landscape sensitivity analysis element is of particular relevance to wind energy developments, but the overall Framework will be used by the Council to inform future decision making on the location of a range of renewable and low carbon energy developments across the area.

How to use the study report

1.3. The study area is the Perth & Kinross Council administrative area, excluding those sections of Perth and Kinross that are within the Cairngorms and Loch Lomond and The Trossachs National Parks. However, the reader may note that some of the maps contained within this report do show the analysis results for the entire administrative area. This is the case for those maps supplied by JHI as part of their background papers.

1.4. The purpose of this document is to describe the technical process involved in developing the assessment methodology and undertaking the GIS analysis and mapping of *strategic* land use sensitivity to low carbon and renewable energy developments, taking into account ecosystem services, existing policy-based limitations and landscape considerations. The detailed methodology for, and results

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[1] Baggio Campagnucci, A; Gimona, A; Poggio, L; Castellazzi, M: *Renewable Energy Supplementary Guidance Task A* (2016)

[2] Baggio Campagnucci, A; Gimona, A; Poggio, L; Castellazzi, M: *Renewable Energy Supplementary Guidance Task B* (2016)

of the environmental assessment can be found within the main SEA Environmental Report which accompanies the SG, and are not repeated within this appendix.

1.5. The overall approach to the study has been informed by advice on the potential impacts and landscape sensitivities associated with low carbon and renewable energy developments, as well as on the practical application of methodologies used in recent landscape capacity studies undertaken for wind energy developments. In respect of wind energy developments specifically, the process follows the method used by Scottish Natural Heritage (SNH) in their 2004 *Study into landscape potential for wind turbine development in East and North Highland and Moray*[3].

1.6. It should be noted that the approach taken ranks locations within the study area from most to least sensitive without comparing them to locations outside of the area of interest, or prejudging which areas should be excluded, apart from those stipulated through existing legislation. In addition, locations are ranked according to the criteria set out in this report. Therefore, <u>no judgement has been made within the study as to the desirability or otherwise of installations</u>, and detailed statements regarding location specific impacts (including mitigation measures) are beyond the scope of the *strategic* framework.

1.7. The data sets included in the analysis (see Table 1 to follow) were agreed between the Perth & Kinross Council (PKC) and JHI members of the project team. The technical process applied in the GIS analysis and mapping of landscape sensitivity to wind turbine developments used a range of sensitivity criteria based on key landscape and visual characteristics, and visual effects. The reader is asked to note that the analysis was conducted at a 250 metre resolution, and therefore at a *strategic* level for the study area. Therefore, as highlighted above at paragraph 1.6, it is <u>not applicable</u> without the use of additional data and analysis work at the individual proposal/site specific scale. At that level more detailed investigations, such as those required by Environmental Impact Assessment, are likely to be necessary.

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[3] http://www.snh.org.uk/pdfs/publications/commissioned_reports/F02AA302_PART1A.pdf

Table 1: Framework and data used for each technology sensitivity model

	Wind	Solar		Hydro
Ecosystem Service	**Carbon Sequestration** **Regulating and Maintaining Services** • Natural Flood Management, Erosion Protection **Provisioning Services** • Food Provision, Drinking Water Supply, Biotic Materials: Timber Production **Cultural Services** • Accessible Recreation, Accessible Historic, Visual Amenity	**Carbon Sequestration** **Regulating and Maintaining Services** • Natural Flood Management, Erosion Protection **Provisioning Services** • Nutrition: Food Provision, Drinking Water Supply, Biotic Materials: Timber Production **Cultural Services** • Accessible Recreation, Accessible Historic and Cultural Experience, Visual Amenity	**Ecosystem Service**	**Carbon Sequestration** **Regulating and Maintaining Services** • Natural Flood Management, Erosion Protection **Provisioning Services** • Nutrition: Food Provision, Drinking Water Supply **Cultural Services** • Accessible Recreation, Accessible Historic, Cultural Experience, Visual Amenity
Planning Considerations	• Groundwater Dependent Terrestrial Ecosystems (GWTES) (Wetland Inventory) • Flooding	• Aerodrome 3 km buffer • Groundwater Dependent Terrestrial Ecosystems (GWTES) (Wetland Inventory) • Flooding Risk	**Areal Criteria**	• Naturalness • Protected Areas (RAMSAR, SSSIs, NNR, Gardens and Designed Landscapes, SPAs, SACs, Areas of Wild Land 2014, NSAs, SLAs, Geological Conservation Review)
Landscape	Landscape Capacity Study: • Land Cover Complexity • Landform Complexity • Landscape Complexity • Naturalness • Existing and Consented Cumulative Wind Turbine Impact • High Sensitivity to Wind LCA Areas	Landscape Capacity Study: • Landcover Complexity • Landform Complexity • Landscape Complexity • Naturalness • Existing and Consented Cumulative	**Linear Criteria**	Surface River Quality: • Fish Barriers Status • Overall Ecological Status • Fish Ecology Status • Morphology Status • Water Abstraction Status • Overall Hydrology Status
Other - Filter	• Group 1 (NSA/National Parks) • Group 2 (Natura 2000 and Ramsar sites, SSSIs, NNRs, Gardens and Designed Landscapes, Inventory of Historic Battlefields, Areas of Wild Land 2014, Carbon Rich Soils, Deep Peat and Priority Peatland Habitat, Community Separation for Consideration of Visual Impact, Special Landscape Areas)		**Cumulative Impact Criteria**	• Existing and Consented (sub-watershed) • Water Abstraction Agriculture • Groundwater Quality

2. Sensitivity to Wind Energy Developments

Methodology

2.1. The process followed to produce the strategic map of land use capacity for wind turbine developments (SLUC Map) involved combining three main data groups in a multi-criteria analysis. These groups are listed below, and a summary diagram of the process is provided at Figure 1 to follow.

- **Ecosystem Services** (ESS) Criteria (Carbon Sequestration; Regulating and Maintaining Services (Natural Flood Management, Erosion Protection); Provisioning Services (Nutrition: Food Provision, Drinking Water Supply, Biotic Materials: Timber Production); Cultural Services (Accessible Recreation, Accessible Historic and Cultural Experience, Visual Amenity).
- **Planning Considerations** defined by policy criteria (including the Scottish Government's Online Renewables Planning Advice for onshore wind developments[4], SEPAs guidance in respect of wetland protection[5] and the Flood Risk Management Planning process[6]).
- **Landscape Sensitivity** criteria.

2.2. At the beginning of the process the PKC Team were keen to try to incorporate an Ecosystem Services (ESS) Approach into the environmental assessment methodology for the Supplementary Guidance. An ESS Approach brings together a range of principles and ideas to be applied to any policy, plan or project that manages the natural environment, whether directly or indirectly. It is about integrating the conservation of natural resources along with social and economic needs and objectives, in a way that sustains the health of the ecosystems on which they depend[7] (*Applying an Ecosystem Approach in Scotland: A Framework for Action* (SNH).

2.3. However, as the development of the assessment methodology evolved it was recognised by the Project Team that it was not sufficient to only include data relevant to the range of ecosystem services within Perth and Kinross, given that the Guidance

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[4] http://www.gov.scot/Topics/Built-Environment/planning/Policy/Subject-Policies/low-carbon-place/Heat-Electricity/renewables-advice
[5] http://www.sepa.org.uk/media/136117/planning-guidance-on-on-shore-windfarms-developments.pdf
[6] https://www.sepa.org.uk/media/163410/nfm_summary.pdf
[7] http://www.snh.gov.uk/docs/C210222.pdf

being developed was of a Town and Country Planning nature. It was therefore necessary to also take account of existing policy-based limitations and landscape considerations.

2.4. The ecosystem services maps produced include current best available data and substitute local data where possible. Each service has been mapped independently and is based on the criteria set out in the appropriate Scottish Government online renewables advice documents. Where it was considered relevant additional national planning criteria has also been applied as a filter. These filters include Scottish Planning Policy (SPP) Group 1 and Group 2 areas, as defined in *Table 1: Spatial Frameworks of Scottish Planning Policy* (2014)[8]. Group 1 areas are those locations where windfarms will not be acceptable, and Group 2 areas are those which need significant protection; however, in some circumstances wind farms may be appropriate in these areas. For the purposes of the assessment, Group 2 areas were considered as being 'significantly sensitive'.

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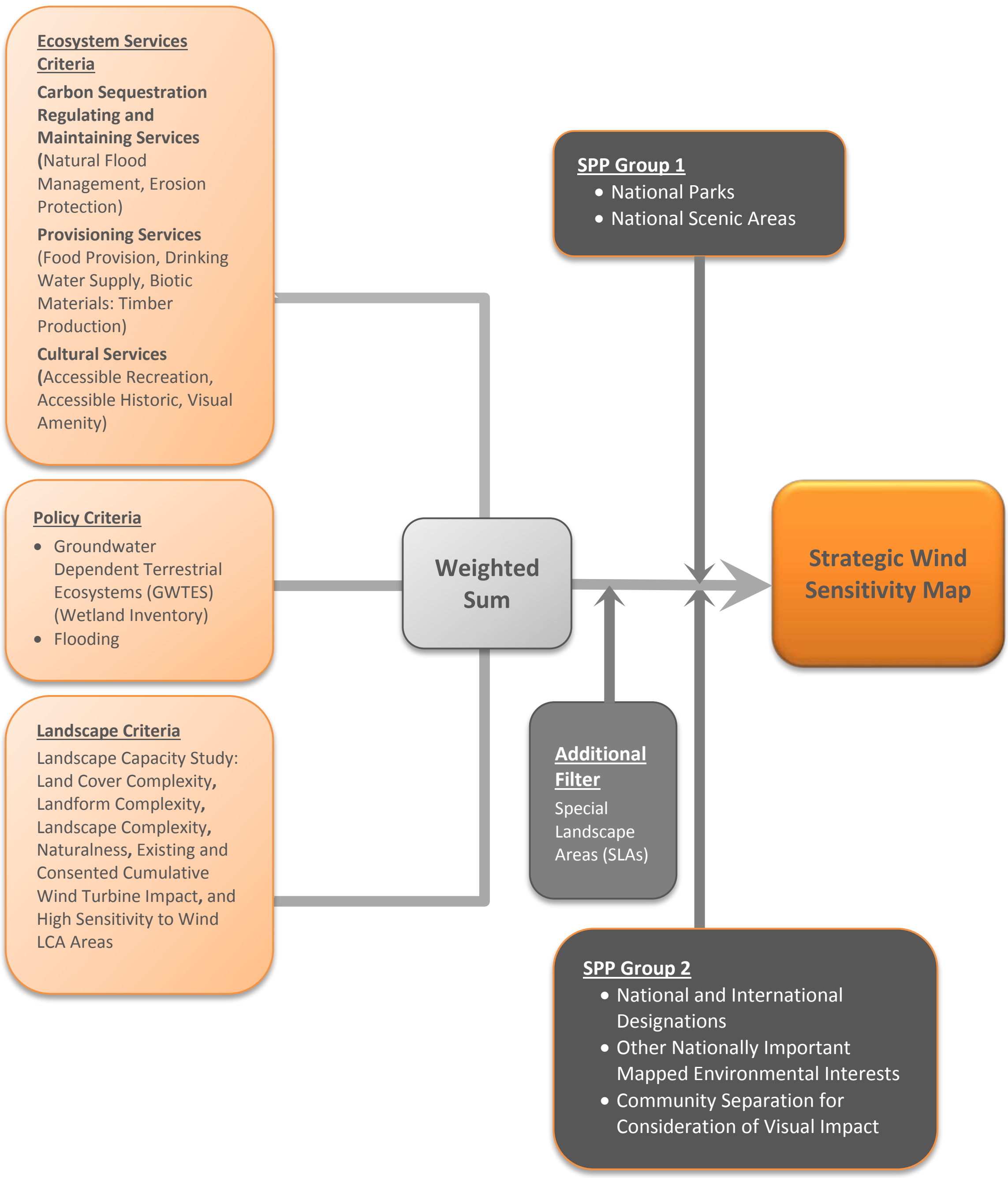
[8] http://www.gov.scot/Topics/Built-Environment/planning/Policy

Figure 1: Process for Producing the Strategic Land Use Capacity for Wind (SLUC) Map



ECOSYSTEM SERVICES CRITERIA

2.5. The ecosystem services used for the assessment were grouped according to the Common International Ecosystem Services classification (version 4.3). This classification is recommended for use in ecosystem services assessments by the European Environmental Protection Agency under its Mapping and Assessing Ecosystem Services Project. This classification uses three groups of services (regulating and maintaining; provisioning; cultural) and within these three groups splits the ecosystem services. Some ecosystem services were renamed to make the assessment relevant to a Scottish context. As per Figure 1, the ecosystem services have been categorised as follows:

- **Regulating and Maintaining Services**
  - Carbon storage
  - Natural Flood Management
  - Erosion Protection
- **Provisioning Services**
  - Nutrition: Food Provision
  - Drinking Water Supply
  - Biotic Materials – Timber Production
- **Cultural Services**
  - Accessible Recreation
  - Accessible Historic and Cultural Experience
  - Visual Amenity

2.6. These ecosystem services underpin our economy, our health and well-being, and are fundamental to our continued existence. It is now widely recognised in Scotland, and internationally, that relevant decision making must take account of human dependency on a range of services that ecosystems can provide.

