

Using an Ecological Site Classification at the landscape scale to guide the restoration of Atlantic Oakwoods within the Ben Lomond National Memorial Park

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1. Introduction

Atlantic oakwoods contribute substantially to our natural and cultural heritage. They support a rich diversity of native flora and fauna including many rare and threatened species whose continued survival depends on the stable ecological conditions created by a moist climate, continuity of woodland cover, and by the presence of native tree and shrub species. Where once these woodlands clothed much of the western seaboard of Scotland, Wales and England, centuries of conversion to other land uses has dramatically reduced woodland cover. The twentieth century saw an accelerated period of change, with Atlantic oakwoods seen, in the context of strategic timber reserves, as unproductive land. The conversion of such woodlands into productive plantations was encouraged through government policy. Between the 1930's and 1970's approximately 30% of semi-natural woodland was converted into plantations of predominantly non-native coniferous species, by either underplanting or restocking of clearfells ((Kirby and May 1989))

In recent decades, there has been considerable interest in redressing these losses by restoring key sites to native woodland. This process has gained further impetus with the publication of Habitat Action Plans for priority woodland types ((Anon 1995)). The Habitat Action Plan for upland oakwoods (which includes Atlantic oakwoods), recommends that restoration of semi-natural oakwood communities should be carried out as a matter of priority, and a target has been set to restore 10 000 ha by 2010. Substantial programmes of restoration are currently underway. The work described in this report was undertaken as part of the Atlantic Oakwood Restoration Project (Life 97) funded by the European Life Programme. The definition of "restoration" is that used by (Thompson, Humphrey et al. in prep) which is - "the process of restoring a native woodland ecosystem to sites where the former ancient semi-natural woodland has largely been replaced by trees, shrubs and other plants of non-native origin".

2. Aims and Objectives

One of the main problems facing managers involved in large restoration schemes, is how to put in place a strategy for native woodland restoration at wider spatial scales where a number of sites need to be considered. One of the first steps in this process is to put together a vision or plan of the potential extent and composition of restored native woodland. This can be difficult to achieve where only fragments of the original woodland cover remain and much of the site and vegetation is inaccessible due to steep terrain, lack of access and dense planting of conifers.

The aim of the work described here was to produce a plan of the potential extent and composition of restored native woodland within two contrasting areas of the Ben Lomond National Memorial Park, by combining the Forestry Commissions Ecological Site Classification (ESC) with ArcView GIS. The Ben Lomond NMP offers considerable scope for testing ESC methodologies, as it contains substantial areas of dense conifer planting and inaccessible terrain.

In the original project, one of the stipulated objectives of the work was to produce operational plans for implementing restoration within the two study areas. However, we now consider this to be beyond the scope of the present study, and suggest that it is more properly dealt with by local managers.

3. Site description

The two study areas are within the Loch Lomond cSAC bordering the east side of the loch (Fig. 1).

The first area, Ross wood (NS370960), is a small southerly extending promontory (100 ha) of relatively low elevation (under 100m) and gentle slopes. The geology comprises Dalradian mica schists, out-cropping in places. The main soil types are brown earths, iron pans, podzols and surface water gleys. Soil depths range from thin rankers up to one metre in places. Originally a semi-natural woodland, Ross wood was underplanted with conifers in the 1950's; the majority of these conifer crops have now been felled as part of a restoration programme. The eastern side of Ross wood was surveyed by SNH in 1992 and in July 1998 Forest Research surveyed the western side, and revisited the areas included in the SNH survey to gather the information necessary for an ESC analysis.

The second area is located within the Ptarmigan woodland block (NN340030), on the western flank of Ben Lomond. The area studied (approx 325 ha) runs the whole length of the forest block (6.5 km), extending from the forest road at approximately 100m elevation, up to the forest fence line at 300 - 400m elevation, a distance of approximately 0.5 km. The study area is steeply sloping with a westerly aspect. The geology is quartz mica schist with frequent outcrops forming sheer rock faces and crags. The soils are mostly thin upland brown earths and rankers with Wetter soils in places. The area is currently covered with dense conifer plantations. Native woodland remnants are restricted to the streamsides and gullies, which bisect the hillside. There are also some pockets of native woodland within the plantations.

4. Ecological Site Classification

Ecological Site Classification (ESC) is a methodology for objectively assessing and classifying a site in terms of its ecological potential for the suitability and yield potential of a given species of tree, or the ecological suitability of the NVC woodland communities.

Similar methodologies have been pioneered in Scandinavia (Cajander 1926; Kuusipalo 1985) and in North America (Krajina 1969; Klinka, Krajina et al. 1989), for mainly natural forest types. In Britain ESC has been developed for use with both plantation and semi-natural forest stands (Pyatt and Suarez 1997). ESC combines the climatic influence with the soil quality of the site. Climate data are predicted from models for any grid reference in Britain. The four variables used to describe the climate are: Accumulated Temperature (AT), Moisture Deficit (MD), Windiness (DAMS) and Continentality (Conrad Index). Soil quality is predicted using knowledge of the soil type and from plant indicator species. The two soil quality variables are Soil Moisture Regime (SMR), describing soil Wetness and Soil Nutrient Regime (SNR), describing nutrient availability.

AT

At the local scale, warmth (AT) varies approximately with elevation, but at the national scale both latitude, longitude as well as elevation affect AT. A threshold temperature of 5 °C is used above which growth in plants is stimulated. For each 10 km square, 5 °C has been subtracted from the monthly mean temperature and multiplied by the number of days in the month. Months with a mean below the threshold temperature have been ignored. AT ranges from 0 to about 2000 degree days in Britain, reaching a maximum of about 1200 degree days around Loch Lomond.

MD

Moisture Deficit is an index of climatic dryness, expressed as the accumulated monthly excess of evaporation over rainfall, and so indicates the dryness of the growing season. The measure of evaporation used in the calculation of MD comes from the Meteorological Office Rainfall and Evaporation Calculation System (MORECS), supplied as mean values over 40 km squares. The data have been interpolated across Britain using elevation in a digital elevation model (DEM), latitude and longitude, using a GIS. MD ranges from 0 in the west of Scotland and at high elevation to about 220 mm in eastern England. MD ranges between 0 – 140 mm around Loch Lomond.

Wind

In Scotland, windiness is probably the second most important limitation to tree growth after warmth. The 'Detailed Aspect Method of Scoring' (DAMS) wind score is an index developed by Quine, 1993 #11, which measures the physiologically constraining effect of wind on growth. It is the most likely constraining factor at modest elevations and close to the west coast of Scotland. DAMS calculations involve a windiness map, elevation, topex and aspect.

Continentality

Continentality expresses the seasonal variation or range of climate due to the distance of the site from the moderating influence of the sea. Oceanic areas tend to have cool summers and mild winters, whereas continental areas exhibit more extremes of warmth and cold. The factor helps shape the length of the growing season and is related to atmospheric humidity and windiness. Relatively continental areas of Scotland occur in the central borders and Perthshire both with a score of 7-8, and about 6 along the eastern shore of Loch Lomond. Continentality is an important factor influencing the development of field and ground layer plants, which determine some NVC woodland communities and a few sub-communities.

