Caledonian Pinewoods

Findings from the Caledonian Pinewood Recovery Project

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Appendix 2

Field survey methodology

Trees for Life

Contents

1. Introduction

The field survey used in the Caledonian Pinewood Recovery project was developed for rapid collection of ecological information relevant to assessing health and resilience, as conceptualised in Appendix 1. Woodland Herbivore Impact Assessment following Armstrong *et al*. (2017, 2020) was incorporated into the methodology, as were elements from the Native Woodland Survey Scotland. The field survey was plot based and sampling was undertaken in both core Caledonian Pinewood and surrounding regeneration zones. Notes and geotagged photos were also taken outwith plots.

The field survey was revised twice over the course of the project. The first revision was made early on during the first phase of the project (2018-2020 fieldwork), when some data categories were simplified and additional categories added. The second revision was made during the second phase of the project (2021 fieldwork), when additional data categories were added and an updated version of the Woodland Herbivore Impact Assessment adopted. Only data categories that were maintained throughout the project or simplified (meaning former categories could be combined to give the equivalent result) were used in the data analysis presented in Appendix 3.

2. Plot placement

Data was gathered from within circular plots of radius 25 m during the survey. Plot locations were determined ahead of field survey through a desk-based exercise. Plots were located in both Caledonian Pinewood and in suitable parts of the surrounding regeneration zone. See 'Caledonian Pinewoods: The Caledonian Pinewood Inventory' in the main report for a description of regeneration zones.

Suitable parts of the regeneration zone were determined using information from the Native Woodland Model (https://openscience.hutton.ac.uk/dataset/native-woodland-model-2004). The Native Woodland Model includes a map of potential woodland types that could develop in the Scottish uplands. The main potential woodland type that is suitable for the development of Caledonian Pinewood is 'W18', which is a woodland community described in the National Vegetation Classification. We also observed that Caledonian Pinewoods were expanding into areas where the potential woodland type was 'W4', which is normally a birch dominated woodland community. We classified potential woodland types predicted by the Native Woodland Model into 3 groups, those considered to have low, medium, and high potential to support native pinewood:

- Low potential to support native pinewood communities were: Birch/Willow; Built-up land; Developed rural land; Inland Water; Juniper; Mixed montane scrub; nodata; Scattered Birch/Willow; Scattered Juniper; Scattered mixed montane scrub; Unsuitable for tree/scrub growth; W10 + W7 Mosaic; W10 Lowland mixed broadleaved with bluebell/wild hyacinth; W10/W16; W10/W7; W10/W8; W11 + W7 Mosaic; W11 Upland Oak-Birch with bluebell/wild hyacinth; W11/W17; W11/W7; W11/W9; W17 + W4 Mosaic; W17 Upland Oak-Birch with blaeberry; W17/W11; W19 Juniper woodland with wood sorrel; W7 + W17 Mosaic; W7 + W4 Mosaic; W7 + W9 Mosaic; W7 Alder-ash with yellow pimpernell; W7/W10; W7/W11; W8 Lowland mixed broadleaved with dog's mercury; W9 + W7 Mosaic; W9 Upland mixed broadleaved with dog's mercury; W9/W11; W7 + W11 Mosaic; W7 + Peatland with scattered trees/scrub; W6 + W11 Mosaic; W6 Alder with stinging nettle.
- Medium potential to support native pinewood communities were: Basin Bog woodland/scrub; Basin Bog woodland/scrub + W11; Peatland with scattered trees/scrub;

Peatland with scattered trees/scrub + W18 Mosaic; Peatland with scattered trees/scrub + W4 Birch with purple moor grass and open ground + W17/W18 Mosaic; Peatland with scattered trees/scrub Mosaic + W4 Birch with purple moor grass and open ground; W11 + basin bog woodland/scrub; W11 + W4 Mosaic; W17/W18; W17/W18 & W4 Birch (with open ground) Mosaic

- High potential to support native pinewood communities were: W18 + Peatland with scattered trees/scrub Mosaic; W18 + W11 Mosaic; W18 + W4 + Peatland with scattered trees/scrub Mosaic; W18 + W4 Mosaic; W18 Scots Pine with heather; W18/W17; W4 + W17 Mosaic; W4 + W18 Mosaic; W4 Birch (with open ground) + Peatland with scattered trees/scrub + W17/W18 Mosaic; W4 Birch (with open ground) + W17/W18 Mosaic; W4 Birch (with open ground) + Peatland with scattered trees/scrub; W4 Birch with purple moor grass & open ground.