2.7. Low carbon and renewable energy development will influence ecosystem structure and processes, as well as affecting the provision of ecosystem services. Incorporating an ecosystem services approach as part of the SEA method will identify the potential change to services, alongside other economic, social and environmental impacts linked to renewable and low carbon energy development and ultimately will assist in identifying the most sustainable locations for future renewable and low carbon energy development.

2.8. The nine ecosystem services listed above were mapped by using and combining a wide range of datasets available from Perth & Kinross Council, JHI, or others derived from spatial models, in order to produce a representation of the current state of ecosystem services across the study area. A further two datasets, Drinking Water and Natural Flood Management, were also used during this stage of the process. These additional layers represent the service provided by waterbodies in supplying drinking water, and the benefits provided by the water environment in helping with natural flood management.

Natural Flood Management

2.9. This dataset provides information regarding the extent to which different natural flood management features have the potential to store and attenuate flows of flood water in different locations. The contribution that the water environment makes to natural flood management on a landscape scale is only ever partial as it works in combination with broader issues, such as: land cover, topography, geology and location. Nonetheless, wetlands and flood plains are important features in terms of natural flood management, and their role depends on a range of factors, including their location within a catchment and their vegetation cover. Waterbodies are also capable of storing water and attenuating flows, but this can vary depending upon factors such as their structure (e.g. whether they contain pools and meanders), the river bed, and their location within the catchment.

Drinking Water

2.10. The service provided by the water environment (lochs, rivers and groundwater) is volumes of water for abstraction and use in drinking water. The data held by JHI, and obtained from the Scottish Government Drinking Water Quality department, shows the relative volumes of water that are abstracted from surface waters for public and private drinking water supplies.

Visual Amenity

2.11. The visual amenity analysis produced as part of the project represents the visual sensitivity, taking into account two sets of viewsheds. The first was from National Park and National Scenic Area boundaries, with 100 metre offset elevation surface (50 metre resolution), and the second was a series of viewshed analyses carried out from points derived from the statistical model. This model identified points likely to have a higher than average appeal in the landscape, having controlled for accessibility i.e. they were weighted in terms of accessibility from key settlements and routes to prioritise those areas more accessible to the public. The two data sets were then summarised together to provide visual sensitivity information from multiple recognised viewpoints.

POLICY CRITERIA

2.12. The policy criteria which were relevant to Planning considerations, apart from those captured by Groups 1 and 2 (SPP), are represented by two datasets. The first layer applied was the Wetland Inventory with a 2 kilometre buffer. Although this layer was not considered mandatory in terms of wind turbine developments, the Project Team included it following review of SEPA's Planning guidance on on-shore windfarm developments as a proxy for the GWDTE (Groundwater Dependent Terrestrial Ecosystems) layer[9]. The guidance document is particularly focussed on peatlands and wetlands. It was considered that the wetlands part lends itself better to strategic criteria, whereas the guidance on peatlands is more easily applied at the individual project level.

2.13. Based on SEPA's guidance, a 250 metre buffer was created around each wetland to create a wetland zone. The presence and absence of wetland zones was then defined within a 250 metre grid across the Council Area, and classified into two values (1 = absence = low sensitivity, and 4 = presence = high sensitivity).

2.14. The second Planning consideration layer was the flood risk map. This dataset is also a binary layer (i.e. presence/absence), and it represents the flood risk map for the Perth and Kinross Area. The dataset was produced by SEPA in 2008 in order to map a range of predicted fluvial and coastal flood events for Scotland. It is used as an indicative flood outline, based on a 0.5% or greater (or 1 in 200 chance) annual probability of fluvial flooding. The layer was reclassified in a binary way for the study, 1 and 4 represent, respectively, the non-risk and the risk value.

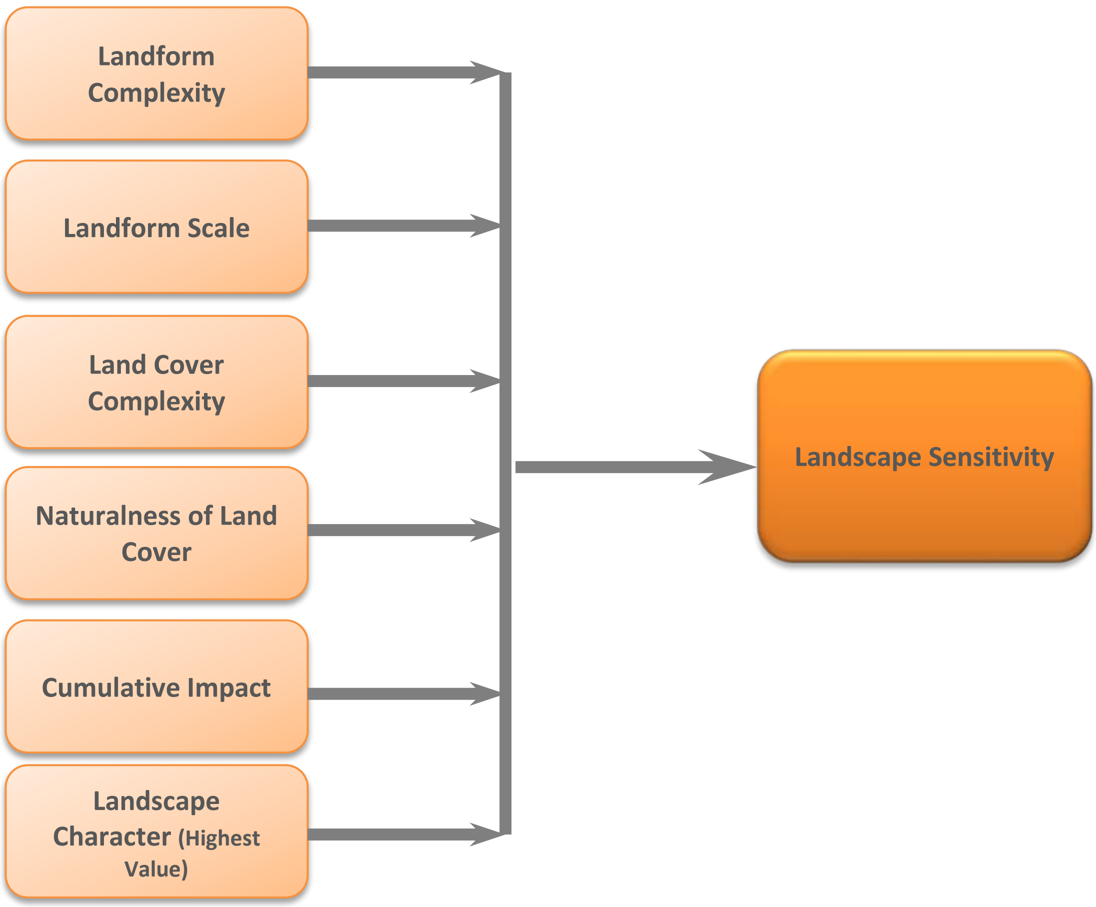
LANDSCAPE CRITERIA

2.15. This section describes the technical process involved in the GIS analysis and mapping of landscape sensitivity to wind turbine developments. The procedure involved combining six factors, four of which were used to describe landscape character sensitivity at pixel level (250 metre resolution), as set out in the previously mentioned SNH 2004 study. An additional two layers were used: Cumulative Visual Impact and Landscape Character, as defined in the 2010 David Tyldesley landscape study[10]. Figure

[9] http://www.sepa.org.uk/media/136117/planning-guidance-on-on-shore-windfarms-developments.pdf
[10] ttp://www.gov.scot/Resource/0046/00466159.pdf

2 below illustrates the components for landscape sensitivity and paragraphs 2.16 to 2.34 explain in more detail each of the six factors.

Figure 2: Components for Landscape Sensitivity

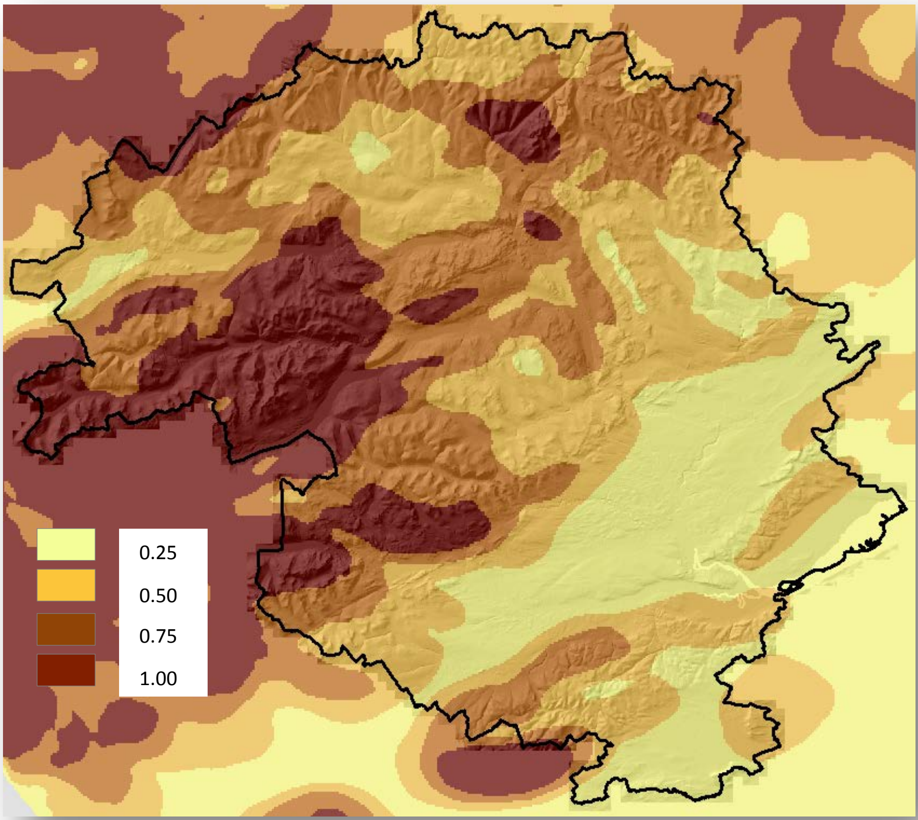


Landform Complexity

2.16. This is the consideration of the overall shape and the degree of complexity of the landform. This factor is one of the most important for the acceptability of wind turbines because of the high variation of the elevation related to the turbine tends to create disharmony in perception. In general the simpler the landform the better the visual relationship is with turbines (Stanton 1996; SNH 2001; Bell 1991).

