5.2. Bréifne Area Landslides Susceptibility Mapping

Xavier Pellicer

Plate 5.1 Rotational landslide and subsequent rock falls occurring in Cuilcagh Mountains, County Leitrim.

5.2.1 Introduction

The aims of this project were to identify and map landslide occurrences in the Bréifne Area in north-west Ireland; to produce a landslide susceptibility map using GIS; and to test a first approach for a methodology for systematic landslide mapping for the whole of Ireland.

The Bréifne Area is located in North West Ireland covering parts of County Sligo, County Cavan and County Leitrim in the Republic, and County Fermanagh in Northern Ireland (Fig. 5.10). It covers an area of 3082 km^2. Due to the lack of readily available datasets such as a DEM and air photographs for County Fermanagh it was decided to exclude it from the study area. The final study area therefore covers a total area of 2129.7 km^2.

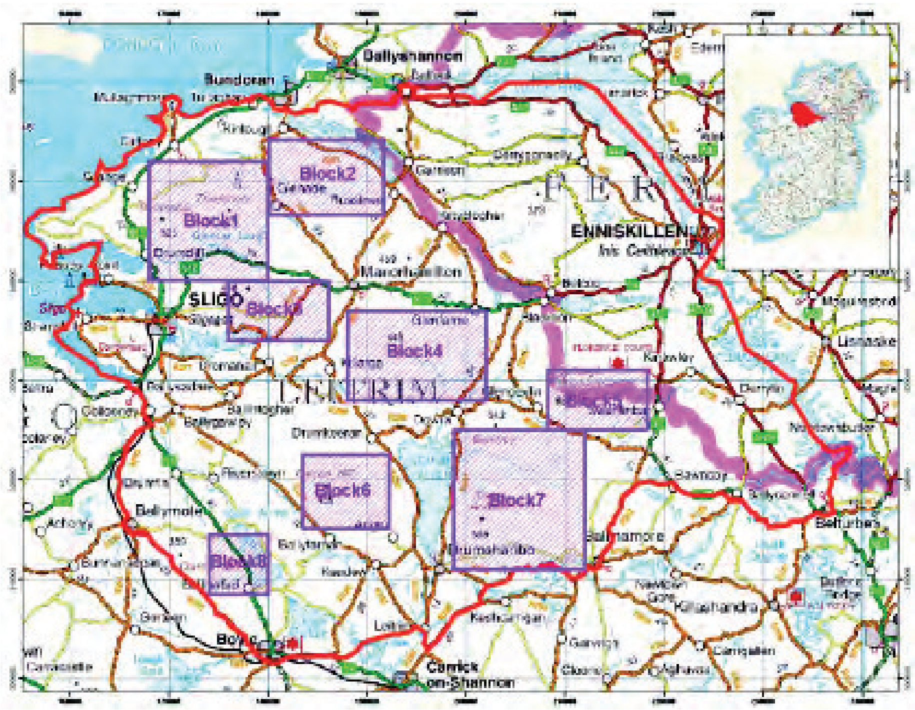


Fig. 5.10. Bréifne area outlined in red. Location of areas where landslide mapping has been focused outlined in purple.

The methodology used to derive the final susceptibility maps was compiled from several literature examples (Santacana et al. 2003, Tangestani 2003, Morton et al. 2003). Due to the large extent of the study area (2129.7 Km^2) and the short length of time available for fieldwork (less than one month), mapping was mainly based on remote sensing techniques such as satellite imagery, aerial photography and orthophotography analysis. All these datasets were combined with digital elevation models (DEM) to facilitate identification and classification of landslide events.

5.2.2 Datasets

The datasets used during the landslide mapping and analysis are displayed in Tables 5.1 and 5.2. All datasets have been tested and a selection was finally made for this project. This decision was based on the scale or resolution of the dataset. High spatial resolution datasets (>1:20,000) have been found to be more efficient for landslide mapping.

Several **thematic datasets** were viewed and compared to assess which ones would be used during the final analysis. Landcover, Bedrock Geology, Quaternary Geology and rock outcrop maps were available for the project and details of these datasets are displayed in Table 5.1. Several landcover maps were available for this project. The Landcover Thematic map supplied by Teagasc was considered the most suitable. Some areas of this dataset were characterized as “Unclassified” and in those areas the Corine landcover map was used to input the class instead. Other thematic datasets used were a Bedrock Geology map at 1:100,000 scale from the Geological Survey of Ireland (GSI) and the Irish Forestry Soil (IFS) parent material maps (available only for Co. Sligo and Co. Cavan) produced by the Spatial Analysis Group in Teagasc.

With regard to **digital datasets**, satellite images were analysed following the methodology used by O’Loingsigh (2005). Landsat ETM+ imagery was not selected as the landslide mapping dataset due to its poor spatial resolution. The EPA/Teagasc DEM with a spatial resolution of 20m was used to generate aspect and slope maps for the area. The combination of black and white orthophotography from 1995 with the DEM using © Fledermaus software, for 3D visualisation, was utilized to map and classify most of the occurrences. This method was compared to digital stereophotography, which was employed in areas where no other elevation data was available.

5.2.3 Methodology

The methodology used is based on a literature review and fieldwork experience. The large number of events mapped dictated which method would be used to produce a landslide susceptibility map. It was decided to use statistical analysis on the data acquired. Fig. 5.12 shows a schematic representation of the methodology employed.

Dataset processing

Following the approach used by O’Loingsigh (2005) Landsat ETM+ imagery was analysed using ERDAS software. The image was pre-processed in order to improve the spatial resolution using the following steps:

1. 6 multispectral bands and panchromatic image were re-projected to Irish GRID using Nearest Neighbour as the resampling method.
2. Image was resampled to 15 metres resolution using a resolution merge method where the panchromatic image was the high-resolution input file. Principal component analysis was the method utilized, and Cubic Convolution was the resampling technique.
3. Image was projected with RGB 542.

Large landslide scars can be observed in Image 1 (Fig 5.11) displayed in magenta and outlined in green. Comparing this to Image 2 (colour orthophoto for the same area), it can be observed how some smaller features cannot be identified in the Landsat image due to pixel size or shadow effect (area outlined in blue). Changes in vegetation in Image 1 gives the same response – magenta area outlined in red – as landslide scars. This could lead to misinterpretation.

Use of Landsat imagery can be useful when no other imagery at a higher resolution is available. Due to availability of colour and black and white orthophotography data with a 1 metre spatial resolution for the study area, Landsat imagery was discarded as a mapping tool.

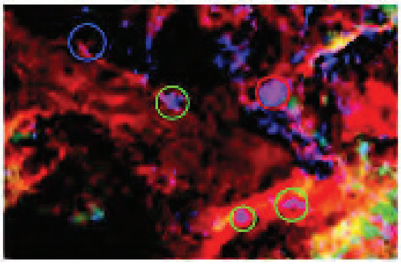


Image 1. Satellite image displayed at 1 to 15,000 scale. 15 metres resolution. RGB 542

Image 2. Colour orthophotography displayed at 1 to 15,000 scale. 1 metre resolution.

Fig. 5.11. Satellite image and aerial photography for same area.

Three main types of aerial photography were used for landslide mapping and classification:

- 1995 black and white national digital stereophotography at 1:40,000 scale.
- 1995 black and white national digital orthophotography at 1:40,000 scale.
- 2000 colour national digital orthophotography at 1:40,000 scale.

Digital Elevation Models at 20m resolution for the area were generated from the EPA DEM in the Republic. The ERA Maptec DEM (50m spatial resolution) for the area in Northern Ireland was resampled to 20m resolution. Datasets for the Republic of Ireland and Northern Ireland were merged to create a unique DEM for the Bréifne Area at 20m spatial resolution.

Slope analysis was evaluated on the 20m resolution EPA DEM and the resampled (20m resolution) ERA Maptec DEM. There was no variation between the two datasets.

Slope analysis was evaluated between 20m EPA DEM and the original 50m resolution ERA Maptec DEM. Differences were spotted in this case. A larger area is covered in the EPA DEM when selecting areas with slope greater than 15°.

The dataset produced from merging the EPA DEM at 20m resolution for the Republic of Ireland, and the ERA Maptec DEM resampled at 20m resolution for Co. Fermanagh, was selected as suitable for further analysis.

The criteria outlined in Chapter 5.1 - "Peat is in excess of 0.5m thick or where the peat slope angle is greater than 15° "- were used to identify potentially vulnerable areas. Peat covered areas were selected from the Teagasc Land Cover map 2004 for the whole area, and from the IFS parent material maps for Counties Sligo and Cavan. Areas with slopes greater than 15° were selected from the slope map derived from the DEM.

Landslide Mapping by Image Analysis

The area of study was reduced to 8 sub-areas (Fig 5.10), named Blocks 1 to 8. These blocks were selected using the following parameters:

- Areas covered by peat.
- Areas with slope gradient >15°

The block areas were created to enable the use of Fledermaus software. The 8 blocks were located based on the number of landslides discovered during a preliminary scanning of the areas defined by the two criteria above using aerial photography. The area covered and the number of events occurring in each block is shown in Table 5.5.

