Appendix 6 – Peatland Restoration Analysis

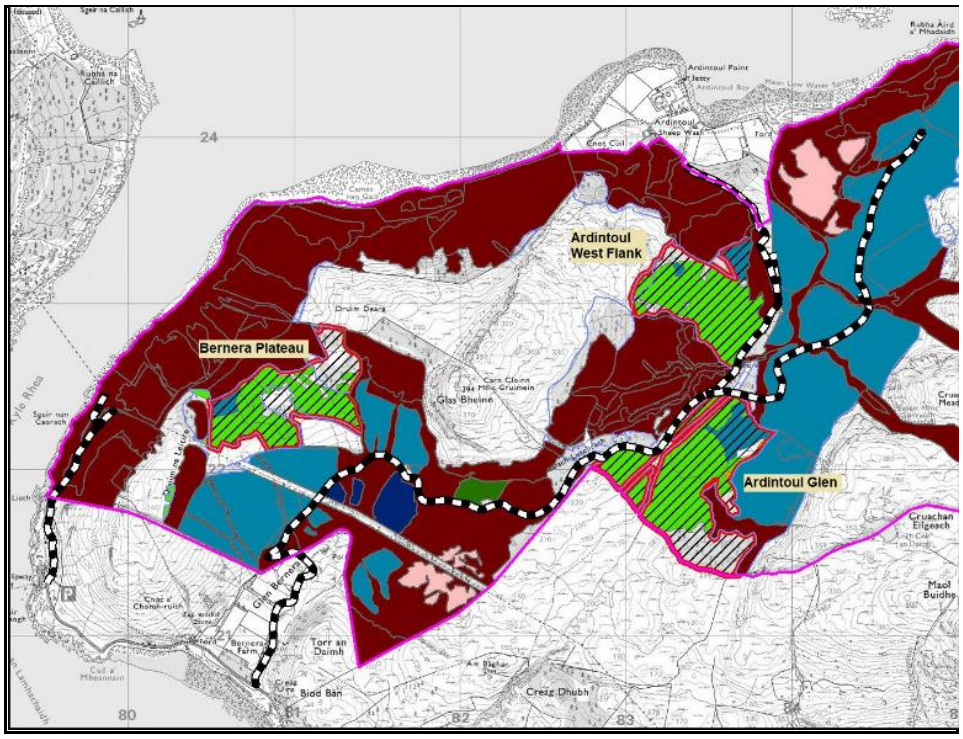
Three areas are proposed for peatland restoration within the bounds of the Glenelg Peninsula LMP in the first five years of the new Plan period (LMP 2024-2034). These are management coupes 08008, 08016 and 08019 (see **Map 4a**) and also illustrated on the map below.

The rationale behind each proposal is outlined here following the decision making process in *FCS Practice Guide 104 – Deciding future management for afforested deep peatland (2015)*.

The proposals are included in **Appendix 4** *EIA Screening Opinion Request* as all pertinent ground is currently afforested (first rotation non-native conifers) and peatland restoration would constitute deforestation. Accordingly the forestry regulator is required to determine whether formal Environmental Impact Assessment is needed to inform approval.

The three proposed sites are "assessed peatlands" i.e. their restoration potential has been arrived at by assessment of inherent features and hydrology, as opposed to "presumption to restore" sites where component peat/habitat types – or proximity to designated peatland – automatically merits restoration.

		Gross Area (ha)	Afforested Area (ha)	Scenario A, B & C peats (% of total)	>50 cm Peat (% of total)	Deforestation / Restocking Proposals
1	Bernera Plateau	37.0	25.9	B: 23.4 ha (63%) C: 5.2 ha (14%) Soils: 7.9 ha (21%)	85	Deforestation: 25.9 ha Restocking (NVC W4): <10%
2	Ardintoul Glen	53.5	38.5	B: 36.3 ha (68%) C: 2.5 ha (5%) Soils: 14.7 ha (27%)	73	Deforestation: 27.8 ha Restocking (W4): 10.7 ha (20%)
3	Ardintoul West Flank	39.7	29.2	B: 11.2 ha (28%) C: 18.1 ha (46%) Soils: 10.4 ha (26%)	69	Deforestation: 21.3 ha Restocking (W4): 7.9 ha (20%)



Peatland Restoration proposal areas – FLS Bernera/Ardintoul block

Area 1: Bernera Plateau {gross area: 37.0 ha; LP/SS/OG = 66/4/30}.