2.17. The complexity of the landforms topography was measured through an analysis of variability of the Digital Elevation Model (DEM). The analysis used the DEM at 50 metre resolution within a 2 kilometre radius from each grid cell to represent the variability of elevation. The result was then reclassified using the four quartile breaks (0.25, 0.5, 0.75, 1). Figure 3 below shows the resultant landform complexity map for the study area.

Figure 3: Landform Complexity Analysis Map



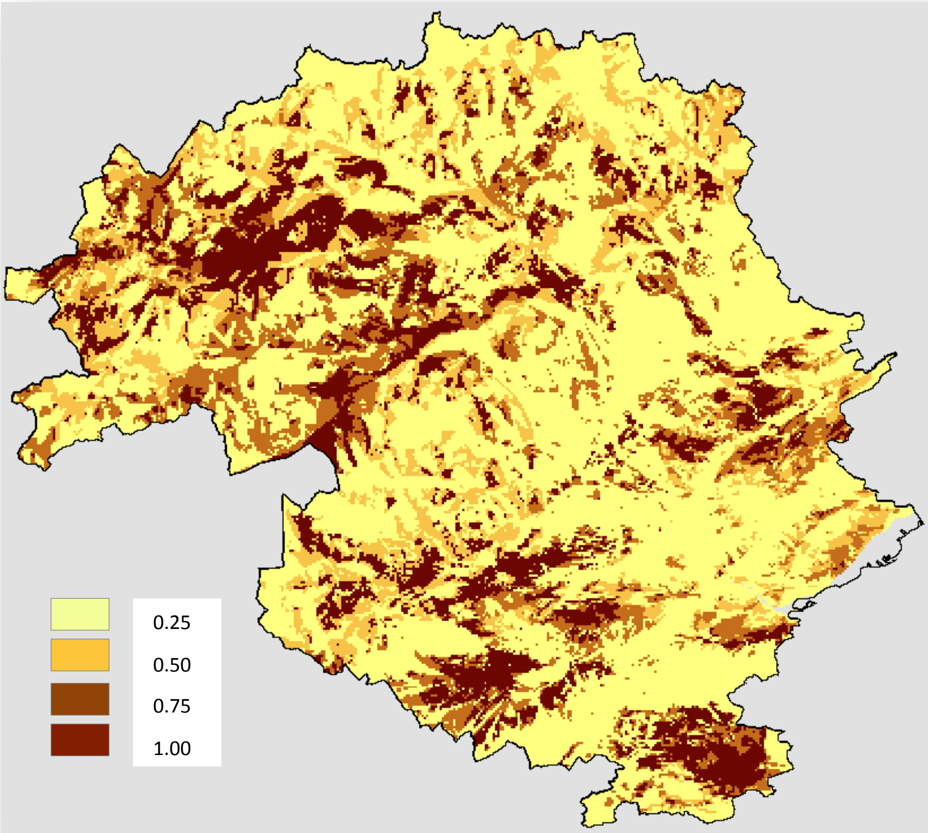
Landform Scale

2.18. This is an assessment of the extent of the openness of the landscape and attempts to capture how a development would relate to the scale of the landscape, including whether it would be likely to dominate the scale of other elements in that landscape. In general, the larger the scale of the landscape, the greater the ability there is to relate to larger development typologies.

2.19. The viewers' perception of the scale factor depends on their position and can be expressed as the combination of the spatial extent of the view and the range in elevation of the landscape over the viewed area, both were developed using the DEM 50 metre resolution.

2.20. A series of viewsheds were created (one from each 5 kilometre regular grid point) and combined from all approved and/or built windfarms and wind turbines over 30 metres in height (within a 10 kilometre radius plus hub height offset of 100 metres). The resulting map was multiplied by the elevation range at the pixel (within 10 kilometres) and reclassified using the usual quartile breaks (0.25, 0.5, 0.75, 1). The 0 value (non-visible areas) was integrated into the first quartile. Figure 4 below shows the output from the landform scale analysis.

Figure 4: Landform Scale Analysis Map



Land Cover Complexity

2.21. This is the consideration of the degree of complexity of the land cover pattern and whether the pattern is strong or fragmented. The land cover complexity depends on the vegetation cover type. Simple, regular, uncluttered landscapes with extensive areas of the same ground cover are likely to be less sensitive to development than areas with more complex, irregular or small scale landscape patterns. Wind turbine installations can compromise the original visual pattern of the landscape, depending on the contrast of patterns the development can create on the landscape.

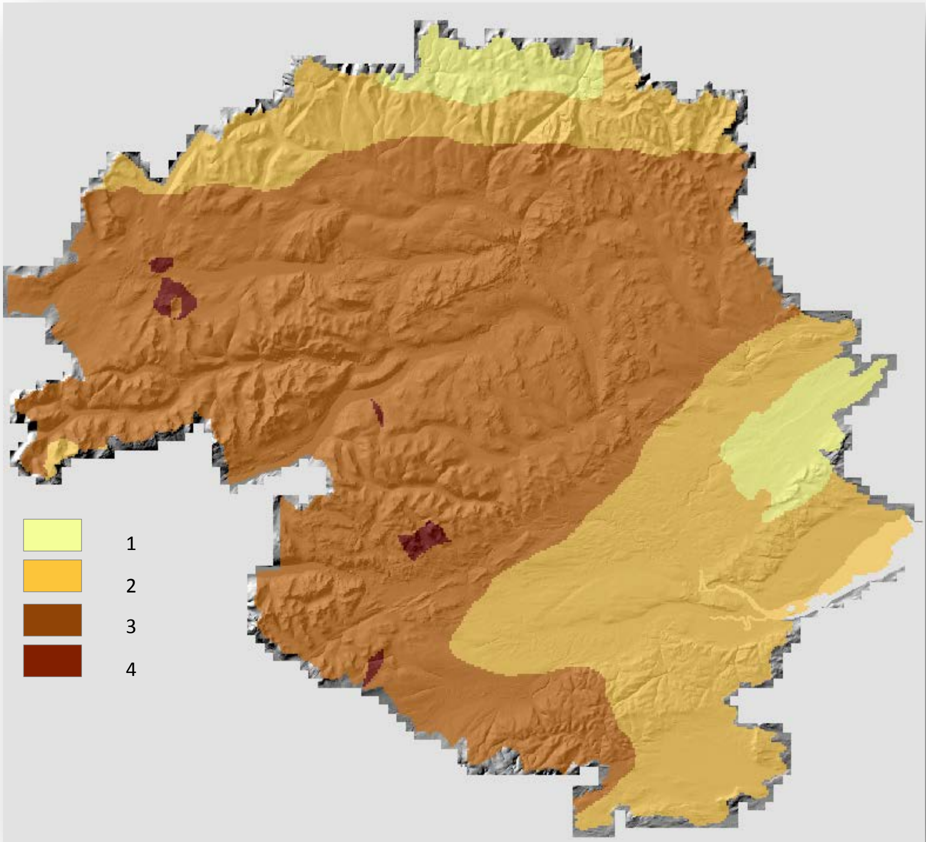
2.22. The Land Cover Complexity map was produced by a zonal analysis at pixel level of a reclassified map (see Table 2 to follow). The reclassification follows the approach applied in the 2004 SNH study and was required in order to simplify the analysis, which considered the number of different land cover types (Land Cover Map (LCM) 2007) within a 10 kilometre radius from each pixel.

Table 2: Land Use/Cover Reclassification Table

LCM 2007 Code	Original	New Code	Reclassification
1	Broadleaved woodland	1	Semi-natural woodland, broadleaved woodland, and scattered trees
2	Coniferous woodland	2	Coniferous woodland
3	Arable and Horticulture	3	Agriculture (no rock, no tree)
4	Improved grassland	3	Agriculture (no rock, no tree)
5	Rough grassland	4	Rough and smooth grasslands and dunes
6	Neutral grassland	4	Rough and smooth grasslands and dunes
7	Calcareous grassland	4	Rough and smooth grasslands and dunes
8	Acid grassland	4	Rough and smooth grasslands and dunes
9	Fen, Marsh and Swamp	4	Rough and smooth grasslands and dunes
10	Heather	5	Heather moorland (no rock, no trees)
11	Heather grassland	5	Heather moorland (no rock, no trees)
12	Bog	6	Peatland and montane (no rock no trees)
13	Montane habitats	6	Peatland and montane (no rock no trees)
14	Inland rock	6	Peatland and montane (no rock no trees)
15	Saltwater	7	Sea
16	Freshwater	8	Inland water
17	Supra-littoral Sediment	9	Cliffs + scattered rock
18	Supra-littoral Rock	9	Cliffs + scattered rock
19	Littoral Rock	9	Cliffs + scattered rock
20	Littoral Sediment	9	Cliffs + scattered rock
21	Saltmarsh	9	Cliffs + scattered rock
22	Urban	10	Settlements and developed rural land
23	Suburban	10	Settlements and developed rural land

2.23. Due to the shortness of time and availability of resources, it was not possible to analyse the distribution of the total number of land cover classes visible from any one location using detailed viewshed analysis. As such, the proportion of the land use classes in each 250 metre grid cell were counted, and it was assumed that all parts of a pixel are visible from its centre (an overestimation). The dominance of the land use classes was then calculated using the four quartiles of the distribution of values as thresholds for interval breaks; the land cover complexity was considered to be 'simple' if any class had more than 75% dominance. The land cover complexity was labelled as 'complex' where multiple classes were present and the percentage of the dominant classes was less than 25%. Figure 5 to follow shows the result of that analysis (0.25 = 4, 0.5 = 3, 0.75 = 2, 1 = 1).

Figure 5: Land Cover Complexity Analysis Map (4 = complex, 1 = simple)



Naturalness of Land Cover

2.24. This is the consideration of the degree of landscape modification by humans (such as roads, settlements, forestry, masts and wind turbines), and how development could affect perceptions of naturalness and the degree of tranquillity experienced. The principle applied here was that semi-natural cover is presumed to be more sensitive to wind turbines.

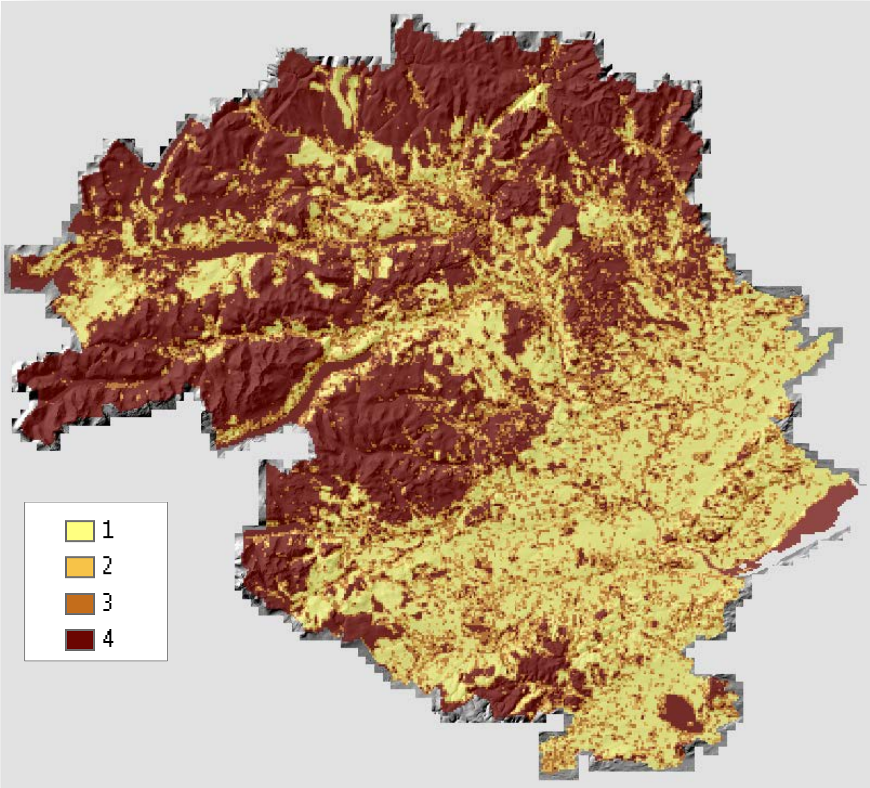
2.25. In order to allow this factor to be considered in the landscape sensitivity analysis, the naturalness of the landscape was determined through a reclassification of semi-natural and human-origin land cover types (LCM 2007) as per the approach suggested by SNH in their 2004 study. Table 3 to follow provides the reclassification scheme applied.

