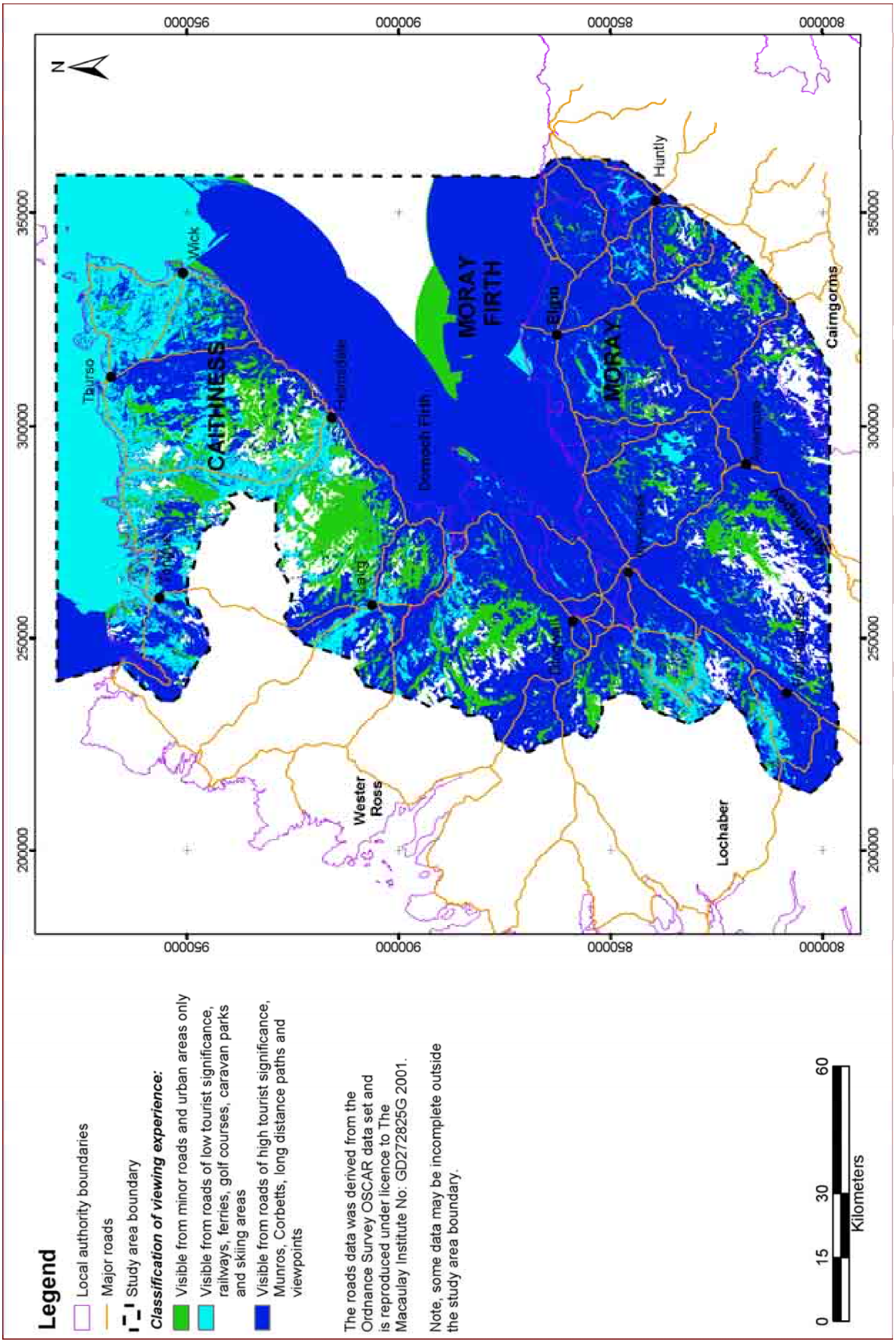
Figure 6.14. Viewing experience.



Number of people viewing the landscape

6.2.29 There is no single source of data on numbers of visitors to any one type of location (e.g. visitor view points), or users of all types of roads, although there are data on a number of population centres. Additional sources have been approached, including the local tourist boards for specific locations, agencies or organisations that manage sites (e.g. Historic Scotland and the National Trust for Scotland), and local authorities for local surveys.

6.2.30 The Forestry Commission of Great Britain conducts forest use and visitors surveys. These surveys include questions on the mode of transport used by the visitor, and the frequency of visits to the specific site and forests in general. However, of the five Forest Districts (FDs) that overlap with the study area (Dornoch, Inverness, Fort Augustus, Lochaber and Moray), detailed survey information only exists for two sites, outside of the study area (Slattadale at Loch Maree in Wester Ross, and Pattack at Kinloch Laggan in Speyside). The results of a new survey are to be published in 2004, and this may give a wider coverage of relevant sites.

6.2.31 The inadequacy of the data from such a wide range of sources to cover all types of viewer observations has led to them being precluded from the analysis. However, the greatest number of observers will be from settlements and transport routes. The influence of settlements can be problematic due to the interrupted views of surrounding areas that are offered from built environments. The calculations of visibility from such areas are also limited by the lack of three-dimensional data on buildings. This dataset of these measures has currently been excluded from the analysis in favour of the road use data that has been obtained from the Highland Council and the Moray Council.

6.2.32 A representation of viewer numbers using settlements could be added, but it is also reasoned that all settlements will be serviced by roads, with the larger settlements having higher numbers of road users, but this does not necessarily mean that some smaller settlements will not also have high road use numbers. Therefore, the road usage data produces scores for the visibility analysis that err on the side of higher sensitivity with respect to settlement population.

6.2.33 The data were collated onto paper maps or schematic, digital, datasets, and were based upon automatic or manual counts of vehicle numbers. The use of either of these sources raised some issues about the consistency of the data across the area (e.g. road usage numbers for some B roads), and a lack of detail for the many minor roads. However, these data do provide a basis for making an assessment of the relative levels of potential views of the landscape for large numbers of people.

6.2.34 Where there was a choice of count data available, the most recent information was chosen, often averaged across two or three days observations. For each council area, the figures reported were the average daily two-way flow. From the raw data from the Highland Council it was apparent that there are large differences in the number of vehicles on the roads at different times of the year (potentially different by a factor of two). These differences would have some significance with respect to the visibility of the turbines in the context of their surroundings in different seasons, but at a strategic level this was not considered sufficient reason to avoid using the data.

6.2.35 Figure 6.15 shows the distribution of land visible with respect to vehicle numbers. The number of road users for Trunk roads, ‘A’ roads and some ‘B’ roads were banded into three classes in consultation with representatives of the roads department at the Moray Council (Table 6.5). The road numbers include cars and commercial vehicles, and take no account of the number of observers that there may be in each vehicle.

Table 6.5. Scores allocated by the mean number of daily two-way road vehicles.

Criterion	Score
Greater than 5 000 vehicles per day	3
500 people to 5 000 vehicles per day	2
Less than 500 vehicles per day	1

6.2.36 The road data were used in combination with the viewshed analyses illustrated in Appendix IX. This provided a basis for identifying the spatial pattern of visibility of the landscape with respect to the number of road vehicles. The highest score for any one location was used in each case.

6.2.37 The output from this model shows the roads that have the highest numbers of vehicles per day (27 220) are in the vicinity of Inverness, including southwards along the A9, and northwards as far as Tain. The A96 between Inverness and Forres has over 10 000 vehicles per day, as has the A82 from Inverness to Drumnadrochit.

6.2.38 The second area with a concentration of stretches of road that have numbers of vehicles above 5 000 per day is in the vicinity of Elgin specifically, the A96 between Elgin and Fochabers, the A941 south from Elgin to Rothes and north to Lossiemouth.

6.3 Combined dataset of visual sensitivity

6.3.1 The datasets representing landscape viewing experience and viewer numbers and visibility of the landscape were then combined, by adding the scores for each dataset, and classified to produce a dataset and map classification of visual sensitivity. The outputs in Figure 6.16 summarise the combination of total visibility, viewing experience and observer levels. This provides a representation of visual sensitivity of the landscape, and Figure 6.17 groups the visual sensitivity into three classes (high, medium and low) for input to the derivation of landscape potential for wind turbine developments.

6.3.2 The areas with the highest visual sensitivity are in the coastal areas surrounding the Moray Firth, central and eastern Caithness, west of Lairg, south-west of Fort Augustus and the A9 south of Aviemore. This pattern of high scores reflects the weighting of the visibility from Trunk roads, roads of tourist interest, and the high levels of terrain visibility in the areas with high surrounding hills.

6.3.3 The areas of moderate visual sensitivity scores are distributed through Caithness and Sutherland, and cover the Pentland Firth. There is also evidence of smaller areas with this score south-west of Inverness and the uplands of Moray. The sensitivity associated with visibility from the ferry routes is evident extending north-east of the Moray Firth, at the edge of the study area.

6.3.4 The lowest scores are to be found in some of the upland areas, including parts of the Monadhliath Mountains, south and south-east Sutherland, north-west of Dingwall, and the western Cairngorms. The low scores for some of these areas reflect the low levels of visibility of the terrain from the road network (e.g. on parts of the Cairngorm Plateau).

Figure 6.15. Roads coded according to daily vehicle numbers.

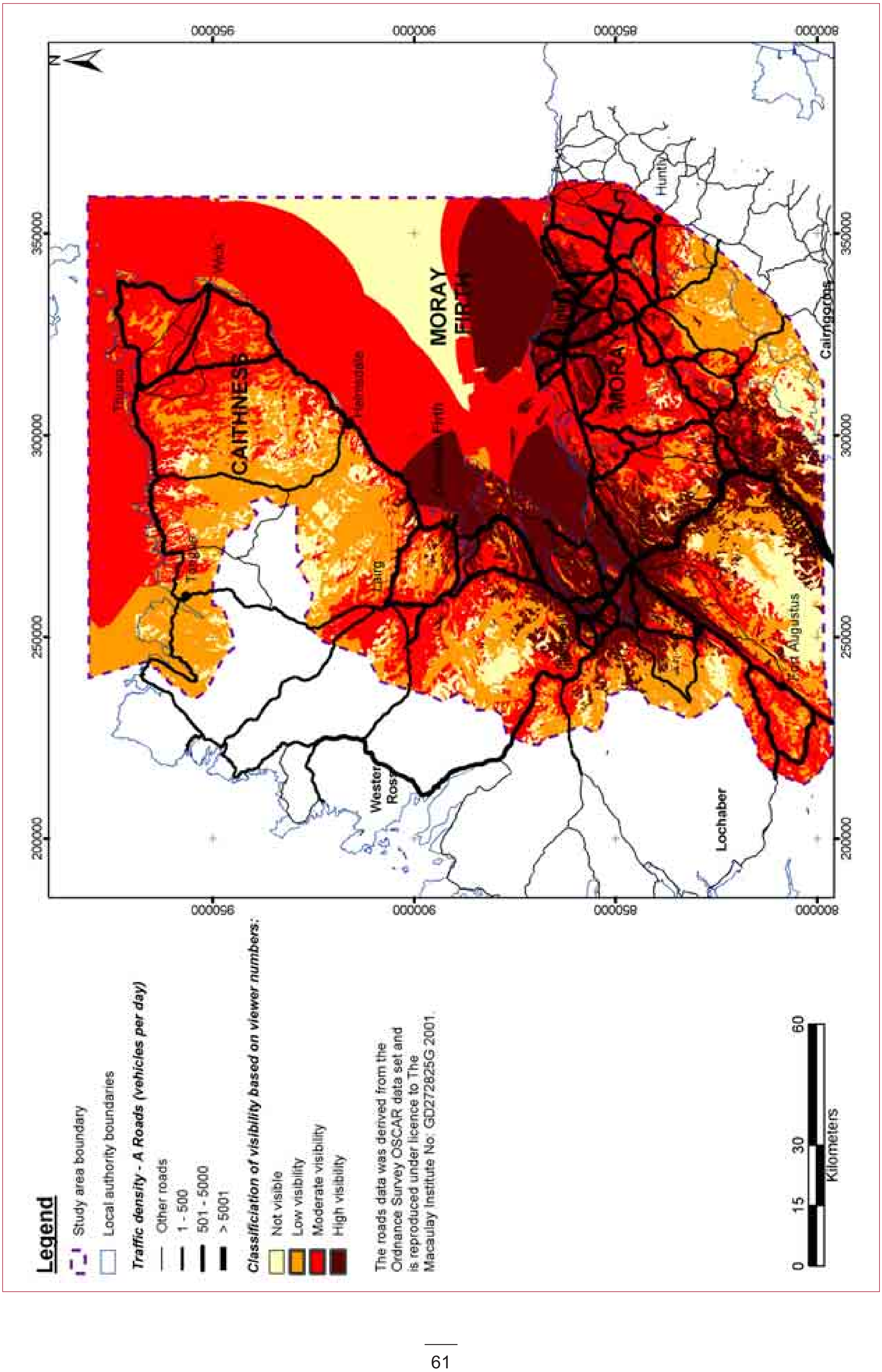


Figure 6.16. Visual sensitivity based on total visibility within the study area, viewing experience and observer levels.

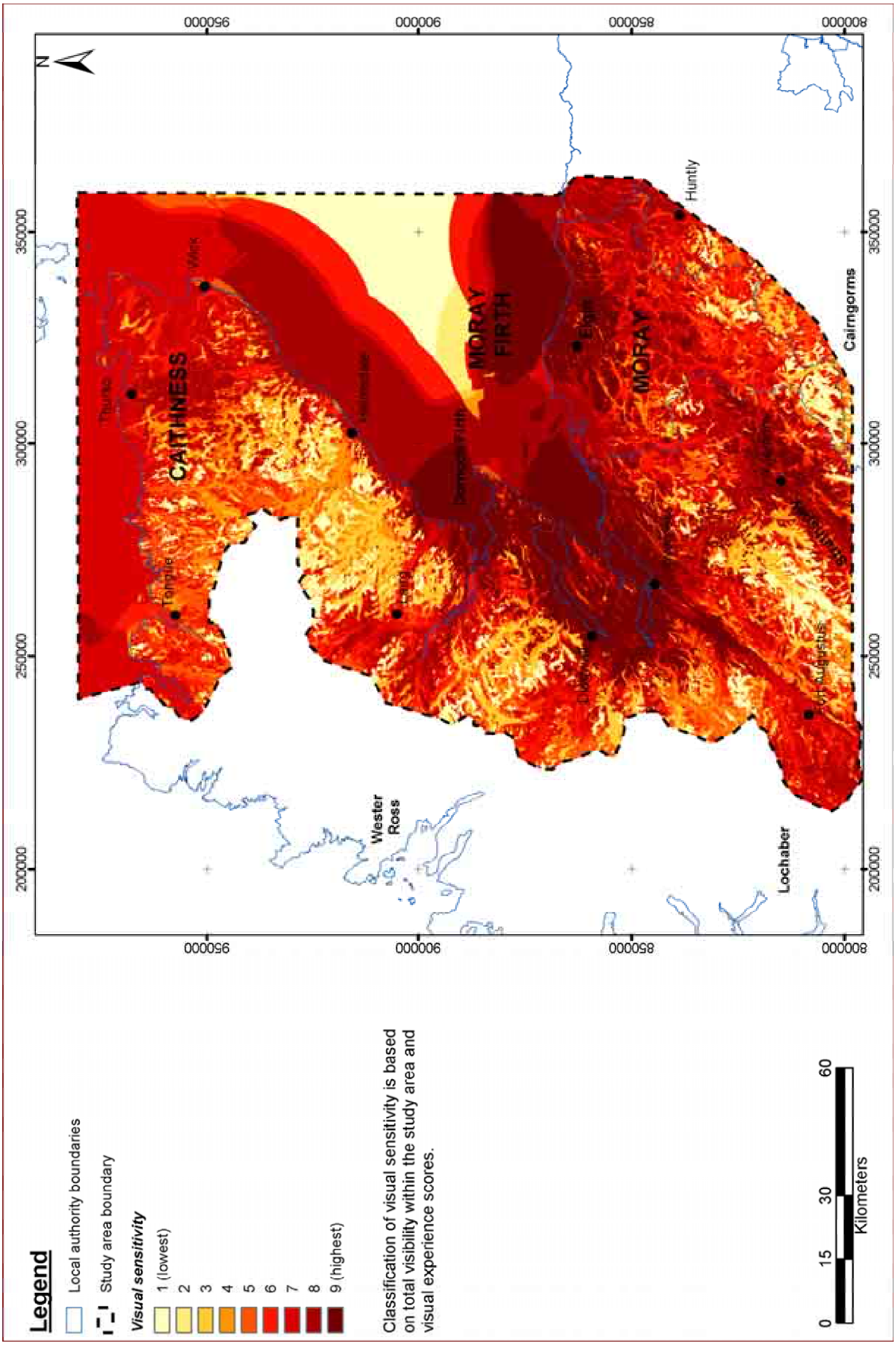
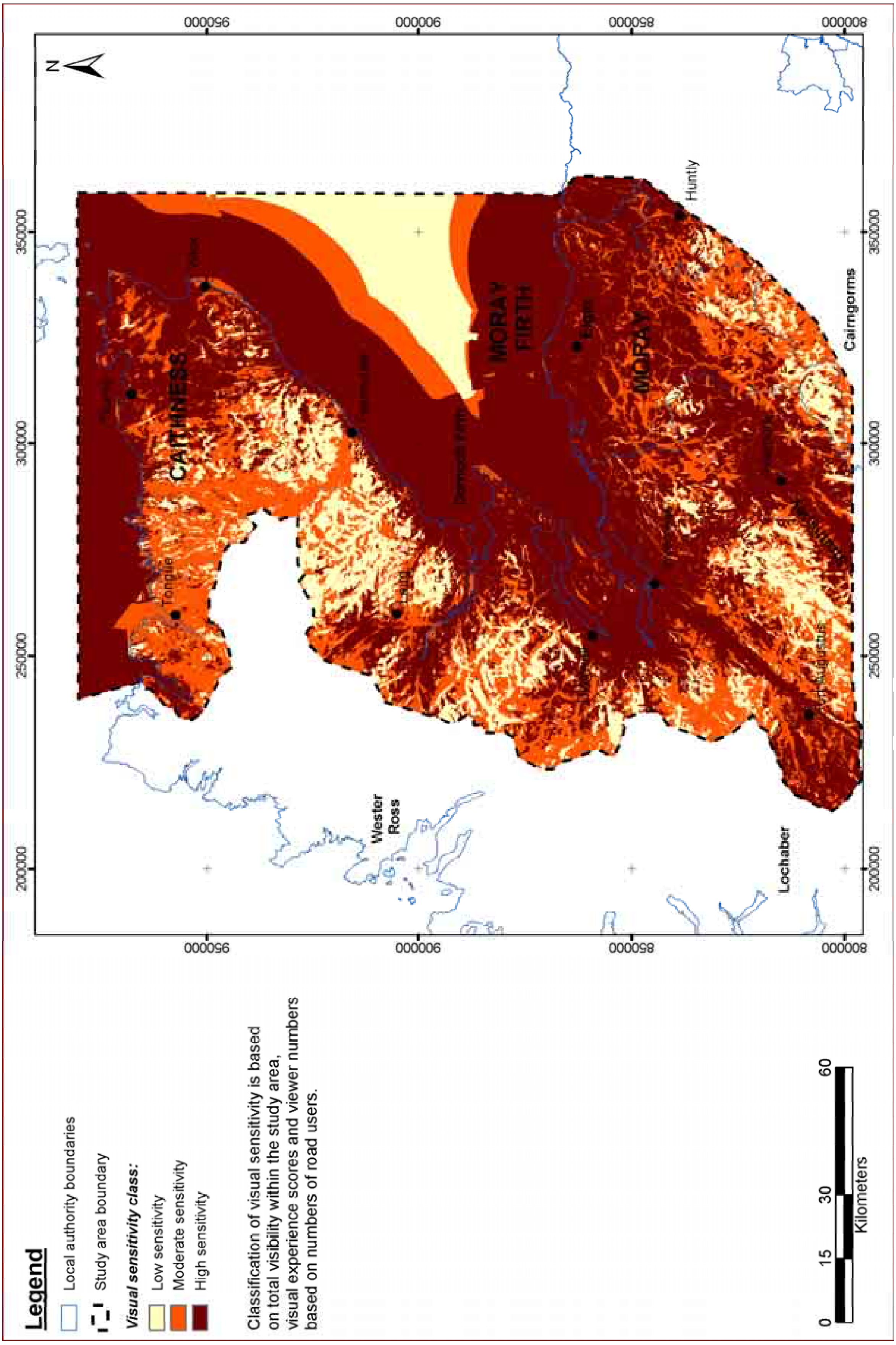


Figure 6.17. Visual sensitivity, in three classes, based on total visibility within the study area, viewing experience and observer levels.