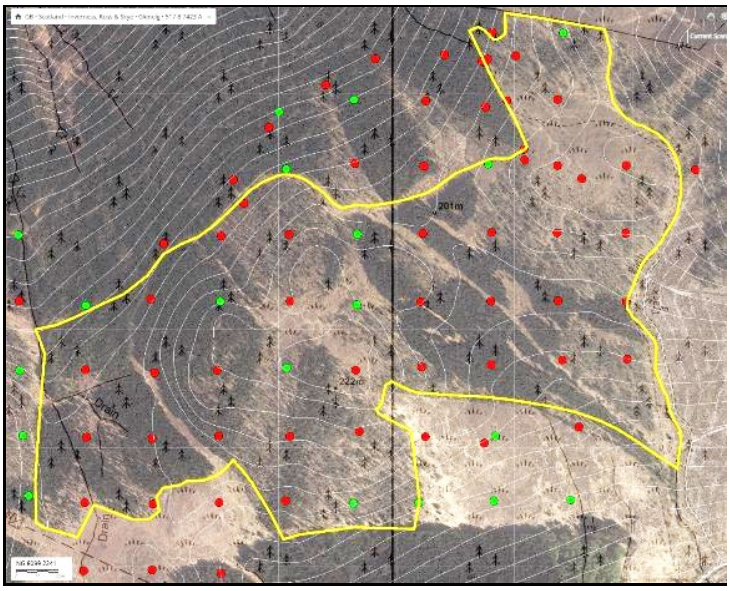


Figure 1: Proposed Restoration area in Yellow; Peat Depth <50 cm: GREEN >50 cm: RED

This upland plateau was ploughed and afforested in 1973/4: Lodgepole pine (24.3 ha) & Sitka spruce (1.6 ha). Trees are likely to have had rock phosphate fertiliser application at planting (possibly subsequently) as was conventional Forestry Commission practice on low fertility afforestation sites at that time. No specific records now exist to evidence this.

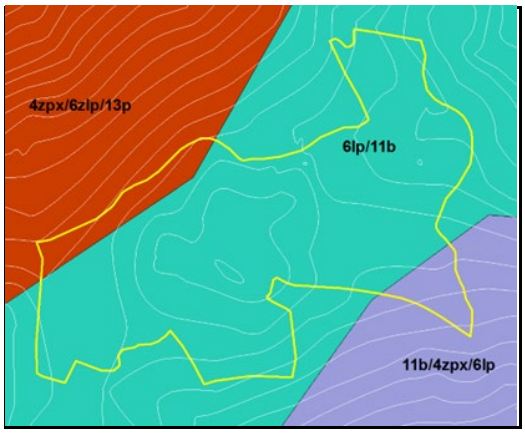
Lodgepole pine of two distinct phenotypes were planted: a slender, more apically dominant inland provenance showing good form but poor growth and a coastal provenance with poorer apical dominance/form (sweeping trunks, heavier branching, high proportion of multi-stemmed trees). Dothistroma needle blight (DNB) infection was first observed in both pine provenances in 2015 and at last survey (2022) was all scored at 2.5 or 3 – i.e. modest to significant needle loss with increasing mortality evident (see Appendix 1 – *Tree Health*). Sitka spruce has grown more uniformly but relatively slowly. Upon this plateau, as well as on adjacent coastal slopes (to north and west), there is a high proportion of windthrow which initially impacted these stands in 2005 storms and spread incrementally since.

Yield Class *(field-based)*:	Lodgepole pine: 2 – 4	Sitka spruce: 10	Downy birch: n/a
Yield Class *(ESC model)*:	Lodgepole pine: 7 – 8	Sitka spruce: 10 – 20	Downy birch: 4 – 5.

Species suitability (ESC): Lodgepole pine, Sitka spruce or Upland birchwood (W4) = 'Suitable'.

DAMS (exposure score): 17 – 18. *(16-18 = Highly Exposed).*

Prior to detailed soil survey (2022), baseline knowledge of underlying soils was James Hutton Institute's (JHI) 1:250k soil classification dataset. This earlier dataset is still the basis for Forest Research's ESC modelling tool for exploring soil type vs. tree species suitability and yield class projections.