Soil Quality

Soil nutrient regime (SNR) can be predicted from soil type, humus form, and/or when available, from the presence and abundance of field layer vascular plants as indicators (Hill, Mountford et al. 1999)[Wilson, 1988 #22]. Soil Moisture regime (SMR) can be calculated from soil type and other measurements. A soil Wetness index of SMR has been derived initially using a rule-based approach from soil classification. The system can therefore operate at different scales providing differing degrees of precision and accuracy in an ESC assessment.

The soil quality methodology within ESC links to Soil Survey of Scotland classification, Avery (1990) classification and to the FC soil classification. It is also ideal for interpreting soil descriptions gained by field survey. The really powerful feature of ESC is that at the stand scale, the presence and abundance of plant indicator species can be used to gain a very precise assessment of SNR, using systems developed by (Ellenberg 1988) and (Wilson 1998).

5. Methods

The two sites are dealt with separately in the report as the survey methods differ.

5.1. Ross wood

Soil quality survey

The vegetation communities of the northern and western area, not surveyed by SNH in 1992, were surveyed and mapped. Detailed vegetation descriptions were carried out for each community. This involved identifying all the vascular plant species and their abundance (% cover) recorded from six, randomly placed 2m x 2m quadrats. The soil type (horizon thickness, colour and texture as well as profile depth) was described within each vegetation community, from which a Forestry Commission soil type and corresponding SMR were assigned. The quantitative vegetation data were used in an ESC analysis to calculate SNR for each vegetation community. In addition, soil descriptions and quantitative vegetation data were collected for discrete vegetation communities within the area surveyed by SNH, and the soil quality was investigated as described above.

Assembly of Data

Aerial Photograph

A 1:20 000 scale aerial photograph of Ross wood was digitally scanned and orthorectified using the 'resample' module in Idrisi (A GIS for handling raster data) in order to register the image to its correct grid referencing system. 'Resample' registers the data in one grid system to a different grid system covering the same area. The process uses polynomial equations to establish a rubber sheet transformation, as if one of the grids were placed on rubber and warped to make it correspond to the other. A registered digital map of the boundary of Ross wood was used as the correspondence grid system.

Soil Data

The orthorectified image was imported into ArcView GIS and the soil survey pits digitised by comparing a field map of the locations with the image (Fig. 2). Vegetation community boundaries were drawn from the vegetation survey and digitised. Each was assigned an SNR value, derived from vegetation indicators. From this an SNR layer was generated for the area (Fig. 3.2) at 50m resolution.

SMR was assigned from the surveyed soil types, and an SMR layer (Fig. 3.3) was produced for the whole area using spatial interpolation (a procedure for predicting the value of attributes from measurements made at point locations within the same area or region). The Kriging interpolation method, a technique that uses regionalised variable theory to incorporate information about the stochastic aspects of spatial variation when estimating interpolation weights, was used. Kriging is a flexible interpolation method and generates a good map for most small data sets.

Kriging was performed using the grid-based graphics program Surfer (Golden Software Inc, Colorado). Surfer specialises in interpolating irregularly spaced data into a regularly spaced grid. An important consideration of the kriging method is the interpretation of the variogram model. Features of the variogram show the spatial autocorrelation and validity of the interpolation procedure for a given dataset. The default linear variogram model provided by

Surfer provided a good estimate of the variation in SMR across the area, and was incorporated into the kriging calculation for the SMR layer.

Climate data

Layers for Moisture deficit (Fig. 3.4) and accumulated temperature (Fig. 3.6) at 50m resolution were calculated using the ESC climate models from elevation (Fig. 3.1), eastings and northings layers. An existing windiness (DAMS) layer (Fig. 3.5) of the area was used in the ESC analysis. Continentality was deemed not to vary significantly across the study area and was left out of the analysis.

Native woodland suitability

Suitability maps of the seven NVC woodland communities were produced in ArcView GIS Spatial Analysis extension, by applying ESC rule-based NVC woodland suitability models (Table 1) to the five input layers (SNR, SMR, AT, MD, and DAMS) .

Table 1. ESC rules for modelling the suitability of NVC woodland communities.

Native Woodland Code	Inputs				
	SNR	SMR	AT	MD	DAMS
W4	>= 1.5 and < 3.5	>= 1.5 and < 3.6	>= 430		< 19
W7	>= 3.7	>= 1.6 and < 4.3	>= 900		< 18.8
W9	>= 3.6	>= 3 and < 5.5	>= 700	< 120	< 21
W11	>= 2 and < 4	>= 3.7 and < 6.1	>= 700 and < 1850	>= 10	< 19.2
W17	>= 1.5 and < 3.2	>= 3.3 and < 5.6	>= 700	< 16-0	< 20
W18	>= 0.5 and < 2	>= 3 and < 6	>= 400		
W19	>= 1.5 and < 3.6	>= 4 and < 6.5	>= 400 and < 1600		< 18

5.2. Ptarmigan Block

Soil quality survey

Access to the steep and densely wooded slopes of the Ptarmigan block was very difficult, and the survey technique could not define the discrete vegetation communities resulting in a more broad brush survey than for Ross wood. The major factor causing variation in soil and vegetation was slope and elevation. The difficulty of access resulted in a different survey method designed along four transects spaced along the length of the Ptarmigan block. Transects were chosen to cut across a complete range of crop type, change in terrain, and to cross remnant native woodland areas. Transects were walked on a compass bearing and distance was measured on a 'walktax'. At 50 m points a soil pit was excavated and the soil described and a line of four 2m x2m quadrats were positioned at 2 m intervals, perpendicular to the transect. All vascular plant species were identified and their abundance recorded. A note was made when crop boundaries were crossed or any other feature such as a stream line was encountered, and a record was made of the distance along the transect that this occurred. SNR was calculated from the plant indicator species and their abundance at each set of quadrats on the transect.

Assembly of data

Aerial Photographs

A 1:20 000 scale aerial photograph of the Ptarmigan block was digitally scanned and orthorectified using the same 'resample' method applied to the Ross wood photograph. A registered digital map of the boundary of Ptarmigan was used as the correspondence grid system. The resulting orthorectified image was imported into ArcView. The soil transects were then digitised (Fig. 4) by comparing the location given on a field map, and bearings and distances travelled in relation to crop types, with the image in the GIS.

Soil Data

Inspection of the transect data semivariogram revealed that in this case kriging was not a suitable method for interpolating SMR. The vegetation community map was also unavailable for use in generating an SNR layer.

These constraints required the formulation of a soil classification model. The data were stratified in 3 elevation bands, and within each, relationships between soil type, slope and curvature of the hillside were investigated to produce broad 'rule of thumb' formula for extrapolating soils across the site (Table 2 and Graphs 1,2 and 3). Topographic slope and curvature were calculated in ArcView GIS from the Digital Terrain Model (DTM) (see Fig. 5.1).