Allocation of plots within Caledonian Pinewood and the regeneration zone was undertaken following a process designed to ensure good coverage of each individual site, without biasing plots towards specific stand or vegetation types. The process is described below:

- First, a survey time was estimated for each site. As a rule, 1 day was allowed for small sites (eg. Loch Dochard, Ardessie, Torphantrick), 2 days for medium sites (eg. Crathie, Crannach) and 3-6 days for large sites (eg. Kinveachy, Glen Tanar).
- The estimated number of survey days was multiplied by 30, and a number of random points equal to the resultant value were generated across Caledonian Pinewood and the regeneration zone using a random point generator in QGIS.
- Points that were very close together or in parts of the regeneration zone considered to have low potential for native pinewood communities were discarded.
- More points were discarded until the number remaining equalled the estimated number of survey days multiplied by 10. The following guidance was followed when discarding points:
    - Where practical, try to ensure that at least 1 point falls within each discrete Caledonian Pinewood fragment.
    - The number of points within each Caledonian Pinewood fragment should be roughly proportion to fragment size.
    - Try to ensure that points are well spread across Caledonian Pinewood fragments.
    - For small sites, try to ensure that at least 4 of the points are within the Caledonian Pinewood.
    - For medium to large sites, try to ensure that there are more points in the Caledonian Pinewood than regeneration zone.
    - For small sites, try to ensure that at least 4 of the points are within the regeneration zone.
    - For medium to large sites, try to ensure that at least 8 of the points are within the regeneration zone.
    - Try to ensure that points are well spread across the regeneration zone.
- In some cases, additional points had to added to achieve these aims. Where this was the case, this was done without the use of aerial imagery to avoid biasing point placement towards specific stand or vegetation types.
- The resultant points represent the locations of plots to be visited during the field survey.

3. Overview of data recorded

Within each plot, data was recorded on the trees, ground vegetation, herbivore impacts, fire evidence, and wood ant nests that were present. General data on the site, location, and survey time were also recorded.

The Domin scale was used to record the cover/abundance of various features in the field. Domin scores 1-3, which are used to describe abundance at low cover, were assigned differently for maturing, mature, old, and dead trees, as individuals at these growth stages can support significant cover. See Figure 3 for details.

Figure 3: Table showing Domin scale with adaptations used during the field survey.

Domin score	cover/abundance (most features)	cover/abundance (maturing/ mature/old/dead trees)
1	<4% (few individuals)	≤1%
2	<4% (several individuals)	>1,≤2%
3	<4% (many individuals)	>2,<4%
4	4-10%	4-10%
5	11-25%	11-25%
6	26-33%	26-33%
7	34-50%	34-50%
8	51-75%	51-75%
9	76-90%	76-90%
10	91-100%	91-100%

For each tree species, the abundance/cover of each growth stage, vegetation layer, and old growth feature was recorded. Information on accessibility was also recorded (ie. whether it was growing from a cliff or ravine, where impacts from large herbivores may be constrained), along with information relevant to assessing herbivore impacts (browsing rates on regeneration and lower shoots, damage). For all tree species collectively, overall abundance/cover was recorded for each growth stage, vegetation layer, and old growth feature class. The Woodland Structure Class was also recorded.

For ground vegetation, presence and abundance/cover was recorded for a subset of species, along with information on accessibility and herbivore impacts (browsing/grazing rates). The height of the field layer at the centre of the plot was also recorded, along with The National Vegetation Classification code for the habitat.

Evidence of historical and recent fire was recorded. The presence of wood ant nests was recorded. Notes were taken of large herbivore signs observed.

An example recording sheets is shown overleaf.