Soil Classification: Figure 2: JHI (1:250k)

and

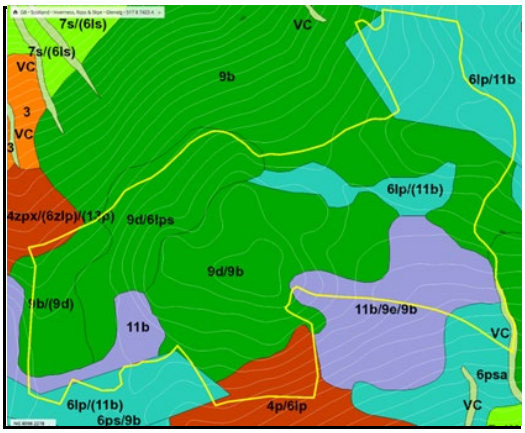


Figure 3: FLS-commissioned survey, 2022

JHI's "6lp/11b" classification is a 50% part-loamy, part-peaty Surface Water Gley and 50% *Calluna/Eriophorum vaginatum* Blanket Bog. The Soil Moisture Regime (SMR) is "Wet" and Soil Nutrient Regime (SNR) is "Very Poor 3".

2022 soil survey found very limited 6lp within this area but instead 9d dominant (Non-Tussocky *Molinia/Eriophorum vaginatum/Tricophorum* Bog) – some in association with 6lp - but mostly in mosaic with 9b (Tussocky *Molinia/Calluna* Bog). 11b (*Calluna/Eriophorum vaginatum* Blanket Bog) is present to slightly greater extent than previously expected.

Peat depth survey (100x100 m resolution) was undertaken, upon receipt of the 2022 soil survey, to determine the extent and continuity of accumulated peat . Over 85% of the site has peat in excess of 50 cm deep with the remaining 15% located where gentle undulations in plateau topography gives some sharper drainage and so more limited peat formation/accumulation (a few discernible 'ridges' and a modest central hillock).

Restoration Consideration:

Updated soil survey reveals a peatier, wetter site than was previously understood to be present (SMR = Very Wet). Manual input of 2022 soil data into ESC gives Lodgepole pine and Sitka spruce as 'Marginal': yield classes predicted as SS: 8-9, LP: 6 and PBI: 4. Both SMR and SNR are stated as limiting factors in this Marginal categorisation – suggesting both drainage and fertility need addressing to ensure successful growth.

FCS Practice Guide 104 describes 9b and 9d peat types as Scenario B and "*should grow pure SS on maintained drained sites, with PK added, in order to achieve a growth rate that allows a positive greenhouse gas balance*". Whilst Sitka spruce has grown modestly here - almost matching the ESC model projection (when up-to-date soil data is used) - the combination of coastal (upland) exposure and peaty soils has resulted in windthrow at a comparatively young age/stature (from 22 years old). With climate change predictions anticipating increased annual rainfall and increased incidence of storm events, growing shallow rooting conifers for timber production on this exposed, coastal, peaty plateau will become increasingly unrealistic but increasingly suited to peatland formation and function (with associated ecological gains of increased mire and bog integrity and extent).

With the UKFS advocating artificial fertiliser use to be "*generally a last resort in practicing sustainable forest management*" and so advocating minimising its application, a further rotation of one or both (marginally suitable) conifer species here is not considered appropriate. Any supplementary fertiliser also has the potential to leach into (and enrich) adjacent undisturbed 11b habitats. Furthermore, the condition of existing deep peats would remain under threat of further deterioration with new, or reinstated, drainage undertaken to ameliorate rooting conditions for any follow-on timber crop.

The potential for successful peatland restoration i.e. the reinstatement of natural drainage character leading to re-wetted peats and restored functionality, is considered to be good. There is little variation and variability of slope across the area which should mean drain blocking and plough ridge/furrow smoothing will have the desired effect over the vast majority (85^{+}%) of the site. The presence of some drier ridges/undulations and hillocks with better drainage character and some local mineralisation of parent rock material indicates that a small proportion of the site may support future upland birchwood development (most probably NVC W4b and c) established either from wind-dispersed seed of pioneer species (downy birch, eared and grey willows) or by planting/restocking. As a consequence the restock/future habitats prescription anticipates 10% W4 woodland regeneration for this site. Creation of more extensive Peatland Edge Woodland has been discounted on account of this habitat type's expected 20% canopy cover threshold and the 50/50 low density NBL/OG planting prescription typically expected to achieve this.