Within each elevation band, the model predicted a number of soil types. Each was given a SMR broadly reflecting the average soil conditions from corresponding locations in the survey. Similarly, SNR was broadly assigned to the predicted soil types by reviewing the average SNR value derived from the ground vegetation at corresponding sample points. The method allowed the prediction of SNR and SMR layers (Fig. 5.2 - 5.3) at 50m resolution on the GIS.

Climate data

Layers for MD (Fig. 5.4) and AT (Fig. 5.5) at 50m resolution were calculated using the ESC climate models from elevation (Fig. 5.1), eastings and northings layers and applying the same rules used to generate the inputs for Ross wood. The Windiness layer (Fig. 5.6) was already generated and Continentality was again excluded.

Native woodland suitability

Suitability maps of the different types of native woodland were produced by overlaying the five input layers (SNR, SMR, AT, MD, and DAMS) in ArcView and applying the same ESC rules (Table 1) used for Ross wood.

Table 2. Relationship between soil type and soil type and slope curvature in different elevational zones.

'Low Elevation' below 170m				
Slope	Curvature score	Soil type	SMR score	SNR score
>= 30 °		Ranker	Fresh	Poor
< 30 °	< -1	Surface water gley	Very Moist	Rich
< 30 °	>= -1	Brown earth	Fresh	Medium
'Mid Elevation' 170m to 270m				
Slope	Curvature score	Soil type	SMR score	SNR score
>= 30 °		Ranker	Fresh	Medium
< 30 °	>= 0	Ironpan	Fresh	Poor
< 30 °	< 0	Surface water gley and peaty gley	Wet	Medium
'High Elevation' above 270m				
Slope	Curvature score	Soil type	SMR score	SNR score
>= 30 °		Ranker	Fresh	Poor
< 30 °	>= -0.3 and < 0.3	Surface water gley and peaty gley	Very Wet	Poor
< 30 °	(>= -0.7 and < -0.3) or >= 0.3	Ironpan	Moist	Poor
< 30 °	< -0.71	Gleyed soils	Very Moist	Poor

6. Results

6.1. Ross wood

Ross wood is classed within the 'warm Moist' climatic zone. Across the site, AT varies from 1330 to 1447 day-degrees above 5 degrees C and MD has a range of 111 to 130 mm (small variations relative to the range experienced in Britain). DAMS scores range from 7 to 12 suggesting that Ross wood is quite sheltered (in Britain the windiest sites have a DAMS score of 22).

The soils of Ross wood are mostly brown earths and peaty gleys although rankers, peats and iron pan soils were also found. Distribution of the soil types is broadly related to topography. The flushed blanket bog and peaty gleys are found on the plateau, terraces and gentle slopes. Brown earths and intergrade ironpan soils occur on the steeper slopes and in some places there is evidence of podzolisation, perhaps reflecting the presence of raised beaches. On water collecting sites, at the base of the slopes, the brown earths are gleyed. Ranker soils occur on the rock outcrops.

Twelve vegetation communities were recognised in the survey (Fig. 6). Ten communities covered the majority of the survey area, and were dominated by one or more of the following species: blaeberry, bell heather, bracken, wavy hair-grass, hardfern and bluebell (*Hyacinthoides non-scripta*). The two remaining communities were unique; one was dominated by birch scrub and the other was a mixture of alder, birch and holly with a very

species Rich understory and herb layer, occurred at the loch side,. Native woodland sub-community codes were assigned to the different communities by SNH staff in the area they surveyed (Fig. 7). The following sub-communities were recognised W4b, W7b, W11b, W17b and W17c; some areas were recognised as combinations of 2 sub-communities.

The majority of the species encountered in the survey were indicators of Poor or Very Poor soil nutrient regime (SNR). Indicators of Poor SNR included bracken, wavy hair-grass, hardfern and wood sorrel. Indicators of Very Poor SNR represented at Ross wood were blaeberry, bell heather and purple moor-grass. Soft creeping grass and sweet vernal-grass also encountered here are indicators of Medium SNR and there were a few indicators of Rich conditions e.g. bluebell.

Species and abundance data recorded in the quadrats surveyed both by Forest Research and SNH, were used to calculate the soil nutrient regime of each community. Most of Ross wood has a SNR of Poor or Poor/Very Poor. There are a few pockets that have Poorer and Richer SNR than this but these only represent a small part of the total area

The native woodlands predicted as being suitable for Ross wood were W4, W11 and W17 (Fig. 8). W11 is suitable over the area with a Poor to Medium SNR but is restricted from areas where the SMR is Wet. In these areas W4 is the most suitable woodland type. Most of the eastern part of Ross wood has a SNR of Poor to Very Poor and the SMR ranges from Fresh to Moist, in this area W17 was found to be the most suitable woodland type. Where SNR is Richer W17 is replaced by W11 and where SMR is Wetter W4 replaces W17.

6.2. Ptarmigan

There is considerable climatic variation across the Ptarmigan block, due to the relatively wide range in elevation. The climate zones (described by the combination of AT and MD) is classed as 'warm Moist' at the road side but changes to 'warm Wet' around 200m elevation and then to 'cool Wet' above this and up to the fence line at around 350m. In Ptarmigan block AT and MD decrease with elevation with ranges of 1300 to 970 day-degrees above 5 degrees C (AT) and 108 to zero mm (MD). The wind climate varies from relatively sheltered to exposed, DAMS scores range from 12 at the road side to 18 at the fence line. The sub-alpine and alpine climatic zones are found above the fence line and up to the top of Ptarmigan ridge, which becomes extremely exposed (DAMS scores of 22 and over). Land below the road to the loch side is more sheltered with DAMS scores decreasing to 8.

In total 54 soil pits were described within the Ptarmigan block. The soils were generally thin, nearly half of the samples described were ranker soils but these were mostly brown, gleyed, peaty or podzolic rankers suggesting the presence of a shallow soil profile. The rest of the soils described were brown earths (12 soil pits), most of which were classed as upland brown earths, iron pan or intergrade ironpan soils (7 soil pits) and peaty and surface-water gleys (4 and 7 soil pits).

The model relating slope curvature and elevation to soil type (Table 2 and Fig. 9) predicted rankers on slopes greater than 30 degrees at all elevations. The other soil types were associated with lesser slopes (gradients less than 30 degrees) and there appears to be some interaction with elevation. At 'low' elevation, upland brown earths were found on all but the most concave sites where they were replaced by surface-water gleys. At 'mid' elevation, ironpan soils replaced upland brown earths on convex slopes, and surface-water gleys and peaty gleys were found on concave slopes. At 'high' elevations level or slightly concave/convex areas are occupied by surface-water gleys and peaty gleys. Where the terrain becomes more concave or convex, ironpan soils appear to form, and where the sites are very concave gleys occur.

SMR reflects the soil types found in the survey, the following defaults were set; rankers and brown earths, and iron pans at 'mid' elevation have a SMR of 'Fresh'; ironpan soils at 'high' elevation are Wetter with an SMR of 'Moist' which becomes 'Very Moist' where they are gleyed. Surface-water gleys and peaty gleys become progressively Wetter with elevation, and are classed as 'Very Moist' at 'low' elevation, 'Wet' at 'mid' elevation and 'Very Wet' at 'high' elevation.