7 PHASE 4: MAPPING LANDSCAPE POTENTIAL FOR WIND TURBINE DEVELOPMENT

7.1 Derivation of the landscape potential datasets

7.1.1 The map of landscape potential for wind turbine development combined the landscape character sensitivity dataset with the landscape visual sensitivity. The decision rules in Table 7.1 were based on the logic that the lower the combined landscape character and visual sensitivities the higher the potential for windfarm development. This simple logic was then reinterpreted using expert opinion in the light of the additional weight that visual sensitivity carries. The rules in Table 7.1 were applied to combine these sensitivity datasets to create the datasets and maps of landscape potential for each of the three sizes of wind turbine development.

Table 7.1. Criteria for determining landscape potential for wind turbine development.

	Visual sensitivity		
Landscape character sensitivity	Low	Moderate	High
Low	High potential	Moderate potential	Low potential
Moderate	High potential	Moderate potential	Low potential
High	Moderate potential	Low potential	Low potential

7.1.2 Figures 7.1, 7.2 and 7.3 show alternative outputs from the combined sensitivity datasets for each of the three sizes of wind turbine development. The same rating of potential (Table 7) was applied in each case.

7.1.3 Figure 7.1 shows the areas with the highest potential as being scattered throughout the uplands, including the Cairngorms, and the Monadlaith Mountains in the south, and the land between Lairg and Helmsdale, and that near the north coast between Tongue and Thurso. The largest single area of high potential is that in the Moray Firth, greater than 25 km from the coast. The areas with the lowest potential in the north are those of central Caithness, the land west of Tongue, west of Lairg, the coastal areas of Cromarty and the Black Isle. To the south the low capacity areas are around Inverness and the Moray coast, Strathspey, and south-west of Fort Augustus.

7.1.4 Figure 7.2 shows the distribution of landscape potential with respect to moderate developments. Areas with the highest potential are in southern Moray, south-east of Inverness and east of Lairg. The lowest areas are in central Caithness, and coastal areas and Strathspey.

7.1.5 Figure 7.3 shows the potential for small developments, which is a similar geographical pattern to that of the moderate developments.

Figure 7.1. Landscape potential for large wind turbine developments.

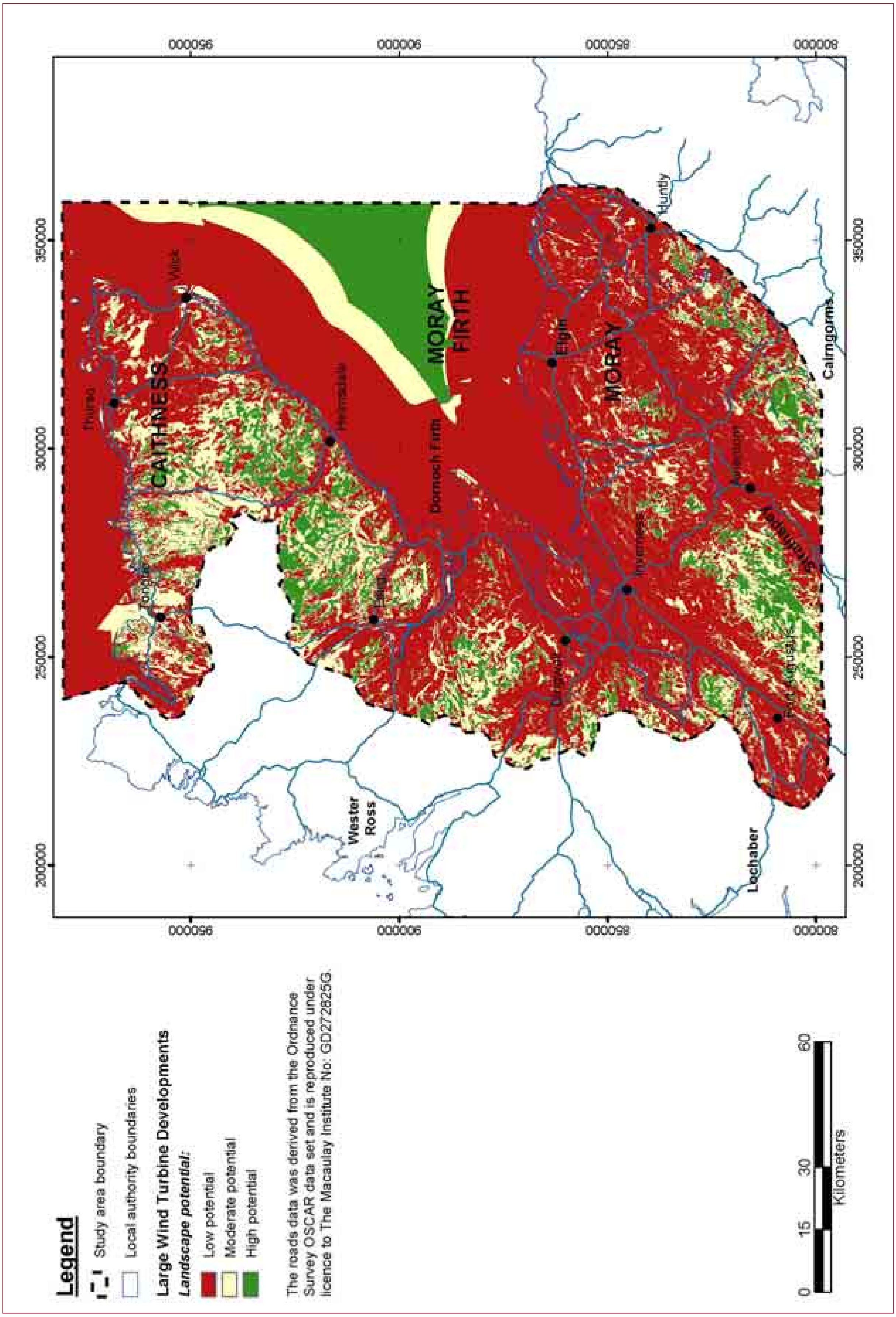


Figure 7.2. Landscape potential for moderately sized wind turbine developments.

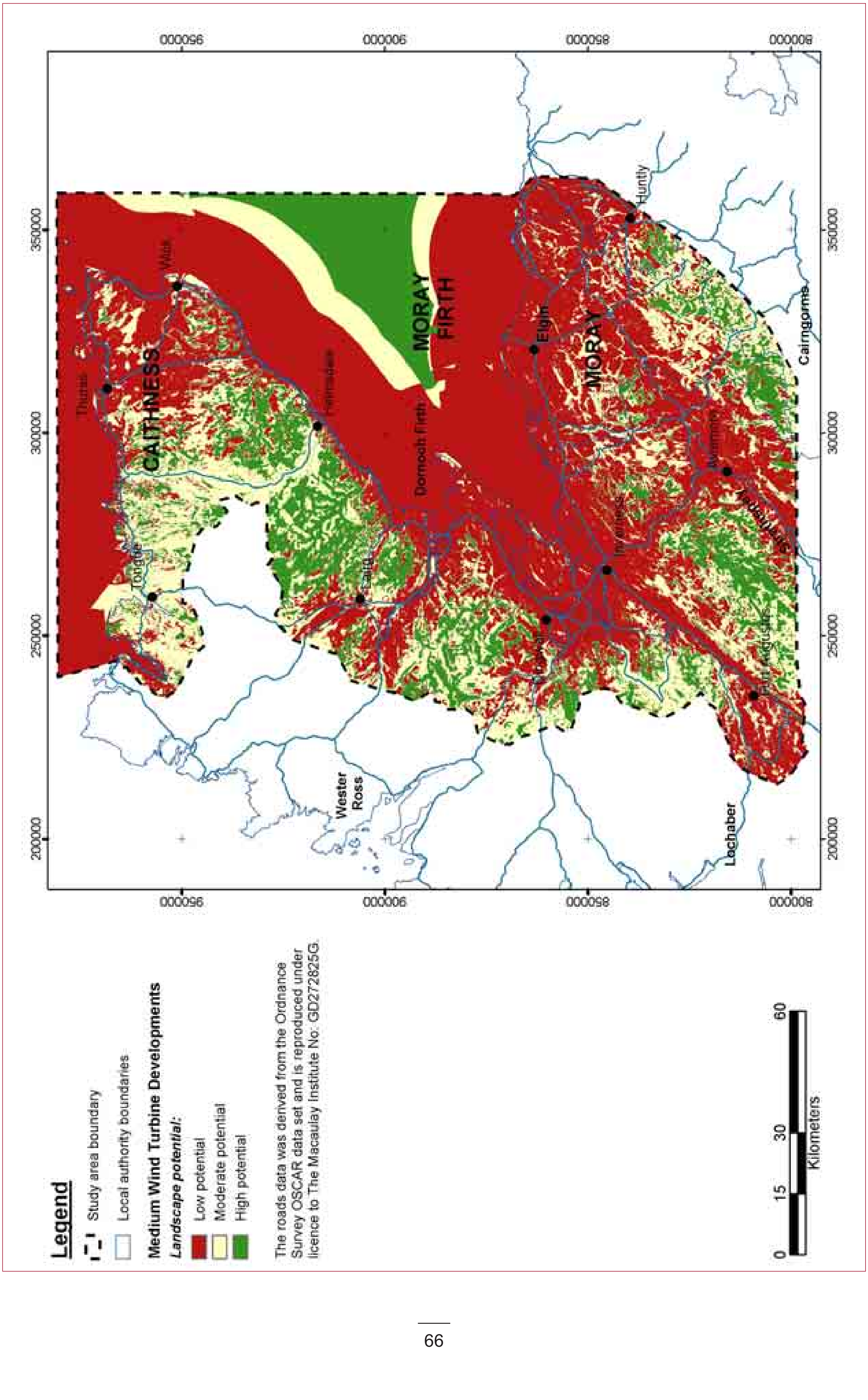
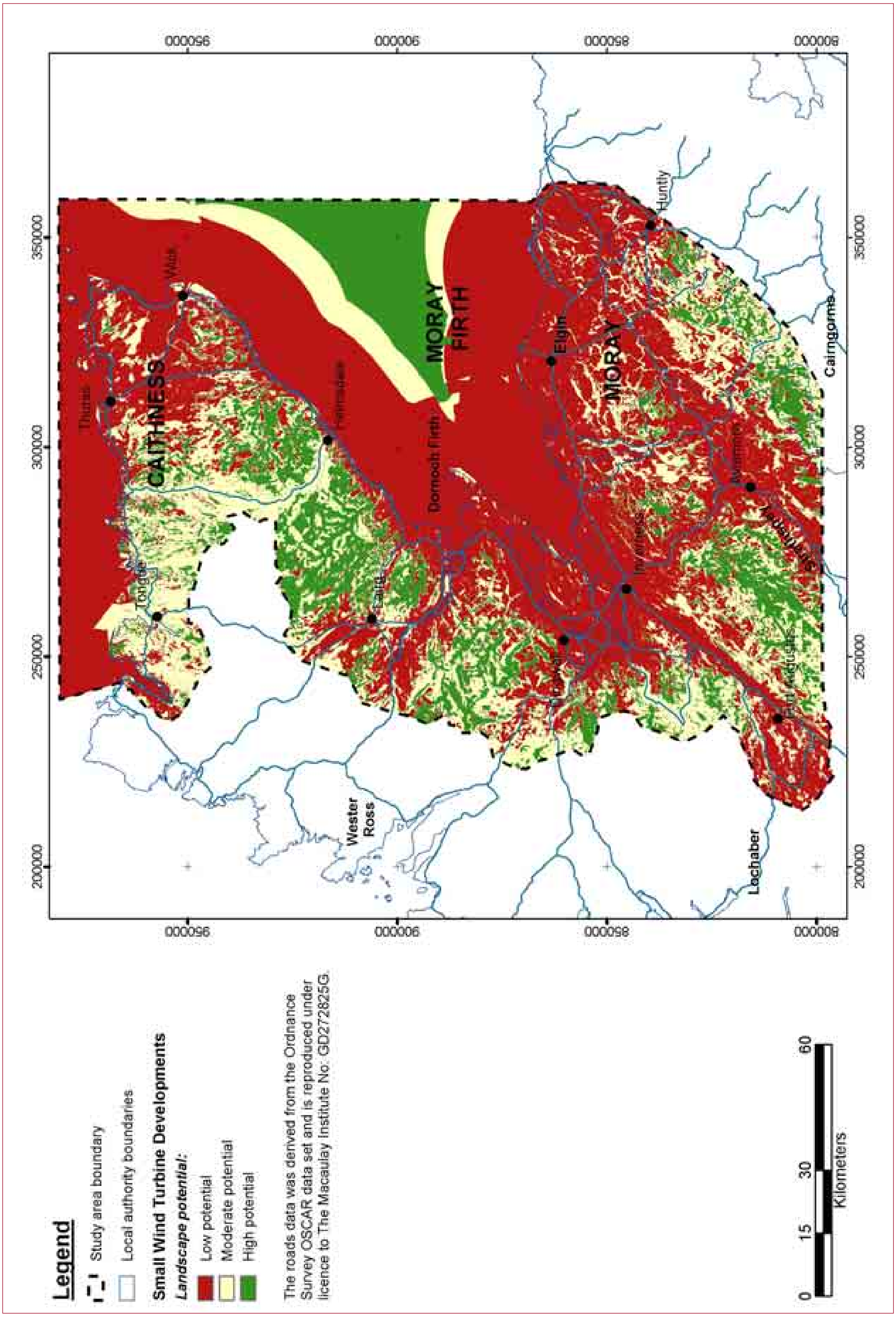


Figure 7.3. Landscape potential for small wind turbine developments.



7.1.6 Table 7.2 summarises the area of land in each landscape potential class for large and small developments. It shows that the area of land in the high potential class is greater for small developments (3 403.7 km^2) than large developments (2 515.4 km^2). It also shows that most of the land is consistently allocated to the same class, irrespective of size of the development. However, 888.3 km^2 of land which would be classed as high potential for small developments is classed as only of moderate potential for large developments, and 2 471.6 km^2 of moderate potential for small developments offers only a low potential for large turbine developments. The change in development size has not resulted in any land being reclassified from high potential to low potential under this scenario.

Table 7.2. Area of classes of land for either small or large turbine developments (km^2).

Small wind turbine developments	Large wind turbine developments			
	Low	Moderate	High*	**Total**
Low	12 280.3	0	0	**12 280.3**
Moderate	2 471.6	3 039.7	0	**5 511.3**
High	0	888.3	2 515.4	**3 403.7**
Total	**14 751.9**	**3 928.0**	**2 515.4**	**21 195.3**

7.2 Accounting for landscape designations and wildland

7.2.1 Other factors will affect the practical application of the three maps of landscape potential for wind turbine development (Figures 7.1, 7.2 and 7.3), such as existing designations of the landscape, in particular NSAs, AGLVs, the Cairngorms National Park as well as the SNH Areas of Search for Wildland. Figure 7.4 shows these factors overlaid on the map of potential for large wind turbine developments.

7.2.2 The NSAs, AGLVs and Cairngorms National Park were processed to derive the envelope of land visible from within these designations, up to a radius of 10 km from the boundary, and the Area of Search for Wildland was buffered up to a distance of 10 km. These were then overlaid upon the map of potential for large wind turbine developments to illustrate the potential constraints that may apply to areas of high potential (Figure 7.5).

7.2.3 Figure 7.6 shows a reinterpretation of the map of landscape potential, taking the classifications as scores and then reducing the score according to the presence of a designated area or, where appropriate, its buffer zone. Originally, a score of three denoted an area with the highest landscape potential and a score of one denoted an area with the lowest potential. It was assumed that the presence of a designated area would reduce the potential, with a lesser reduction in potential being attributable to the 10 km buffer zones or the SNH areas of search for wildland. Therefore, the designated areas were given a score of minus two and the other areas were given a score of minus one. The negative scores were additive so that an area affected by more than one designation or by a designation and, say, an SNH area of search for wildland, would have the total of the negative scores applied to the score it had received in the original map of landscape potential. This resulted in a scale from 'plus three' to 'minus six'. 'Plus three' indicates an area of high potential that is totally unaffected by either designation or their buffer zones and 'minus six' indicates an area that was classified as having low potential and is affected by more than one designation and/or buffer zone. These scores are summarised below:

- Starting scores: 3 = highest potential; 1 = lowest potential.
- Designated areas (NSA / AGLV / NP) = –2.
- 10 km buffer / SNH area of search for wild land = –1.
- Scores are additive and final range of scores is from –6 to +3.

Figure 7.4. Designated areas overlaid on the map of landscape potential for large wind turbine development.

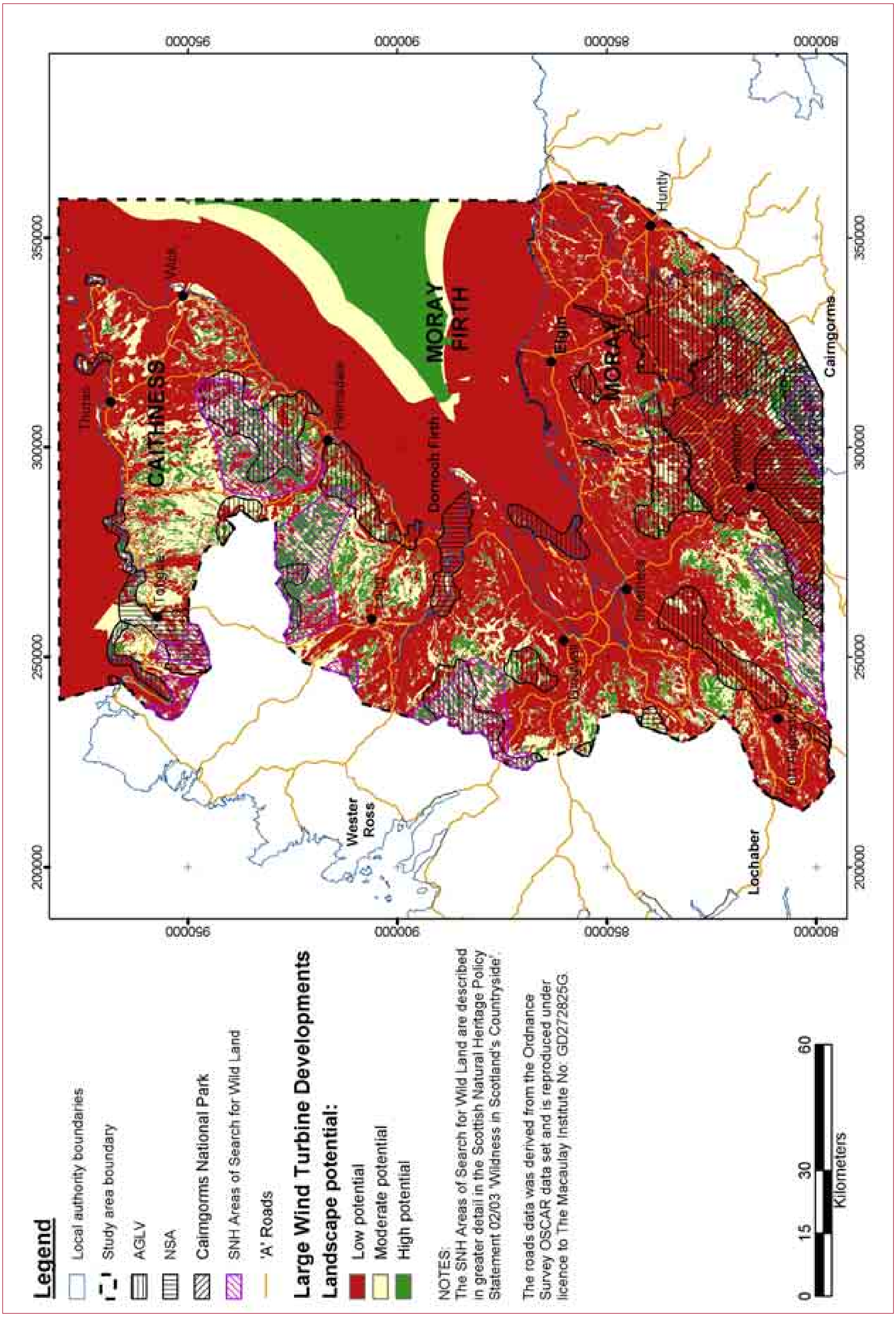


Figure 7.5. Visibility of designated areas, up to 10 km, and area of search for wild land overlaid on the map of landscape potential for large turbine development.