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Area 2: Ardintoul Glen {gross area: 53.5 ha; LP/SS/HL/OG = 39/12/1/48}.

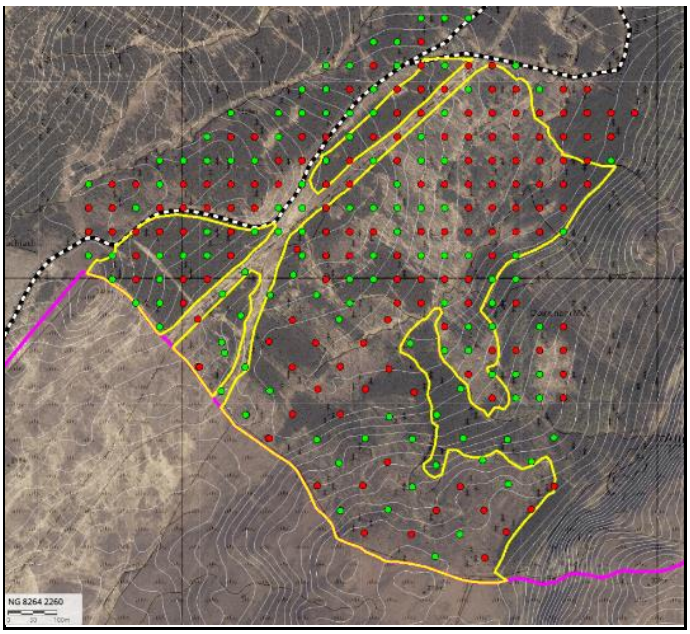


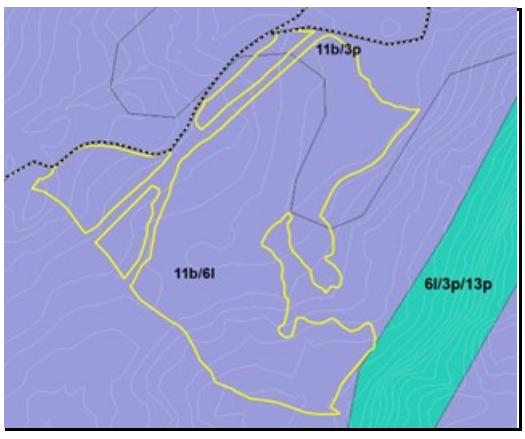
Figure 4: Proposed Restoration area in Yellow; Peat Depth <50 cm: GREEN >50 cm: RED

This glen floor site was ploughed and afforested in 1977: currently there is Lodgepole pine (20.8 ha), Sitka spruce (6.2 ha) and hybrid larch (0.6 ha). An additional 10.8 ha was originally afforested but then burned in a neighbour's muirburn operation (c. 2010) and not subsequently restocked/regenerated since then (gross open ground: 25.9 ha). The original planting is likely to have had rock phosphate application (as Area 1) but no records now exist.

As with Area 1 , two Lodgepole pine provenances were planted (slender inland provenance and bushier coastal provenance), both have grown poorly and all are infected with *Dothistroma* needle blight infection (score 3 in 2022 survey i.e. significant needle loss and mortality evident). Sitka spruce has grown more uniformly but slowly in comparison to Sitka planted immediately east from here on the sloping flanks of the glen (i.e. freer draining).

Yield Class *(field-based)*:	Lodgepole pine: 2 – 6	Sitka spruce: 10	Downy birch: n/a
Yield Class *(ESC model)*:	Lodgepole pine: 5	Sitka spruce: 5	Downy birch: 3.
Species suitability (ESC):	Lodgepole pine/downy birch = Marginal; Sitka spruce = Unsuitable.		
DAMS (exposure score):	16 – 18. *(16-18 = Highly Exposed).*		

Prior to detailed soil survey (2022), baseline knowledge of underlying soils was James Hutton Institute's (JHI) 1:250k soil classification dataset. This dataset is still used in Forest Research's ESC modelling tool for exploring soil type vs. tree species suitability and yield class projections.