Vegetation sampled along transects and SNR indicated

Along each transect, some samples coincided with at least one patch of remnant native woodland, although most of the sample points were within conifer stands with five different crop types being sampled in total.

The ground vegetation survey included all vascular plants; mosses were not recorded. Between 15 and 30 species of vascular plant were found along each transect. The diversity of ground flora appeared to be related to the crop type as those transects which sampled native woodland patches most frequently, yielded longer species lists. Common species were wood sorrel, sweet vernal grass, and wavy hair-grass. These were recorded in all transects and occurred at most elevations with abundance of 15% or more. Other species, which occurred with high abundance but less frequently, were creeping bent-grass, bracken, dogs mercury, sheep's fescue, bluebell (*Hyacinthoides non-scripta*), heath bedstraw, purple moor-grass, creeping soft grass and wild garlic. There were many other species which were found in most transects but in low abundance. These include primrose, hardfern, common violet, yellow pimpernel, tormentil and broad buckler fern.

Ground vegetation was used to indicate SNR at each sample point. Vegetation at over half of the sites sampled, indicated 'Poor' SNR; at the remainder mainly 'Medium' SNR was indicated. There were a few 'Rich' SNR sites, and none of the sites had 'Very Poor' SNR. SNR values have been linked to soil types in the predictive rules devised for the Ptarmigan block soils, see Table 2.

Fig. 10 shows that most of the Ptarmigan block is suitable for W11 oak woodland, but with significant areas of W4 on Wetter soils, and some pockets of W7 at the lower elevations. The model predicts that the area above the fence line will be mostly unsuitable for woodlands. Where woodland could establish it is predicted as a mix of W11, W17, W18 and some W4.

7. Discussion

7.1 Ross wood

The intensive vegetation survey of Ross wood produced a complex classification of ground vegetation communities, with the same species predominating throughout many of the communities. However, the calculated SNR data layer is relatively simple, with most of Ross wood having a Poor SNR. The re-survey of the east side of Ross wood (original survey by SNH 1992) was by comparison, brief. However, the quadrat data collected compares well with the SNH site descriptions of the vegetation being dominated by blaeberry.

The model of SMR produced by the kriging method, although only approximate, appears realistic. A comparison of SMR with vegetation shows that the Wet areas correspond well with the areas dominated by Purple moor-grass and *Sphagnum spp.* and SMR also appears to

be related to topography as would be expected. The flat areas and plateaus having a Wetter SMR and the sloping ground having a drier SMR.

Producing a realistic model of SMR at Ross wood is important. Woodland type is limited by soil quality and not by climate, and as there is very little variation in SNR (mainly Poor or Very Poor/Poor), it is SMR which dictates where the different woodland types are located in this area. The predicted woodland types are W4, W11 and W17; W4 occurring on the Wetter areas and W11 and W17 on the drier areas.

There is good correspondence between the woodlands described by the SNH survey and those predicted as being suitable by ESC. SNH used the standard NVC woodland survey whereby the habitat or community is classified by the dominant species. In this case oak, resulting in an oakwood designation. By comparison, ESC uses ground vegetation and soil alone with no regard to canopy species, but the ESC methodology predicts the same suitable woodland types as the NVC method. The soils of the eastern part of Ross wood are Very Poor podzols and ironpan soils, and the vegetation is dominated by blaeberry, an indicator species of Very Poor conditions. It is possible that this site is only marginally suited to W17 woodland and we might expect it to be dominated by birch with very few oak. The current dominance of oak may be the result of past management. Oak has been planted and coppiced since the 1700s ((Dargie and Simpson 1992)). ESC predicts W18 as a suitable alternative to W17 and with no intervention, we might equally expect a woodland dominated by birch with a scattering of pine as well as oak at these sites.

7.2 Ptarmigan

Lack of survey data from the ptarmigan site makes accurate prediction of soil quality difficult. Although regular transect sampling is commonly used to survey hillsides such as this one, the transects were too widely spaced to allow surface interpolation, using geostatistical methods, with any degree of accuracy. Consequently the kriging method could not be used to interpolate soil quality across the site.

A rule-based model was developed in place of kriging to predict soil types in relation to terrain. This appears to work well as predictions compare favourably with the findings of (Gissop 1975), who carried out a soil survey of this area. He writes “ On the slopes, soils are relatively thin, freely draining upland brown earth rankers and skeletal soils of loam to sand loam texture giving way to iron pans on slopes at higher elevation. Locally, on shelves and terraces, are found Wetter surface-water gleys and peaty gleys.”.

SMR and SNR classes associated with the soil types in the model are fairly approximate but do reflect the sites encountered on the hillside. Not all the sample points occurring at the same elevation and on the same terrain had identical SMR (from soil type) and SNR (from vegetation cover); the most frequently represented SMR and SNR class was taken as the default. A perfect match between soil types, elevation and terrain shape cannot be expected as fine changes in terrain may not be represented at the 50m resolution of the DTM data set. The model produced will be likewise coarse and may not predict the finer landscape features such as gullies and their associated changes in soil quality.

Climatic conditions changed with increasing elevation but did not restrict any of the NVC woodland types tested. Above the fence line and at higher elevations climatic conditions influence woodland suitability with most of the area being classed as unsuitable with the exception of a few sheltered pockets. The location choice of the different woodland types within Ptarmigan block is directed by soil quality. Most of the area at the lower elevation is suitable for W11 having soils that are Poor to Medium SNR and Fresh SMR. Among W11 patches of W7 and W4 are predicted. W7 is the only woodland suited to the Very Moist and Rich areas and W4 the only suitable woodland type for areas with Wet SMR. At higher

elevation where climatic conditions allow; W17, W18 and W4 are predicted. The relative position of the woodland types being again the result of the soil quality factors. The accuracy of soil quality data and its impact on woodland choice at these high elevations should be treated with caution as no soil or vegetation data was collected from above the fence line where each transect ended.

SNH carried out an NVC survey of the area below the road down to the loch edge. This area was not included in the 1998 Forest Research survey. However, the soil model was extended to cover this area and the ESC predictions match the SNH findings well. The SNH survey found the area to be predominantly W11a with a few patches of W7c; ESC predicts W11 and a limited amount of W7. SNH report some areas tending towards W17 but these were too small to map; they have not been represented in the ESC prediction as they are probably below the resolution of the model.

2. Conclusions and Recommendations

The use of Ecological Site Classification at the landscape scale at these two sites within the Ben Lomond National Memorial Park has produced sensible woodland choices which both support and expand the woodland survey carried out by SNH in 1992. ESC predicts that the western half of Ross wood will be dominated by W11 and that central part will be W4. The eastern half of Ross wood appears to have Poorer soils and here ESC predicts W17 as the dominant woodland type but also equally suitable is W18. This result indicates that with no intervention, this area may revert to woodland of predominantly birch with some oak and pine mixed in. Woodland choice within the Ptarmigan block can be generally applied but caution should be exercised when dealing with fine landscape feature e.g. gullies which will have been missed when applying the model based on coarse resolution data. From the fenceline down to the loch shore ESC predicts W11 as being suitable over most of the ground except in the flushes where W7 is suitable below approximately 100m, and W4 as the most suitable woodland above 100m.