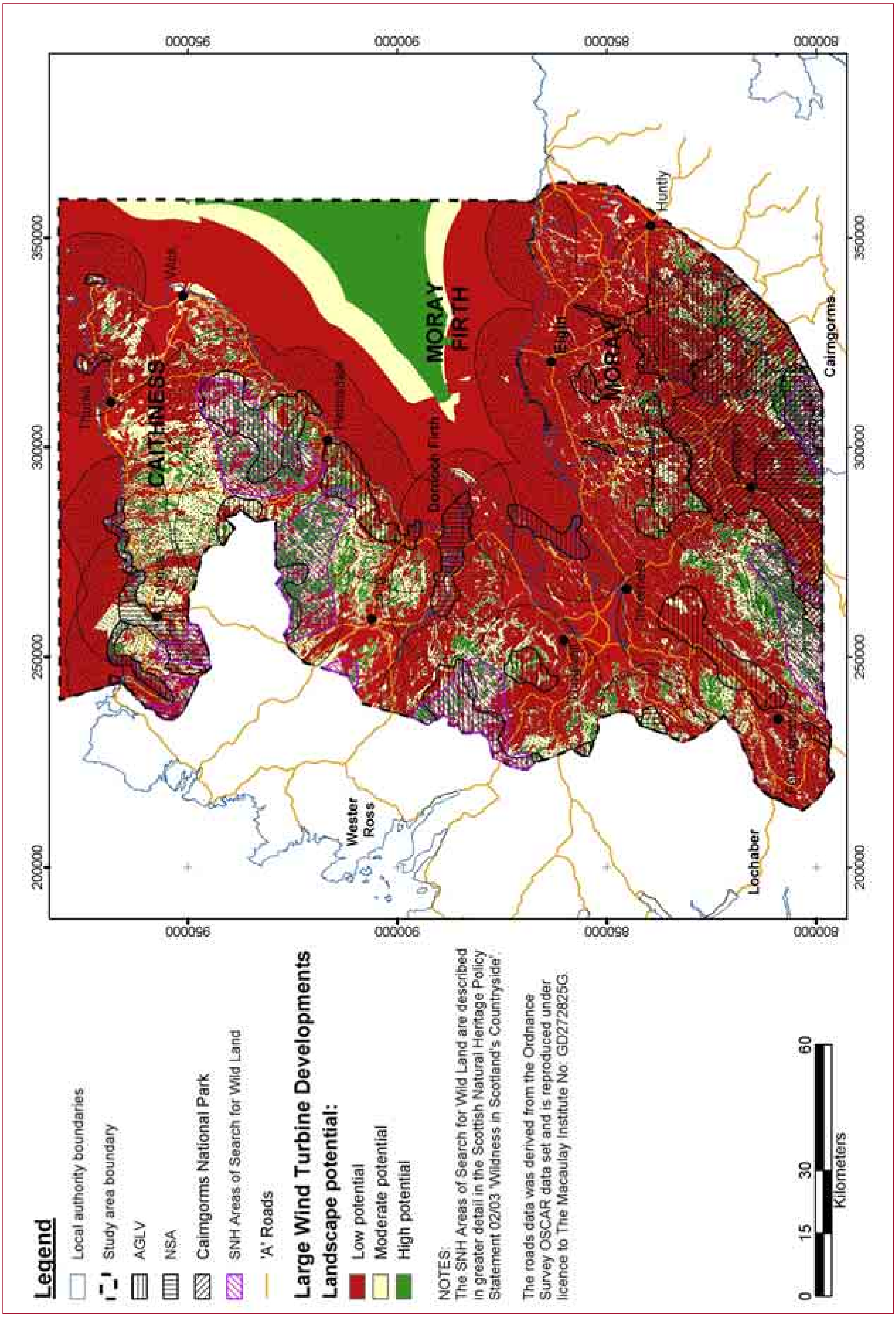
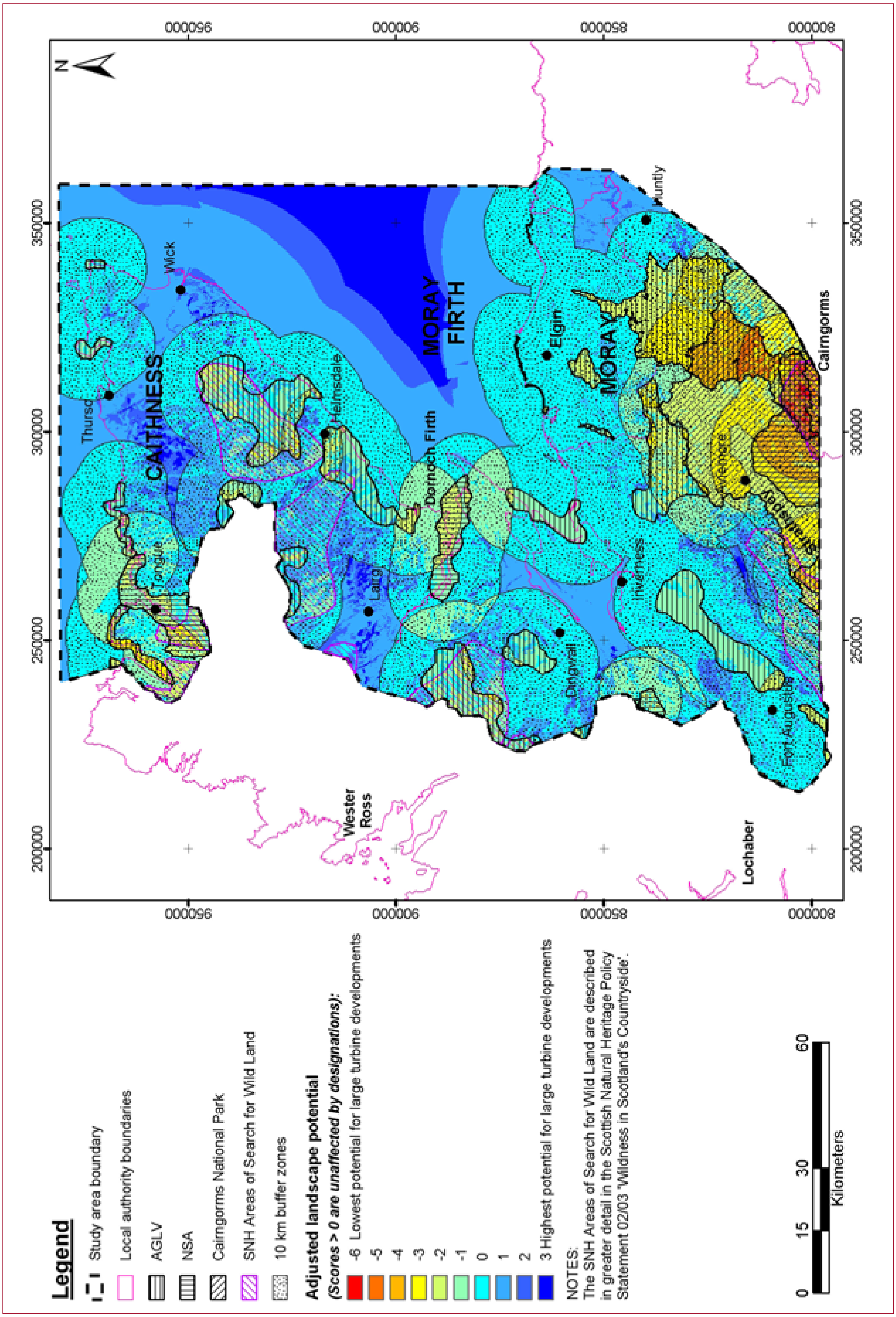


Figure 7.6. Reinterpretation of the classification of landscape potential for large wind turbine developments with respect to the presence of landscape designations.



7.3 Accounting for Landscape Character Assessments

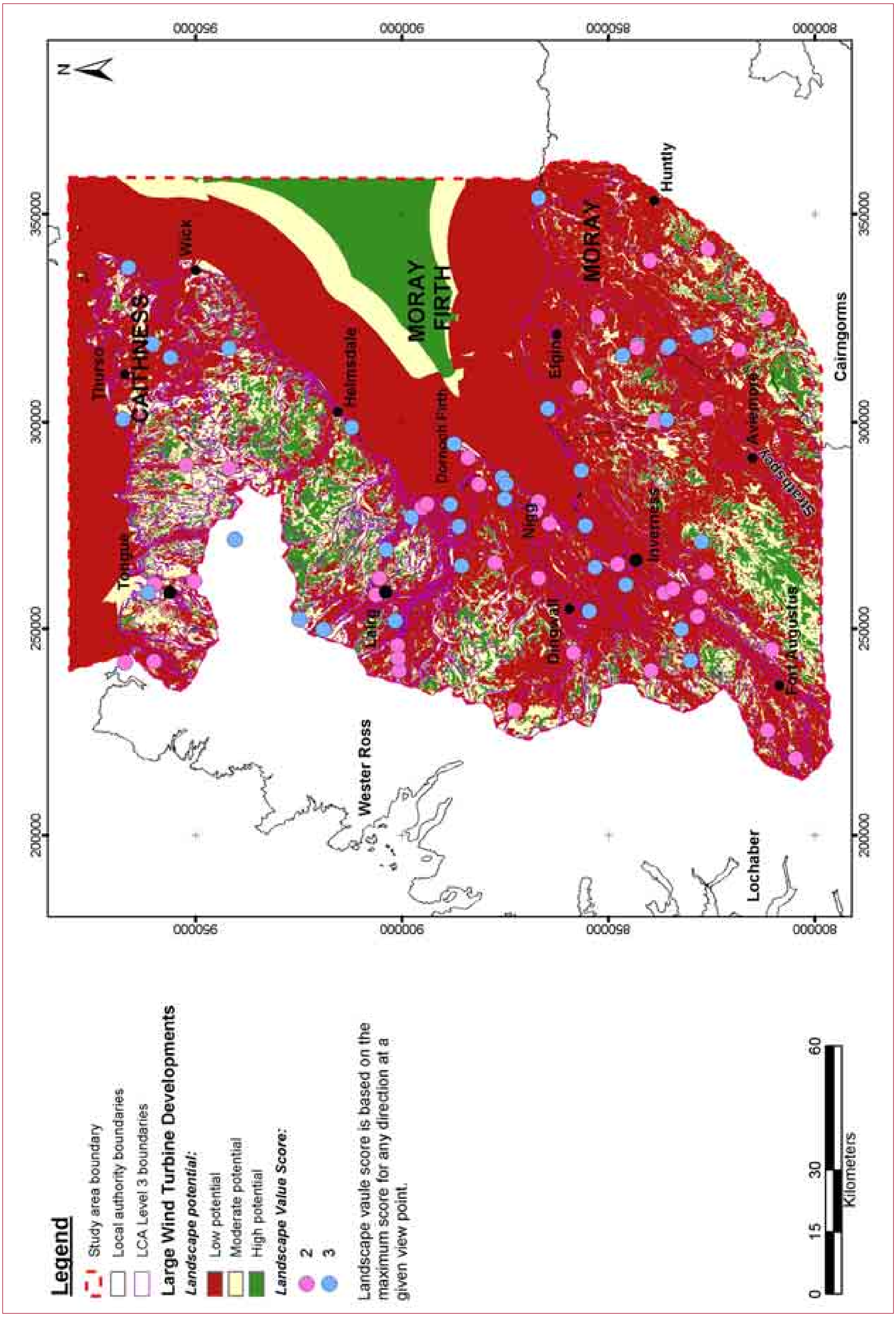
7.3.1 The landscape potential datasets can be associated with the LCA data, and the field observations of landscape value. Figure 7.7 shows the LCA boundaries, recoded according to the level-three classification, overlaid upon the landscape potential dataset for large developments. The field observations of predicted landscape value (shown as pink and blue dots) have been overlaid as a top layer. However, this top layer has not been included in the analysis.

7.3.2 The figure shows that, at the level-three classification, some LCA units clearly have a low potential for turbine developments, particularly those in coastal regions such the 'Highland and Island crofting landscapes'. The level-three LCA unit that comprises the most extensive areas of high potential land is also that which occupies the largest geographical extent within the study area: 'High, massive, rolling, mountains of the Highlands and Islands'. It stretches from the Monadhliath Mountains north-east to Rothes, and western and central Moray, plus large areas of the northern part of the area.

7.3.3 The pattern of landscape potential levels is highly heterogeneous compared to the dimensions of the LCA units. This reflects the comparatively high spatial resolution of the underlying data used in the GIS, to which the classification schemes are applied and the point-by-point assessments of landscape sensitivity and visual sensitivity and landscape capacity. This is in comparison to the wider perspective applied in the field by the surveyors who mapped the LCA units. Therefore, there was no likelihood of the LCA and potential units matching in other than broad spatial patterns.

7.3.4 Some LCA units, such as the 'Peatland landscapes' of Caithness, appear to be evenly split between capacity classes Low and Moderate. This may reflect the levels of landform complexity and scale that will change further inland and westwards. A sensitivity analysis of the classification schemes may reveal modifications that may align the boundaries of the landscape potential classification levels more closely to the LCA units. However, such an analysis has not been carried out.

Figure 7.7. LCA units at level 3 and landscape value assessments overlaid upon landscape capacity for large wind turbine developments.



7.4 Digital datasets

7.4.1 The landscape capacity datasets for each of the three sizes of wind turbine development provide representations of the different scorings and weightings. The mechanisms required to produce the final outputs are provided by most standard GIS packages (*e.g.* ArcView and ArcGIS). The figures reproduced in this report illustrate the development and output of datasets of landscape character sensitivity to wind turbine developments, visual sensitivity and the potential for wind turbine developments. The input datasets used in the production of the landscape character sensitivity, visual sensitivity, and landscape value can be used individually, or in combination, to address questions about the composition of the final map of potential for any given location.

7.4.2 The datasets of field observations of the components of landscape character and of landscape value are also provided for aiding in the interpretation of the maps of landscape potential.

7.4.3 The datasets were combined to enable the contribution of the principal inputs landscape character sensitivity and visual sensitivity to be assessed for each cell. The use of these data within ArcView enables the user to enquire into over which LCA units the scores representing landscape potential fall. They also enable an interpretation with respect to the nearest field observation, but the user should be cautious about interpolating the field scores of landscape value between the nearest to that of interest.

8 PHASE 5: CUMULATIVE IMPACTS

8.1 Identification of sensitive sites

8.1.1 The method for assessing the spatial distribution of sites at which there would be sensitivity to multiple wind turbine developments is described below, with reference to the more detailed description contained in Appendix X. These analyses have been run for both the Caithness and Moray areas to enable comparisons of the outputs for two geographical areas that have very different landscape characteristics. However, the analysis was only run for areas of land. Near inshore areas were not considered, although the same approach would be valid.

8.1.2 The methodology uses a random selection of potential sites within an area, of which the potential visibility is calculated for each site. Random points are used to reflect the independence of the assessment from non-landscape related constraints, such as wind speed or land use. The output is an assessment of the land that is most sensitive to combined views of the random points. These data are then processed to highlight the 'hot spots' from which combinations of random points may be visible. The threshold defining the level of combination can be altered according to the likely level of development in an area, or to explore different scenarios of development with the landscape capacity and two sensitivity datasets.

8.1.3 The 'hot spots' then form the input to the calculation of visibility, which identifies those potential development locations that may be most visible. The output from this calculation is an indication of the sites where developments may be most visible from multiple locations.

8.1.4 A refinement of the method has been to include the locations of existing developments, or proposals, in place of a random point, and to ask of the DST which areas would have the highest level of common visibility together with specified sites (such as existing developments, or those of proposals).

8.1.5 Examples of the outputs from these analyses are shown in Figures 8.1 and 8.2, for Moray and Caithness respectively. The output from this analysis can then be overlaid upon the landscape capacity and visual sensitivity datasets to categorise the types of landscapes that may be highlighted as offering views of multiple turbine developments.

Moray

8.1.6 Figure 8.1(a) shows the distribution of the land that is calculated to have the highest risk of cumulative visual impacts, taking account of a set of theoretical observers from across the Moray Council area, and adjacent land. It shows which land areas would be most visible from multiple locations, which would also have views of five developments, including those at Paul's Hill, Cairn Uish and Drummuir. These areas are concentrated around the coast, with areas inland that include the vicinity of Paul's Hill, principally to the west and north, and south-west of Cairn Uish. There are no hot spots (based upon the equivalent thresholds) near Mains of Drummuir.

8.1.7 When overlaying the areas of high sensitivity to development on the landscape sensitivity data (Figure 8.1(b)), it shows that the areas on the coast are predominantly low in sensitivity, with a small extent that is of moderate sensitivity, mainly to the east, and around Burghead. The largest inland area is that around Paul's Hill, which is split between the high and moderate sensitivity classes, as is the area north-east of Cairn Uish. Overall, in the inland areas of Moray most of the areas of sensitivity to cumulative visual impacts are on land with a moderate landscape sensitivity class (to large turbine developments).

8.1.8 With respect to visual sensitivity (Figure 8.1(c)), the coastal areas of high cumulative visual impacts are almost exclusively on high sensitivity classes. Inland, the distribution north-east of Cairn Uish occupies the moderately sensitive class, and the area around Paul's Hill occupies all three classes, but predominantly those of a low and moderate sensitivity. The scores for the latter area may reflect the plateau nature of the terrain, and the distance away from most roads, or other vantage points. Therefore, the visual sensitivity scores for such an area are lower than those on more sloping terrain, or lower lying terrain in the Moray area.

8.1.9 The final maps of landscape potential to wind turbine development (Figure 8.1(d)) show that the areas with high landscape potential and those of potentially high cumulative visual impacts are in the south-east of Moray near the border with Aberdeenshire. There are also some smaller areas to the west, on the border with Highland.

8.1.10 The coastal areas of high cumulative visual impact occupy land with a low potential for turbine development, and the inland areas occupy all three classes. Around Paul's Hill, the dominant class is that of high potential, surrounded by a band of moderate potential land. This compares to the area around Cairn Uish, which is dominated by low and moderate potential land, with the areas of high cumulative impact occupying each class to the north-east of the development site.

Caithness

8.1.11 In Caithness, the areas of highest cumulative visual impact occupy land that is predominantly of moderate landscape character sensitivity, but also includes some areas of high sensitivity such as around Ben Alisky and the slopes around Morven (Figure 8.2(a)). However, there are also some areas of low sensitivity west of Altnabrec, and smaller areas north-west of the current turbines at Boulfruich.

8.1.12 The inclusion of the existing developments at Dounreay and Forss influences the identification of that area as sensitive to cumulative visual impacts, which coincides with land of mainly low and moderate landscape sensitivity, but a little high sensitivity on the slopes of Beinn Ratha to the south-west. The areas of high cumulative visual impacts are extensive in areas of low visual sensitivity (Figure 8.2(c)) in the south-west of Caithness, but also include areas of high visual sensitivity north-west of Berriedale, and around Dounreay, Forss and Thurso.

8.1.13 A comparison of the areas of high cumulative visual impact and the final data on potential for large turbine developments (development scenario 1) (Figure 8.2(d)), showed that the areas of high potential, and outwith the areas of high cumulative visual impacts are located in the north-west of Caithness, and to a lesser extent in the south-east, whereas, the areas of highest landscape potential, and high cumulative visual impacts are in the south-west of Caithness, between Strath of Kildonan and Boulfruich. However, there are also areas of low capacity in the same vicinity such as Ben Alisky, as are the areas around Dounreay and Forss.

8.1.14 Relaxing the condition that the areas of low potential with cumulative visual impacts include those where the landscape is predominantly natural (i.e. a high degree of land cover naturalness) would extend the coverage across more of Caithness. Details are shown in Appendix IX of the areas that would be most sensitive to turbine developments with respect to cumulative issues would still be in the south-west of the area (Figure A.IX.VII).

8.1.15 Similarly, the majority of the area of Caithness is classified as being low or moderate in capacity for large turbine developments, and outwith the area highly sensitive to cumulative visual impacts. However, relaxing the limitation that there must be at least seven developments visible, including those at Berriedale, Boulfrouich, Forss, Achkeepster and Dounreay, would extend the area across more of Caithness.

Comparison

8.1.16 The distribution of the areas of high sensitivity (using the threshold of seven developments) is more extensive and less fragmented in Caithness compared to that in Moray. This is despite a high threshold of the number of developments that must be visible before being classified (seven compared to five in Moray). This pattern is generally due to the more level and lower lying terrain in Caithness compared to the more extensive areas of mountainous and rolling terrain in Moray.

8.1.17 The thresholds used in the derivation of areas of potentially high cumulative visual impact can be altered to accommodate new circumstances, such as recent development approval, so that the assessment remains up-to-date for subsequent developments.

Figure 8.1(a). Locations visible by more than the highest mean number of 'theoretical observers' (194 from 4 runs) combined with a high degree of naturalness (70%).