Soil Classification Codes: Figure 5: JHI (1:250k); *and* **Figure 6: FLS-commissioned survey, 2022.**

JHI's "11b/6l" classification was 50% *Calluna/Eriophorum vaginatum* Blanket Bog with 50% Peaty Surface Water Gley (with some loam). The Soil Moisture Regime (SMR) is "Wet" and Soil Nutrient Regime (SNR) is "Very Poor 3".

2022 soil survey found only limited 11b within this area but instead 9b dominant (Tussocky *Molinia/Eriophorum vaginatum/Tricophorum* Bog), commonly in association with 6l (60/40 composition), but also some 6l/9b (60/40) on areas of more obvious sloping or undulating terrain.

Peat depth survey (100x100 m resolution) was undertaken after receipt of the 2022 soil survey, to determine the extent and continuity of accumulated peat . 73% of the site has peat in excess of 50 cm deep with the remaining 27% located where glen floor topography gives better drainage character and so limited peat formation/accumulation.

Restoration Consideration:

Updated soil survey revealed 11b (Calluna/Eriophorum bogs) to be not the predominant peat/soil type but rather 9b (Tussocky Molinia/Calluna bog) – some in 60/40 mosaic with 6l (Peaty Surface Water Gleys with some loam) - and other areas where 9b is sub-dominant (40/60) with 6l. The general SMR is wetter than is typical for 11b, however the SNR is Poor as opposed to Very Poor 3 for 11b. Manual input of 2022 soil data into ESC gives Lodgepole pine and Sitka spruce as 'Marginal': yield classes predicted as SS: 8-10, LP: 6 and PBI: 4. Both SMR and SNR are stated as limiting factors in this Marginal categorisation – suggesting both drainage and fertility need addressing to ensure successful growth.

FCS Practice Guide 104 describes 9b peat type as Scenario B and "*should grow pure SS on maintained drained sites, with PK added, in order to achieve a growth rate that allows a positive greenhouse gas balance*". Whilst Sitka spruce has grown modestly with fertiliser here - almost matching the ESC model projection (when up-to-date soil data is used) - the DAMS exposure and extent of peat-based soils is likely to result in early to mid-rotation windthrow in a follow-on spruce restocking. Increased annual rainfall and incidence of storm events brought about by climate change will increase this possibility as well as decreasing growth performance. However reinstatement of open ground bog mosaic here – contiguous (and hydrologically connected) with open ground bog/mire communities to the south – will provide biodiversity gains that would otherwise be missed if existing drains were renovated and follow-on crops fertilised here.

Additionally, the UKFS stipulates artificial fertiliser use to be "*generally a last resort in practicing sustainable forest management*" and so advocates minimising its application unless restocking with productive conifers offered a clear and significant net carbon gain (and insignificant biodiversity gain foregone).

As with Area 1, the potential for successful peatland restoration i.e. the reinstatement of natural drainage character leading to re-wetted peats and restored functionality, is considered to be good. It is a relatively flat glen floor with only limited internal variability in terms of slopes, ridges and hillocks and so should re-wet effectively from drain blocking and plough ridge/furrow smoothing operations.

The presence of these drier ridges/undulations and hillocks with better drainage character and some local mineralisation (hence 6l/9b mosaic) indicates that a proportion of the site may support future upland birchwood development (NVC W4) established either from wind-dispersed seed of pioneer species (downy birch, eared and grey willows) or by planting/restocking. As a consequence the restock/future habitats prescription anticipates 20% W4 Peatland Edge Woodland across the gross restoration area.

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Area 3: Ardintoul West Flank {gross area: 39.7 ha; LP/SS/OG = 61/12/27}.