Site: [redacted]	Plot: core 1	Grid: [redacted]	Date: 23/9/19 Time: 10:20-10:50 13:15-13:30	Stand: OS + ravine mature complex NVC: M15+W18/17

Species	VR	ER	PI	M1	M2	M3	T1	T2	Rot sites	Holes/pools	Dwd atchd	Hollowing	T	Stdg + bark	Stdg no bark	Snag + fallin	Stmp + fallin	Uprooted	T	T1 inaccess	T1 biogenic	T2 inaccess	T2 biogenic	VR inaccess	VR biogenic	Basal	Epi/lwr	Regen	Damage
SP	✓ 2	✓ 2	✓ 2	✓ 3			✓ 3	✓ 3												✓ 10		✓ 10		✓ 9			✓ 3	✓ 4+	
B	✓ 2	✓ 2	✓ 4	✓ 5			✓ 6	✓ 2		✓ 2			✓ 2							✓ 6		✓ 10				✓ 3		✓ 3	
R	✓ 2	✓ 3						✓ 3														✓ 10						✓ 3	
W	✓ 2			✓ 1			✓ 1	✓ 1			✓ 1		✓ 1							✓ 10		✓ 10					✓ 3	✓ 3	
Hy		✓ 1	✓ 1					✓ 2														✓ 10							
J	✓ 1																							✓ 10					
?broadleaf																✓ 1			✓ 1										
Total	3	3	4	6			6	4		2	1		2			1			1	6		10		7		Grd: 2	Hgt: 30	FScr:	Brn: ✓4 Ant:

Species	Cvr	Brsg/grzg	Inaccess
Bell H	✓ 2	✓ 3	
Calluna	✓ 6	✓ 2	
Tetralix	✓ 4	✓ 2	
Hard fern	✓ 3	✓ 3	✓ 9
Bladdery	✓ 4	✓ 3	✓ 7
Honeysuckle	✓ 2	✓ 3	✓ 10
Dryopteris ☆	✓ 4	✓ 1	✓ 7
Bracken	✓ 4		
Luzula	✓ 3		✓ 10
Molinia	✓ 7	✓ 1	
Succisa	✓ 3	✓ 8	

Heath rush, bog asphodel, racomitrium, purple spoonwort, cladonia, sundew (very low), sphagnum

human tracks disturbing ~10% plot, bat deer pobs 2

tormentil bits

wood sage, violet

☆ one scaly male fern + hay scented buckler fern

4. Recording trees and shrubs

Each tree and shrub species within each plot was recorded. For each species, the following attributes were recorded:

4.1. Growth stages

Tree and shrub species were grouped into growth classes, as shown in Figure 4a. Each growth class had different criteria used to identify trees and shrubs at different growth stages, as shown in Figure 4b.

Growth stages are the different developmental phases that trees and shrubs progress through over their lifetimes. We recognised the following growth stages:

- Seedlings, also known as visible regeneration (VR): the earliest growth stage. Some trees and shrubs and trees exposed to adverse pressures may not develop beyond this stage. Those that are heavily browsed can develop into 'old seedlings', which have resprouted repeatedly but cannot maintain young growth as gets removed.
- Saplings, also known as established regeneration (ER): the second growth stage. Trees and shrubs at this stage remain vulnerable to browsing pressure and debarking.
- Maturing, also known as pole immature (PI): the third growth stage, when trees and shrubs are developing towards maturity. Trees and shrubs at this stage are much less vulnerable to browsing. Some that grow in very wet, windy or nutrient limited sites may not develop beyond this stage but can still attain great age.
- Mature (M1): the forth growth stage, when trees and shrubs have successfully developed to maturity and their reproductive capacity is at its peak. From this stage onwards trees become more vulnerable to wind throw, particularly if they're growing on shallow or very wet soils.
- Old, also known as late mature (M2) or post-mature (M3): the final growth stages before death. Trees and shrubs at this stage are typically old show signs of senescence and decay, including attached dead braches and rot holes. The oldest may also have hollowing of the trunk. M2 and M3 stages were recorded separately in the field survey during the first phase of the project, and recorded together during the second phase of the project.

Growth stages were defined primarily using the height and diameter of trees and shrubs, as described in Figure 4b. The abundance/cover at each growth stage was recorded using the Domin scale as described in Figure 3.

Figure 4a: Table showing growth classes of trees and shrubs modified from the Native Woodland Survey of Scotland and Fay (2007).