Table 3: Reclassification Scheme of the Land Cover Map (LCM 2007)

Mainly Semi-Natural Land Cover Origin	Mainly Human Origin
Semi-natural woodland and scattered trees (all rough grassland, or heather moorland classes, in which there were scattered trees, but moorland excluded areas of muirburn and rock) Rough grassland (excluding scattered trees and rock)	Agriculture (including arable and improved pasture)
Cliffs and scattered rock (excluding any evidence of heather muirburn) Inland water Sea	Coniferous woodland (including recently felled and new plantations) Heather moorland with burning
Bracken (excluding rock and scattered trees) Peatland (excluding workings) and montane vegetation Heather moorland (excluding muirburn, scattered trees and rocks)	Smooth grassland Settlements and developed rural features Peatland (commercial extraction)

2.26. The analysis was made up of a series of zonal statistics within each of the 250 metre grid cells to count the "percentage semi-natural" and the "percentage non semi-natural" land covers. The two datasets obtained through the reclassification in Table 3 were summed to 100% in each feature zone. The resulting percentage for semi-naturalness was then reclassified using the four quartile threshold values (0.25, 0.50. 0.75, 1). See Figure 6 below for the output from that analysis work.

Figure 6: Degree of Semi-Naturalness Analysis Map (4 = High, 1 = Low)



Cumulative Landscape and Visual Impact Assessment (CLVIA)

2.27. This further analysis was undertaken in order to describe, visually represent and assess the ways in which a proposed windfarm could have additional impacts within the landscape character type and in the surrounding area when considered alongside other existing, consented or proposed windfarms. The analysis considered all of the installed and approved wind turbines taller than 30 metres (height) or groups of turbines within a 10 kilometre extent.

2.28. Visual sensitivity of the landscape was defined according to the following three factors:

i. The number of visible wind farms from each pixel;
ii. The number of individual wind turbines in a visible wind farm;
iii. The distance of the observer from each wind turbine.

2.29. Due to time constraints, it was not possible to establish the distance of each single wind turbine from each grid cell of the landscape. Therefore, as an alternative, distance was separated into classes and, based upon the 50 metre resolution Digital Elevation Model (DEM), a model was set up to count how many turbines are seen by each grid cell in the landscape, weighted by distance class. The reasoning being that distant objects weigh less (in the analysis) than close ones.

2.30. Viewshed analysis from each pixel was used to quantify the number of wind farms the observer is able to see (i.e. Factor i. in paragraph 2.28 above). The analysis took into account the height of each wind turbine as the offset parameters with a visible radius of 10 kilometre distance.

2.31. For point iii. weighted distance buffers of 1.5, 5 and 10 kilometres were used. The applied formula returns the effective number of visible turbines, accounting for the offset distance parameters in each grid cell.

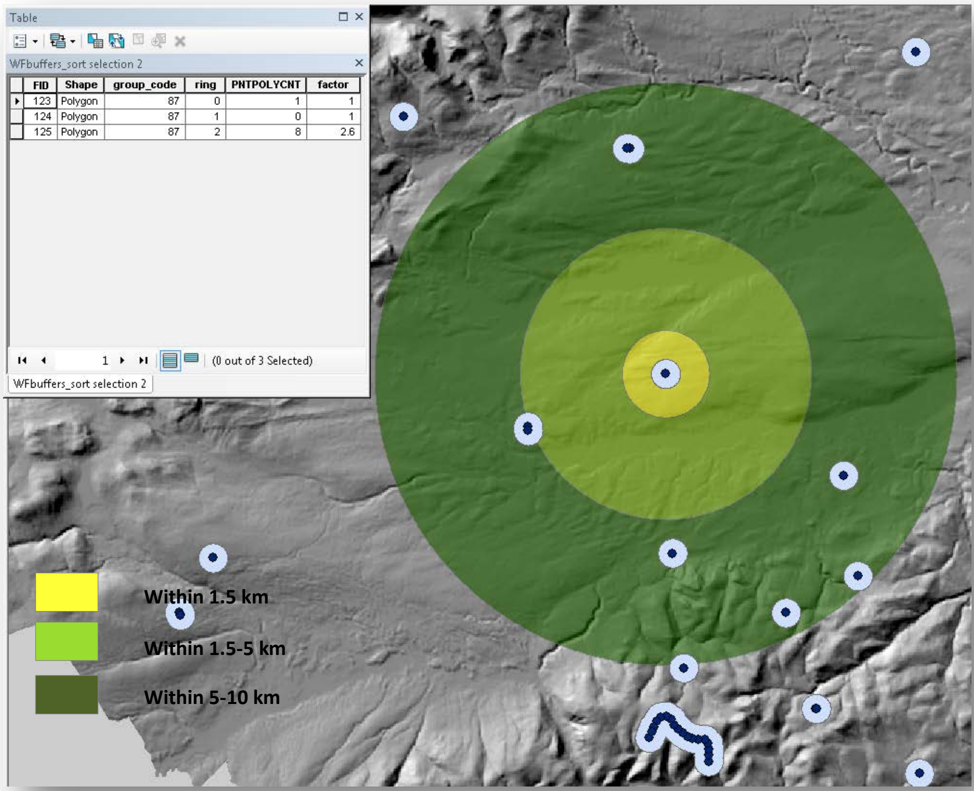
Equation 1 (Eq. 1)

$$\boldsymbol{Eff.n} = (\mathrm{nWT\_Ring0} * 1) + (\mathrm{nWT\_Ring1} * 0.5) + (\mathrm{nWT\_Ring2} * 0.2)$$

nWt = no. of wind turbines seen by each wind farm
Ring0 = within 1.5km
Ring1 = within 1.5-5km
Ring2 = 5-10km

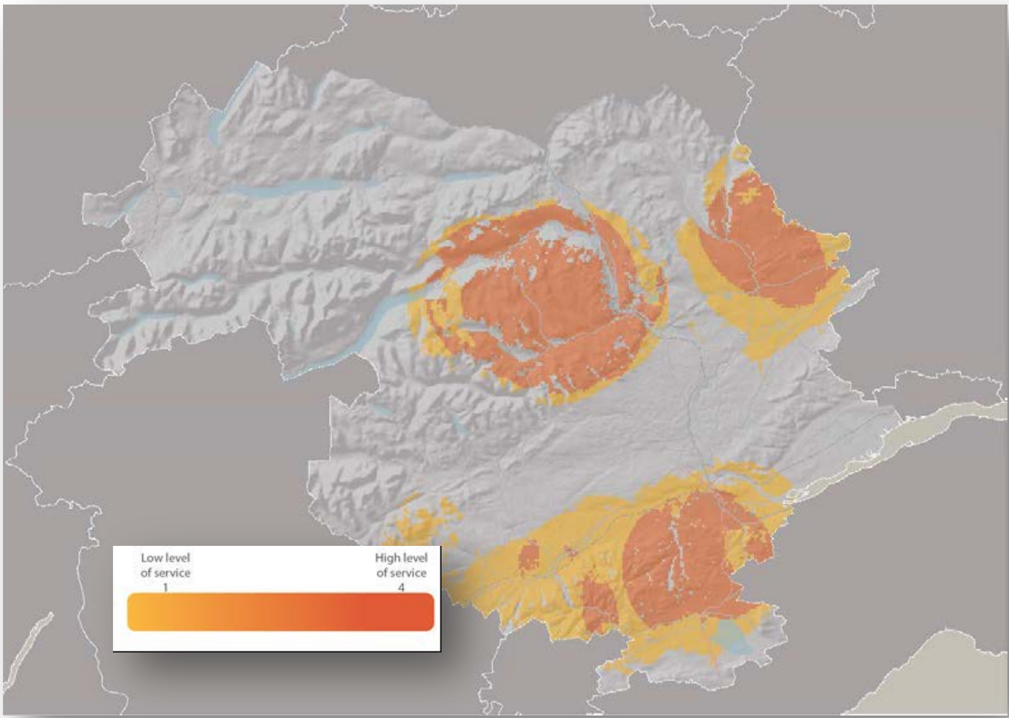
2.32. Figure 7 to follow illustrates the approach taken, and the inset table shows the calculation (Eq. 1) of the cumulative impact for the central cell. The reference to 'factor' in the table means distance-weighted number of turbines. In the case of Figure 7 the total written in the central cell is 2.6.

Figure 7: Illustration of Cumulative Impact Calculation (Eq.2)



2.33. The analysis was repeated across all of the wind turbines. The results were rasterised and added together to produce a final Cumulative Visual Impact map for the study area (Figure 8 to follow). The four quartiles of the distribution of values were then used to classify cells.

Figure 8: Cumulative Visual Impact of Wind Energy Structures and Existing Wind Turbines



Map Published 2017

Landscape Character

2.34. This piece of the analysis used part of the results from the 2010 David Tyldesley Associates *Landscape Study to Inform Planning for Wind Energy*[11] (The Tyldesley Report). The Tyldesley Report further developed upon the Landscape Character Types first identified in the 1999 Land Use Consultants *Tayside Landscape Character Assessment*[12], by identifying those landscape character units of highest sensitivity (L1 to L3) where wind energy and other large scale development would be considered inappropriate. The criteria used to define these areas (L1 to L3) are set out in Table 4 to follow, and an associated map is provided at Figure 10. A list of the relevant named

[11] http://www.gov.scot/Resource/0046/00466159.pdf
[12] http://www.snh.org.uk/publications/on-line/LCA/tayside.asp

landscape character types and subunits has also been included at the end of this section (see Table 5).

