Wild Trees Survey

Knoydart Methodology

Trees for Life

1. Conceptual framework

Healthy and resilient wild tree populations and woodland habitats can better support wildlife, recover after disturbance, and adapt to change. Important characteristics of health and resilience are [1]:

1. Diversity, which includes the genetic diversity of populations, the range of different native tree species present, and the range and quality of habitats that they help provide.
2. Continuity, which includes the ability of wild tree populations to maintain themselves through regeneration and recruitment, and replenishment of important habitat features like deadwood.
3. Mobility, which includes the ability of wild tree populations to expand into the wider landscape to help track changes in climate.
4. Connectivity, which includes the scale of woodland habitats and how well joined up they are.

Pressures that can influence health and resilience include herbivore impacts, non-native species, and fire.

These health and resilience characteristics informed the design of the Wild Trees Survey and guide development of management recommendations.

2. Identifying refuges

An area of search spanning the landscape or landholding is established. Potential refuges are then identified across the area of search from historical maps and aerial imagery. They include:

- Areas where unenclosed tree symbols were depicted on the 1st OS map, the first map of the Highlands accurate at finescale.
- Areas where semi-natural woodland or scattered trees can be identified from aerial imagery.

Potential refuges are assigned corresponding local placenames where possible.

3. Survey plots and transects

Most field data is recorded within plots and along transects.

Plots are placed in a grid across refuges, typically at a density of 1 plot every 2 hectares, but lower densities can be used if appropriate. Additional plots can be placed outside refuges if required to establish a wider baseline – a grid of plots at a density of 1 plot every 8 hectares was used outside refuges at Knoydart. The centroid of each plot corresponds with the centroid of a six-figure British National Grid square. Plots are circular with a radius of 10 m. Each has a nested 5.6 m radius subplot.

Transects are placed along watercourses within refuges. Additional transects can be placed outside refuges if required. They start 50 m upstream from the confluence and are typically repeated every 200 m thereafter. Transects are 10 m in length and run upstream along the watercourse. They extend 2.5 m perpendicular from the edge of each bank, or 2.5 m perpendicular from the edge of associated steep slopes if these are present.

Data collected in both plots and transects include general attributes like surveyor, date, and time; presence of regeneration by tree species; abundance of maturing, mature, senescent, and dead trees by tree species; browsing rates on regeneration and lower shoots by tree species; and a list of refugial species* present. Additional data collected in plots only included the abundance and height of regeneration*; vegetation composition and structure*; and browsing levels on 7 vegetation browsing indicator species. Further details are provided in Appendix 1.

Data categories with an ‘*’ are collected within subplots rather than from the whole plot area. Additional field data is recorded as notes where features of interest are found outwith plots and transects.

4. Data analysis and interpretation

Following data collection, raw data is processed to calculate relevant diversity, continuity, herbivore impacts, and non-native species metrics. This includes scaling of tree abundance data from plots and transects to calculate estimated abundance totals and average densities. Tree recruitment values are determined by regressing abundances at different growth stages and interpreting the overall trend. Raw tree and vegetation browsing data are categorised by palatability class and processed following an adaptation of Armstrong *et al*. (2023) [2] to calculate impact scores for 5 indicators, see Appendix 1 for details. An overall herbivore impact score is then assigned to each plot based on interpretation of these indicator scores. Maps of processed plot, transect, and note data (as appropriate) are created to show the distribution and variability of tree species composition, diversity, growth structure, established density, and regeneration density; refugial species diversity; herbivore impacts, and browsing rates for different tree and vegetation palatability classes; and presence of non-native species. Processed plot, transect, and note data are also counted, summed, or averaged (as appropriate) to generate refuge and site-level data. Recovery priority levels are assigned following according to criteria given in Appendix 2.

5. References

1. Rainey, J. and Holmes, F. (2023) Caledonian Pinewoods: Findings from the Caledonian Pinewood Recovery Project. Trees for Life
2. Armstrong, H., Black, B., Holl, K. & Thompson, R. (2023) The Woodland Herbivore Impact Assessment Method User Guide

Appendix 1
Field data recording

1. Standard plot and transect attributes

Site name, refuge name, plot/transect ID, surveyor name, and date are recorded as standard at each plot and transect.