Growth class	**Species**
1: Small shrubs	blackthorn, broom, elder, gorse, juniper, rhododendron
2: Large shrubs	hazel
3: Small trees	aspen, birch, bird cherry, crab apple, hawthorn, holly, rowan, whitebeam, small willow species, yew
4: Large trees 1	alder, ash, gean, lodgepole pine, oak, Scots pine
5: Large trees 2	beech, fir, hemlock, spruce, sycamore, large willow species, wych elm

Figure 4b: Assignment of growth stages to trees and shrubs modified from the Native Woodland Survey of Scotland and Fay (2007).

	Growth class				
Growth stage	1: Small shrubs	2: Large shrubs	3: Small trees	4: Large trees 1	5: Large trees 2
Seedlings (VR)	dgl <5cm, hgt <1m	dgl <5cm, hgt <1m	hgt <1m	hgt <1m	hgt <1m
Saplings (ER)	dgl 5cm-15cm or hgt >1m	dgl 5cm-20cm or hgt >1m	hgt >1m	hgt >1m	hgt >1m
Maturing (PI)			dbh 7-20cm	dbh 7-30cm	dbh 7-35cm
Mature (M1)	dgl 15-30cm	dgl 20-60cm	dbh 20-40cm	dbh 30-70cm	dbh 35-80cm
Old (M2)			dbh 40-60cm	dbh 70-110cm	dbh 80-130cm
Old (M3)	dgl >30cm	dgl >60cm	dbh >60cm	dbh >110cm	dbh >130cm

dgl = diameter of stem or stool at ground level
hgt = height
dbh = diameter at breast height

4.2. Vegetation layers

Vegetation layers that trees and shrubs formed a part of were recorded. Any tree over 4 metres tall was considered part of the canopy, which is the uppermost vegetation layer. Any tree or shrub between 1 and 4 metres tall was considered part of the understory, which is the middle vegetation layer. Trees or shrubs between 1 and 4 metres tall were still recorded as part of the understory even if a tree canopy was absent. The understory could include large trees that had fallen over and resprouted ('phoenix' trees). Pictures of vegetation layers are shown in Figure 4c.

The abundance/cover of canopy and understory within plots was recorded per species using the Domin scale as described in Figure 3.

4.3. Old growth features

Old growth features include living trees with decay features, old trees, and dead trees. Old trees are considered in Section 4.1, while living trees with decay features and dead trees are considered in this section. Old growth features are important for many specialised and threatened fungi, lichens, bryophytes, and invertebrates.

For each tree species:

- 4 possible classes of living trees with decay features were recorded as described in Figure 4d and shown in Figure 4e. The abundance/cover of living trees with decay features was recorded using the Domin scale as described in Figure 3.
- 5 possible classes of dead tree were recorded as described in Figure 4f and shown in Figure 4g. Only trees that were completely dead were recorded it this category – those that have dead trunks but had resprouted from the base were recorded as living trees with decay features. Dead trees that could not be identified at species level were recorded as 'unidentified tree', 'unidentified conifer' or 'unidentified broadleaf'. Estimated abundance/cover of dead trees when they were still alive was recorded using the Domin scale as described in Figure 3.

Figure 4c: Vegetation layer pictures. Understory is present in the open (upper picture), and understory under a canopy (lower picture)