Figure 9: Tayside Landscape Character Types (DTA, 2010)

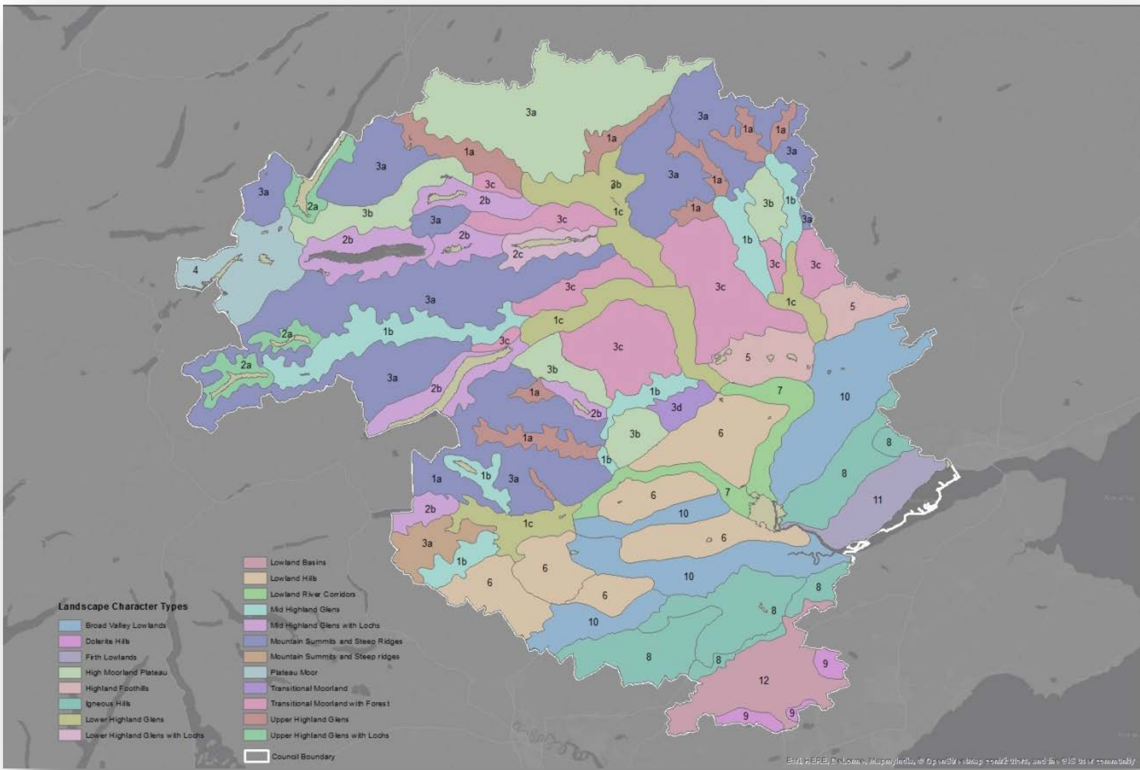
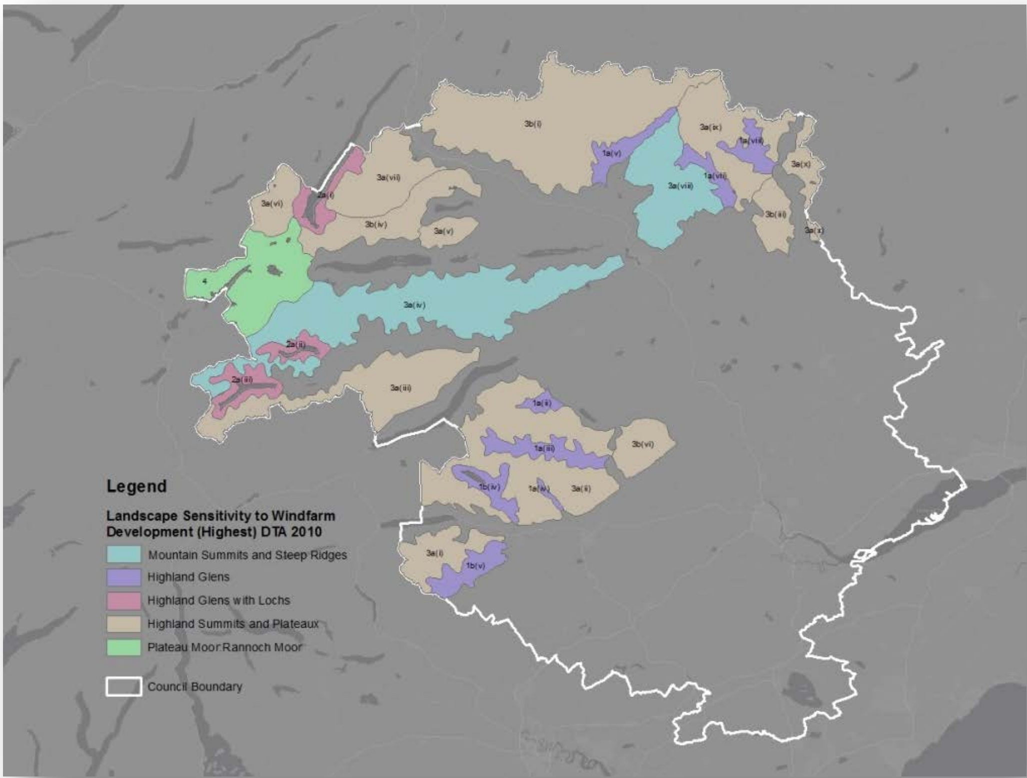


Table 4: Criteria for Landscapes of the Highest Sensitivity

Criteria indicating the most sensitive landscapes which are considered inappropriate for wind energy development	
Landscape Criterion	**Areas of Highest Sensitivity**
L1: Landscape Experience	Landscape where people are likely to feel a particularly strong sense of solitude, remoteness and/or peacefulness/tranquillity, emptiness, naturalness or wildness and, apart from natural movements, such as wind and clouds, have little or no movement, and exhibit particularly strong sense of stillness or calmness.
L2: Land Use and Change	Landscapes with no obvious or extremely limited evidence of modern settlement, buildings, infrastructure or main roads, no or only very localised forestry plantations or intensive agriculture, obviously unspoilt, historic landscapes and inventory Designed Landscapes.
L3: Rarity	Landscapes which are rare or unusual landscape character types which retain their distinctiveness and merit protection in the interests of sustaining good representative examples of each landscape character type.

Figure 10: Landscape Character Types – Highest Sensitivity to Wind Developments (Based on 2010 DTA Study)



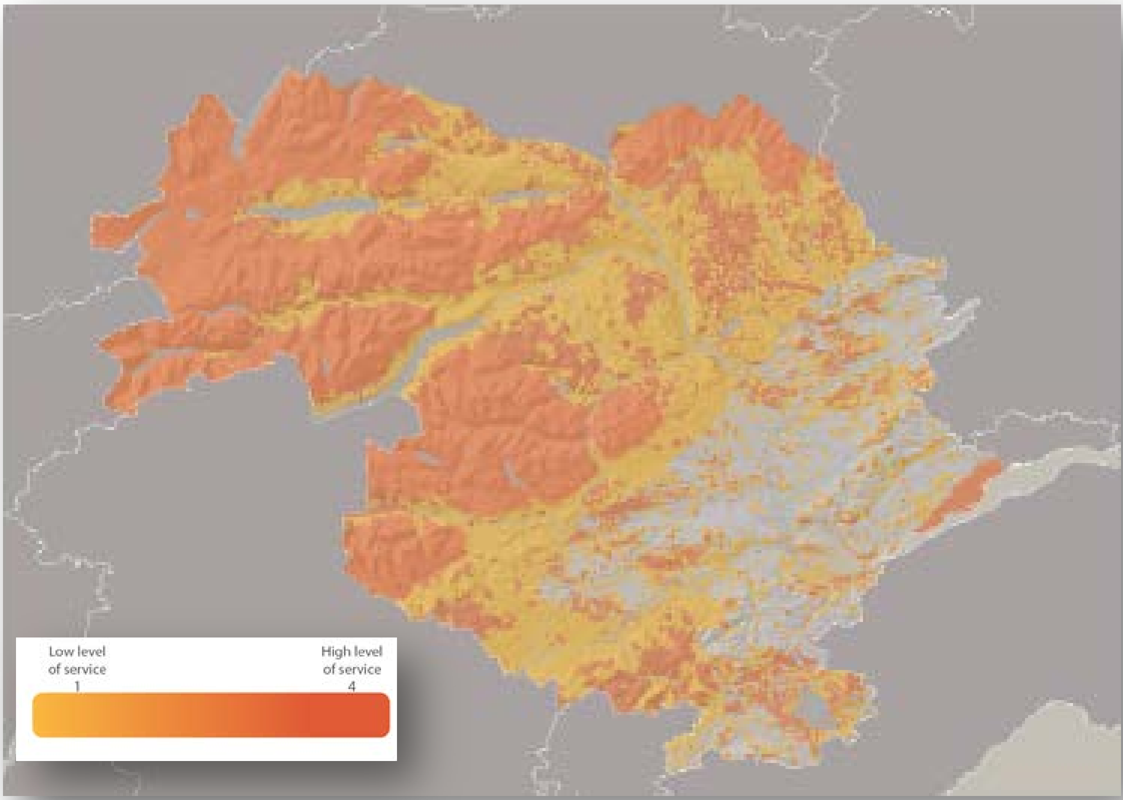
Note: All of the Landscape Units shown in Figure 10 above are categorised as both L1 and L2, apart from Plateau Moor which is L1 to L3.

Landscape Criteria – Final Output

2.35. Finally, Figure 11 represents the final output map, which is the result of combining five the six components of landscape sensitivity as per paragraphs 2.16 to 2.34 of this paper. Please note that the cumulative visual impacts of existing wind energy developments are shown separately in Figure 8.

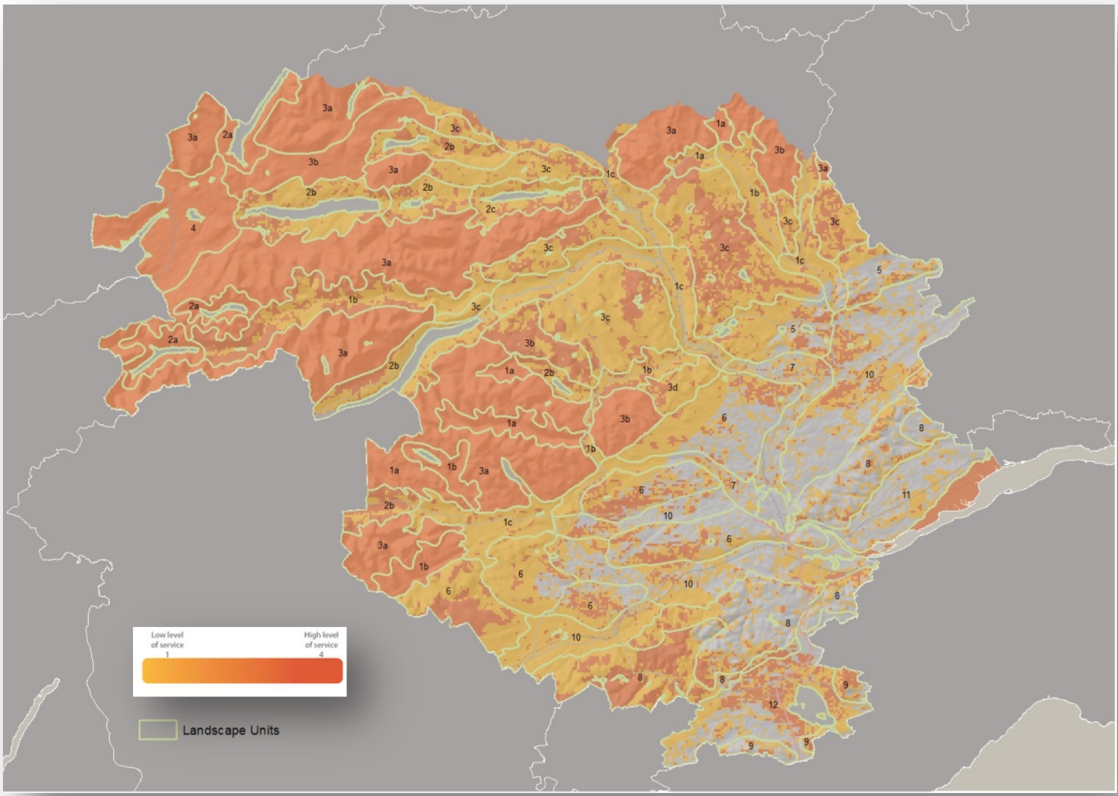
2.36. This resultant map is important because the impact of a development will depend on how, and from where, it is experienced; for example, from inside a residence, while moving along a road, or from a remote mountaintop. These factors are taken into account in our model when determining the sensitivity of the landscape and visual resources, and the people that will be affected by the development, and will help to inform the decision making processes for planning applications for wind energy developments.