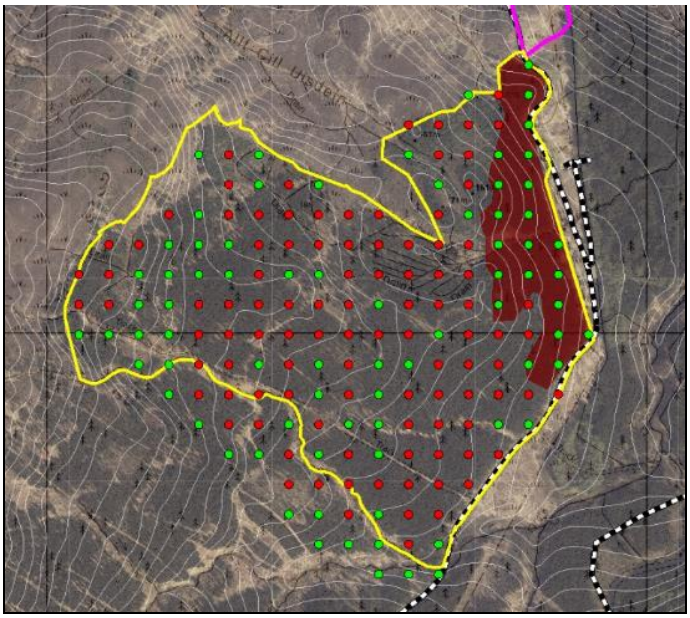


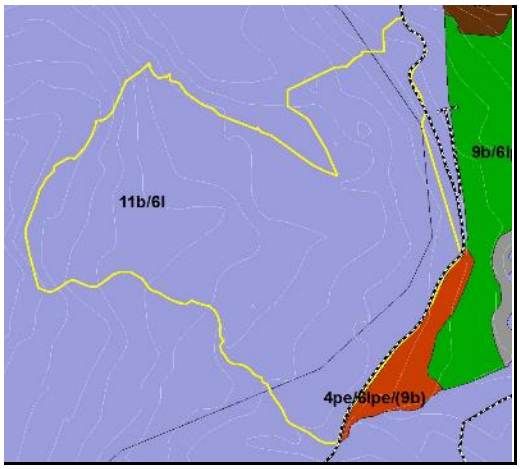
Figure 7: Proposed Restoration area in Yellow; Peat Depth <50 cm: GREEN >50 cm: RED

This gently sloping (slightly terraced) terrain on the western side of the Ardintoul glen was ploughed and afforested in 1979 with Lodgepole pine (24.4 ha) & subsequently expanded with an additional 4.8 ha Sitka spruce planted in 1989 on the north-east and north-west margins of this coupe. Trees are likely to have had rock phosphate fertiliser application at planting (possibly subsequently) as was conventional Forestry Commission practice on low fertility afforestation sites at that time. No specific records now exist to evidence this.

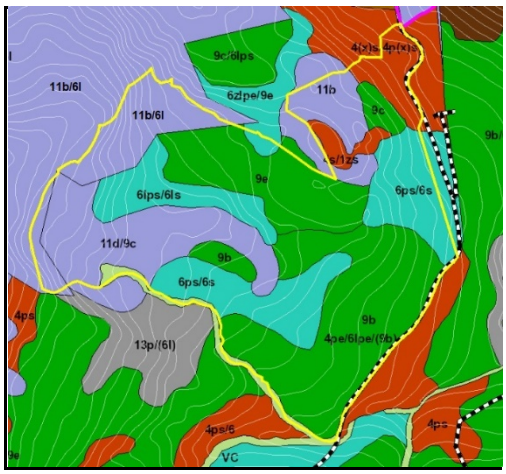
Lodgepole pine (bushy, coastal provenance) is showing both poor form and growth and is heavily infected by *Dothistroma* needle blight infection (score 3 in 2022 survey i.e. significant needle loss and mortality evident, see Appendix 1 – *Plant Health*). Sitka spruce has grown more uniformly and comparatively well (YC: 8) on moderate slopes in the north-west but poorly (YC: 4) on slacker gradients/peat-dominant flatter terraces/plateaus.

Yield Class *(field-based)*:	Lodgepole pine: 6	Sitka spruce: 4 – 8	Downy birch: n/a
Yield Class *(ESC model)*:	Lodgepole pine: 5	Sitka spruce: 5 – 8	Downy birch: 3 - 4
Species suitability (ESC):	Lodgepole pine/downy birch = 'Marginal'; Sitka spruce = Unsuitable.		
DAMS (exposure score):	15 - 17. *(16-18 = Highly Exposed).*		

Prior to detailed soil survey (2022), baseline knowledge of underlying soils was James Hutton Institute's (JHI) 1:250k soil classification dataset. The earlier dataset is still used in Forest Research's ESC modelling tool for exploring soil type vs. tree species suitability and yield class projections.