Block Number	Area (sq. km)	Number of events mapped
1	143.4	269
2	90.4	92
3	60.8	22
4	12.6	82
5	60.6	83
6	59.9	38
7	151.7	98
8	35.8	0
Total	615.2	684

Table 5.5 Area and number of events identified in each block.

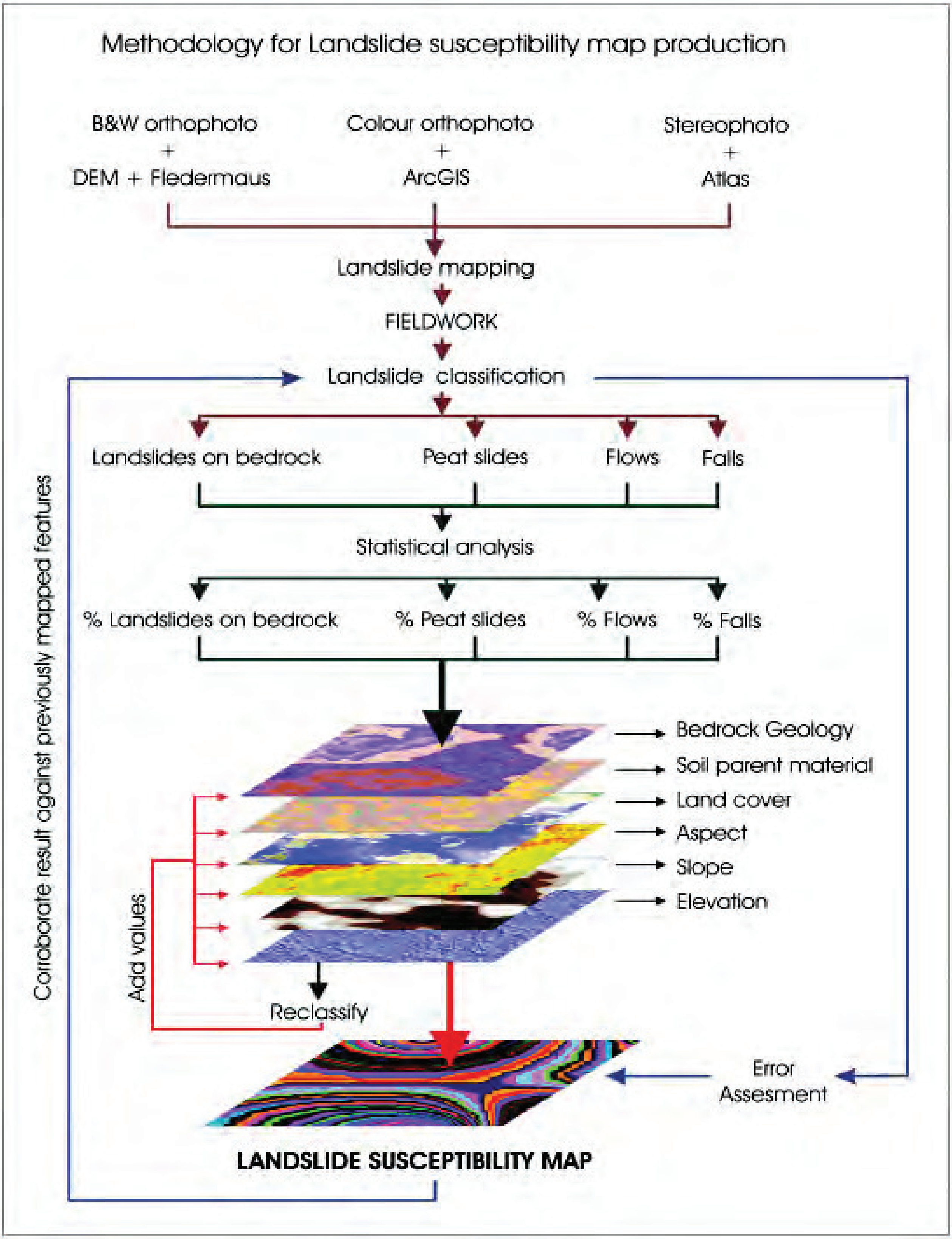


Fig. 5.12. Landslide susceptibility mapping methodology

Black and white orthophotography was merged for each block separately. It was subsequently processed using ArcGIS software in order to obtain an image with superior contrast and quality. Block areas were draped on a 20m spatial resolution DEM and displayed with Fledermaus software. Due to problems arising during the resolution merge in ArcGIS, the orthophotography had to be resampled to 2m spatial resolution. Use of Fledermaus software greatly improved the display and understanding of the landslide mechanism operating in each slide. This greatly enhanced identification of landslide occurrences and this was the key software for landslide identification and classification. Events were simultaneously digitised using ArcGIS 8.3.

170 events were mapped with the Teagasc digital stereophotography using Atlas software. Its more accurate elevation values permitted the detection of events not recognized by other methods. In addition, areas outside the blocks were also surveyed using this method. A total of 23 events were located outside the blocks.

The following parameters were recorded and digitised during landslide identification:

Location of landslide crown.

Landslide length and orientation.

Landslide class based on type of movement and mechanism. A list of codes used for classification is shown in Table 5.6.

The classification obtained was checked, corroborated, and refined during subsequent fieldwork.

A total of 694 events were identified, digitised, classified and stored in an Access database, prior to field investigation.

Fieldwork

The first stage of the short fieldwork programme involved visiting sites where good examples of landslides had been recorded during image analysis. The second stage of the fieldwork was focused on visiting sites where the landslide classification using aerial photography required further investigation.

A total of 52 landslides were recorded. There were 17 peat slides. There were 18 rotational bedrock slides with associated rock falls and debris flows. 5 events were classified as falls and topples occurring in both bedrock and earth; rock falls were recorded on limestone or sandstone bedrock while rock topples occur on strongly jointed sandstone bedrock. A single earth flow and a debris flow were recorded on shale bedrock. 10 events were classified as complex in that they involved more than one mechanism.

98 digital photographs were taken and their orientation and location was recorded. They are stored in the Bréifne landslide database.

Landslide dimensions were difficult to record during fieldwork, especially for large-scale landslides. Use of the DEM and aerial photography was found more suitable for this purpose.

About 30% of the 52 landslides recorded during fieldwork were incorrectly or insufficiently classified during the previous image interpretation. 50% of the peat slides classified during image interpretation had been erroneously categorized. Several events classified as bog bursts had to be reclassified as peat erosion features. Conversely, some areas classified as peat erosion or peat creep during image interpretation, were in fact found to be bog bursts. Events classified prior to the fieldwork were revised using the imagery and reclassified where necessary.

Fieldwork was essential to properly categorize and catalogue land movements previously identified and classified using the aerial photography images.

Landslide Classification.

Landslides were classified using a coding system (Table 5.6) especially created for this project. The final classification was based on the classification of landslides types used by the British Geological Survey (Northmore, 1996). The peat classification used was that of Boylan (Personal communication, 2005).

In total 694 events were classified from the image interpretation. They were divided into four groups:

- Peat slides
- Bedrock slides
- Flows
- Falls*

CODE	NAME	DESCRIPTION
FALLS		
FA_FR	Rock Fall	Mass detached from steep slope/cliff.
FA_FD	Debris Fall	Mass of coarse material detached from steep slope/cliff.
FA_FE	Earth Fall	Mass of fine material detached from steep slope/cliff.
FA_TR	Rock Topple	Mass detached from steep slope/cliff with forward rotation about a pivot point.
FA_TD	Debris Topple	Mass of coarse material detached from steep slope/cliff with forward rotation about a pivot point.
FA_TE	Earth Topple	Mass of fine material detached from steep slope/Cliff with forward rotation about a pivot point.
FA_U	Undifferentiated Fall	Undifferentiated mass detached from steep slope/cliff.
SLIDES		
SL_RSI	Single Rotational Slide	Sliding outwards on one concave failure surface.
SL_RM	Multiple Rotational Slide	Sliding outwards on more than one concave failure surfaces converging on main surface.
SL_RSC	Successive Rotational Slide	Sliding outwards on more than one successive concave failure surfaces.
SL_RU	Undifferentiated Rotational Slide	Undifferentiated rotational movement sliding outwards on one or more concave failure surfaces.
SL_TR	Translational Rock Slide	Rock sliding on a planar failure surface running more or less parallel to the slope.
SL_TD	Translational Debris Slide	Debris sliding on a planar failure surface running more or less parallel to the slope.
SL_TE	Translational Earth Slide	Earth sliding on a planar failure surface running more or less parallel to the slope.
SL_TU	Undiferentiated Translational Slide	Undifferentiated material sliding on a planar failure surface running more or less parallel to the slope.
SL_MADE	Slide caused by human activity	
SL_U	Undifferentiated Slide	Undifferentiated Bedrock Slide.
SL_PT_B	Bog Burst	Catastrophic failure of structural and hydrological integrity of a peat bog causing peat flow
SL_PT_U	Undifferentiated Peat Slide	Peat slide, unknown mechanism
FLOWS		
FW_D	Debris Flow	Flow of saturated mass of coarse material (gravel or coarser)
FW_E	Earth Flow	Flow of saturated mass of fine material (clay, silt, sand)
FW_S	Solifluction Flow	
COMPLEX		
CX_RT	Complex Rotational /Translational Slide	Composite non-circular part rotational/part translational slide grading to earth flow at toe
CX_FRD	Complex Continuous Rock Fall	Continuous process generating scree deposits.
CX_SFWEFR	Complex Slump-Earthflow with Rock fall debris	Slide involving rotational movement, simple or multiple, and earth flow and rock fall debris on the surface
CX_UND	Complex Undifferentiated Slide	Slide involving two or more of the main movement types in combination
CX_DE	Complex Debris flow	Debris flow involving two or more mechanisms and materials.