Figure 11: Landscape Sensitivity to Wind Energy Developments Map



Map Published 2017

Figure 12: Landscape Sensitivity to Wind Energy Developments with DTA 20210 Landscape Units



Map Published 2017

Table 5: Tayside Landscape Character Types and Landscape Units

Landscape Character Types	Landscape Units
1 Highland Glens	
1a Upper Highland Glens	1a(i) Glen Garry
	1a(ii) Glen Quaich
	1a(iii) Glen Almond
	1a(iv) Glen Turret
	1a(v) Glen Tilt
	1a(vi) Glen Brerachen
	1a(vii) Glen Fearnach
	1a(viii) Glen Lochsie & Glen Taitneach
	1a(ix) Gleann Beag / Upper Glen Shee
1b Mid Highland Glens	1b(i) Glen Lyon
	1b(ii) Strathbraan
	1b(iii) Sma. Glen
	1b(iv) Glen Lednock
	1b(v) Glen Artney
	1b(vi) Strathardle
	1b(vii) Mid Glen Shee

Landscape Character Types	Landscape Units
1c Lower Highland Glens	1c(i) River Garry / River Tummel
	1c(ii) Strath Tay
	1c(iii) Strathearn
	1c(iv) Lower Glen Shee
2 Highland Glens with Lochs	
2a Upper Highland Glens with Lochs	2a(i) Loch Ericht
	2a(ii) Loch an Daimh
	2a(iii) Loch Lyon
2b Mid Highland Glens with Lochs	2b(i) Loch Errochty
	2b(ii) Loch Rannoch
	2b(iii) Dunalastair
	2b(iv) Loch Tay
	2b(v) Loch Earn
	2b(vi) Loch Freuchie
2c Lower Highland Glens with Lochs	2c Loch Tummel
3 Highland Summits and Plateaux	
3a Mountain Summits & Steep Ridges	3a(i) Ben Vorlich & the Forest of Glanartney
	3a(ii) Creag Liath/Creag Ruadh/Creag Uchdag/ben Chonzie/Meall Dubh/Meall nam Fuaran/Creagan na Beinne Ranges
	3a(iii) Ben Lawers and Beinn Heasgarnich Group
	3a(iv) Beinn Mhanach/Stuch an Lochain/Meall Buidhe/Carn Gorm/Schiehallion/Farragon Hill Ranges
	3a(v) Beinn a. Chuallaich
	3a(vi) Rannoch
	3a(vii) Talla Bheith Forest
	3a(viii) Ben Vrackie/Ben Vuirich/Beinn a. Ghlo Range
	3a(ix) Carn an Righ/Meall a. Choire Bhuidhe/Carn Bhinnein/Ben Gulabin Ranges
	3a(x) Meall Gorm/Carn an Daimh/Mount Blair Ranges
3b High Moorland Plateau	3b(i) Forest of Atholl
	3b(ii) North East Blair Atholl
	3b(iii) Coire a. Bhaile
	3b(iv) Craiganour Forest
	3b (v) Meall Dearg/Meall a. Choire Chreagaich
	3b(vi) Meall nan Caoraich
3c Transitional Moorland with Forest	3c(i) Meall a. Chathaidh
	3c(ii) Tummel Forest
	3c(iii) Drummond Hill
	3c(iv) Weem Hill/Dunfallandy Hill
	3c(v) Craigvinean Forest
	3c(vi) Forest of Clunie
	3c(vii) Knock of Balmyle
	3c(viii) Forest of Alyth
3d Transitional Moorland	3d Obney Hills
4 Plateau Moor	4 Rannoch Moor
5 Highland Foothills	5(i) Clunie Foothills
	5(ii) Alyth Foothills 6 Lowland Hills
6 Lowland Hills	6(i) Knaik Hills
	6(ii) Drummond Hills
	6(iii) Strathallan Plateau

Landscape Character Types	Landscape Units
	6(iv) Gask/Dupplin Ridge & Moncreiffe Hill
	6(v) Keillour Ridge / Methven Hills
	6(vi) Logie Almond / Bankfoot Plateau 7 Lowland River Corridors
7 Lowland River Corridors	7(i) Strath Tay
	7(ii) Glen Almond 8 Igneous Hills
8 Igneous Hills	
8a Ochil Hills	8a(i) Ochil Western & Central Hills and Glens
	8a(ii) Ochil Northern & Central Hills and Glens
8b Sidlaw Hills	8a(iii) Ochil Southern & Eastern Hills and Slopes
	8b(i) Sidlaw Southern & Central Hills and Slopes
	8b(ii) Sidlaw Eastern Plateau 9 Dolerite Hills
9 Dolerite Hills	9(i) Lomond Hills
	9(ii) Benarty Hills
	9(iii) Cleish Hills 10 Broad Valley Lowlands
10 Broad Valley Lowlands	10(i) Strathmore
	10(ii) Pow Water Valley
	10(iii) Strathearn
	10(iv) Strathallan
11 Firth Lowlands	11 Braes of Gowrie
12 Lowland Basins	12 Loch Leven Basin

Source: David Tyldesley Associates (2010) *Landscape Study to Inform Planning for Wind Energy*

SCOTTISH PLANNING POLICY GROUP 1 AND 2 AREAS

2.37. To reflect the constraints in Scottish Planning Policy (2014), two further datasets were used. The first was SPP Group 1 areas, which are *"areas where wind farms will not be acceptable"*, in particular these are represented by the National Parks and National Scenic Areas. A second layer of constraints, defined by Group 2 of SPP as *"areas of significant protection"*, are those areas where further consideration will be required to demonstrate that development proposals would not lead to significant effects on the qualities of these areas. Table 6 below shows the list of layers which were merged to create the Group 2 dataset.

Table 6: SPP 2014 Group 2 - Significant Protection Areas

Group 2: Areas of Significant Protection:

Recognising the need for significant protection, in these areas wind farms may be appropriate in some circumstances. Further consideration will be required to demonstrate that any significant effects on the qualities of these areas can be substantially overcome by siting, design or other mitigation.

National and International Designations	Other Nationally Important Mapped Environmental Interests	Distance from Inhabited Areas for Consideration of Visual Impact	Other Local Development Plan Considerations
• World Heritage Sites • Natura 2000 and Ramsar sites • Sites of Special Scientific Interest • National Nature Reserves • Sites identified in the Inventory of Gardens and Designed Landscapes • Sites identified in the Inventory of Historic Battlefields	• Areas of wild land as shown on the 2014 SNH map of wild land areas • Carbon rich soils, deep peat and priority peatland habitat	An area not exceeding 2km around cities, towns and villages identified in the local development plan with an identified settlement envelope or edge. The extent of the area will be determined by the planning authority based on landform and other features which restrict views out from the settlement.	• Special Landscape Areas

2.38. Special Landscape Areas (SLAs), which is a regional landscape designation was also included as an additional filter for consideration for wind energy developments. SLAs are areas which have been designated for their special landscape characteristics and as such are likely to be sensitive to wind energy developments. This designation has been incorporated into SPP Group 2 to ensure that these areas are afforded suitable protection. Their inclusion within the framework does not preclude any form of wind energy development, but rather it will be the responsibility of applicants and developers to demonstrate that any potential impacts will be minimised or avoided, and that suitable mitigation measures are implemented, where appropriate.

MULTI-CRITERIA COMBINATION

2.39. A schematic description of this process was provided earlier in this paper at Figure 1. The three main groups of criteria (Ecosystem Services, Planning Policy and Landscape Sensitivity) were combined linearly applying a weighted combination method. JHI constructed a weighted combination model using an ArcGIS Model Builder environment, and implemented the processing of the three clusters of layers (criteria). Each cluster was used to produce a sensitivity map which can be interpreted, respectively, as Ecosystem Services Sensitivity, the Planning Considerations Sensitivity, and the Landscape Sensitivity. In the model each single component layer was equally weighted and the sum of weights normalised to sum to 1. The following formula was used in the model:

Equation 2 (Eq. 2)

$$W'(i) = (W(i) / \sum_{n}^{1}(W(i))$$

and the $Sensitivity_{group(i)} = (\sum_{n}^{1}(Layer(i) * W'(i))$ Eq.(2)

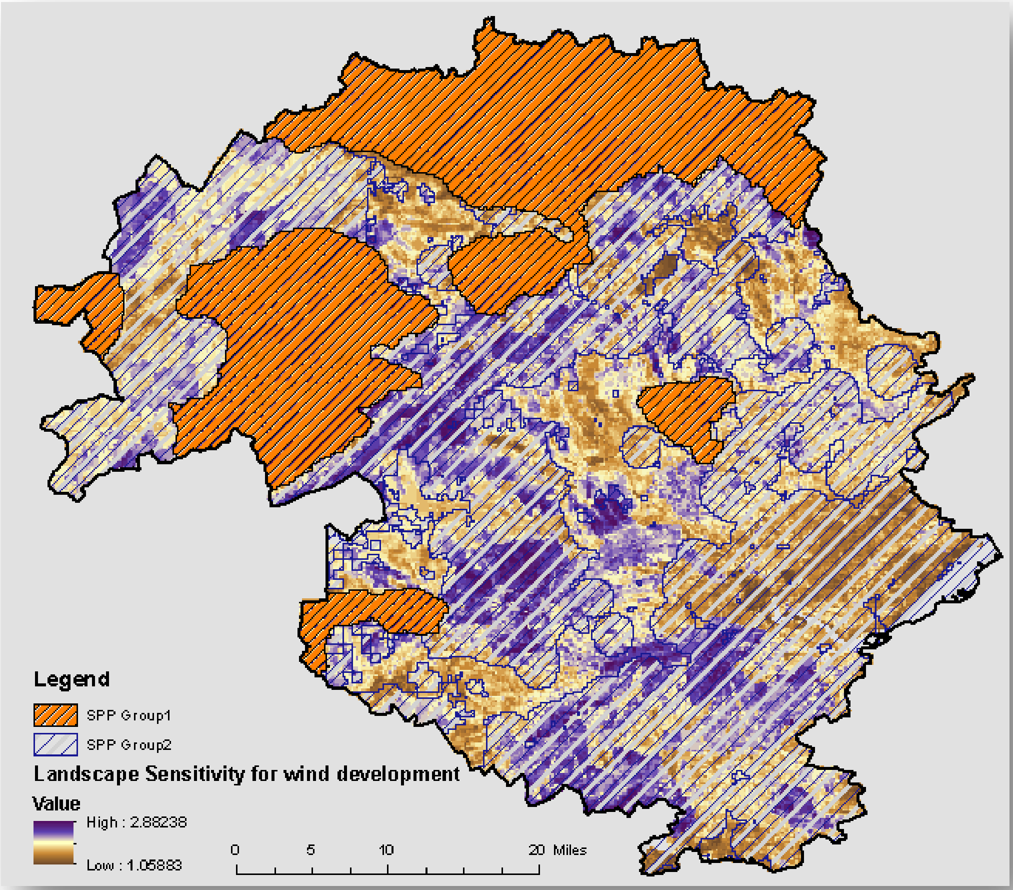
where *W'(i)* is the normalised weight sum to 1 and *W(i)* is the user weight.

The Sensitivity group in Equation 2 denotes the weighted sum across each cluster of data set considered in the model.

2.40. The resulting Strategic Landscape Sensitivity Map is shown at Figure 13. It describes the joint pressure of landscape sensitivities, and complements the approach for identifying those areas that are likely to be least and most appropriate for development as set out in SPP (2014).

2.41. The approach used allows the modification of the individual layer weights in order to give maximum flexibility to the end users and stakeholders, and allow the consequences of changing weights at the component layer level to be explored. The effect of the choice transmits to the cluster to which each layer belongs.