3. References

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4. Acknowledgements

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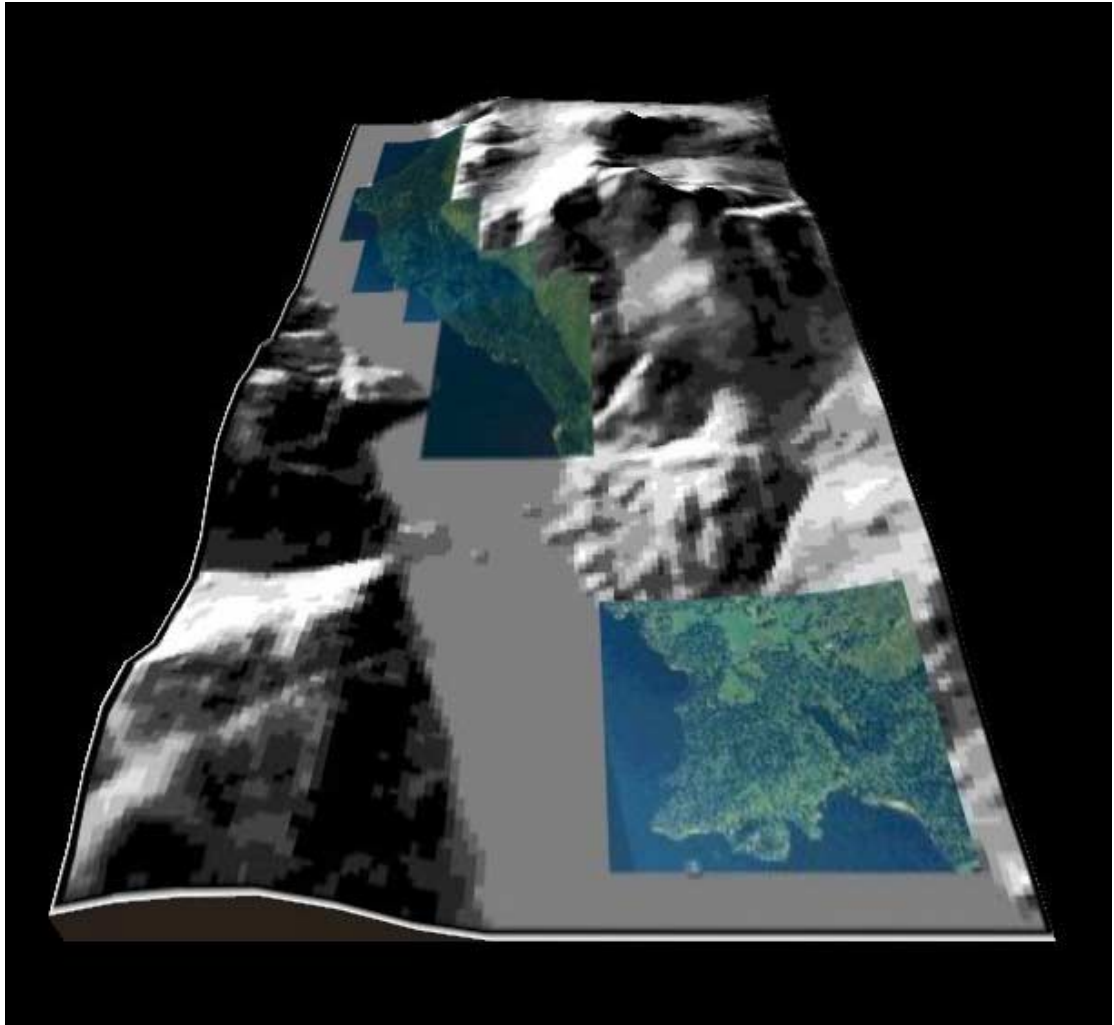
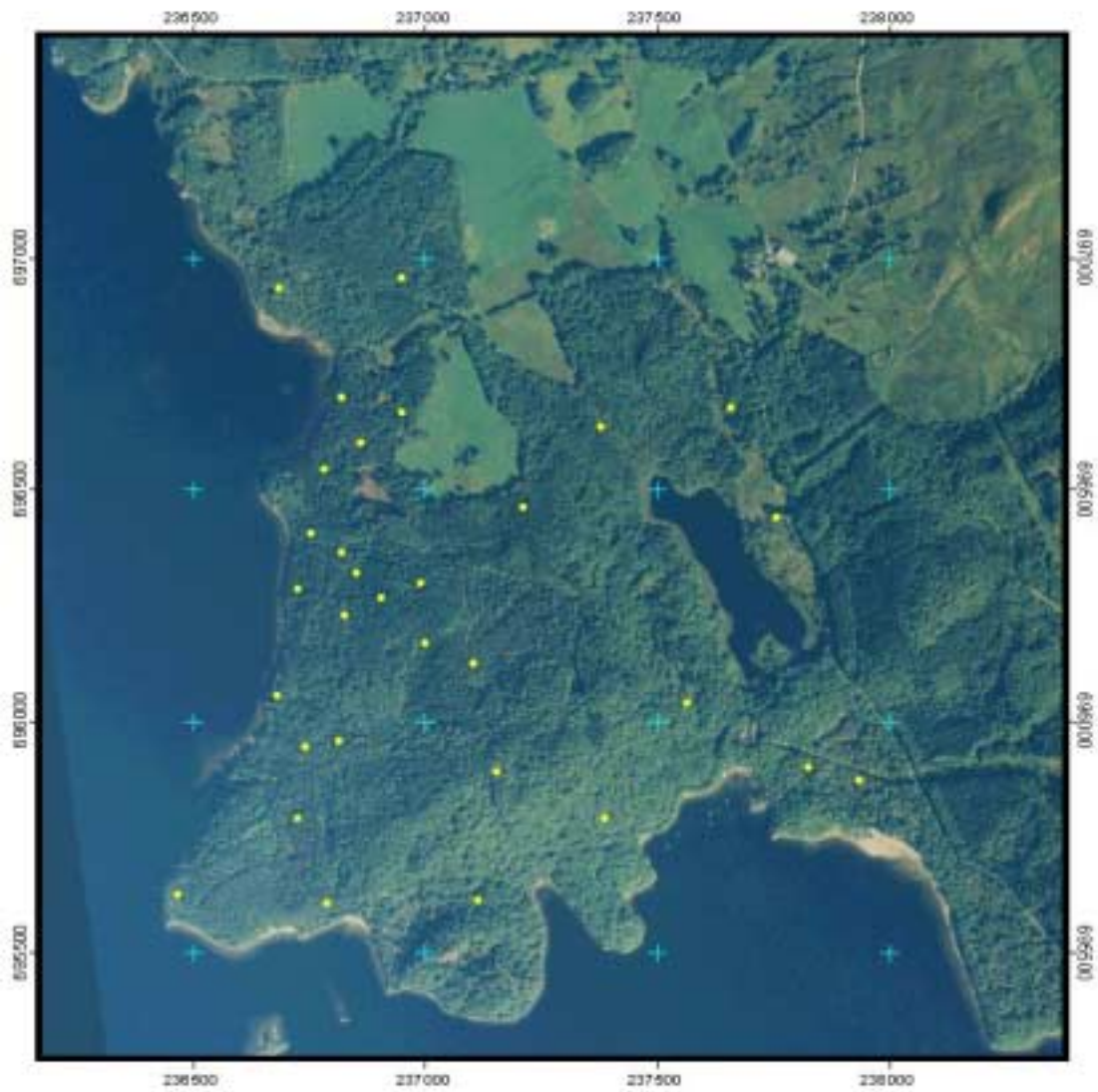
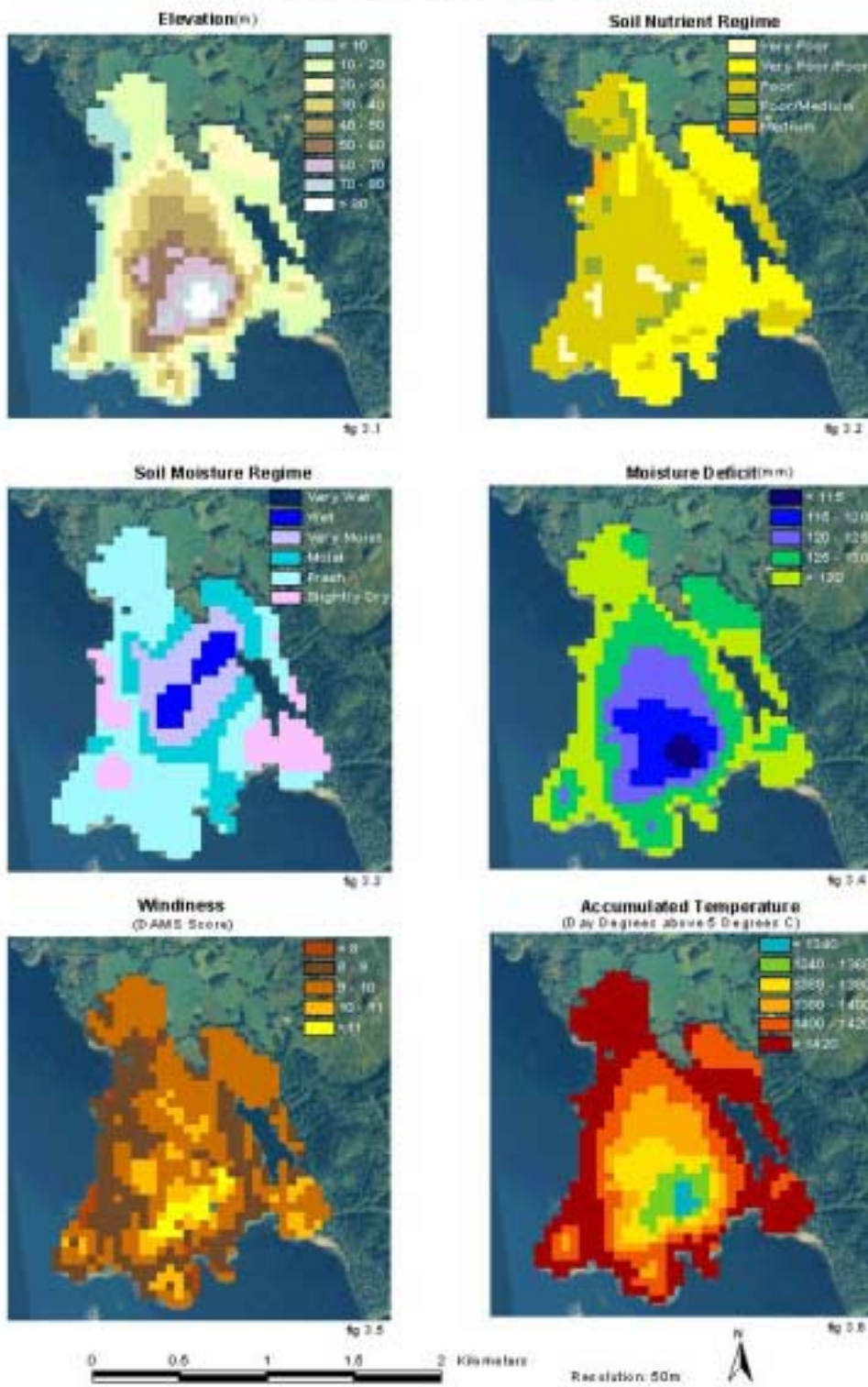