Table 5.6. Landslide classification (Northmore, 1996) modified. Peat classification by Boylan (Personal communication, 2005).

** 14 Topples were mapped during the project, statistical analysis with this small sample may be misrepresentative. It was decided to categorize them as falls.*

Landslide classification figures for the 694 events are shown in Table 5.7. It was decided to omit the man-made slides from the analysis, therefore, a total of 691 events were used for the statistical analysis.

Statistical Analysis

Landslides mapped during image interpretation and fieldwork were coded as seen in Table 5.6. Landslide classes were treated separately during the statistical analysis. The literature review and the fieldwork observations reveal that factors triggering landslides differ depending on the landslide type. The division of the landslides into the four groups described above was considered the best approach to get an adequate number of slides for statistical analysis, and to group slides where triggering and conditioning factors are be similar.

The conditioning factors treated during the statistical analysis are listed below. Other conditioning factors such as rainfall or structural geology were not included as the available datasets were not suitable for this exercise:

Bedrock type

Soil parent material

Land cover

Slope

Aspect

Elevation

Type	Mechanism type - code	Number of events
Bedrock Slides	Multiple Rotational Slide - SL_RM	5
	Single Rotational Slide - SL_RSI	2
	Undifferentiated Rotational Slide - SL_RU	85
	Translational Debris Slide - SL_TD	2
	Translational Rock Slide - SL_TR	4
	Complex Slump-Earthflow with Rock fall debris - CX_SFWEFR	4
Total		**102**
Peat Slides	Bog Burst - SL_PT_B	131
	Undifferentiated Peat Slide - SL_PT_U	99
Total		**230**
Flows	Debris Flow - FW_D	41
	Earth Flow - FW_E	14
	Complex Debris flow - CX_DE	23
Total		**78**
Falls	Rock Fall - FA_FR	108
	Debris Fall - FA_FD	9
	Earth Fall - FA_FE	6
	Rock Topple - FA_TR	14
	Complex Continuous Rock Fall - CX_FRD	144
Total		**281**
Other	Slide caused by human activity - SL_MADE	**3**
TOTAL		**694**

Table 5.7. Number and type of landslides mapped.

The percentage of events occurring on each of these six conditioning factors was computed. This percentage was subsequently applied to measure the weight of each conditioning factor for the susceptibility map production (*e.g. 27% of Bedrock Slides occur on Shale. A weight of 27 was given to areas underlain by Shale bedrock*). The same principle was applied to each landslide type combined with each conditioning factor.

Bedrock

The bedrock geology of the Bréifne area is rather complex. Numerous bedrock formations are present in the area and bedrock type is a very important factor in susceptibility to landsliding. The percentage of events occurring on each formation was calculated. A simplified bedrock geology map, containing nine bedrock types was selected for the analysis. The reasons for using a simplified map of nine bedrock types are listed below:

- The bedrock formations are regionally distributed and would give higher weights in areas where events are concentrated.
- A smaller number of bedrock types in the analysis will give a better distribution of weights.
- Simplified bedrock geology types have similar structural, petrological and lithological characteristics.

The percentages calculated for each landslide type are shown in Fig. 5.13. It should be noted that Limestone, Sandstone and Shale comprise the highest percentages of events.

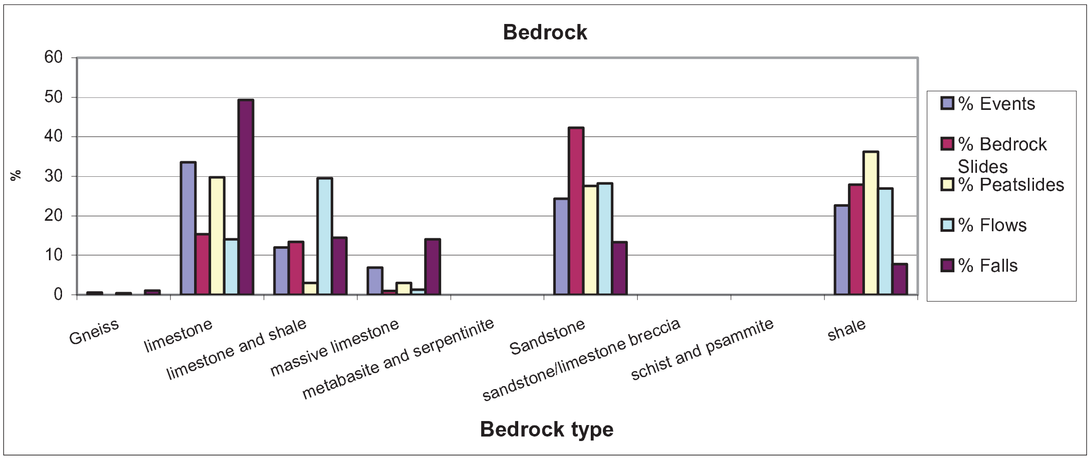


Fig. 5.13 Percentage of Landslides by Bedrock type.

Soil parent material (Subsoil)

Not all of the study area is covered by this thematic dataset. The Co. Leitrim dataset was not available for this study. A total of 399 events are within the areas covered by Co. Sligo and Co. Cavan. These were categorized as follows.

- 66 Bedrock slides
- 128 Peat slides
- 55 Flow
- 144 Falls

Only five soil parent material types were involved in the slide events in the area. Final calculations (Fig. 5.14) show bedrock slides and falls occurring mostly on areas where rock is at or close to the surface. Peat slides take place in peat-covered areas, but, according to the IFS parent material map, some occurrences are happening in non-peat covered areas. This may be explained by the fact that only those areas with peat of 1m+ in depth are mapped as peat covered, and slides may occur in areas of thin peat. Flows chiefly occur on rock at or near surface. This is attributable to the fact that 60% of the flows occur in areas dominated by shale, or limestone and shale, and these are bedrock types susceptible to flowing when water saturated.

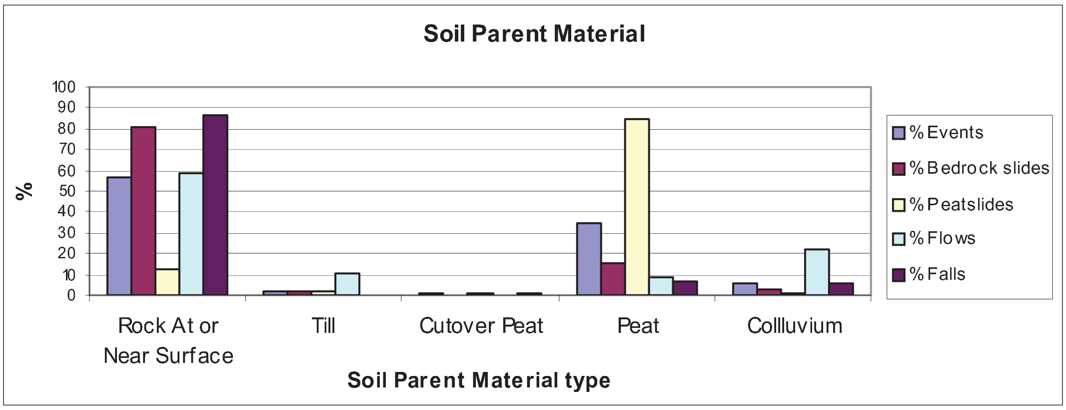


Fig. 5.14 Percentage of Landslides by Soil parent material type.

Landcover Map

The landcover map covers the whole area within the Republic of Ireland. The map has 15 different landcover types. Landslide events occur in 10 of these classes. All events mapped have been used to compute statistics. Final results are shown in Fig. 5.15.

Most of the land and peat slides occur on Bog and Heath. Peat cover was one of the factors used to decide where to focus the survey and this may have influenced the distribution of the data. It also has to be noted that very few events are occurring on bare rock or rocky complex. This is due to the small area (0.2% of the total) covered by these two landcover types. A similar situation is shown in bog, this landcover type covers only 0.8% of the map.

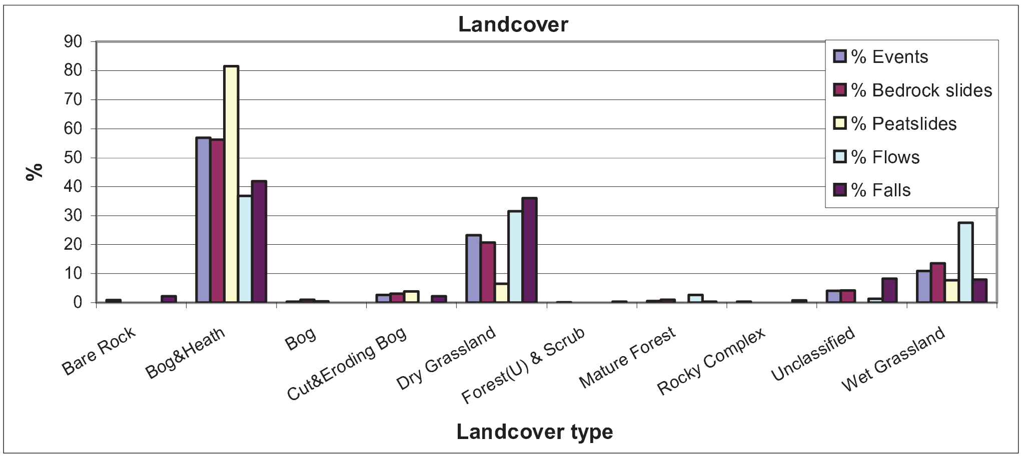


Fig. 5.15 Percentage of Landslides by land cover type.