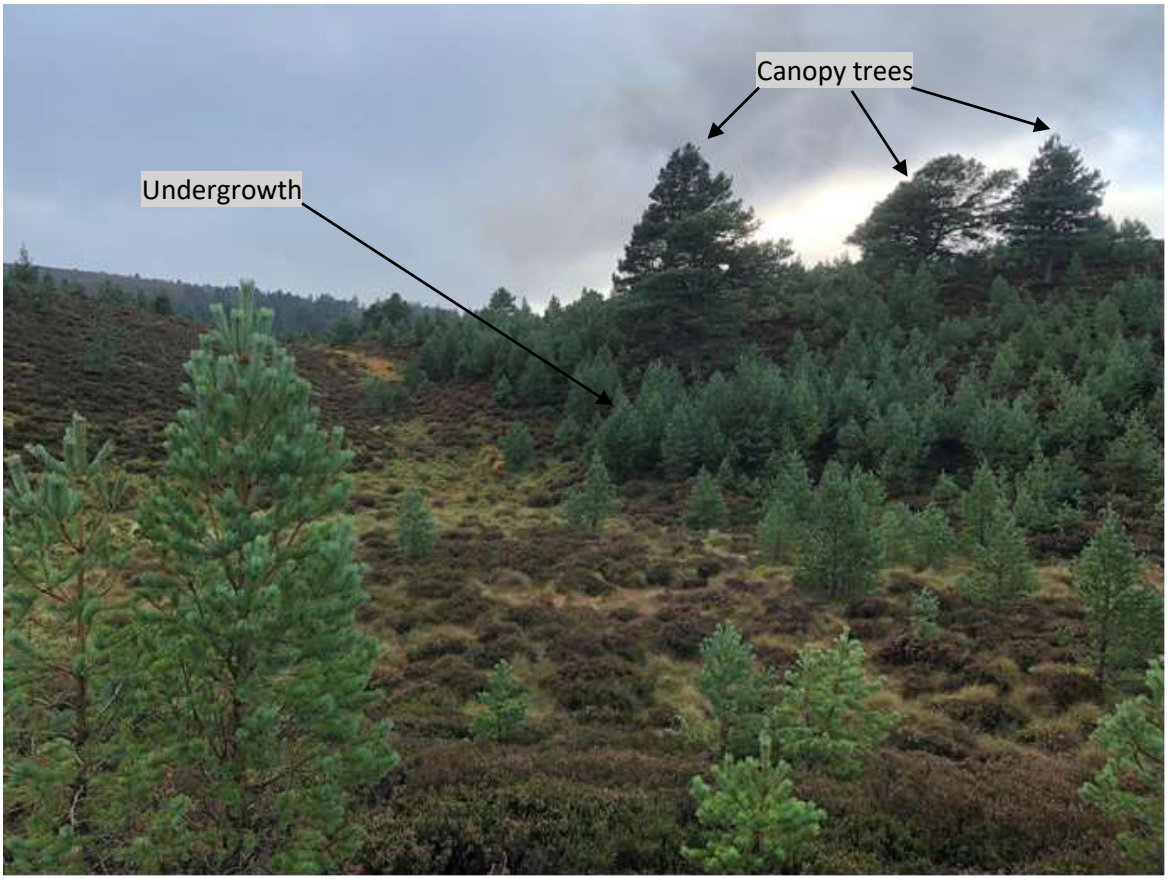

Figure 4d: Table showing decay features on living tree classes adapted from Fay (2007).

Decay feature	**Description**	**Minimum size**	
		Growth class 1-3	Growth class 4-5
Rot sites	*Rot sites associated with wounds which are decaying* Following bark loss, wounding or limb loss wood may be colonised by fungi and other microorganisms. Rot is typically visible on the surface of the tree following bark disruption or damage. Rot sites may be apparent within the stem or branches or where a stem or branch has fractured and wood become colonised by fungi. Such sites can then become important for a range of saproxylic species.	100cm^2	400cm^2
Holes and water pockets	*Holes and water pockets in the trunk and mature crown* Rot holes can develop through limb loss and bark wounds, and are expanded by digestive activity of microorganisms (particularly wood decay fungi) and invertebrates, and when inundated can form water pools. They can become occupied by invertebrates, mammals, reptiles, birds and bats.	3-15cm diameter	5-15cm diameter
Attached Deadwood	*Dead branches or stems (attached)* Attached deadwood is typically colonised by decay fungi and depending on its hydration, exposure, and elevation may support different suites of species.	10cm diameter	15cm diameter
Hollowing	*Any hollowing in the trunk or major limbs*	NA	NA

Figure 4e: Pictures of decay features on living trees. Rot sites on birch (top left) and Scots pine (bottom left). Hollowing and deadwood attached to birch (top right), and deadwood attached to Scots pine (bottom right)

