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Monitoring of vegetation change through permanent woodland plots in Killarney National Park: A 30-year review

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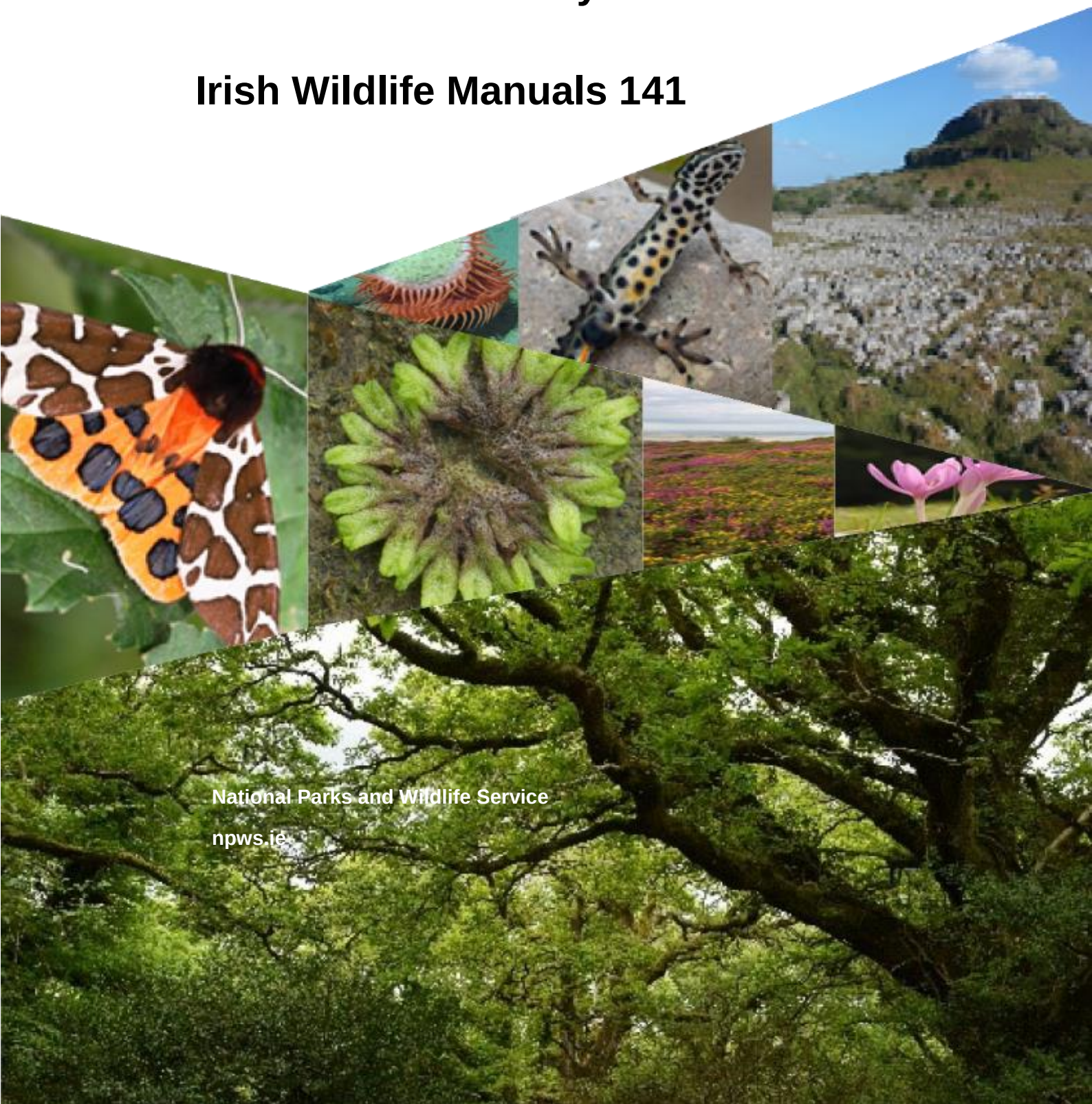

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Keywords: Killarney National Park, Long-term monitoring, Woodland, Oak woodland, Yew woodland, Holly woodland, Natural regeneration, Grazing, Invasive species, *Rhododendron*.

Front cover, small photographs from top row:

A deep water fly trap anemone *Phelliactis* sp., Yvonne Leahy; **Common Newt** *Lissotriton vulgaris,* Brian Nelson; **Limestone pavement**, Bricklieve Mountains, Co. Sligo, Andy Bleasdale; **Garden Tiger** *Arctia caja,* Brian Nelson; **Violet Crystalwort** *Riccia huebeneriana*, Robert Thompson; **Coastal heath**, Howth Head, Co. Dublin, Maurice Eakin; **Meadow Saffron** *Colchicum autumnale*, Lorcan Scott

Bottom photograph: **Tomies oak woodland**, Killarney National Park, Jessica Hamilton

Monitoring of vegetation change through permanent woodland plots in Killarney National Park: A 30-year review

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Contents

Executive Summary

This report marks 30 years since the establishment of permanent plots within Killarney National Park which monitor regeneration and vegetation changes across three types of semi-natural woodland. In total there are eighty-seven permanent plots which are spread across six woodlands: Derrycunihy, Tomies, Muckross, Glaisín na Marbh (Oak woods), Coomclachan (Holly wood), and Reenadinna (Yew wood). Of the eighty-seven plots, all but one was successfully re-located and surveyed during the 2021 monitoring period. The project originally started in 1991 with fifty-three plots, each 4 m x 4 m. This increased to sixty-nine in 1996 when a further sixteen plots were added (ten in Reenadinna and six in Coomclachan). The final total of eighty-seven plots was reached in 1997 when eighteen plots were added at Glaisín na Marbh. Since 1991, monitoring has been carried out every five years, in 1996, 2001, 2006, 2011, and most recently 2021. No monitoring was carried out in 2016. Most of the plots were re-located with relative ease thanks to the compilation of GPS data by Killarney National Park staff. Many of the plots were missing markers and several had not been exactly demarcated (*i.e*. they were less or more than 4 m x 4 m); this was rectified. Anthropogenic activity affecting the plots was evident in at least three of the plots, with markers (benignly) moved or tidied up by passing people, along with the well-intentioned removal of *Rhododendron* from another plot.

No sustained regeneration of any of the core tree species was recorded during this survey; this has been a constant finding both in the literature and in previous reports produced as part of this long-term study. In 2021, out of a total of 527 saplings recorded, 407 were *Ilex aquifolium* (Holly). Despite *Quercus petraea* (Sessile Oak) being the dominant species in the Oak woods, only four *Quercus* saplings were recorded during this survey, all of which were recorded on the Muckross Peninsula (three in Camillan Wood, one in Reenadinna). No *Quercus* saplings were recorded from the other Oak woods (Glaisín na Marbh, Tomies or Derrycunihy). No *Taxus baccata* saplings were recorded from Reenadinna Yew Wood, and there have been none recorded in plots within that woodland since 1996.

2020 was a mast year for *Ilex aquifolium* and care should be taken when interpreting the high number of seedlings recorded across all the woodlands in the 2021 survey. The number of seedlings (of *I. aquifolium* and any other species) is not necessarily indicative of how many will persist and go on to become saplings.