Slope

The slope map was generated from the DEM for Bréifne, using Spatial Analyst Extension in ArcGIS 8.3 software. Slope is considered a major conditioning factor for landslide occurrence, although while landslide type varied

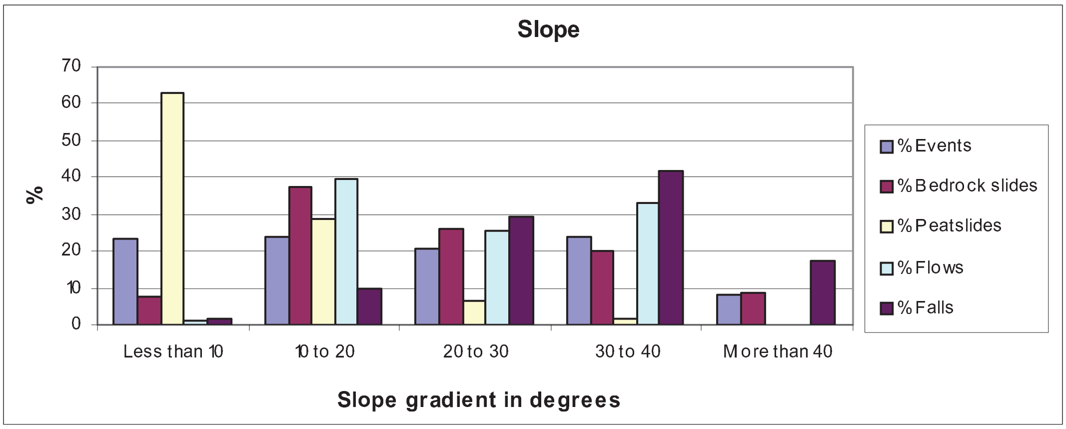


Fig. 5.16 Percentage of Landslides by slope gradient

with slope, overall 20-25% of all events occurred in each of the intervals from less than 10º to 30-40º. Slope data was divided in ranges of 10° and the percentage of slides occurring in each range calculated (Fig. 5.16).

Bedrock slides and falls predominantly occur on slopes steeper than 20°. Flows are likely to occur on slopes steeper than 10° and peat slides are more predominant on slopes from 0° to 20°.

Aspect

A directional aspect map was also generated from the DEM for the Bréifne Area using Spatial Analyst Extension in ArcGIS 8.3 software. It was divided into ranges of 22.5° and the percentage of slides occurring in each range computed (Fig. 5.17).

Landslides occur in all directions. Directional aspect does not appear to have an important role as a conditioning factor as percentage values are very similar to each other, therefore weight for this conditioning factor will tend to be evenly distributed.

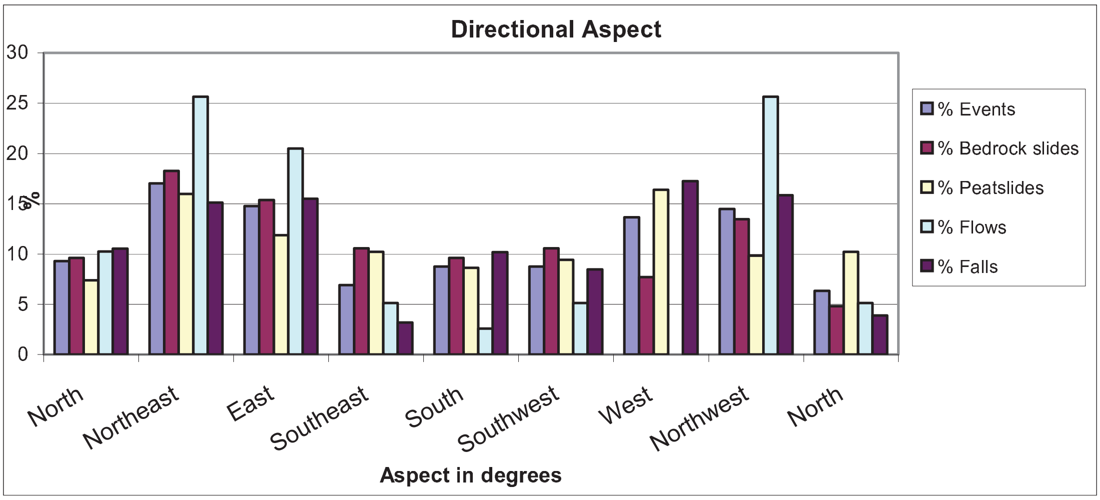


Fig. 5.17 Percentage of Landslides by aspect range.

Elevation

The DEM was analysed to obtain the number of slides occurring at each elevation. It was found to be a major landslide conditioning factor. Very few slides occur under an elevation of 200m. The dataset was divided into ranges of 100m and the number of events occurring in each computed (Fig. 5.18).

Bedrock slides usually take place between 200 and 500 metres O.D. Flows are the only type of event occurring below 200m. Peat slides and falls happen mainly between 300m and 500m. A rainfall dataset for the area with a suitable spatial resolution was not available. It is likely that elevation would be partly related to this triggering factor, which was not examined during this study.

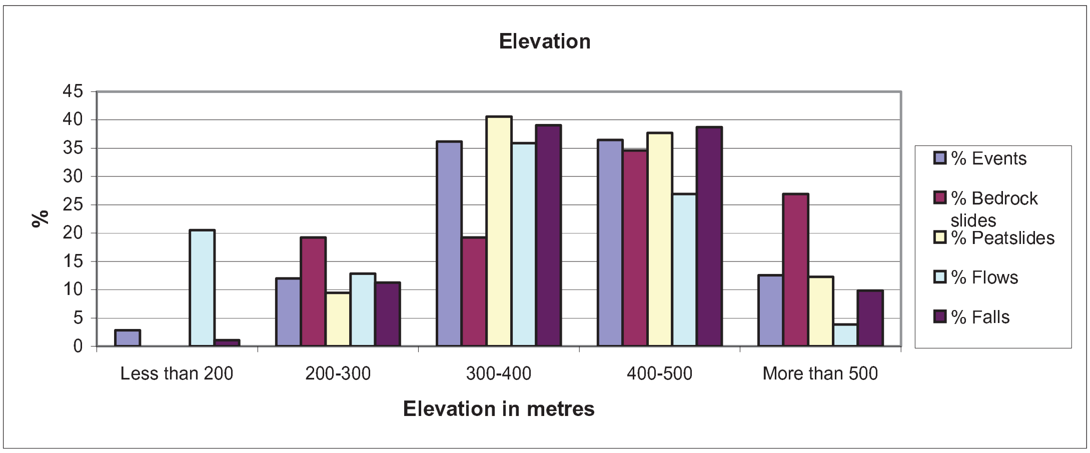


Fig. 5.18 Percentage of Landslides by elevation range.

Statistical Data Processing

As mentioned above weight values were extracted from the percentage of events occurring in each class within a conditioning factor. Datasets previously used were transformed to raster format at 25m resolution. The final landslide susceptibility maps were released at this resolution.

Raster datasets were reclassified using different values for each landslide type *(e.g. Shale was reclassified to 27 for bedrock slides, to 36 for peat slides, to 27 for flows, and to 8 for falls (Fig.5.12). Elevation from 400m to 500m was reclassified to 35 bedrock slides, to 38 for peat slides, to 27 for flow, and to 39 for fall (Fig. 5.17)*.

> **Lack of data for soil parent material.** Due to the fact that Co. Leitrim had no soil parent material data available at the time of the study, this area was reclassified with a value of **20** (average of values). As data for this area becomes available, reclassification for soil parent material should be performed to obtain a more accurate final classification.

Reclassification was performed on each layer (conditioning factor) for each landslide type. 24 layers (6 for each landslide type) were reclassified and used to produce the susceptibility map.

As a final step, reclassified layers for each landslide type were summed using Spatial Analyst. On the resulting susceptibility maps high pixel values indicate high susceptibility to landsliding and low pixel values represent low susceptibility. Maximum and minimum values of susceptibility vary depending on the type of landslide (Table 5.8 – see Table Appendix).

Landslide susceptibility was divided into 7 levels indicating high to low susceptibility. Manual method and Equal interval breaks were used to make divisions between levels of susceptibility (Table 5.9 – see Table Appendix).

Knowledge gained from fieldwork suggested the employment of the manual method as a more realistic approach (Maps 1, 3, 5 and 7 – see Map Appendix). Using this approach, areas with extremely high susceptibility to landsliding are represented by very high values, whereas low susceptibility areas are represented by a wide range of lower values. Nevertheless, a landslide susceptibility map using equal interval breaks is presented (Maps 2, 4, 6 and 8 – see Map Appendix).