2. Recording trees

Tree species encountered at each plot and transect are recorded. For each tree species, the following attributes are recorded:

- Wildness (categories: 'assumed wild' / 'assumed planted' / 'mixed: earlier growth stages planted' / 'mixed: other' / 'uncertain')
- Regeneration present (Y/N)
- Abundance of maturing trees (number)
- Abundance of mature trees (number)
- Abundance of senescent trees (number)
- Abundance of dead trees (number)
- Browsing on regeneration ('N/A' / 'absent: no browsing' / 'light: <25% browsed' / 'moderate: 25-75% browsed' / 'heavy: 75-90% browsed' / 'very heavy: >90% browsed')
- Browsing on lower shoots ('N/A' / 'absent: no browsing' / 'light: <25% browsed' / 'moderate: 25-75% browsed' / 'heavy: 75-90% browsed' / 'very heavy: >90% browsed')
- Damage from herbivores ('N/A' / 'absent: no damage to receptive trees' / 'light: <5% of receptive trees damaged' / 'moderate: 5-20% of receptive trees damaged' / 'heavy: 20-50% of receptive trees damaged' / 'very heavy: >50% of receptive trees damaged')

Additionally, the abundance and height of regeneration is recorded within each 5.6 m subplot. This is recorded separately for natural regeneration of native trees, planted native trees, and non-native trees.

- Abundance categories are: 'N/A' / '0' / '1-3' / '4-6' / '7-10' / '11-20' / '21-30' / '>30'. These correspond with densities of 0, 100-300, 400-600, 700-1000, 1100-2000, 2100-3000, and >3000 trees per hectare respectively.
- The height of the 4 tallest naturally regenerating seedlings or saplings are recorded. Height categories are: '0 cm' / '>0-5 cm' / '>5-10 cm' / '>10-20 cm' / '>20-30 cm' / '>30-40 cm' / '>40-50 cm' / '>50-60 cm' / '>60-70 cm' / '>70-80 cm' / '>80-90 cm' / '>90-100 cm' / '>100-110 cm' / '>110-120 cm' / '>120-130 cm' / '>130-140 cm' / '>140-150 cm' / '>150-160 cm' / '>160-170 cm' / '>170-180 cm' / '>180-190 cm' / '>190-200 cm'.
- Height of planted and non-native regeneration is recorded collectively using the following categories: 'N/A' / 'all <1 m' / 'most <1 m' / 'mixed' / 'most >1 m' / 'all >1 m'. Regeneration density and height data is not recorded at transects.

A list of native tree species is given is Table 1. Different tree growth stages are defined in Table 3.

3. Recording refugial species

Refugial species encountered at each transect and within the nested 5.6 m subplot plot of each plot are recorded. A list of species considered refugial is given in Table 2.

4. Recording vegetation

Information about vegetation composition and structure is recorded within plots. The primary reason for this is to establish a baseline against which future vegetation change can be monitored. As such, a point intercept method has been chosen, as this minimises surveyor variation associated with estimating vegetation cover by eye.

To record vegetation composition and structure, a thin rod is placed vertically at 8 locations within each nested 5.6 m subplot. These are approximately 2 m and 5 m north, east, south and west from the centre of the plot. Vegetation intersecting with the rod is recorded to species level where possible, or to group level for some taxa (eg. smooth grasses, sphagna, feathermosses). The maximum height of interception is also recorded using the categories: '0 cm' / '>0-5 cm' / '>5-10 cm' / '>10-20 cm' / '>20-30 cm' / '>30-40 cm' / '>40-50 cm' / '>50-60 cm' / '>60-70 cm' / '>70-80 cm' / '>80-90 cm' / '>90-100 cm' / '>100 cm' / 'N/A'.

Browsing rates on key indicator species are also recorded at plot level. Within the 10 m radius plot, browsing is recorded on blaeberry, bramble, raspberry, hard fern, bog myrtle, ling heather and bell heather where these species are present. Categories are: 'N/A' / 'absent: no browsing' / 'light: shoot tips <25% browsed' / 'moderate: shoot tips 25-75% browsed' / 'heavy: shoot tips >75% browsed' / 'very heavy: shoots >90% browsed'.