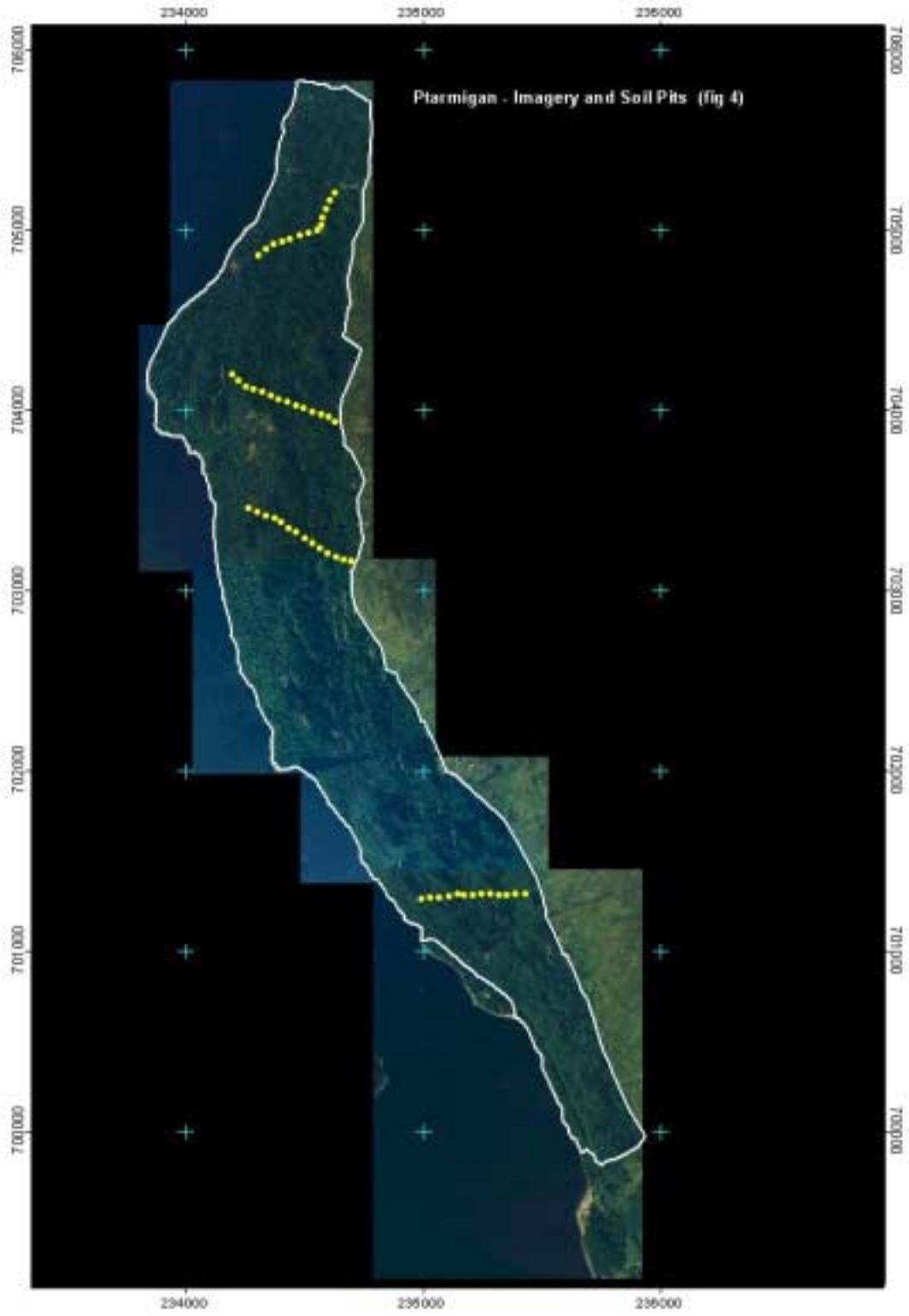
Fig 1

Ross Wood - Imagery and Soil Pits (fig 2)

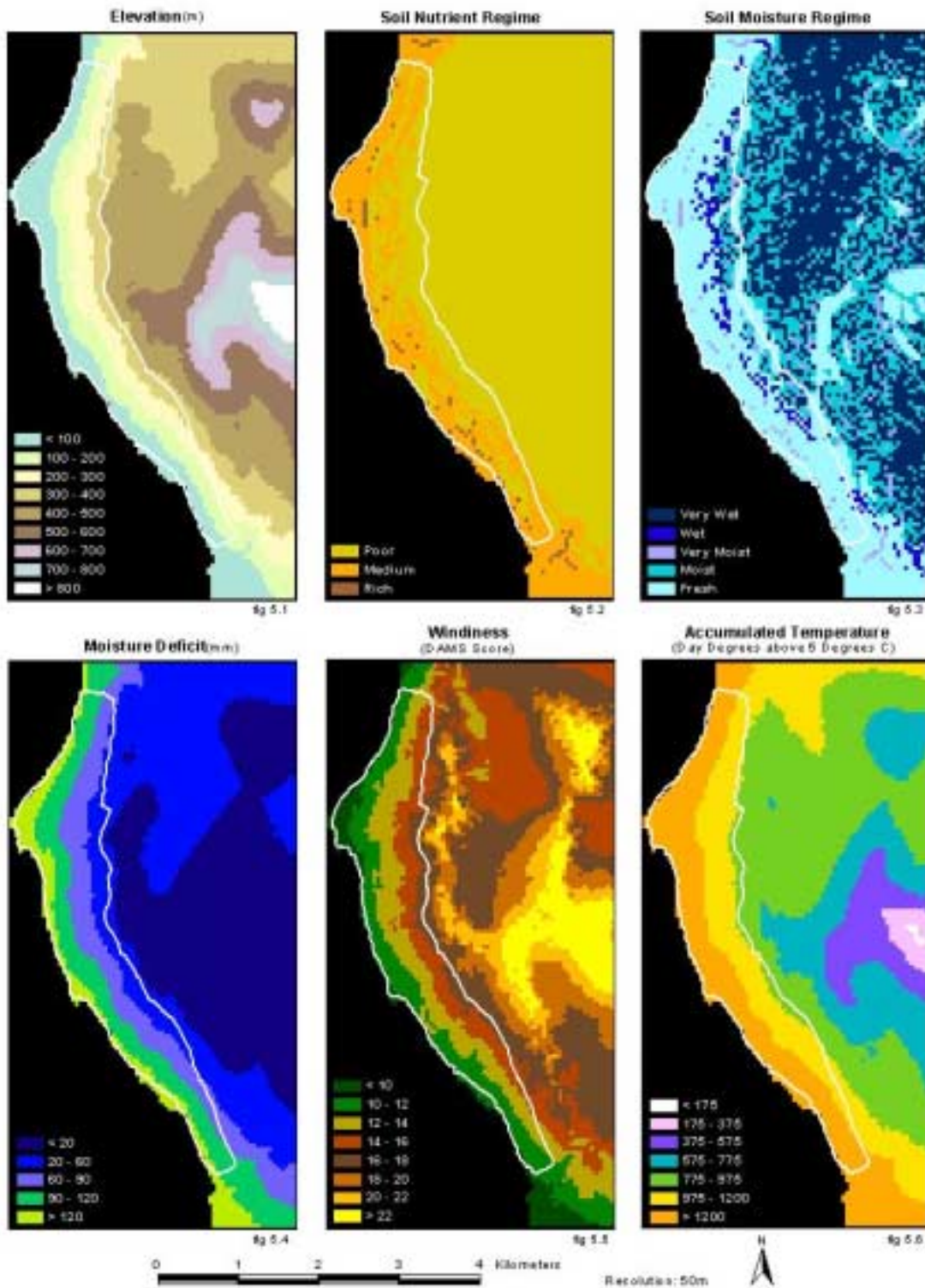


Ross Wood - Elevation and ESC Inputs (fig 3)