Landslide susceptibility maps for landslides in bedrock, peat slides, flows and falls at 1 to 500,000 scale can be viewed in the Map Appendix. See list of maps below:

Map 1 – Landslide susceptibility map for bedrock slides using manual method breaks.

Map 2 – Landslide susceptibility map for bedrock slides using equal intervals breaks.

Map 3 – Landslide susceptibility map for rock, debris, earth fall and toppling using manual method breaks.

Map 4 – Landslide susceptibility map for rock, debris, earth fall and toppling using equal intervals breaks.

Map 5 – Landslide susceptibility map for debris and earth flow using manual method breaks.

Map 6 – Landslide susceptibility map for debris and earth flow using equal intervals breaks.

Map 7 – Landslide susceptibility map for peat slides using manual method breaks.

Map 8 – Landslide susceptibility map for peat slides using equal intervals breaks.

Error Assessment

As a final exercise, susceptibility map results were compared to previously mapped landslides. The aim of this exercise is to statistically analyse the number of landslides mapped within each susceptibility range. The manual method of classification was used for this assessment.

The first analysis showed the following results;- 20% of bedrock slides, 10% of peat slides, 20% of flows and 15% of falls were contained within areas of low susceptibility values. These events were individually reviewed and it was noted that most of the events occurring in low susceptible areas are within Co. Leitrim or at the outskirts of the study area. The area covered by Co. Leitrim has soil parent material weight values of 20 (averaged) due to the lack of data (See Statistical Data Processing) and this was subsequently identified as the reason for such low susceptibility results in areas with landslide occurrences. The analysis should be undertaken once more when a soil parent material map for the area is available and error assessment results computed again using its outcome.

As the dataset was not available at the time, manual corrections were applied to the slides occurring in areas affected by low susceptibility values. Rock outcrop data, Teagasc land cover map and Corine land cover map were used for this purpose. Table 5.10 illustrates the percentage of events within each susceptibility category after applying the manual corrections. Note how more than 90% of the events are confined to areas with medium or higher susceptibility values. 58% of bedrock slides, 70% of peat slides, 52% of flows and 50% of falls occur within high, very high and extremely high susceptibility values.

Susceptibility	% Bedrock Slides	% Peatslides	% Flows	%Falls
Extremely High	8.82	19.01	8.97	9.22
Very High	18.63	15.29	19.23	4.96
High	32.35	36.36	23.08	35.46
Medium	36.27	29.34	41.03	47.52
Low	3.92	0	7.69	2.48
Very Low	0	0	0	0
Extremely Low	0	0	0	0.35

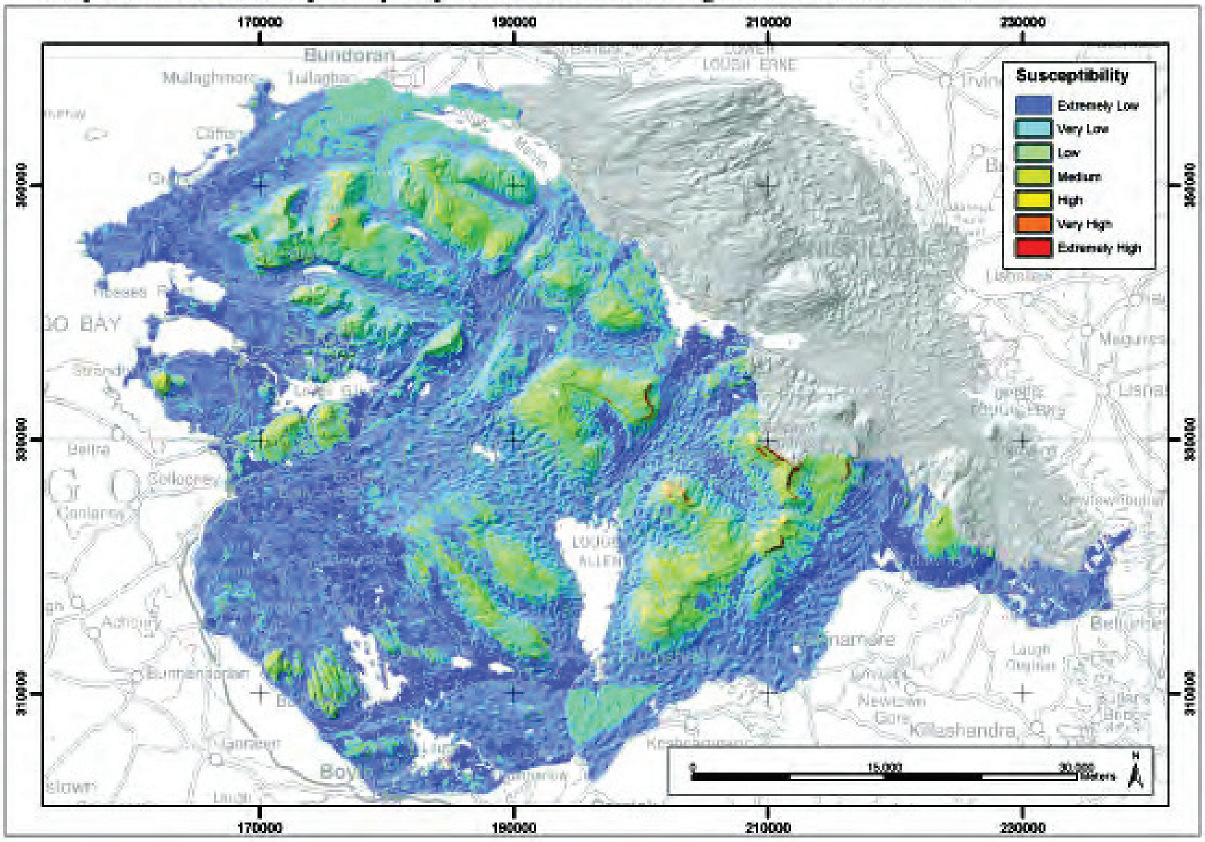
Table 5.10 Percentage of events mapped contained within each susceptibility category.

5.2.4. Conclusions and Recommendations

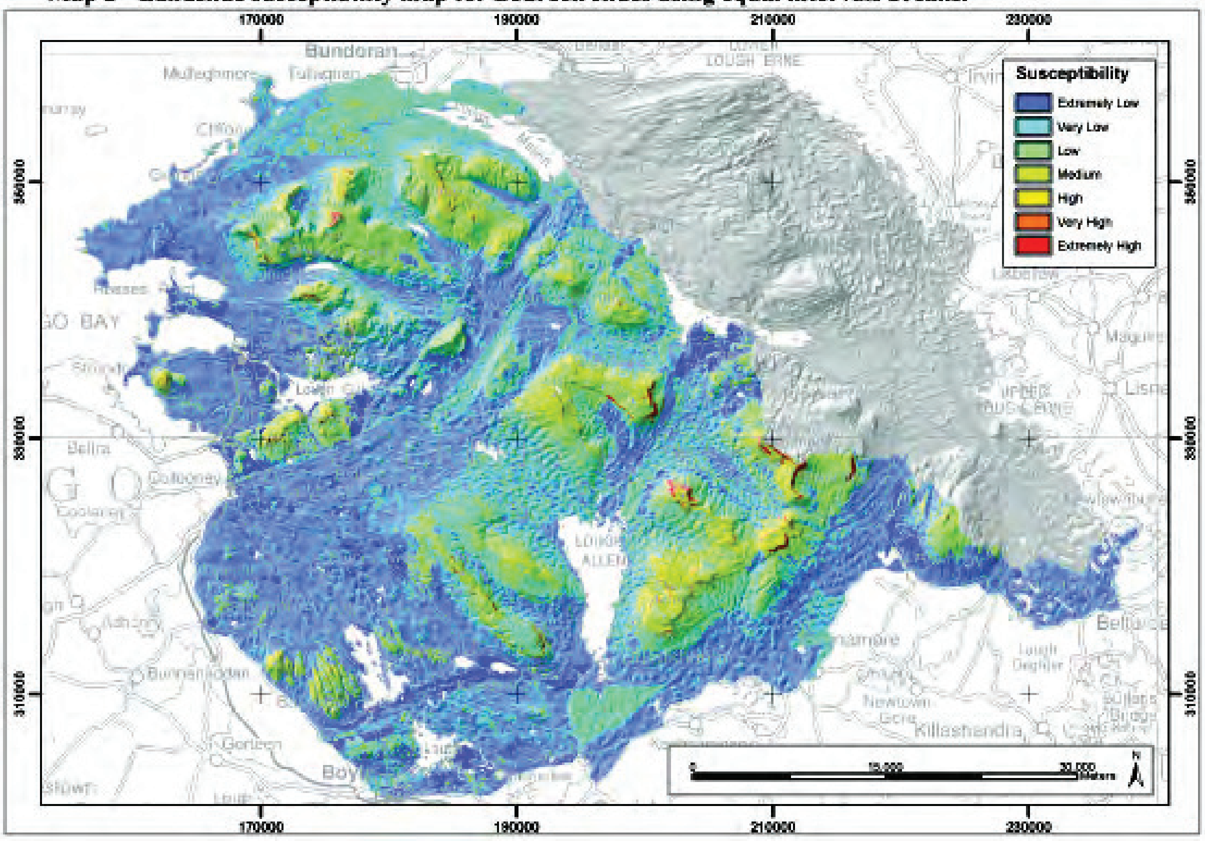
- Landsat ETM+ imagery (RGB 542) can be used as a first approach to locate scars produced during landsliding. It has to be noted that the response of these scars is often similar to the response of other features in the image. The low resolution of this data makes it unsuitable for landslide mapping and classification.
- The combination of colour, and black and white, aerial photography analysis was the most suitable method for landslide mapping. The use of Fledermaus software and digital stereophotography to display 3-D aerial photography greatly improved the identification and classification of events.
- Fieldwork was found to be of major importance in landslide mapping and classification. Accurate classification can be only performed after field assessment.
- Accuracy of classification is fundamental in the methodology used in this project. A large number of events were mapped. However, it was not possible to achieve a highly accurate classification due to the short timeframe of the project (less than 2 months). More fieldwork and image analysis would be needed, and is recommended for future work.
- The thematic datasets used as conditioning factors seem to be appropriate. Use of other data such as rainfall data, distance from crown to watershed and accurate structural geology data (bed jointing, fault distribution and bed dipping) would have enhanced the classification and the resultant susceptibility mapping.
- The error assessment has shown a high correlation between the landslide susceptibility map and the actual mapped events. The final result can be considered very satisfactory. Integration of additional conditioning factors as mentioned above would greatly improve the landslide susceptibility maps produced. The methodology used during this project allows the integration of new datasets to derive the final landslide susceptibility map outputs.
- Existing spatial datasets can be used to produce a robust landslide susceptibility map in the Irish context. The study demonstrates the applicability of international practices in this area and usefulness of such mapping, particularly when carried out in conjunction with follow up field investigation and ground truthing.