Vegetation attributes are not recorded at transects.

5. Determining herbivore impacts

The Woodland Herbivore Impact Assessment (Armstrong *et al*. 2023), or WHIA, is the standard method for determining herbivore impacts in woodland in Scotland. A simplified method known as WHIA lite (Woodland Habitat Impact Assessment lite) has also been developed by NatureScot as part of the Deer Management Best Practice Guidance series.

The WHIA has been simplified and adapted to integrate with the Wild Trees Survey (WTS HIA). Key adaptations are detailed in Table 4 and summarised below:

- Use of 10 m rather than 25 m radius survey plots
- Varying the number of plots according to the size of refuges
- Recording browsing rates at species level rather than for individual trees
- Use of 5 rather than 7 indicators of herbivore impact
- Restriction of the number of ground vegetation species considered to 7

Overall, the effect of these adaptations is to place the WTS HIA somewhere between the WHIA and WHIAlite in terms of complexity. Other than adaptations described, the WTS HIA follows Armstrong *et al*. 2023.

Table 1: List of native tree and shrub species

Alnus glutinosa (Alder)	Ribes sp. (Currant)
Betula nana (Dwarf birch)	Salix arbuscula (Mountain willow)
Betula pendula (Silver birch)	Salix aurita (Eared willow)
Betula pubescens (Downy birch)	Salix capraea (Goat willow)
Betula sp. (Birch)	Salix cinerea (Grey willow)
Corylus avellana (Hazel)	Salix herbacea (Dwarf willow)
Crataegus monogyna (Hawthorn)	Salix lanata (Woolly willow)
Cytisus scoparius (Broom)	Salix lapponum (Downy willow)
Euonymus europaeus (Spindle)	Salix myrsinifolia (Dark-leaved willow)
Frangula alnus (Alder buckthorn)	Salix myrsinites (Whortle-leaved willow)
Fraxinus excelsior (Ash)	Salix pentandra (Bay willow)
Ilex aquifolium (Holly)	Salix phylicifolia (Tea-leaved willow)
Juniperus communis (Juniper)	Salix purpurea (Purple willow)
Juniperus communis nana (Prostrate juniper)	Salix repens (Creeping willow)
Malus sylvestris (Crab apple)	Salix reticulata (Net-leaved willow)
Pinus sylvestris (Scots pine)	Salix sp. (Willow)
Populus nigra (Black poplar)	Sambucus nigra (Elder)
Populus tremula (Aspen)	Sorbus aucuparia (Rowan)
Prunus avium (Gean)	Sorbus rupicola (Rock whitebeam)
Prunus padus (Bird cherry)	Sorbus sp. (Whitebeam)
Prunus spinosa (Blackthorn)	Taxus baccata (Yew)
Quercus petraea (Sessile oak)	Ulex europaea (Gorse)
Quercus robur (Pedunculate oak)	Ulex gallii (Western gorse)
Quercus sp. (Oak)	Ulmus glabra (Wych elm)
Ribes rubrum (Red currant)	Viburnus opulus (Guelder rose)
Ribes spicatum (Erect-spiked red currant)	