Figure 13: Perth and Kinross Strategic Landscape Sensitivity to Wind Energy Developments



OPPORTUNITY MAP

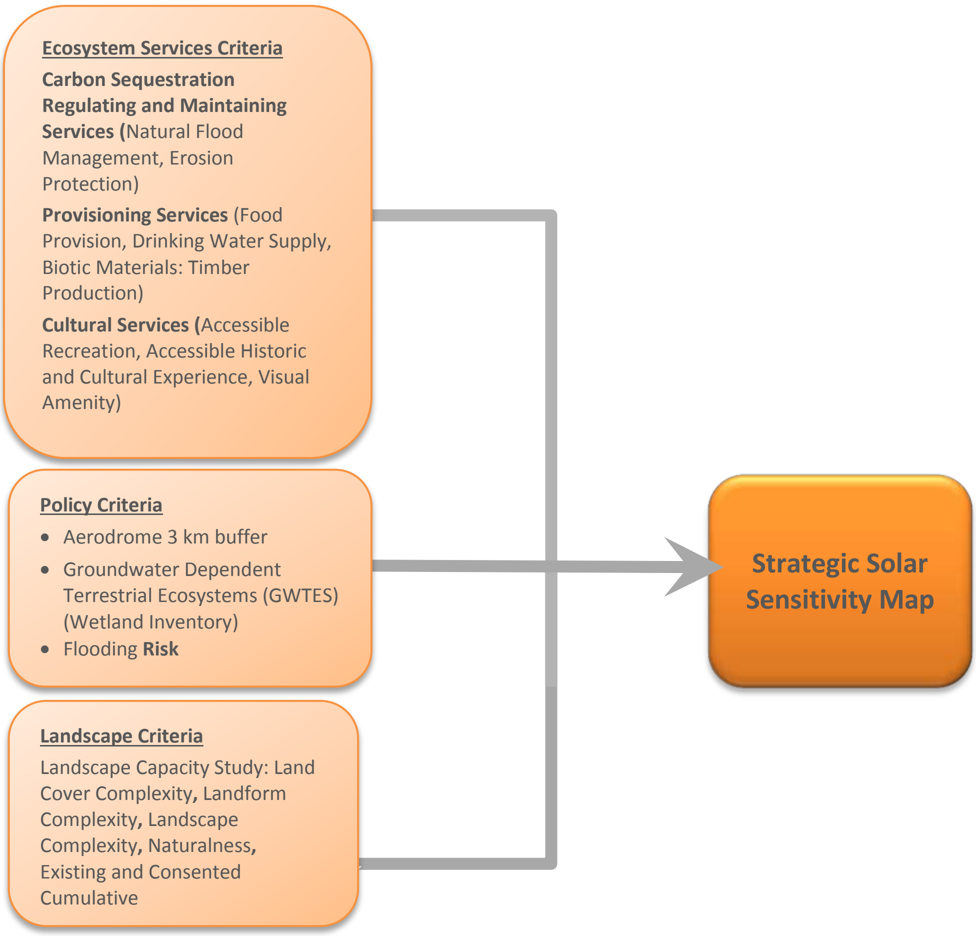
2.42. Opportunity maps were produced for each technology. By overlaying potential opportunity areas with the Strategic Land Use Capacity maps, resulting from the multi criteria analysis (MCA), it is possible to further identify where opportunities exist in preferred (i.e. low sensitivity areas). This work builds on the existing pattern of development and is intended to effectively spatial plan future low carbon and renewable energy in the region.

3. Sensitivity to Solar Energy Developments

Methodology

3.1. This section describes the approach taken to represent the sensitivity of solar energy developments. The process followed to produce the strategic map of land use sensitivity to solar energy developments (SLUS Map) followed the standard division into the three main groups, as already described in Section 2 of this report for wind: the ESS Criteria (Carbon Sequestration; Regulating Services (Natural Flood Management; Erosion Protection); Provisioning Services (Nutrition: Food Provision, Drinking Water Supply, Biotic Materials: Timber Production); Cultural Services (Accessible Recreation, Accessible Historic and Cultural Experience, Visual Amenity); the Policy Criteria (comprising SEPAs guidance for Wetland protection, and some derived layers which were considered by the Project Team to be important for solar sensitivity); and the Landscape Criteria which was used for the Wind sensitivity mapping. Figure 14 to follow provides a summary of the process.

Figure 14: Process for Producing the Strategic Land Use Capacity to Solar (SLUC) Map



ECOSYSTEM SERVICES CRITERIA

3.2. The assessment for solar energy developments also considered nine ecosystem services to produce a representation of the current situation through using and combining a wide range of datasets (see paragraphs 2.5. to 2.11. of this report in relation to wind energy developments). The data and considerations of particular relevance to solar technology are listed in Table 1 at the beginning of this report.

PLANNING CONSIDERATIONS

3.3. Some of the planning considerations applicable to solar energy developments were also used in the assessment for sensitivity to wind energy developments; for example the Wetland Inventory dataset. The information to follow concentrates on those considerations which have not been described under the previous models for wind.

Aerodrome Buffer

3.4. This layer is one of the parameters which could affect the installation of large photovoltaic arrays, as it represents a constraint identified by the Scottish Government in order to maintain the security around the main aerodromes and airports and as such might limit the development process. Scottish Government Guidance on Large Photovoltaic Arrays (2013)[13] indicates that a minimum buffer of 3 kilometres from all aerodromes is to be respected.

Existing Solar Panels

3.5. The Project Team considered that existing panels (over 1 Megawatt (MW) could work as a limiting factor on the development of solar energy developments. The existing panels were counted in 250 metre grid cells which were then classified as the most valuable parcels where the number of existing panels was low. Once again the four quartile breaks were used.

LANDSCAPE CRITERIA

3.6. The landscape criteria considered as part of the sensitivity to solar energy developments assessment were similar to those applied to the wind energy model, but the landscape character and visual cumulative impact layers were omitted. In addition, existing operational and consented commercial solar schemes (greater than

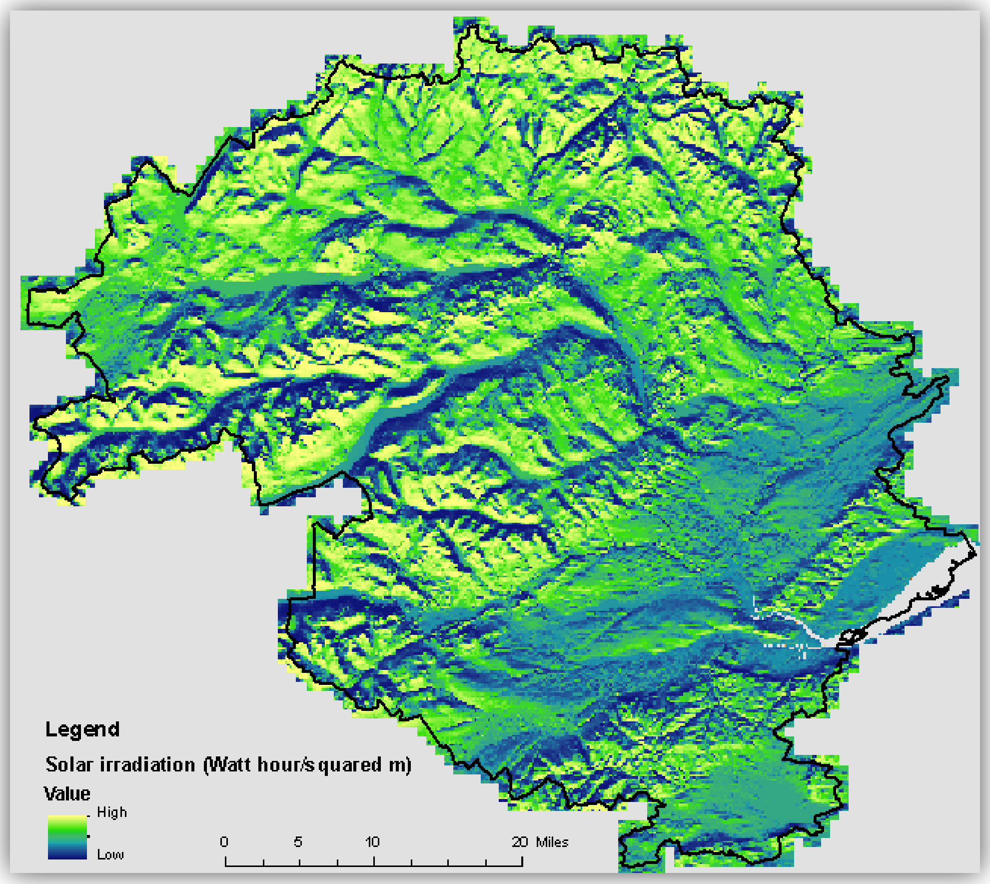
[13] https://beta.gov.scot/publications/large-photovoltaic-arrays-planning-advice/

1 MW) within the landscape character type and in the surrounding area, were also included to help address likely cumulative impacts.

OPPORTUNITY MAP

3.7. In the solar energy model, the opportunity map was recognised as the solar annual irradiation map at 250 metres (see Figure 15). This map can be overlaid with the sensitivity map to define the most suitable area for the new future installation.

Figure 15: Solar Irradiation Map



4. Sensitivity to Hydro Energy Developments

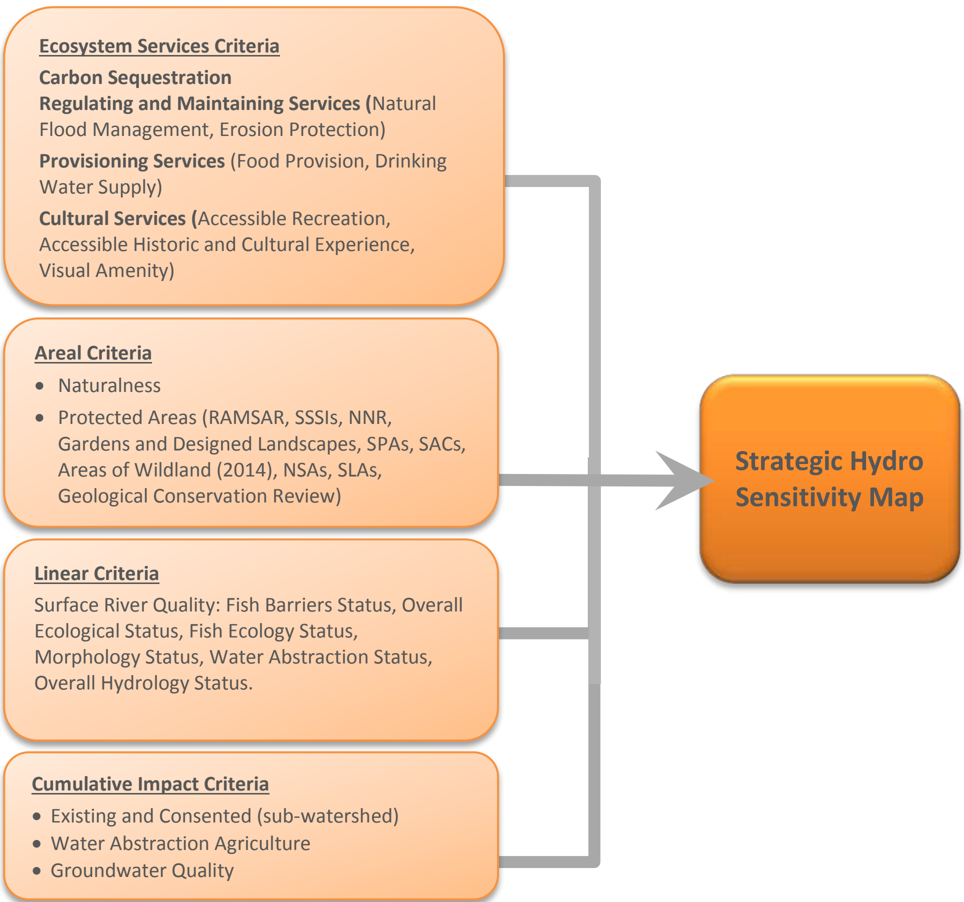
Methodology

4.1. This section describes the approach taken to represent the sensitivity of hydro energy developments. The hydro sensitivity model followed a slightly modified architecture where criteria were divided into four main groups:

- **Ecosystem Services** - excluding Food and Timber Production as unlikely to be affected.
- **Areal** - Naturalness and a protected areas layer
- **Linear** - a number of datasets which describe the river classification, considering different SEPA quality parameters , and
- **Cumulative Impact** – represented by a combination of water abstraction and existing hydro developments.