CHAPTER 5.2 - MAP APPENDIX

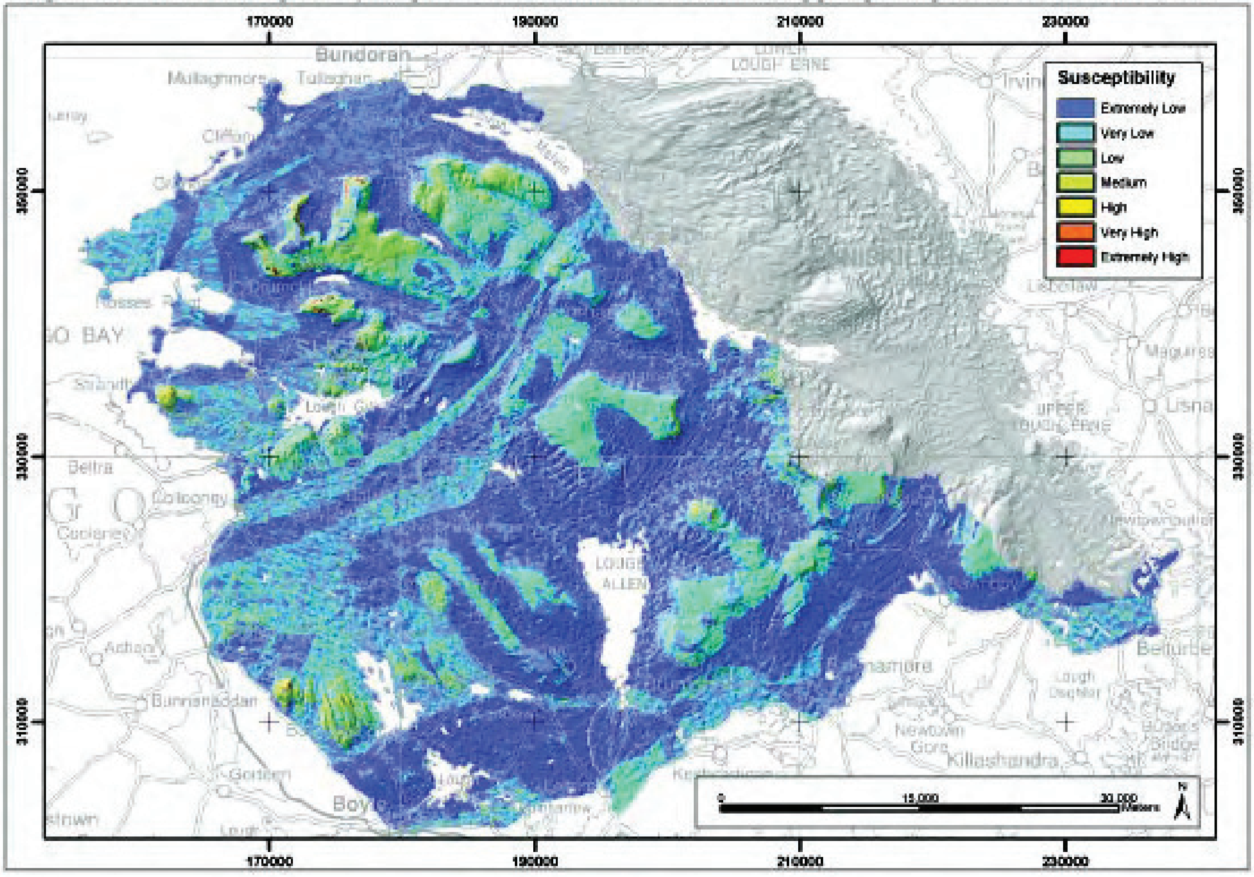
Map 1 - Landslide susceptibility map for Bedrock slides using manual method breaks.



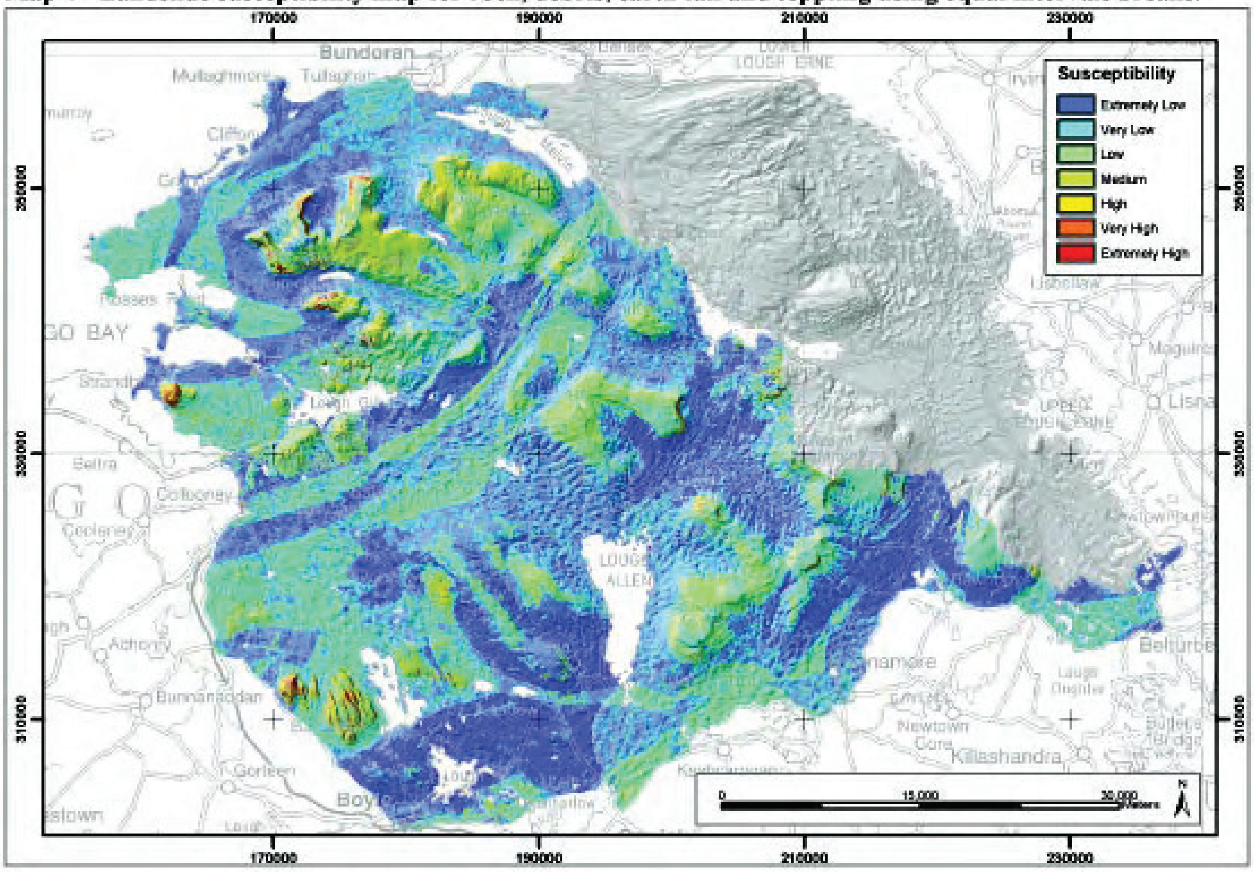
Map 2 - Landslide susceptibility map for Bedrock slides using equal intervals breaks.