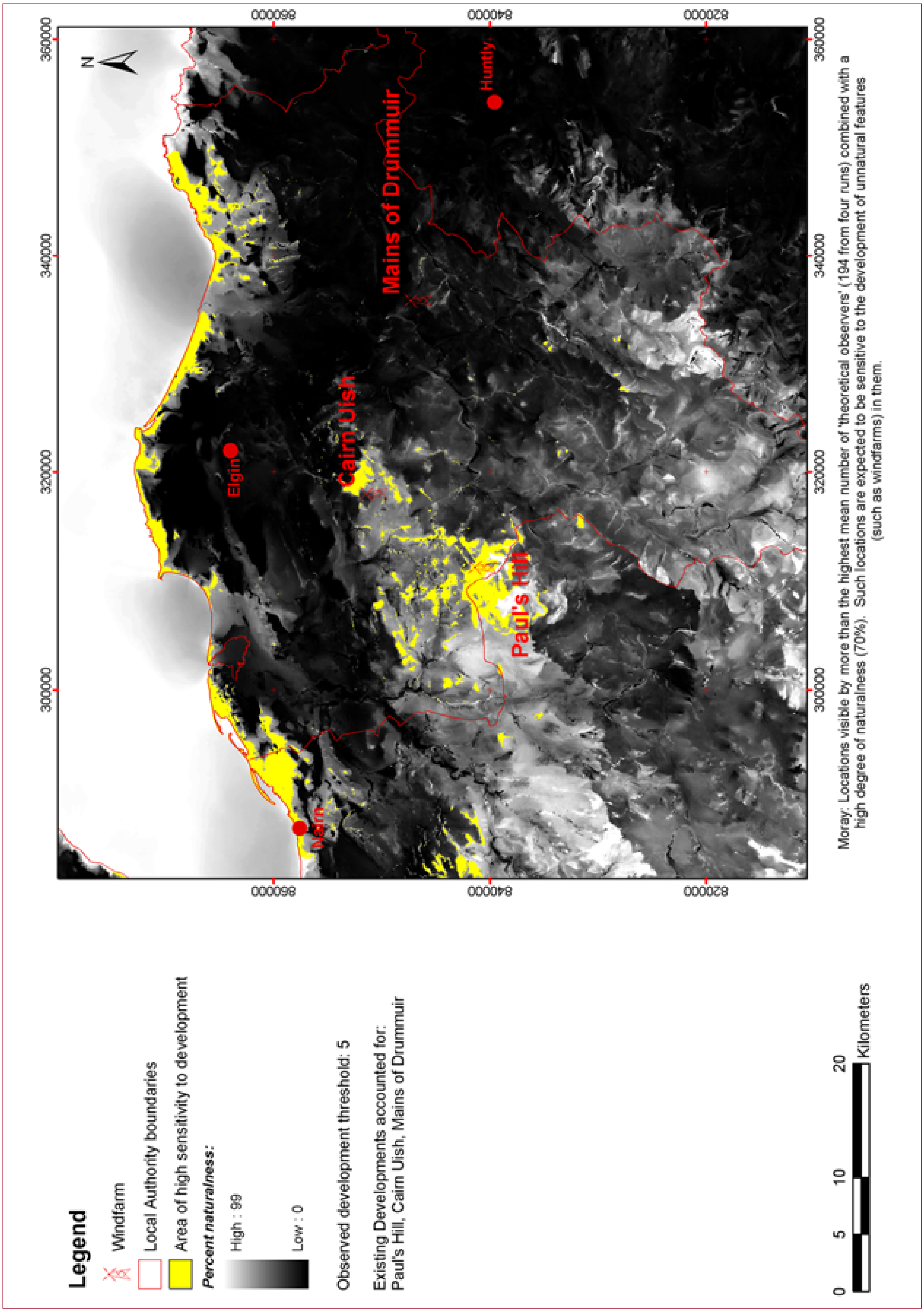


Figure 8.1(b). Locations of high visibility from theoretical observers and landscape character sensitivity: Moray, threshold 5.

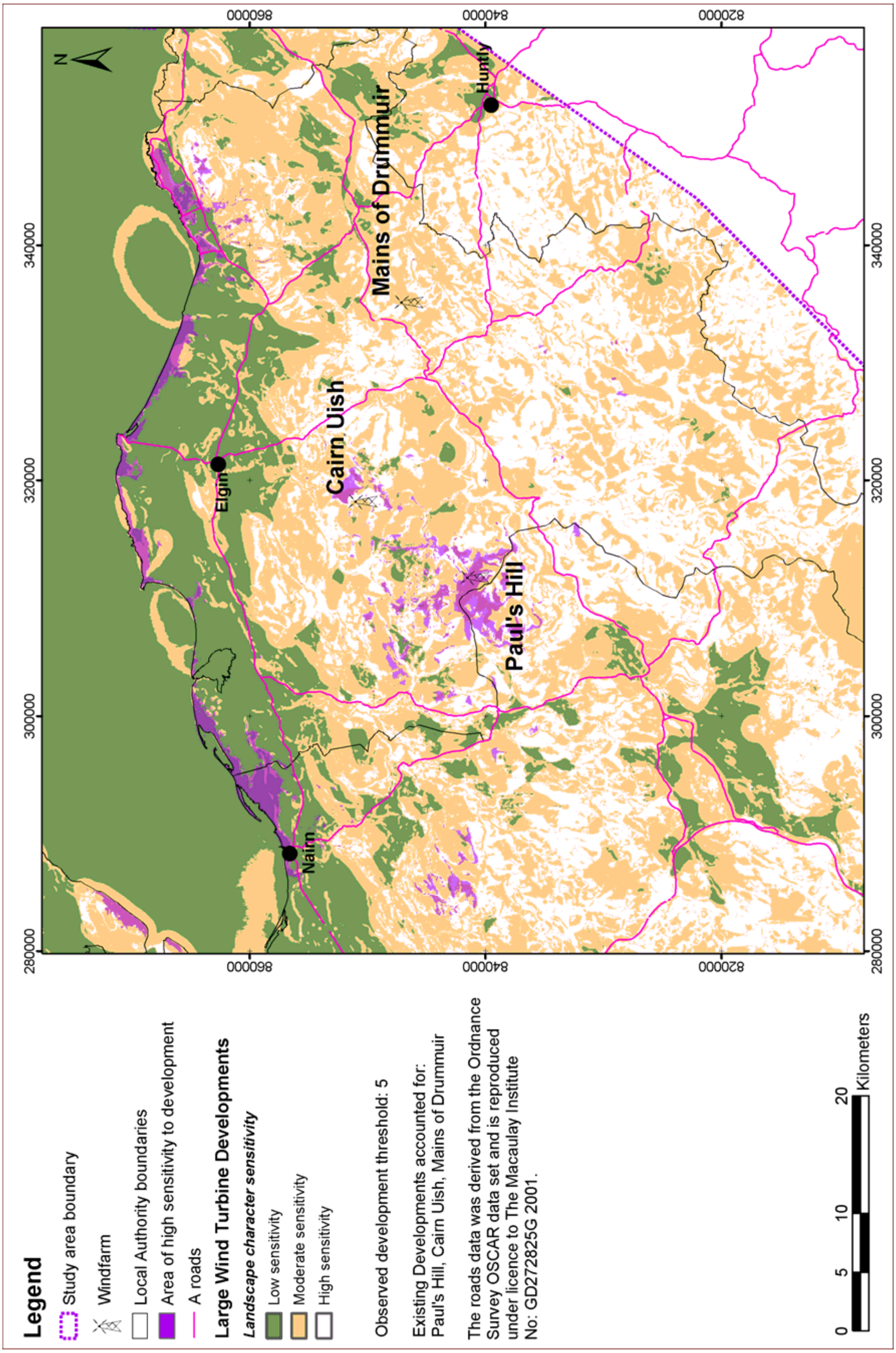


Figure 8.1(c). Locations of high visibility from theoretical observers and visual sensitivity: Moray, threshold 5.

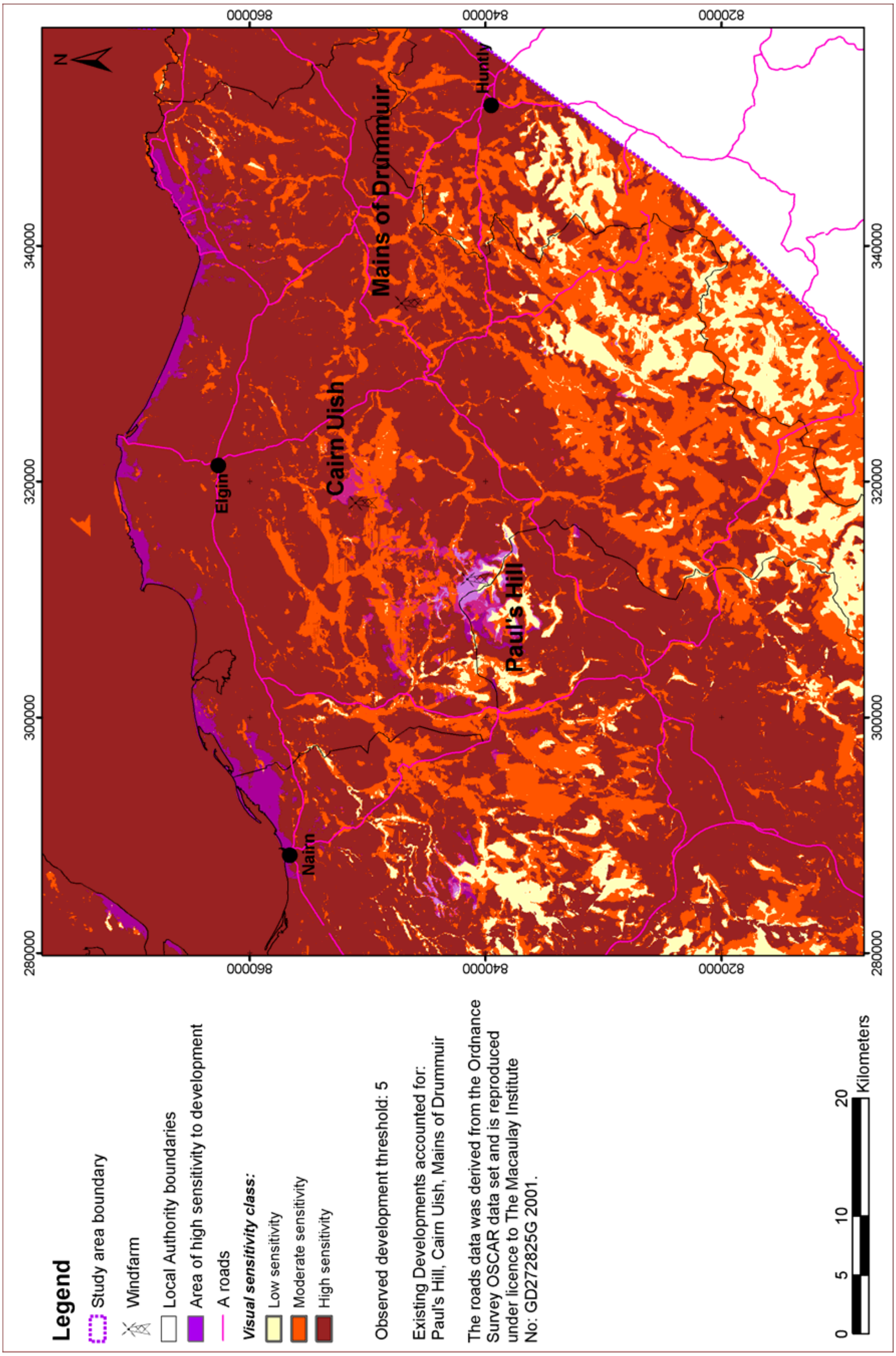


Figure 8.1(d). Locations of high visibility from theoretical observers and landscape potential for wind turbine development: Moray, threshold 5.

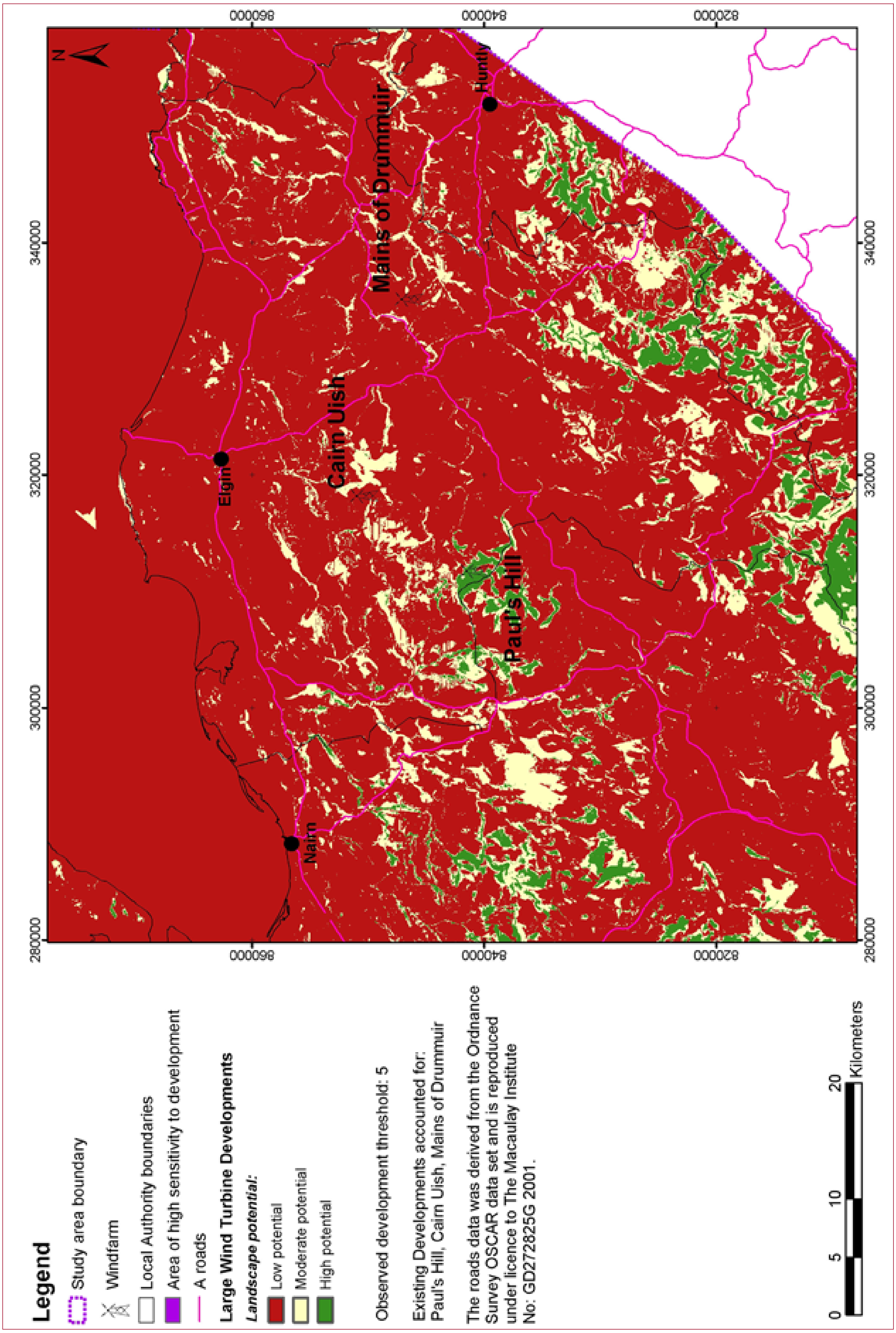


Figure 8.2(a). Locations visible by more than the mean number of 'theoretical observers' (234) able to see a given location with a high degree of naturalness (>70%).

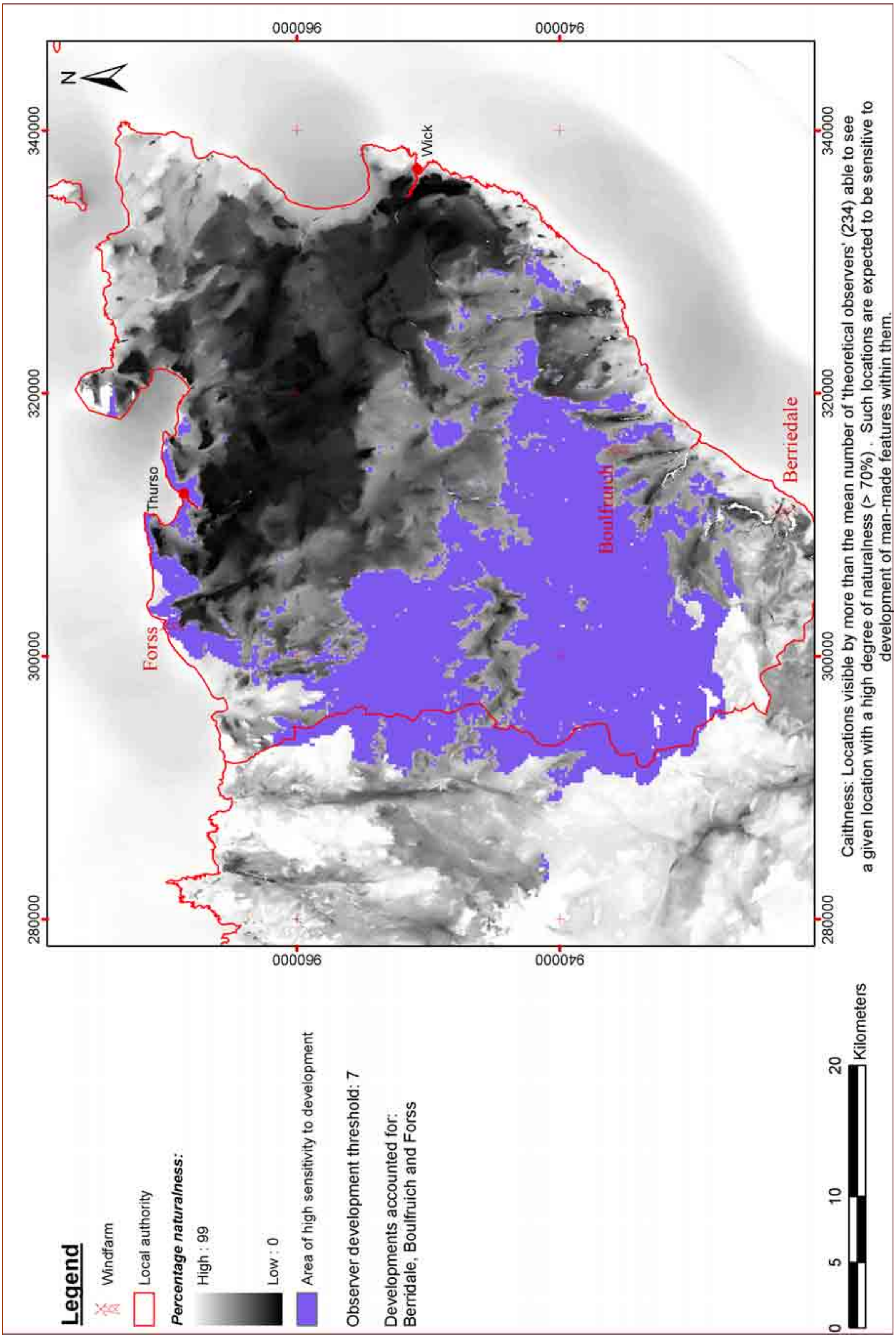


Figure 8.2(b). Locations of high visibility from theoretical observers and landscape character sensitivity: Caithness, threshold 7.

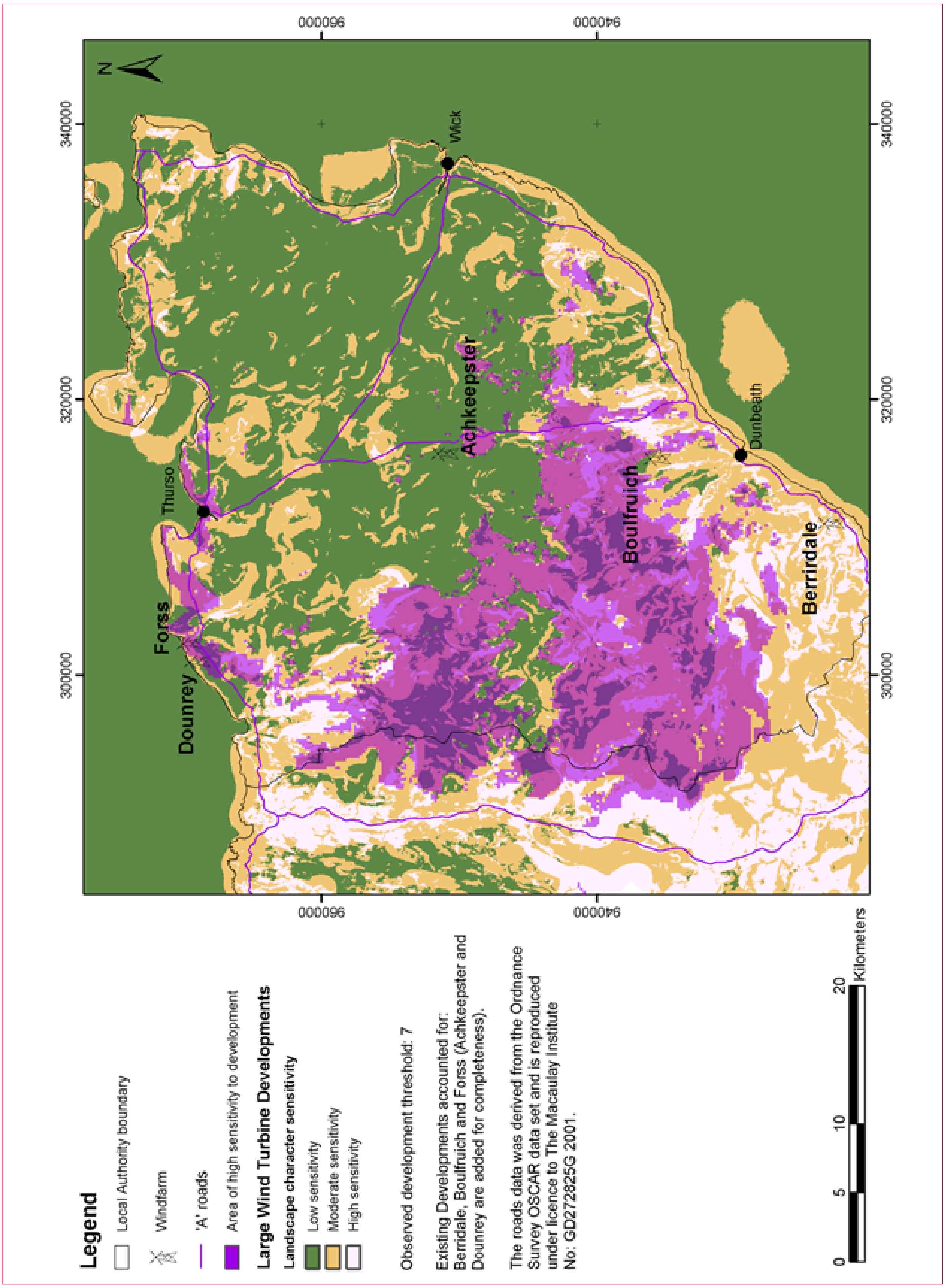


Figure 8.2(c). Locations of high visibility from theoretical observers and visual sensitivity: Caithness, threshold 7.