Table 2: List of refugial species

Lichens	
Gabura fascicularis (Octopus suckers)	distinctive rainforest indicator species (Plantlife, 2023)
Leptogium brebissonii (Blobby jelly-skin lichen)	distinctive rainforest indicator species (Plantlife, 2023)
Leptogium burgessii (Frilly-fruited jelly-skin lichen)	distinctive rainforest indicator species (Plantlife, 2023)
Lobaria pulmonaria (Tree lungwort)	distinctive rainforest indicator species (Plantlife, 2023)
Lobarina scrobiculata (Lob scrob)	distinctive rainforest indicator species (Plantlife, 2023)
Nephroma laevigatum (A kidney lichen)	distinctive rainforest indicator species (Plantlife, 2023)
Nevesia sampaiana (Brown-shingle lichen)	distinctive rainforest indicator species (Plantlife, 2023)
Pannaria conoplea (Mealy-rimmed shingle lichen)	distinctive rainforest indicator species (Plantlife, 2023)
Pannaria rubiginosa (Red-eyed shingle lichen)	distinctive rainforest indicator species (Plantlife, 2023)
Pectenia atlantica (Felt lichen)	distinctive rainforest indicator species (Plantlife, 2023)
Pectenia plumbea (Plum-fruited felt lichen)	distinctive rainforest indicator species (Plantlife, 2023)
Peltigera collina (A dog lichen)	distinctive rainforest indicator species (Plantlife, 2023)
Pseudocyphellaria citrina (Yellow specklebelly)	distinctive rainforest indicator species (Plantlife, 2023)
Pseudocyphellaria intricata (Smooth specklebelly)	additional rainforest indicator species
Pseudocyphellaria norvegica (Norwegian specklebelly)	distinctive rainforest indicator species (Plantlife, 2023)
Ricasolia amplissima (Parchment lichen)	distinctive rainforest indicator species (Plantlife, 2023)
Ricasolia virens (Green satin lichen)	distinctive rainforest indicator species (Plantlife, 2023)
Sticta fuliginosa (Wee sticta)	distinctive rainforest indicator species (Plantlife, 2023)
Sticta limbata (Floury sticta)	distinctive rainforest indicator species (Plantlife, 2023)
Sticta sylvatica (Big sticta)	distinctive rainforest indicator species (Plantlife, 2023)
Bryophytes	
Anastrepta orchadensis (Orkney notchwort)	pinewood and northern hepatic mat associated species
Anastrophyllum alpinum/joergensenii (Joergensen's notchwort)	northern hepatic mat species (Hodd et al. 2011)
Anastrophyllum donnianum (Donn's notchwort)	northern hepatic mat species (Hodd et al. 2011)
Bazzania tricrenata (Lesser whipwort)	northern hepatic mat species (Hodd et al. 2011)
Bazzania trilobata (Greater whipwort)	distinctive rainforest indicator species
Herbertus hutchinsiae (Juniper prongwort)	northern hepatic mat species (Hodd et al. 2011)
Mastigophora woodsii (Wood's whipwort)	northern hepatic mat species (Hodd et al. 2011)
Plagiochila carringtonii (Carrington's featherwort)	northern hepatic mat species (Hodd et al. 2011)
Plagiochila killarniensis/spinulosa/punctata/atlantica (rainforest featherworts)	distinctive rainforest indicator species (Plantlife, 2023)
Ptilium crista-castrensis (Ostrich-plume feather-moss)	pinewood associated species
Scapania gracilis (Western earwort)	distinctive rainforest indicator species (Plantlife, 2023)
Scapania nimbosa (Cloud earwort)	northern hepatic mat species (Hodd et al. 2011)
Scapania ornithopoides (Bird's-foot earwort)	northern hepatic mat species (Hodd et al. 2011)
Sphagnum austinii (Austin's bog-moss)	distinctive and uncommon species associated with high-quality peatland
Sphagnum fuscum (Rusty bog-moss)	distinctive and uncommon species associated with high-quality peatland
Ferns and lycopods	
Dryopteris aemula (Hay-scented buckler fern)	Ancient Woodland indicator species (Crawford, 2009)
Gymnocarpium dryopteris (Oak fern)	Ancient Woodland indicator species (Crawford, 2009)
Hymenophyllum tunbrigense (Tunbridge filmy-fern)	Ancient Woodland indicator species (Crawford, 2009)
Hymenophyllum wilsonii (Wilson's filmy-fern)	Ancient Woodland indicator species (Crawford, 2009)
Osmunda regalis (Royal fern)	grazing-sensitive and associated with tall herb communities
Phegopteris connectilis (Beech fern)	Ancient Woodland indicator species (Crawford, 2009)
Polypodium vulgare/inter. (Polypody)	Ancient Woodland indicator species (Crawford, 2009)
Polystichum aculeatum (Hard shield-fern)	Ancient Woodland indicator species (Crawford, 2009)
Polystichum lonchitis (Holly-fern)	grazing-sensitive and associated with tall herb communities
Polystichum setiferum (Soft shield-fern)	Ancient Woodland indicator species (Crawford, 2009)