The cover of non-native species has increased, particularly of *Fagus sylvatica* (Beech). The non-native *Luma apiculata* (Chilean Myrtle) was recorded in Reenadinna Yew Wood for the first time; it has the potential to become invasive in the Killarney woodlands. A second species of *Cotoneaster* was recorded within the plots for the first time. Several species of this genus are already naturalised within the Park.

In April of 2021, a large wildfire spread across part of the Park and its environs, causing widespread damage. Five of the eighty-seven permanent plots were affected, with four completely burnt over and one partially burnt.

A number of recommendations are presented at the end of this report that focus on the continuation of this monitoring programme and the ongoing management of the Killarney woodlands.

Acknowledgements

- The establishment of the permanent plots in 1991 and the successive resurveys of these in 1996, 2001, 2006, 2011 and 2021 were all funded by Dúchas and the National Parks and Wildlife Service.
- Special thanks are given to Katharine Woods and Conor Cleary for their enthusiasm and hard work in the field (Figure 1).
- We are indebted to the staff of Killarney National Park, especially Danny O'Keeffe who provided excellent logistical support throughout. In particular, special thanks are given to rangers Mary Sheehan and Sean Forde for their support before, during and after the survey.
- Gratitude is also extended to Dr Thérèse Higgins and Dr Kathryn Freeman for the provision of historical maps and field notes which aided plot location and identification.
- Finally, we wish to acknowledge the financial support for this resurvey from National Parks and Wildlife Service and the ongoing support and guidance from Dr Jenni Roche.
- All maps were created with Google Satellite imagery, and each is credited to their specific source.

Figure 1 2021 survey team: Jessica Hamilton (left) with TCD undergraduates Conor Cleary and Katharine Woods. Photograph Daniel L. Kelly.

1 Introduction

1.1 Project history

This report marks the 30th year of long-term woodland monitoring in Killarney National Park. The project commenced in 1991 with the establishment of fifty-three 4 m x 4 m plots, which has since increased to eighty-seven (Table 1; Appendix 1). Up until 2011, the woodlands were surveyed every five years: 1991 (Hayes *et al*., 1991), 1996 (Higgins *et al*., 1996), 2001 (Higgins *et al*., 2001), 2006 (Casey *et al.*, 2007), and 2011 (Newman *et al*., 2014a). No monitoring was carried out in 2016 and thus the 2021 monitoring marks ten years since the last survey was carried out. An example of a 4 m x 4 m plot is given in Figure 2.

Table 1 History of plot establishment. Table reproduced from Newman et al., 2014a.

Woodland	Site Code	Year of plot establishment	No. of permanent plots
Derrycunihy	D	1991	18
Tomies Wood	T	1991	16
Muckross	M	1991	19
Coomclachan	C	1996	6
Reenadinna	R	1996	10
Glaisín na Marbh	G	1997/8	18
Total			**87**

Figure 2 Canopy plot marked out. Photograph Jessica Hamilton.

1.2 The woodlands of Killarney National Park

Renowned for its array of scenic landscapes and natural beauty, Killarney National Park encompasses over 10,000 hectares which include a wide range of habitats including peatlands, aquatic habitats, and woodlands (NPWS, 2005). The park contains the largest extant tract of semi-natural woodland in all of Ireland and is of the highest conservation value. Numerous woodlands within Killarney National Park have been identified as Ancient and Long-established Woodland (Perrin & Daly, 2010).

These woodlands can be roughly broken down into three main types; old oak woodland (Figure 3), for which the Park is perhaps best known, yew woodland and wet alder carr woodland (Kelly, 1981).

These three woodland types correspond respectively with the habitats 91A0 Old sessile oak woods, *91J0 *Taxus baccata* woods and *91E0 Alluvial forests (Perrin *et al.*, 2008), which are listed under Annex I of the EU Habitats Directive. In total, semi-natural woodland within the Park covers an area of approximately 1,400 hectares; it occurs at elevations of approximately 30 m to 300 m above sea level (Figure 4).

Overgrazing by both domestic and wild herbivores has been a consistent feature across all the woodlands and this is illustrated by the lack of saplings and greatly diminished field and shrub layers throughout the woodlands, along with an obvious browsing line. The invasive alien shrub *Rhododendron ponticum* has infested many of the oak woodlands and has caused significant damage and habitat loss. This management issue is dealt with briefly in section 1.3.

As well as being a National Park, the Park is designated as a Special Area of Conservation (SAC) under European legislation, (Killarney National Park, Macgillycuddy's Reeks and Caragh River Catchment SAC Site code 000365); Special Protection Area (SPA), (Killarney National Park SPA Site code 004038); and as a Biosphere Reserve under the United Nations Educational, Scientific and Cultural Organisation (UNESCO) (NPWS, 2013).

Figure 3 Tomies Wood, summer 2021. Photograph Jessica Hamilton.

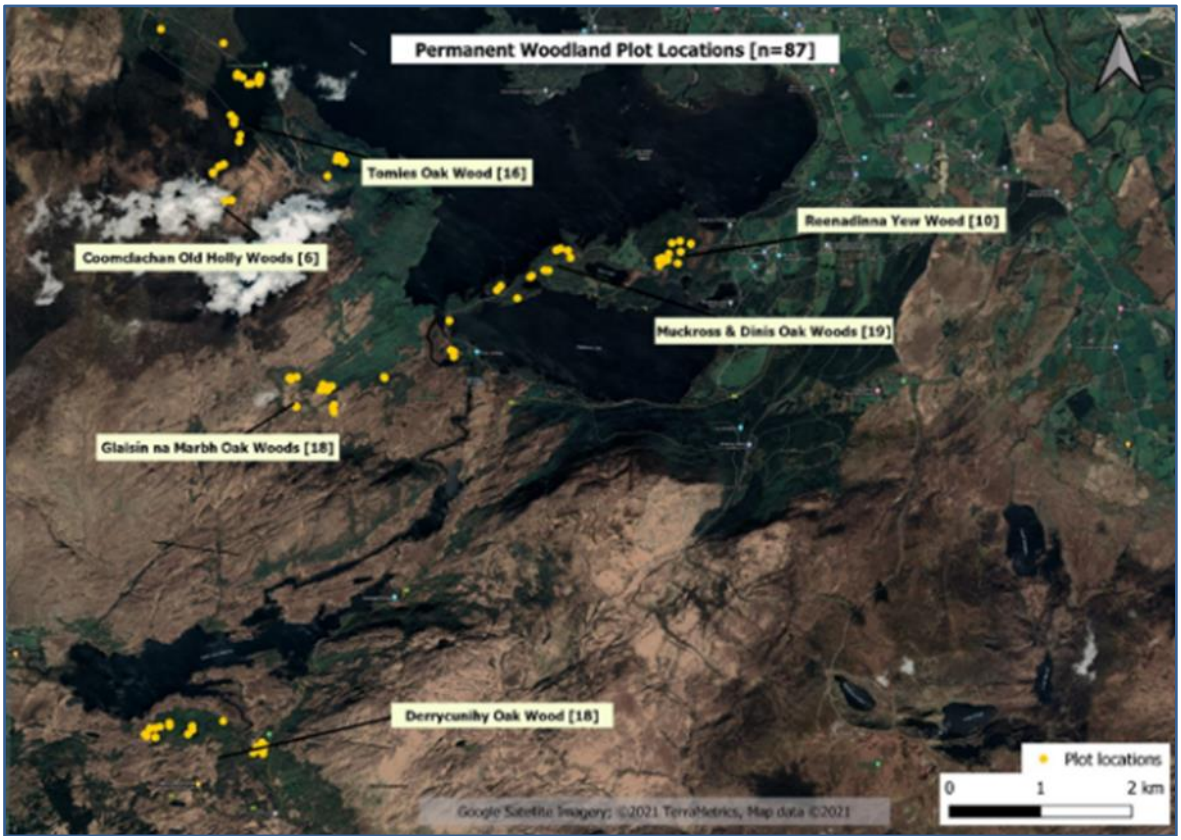

Figure 4 Overview of the locations of the six woodlands where the permanent plots are located.