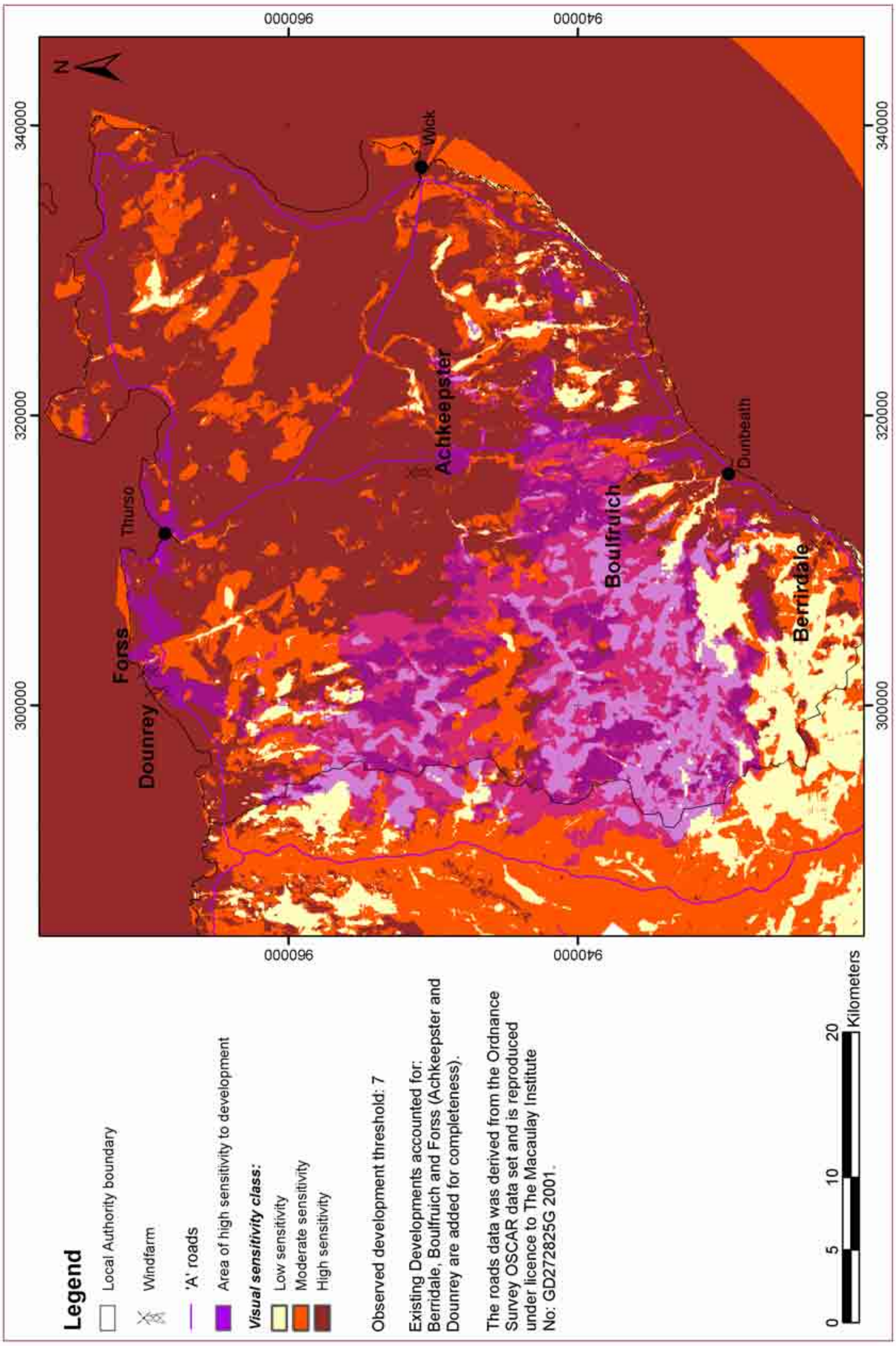
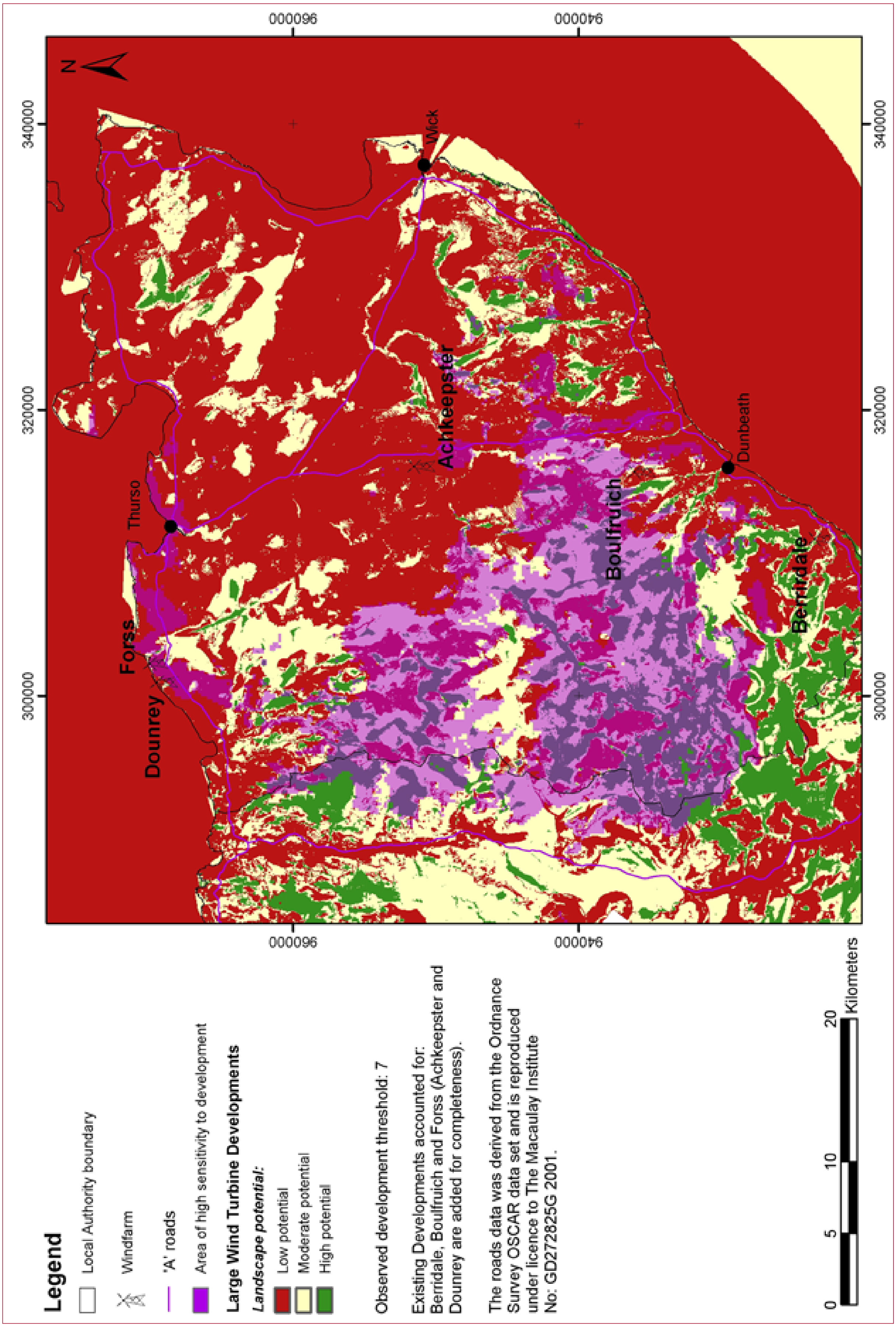


Figure 8.2(d). Locations of high visbility from theoretical observers and landscape potential for wind turbine development: Caithness, threshold 7.



8.2 Impacts and ordering with respect to an example viewpoint: combined view from the road network

8.2.1 The extent to which any one turbine, or an entire wind turbine, may be visible is largely dependent upon the topography surrounding the wind turbine. The extent to which such a development may have a visual impact on the landscape depends upon considerations of other factors. These factors include the nature of the site from where the development is visible, and the context of the site in terms of the character of the area and any sense that the introduction of the feature will be inappropriate in the context.

8.2.2 A test was carried out for developments in both Moray (Figure 8.3) and Caithness (Figure 8.4). The visibility of each of the sites in Moray, or the surrounding area, considered to have existing developments (Paul's Hill, Cairn Uish, and the Glens of Foudland) were analysed with respect to the local road networks (A and B class roads). The proposed farms at Drummuir and Aultmore were added to this analysis to assess the order in which they would increase the total length of roads from which they may be visible. Table 8.1 summarises the lengths of road from which turbines may be visible at the sites identified, and Table 8.2 shows the lengths by combination of developments.

8.2.3 With respect to transport, the data derived on visual sensitivity in Section 6 may be used in weighting the significance of the impact of the visibility of the individual, or combination of, wind turbines.

8.2.4 The cumulative visibility was assessed using alternative sequences of development and the results showed that the extent to which turbines could become increasingly visible from the road network might be different depending upon the order of development.

8.2.5 The input data for this analysis comprised of the visibility calculations for each development site, intersected on each other, and then on the road network. This provides a unique combination of codes that can be reordered to assess the implications of different orders of development on the length of road from which different combinations may be visible.

8.2.6 Alternative orders of development were explored with some examples determined by ordering the increase in the length of A class roads from which one or more developments may be visible. Both options resulted in Paul's Hill being developed first, followed by Aultmore and Drummuir (Figure 8.5). To minimise the increase in the cumulative length of visibility from 'A' roads Cairn Uish would be developed fourth and Glens of Foudland last. The order of the last two is reversed if the plan is to minimise the much greater difference in the cumulative lengths of potential views of turbines from C Class and Minor roads.

Table 8.1. Lengths of roads from which each turbine development site may be visible: Moray.

	A Roads (km)	B Roads (km)	C Roads (km)	Total (km)
Not visible	531.2	453.9	4459.6	5444.7
Paul's Hill	11.7	3.5	538.2	553.5
Cairn Uish	43.1	66.7	910.8	1020.6
Glens of Foudland	43.7	58.5	666.9	769.2
Drummuir	53.7	92.4	782.3	928.4
Aultmore	46.9	27.7	797.4	872.1
Total	730.3	702.8	8155.2	9588.4

Table 8.2. Lengths of roads from which each combination of turbine developments may be visible: Moray.

Combination of Turbine Development Sites	A Roads (km)	B Roads (km)	C Roads (km)	Total (km)
Paul's Hill	9.3	1.8	82.4	93.6
Cairn Uish	25.1	46.9	560.4	632.4
Paul's Hill + Cairn Uish	0.1	0.5	42.4	43.0
Glens of Foudland	36.0	39.7	584.9	660.6
Paul's Hill + Glens of Foudland	0.0	0.0	0.0	0.0
Cairn Uish + Glens of Foudland	0.0	0.0	0.0	0.0
Paul's Hill + Cairn Uish + Glens of Foudland	0.0	0.0	0.0	0.0
Drummuir	30.1	45.1	277.5	352.7
Paul's Hill + Drummuir	2.3	0.8	18.3	21.4
Cairn Uish + Drummuir	7.7	4.5	120.4	132.6
Paul's Hill + Cairn Uish + Drummuir	0.0	0.0	11.5	0.0
Glens of Foudland + Drummuir	1.1	0.4	22.3	23.8
Paul's Hill + Glens of Foudland + Drummuir	0.0	0.0	0.0	0.0
Cairn Uish + Glens of Foudland + Drummuir	0.0	0.0	0.0	0.0
Paul's Hill + Cairn Uish + Glens of Foudland + Drummuir	0.0	0.0	0.0	0.0
Aultmore	25.2	15.8	382.5	423.5
Paul's Hill + Aultmore	0.0	0.0	0.2	0.0
Cairn Uish + Aultmore	4.6	0.8	47.1	52.5
Paul's Hill + Cairn Uish + Aultmore	0.0	0.0	0.4	0.0
Glens of Foudland + Aultmore	4.8	1.1	34.8	40.7
Paul's Hill + Glens of Foudland + Aultmore	0.0	0.0	0.0	0.0
Cairn Uish + Glens of Foudland + Aultmore	0.0	0.0	0.0	0.0
Paul's Hill + Cairn Uish + Glens of Foudland + Aultmore	0.0	0.0	0.0	0.0
Drummuir + Aultmore	4.9	10.3	178.5	193.7
Paul's Hill + Drummuir + Aultmore	0.0	0.0	0.4	0.0
Cairn Uish + Drummuir + Aultmore	5.6	14.0	128.6	148.1
Paul's Hilla + Cairn Uish + Drummuir + Aultmore	0.0	0.0	0.0	0.0
Glens of Foudland + Drummuir + Aultmore	1.9	1.5	24.8	28.3
Paul's Hill + Glens of Foudland + Drummuir + Aultmore	0.0	0.0	0.0	0.0
Paul's Hill + Cairn Uish + Glens of Foudland + Drummuir + Aultmore	0.0	0.0	0.0	0.0

8.2.7 Figures 8.3 to 8.9 show the effects of the cumulative length of roads from which turbines may be visible, including the order of development, which reflects the chronology of applications for planning permission. Figures 8.3 and 8.4 show the extent of the area of land considered in Moray and Caithness.

8.2.8 From Figures 8.5 and 8.6, Cairn Uish would appear to contribute most in raising the level of visibility from the road network, with the addition of Paul’s Hill output to this ordering adding little.

8.2.9 The analysis of the potential cumulative visual impacts of developments with respect to the road network, and landscape character classes, has also been applied to the area of Caithness. Table 8.3 shows the summary of road length from each of the five developments: Berriedale, Boulfruich, Forss, Achkeepster and Dounreay.

Figure 8.3. Visibility of five proposed developments in Moray from the road network.

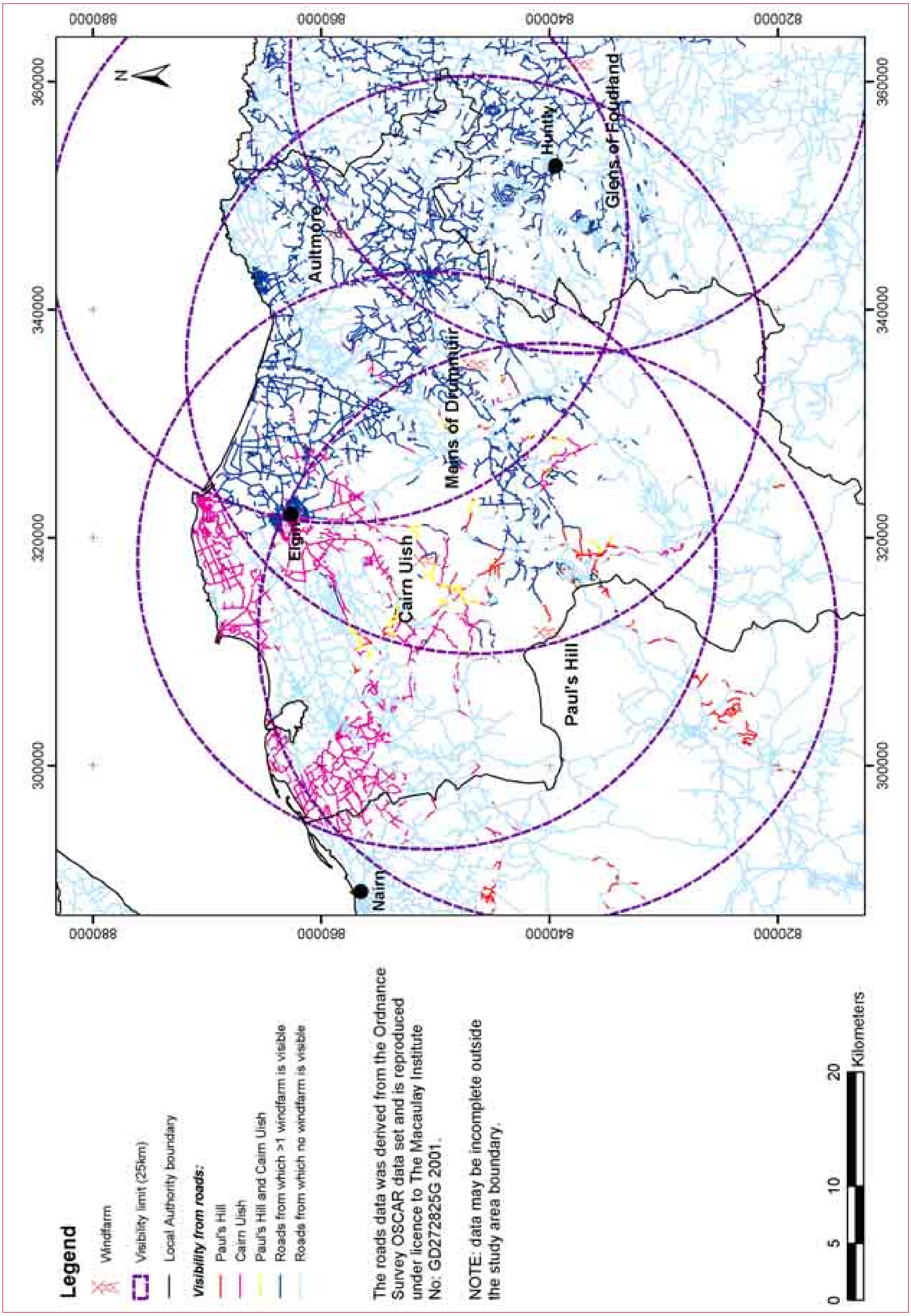


Figure 8.4. Visibility of five proposed developments in Caithness from the road network.