Soil Classification Codes: Figure 8: JHI (1:250k); *and* **Figure 9: FLS-commissioned survey, 2022.**



JHI's entirely "11b/6l" classification is 50% *Calluna/Eriophorum vaginatum* Blanket Bog and 50% Peaty Surface Water Gley (with some loam). The Soil Moisture Regime (SMR) is "Wet" and Soil Nutrient Regime (SNR) is "Very Poor 2".

2022 soil survey found more variation in soils across the site: only limited class '11' blanket bogs towards the upper margins of this coupes – 11d (*Eriophorum* bog) with 9c (Tussocky Molinia/Eriophorum bog) at 50/50 composition; and 11b (*Calluna/Eriophorum* Blanket Bog) with 6l (Peaty Surface Water Gley with some loam) at 50/50 composition. Pure 9e and 9b peats occupy much of the central and lower south-eastern areas of the site respectively (9e: Weakly flushed Molinia bog with *Tricophorum*, *Eriophorum* and *Calluna*; 9b: Tussocky *Molinia*/*Calluna* bog). Some (16%) of the site contains classification '6' peaty surface water gleys (s: stony, p: peaty, s: stony) on terraced slopes. In the north-eastern corner on the steepest sloping terrain above the forest road – these peaty surface water gleys grade into podzolic iron pan soils (4s, 4xs and 4ps) and so with little functioning peat-dominant vegetation or substrate.

Peat depth survey (100x100 m resolution) was undertaken, upon receipt of the 2022 soil survey, to determine the extent and continuity of accumulated peat . After excluding the 5.2 ha area of gleyed and podzolic soils on moderate slopes in the north-eastern portion of the coupe, 69% of the remaining site has peat in excess of 50 cm deep with the remaining 31% located where the loosely terraced terrain gives shallow linear ridges of gleyed (6l, p and s soils) where better drainage has limited peat formation/accumulation.

Restoration Consideration:

With the exception of the most north-westerly 5.2 ha section of this site (with podzols & ironpans and SS YC 10), current timber crops have performed poorly within the main portion of this site (LP YC: 6, SS: 4 - 8) despite pre-ploughing and fertilisation and all pine has succumbed to *Dothistroma* needle blight. ESC modelling (based on the historic JHI dataset) gives yield class predictions that approximate to growth performance in (fertilised) reality. This earlier soils data suggested majority 11b soils/peat across the site (SMR = Wet, SNR = Very Poor 2) whereas 9b and 9e dominate (SMR = Very Wet, SNR: Poor) which ESC states is 'Marginal' suitability for Sitka spruce (YC: 6-10) and Lodgepole pine (YC: 6) and Suitable for downy birch (YC: 4) – i.e. a similar growth performance to that given for JHI soil classifications as the slightly wetter SMR reality is compensated by slightly better nutrient status ('Poor' as opposed to 'Very Poor'). These are 'threshold' growth performances with regard to restoration decision-making (FCS Practice Guide 104) meaning the potential for net positive greenhouse balance from restocking is equivalent to that achieved by peatland restoration. Given the additional ecological benefits that restoration/extension of natural habitats would have over a second rotation of non-native conifers, as well as the anticipation that climate change will make the site wetter and more frequently windy in the future, the decision to restore has been made. This also avoids the application of artificial fertilisers which UKFS advocates as "generally a last resort in practicing sustainable forest management". In this instance its application (again with embedded carbon footprint) would only produce another marginal spruce crop and no net carbon gain.

The site does contain discrete ribbons/belts of peaty gleyed 6b soils which correlate closely to the areas of surveyed shallow peats found in the 2022 and these have the (ESC-modelled) potential to support some marginal upland birchwood (NVC W4) woodland which would be initiated by manually screefed restocking and accounting for 20% of the restoration area. The 5.2 ha north-westerly slopes (over podzols and gleys) will be restocked with upland birchwood species (hinge mounded) to achieve minimum YC 4 growth and slopes that offer no restoration potential (dark red area: Figure 7).