4.2. The application of a modified approach was due to the physical difference of the dataset used to represent the hydro features – many of the datasets the Project Team considered for inclusion in the model were line features, and as such the information reflects the physical representation of the object. Therefore, it was decided to cluster together in a separate group all of the river quality data. Figure 16 to follow provides a summary of the process.

Figure 16: Process for Producing the Strategic Land Capacity to Hydro (SLUC) Map



ECOSYSTEM SERVICES CRITERIA

4.3. This technology used seven out of the nine ecosystem services already used in the other sensitivity assessments. The Project Team considered that Food and Timber Production were unlikely to be affected by hydro energy developments.

AREAL CRITERIA

4.4. The Areal Criteria are represented by two layers: Naturalness, and the Protected Areas layer. Please refer to paragraphs 2.24. to 2.26. of this report for details of how Naturalness of Land Cover was incorporated into the assessment process. The second layer: Protected Areas, is the combination of the SNH datasets listed in Table 7 below. The spectrum of datasets were merged and set as high sensitivity if the study area was overlapped by at least one of the international and national designations. The reader is asked to note that other criteria such as the presence of battlefields and historical sites are already included in the Ecosystem Services Criteria (see Figure 16: Process for Producing the Strategic Land Use Capacity to Hydro (SLUC) Map)

Table 7: List of Protected Areas used in the Hydro Model

Protected Areas
Special Protection Areas (SPAs)
Special Conservation Areas (SCAs)
Geological Conservation Review (GCR)
National Scenic Areas (NSAs)
Wildland Areas
Sites of Special Scientific Interest (SSSIs)
Special Landscape Areas (SLAs)
RAMSAR
Garden and Designed Landscapes
National Nature Reserve (NNR)

LINEAR CRITERIA

4.5. As previously highlighted at paragraph 4.2. above an additional group was created to distinguish the entire group of linear feature layers from the Areal one. The Project Team included the following datasets in the consideration of river quality.

<u>Overall Ecological Status</u>

4.6. In general, the classification of surface waterbodies describes by how much their condition or status differs from near-natural conditions. Waterbodies in a near-natural condition are at high status. The objective of the Water Framework Directive is for all waterbodies to improve to Good Ecological Status, and for deterioration in status to be prevented. Ecological status has been used to set the sensitivity of the river to the potential development of hydro power structures.

Fish Barriers Status

4.7. This dataset assesses whether the main migratory fish species in Scotland are likely to be able to pass a barrier. It then uses this information to determine the impact of each barrier in terms of the amount of habitat which would be available to migratory fish under reference conditions, but which has been rendered unusable by artificial barriers to migration. The limits for classifying impact of barriers on river continuity have been set by UK Technical Advisory Group (UK TAG) and are outlined in Table 8. For the purposes of the assessment the four statuses were reclassified into four classes from high (good status) to low sensitivity (poor status).

Table 8: Classification Limits for River Continuity Assessment

High Status	Good Status	Moderate Status	Poor Status
Severe impairment of fish movement to, or from rivers draining 1% of the upstream river length or part thereof.	Severe impairment of fish movement to, or from rivers draining 5% of the upstream river length or part thereof.	Severe impairment of fish movement to, or from rivers draining 20% of the upstream river length or part thereof.	Severe impairment of fish movement to, or from rivers draining greater than 20% of the upstream river length or part thereof.

Note: a severe impairment of fish movement is defined in the Supporting Guidance Classification Direction as being *"more than 80% of fish that would otherwise be able to move upstream to or downstream from, the river or part concerned are, in SEPAs judgement, unable to do so because of man-made barriers to their movement."* Man-made barriers are classified as either *"passable high impact"* or *"impassable"* for salmon and trout using the Water Framework Directive (WFD) 111 methodology.

Fish Ecology Status

4.8. This is a subset of the SEPA dataset. The classification method adopted by SEPA allows the assessment of fish in rivers according to the requirements of the Water Framework Directive (WFD). It incorporates fish abundance, taxonomic composition and age structure. The classification used is provided, based on boundary values derived from Ecological Quality Ratio (EQR) values for idealised fish populations conforming to the normative definitions provided by the WFD.

Morphology Status

4.9. The morphological status of rivers was extracted from the Water Environment and Water Services (Scotland) Act 2003 dataset. SEPA calculated the morphological condition values for the relevant features of each river. In particular, the status considers a range of characteristics which are indicative of each river type such as the valley form, the channel slope, the sinuosity and the dominant bedrock. In the absence of morphological alterations, further characteristics are considered by SEPA where the river type cannot be readily distinguished in accordance with the columns other parameters.

Water Abstraction Status

4.10. Where an environmental standard for river flow specified under Column 5 of Table 9 below (Table B1.2 extracted from the Scottish Governments *Environmental Protection – The Scotland River Basin District (Standards) Directions 2014*[14]) equates to more than 25% of Qn_{98}, when river flow is $\leq Qn_{98}$ SEPA may introduce such further restrictions on abstractions as it considers necessary for the purposes of protecting parts of the water environment, the aquatic plants or animals of which are, in SEPA's opinion, particularly sensitive to low flow conditions. The use of this separate layer provided important information on the abstraction condition in each part of the river.

[14] http://www.gov.scot/Resource/0045/00457867.pdf

Table 9: Extract from *Environmental Protection – The Scotland River Basin District (Standards) Directions 2014*

Table B1.2: "Good" environmental standards for river flows, except where the environmental standards specified in Table B1.3, B1.4 or B1.5 apply				
Maximum permitted total abstraction per day as a proportion of daily natural flow (Q_n)				
Good				
Column 1	*Column 2*	*Column 3*	*Column 4*	*Column 5*
River Type	*Daily flows ≥ Q_{n60} to < Q_{n5}*	*Daily flows < Q_{n60} to Q_{n70}*	*Daily flows < Q_{n70} to Q_{n95}*	*Daily flows < Q_{n95}*
A1	35 % of daily Q_n	30 % of daily Q_n	25 % of daily Q_n	20 % of Q_{n95}
A2 (downstream), B1, B2, C1, D1	30 % of daily Q_n	25 % of daily Q_n	20 % of daily Q_n	15 % of Q_{n95}
A2 (headwaters), C2, D2	25 % of daily Q_n	20 % of daily Q_n	15 % of daily Q_n	10 % of Q_{n95}

Overall Hydrology Status

4.11. Modelled hydrology uses Low Flows Enterprise (LFE) to model flows. It models natural flows (reference conditions) and licenced flows. The latter are based on the flows expected if all licences were used to their maximum. The difference between these two is the basis for deriving standards for High, Good, Moderate, Poor and Bad status of a river.

CUMULATIVE IMPACT CRITERIA

4.12. The Project Team decided to represent the cumulative impact using a pragmatic approach, taking into account all of the data and resources available for this purpose. A group of three layers was produced to define the areas which are likely to be influenced more by new hydro power developments.

Existing Hydroelectric Structures

4.13. The existing hydro dataset is a count performed by the Project Team inside each sub-watershed in the Perth and Kinross Area. The count considered all existing hydroelectric structures present along the rivers, as well as the structures along the secondary streams.

Water Abstraction for Agriculture

4.14. Some farmers i.e. dairy farmers, take their water from mains supplies, while others take water directly from waterbodies. These abstractions may be taken from surface waterbodies and from groundwater. All abstractions are controlled by SEPA using

General Binding Rules (GBRs), Registrations and Licences. Abstractions of >50 cubic metres per day require a licence; this water is generally used by farmers for irrigating arable crops and some is also used for livestock drinking water. The data shows the size of abstraction from the water environment for agriculture that SEPA has licensed; these have been assigned to waterbodies, although some are taken from groundwater. The data also shows the maximum licensed volume for abstraction at any one time. Most farmers will not make use of all of this water as agricultural irrigation usually occurs during the period from June to September. The data shows that most large abstractions are in East Fife, Perth and Kinross, and Angus.

<u>Groundwater Quality</u>

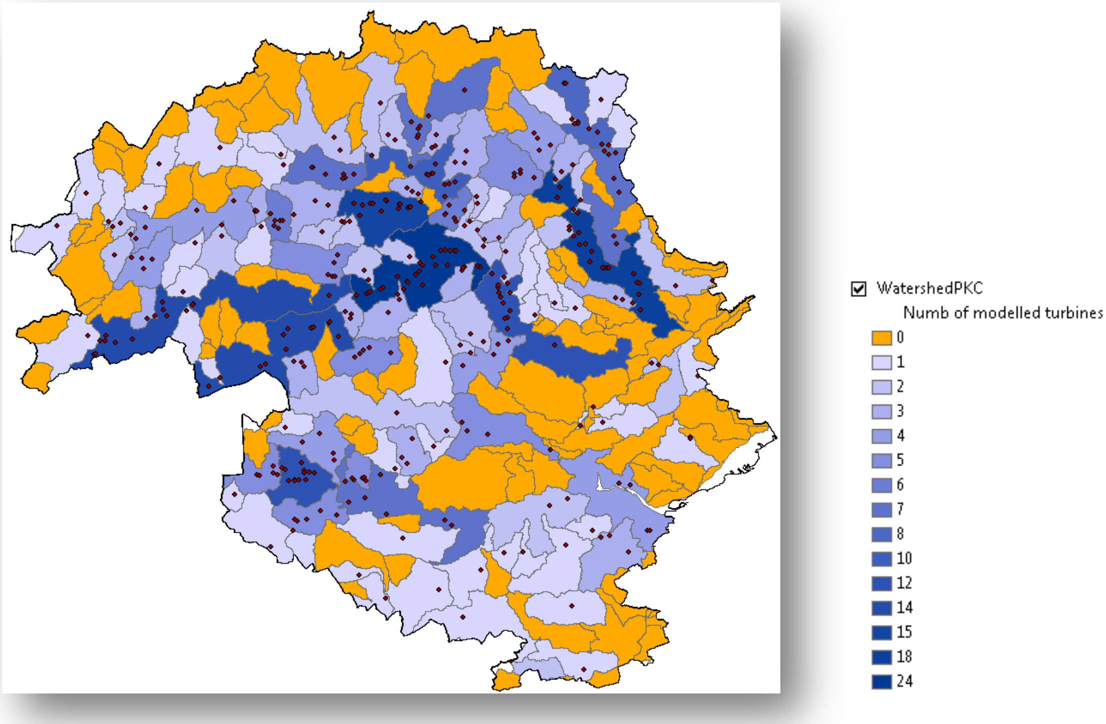
4.15. The SEPA dataset describes the groundwater quality attribute which is divided into Good/Poor classification. It represents the quality of the three levels of aquifers. The Project Team decided to disaggregate the three levels information and mapped each of them using the groundwater water quality data, so the sensitivity classification was given 1 to 4 respectively. The three maps were combined afterwards by the maximum in order to be as conservative as possible for the protection of the resource. The high sensitivity value was used for the 'Good' condition aquifer, and low sensitivity value for the 'Poor' water quality conditions.

OPPORTUNITY MAP

4.16. The results of a previous study by BabyHydro (2011)[15] were used. These comprised a dataset of points representing turbines, and lines representing the stretch of rover between intake and turbine, which may be projected onto maps or searched by location. It should be noted that this prediction should only be taken as a guide and an indication of financial attractiveness, but it is a good means of deciding whether to instruct an engineer to visit the site and refine the layout. It was decided to use the modelled turbines as an indicator and summarised the opportunity at watershed level. A zonal statistic was therefore performed which counted the modelled turbines inside the catchments areas.

[15] Babyhydro (2011). Hydropower capacity. Outputs and Methodology. Report for the Perth & Kinross Council.

Figure 17: Number of Modelled Turbines within the Perth and Kinross Catchment Areas



5. Contacts and Team Credits

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