1.3 Rhododendron

Rhododendron ponticum (hereafter referred to as *Rhododendron*) is an evergreen, broadleaved shrub that belongs to the Ericaceae (Heather) family (Figure 5). It is much-branched with large waxy leaves and conspicuous purplish-pink flowers that appear from May-July. The exact date *Rhododendron* arrived at Killarney is unknown. Cross (1981) suggested that the shrub was planted in Derrycunihy wood in the 19th century or before.

Rhododendron is highly invasive and is a prolific seed producer, with a single large plant capable of producing more than 1 million seeds (Cross, 1981). *Rhododendron* has no natural predators in Ireland and is avoided by grazing animals as the stems and leaves contain toxic levels of grayanotoxins. These act as neurotoxins in a wide range of animals, both vertebrates and invertebrates.

The history of *Rhododendron* management in the woods of Killarney National Park is chequered. Attempts at control began on a significant scale in the late 1960s. Since that time, clearance has been undertaken by a variety of groups, including National Park staff, voluntary organisations, Forestry Department staff, contractors, social employment schemes and local firewood schemes. A wide variety of control methods have been employed: pulling up seedlings, digging up seedlings, chemical treatment of snipped seedlings, digging up plants or stumps, foliar spraying, and chemical treatment of stumps or regrowth. Various combinations of these methods have been used in five of the six woods in which the plots are located – no *Rhododendron* management has been applied in Coomclachan.

Figure 5 *Rhododendron ponticum*. Photographs Jessica Hamilton.

1.4 Oak woods

Out of the total of 87 plots, the vast majority are those within oak woodland, which are spread across four separate woodland areas: Tomies, Derrycunihy, Glaisín na Marbh and the oak woods of the Muckross Peninsula. The oak woodlands are largely dominated by mature *Quercus petraea* (Sessile Oak) with an understory of *Ilex aquifolium* (Holly). Other frequent tree species include *Betula pubescens* (Downy Birch) and *Sorbus aucuparia* (Rowan), with *Taxus baccata* (Yew) and *Arbutus unedo* (Strawberry Tree) also encountered.

The ground flora varies depending on the soil conditions and light availability. The most frequently encountered species include *Luzula sylvatica* (Great Wood-rush), *Blechnum spicant* (Hard Fern), *Potentilla erecta* (Tormentil) and *Oxalis acetosella* (Wood-sorrel). *Calluna vulgaris* (Ling Heather) and *Vaccinium myrtillus* (Bilberry) are also frequent. The woodlands are also known for their bryophyte richness, of which many notable species are found within the woods. Another noted feature of the Killarney woodlands are the many fern species. These include *Hymenophyllum tunbrigense* and *H. wilsonii* (Filmy-ferns), which often appear more like bryophytes, growing in luxuriance on deadwood and sprawling across damp rock faces. Other features of the Killarney oak woods include members of the ‘Lusitanian’ flora, a group of species with their headquarters in the Mediterranean/Iberian region that are considered native to Ireland but, for the most part, do not occur in Britain. They have curious distributions in Ireland, being largely restricted to the south-west (Webb, 1982; Beatty *et al*., 2015). Examples of the group include *A. unedo*, *Saxifraga spathularis* (St. Patrick’s Cabbage) and *Euphorbia hyberna* (Irish Spurge), which occur in varying quantities in the oak woods and their environs. Typical floristic components are shown in Figure 6.

Figure 6 Typical floristic components of Killarney oak woods. Top L-R *Euphorbia hyberna, Sorbus aucuparia, Calluna vulgaris*. Middle: *Vaccinium myrtillus, Quercus petraea, Luzula sylvatica.* Bottom: *Blechnum spicant, Lonicera periclymenum, Ilex aquifolium.* Photographs Jessica Hamilton.

Muckross Oak Woods

The Muckross Oak Woods refer to the woodlands located on the Muckross Peninsula with plots spread across Camillan, Brickeen and Dinis (Figure 4). In total they cover approximately 1 km2.

Glaisín na Marbh

The oak woodlands of Glaisín na Marbh are located on the lower slopes of Shehy Mountain, west of Dinis (Figure 4). These woodlands are the most remote of all the woods surveyed, yet they contain clear evidence of past human settlement with old field systems and ruins present.

Tomies Wood

The oak woods of Tomies are located on the western shores of Lough Leane and cover a large expanse of woodland, approximately 4 km2. (Figure 4).

Derrycunihy

The oak woods of Derrycunihy are the most southerly of all the plots and are located south of the Upper Lake within the townland of Derrycunihy (Figure 4). The woods are also designated as a nature reserve (Derrycunihy Wood Nature Reserve).

1.5 Coomclachan Holly Wood

The holly woods of Coomclachan are located west of Lough Leane and sit in a valley above Tomies Wood (Figure 4). Coomclachan differs greatly from the other two woodland types included in the study as they are dominated by a mature canopy of *Ilex aquifolium*. Other mature tree species, such as *Betula pubescens* and *Sorbus aucuparia*, are found only rarely. The woods are of a small size and are relatively open in nature, often with a very grassy or bracken-dominated field layer (Figure 7). The ground flora is broadly similar to that of the oak woods. Grazing pressure is high; there is a distinct browse-line present across the entirety of the holly woods and little to no tree regeneration is present.

Figure 7 The open, low holly woods of Coomclachan. Photograph Jessica Hamilton.

1.6 Reenadinna Yew Wood

Covering an area of approximately 60 ha, Reenadinna Yew Wood is the largest yew woodland in Ireland and is located on the Muckross Peninsula where it occurs over Carboniferous limestone (Figure 4). The woods occur as two blocks, both dominated by *Taxus baccata* (Yew), with *Fraxinus excelsior* (Ash) and *Corylus avellana* (Hazel) also frequent. The herb layer is generally very scanty due to the dense shade cast by the yew canopy. Where light levels allow, herb species such as *Brachypodium sylvaticum* (False Brome), *Potentilla sterilis* (Barren Strawberry), *Sanicula europaea* (Sanicle), *Viola riviniana* and *V. reichenbachiana* (Dog-violets) and *Rubia peregrina* (Wild Madder) occur, alongside ferns such as *Asplenium scolopendrium* (Hart's-tongue Fern), (Figure 8). Bryophyte cover on the ground tends to be almost continuous, however it is typically dominated by only a handful of species.

Figure 8 Top L-R *Taxus baccata*, *Viola reichenbachiana*, *Asplenium scolopendrium*. Middle: *Sanicula europaea*. Bottom left: *Brachypodium sylvaticum*. Main photo: Reenadinna Yew Wood. Photographs Jessica Hamilton.