Spinulum annotinum (Interrupted clubmoss)	pinewood associated species
Flowering plants	
Adoxa moschatellina (Moschatel)	Ancient Woodland indicator species (Crawford, 2009)
Ajuga reptans (Bugle)	woodland associated species
Alchemilla glabra (Smooth lady's-mantle)	tall herb
Allium ursinum (Ramsons/Wild garlic)	Ancient Woodland indicator species (Crawford, 2009)
Andromeda polifolia (Bog rosemary)	browsing-sensitive peatland associated species
Anemone nemorosa (Wood anemone)	Ancient Woodland indicator species (Crawford, 2009)
Angelica sylvestris (Angelica)	tall herb
Arctostaphylos uva-ursi (Bearberry)	browsing-sensitive montane dwarf shrub
Arctous alpina (Alpine bearberry)	browsing-sensitive montane dwarf shrub
Brachypodium sylvaticum (False brome)	Ancient Woodland indicator species (Crawford, 2009)
Bromopsis ramosa (Hairy brome)	Ancient Woodland indicator species (Crawford, 2009)
Carex atrata (Black alpine-sedge)	grazing-sensitive and associated with tall herb communities
Carex laevigata (Smooth-stalked sedge)	Ancient Woodland indicator species (Crawford, 2009)
Carex pallescens (Pale sedge)	Ancient Woodland indicator species
Carex pendula (Pendulous sedge)	Ancient Woodland indicator species (Crawford, 2009)
Carex remota (Remote sedge)	Ancient Woodland indicator species (Crawford, 2009)
Carex sylvatica (Wood-sedge)	Ancient Woodland indicator species (Crawford, 2009)
Cephalanthera longifolia (Sword-leaved helleborine)	Ancient Woodland indicator species (Crawford, 2009)
Chamaenerion angustifolium (Rosebay willowherb/Fireweed)	tall herb
Chrysosplenium alternifolium (Alternate-leaved golden saxifrage)	Ancient Woodland indicator species (Crawford, 2009)
Chrysosplenium oppositifolium (Opposite-leaved golden saxifrage)	Ancient Woodland indicator species (Crawford, 2009)
Cicerbita alpina (Alpine blue-sow-thistle)	tall herb
Circaea alpina (Alpine enchanter's nightshade)	Ancient Woodland and montane associated
Circaea lutetiana (Enchanter's nightshade)	Ancient Woodland indicator species (Crawford, 2009)
Circaea sp. (Enchanter's nightshade)	Ancient Woodland indicator species (Crawford, 2009)
Circaea x intermedia (Upland enchanter's nightshade)	Ancient Woodland indicator species (Crawford, 2009)
Cirsium heterophyllum (Melancholy thistle)	tall herb
Conopodium majus (Pignut)	Ancient Woodland indicator species (Crawford, 2009)
Corallorhiza trifida (Coralroot orchid)	wet woodland specialist species
Cornus suecica (Dwarf cornel)	montane woodland associated species
Crepis paludosa (Marsh hawksbeard)	tall herb
Dactylorhiza viridis (Frog orchid)	tall herb associate
Drymochloa sylvatica (Wood fescue)	Ancient Woodland indicator species (Crawford, 2009)
Elymus caninus (Bearded couch)	Ancient Woodland indicator species (Crawford, 2009)
Empetrum nigrum (Crowberry)	pinewood and montane associated species
Epipactis helleborine (Broad-leaved helleborine)	Ancient Woodland indicator species (Crawford, 2009)
Equisetum sylvaticum (Wood horsetail)	Ancient Woodland indicator species (Crawford, 2009)
Ficaria verna (Lesser celandine)	woodland associated species
Filipendula ulmaria (Meadowsweet)	tall herb
Fragaria vesca (Wild strawberry)	Ancient Woodland indicator species (Crawford, 2009)
Galium boreale (Northern bedstraw)	grazing-sensitive and associated with tall herb communities
Galium odoratum (Woodruff)	Ancient Woodland indicator species (Crawford, 2009)
Geranium robertianum (Herb robert)	woodland associated species
Geranium sylvaticum (Wood crane's-bill)	tall herb
Geum rivale (Water avens)	tall herb
Geum urbanum (Wood avens)	woodland associated species
Goodyera repens (Creeping lady's-tresses)	Ancient Woodland indicator species (Crawford, 2009)
Hammarbya paludosa (Bog orchid)	distinctive and uncommon species associated with peatland
Hedera helix/hibernica (Ivy)	browsing-sensitive liana