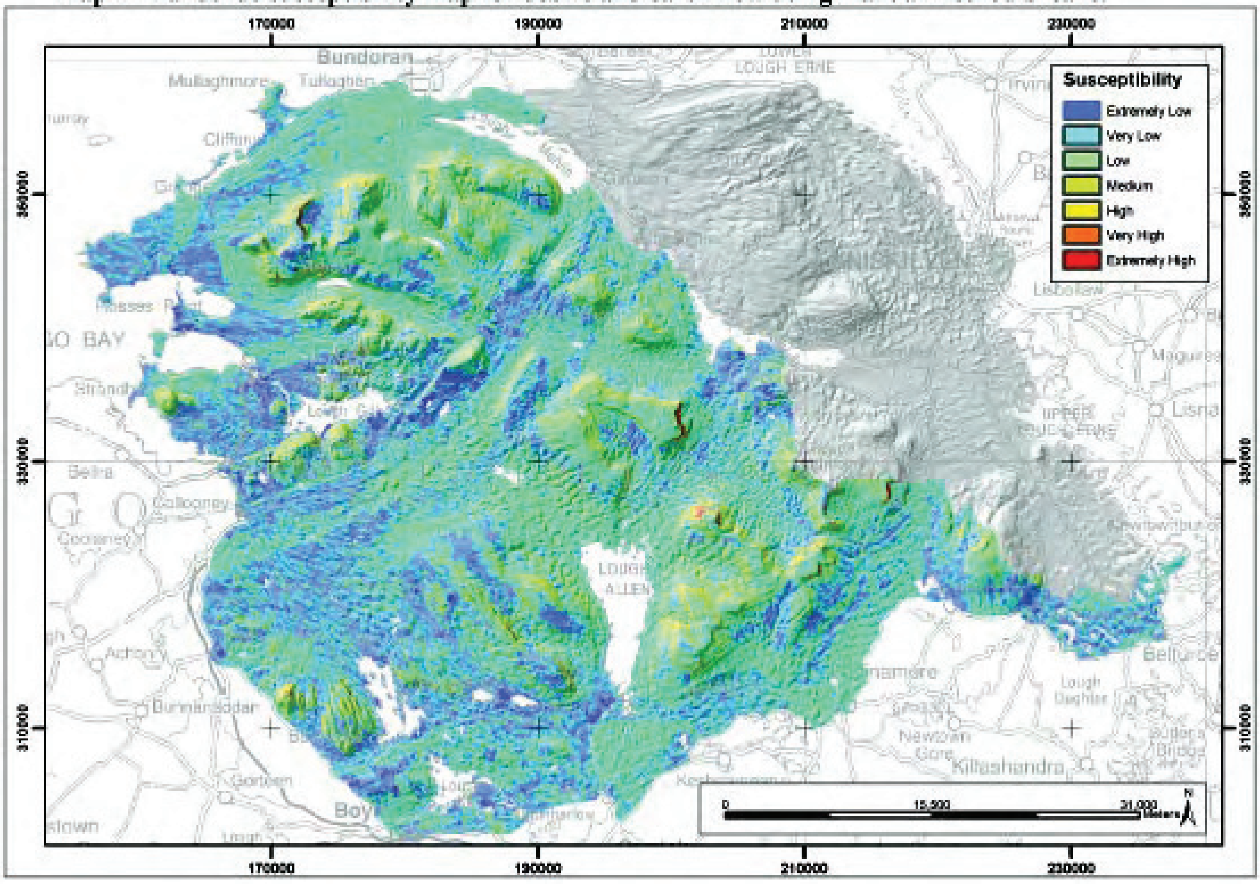
Map 3 - Landslide susceptibility map for rock, debris, earth fall and toppling using manual method breaks.



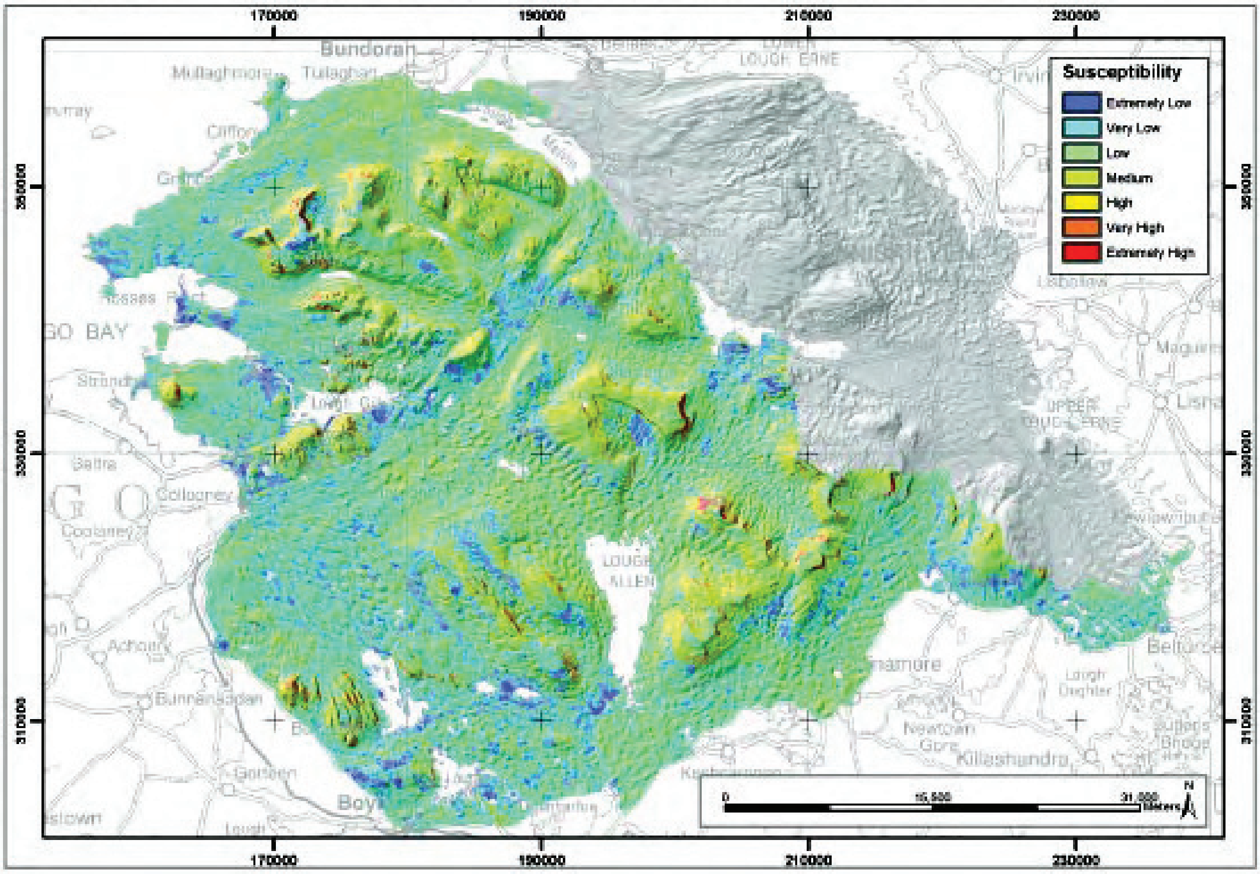
Map 4 - Landslide susceptibility map for rock, debris, earth fall and toppling using equal intervals breaks.