Figure 4f: Table showing dead tree classes

Deadwood type	**Description**	**Classification**
Standing deadwood with bark	*Upright dead trees or shrubs which have not yet lost their bark* This indicates that the tree has died relatively recently. May be important for bark beetles	Bark attached to >30% of the tree/shrub >60% of tree/shrub height still upright
Standing deadwood without bark (bones)	*Upright dead trees or shrubs which have lost their bark, exposing underlying wood* This deadwood type can be very important for rare and specialised lichens, and are referred to as tree 'bones' by lichenologists	Bark attached <30% of the tree/shrub >60% of tree/shrub height still upright
Snag and associated fallen deadwood	*Dead tree that has been snapped part way along the trunk, leaving an upright part and a fallen or loosely attached part* The area of the snag where the snap has occurred often has a very large surface area of splintered wood, which can be ideal for fungal growth	<60% but >20% of the tree/shrub height still upright
Stump and associated fallen deadwood	*Dead tree that has been snapped or cut at the base, leaving a stump (still anchored to the ground) and a large mass of fallen deadwood* Fallen deadwood is important for bryophytes, invertebrates and fungi, whilst stumps can be important for rare lichens	<20% of tree/shrub height still upright make a note if stumps have been cut and if timber appears to have been removed
Uprooted fallen deadwood	*Dead tree that has fallen over and upturned its root plate (roots on one half of the tree are no longer anchored to the ground)* Fallen deadwood is important for bryophytes, invertebrates and fungi, whilst uprooted root plates can provide microsites for regeneration	Uprooted trees/shrubs that have fallen to the ground or are suspended close to the ground.

Figure 4g: Pictures of dead trees. Standing dead Scots pine with bark attached (top left), standing dead oak bones (top right) and Scots pine bones along with a Scots pine snag (bottom).

Figure 4g (continued): Pictures of dead trees. Fallen Scots pine deadwood associated with a stump (top left), a Scots pine stump (top right) and an uprooted dead Scots pine (bottom).

4.4. Accessibility

Accessibility of trees and shrubs can play a role in how regeneration takes place in landscapes where high herbivore impacts are widespread. The following classes of tree and shrub accessibility were considered during the field survey:

- Accessible: Trees and shrubs growing from the ground in areas where topology does not significantly restrict or exclude herbivore access.
- Inaccessible: Trees and shrubs growing from the ground, in rock crevices or atop boulders in areas where herbivore access is significantly restricted or excluded due to topology. These conditions were most often present on crags, cliffs, boulder-fields or in steep sided ravines.
- Biogenic: Trees and shrubs growing from other biological structures, such as live trees, deadwood or on soil elevated by upturned root plates. Those growing from live trees are known as 'air trees', and dead trees with regeneration taking place on them are known as 'nurse trees'.

If regeneration is mostly taking place in inaccessible and biogenic microsites, this can indicate that herbivore impacts are too high. However, other factors can also differ between accessible and inaccessible sites, such as management history (inaccessible sites are more difficult to clear), amount of bedrock exposure, peat accumulation and microclimate.

For each tree and shrub species, the proportions of individuals in different vegetation layers (first phase of the project) or growth stages (second phase of the project) found in inaccessible and biogenic areas were recorded. Proportion classes were matched to the Domin scale (see Figure 3).

By separately considering the microsites that canopy trees, undergrowth trees and visible regeneration are found, inferences can be made about long term herbivore impacts across the site. Therefore, the proportion of trees in the canopy, undergrowth and of visible regeneration that are located in inaccessible and biogenic microsites are recorded per species using the Domin scale. Further details are given in Table 5. The proportion of trees in accessible microsites is not recorded, but can be calculated later by subtracting inaccessible and biogenic proportions from the total.

Pictures of inaccessible and biogenic trees are shown in Figure 4h.

Figure 4h: Pictures of inaccessible and biogenic trees. Partly inaccessible Scots pine seedling growing on a crag – note that the more accessible side has been heavily browsed (top left), inaccessible maturing Scots pine (top right), inaccessible mature Scots pine (bottom left), and 'biogenic' regeneration taking place on a Scots pine root plate (bottom right).

Figure 4h (continued): Pictures of inaccessible and biogenic trees. Biogenic Scots pine and birch growing from a now rotted away root plate (top left), and biogenic Scots pine trees growing from decaying stumps (top and bottom right) and a now rotted away root plate (bottom left).

4.5. Herbivore impact

Woodland Herbivore Impact Assessment was incorporated into the survey. This followed Armstrong *et al*. 2017 & 2020. The 2017 version of the method was used during the first phase of the project and the 2020 version during the second phase. Browsing rates were recorded on basal shoots, epicormic and lower shoots, and seedlings and saplings, and damage recorded, as shown in Figure 4i.