2. April 2021 wildfire

On the 24th April 2021, a wildfire spread across the Park and caused severe damage across large tracts of habitat. Provisional analysis of Sentinel-2 Satellite data indicate a burn area of approximately 2015 ha of which 1461 ha were within the National Park (Jenni Roche pers. comm.). Extensive damage occurred to woodland edges, groves and isolated trees, however for the most part the fire did not burn far into the old oak woodlands. Out of the 87 woodland plots, five were burnt to varying degrees (see Figure 9). In the Dinis area (one of the worst affected areas), four plots were completely burnt over (ME1, MO3, ME2 and ME3) and at Glaisín na Marbh, plot GG5 was approximately 50% burnt. At this time, it is too early to tell which species will be able to recover from the damage and what way the vegetation will respond. These plots were therefore excluded from the general analyses, however general observational and baseline data were collected and are summarized in section 5.5.

Figure 9 Plots burnt in the 2021 wildfire

3. Methods

3.1 Survey terminology

The terminology used in this report largely follows that used in previous reports, in the categorisation of seedlings, saplings, woodland structure, and woodland name codes. An additional category was introduced for the 2021 survey: 'S4', for saplings that were greater than 2 m in height.

The recording categories used for seedlings and saplings are shown in Table 2, with the woodland structure codes in Table 3

Table 2 Recording categories for seedlings and saplings. Modified from (Newman *et al*. 2014a)

Code	Growth Form
S1	Seedlings <1 year old (still possessing cotyledons)
S2	Seedlings >1 year old (not possessing cotyledons) but < 25 cm in height.
S3	Saplings (25 cm-200 cm in height)
S4	Saplings > 200 cm in height

Table 3 Plot Types. Modified from (Newman *et al*. 2014a)

Code	Description
C	Closed canopy plot
E	Edge of woodland
G	In woodland gap (break in canopy roughly equal to the width of a canopy tree-crown)
O	Areas of open habitat adjacent to woodland
RC	Areas under closed canopy that were cleared of *Rhododendron* shortly prior to the start of the study
O	Open areas adjacent to woodland habitat that were cleared of *Rhododendron* shortly prior to the start of the study

3.2 Re-finding of plots

The re-finding of plots was greatly eased by utilising a combination of the following:

- GPS co-ordinates held within previous reports and consolidated by Park Rangers (Appendix 2)
- Previous reports which showed location maps (Higgins *et al.*, 1996; Higgins *et al*., 2001; Casey *et al*., 2007; Newman *et al.,* 2014a)
- Photos of plots, (Hayes *et al*., 1991, Higgins *et al.,* 1996, Newman *et al*., 2014a)
- Plot markers: most plots have at least two markers, either wooden or metal depending on the woodland being surveyed.

Over the duration of the 2021 survey, it was noted that approximately 10% of the eighty-seven plots were of incorrect size, with several being 5 m x 5 m or even 5 m x 3 m. The markers were repositioned back to the original 4 m x 4 m plot size. The most challenging plots to re-locate were two of the *Rhododendron* plots which were completely taken over by the growth of *Rhododendron* (TRC1, TRC2) as they are located under an extremely dense thicket of this invasive shrub. With a combination of GPS location data and the re-finding of markers, they were successfully located. However, it is likely that they were not located precisely in 2011. Even with the photos in hand, due to the exponential increase in *Rhododendron* cover, it was difficult to ascertain the exact layout of the plot, particularly when more than one marker was missing.

Very few plots possess a complete set of four markers, with numerous having just two, or even just the one; a single plot contained no markers. Many of the markers appeared to have been moved, either for the sake of 'tidiness' or being casually picked up by passers-by. One metal marker from a plot approximately 100 m away was found in Muckross Lake and was safely retrieved and repositioned. At the very eastern edge of Tomies Wood, all four metal markers of plot TR01 were found piled up against an Oak tree, approximately 50 m from the actual plot location. For each plot, it was noted how many markers were present/missing and it is anticipated that they will be replaced by Park Rangers in the coming months.

The majority of markers were in the form of metal stakes. At Coomclachan, however, numerous plots had wooden stakes, many of which had rotted, or at least partially so. Reenadinna is the only woodland to have no ground markers as the absence of soil prevents the sinking and holding of markers. An aluminium metal tag on a corner tree therefore remains the only plot marker in these woodlands - many of these, however, have since fallen off.

3.3 Vegetation sampling

Fieldwork was carried out by Ms Jessica Hamilton (botanist/ecologist) with the assistance of Ms Katharine Woods and Mr Conor Cleary (3rd year undergraduate students at Trinity College Dublin). Fieldwork was carried out over a seven-week period, commencing on Monday 31st of May, and concluding on the 16th of July 2021. The vegetation and environmental parameters that were recorded from each plot are listed in Table 4. A comprehensive vascular plant survey was carried out in each of the plots, with each species being assigned a cover percentage to the nearest 5%. Species that had <5% were assigned 1%, 2% or 3% as appropriate. Total bryophyte cover was recorded but individual species were not identified. Taxonomic names follow Stace (2019) for vascular plants. The quantity and cover of tree seedlings and saplings were also recorded.

Table 4 Vegetation and environmental parameters recorded for each plot

Canopy cover (% cover)	Woody species (% cover)
Rock (% cover)	Ferns, herbs and graminoids (% cover)
Bare soil (% cover)	Ground bryophytes (% cover)
Litter (% cover)	Coarse woody debris (% cover)
Tree seedling abundance	Tree seedling (% cover)

The recording sheet in Appendix 3 was used to record field data. Over the course of the history of the project, there have been three taxa which have caused difficulty with accurate identification. Although these species were identified down to species level in the field in 2021, for consistent data analysis, the following species were amalgamated: *Ulex europaeus* and *U. gallii* have been treated as *Ulex* spp.; *Agrostis capillaris*, *A. canina*, and *A. vinealis* have been treated as *Agrostis* spp.; and *Viola reichenbachiana* and *V. riviniana* have been treated together as *Viola* spp.

A new category was introduced in 2021 to record deadwood within the plots, specifically coarse woody debris (CWD), which for the purpose of this study refers to woody debris that was >5 cm in diameter. Like other parameters it was recorded as a percentage cover within the plot. Deadwood is an integral part of a healthy woodland and generally includes a range of different sizes of wood (Sweeney, *et al*., 2010). It is important not only in defining habitat structure but, perhaps more importantly, it provides vital habitat for many species of invertebrate (Brin, *et al.,* 2011). Notable among these are saproxylic beetles, of which Killarney National Park is an important stronghold for several rare species (Alexander & Anderson, 2012). A number of these rarities were observed and recorded during the 2021 monitoring period (Figure 10).

Figure 10 Three notable beetle species casually recorded during 2021 survey. L-R: *Thanasimus formicarius, Leptura aurulenta, Aromia moschata*. Photographs Jessica Hamilton.

- ***Thanasimus formicarius*** (Ant Beetle): Recorded from three of the oak woodlands; Derrycunihy, Tomies and Camillan Woods on the Muckross Peninsula. Always observed on mature *Ilex aquifolium*, often under the same piece of bark as *Rhopalomesites tardyi,* a species that it is associated with (Alexander & Anderson, 2012). As well as individuals, several copulating pairs were observed.
- ***Leptura aurulenta*** (Hornet Beetle): A species that is primarily confined to Counties Kerry, Cork, and Wicklow (Alexander & Anderson, 2012), specimens were noted from the Glaisín na Marbh oak woods, associated with sunny spots on the edge.