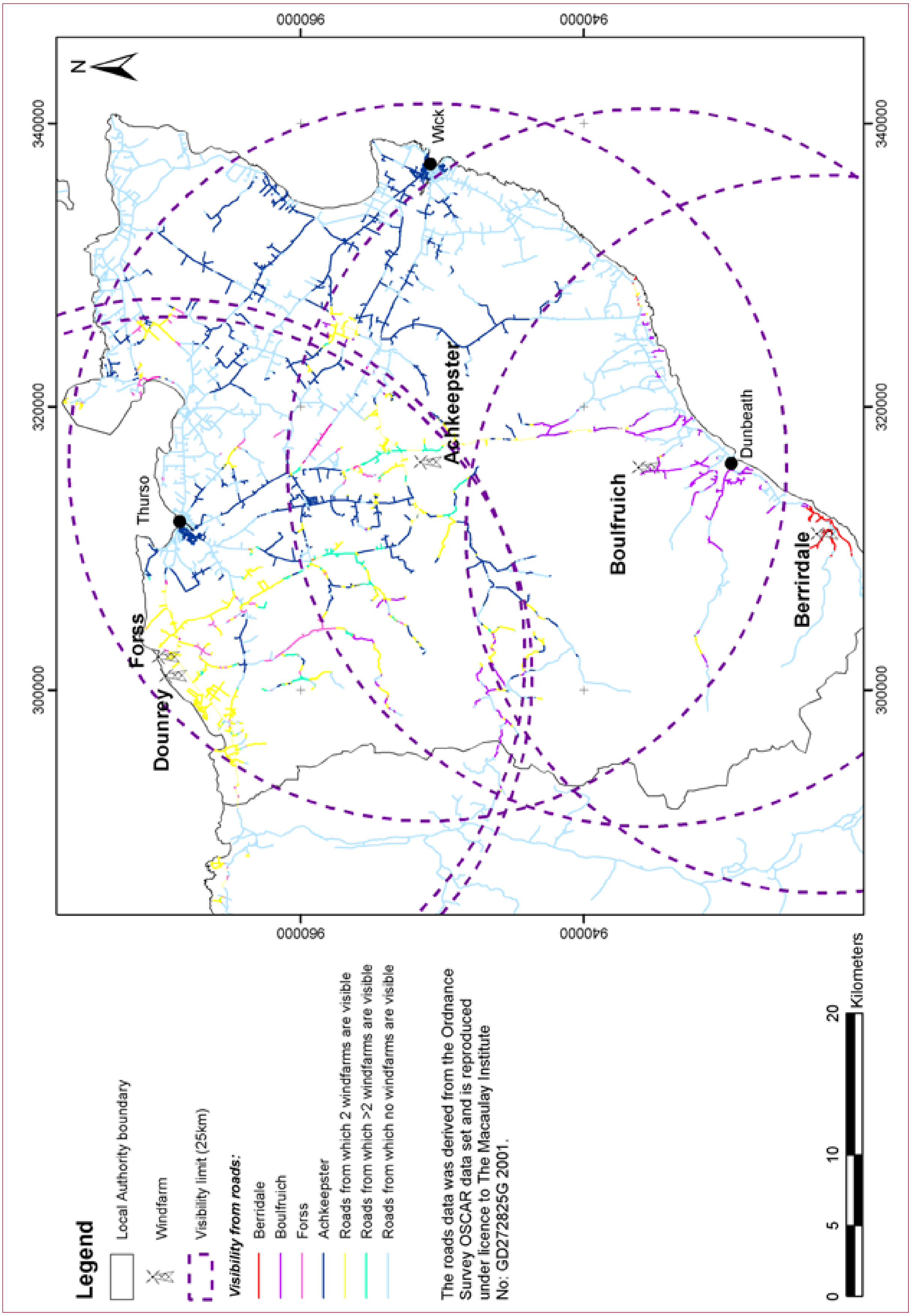
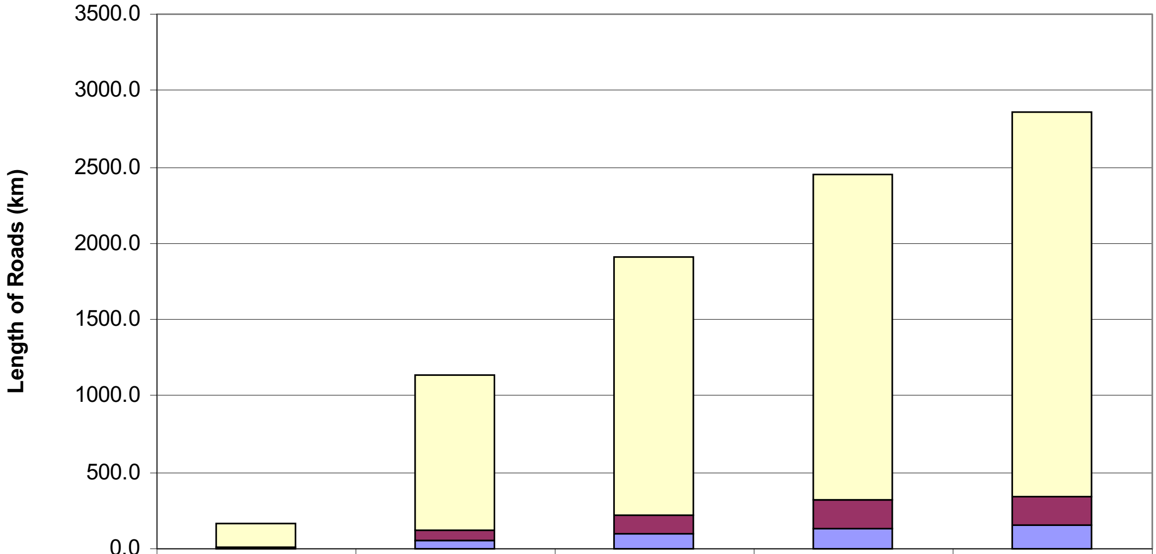


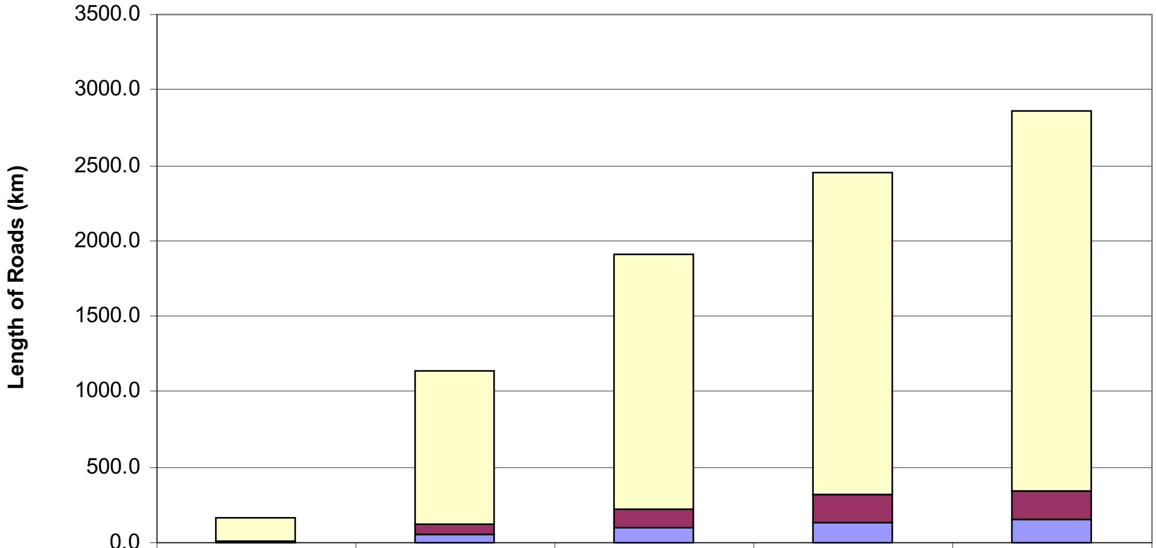
Figure 8.5. Cumulative length of roads from which turbine developments may be visible: development scenario 1: Moray.



	Paul's Hill	+ Cairn Uish	+ Glens of Foudland	+ Drummuir	+ Aultmore
C Roads	155.8	1012.2	1679.1	2135.0	2517.5
B Roads	3.5	69.7	127.8	183.3	183.3
A Roads	11.7	54.7	98.4	133.5	158.6

Addition of Development Site

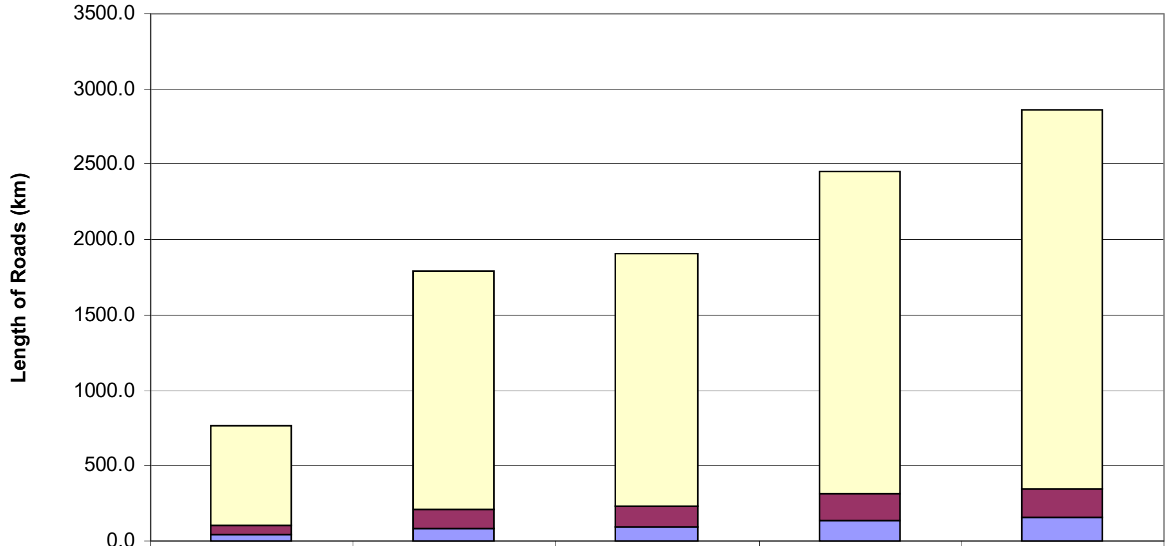
Figure 8.6. Cumulative length of roads from which turbine developments may be visible: cumulative development scenario 2: Moray.



	Paul's Hill	+ Cairn Uish	+ Glens of Foudland	+ Drummuir	+ Aultmore
C Roads	155.8	1012.2	1679.1	2135.0	2517.5
B Roads	3.5	69.7	127.8	183.3	183.3
A Roads	11.7	54.7	98.4	133.5	158.6

Addition of Development Site

Figure 8.7. Cumulative length of roads from which turbine developments may be visible: development scenario 3: Moray.



	Glens of Foudland	+ Cairn Uish	+ Paul's Hill	+ Drummuir	+ Aultmore
C Roads	666.9	1577.7	1679.1	2135.0	2517.5
B Roads	58.5	125.3	127.8	183.3	183.3
A Roads	43.7	86.8	98.4	133.5	158.6

Addition of Development Site

Table 8.3. Lengths of roads from which each turbine development site may be visible: Caithness.

Site	A Roads (km)	B Roads (km)	C Roads (km)	Total (km)
Berridale	9.3	344.1	3200.5	3554.0
Boulfruich	25.9	310.0	3263.1	3599.0
Forss	31.1	301.5	2966.5	3299.1
Achkeepster	44.1	631.3	5053.5	5728.9
Dounrey	21.7	305.8	2768.2	3095.7
Total	2647.6	1892.8	17251.8	21792.2

8.2.10 The results in Table 8.3 show that the turbine development at Achkeepster would be visible along the greatest length of road. The road lengths from which this site would be visible are greatest for 'A', 'B' and minor class roads. The order of road length from which any given development may be visible is different for each class of road for all of the other developments.

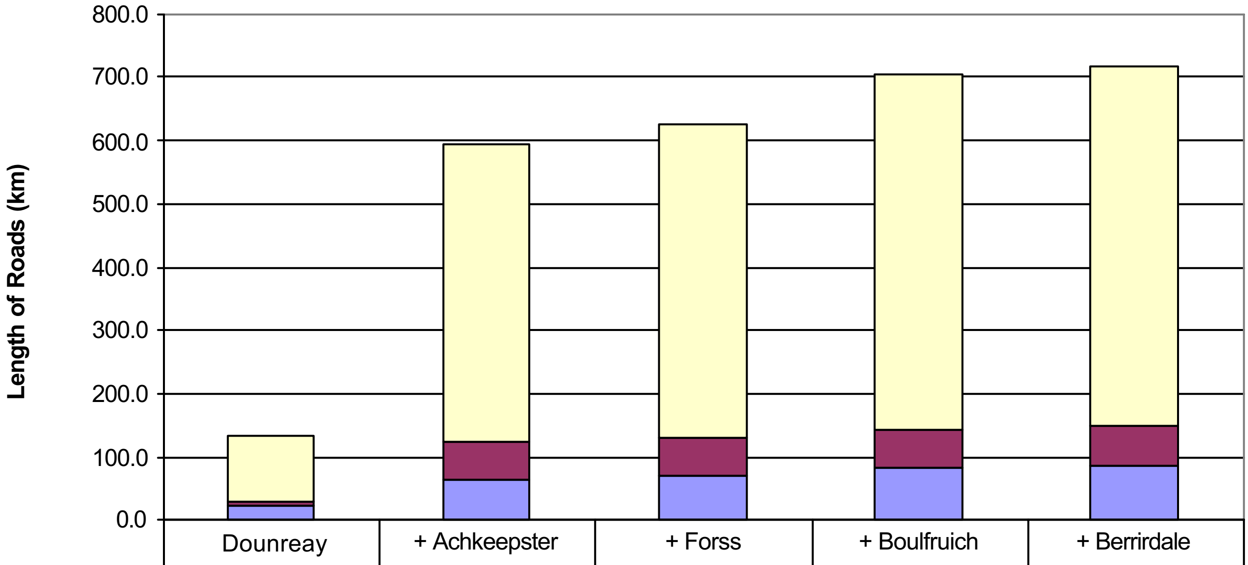
8.2.11 Table 8.4 shows the length of road from which each combination of development may be visible. This shows that the development at Achkeepster would be the only one visible from 26.5 km of 'A' class road. Achkeepster and Boulfruich would be jointly visible from another 10.9 km of such roads. The site at Forss may be visible from 6.2 km and that at Dounreay visible from only 0.4 km when considered on their own. However, in combination these developments may be visible from 18.4 km of 'A' class roads, reflecting the close proximity of each site.

8.2.12 A similar pattern is apparent for the 'B' and minor class roads, i.e. that a development at Achkeepster may have the largest single exposure to views from roads, and the combinations of Boulfruich and Achkeepster, and Forss with Achkeepster.

Table 8.4. Lengths of roads from which each combination of turbine developments may be visible: Caithness.

Combination of Turbine Development Sites	A Roads (km)	B Roads (km)	C Roads (km)	Total (km)
Berridale	6.1	0.0	8.8	14.8
Boulfruich	9.0	1.1	64.4	74.5
Berridale + Boulfruich	1.5	0.0	0.6	2.0
Forss	6.2	0.1	27.3	33.6
Berridale + Forss	0.0	0.0	0.0	0.0
Boulfruich + Forss	0.0	0.0	0.4	0.4
Berridale + Boulfruich + Forss	0.0	0.0	0.0	0.0
Achkeepster	26.5	41.3	288.2	356.0
Berridale + Achkeepster	0.0	0.0	0.0	0.0
Boulfruich + Achkeepster	10.5	9.6	48.0	68.1
Berridale + Boulfruich + Achkeepster	0.0	0.0	0.0	0.0
Forss + Achkeepster	1.8	3.2	23.6	28.6
Berridale + Forss + Achkeepster	0.0	0.0	0.0	0.0
Boulfruich + Forss + Achkeepster	2.5	0.7	3.5	6.7
Berridale + Boulfruich + Forss + Achkeepster	0.0	0.0	0.0	0.0
Dounrey	0.4	0.6	2.5	3.6
Berridale + Dounrey	0.0	0.0	0.0	0.0
Boulfruich + Dounrey	0.0	0.0	0.2	0.2
Berridale + Boulfruich + Dounrey	0.0	0.0	0.0	0.0
Forss + Dounrey	18.4	1.4	87.7	107.5
Berridale + Forss + Dounrey	0.0	0.0	0.0	0.0
Boulfruich + Forss + Dounrey	0.0	0.1	1.6	1.6
Berridale + Boulfruich + Forss + Dounrey	0.0	0.0	0.0	0.0
Achkeepster + Dounrey	0.1	0.0	1.6	1.7
Berridale + Achkeepster + Dounrey	0.0	0.0	0.0	0.0
Boulfruich + Achkeepster + Dounrey	0.6	0.5	0.4	1.4
Berridale + Boulfruich + Achkeepster + Dounrey	0.0	0.0	0.0	0.0
Forss + Achkeepster + Dounrey	0.4	0.6	9.1	10.1
Berridale + Forss + Achkeepster + Dounrey	0.0	0.0	0.0	0.0
Berridale + Boulfruich + Forss + Achkeepster + Dounrey	1.8	2.7	4.3	8.8

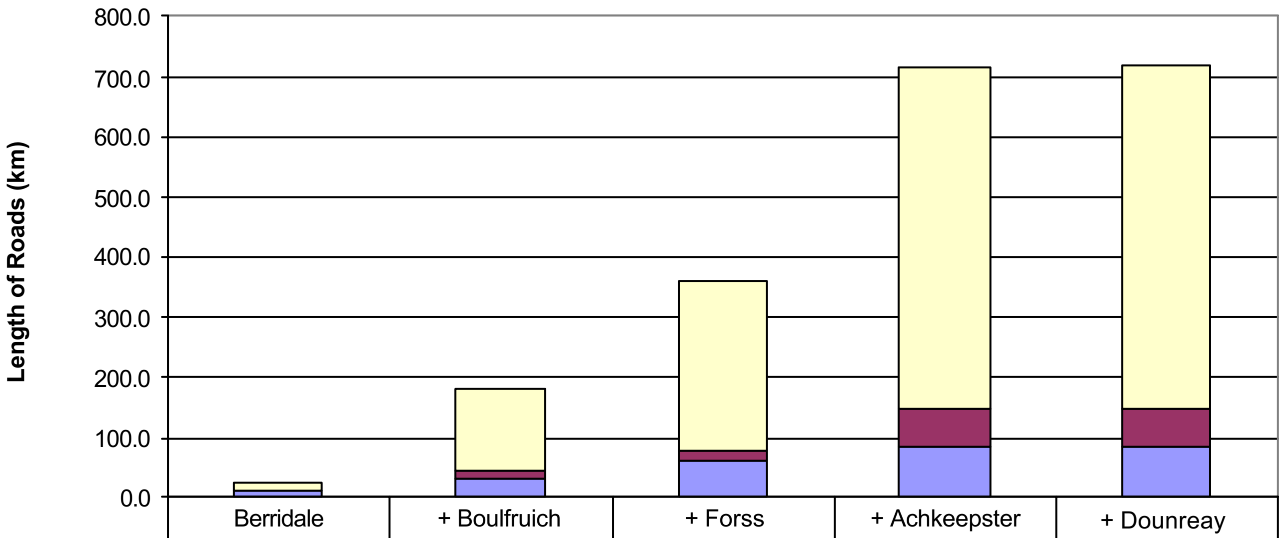
Figure 8.8. Cumulative length of roads from which turbine developments may be visible: development scenario 1: Caithness.



	Dounreay	+ Achkeepster	+ Forss	+ Boulfruich	+ Berrirdale
C Roads	107.5	470.9	498.7	563.6	572.4
B Roads	5.8	60.5	60.5	61.6	61.6
A Roads	21.7	63.0	69.1	79.6	85.7

Addition of Development Site

Figure 8.9. Cumulative length of roads from which turbine developments may be visible: development scenario 2: Caithness.



	Berridale	+ Boulfruich	+ Forss	+ Achkeepster	+ Dounreay
C Roads	13.6	132.3	280.1	569.9	572.4
B Roads	2.7	14.6	19.8	61.1	61.6
A Roads	9.3	31.9	58.7	85.2	85.7

Addition of Development Site

8.2.13 A comparison of the histograms in Figures 8.8 and 8.9, for Caithness, shows that the addition of Achkeepster second to that of Dounreay would increase the level of visibility from the road network of at least one turbine, to almost the maximum level achieved by all five developments. This is predominantly with respect to the minor road network, and reflects the intensity of that network along the northern parts of the area.

8.3 Impacts and ordering with respect to an example viewpoint: sequence of views from the road network

Moray

8.3.1 As noted in Section 5.1 it is suggested that the interrelationship of the siting of wind turbine developments in complex landforms may introduce visual confusion, disharmony and a lack of balance (Stanton 1996; SNH 2001; Bell 1991). This is caused by the sequencing of views in which opportunities to view turbines are interspersed with no such views. This arises predominantly in the more complex terrain.

8.3.2 The visibility analysis includes an assessment of the landscape complexity and naturalness and this can be extended to include analyses along selected roads, with the data being drawn from the analyses in phases 2 and 3. These are used as the main viewpoints for analysis instead of the continuous series.

8.3.3 The graph in Figure 8.10 shows the level of naturalness of the landscape, as derived in Section 5, with a route from Grantown-on-Spey, to Keith, Elgin and returning to Grantown via Dava Moor. It illustrates the change in level of land cover naturalness experienced by the vehicle occupants along the route.

Figure 8.10. Example of land cover naturalness experienced from a route through Moray (a brighter image equates to higher percentage naturalness).