Hyacinthoides non-scripta (Bluebell)	Ancient Woodland indicator species (Crawford, 2009)
Hypericum androsaemum (Tutsan)	Ancient Woodland indicator species (Crawford, 2009)
Hypericum pulchrum (Slender St John's-wort)	Ancient Woodland indicator species (Crawford, 2009)
Lathraea squamaria (Toothwort)	Ancient Woodland indicator species (Crawford, 2009)
Linnaea borealis (Twinflower)	Ancient Woodland indicator species
Lonicera periclymenum (Honeysuckle)	browsing-sensitive liana
Luzula pilosa (Hairy woodrush)	Ancient Woodland indicator species (Crawford, 2009)
Luzula sylvatica (Great woodrush)	Ancient Woodland indicator species (Crawford, 2009)
Lysimachia nemorum (Yellow pimpernell)	Ancient Woodland indicator species (Crawford, 2009)
Melampyrum pratense (Common cow-wheat)	Ancient Woodland indicator species (Crawford, 2009)
Melampyrum sylvaticum (Small cow-wheat)	Ancient Woodland indicator species (Crawford, 2009)
Melica nutans (Mountain melick)	Ancient Woodland indicator species (Crawford, 2009)
Melica uniflora (Wood melick)	Ancient Woodland indicator species (Crawford, 2009)
Mercurialis perennis (Dog's mercury)	Ancient Woodland indicator species (Crawford, 2009)
Milium effusum (Wood millet)	Ancient Woodland indicator species (Crawford, 2009)
Moehringia trinervia (Three-nerved sandwort)	Ancient Woodland indicator species (Crawford, 2009)
Moneses uniflora (One-flowered wintergreen)	pinewood associated species
Myosotis sylvatica (Wood forget-me-not)	Ancient Woodland indicator species (Crawford, 2009)
Neottia cordata (Lesser twayblade)	pinewood associated species
Neottia nidus-avis (Bird's nest orchid)	Ancient Woodland indicator species (Crawford, 2009)
Orchis mascula (Early purple orchid)	woodland associated species
Orthilia secunda (Serrated wintergreen)	Ancient Woodland indicator species (Crawford, 2009)
Oxalis acetosella (Wood sorrel)	Ancient Woodland indicator species (Crawford, 2009)
Oxyria digyna (Mountain sorrel)	tall herb
Paris quadrifolia (Herb paris)	Ancient Woodland indicator species (Crawford, 2009)
Poa nemoralis (Wood meadow-grass)	Ancient Woodland indicator species (Crawford, 2009)
Polygonatum verticillatum (Whorled Solomon's seal)	Ancient Woodland indicator species (Crawford, 2009)
Potentilla sterilis (Barren strawberry)	Ancient Woodland indicator species (Crawford, 2009)
Primula vulgaris (Primrose)	Ancient Woodland indicator species (Crawford, 2009)
Pyrola media (Intermediate wintergreen)	Ancient Woodland indicator species
Pyrola minor (Common wintergreen)	Ancient Woodland and montane associated
Ranunculus auricomus (Goldilocks buttercup)	Ancient Woodland indicator species (Crawford, 2009)
Rhodiola rosea (Roseroot)	tall herb
Rosa canina (Dog rose)	browsing-sensitive thorny shrub
Rosa pimpinellifolia (Burnet rose)	browsing-sensitive thorny shrub
Rubus chamaemorus (Cloudberry)	montane woodland associated species
Rubus fruticosus (Bramble)	browsing-sensitive thorny shrub
Rubus idaeus (Raspberry)	browsing-sensitive thorny shrub
Rubus saxatilis (Stone bramble)	woodland and tall herb associated species
Sanicula europaea (Sanicle)	Ancient Woodland indicator species (Crawford, 2009)
Saussurea alpina (Alpine sawwort)	tall herb
Schedonorus giganteus (Giant fescue)	Ancient Woodland indicator species (Crawford, 2009)
Scirpus sylvaticus (Wood club-rush)	Ancient Woodland indicator species (Crawford, 2009)
Scrophularia nodosa (Figwort)	Ancient Woodland indicator species (Crawford, 2009)
Silene dioica (Red campion)	woodland and tall herb associated species
Solidago virgaurea (Goldenrod)	tall herb
Stellaria holostea (Greater stitchwort)	Ancient Woodland indicator species (Crawford, 2009)
Stellaria nemorum (Wood stitchwort)	Ancient Woodland indicator species (Crawford, 2009)
Teucrium scorodonia (Wood sage)	woodland associated species
Trientalis europaea (Chickweed wintergreen)	Ancient Woodland indicator species (Crawford, 2009)
Trollius europaeus (Globeflower)	tall herb
Vaccinium microcarpum/oxy. (Cranberry)	grazing-sensitive and bog woodland associated species
Vaccinium uliginosum (Bog blaeberry)	pinewood associated species
Vaccinium vitis-idaea (Cowberry)	pinewood associated species