Figure 4i: Table showing how herbivore impacts on trees and shrubs were recorded following Armstrong et al. 2017 & 2020

Impact on	Browsing/damage rate				
	Absent: 0	Light: 1	Moderate: 2	Heavy: 3	Very heavy: 4
Basal shoots Includes all accessible shoots sprouting from tree bases. Score N/A if it is unclear whether shoots have been browsed or died back	Absent	<10% of the current year's growth (only shoot tips) removed	10-50% of the current year's growth removed. No older woody shoots browsed	50-90% of the current year's growth removed. Some older woody shoots browsed	>90% of the current year's growth removed. Short study stems, difficult to see on some species. Most older, woody shoots browsed
Epicormic & lower shoots Includes all shoots on tree trunks (epicormic), lower branches or fallen trees that are within reach of herbivores	Absent	<30% of the current year's growth removed (2017) <25% of the current year's growth removed (2020)	30-80% of the current year's growth removed (2017) 25-75% of the current year's growth removed (2017)	>80% of the current year's growth removed (2017) 75-90% of the current year's growth removed (2020)	All outer shoots removed (including many old, woody shoots) and remaining growth old and woody (2017) >90% of outer shoots removed (including many old, woody shoots) and remaining growth old and woody (2020)
Seedlings and saplings Seedlings and saplings less than 2 m tall	Absent	<30% of the current year's growth removed (2017) <25% of the current year's growth removed (2020)	30-80% of the current year's growth removed (2017) 25-75% of the current year's growth removed (2017)	>80% of the current year's growth removed (2017) 75-90% of the current year's growth removed (2020)	All outer shoots removed (including many old, woody shoots) and remaining growth old and woody (2017) >90% of outer shoots removed (including many old, woody shoots) and remaining growth old and woody (2020)
Damage Bark stripping and stem breakage. Score as N/A if all damage occurred prior more than a year ago, but take a note of this	Absent	Recent bark stripping generally hard to find. There may be one stripped or frayed tree and/or occasional snapping by cattle and/or deer	<20% of live stems, and recently fallen branches, showing signs of recent bark stripping. Sometimes one individual tree is badly bark stripped, and/or <10% (but more than occasional) live stems of saplings <5cm dbh snapped by cattle and/or red deer	20-50% of live stems, and recently fallen branches, showing recent bark stripping. And/or 10-20% of live stems of saplings <5cm dbh snapped by cattle and/or red deer	>50% of live stems, and recently fallen branches, showing recent bark stripping that may be severe. And/or >20% of live stems of saplings <5cm dbh snapped by cattle and/or red deer

4.6. Fire scarring

Trees exposed to fire can develop distinctive charring on their wood and bark, as shown in Figure 4j. This can persist for many decades. Presence of fire scarring was recorded within plots and across the site more generally.

Figure 4j: Fire scarred Scots pine bark (left) and wood (right).

5. Recording ground vegetation

Vegetation other than trees and shrubs was considered ground vegetation. A subset of ground vegetation species relevant to assessing herbivore impacts were recorded during the survey. This subset was expanded to include additional ecologically important species during the second phase of the project. The list of species recorded is given in Figure 5a. The abundance/cover of each was recorded using the Domin scale as described in Figure 3. Notes on the presence of any unusual or rare species were taken.

Figure 5a: Table showing ground vegetation species recorded

Recorded during first and second phase of project	
Species	**Palatability**
Bramble	Very palatable
Stone bramble	Very palatable
Raspberry	Very palatable
Honeysuckle	Very palatable
Dog rose	Very palatable
Ivy	Very palatable
Blaeberry	Very palatable
Broom	Very palatable
Valerian	Very palatable
Meadowsweet	Very palatable
Angelica	Very palatable
Buckler ferns	Very palatable to deer, otherwise unpalatable
Great woodrush	Very palatable to cattle, moderately palatable to deer, otherwise unpalatable
Bog myrtle	Moderately palatable
Ling heather	Moderately palatable
Bell heather	Moderately palatable
Devil's bit scabious	Moderately palatable
Lemon scented fern	Moderately palatable to deer, otherwise unpalatable
Lady fern	Moderately palatable to deer, otherwise unpalatable
Hard fern	Moderately palatable to deer, otherwise unpalatable
Purple moor grass	Moderately palatable to cattle, otherwise unpalatable
Soft rush	Moderately palatable to cattle, otherwise unpalatable
Sharp-flowered rush	Moderately palatable to cattle, otherwise unpalatable
Cross-leaved heath	Slightly palatable
Primrose	Slightly palatable
Bracken	Slightly palatable
Tufted hairgrass	Slightly palatable
Recorded during second phase of project only	
Cowberry	N/A
Crowberry	N/A
Bearberry	N/A
Cloudberry	N/A

5.1. Accessibility

Accessibility can influence the distribution and abundance of palatable ground vegetation species in landscapes where herbivore impacts have been high for a long period. Ground vegetation was considered inaccessible if growing in areas where herbivore access was significantly restricted or excluded due to topology. These conditions were most often present on crags, cliffs, boulder-fields or in steep sided ravines. An example is shown in Figure 5b.