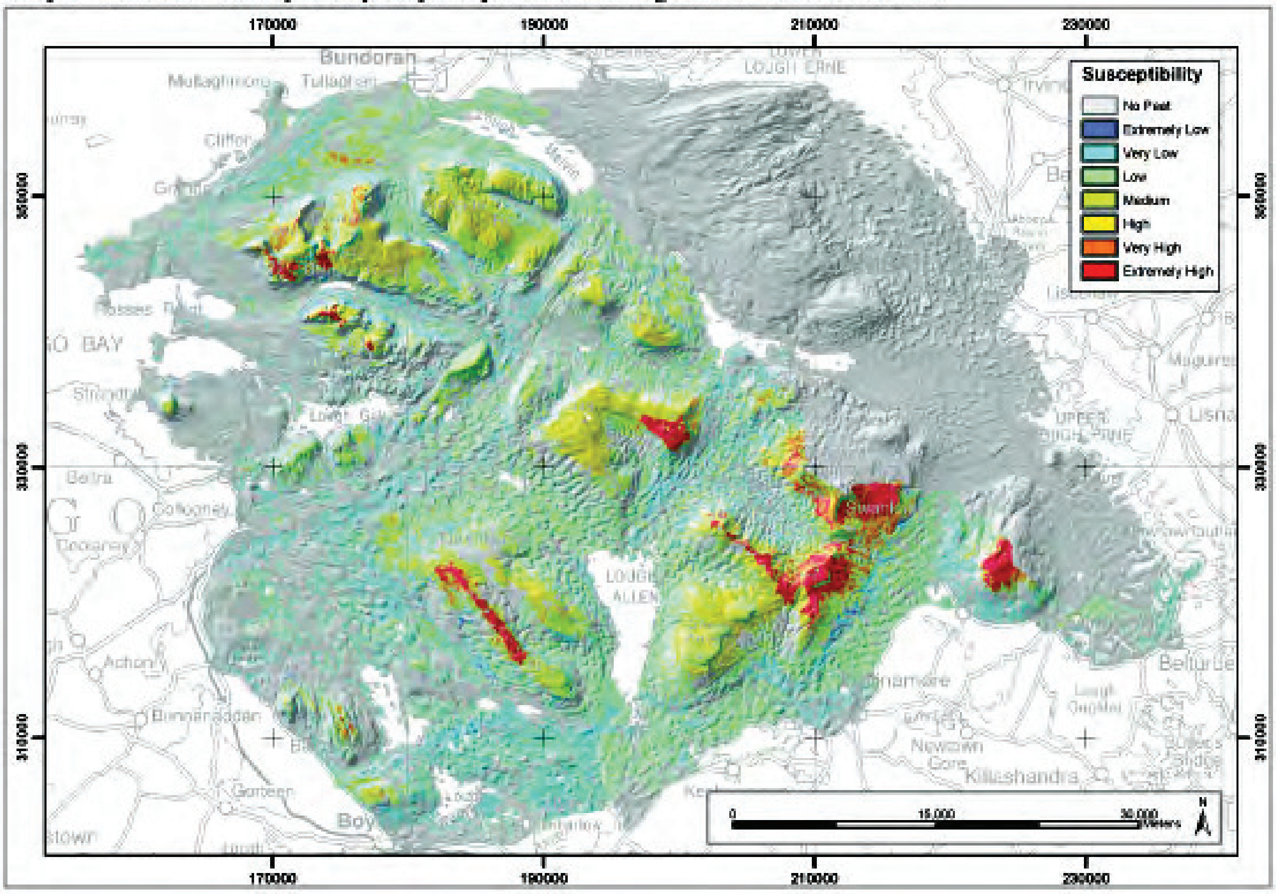
Map 5 - Landslide susceptibility map for debris and earth flow using manual method breaks.



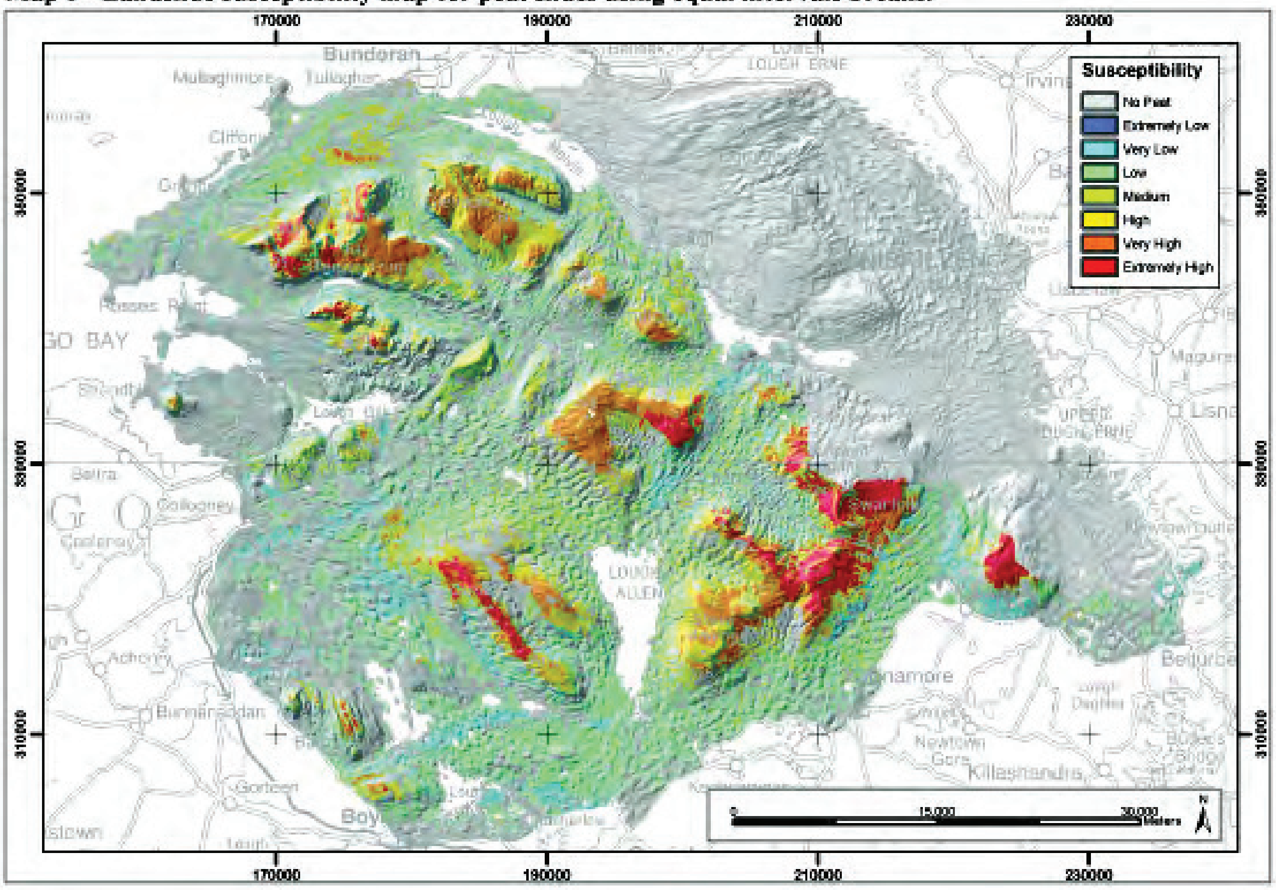
Map 6 - Landslide susceptibility map for debris and earth flow using equal intervals breaks.



Map 7 - Landslide susceptibility map for peat slides using manual method breaks.



Map 8 - Landslide susceptibility map for peat slides using equal intervals breaks.



CHAPTER 5.2 – TABLE APPENDIX

Bedrock slides	Maximum	Minimum	Type Maximum	Type Minimum
Bedrock	42	0	Sandstone	Various
Soil parent material	80	0	Rock at or near surface	Cutover Peat
Landcover	56	0	Bog & Heath	Various
Slope	38	8	10 to 20	Less than 10
Altitude	35	0	400-500	Less than 200
Aspect	18	5	Northeast (22.5-67.5)	North (337.5-360)
Total	269	13		

Table 5.8a. Maximum and minimum weights and class affected for Bedrock slides.

Peat Slide	Maximum	Minimum	Type Maximum	Type Minimum
Bedrock	36	0	Shale	Various
Soil parent material	84	1	Peat	Various
Landcover	82	0	Bog & Heath	Various
Slope	63	0	Less than 10	More than 40
Altitude	41	0	300-400	Less than 200
Aspect	16	7	West(247.5-292.5)	North (0-22.5)
Total	322	8		

Table 5.8b. Maximum and minimum weights and class affected for Peat slides.

Flows	Maximum	Minimum	Type Maximum	Type Minimum
Bedrock	29	0	limestone and shale	Various
Soil parent material	58	0	Rock at or near surface	Cutover Peat
Landcover	37	0	Bog & Heath	Various
Slope	40	0	10 to 20	More than 40
Altitude	36	4	300-400	More than 500
Aspect	26	3	Northeast (22.5-67.5)	South (157.5-202.5)
Total	226	7		

Table 5.8c. Maximum and minimum weights and class affected for Flows.

Falls	Maximum	Minimum	Type Maximum	Type Minimum
Bedrock	49	0	limestone	Various
Soil parent material	87	0	Rock at or near surface	Till
Landcover	42	0	Bog & Heath	Various
Slope	42	1	30 to 40	Less than 10
Altitude	39	1	300-400/400-500	Less than 200
Aspect	17	3	West (247.5-292.5)	Southeast (112.5-157.5)
Total	276	5		

Table 5.8d. Maximum and minimum weights and class affected for Falls.

Susceptibility	Equal interval		Manual method	
	From	to	From	to
Extremely high	230	269	250	269
Very high	192	230	220	250
High	154	192	180	220
Medium	115	154	140	180
Low	77	115	90	140
Very low	38	77	50	90
Extremely low	0	38	0	50

Table 5.9a. Equal interval and manual method divisions applied to Bedrock slides.

Susceptibility	Equal interval		Manual method	
	From	to	From	to
Extremely high	276	322	300	322
Very high	230	276	270	300
High	184	230	230	270
Medium	138	184	170	230
Low	92	138	110	170
Very low	46	92	60	110
Extremely low	0	46	0	60

Table 5.9b. Equal interval and manual method divisions applied to Peat slides

Susceptibility	Equal interval		Manual method	
	From	to	From	to
Extremely high	194	226	210	226
Very high	161	194	190	210
High	129	161	160	190
Medium	97	129	130	160
Low	65	97	90	130
Very low	32	65	50	90
Extremely low	0	32	0	50

Table 5.9c. Equal interval and manual method divisions applied to Flows.

Susceptibility	Equal interval		Manual method	
	From	to	From	to
Extremely high	237	276	255	276
Very high	197	237	230	255
High	157	197	200	230
Medium	118	157	150	200
Low	79	118	100	150
Very low	39	79	60	100
Extremely low	0	39	0	60

Table 5.9d. Equal interval and manual method divisions applied to Falls.