Valeriana officinalis (Valerian)	Ancient Woodland indicator species (Crawford, 2009)
Veronica montana (Wood speedwell)	Ancient Woodland indicator species (Crawford, 2009)
Vicia sylvatica (Wood vetch)	Ancient Woodland indicator species (Crawford, 2009)
Viola riviniana (Common dog violet)	woodland associated species
Invertebrates	
Formica sp. nest (Wood ant nest)	Ancient Woodland indicator species

Table 3: Growth stage categories

Group	regeneration	Maturing	mature	senescent	dead
Trees (alder, silver and downy birch, ash, crab apple, Scots pine, black poplar, aspen, gean, tree forms of bird cherry, oaks, goat willow, grey willow, bay willow, purple willow, rowan, whitebeams, yew, wych elm, non-native conifers)	height < 2 m	height > 2 m and with fewer than 3 characteristics of maturity*	height > 2 m and with 3 or more characteristics of maturity*	height > 2 m, previously mature, and with 1 or more characteristics of post-maturity**	dead trees that were previously mature or senescent
Large shrubs (hazel, hawthorn, holly, erect forms of juniper, shrubby forms of bird cherry, eared willow, dark-leaved or tea-leaved willow in non-montane habitats, elder, tree cotoneaster, rhododendron)	height < 1 m	height > 1 m and with fewer than 3 characteristics of maturity*	height > 1 m and with 3 or more characteristics of maturity*	height > 1 m, previously mature, and with 1 or more characteristics of post-maturity**	dead shrubs that were previously mature or senescent
Small shrubs (broom, spindle, alder buckthorn, shrubby forms of juniper, blackthorn, currants, woolly willow, downy willow, dark-leaved willow in montane habitats, whortle-leaved willow, tea-leaved willow in montane habitats, gorse, western gorse, guelder rose)	length of longest stem < 50 cm	length of longest stem > 50 cm and with fewer than 3 characteristics of maturity*	length of longest stem > 50 cm and with 3 or more characteristics of maturity*	length of longest stem > 50 cm, previously mature and with 1 or more characteristics of post-maturity**	dead shrubs that were previously mature or senescent
Creeping shrubs (dwarf birch, prostrate juniper, mountain willow, dwarf willow, creeping willow, net-leaved willow, creeping cotoneaster)	length of longest stem < 50 cm, or forming patches no more than 50 cm in diameter	length of longest stem 50 - 100 cm, or forming patches no more than 1 m in diameter	length of longest stem > 100 cm, or forming patches greater than 1 m in diameter	N/A	dead shrubs that were previously maturing or mature

*__characteristics of maturity__:

- well-developed crown
- branches from lower trunk are substantial and no longer twiggy
- secondary bark characteristics such plates, furrows or pits have developed along much of the lower trunk
- typical trunk size for species at maturity

**__characteristics of post-maturity__:

- crown dying back
- tree or shrub losing vigour
- hollowing of the trunk or lower branches
- signs of rot or decay
- bracket fungi or other decay-associated species growing on the trunk
- significant quantities of attached deadwood
- trunk considerably thicker than typical for species at maturity