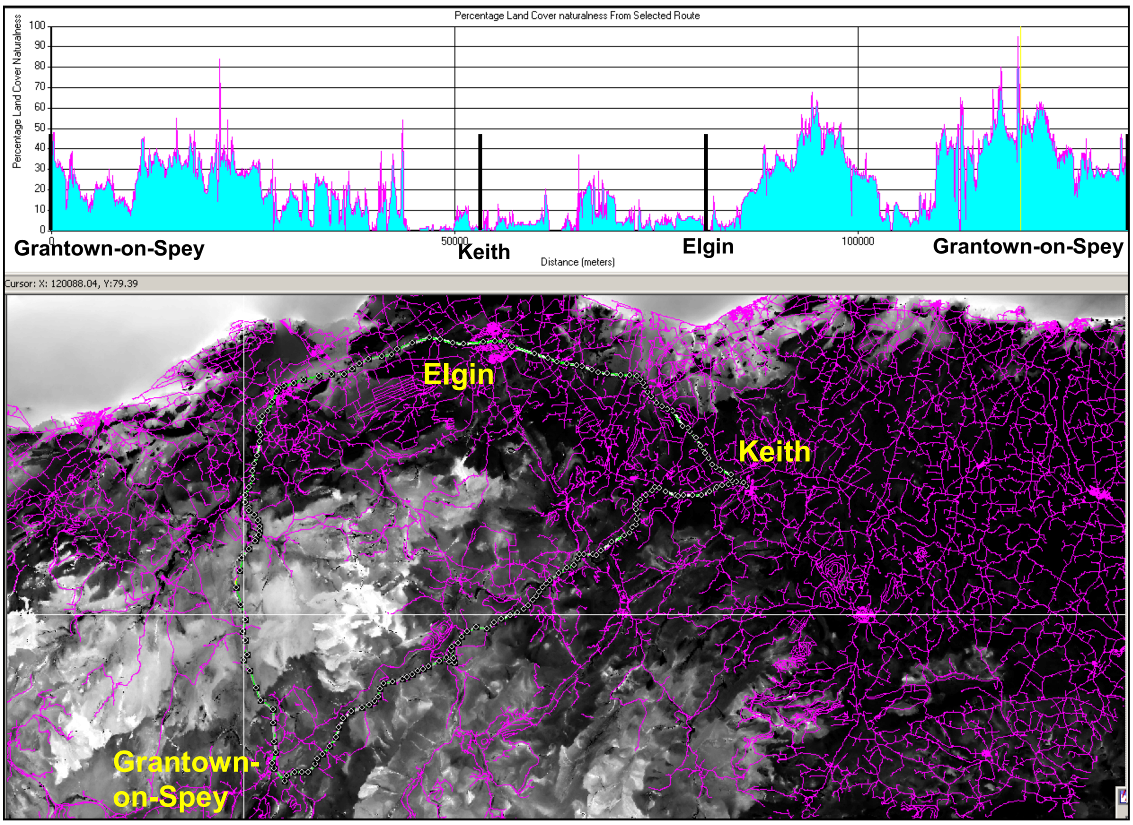
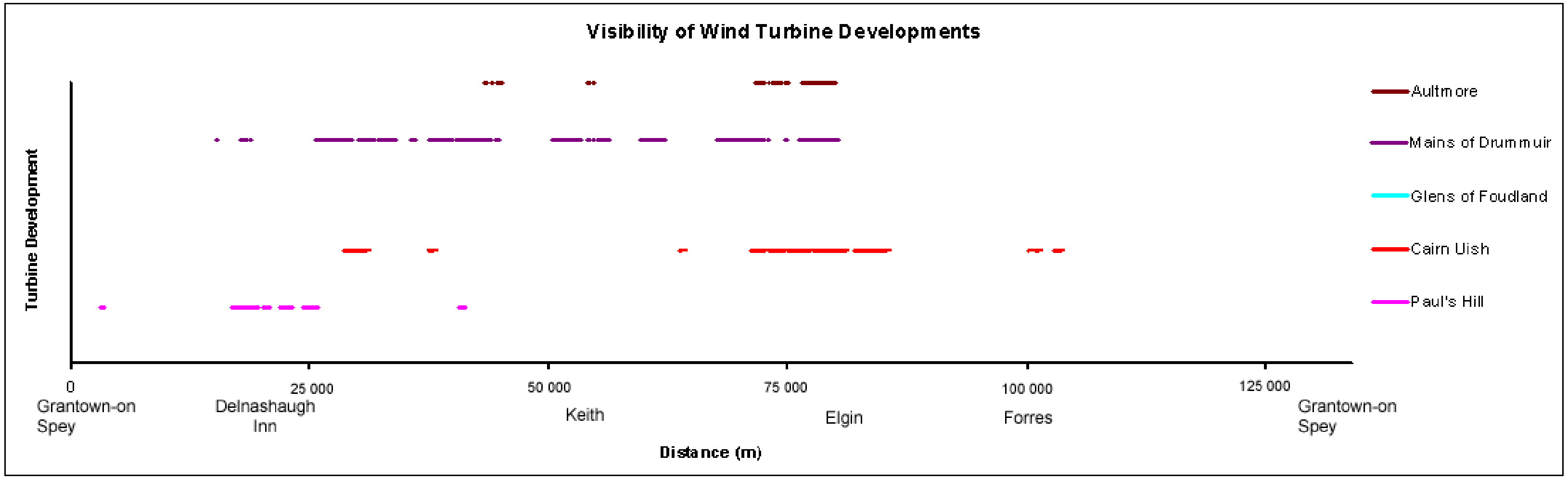


Figure 8.11. Visibility of turbine developments in Moray from a selected route.



Visibility of turbine developments at the five sites in Moray used within the study. Each line represents the stretch of the route from which the development may be visible. Comparisons between each line for any one position along the route enables an interpretation of the combination of developments that may be visible, and the frequency with which each development may be seen from the vehicle.

8.3.4 The route shown in Figure 8.11 from Grantown-on-Spey to Keith, Elgin, Forres and back to Grantown-on-Spey has been analysed with respect to the five developments considered in Moray, and reported in Figures 8.3, and 8.5 to 8.7, and Tables 8.3 and 8.4. The figure shows the sections of road from which each development may be visible along the route.

8.3.5 The method developed uses an overlay of the combined visibility of the turbine developments and compares it to the road network. The potential visibility of each development from the route can be compared and, for any single location, the number and identity of each development visible can be recorded. The along-route patterns of visibility can also be interpreted, with some developments potentially being visible from longer stretches of the route (e.g. Mains of Drummuir).

8.3.6 The development at Glens of Foudland is not visible from anywhere along this route. However, drivers may see developments at Paul's Hill and Mains of Drummuir, followed by a short view of Cairn Uish between Grantown-on-Spey and Keith. Between Keith and Elgin, it may be possible to see developments at Mains of Drummuir, Aultmore and Cairn Uish in different directions of view. After Elgin, views may only be possible of Cairn Uish, from along the route selected.

Caithness

8.3.7 A similar analysis of the visibility of developments has been made for Caithness as has been reported for Moray above. Figure 8.12 shows the level of naturalness of the landscape, with a route from Latheron, north-east along the A99 towards Wick, John o' Groats, west along the A836 to Thurso, and then south on the A9 back to Latheron.

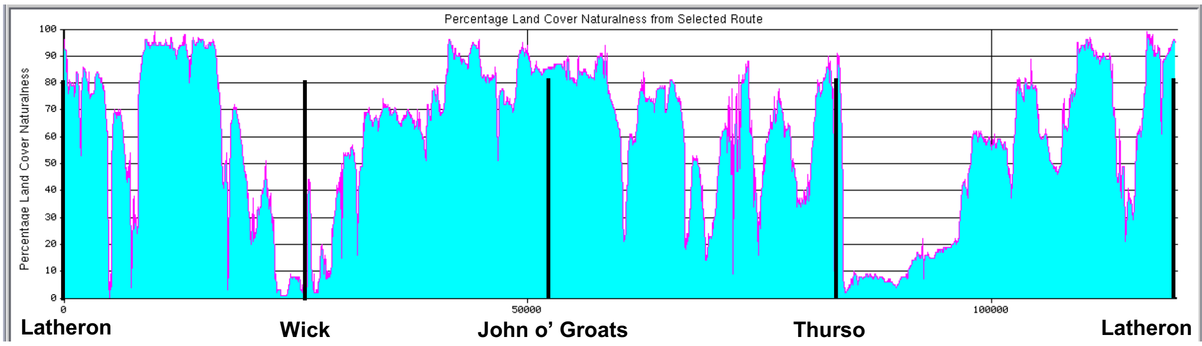
8.3.8 The graph shows the changes in the level of land cover naturalness visibile along the route. The route starts in an area for which the analysis suggests a high level of naturalness of land cover in thew view, with moorland and the views of the sea being contributing factors. In the vicinity of Thrumster, the proportion of land cover occupied by improved pasture and arable activity becomes dominant in the view, thus reducing the apparent naturalness in the view until north of Wick.

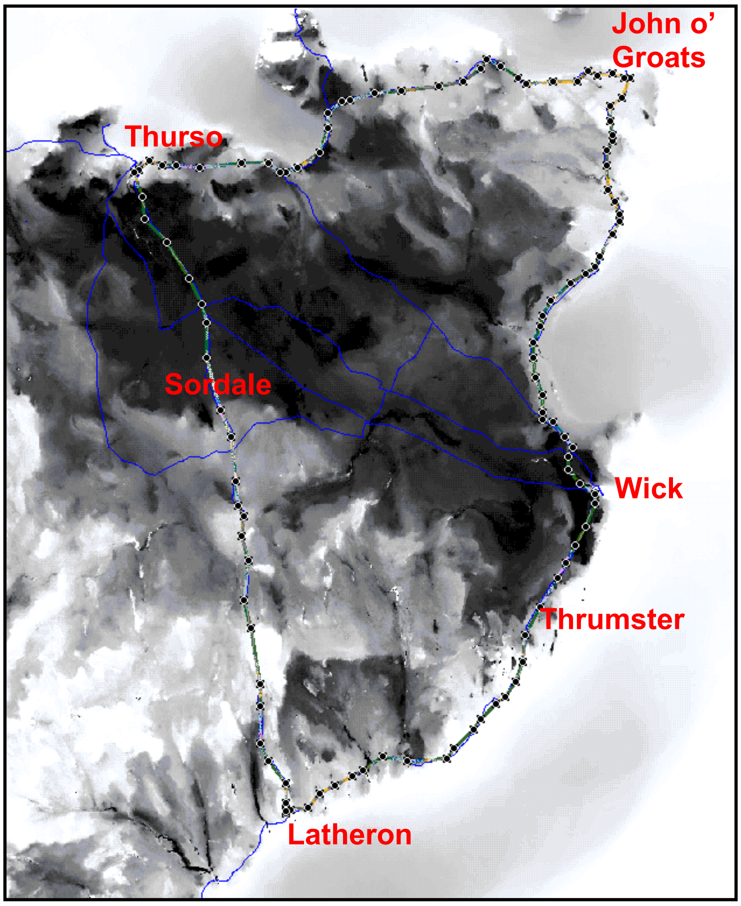
8.3.9 The views of agricultural land dominate again once the route turns south at Thurso, until approximately Sordale, after which the views predominantly contain peatland vegetation, moorland and some lochs, and thus have a high level of naturalness.

8.3.10 The same route is shown in Figure 8.13, this time with respect to the developments reported in Figure 8.8 and 8.9, and Tables 8.3 and 8.4 (i.e. Berridale, Forss, Dounreay, Boulfruich and Achkeepster). The figure shows the sections of road from which each development may be visible along the route, using the same method as in the preparation of Figure 8.11.

8.3.11 The results show that between Latheron and Wick, there are only a few, limited views of existing turbines, and that north of Wick, views of turbines would be restricted to those of the future development at Achkeepster. On the coast road between John o' Groats and Thurso, views are again limited, with a stretch along which turbines at Forss would be visible, and a few intermittent views of Achkeepster.

Figure 8.12. Example of land cover naturalness experienced from a route through Caithness (a brighter image equates to higher percentage naturalness).

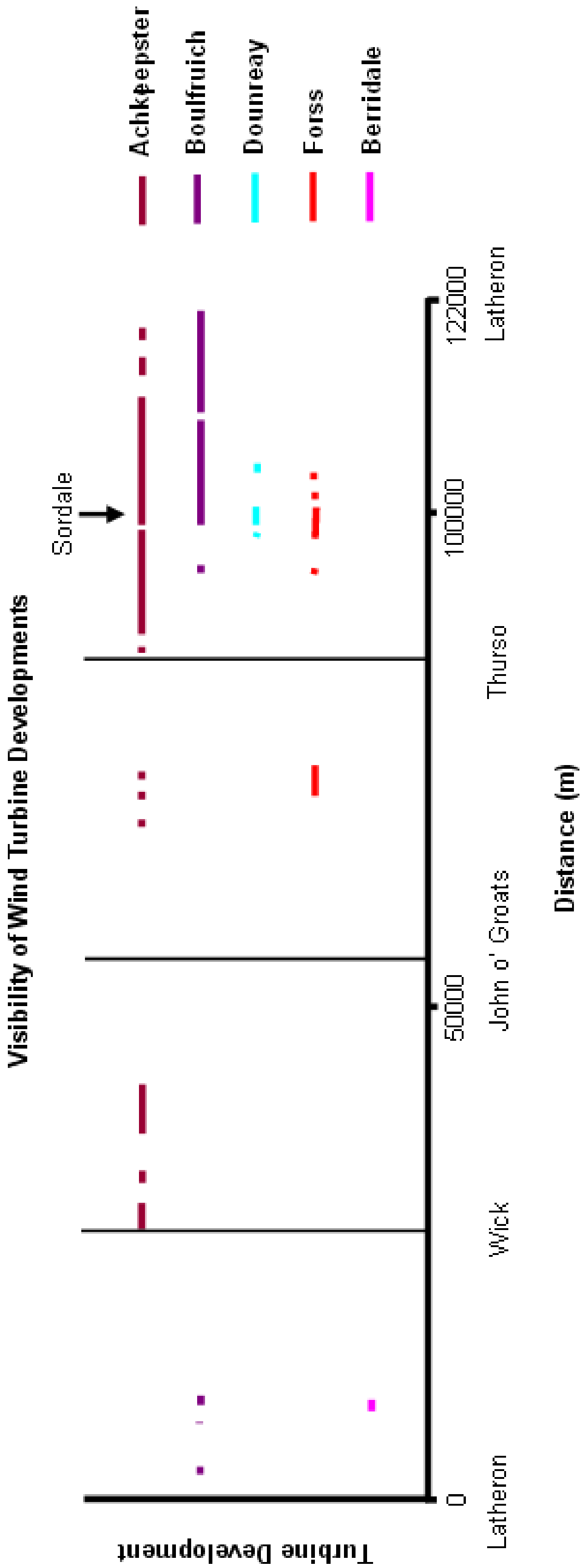




8.3.12 However, on the A9, between Thurso and Latheron, there would be more extensive views of several developments, with those the longest period of viewing being of Achkeepster, but views also offered of Boulfruich for the majority of that section of the route.

8.3.13 On one, small stretch of road (approximately in the vicinity of Sordale), four developments may be visible (Achkeepster, Boulfruich, Dounreay and Forss), although two would be in a southerly direction (Achkeepster and Boulfruich), and two to the north (Dounreay and Forss), thus not all would be in the same field of view.

Figure 8.13. Visibility of turbine developments in Caithness from a selected route.



Visibility of turbine developments at the five sites in Caithness used within the study. Each line represents the stretch of the route from which the development may be visible. Comparisons between each line for any one position along the route enables an interpretation of the combination of developments taht may be visible, and the frequency with which each development may be seen from the vehicle.

9 DISCUSSION

9.1 Study area and data

9.1.1 The extent of the study area could be modified to include some logical connections in the landscape, its visibility, or its use, such as an extension to the west coast along the road to Ullapool and the inclusion of all of the land visible from the road between Lairg and Tongue. This would produce an assessment reflecting the use of the landscape without introducing boundaries that may now be considered study specific. The results on the capacity and sensitivity mapping in Sections 5 and 7 extend beyond the agreed study area boundary as there is little difference in the landscape character of these areas and field observations included the land in its immediate vicinity.

9.1.2 Certain datasets are limited in their content, the consequences of which are discussed below, but other datasets are very limited. The most significant gap is data on the numbers of people that view the landscape, as noted in Section 6.2. This has constrained the aspects of the model that relates to this factor to an example which is considered incomplete for practical use across the area. This topic could make a significant impact upon the output of the modelling of landscape potential and merits being addressed in detail.

9.1.3 As described in Appendix A.III.VII with regard to railways, the funicular railway in Cairngorm has not been included in the analyses. This omission should be included in any improvements in the approach. Similarly, the routes of ski lifts could be added, and processed in a similar manner to that for LDRs and roads.

9.2 Field observations

9.2.1 There are some limitations to the approach taken to the selection of field observation points, and the sensitivity of the outputs has not been assessed with respect to all of these. The use of the eight cardinal points for recording the views at each point had the advantage of a standard approach which guaranteed a minimum coverage. This was recorded in a manner that could be readily converted into summary sheets for interpretation and verification of field notes at each point. They also provided a basis upon which individual measures of landscape character could be assessed and thus a field check upon the outputs from the spatial analyses (e.g. the complexity of land cover).

9.2.2 However, the field observations did not provide a panorama of the view at a point, and thus some key features could be excluded from the interpretation of the photographic records. The recording of the data also assumes an equal importance is placed upon the view in each direction, which is unlikely always to be the case. The imagery can be used for verification of the spatial analyses but, due to the lack of lateral overlap between the images, there will be gaps in the coverage of views in the directions that offer what may be regarded as the best quality views from a viewpoint. Therefore, the assessment of the content and qualities of the view may be underestimated when interpreted from this source of data.

9.2.3 The scoring system used includes a weighting, whereby there is more likelihood of a score occupying the middle range than either the higher or lower ranges. This is to reflect the expectation that there should be a normal distribution of scores with many more in the average range than at either extreme.

9.3 Spatial analyses

9.3.1 The spatial resolution of the analyses is a cell of 50 m x 50 m. This provides a representation of certain datasets that can be utilised at a strategic level, such as variation in altitude and slope. However, this resolution is higher than the relatively low variation in some of the other relevant datasets may merit (e.g. the LCA units). The content of the LCA data varies across the study area, from large geographical areas represented by a single polygon at the level of the basic classification summary levels (e.g. INV2, rolling uplands, in the Cairngorms) to units that are specific to the level of individual land cover polygons (e.g. CLS16, small farms and crofts, in Caithness and Sutherland).

9.3.2 The principle behind most of the analyses was to process the input data in terms of its potential visibility from each 50 m x 50 m cell, using a sample of 500 m x 500 m intervals for representation of the features (see Appendix A.III.II). This was possible for all of the land cover data, terrain visibility and all visible receptors. However, constraints on time prevented this being undertaken for the calculation of the range in terrain landforms. Therefore, it would be desirable to include a sensitivity test of the significance of such a calculation on the final capacity map, and combined map.

9.3.3 The analysis of visibility of the land takes no account of the character of the landscape, its structure, nor the potential contributions made by cultural features that may influence people's responses to changes in the landscape, such as the introduction of wind turbines. However, the analysis used does provide an indication of where changes in land use may be most visible, and the capacity map provides a basis for interpreting the significance of those changes with respect to measures of the character of the area.

9.3.4 A comprehensive evaluation of the datasets of landscape potential for turbine development would now incorporate a summary of the areas of land in the categories of the dataset that have been triggered by each rule as a proportion of that resource, for example, the area of upland moorland in Moray that may be included within a class of High Landscape Character Sensitivity Capacity and Low Visual Sensitivity, as a proportion of the total area of all upland moorland. This would enable the consequences of a decision to develop in such an area to be assessed with respect to the portfolio of the land resources of the study area. No such evaluation has been undertaken for the datasets presented.

9.3.5 Changes in the rules and processing of individual datasets could reallocate land between classes. Specific changes could have particular influence in certain geographical areas of the country, and exploring where those changes would occur, would require further sensitivity analyses of the models.

9.4 Scale

9.4.1 The derivation of data representing the scale of the landscape used elevation and terrain visibility as the key inputs, and each of these datasets rely upon the Ordnance Survey 1:50 000 DTM for their derivation. As noted in Appendix III with regard to elevation, the potential implications for the results of this study are that for any individual point, some areas of land may be hidden whereas analyses of the DTM may suggest that they would be visible, and others visible despite the analyses implying that they would be hidden. Across all observations for the study area, the RMSE (Root Mean Squared Error) quoted by the Ordnance Survey is likely to be valid, and thus errors in any one observation would be likely to be less than the view of a single building.

9.4.2 A study of the implications of using DTM data at different spatial resolutions as inputs to calculations of visibility of wind turbines (Miller 2000) showed that estimates of the areas of greater impact were smaller when using data at finer (10 m x 10 m or 1 m x 1 m) resolutions. At lower resolutions the level of visibility, such as in the output of cumulative impacts are likely to be over-estimated. Neither the estimates of error, nor the higher resolution data have been built into the intervisibility analysis because of the current implications for the level of processing. However, this technical improvement may be considered in future studies.

9.5 Naturalness

9.5.1 Amongst the limitations of deriving a measure of naturalness from the visibility of land cover types are the level of detail of the interpretation and classification of the source of land cover data. For example, the shape of land cover features is not taken into account. Therefore, no distinction is made between the perceptions of forest stands that are rectilinear in shape, compared with those that have boundaries that follow the underlying shape of the terrain. The omission of individual buildings, referred to in Appendix A.III.II, due to the level of detail within the 1:25 000 scale land cover dataset has the potential for reducing the level of naturalness compared to that recorded in the field, as individual features (such as small groups of buildings) will not be represented within the analyses.

9.5.2 These limitations are of direct relevance at the level of an Environmental Statement, and can be considered site specific. Their importance at the strategic level is low, and their significance was considered on a case-by-case basis for each of the field observations. These issues are discussed further in Appendix A.V.