- ***Aromia moschata*** (Musk Beetle): A handful of adult individuals were noted and were recorded mid-flight in upland habitat above Tomies Wood and resting on old *Salix* sp. at Dinis.

Other saproxylic species casually observed include: *Pogonocherus hispidus, Rutpela maculata, Rhagium bifasciatum, R. mordax, Grammoptera ruficornis, Pyrochroa serraticornis, Rhopalomesites tardyi.*

3.4 Photography

All plot photographs were taken using a DSLR digital camera and for consistency were taken at the same compass bearing as in previous years. For plots with ambiguous corners/features, extra photos were taken of recognisable features which will help re-locating the plots in the future. Most of the photos also show the tapes and/or plot markers, which will further aid their re-location. All photographs were digitally archived and thus made available for future use.

4. Data Analysis

4.1 Ground vegetation

Changes in ground vegetation have been recorded by plotting mean species richness from the plots within each wood and comparing the plots under closed canopy with those under canopy gaps. The ground vegetation data from all plots in 1996 and 2021 were also subjected to non-metric multidimensional scaling (NMDS), an ordination technique that uses indirect gradient analysis to assess the similarity among all the vegetation plots for the specified years.

4.2 Tree regeneration

Each of the woodlands is dealt with individually in section 5.3. For each woodland the number of S1/S2 seedlings is graphed against the number of S3/S4 saplings to show persistence of the latter. A table of the total number of seedlings and saplings for each woodland is also presented.

4.3 *Rhododendron*

The changes in *Rhododendron* cover and abundance were looked at in two ways:

The *Rhododendron* plots

- Eighteen of the eighty-seven plots are *Rhododendron* plots, the codes of which are as follows: TRC1, TRC2, TR01, TR02, G12, G11, MR03, MR02, MRC3, MRC2, MRC1, MR01, DRC2, DR01, DRC3, DR02, DRC1, DR03. Data collected from 2021 are presented and discussed in Section 5.4

***Rhododendron* in the general plot network**

- The changes in cover and abundance of *Rhododendron* over the 30-year course of the study are graphed and discussed briefly in Section 5.5.

5. Results

5.1 Ground flora

The data were gathered from eighty-seven plots across three woodland types (Oak woodland, Yew woodland and Holly woodland). The total number of vascular plant species recorded across the woodlands in 2021 was 97 (Appendix 4). The species richness for each monitoring period is compared for canopy and gap plots in Figures 11 and 12. These species include forbs, shrubs, graminoids and ferns, but exclude trees and tree seedlings. The number of species in each plot has remained relatively stable in three of the oak woods (Tomies, Derrycunihy and Muckross) - and also in Reenadinna, with little changes in the number of species per plot within either canopy or gap plots.

In contrast, the species richness recorded in both Coomclachan and Glaisín na Marbh has consistently increased each year (Figures 11 and 12). In 1998 at Glaisín na Marbh, the average number of species in both the canopy and gap plots was six. The 2021 data show that the average has now increased to twelve in the canopy plots and thirteen in the gap plots. Two gap plots were particularly high with twenty-three and thirty-one species recorded (Figures 12). Figure 13 shows plot GG1at Glaisín na Marbh which had a species richness of 31. In Coomclachan, the average number of species in the canopy plots has increased from nine in 1991, to fourteen in the 2021 survey. The gap plots show less change but still include an increase in the average number of species, from twelve to fourteen. It is also notable that the canopy has become more open in the gap plots in both Coomclachan and Glaisín na Marbh while it has tended to become more closed in the other woodlands (Figures 14 and 15).

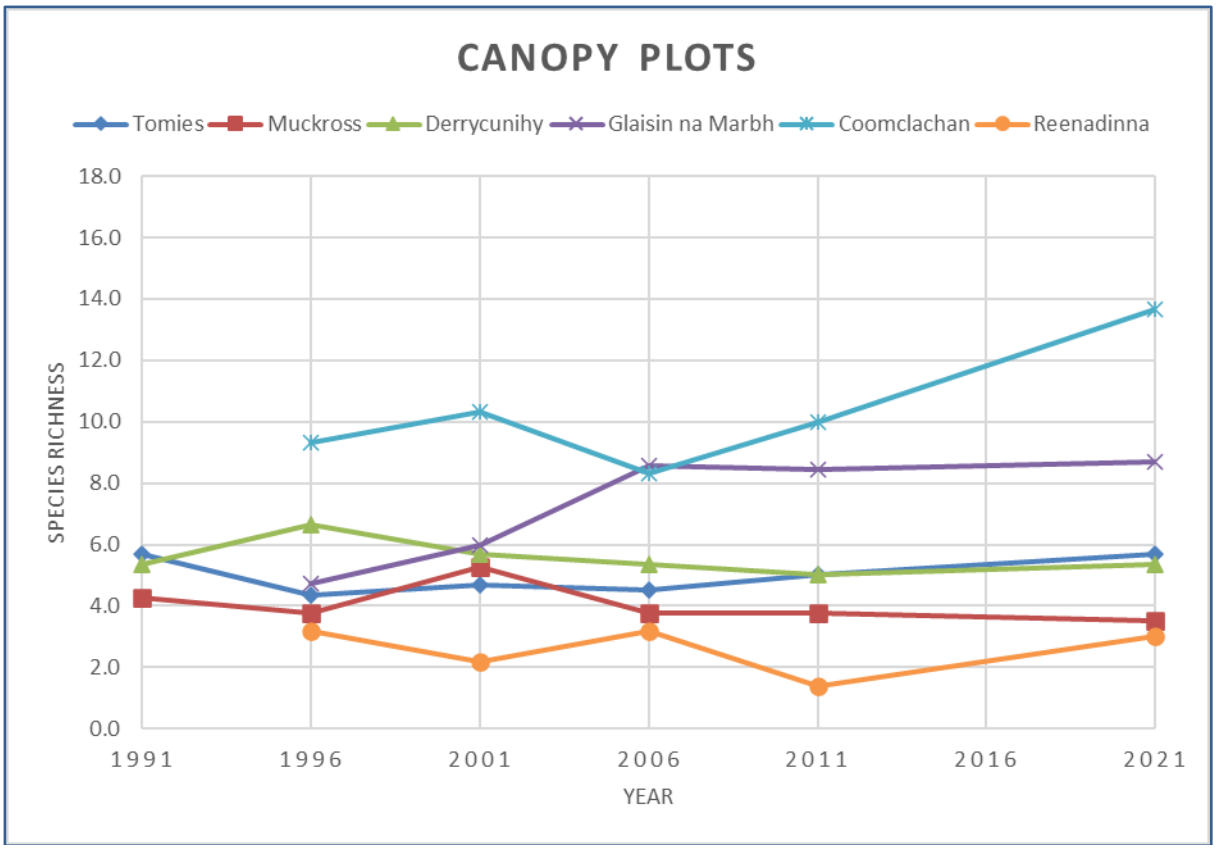

Figure 11 Change in mean species richness across canopy (n=25) plots.