Table 4: Comparison between woodland herbivore impact assessment methods

WHIA	WHIA lite	WTS HIA	comments
Data recorded within 25 m radius survey plots	Data recorded within 25 m radius survey plots	Data recorded within 10 m radius survey plots	While WTS HIA survey plots are smaller, most survey areas will include a much larger number of plots than is typical for the WHIA or WHIA lite.
Typically 5 – 10 survey plots per site	Typically 2 – 8 survey plots per site	Number of survey plots depends on size of refuge, with typical density of 1 plot every 2 hectares	
Browsing rates recorded for individual trees	Browsing rates recorded collectively for palatable and unpalatable tree classes	Browsing rates recorded at tree species level	
Uses 7 indicators of herbivore impact (ground disturbance; bark stripping, fraying & stem breakage; basal shoots; epicormic and lower shoots; seedlings and saplings; preferentially browsed or grazed plants; other plants)	Uses 3 indicators of herbivore impact (seedlings/saplings; lower shoots; ground vegetation). The lower shoots indicator also includes basal shoots	Uses 5 indicators of herbivore impact (regeneration; lower shoots; damage; preferentially browsed plants; other plants)	'Regeneration' is equivalent to the 'seedlings and saplings' WHIA indicator. 'Lower shoots' is an amalgamation of the 'epicormic and lower shoots' and 'basal shoots' WHIA indicator. Assignment of impact scores follows the method for 'epicormic and lower shoots'. 'Damage' is equivalent to the 'bark stripping, fraying & stem breakage' WHIA indicator. 'Preferentially browsed plants' is equivalent to the 'preferentially browsed or grazed plants' WHIA indicator. 'Other plants' is equivalent to the 'other plants' WHIA indicator.
Considers browsing/grazing rates on a wide range of ground vegetation species	Considers browsing/grazing rates on 5 ground vegetation species: blaeberry, bramble, raspberry, bog myrtle, and hard fern	Considers browsing/grazing rates on 7 ground vegetation species: blaeberry, bramble, raspberry, bog myrtle, hard fern, ling heather, and bell heather	

6. References

Armstrong, H., Black, B., Holl, K. & Thompson, R. (2023) The Woodland Herbivore Impact Assessment Method User Guide

Crawford, C. (2009) Ancient woodland indicator plants in Scotland. Scottish Forestry, Vol. 63

Hodd, R. and Sheehy Skeffington, M. (2011) Mixed northern hepatic mat: a threatened and unique bryophyte community. Field Bryology No. 104.

NatureScot (2022) WHIA lite

Plantlife (2023) Rapid Rainforest Assessment

Appendix 2

Assigning priority levels

Priority level	Description	Indicators
Very High	Critical stage of decline	Very High if any of the following criteria are met: 1. Large parts of refuge support only senescent or dead trees *(≥10 ha or ≥20% of refuge supports only senescent or dead trees)* 2. Established tree density is very low and declining *(established tree density ≤100 trees/ha and recruitment chronically low)* 3. Key species at imminent risk of extinction *(any key species* population size <50 and most individuals are senescent or dead)* 4. PAWS with mature or senescent wild trees threatened by growth of non-native trees
High	Declining but not critical	High if not Very High and any of the following criteria are met: 1. Smaller parts of refuge support only senescent or dead trees *(4-10 ha or 5-20% of refuge supports only senescent or dead trees)* 2. Established tree density is low and declining *(established tree density ≤400 trees/ha and recruitment low or chronically low)* 3. Key species are declining but not imminently threatened with extinction *(all key species* population sizes ≥50, or if <50 most individuals are maturing or mature)* 4. Non-native species are significant and spreading *(non-native species present in ≥10% of plots or at mean density of ≥100 trees/ha)*
Medium	Stable/improving but not meeting potential	Medium if not High or Very High and any of the following criteria are met: *1.* The amount of regeneration diversity being suppressed by overbrowsing is significant *(≥25% of regen diversity suppressed per plot)* 2. Herbivore impacts are generally medium to high or greater *(>50% of plots have medium to high or greater levels of herbivore impacts)* 3. Browsing indices for palatable regeneration and very palatable vegetation are no more than moderate 4. Very invasive non-native species like *Rhododendron ponticum* or western hemlock are present, or regeneration of non-native species recorded.

Low	Stable/improving and meeting potential	Low if not Medium, High or Very High

* species are considered key species if the refuge supports a high proportion of the total population, or if the species is or was a dominant component of the woodland