9.5.3 The approach taken to analyse the extent of the naturalness of the landscape within a view has been based upon the visibility of the land cover types within a 10 km radius of view (as described in Appendix A.III.II).

9.5.4 However, not all visual cues that may suggest that a land cover feature has been significantly influenced by man are considered by the approach described. There are four examples that are of potentially the greatest significance.

1. The resolution of the content of the land cover data is insufficient to represent the variation in the spatial distribution of component features of certain classes. Therefore, classes such as those containing ‘scattered rock’ or ‘scattered trees’ are taken into account, but this dataset does not consider any emphasis of the visual impression of their presence (e.g. due to the clustering of either of these types of feature).
2. Scattered farmsteads have not been separated from agricultural land cover units within which no such classes are represented. This is because it is assumed that farmsteads will be synonymous with the agricultural land class (i.e. arable or improved pasture) and thus will not influence the over-riding impression of a non-natural landscape.
3. The shape of individual features may imply a greater or lesser degree of naturalness in the visual landscape. For example, rectilinear blocks of woodland would convey a sense of a non-natural landscape compared to one in which man’s influence has either been low, or in which feature design has mitigated effects of a non-natural landscape.
4. Evidence of heather burning has been accounted for by allocating the visibility of the relevant visibility classes for heather moorland to the natural (where there is no evidence of muirburn) or non-natural classes (where there is evidence of muirburn). However, the extent to which muirburn will be visually distinguished in the landscape depends upon several factors, including the length of time since the burning, and the slope and angle of view of the observer to the area of moorland. Therefore, the allocation of those areas within which there has been muirburn to the non-natural class may underestimate the apparent naturalness of the landscape.

9.6 Land cover complexity

9.6.1 The approach taken to analyse the complexity of the land cover in the view has been based upon the visibility of the land cover types within a 10 km radius of view (as described in Appendix A.III.II). As with the derivation of measures of naturalness, not all visual cues will be considered adequately by the approach adopted. For example, evidence of muirburn may not be interpreted by all observers as increasing the apparent complexity of the land cover, as it may still be considered as evidence of heather moorland, and the presence of grasses may not detract from that general impression. Therefore, the allocation of areas of muirburn will potentially over-estimate the impression of land cover complexity.

9.6.2 Limitations include the lack of detail recorded within the land cover data, and thus the scale of the content. However, the inclusion of a class that relates to rockiness and cliffs contributes information on a class that is inherently more complex than other land cover types. Similarly, individual buildings outwith agricultural areas will not be represented within the analyses, therefore potentially reducing the level of land cover complexity compared with that recorded in the field.

9.6.3 Finally, the classification of wind turbine developments could be further incorporated into the assessment of land cover complexity, by considering them as a unique land cover type and not only as an extension to the influence of man on the landscape.

9.7 Landform complexity

9.7.1 The use of a small-scale dataset that represents landform (at a cartographic scale of 1:250 000) will be inadequate to convey detail in the texture of the surface (e.g. the structure of individual rocks, and variability in the size of rock outcrops). The approach adopted has not been as comprehensive as that for land cover complexity, naturalness or scale, where measures of land visibility underpin most of the calculation. The use of variation in elevation as the principal measure of landform complexity does not fully convey the sense of convexity or concavity, nor features such as ridgelines.

9.7.2 However, as noted in the comparison between landform complexity and the mapped data on landform, these appear to represent the key aspects of variation that are relevant to the assessment of character with respect to sensitivity to wind turbine developments.

9.7.3 The alternative illustrated approach, which used mapped areas of mountainous characteristics in combination with elevation range and the visibility of cliffs and rockiness, will still underestimate the potential visibility of mountainous land. The geographical extent of the visibility of mountains could continue well beyond the areas mapped.

9.8 Visual sensitivity

9.8.1 The use of a 10 km radius of view for the roads, railways and LDRs could be increased to match the 25 km of the static viewpoints. This would require greater processing time, but could be completed over a period of a month. However, it would be preferable to include a distance decay element to the model, which has been tested under different viewing conditions (e.g. different atmospheric conditions and potential pollution climates).

9.8.2 The derivation of datasets of visibility for the road, rail and footpath network for the entire north of Scotland also enables a more rapid application of the methodology outside the boundary of the current study area. Alternative options for modelling the cumulative visual impact of developments is also feasible as this can incorporate the potential sensitivity on routes between sites (e.g. locations of visitor interest), even if one or both ends of the route are outwith the study area.

9.8.3 The lack of data on the use of each type of viewpoint limits the potential to weight the sensitivity map. A more comprehensive search for sources of data may provide a better basis upon which to consider the differences in sensitivity with respect to the number of people who view the landscape. Access to additional data on user numbers may also be supplemented by data on the identification of the landscape, or views, as a significant reason for visiting sites. However, there is a risk that the use of such data may be too simplistic and offer no real insight as to the relative importance of active or passive viewing of landscape. It also offers no direct link to assessments of public attitudes towards change within the landscape.

9.9 Landscape value

9.9.1 The representation of landscape value has proven to be one of the most challenging issues to address. It has been recognised in the methodology that the value of landscape cannot be simply represented via digital spatial datasets. However, some of the characteristics that contribute towards landscape value, as assessed in the field, can be associated with the units of the data of the Landscape Character Assessment.

9.9.2 The approach taken, of a model of landscape value in which the field observations were combined with the descriptions provided by the LCA data, gives the user of the landscape potential, landscape character sensitivity and visual sensitivity datasets an additional basis for drawing conclusions about the suitability of the landscape to the introduction of wind turbines in a general area. Here the study would benefit from further field observations, increasing the depth of coverage of the underlying data for expert interpretation of the potential significance of the local landscape.

9.9.3 The assessment of landscape values could also be complemented by consultations and surveys, to identify attitudes towards changes in the landscape, and those landscape issues that rank as most significant in public opinion. Surveys are undertaken using conjoint analysis techniques, in which views of landscapes are scored according to preferences, and subsequently assessed against the factors used in predicting landscape sensitivity and landscape value. This provides one means of calibrating the predicted scores, for involving local opinion, and without raising the specific issues of wind turbines. The outputs could be used in the selection of alternative weightings for the derivation of models of landscape character sensitivity and visual sensitivity.

9.9.4 A separate survey could be carried out, using visual imagery, to assess the potential significance of the introduction of wind turbines into the landscape, and thus into views that represent different levels of landscape potential.

9.10 Landscape potential

9.10.1 The incorporation of the viewsheds of turbine developments within the classification of both land cover complexity and naturalness provides one means of measuring their effects on the landscape character element of the model. However, a consequence of this approach is that it could be self-reinforcing, in that the introduction of turbines will change the landscape potential dataset progressively such that it may imply an increased opportunity for more turbines. The balancing factor of the datasets of visual sensitivity and value will not be influenced. Therefore, it is the role of the cumulative visual impact element of the models to indicate the geographical distribution of the potential ‘hotspots’ with respect to the sensitivity datasets. This implies the potential for a feedback loop between the introduction of turbine developments and the assessment of the landscape’s capacity and sensitivity to such developments. The modelling work undertaken in this study has not sought to automate such feedback, but this would appear to be possible, although requiring work on calibration and possible linkages to studies of public attitudes.

9.10.2 The SNH policy statement on renewable energy (No. 01/02) (SNH 2002b) notes that there is likely to be a need for change to be accepted in some of Scotland's landscapes'). The results from this study suggest that some areas may have the capacity to accept the introduction of some wind turbine development, where the sensitivity to change may be relatively small.

9.10.3 However, the assessment of sensitivity will always be subject to site-specific factors, and conditions may apply which mean that the worse case scenario of lighting and atmosphere could still imply an unacceptable level of visual impact due to development.

9.10.4 The descriptions of output relating to landscape character sensitivity to wind turbine developments can be used to '… steer development which is of a scale (individually or cumulatively) that changes landscape character towards areas where the landscape is already developed or visually man-modified …'. These areas have been shown to tend to be consistent with the policy statement which notes that visually man modified landscapes may be '... relatively close to centres of population. Such areas may include agricultural land, forests or brownfield land …'. However, in this study forested land was dealt with in two opposite ways: coniferous woodland was classified as being influenced by man; and semi-natural and broadleaved woodlands were classified as being mainly natural.

9.10.5 The outputs from the overlay of the landscape character sensitivity and visual sensitivity datasets appear to be consistent with many aspects of the Policy Statement, but the use of the visual sensitivity data will direct away from these same '… centres of population.' The correctness of the areas identified as being most suited to development in Section 7 could be tested further by:

1. Modification of the rules used in deriving the classification, such as including more information on the use of the landscape (as noted in Section 6.2).
2. Conducting a study into public attitudes, stratified by the classes of the final map of landscape potential.

9.10.6 The second option could assist in identifying where the acceptability of turbine developments may be more or less associated with landscape related issues in different parts of the country. For example, attitudes towards the landscape and development may vary between areas that have scored equally highly in terms of visual sensitivity, but in one site due to visibility from settlements, and another visibility from the road network. The ability to address this type of interrogation of the data is one advantage of the methodology adopted, and the use of the GIS tools.

9.10.7 The objective of protecting 'Areas which are highly valued for recreation and amenity …' is directly represented within the logic of the visual sensitivity map, although not all areas of recreational value may be adequately represented. Omissions include inshore recreational activities and passive use of landscape when walking across open land.

9.10.8 The study also enables some limited consideration to be given to issues of inshore turbine developments, including the use of oil industry structures, where close to shore. This should enable support for the SNH Policy Statement objective of encouraging such activities where they are 'Outwith areas of high scenic or marine wildlife value …'. Indeed the methodology should support '… the strategic identification of appropriate locations …'.

9.10.9 Finally, in this study there has been no assessment of the landscape factors related to wider consideration of changes in land use, such a other built structures, or other sources of renewable energy which could include short-rotation coppice, wave, hydro-electric, or tidal sources of power.

9.10.10 An overview of the applicability of the models of landscape character sensitivity, in combination with the national LCA, could be undertaken. The value of such an overview is that several factors may be considered together, such as:

1. The capacity of the landscape to accommodate other sources of electricity from renewable sources.
2. Identification of potential competition for resources in the same geographical area for different means of electricity production, and the combined impacts on the landscape from development of renewable energy from more than one source (e.g. small scale hydro and wind energy).

9.10.11 A final element of the evaluation of the development scenarios is the role of the dataset of landscape potential in strategic planning and the linkage between the identification of sites offering potential for development with site-specific measures of impact assessment. The provision of information at a site level from certain datasets derived in this study for each area could only be used as a guide and as an input to inform the Environmental Statement. However, the analysis of potential cumulative visual impacts can directly accommodate any proposed development.

9.10.12 The analysis of offshore wind power production has been limited. This is partly due to the limited scope for making observations in the offshore environment. There is scope for further work on this topic, possibly by using photographs, montages or computer visualizations to inform modelling of such environments. This may attract greater attention in the near future and for which combinations of resource potential, and other constraints, may be combined with the landscape models.

9.11 Cumulative visual impact

9.11.1 The approach to assessing the potential cumulative effects of turbine developments illustrated in this section can be extended by consideration of the landscape character of the locations of the developments, and the classification of development type as described in Section 5.2.

9.11.2 The examples of the cumulative visual impact of wind turbines presented for the Moray and Caithness areas would, in practice, include exposure to wind turbines from a number of directions, and cumulatively when travelling along the roads. To assess the effect on the observer of such a sequence of views would benefit from experimental work on driver and passenger attitudes to the experience. This could be facilitated by visualizations of the scenes viewed from the routes under different conditions.

9.11.3 As noted in Section 8.3, consideration of the cumulative impact of turbines is more than only a question of the number of developments visible at any location. The value of the work on cumulative assessment in combination with landscape character sensitivity and visual sensitivity is that it is now possible to assess one contribution that turbines make to the landscape at any specified point, or along a transport route. Further assessment can be made, for example, of the impact on the naturalness of the landscape. Thus a direct link can also be made to the contribution that additional developments may make to the complexity of the land cover and use.

9.11.4 The significance of this part of the study would benefit from subjecting it to a survey of public attitudes to turbines. This would enable calibration of the length of time, and number of turbines, that would be considered to make a significant, negative, impact on the landscape.

10 FUTURE METHODOLOGICAL DEVELOPMENTS

10.1 Methods

10.1.1 The methods used, or developed, within this project have provided a basis for identifying areas where there may be the greatest landscape character sensitivity and visual sensitivity to wind turbine development. The results should be considered as indicative of where visual impacts may be more or less depending upon the landscape character and local viewpoints.

10.1.2 The methods used in the development of the landscape character sensitivity and visual sensitivity datasets enable some flexibility in the development scenarios that may be considered. Specifically, testing can be undertaken of alternative input data to test new hypotheses on the representation of landscape potential to wind turbine developments. The approach, although developed within ERDAS IMAGINE, can be implemented in most GIS packages, with only the nature of the implementation and testing differing.

10.2 Data

10.2.1 The application of GIS in the provision of information to aid in decision-making can be limited because of the lack of suitable data, either due to inappropriate scales, low reliability or unavailability of data on the topic. Although the approach used enables weights to be allocated to different datasets, the outputs depend upon the weightings used, and simplifications necessary in such combinations should be recognised so as not to over- or understate the significance of change in any particular area.

10.2.2 Priorities for future work could focus on the following topics:

1. consideration of the significance of the designation of the Cairngorms and surrounding area as a National Park.
2. testing and inclusion of land cover and use data from new sources, such as the Ordnance Survey and the National Woodland Inventory.
3. combining the landscape character sensitivity and visual sensitivity datasets with a wider strategic appraisal of potential constraints to wind turbine development.
4. maintenance of the underlying spatial database to ensure currency of the basis of the geographic models.
5. testing of the levels of the sensitivity classification using surveys of public attitudes towards wind turbine developments.

10.2.3 The use of the LCS88 data has a number of limitations, principally in terms of the date of compilation. The source data is aerial photography from between 1988 and 1991. There have been changes in land cover, such as the planting of new coniferous woodland, since the collection of those data, which will have had some consequences on the derivation of certain datasets, such as land cover naturalness and complexity. No sensitivity test has been conducted on the significance of changes in land cover, but note was made of these changes when conducting the field assessments.

10.2.4 It is also acknowledged that there is potential for misclassification between woodland and other classes, i.e. the classification of a non-woodland class as woodland, or the classification of woodland as non-woodland, and between the woodland classes used. However, some errors in interpretation will probably have a minor impact on the results of the analyses in this study due to the groupings of land cover types within the rule bases. For example, errors in interpretation between heather moorland without evidence of muirburn, and peatland vegetation, are likely to be masked because such classes are grouped together within the derivation of naturalness.

10.2.5 The most accurate dataset of woodland will be that of the woodland inventory of the Forestry Commission. This dataset is compiled from aerial photographic interpretation and extensive field data, and is being continually revised and updated as relevant information becomes available. However, the data is not generally available external to the Forestry Commission and thus access may be a future option that could be considered and negotiated. The use of the OS Master Map dataset (Ordnance Survey 2002f) would provide the most widely available data, of geometric accuracy of woodland data, and that of the urban areas. The maintenance of data currency for features such as woodland is the subject of on-going discussion between Ordnance Survey and the user community.

10.2.6 It is not possible to subdivide the types of urban or built land from the datasets used in this study. In contrast to the underestimation of the sensitivity of views from settlements due to the omission of small hamlets or clusters of buildings in rural areas, the level of sensitivity from larger settlements may be overestimated. This is because the latter includes all land within such a settlement and thus could be interpreted as scoring views from buildings the same as from parks, shops or brownfield sites. However, such overestimation is likely to be marginal with the objective being a strategic overview, and the analyses do not seek to represent actual views from individual buildings.

10.2.7 Future developments in methodology could also consider a comparison to be made between analyses using polygonal data such as that of LCS88, or the Ordnance Survey Master Map dataset, with a point-based representation of buildings using the Ordnance Survey Address Point dataset (Ordnance Survey 2002d). The Address Point data would have the advantage of representing each building individually, and on the same basis as other point-based data such as viewpoints, Munros and Corbetts.

10.2.8 Use of the Ordnance Survey Master Map dataset as an input could also offer advantages for future improvements, because of the level of detail with which it represents geographical objects related to relevant land uses. For example, analyses of data at this level of detail would enable the incorporation of algorithms to consider the presence of boundary features such as fences and walls, and individual buildings across any area of Scotland. The two principal reasons why these data were not considered are:

1. the extensive processing that this would have necessitated.
2. analysis that may be considered too close to that of site specific Environmental Assessments.

10.2.9 In the near future, it is likely that strategic assessments will be made at larger cartographic scales to facilitate demands for combining data at greater levels of detail. A similar argument is likely to be applied to the use of digital representations of terrain.

10.2.10 Future developments in the derivation of landform complexity would be able to use the identification of the mountainous areas from a combination of landform data and ranges in elevation, and use these as inputs to the calculation of visibility, in a similar fashion to that used in the analysis of land cover complexity. This approach would produce a dataset that was not sensitive to the visual shielding of mountainous features by intervening land.

10.2.11 An improvement to the sensitivity map would include the extension of considerations of landscapes to include data on historic landscapes using the Historic Landscape Assessment (HLA) from Historic Scotland. Currently, there are few parts of the study area for which there is HLA data. The exceptions are around the Cairngorm Mountains and Strathspey.

10.2.12 The most significant factor associated with the data will be to maintain its currency. Changes in land cover, the development of new roads, introduction of new LDRs or visitor attractions, and the construction of wind turbines developments will all contribute towards changes in the landscape potential of the area with respect to the visual impacts of wind turbines on the landscape, directly or cumulatively. Joining-up national data infrastructures such as the data collections activities of the Ordnance Survey, Forestry Commission and Scottish Natural Heritage may assist in linking strategic planning of changes that affect the landscape.

10.3 Outputs

10.3.1 The outputs from the strategic modelling have not dealt extensively with the topics of reporting or presentation of the results, both of which are important elements in the process of supporting decision making. Outputs may be more usefully restructured around any specified spatial unit to provide an input to further analysis. Examples include restructuring according to local authority boundaries and sub-areas or access to appropriate electricity infrastructure.

10.3.2 The relationship between landscape potential and LCA units has been addressed by associating the descriptions of the LCAs with the spatial units of the capacity maps. However, the diversity in characteristics such as landform within the LCA units is such that such an association remains only indicative. The user can be informed of the nature of the landscape components, its sensitivity to turbine developments, the levels of visual sensitivity that are relevant at any one location, and therefore the basis for the assessment of landscape potential for turbine development. The figures in the report are 'views' of the underlying database, but the digital datasets provide the basis for assisting in informing the user of the issues pertinent in a general area, and the landscape factors that may be of most significance when considering an application.

10.3.3 The options for reporting the assessment of landscape potential raise some methodological issues, and a few principal issues, in terms of the provision of accessible materials to a wider range of stakeholders. However, some opportunities for communicating the results in ways that are of most relevance to users and decision makers could be considered. For example, in assessing the potential for different areas to contribute to achieving targets for renewable energy production, consideration could be given to the combination of models of wind resources, the capacity to absorb wind turbines, and the sensitivity of the landscape to accommodate such changes. The reporting of the outputs from such a combination could be geographically specific, but based on sub-dividing local authority areas based upon factors other than administrative boundaries. The risk of misuse or misunderstanding of the datasets is always present, but providing such outputs in a digital form may assist in raising awareness of the wider issues associated with renewable energy, and facilitates evaluation by converting the GIS data to an interactive map-based format accessible via the Internet.

10.4 Cumulative issues

10.4.1 The issue of cumulative impacts remains one of the most problematic to resolve in an unambiguous manner. The current study could form the basis of a more specific strategic analysis on site suitability for windfarm development in Scotland. It is suggested that it would be useful to identify those areas that would be preferable for windfarm development to maximise the generation capacity while minimising the visual impact. The purpose of such a procedure would be to enable Councils and SNH to make proactive decisions on windfarm development and avoid the necessity of having to refuse a good planning application because an earlier decision allowed a development in a location whose prominence gives an unduly great contribution to the cumulative impact of other proposals. In other words a windfarm development application, considered in isolation, may appear to represent a sound proposal but carries with it (if approved) a heavy opportunity cost in terms of the acceptability of any further windfarms in that area.

10.4.2 The question can be simplified into two parts:

1. What is the threshold for the number of windfarm developments in an area?
2. Which sites would result in the lowest visibility?

10.4.3 The answers to both these questions are inter-dependent to a certain extent because the threshold may be set higher due to keeping the curve of visibility lower. This can be resolved by combining the output of this study with wind data to narrow down the suitable areas to suitable sites with potential for economic electricity generation. Large contiguous areas may need to be subdivided for further analysis purposes, by identifying the most suitable/likely portion of such areas (e.g. hill tops as opposed to valley sides or bottoms). Having identified a set of hypothetical windfarm sites, the order for development that keeps the cumulative visual impact as low as possible could then be determined. Ordering the developments is performed to determine the most suitable sites and help to determine the cut-off threshold. The order would not be intended to represent the actual sequential order of development but to identify the best sites.

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