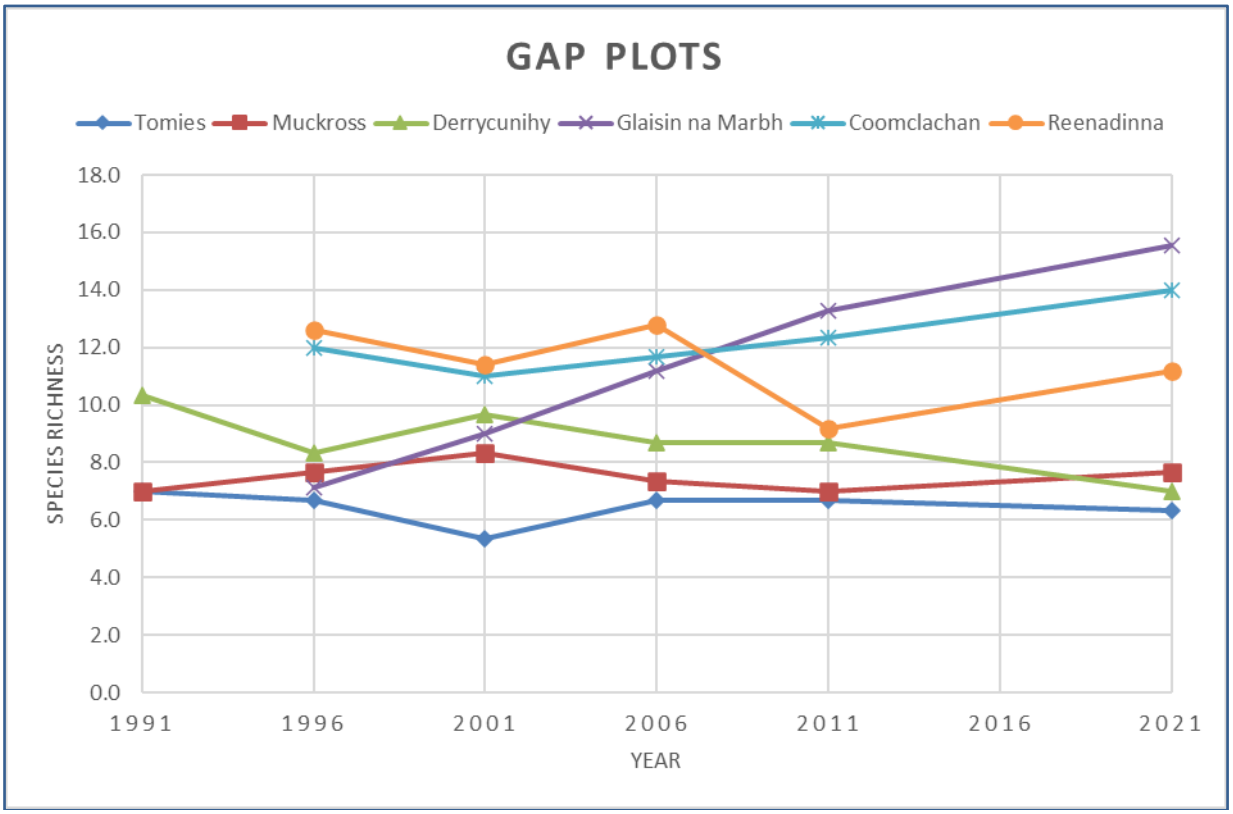

Figure 12 Change in mean species richness across gap (n=24) plots

Figure 13 Glaisín na Marbh plot GG1 which had a species richness of 31. Photograph Jessica Hamilton.

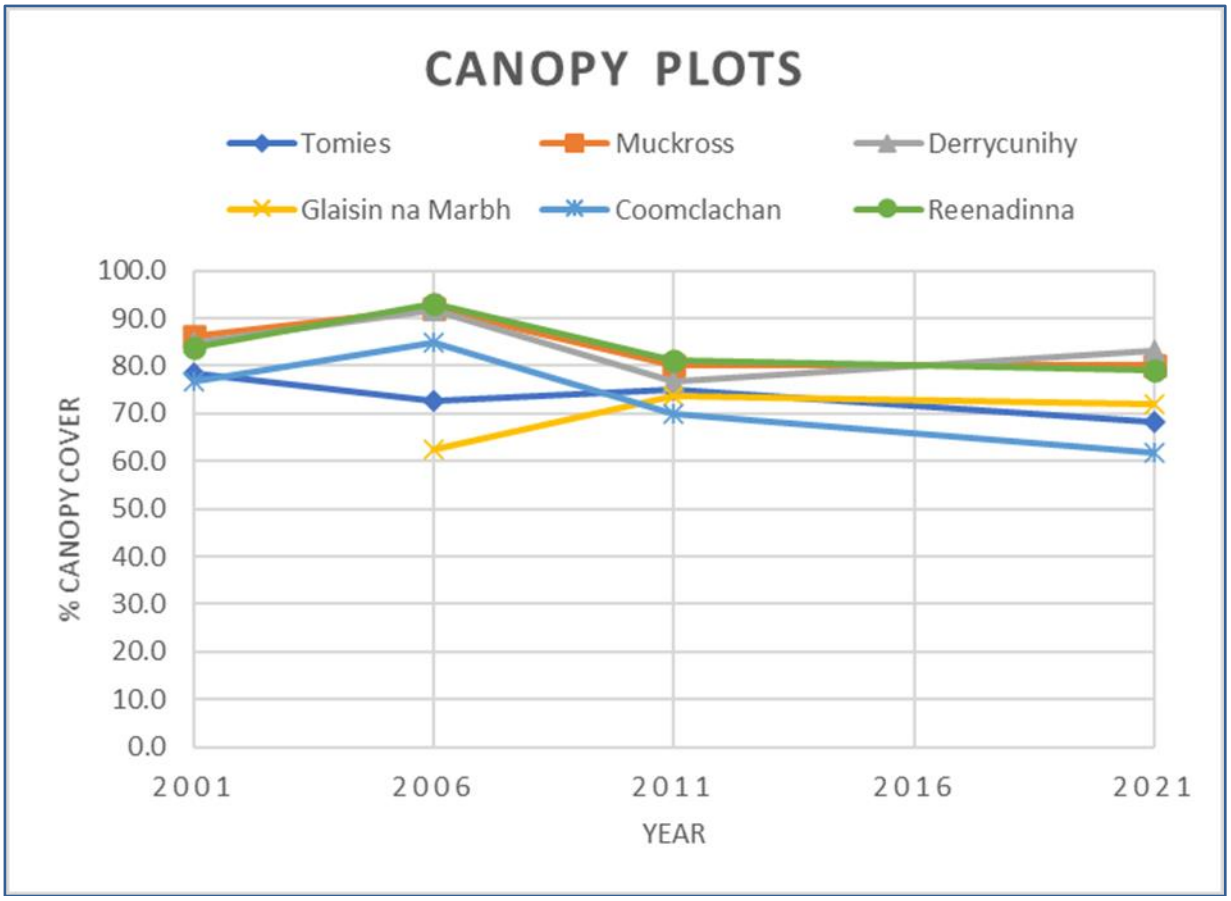

Figure 14 Change in mean canopy cover across canopy (n=25) plots.