For each ground vegetation species, the proportions found in inaccessible areas was recorded. Proportion classes were matched to the Domin scale (see Figure 3).

Figure 5b: Very palatable Ivy restricted to an inaccessible area on the overhang of a ravine

5.2. Herbivore impact

Woodland Herbivore Impact Assessment was incorporated into the survey. This followed Armstrong *et al*. 2017 & 2020. The 2017 version of the method was used during the first phase of the project and the 2020 version during the second phase. Browsing/grazing rates were recorded on ground vegetation growth, and ground disturbance was recorded, as shown in Figure 5c.

Figure 5c: Table showing how herbivore impacts on ground vegetation were recorded following Armstrong et al. 2017 & 2020

Impact on	**Browsing/grazing rate and disturbance**				
	Absent: 0	Light: 1	Moderate: 2	Heavy: 3	Very heavy: 4
Ground vegetation growth Includes evidence of browsing and/or grazing on species listed in Figure 5a.	Absent	<25% of leading shoots browsed or leaves grazed (2017) <25% of the total number of shoots browsed or leaves grazed (2020)	25-75% of leading shoots browsed or leaves grazed (2017) 25-75% of the total number of shoots browsed or leaves grazed (2020)	>75% of leading shoots browsed or leaves grazed (2017) 75-90% of the total number of shoots browsed or leaves grazed (2020)	all leading shoots browsed or leaves grazed (2017) >90% of the total number of shoots browsed or leaves grazed (2020)
Ground disturbance Ground disturbance by animals through trampling, creation of pathways, wallowing and rooting within the past year. Score as N/A if ground is composed of boulders or scree.	Absent	<5% of ground disturbed by large herbivores. Large herbivore pathways rare and almost completely vegetated	5-15% of ground disturbed by large herbivores. Large herbivore pathways are not hard to find but largely vegetated, or pathways rare but unvegetated. There may be heavier disturbance around feeding areas and pig shelters	>15-30% of ground disturbed by large herbivores. Large herbivore pathways frequent and partially, or mostly, unvegetated. For livestock areas, there may be some poached and/or unvegetated ground, especially if the ground is wet. There may be heavier disturbance around feeding areas and pig shelters	>30% of the ground disturbed by large herbivores. Large herbivore pathways are frequent, wide and wholly unvegetated. There may be some kicked out clods of turf and *Sphagnum* as well as well-defined deer wallows. For livestock areas, there may be substantial areas of bare ground, especially if wet. There may be heavier disturbance around feeding areas and pig shelters

5.3. Burning

Ground vegetation can be affected by burning, particularly if it is made up of flammable species such as ling heather *Calluna vulgaris* or purple moor grass *Molinia caerulea*. Burnt vegetation can be identified by charring, and dead heather stems surrounded by very short regrowth, as shown in Figure 5d. The cover of burnt vegetation was recorded using the Domin scale as described in Figure 3.

Figure 5d: Recently burnt ground (above) and recovering burnt ground (below)

5.4. Height

The approximate mean height of tall ground vegetation within the centre of the plot was recorded to the nearest 5cm.

5.5. Wood ant nests

Wood ants are key species in pinewoods: they help to control numbers of pine-feeding insects (by eating them), disperse plant seeds, and their nests provide a home for other insects.

The presence of wood ant nests was recorded within plots and more widely. A Wood ant nest is shown in Figure 5e.

Figure 5e: Large Wood ant nest

6. References

Armstrong, H., Black, B., Holl, K. & Thompson, R. (2017, 2020) Assessing Herbivore Impact in Woodlands: An Observation-based Method.

Fay, N. (2007) Defining and Surveying Veteran and Ancient Trees.