Appendix 7 - Key policies and publications

The key legislation, policies and practice guidance used in the preparation of this Plan - and to which FLS delivery will comply - are listed below:

Legislation

Forestry and Land Management (Scotland) Act 2018

Forestry Act (1967 as amended)

Plant Health Act (1967)

Forestry Commission Bye-laws (1982)

Planning (Scotland) Act 2019

Deer (Scotland) Act 1996

Land Reform (Scotland) Acts 2003 and 2016

Health and Safety at Work Act 1974

Water Environment and Water Services (Scotland) Act 2003

Water Environment (Controlled Activities) (Scotland) Regulations 2005

Flood Risk Management (Scotland) Act 2009

Nature Conservation (Scotland) Act 2004

Wildlife and Natural Environment (Scotland) Act 2011

Wildlife and Countryside Act 1981 (variation of Schedules A1 and 1A)(Scotland) Order 2013

Forestry (Environmental Impact Assessment)(Scotland) Regulations 2017

Environmental Impact Assessment (Miscellaneous Amendments)(Scotland) Regulations 2017

Forest Reproductive Material: Regulations Controlling Seed Cuttings and Planting Stock for Forestry in Great Britain, Forestry Commission Scotland 2007.

Corporate Policies and Strategies

Forestry Commission (2017) The United Kingdom Forestry Standard (Fourth Edition). FC, Edinburgh.

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Forestry and Land Scotland (2018) The National Spatial Overview. FLS, Edinburgh.

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Highland Forest and Woodland Strategy (2018) The Highland Council, Inverness.

Scottish Forestry (2021) Restocking Density for Native Broadleaves. SF policy update (May 2021).

Forestry Commission Scotland (2017) FES Dothistroma Needle Blight Strategy (version 3, June 2017)

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Broadmeadow, M ed. (2002) Climate Change Impacts on UK Forests - Bulletin 125. FCS, Edinburgh.

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SEPA. The Highland Council (2016) Highland and Argyll Local Flood Risk Management Plan (2016 – 2022). The Highland Council, Dingwall.

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Forestry Commission Scotland (2015) Long-term Management on Steep Slopes – LTMSS Information Note 1.

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Ritchie M and Wordsworth J (2010) Identifying the Historic Environment in Scotland's Forests and Woodlands. FCS, Edinburgh.

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Forestry and Land Scotland (2021) Archaeology and the Historic Environment. FLS internal communication, Inverness.

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Forestry Commission (2018) Guidance for the preparation of land management plans on Scotland's National Forest Estate. FCS, Edinburgh.

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Forestry Commission (2003) Management of Semi-Natural Woodlands - Upland Birchwoods – Practice Guide 6. FC, Edinburgh.

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Thompson, R (2009) Management of PAWS on the National Forest Estate in Scotland. FCS, Edinburgh.

Thompson, R (2009) Natural Reserves Guidance. FLS internal communication, Edinburgh.

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Forestry Commission Scotland (2014) Deer Management on the National Forest Estate - Current Practice and Future Directions. FCS, Edinburgh.

Forestry Commission (2013) Managing public safety on harvesting sites - Practice Note. FC, Edinburgh.

FCS Guidance Note 35a Forest operations and bats in Scotland (2007, revised 2009)

FCS Guidance Note 32 Forest operations and birds in Scottish Forests (2006)

FCS Guidance Note 34 Forest operations and European Protected Species in Scottish Forests (2007)

FCS Guidance Note 35c Forest operations and otters in Scotland (2009)

FCS Guidance Note 31 Forest operations and wildlife in Scottish Forests (2006)

FCS Practice Note 31 Managing forests for white-tailed Eagles (2011)

Location-specific literature

Landscape Character Assessment: Skye and Lochalsh – Landscape Evolution and Influences (2019). NatureScot.

Scottish Environment Protection Agency (2021) Flood Risk Management Plan – Highland and Argyll Local Plan District.

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Coffey (2014) Phase 2 Slope Geotechnical Assessment – Duich House BGS Polygon (FCS-commissioned survey & report)

Coffey (2014) Phase 2 Slope Geotechnical Assessment – Ratagan BGS Polygon (FCS-commissioned survey & report)

Mott Macdonald (2018) – Moyle, Loch Duich Geotechnical and Hydrological Assessment (FCS -commissioned survey & report)