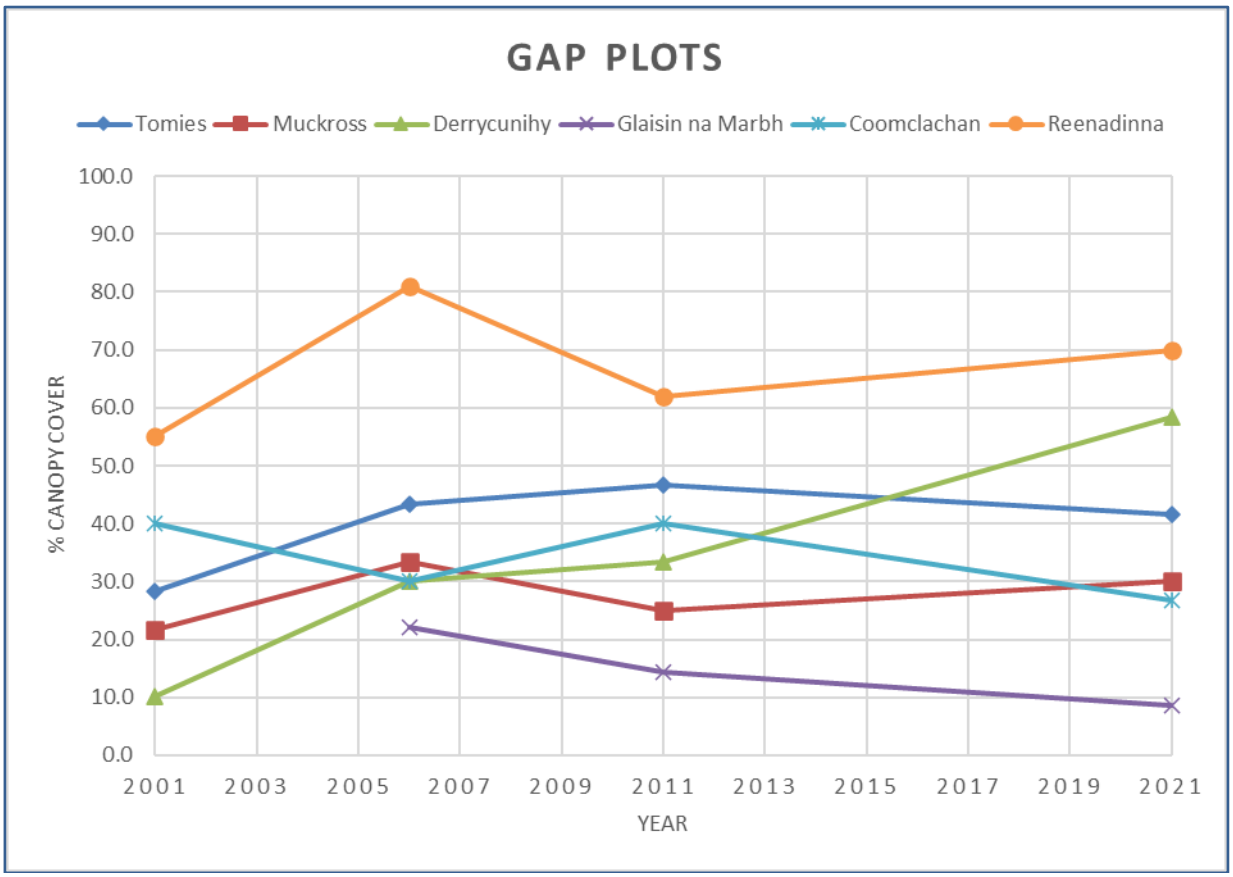

Figure 15 Change in mean canopy cover across gap (n=24) plots.

In the NMDS ordinations each symbol represents the vegetation data from a plot, with each of the six woods depicted by a different symbol (Figures 16 and 17). The data from 2021 are compared with the data from 1996/98 rather than 1991 to include a comparison of change in Glaisín na Marbh, which was not surveyed in 1991. The relative positions of the plots in the ordination represents their similarity; plots that have very similar vegetation will be close together.

The Reenadinna plots (filled triangle symbol), are clustered together on the left side of the ordination in both years (Figures 16 and 17), demonstrating the distinctive flora of the yew wood (over limestone) compared to the other woods (over old red sandstone). In 1996/98 all the other plots are reasonably mixed together with the ordination illustrating that none of the other woods has a particularly distinctive flora (Figure 16). In the 2021 ordination, more clustering of the plots within specific woods is evident (Figure 17). The Coomclachan plots (open square symbol) are all in the lower part of the ordination and just above these are a cluster of Glaisín na Marbh plots (filled square symbol). This suggests that over the last 25 years these woods have become more distinct from each other and from the other woods. This is consistent with the trend of increasing species richness over time in these woods, as described above. They also appear to be becoming more heterogeneous. A comparison of Tomies, Muckross and Derrycunihy plots in the two ordinations shows that they remain integrated, demonstrating an overall similarity in the flora across these three woods.