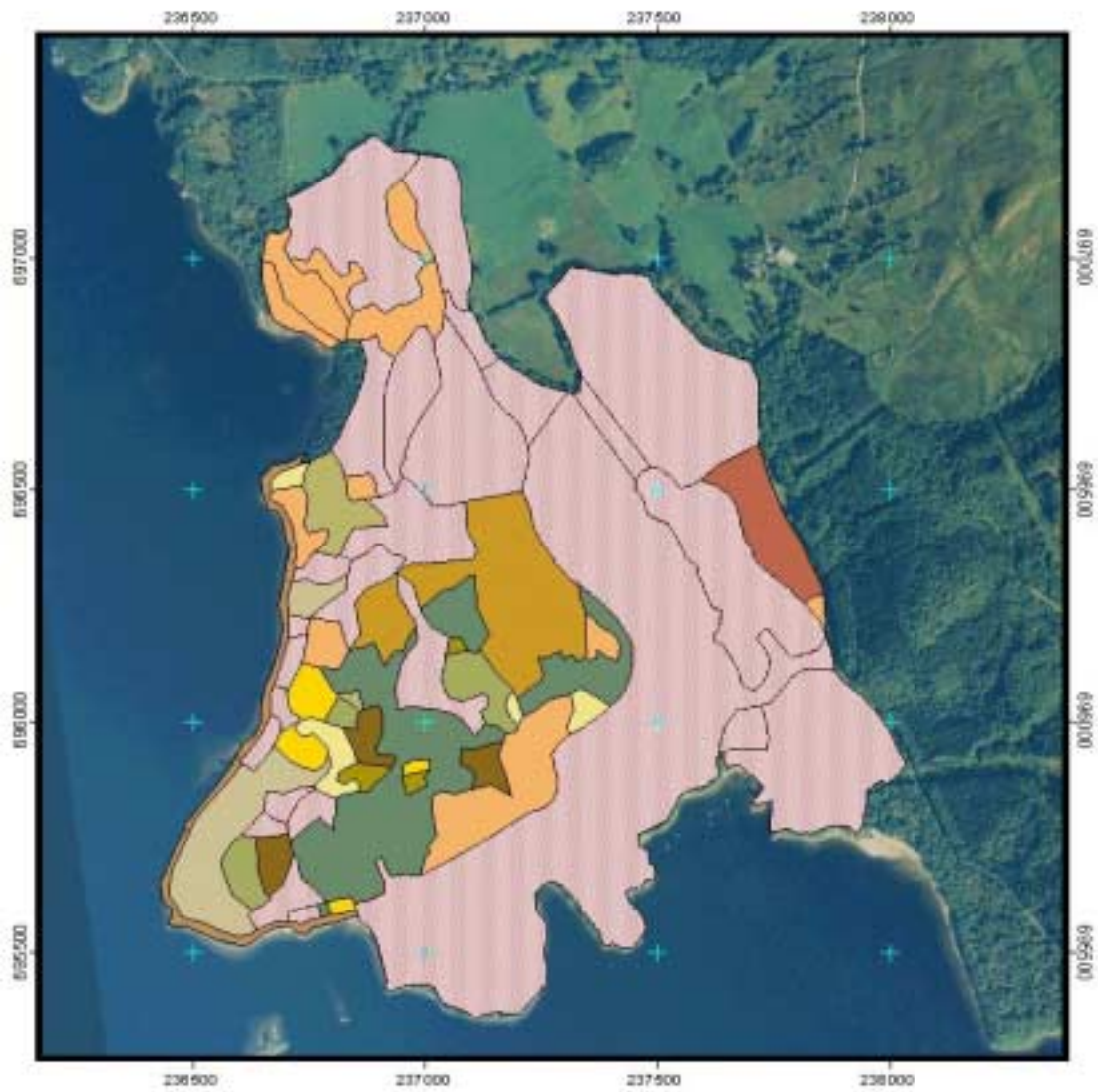




Parmigan - Elevation and ESC Inputs (fig 5)

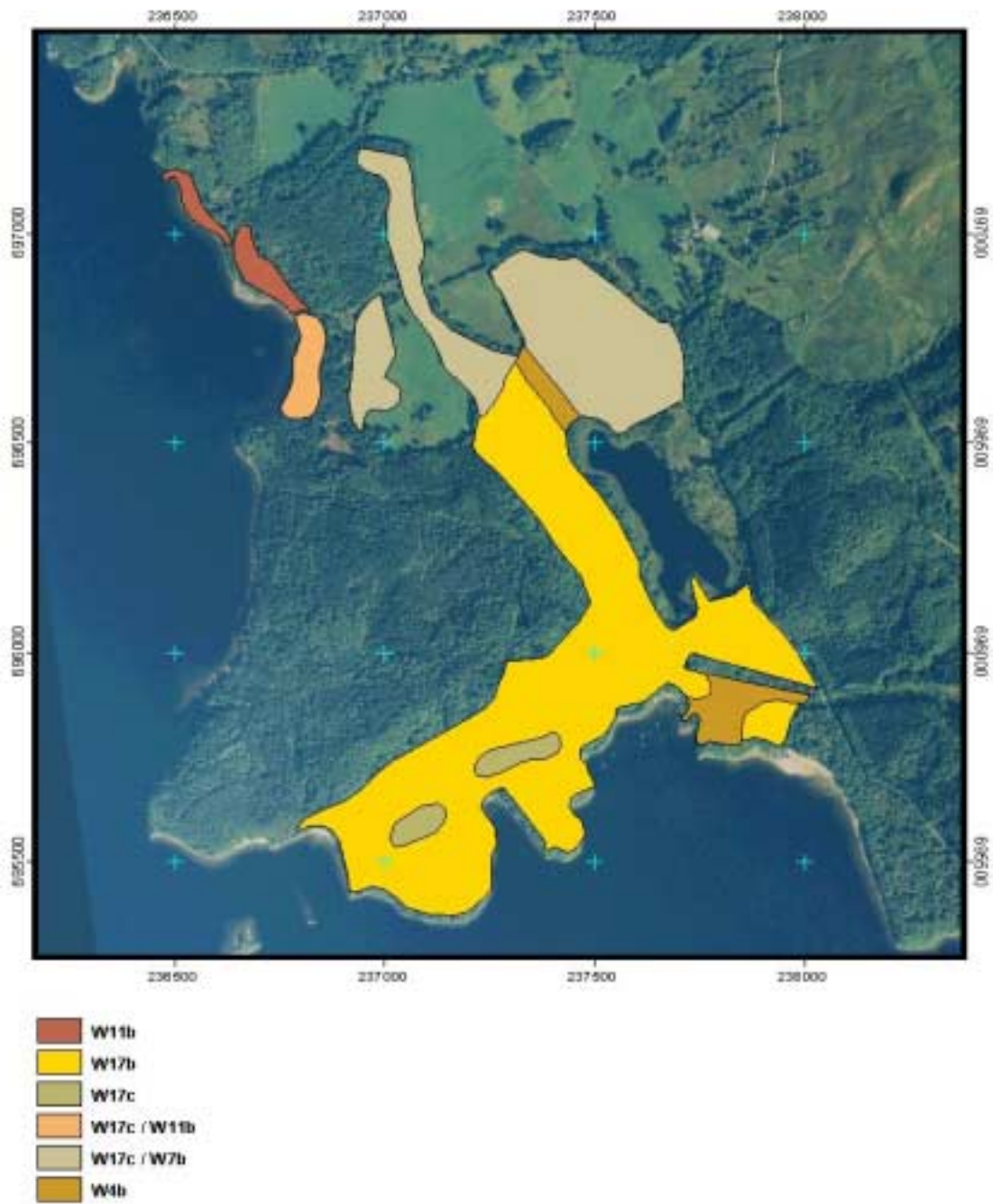


Ross Wood - Vegetation Communities (fig 6)



- | | |
|--|---|
| Birch / Bramble | Erica / <i>V. myrtillus</i> only |
| Bracken / hardfern | Lochside community |
| Bracken / hardfern / <i>D. flexuosa</i> | No community identified |
| Bracken / Grasses / <i>Oxalis acetosella</i> | <i>Vaccinium</i> / Bracken |
| Bracken, <i>E. cinerea</i> , <i>V. myrtillus</i> | <i>Vaccinium</i> / <i>D. flexuosa</i> |
| <i>D. flexuosa</i> dominant | <i>Vaccinium</i> dominant |
| Erica / <i>V. myrtillus</i> - <i>V. diverse</i> | |

Ross Wood - Sub-Communities (fig 7)



Ross Wood - Native Woodland Suitability Map (fig 8)