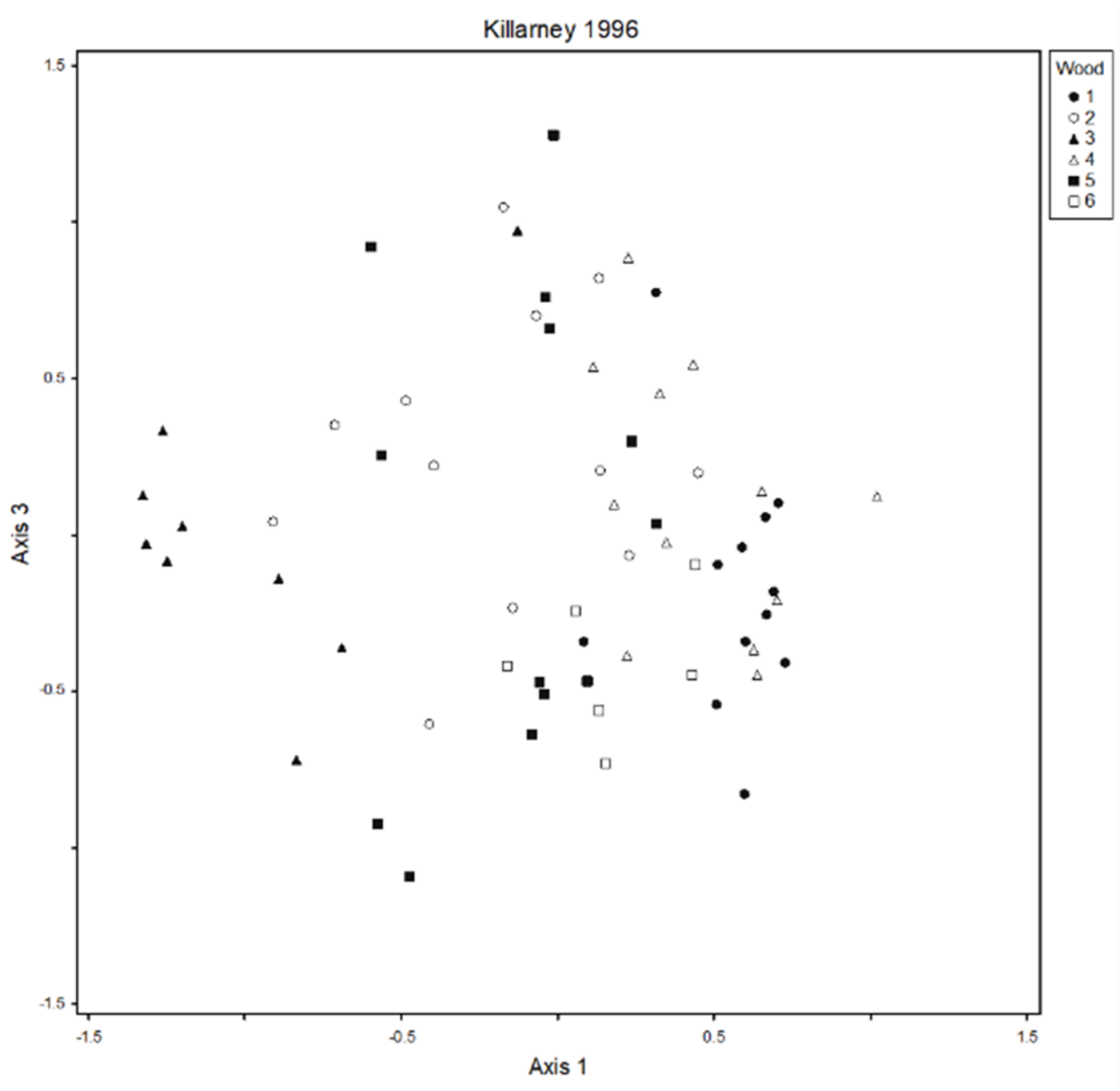

Figure 16 NMDS Ordination of Killarney plot data from 1996/98. Wood codes: 1 filled circle: Tomies, 2 open circle: Muckross, 3 filled triangle: Reenadinna, 4 open triangle: Derrycunihy, 5 filled square: Glaisín na Marbh, 6 open square: Coomclachan.

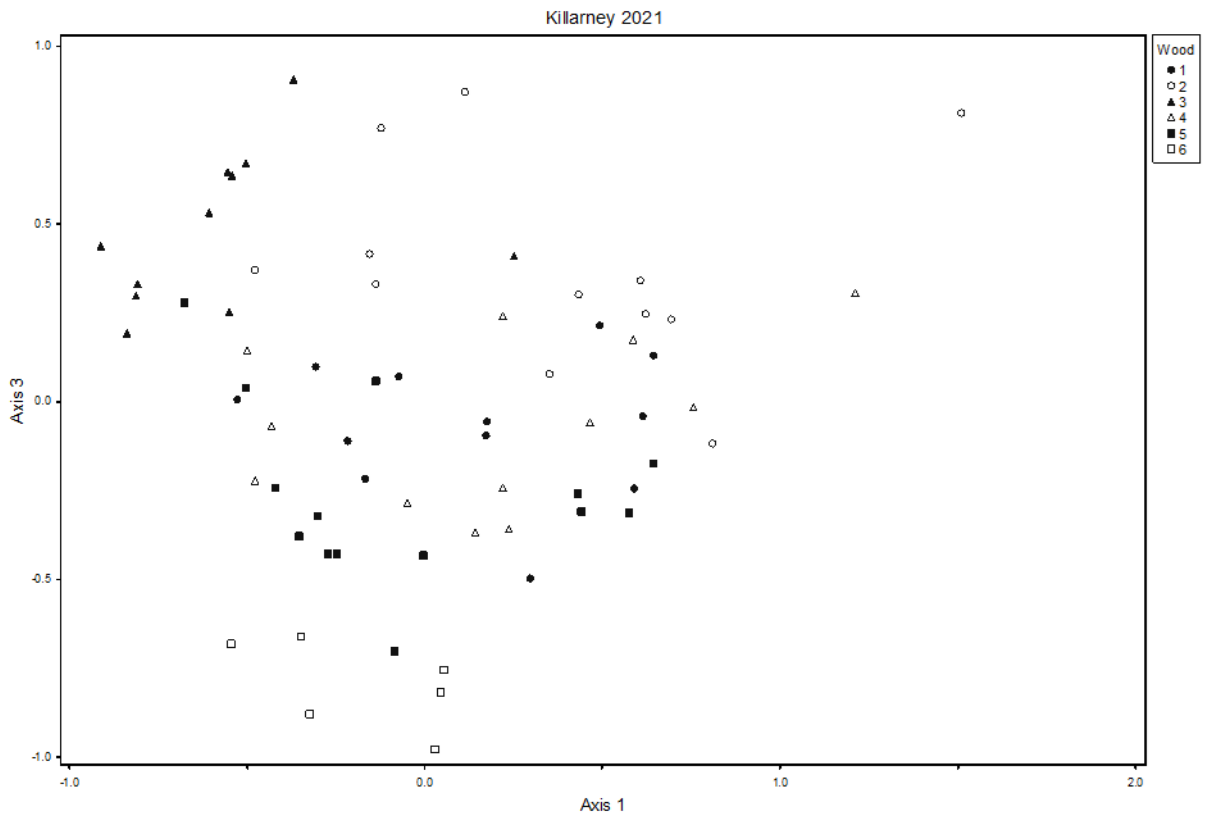

Figure 17 NMDS ordination of Killarney plot data from 2021. Wood codes: 1 filled circle: Tomies, 2 open circle: Muckross, 3 filled triangles: Reenadinna, 4 open triangle: Derrycunihy, 5 filled square: Glaisín na Marbh, 6 open square: Coomclachan.

5.2 Tree regeneration

Tables 5 and 6 below summarize the abundance of saplings (S3/S4) recorded during the 2021 monitoring period.

Table 5 Abundance of saplings of core species recorded in the woodlands

Tree species	Common Name	Number of saplings (S3/S4)
Quercus petraea	Sessile Oak	4
Ilex aquifolium	Holly	407
Betula pubescens	Downy Birch	43
Sorbus aucuparia	Rowan	21
Taxus baccata	Yew	0
Fraxinus excelsior	Ash	22
Corylus avellana	Hazel	9
Arbutus unedo	Strawberry Tree	1
Fagus sylvatica	Beech	18

Table 6 Number of saplings recorded across the six woodlands.

Woodland	Number of saplings (S3/S4)
Muckross	281
Derrycunihy	18
Tomies	9
Glaisín na Marbh	2
Coomclachan	0
Reenadinna	9

5.2.1 Muckross Oak Woods

Since the project began, seventeen tree species have been recorded as regenerating within the Muckross Oak Woods plots, of which fifteen are native species. A single S1 seedling of *Pinus contorta* (Lodgepole Pine) was recorded in 1991 in plot MO1, but did not persist or reappear in this or any other plot. During the 2021 survey, as in the other woodlands, *Ilex aquifolium* (Holly) was the most frequent and abundant species regenerating, and over 1000 seedlings (S1/S2) were recorded across all the plots.

The Muckross Oak Woods show slightly less herbivore damage compared to other oak woods (*e.g*. Tomies) and in some places showed good regeneration. The Muckross Oak Woods were the only woods out of all six to contain S4 saplings of native species. Some of those S4 saplings in the Muckross Oak Woods however were of non-native *F. sylvatica* (Beech). Overall *F. sylvatica* was recorded from four of the plots, (MG2, MO2, MC2 and MC3); S4 saplings of this species were recorded once, in MG2. In contrast, only three saplings of *Quercus petraea* were recorded across all the Muckross Peninsula plots and they were notably browsed and stunted for their age.

Figure 18 below compares numbers of seedlings recorded with numbers of saplings, across the 30-year study. These data highlight that the numbers of seedlings have little bearing on the likelihood of survival into the sapling stage.

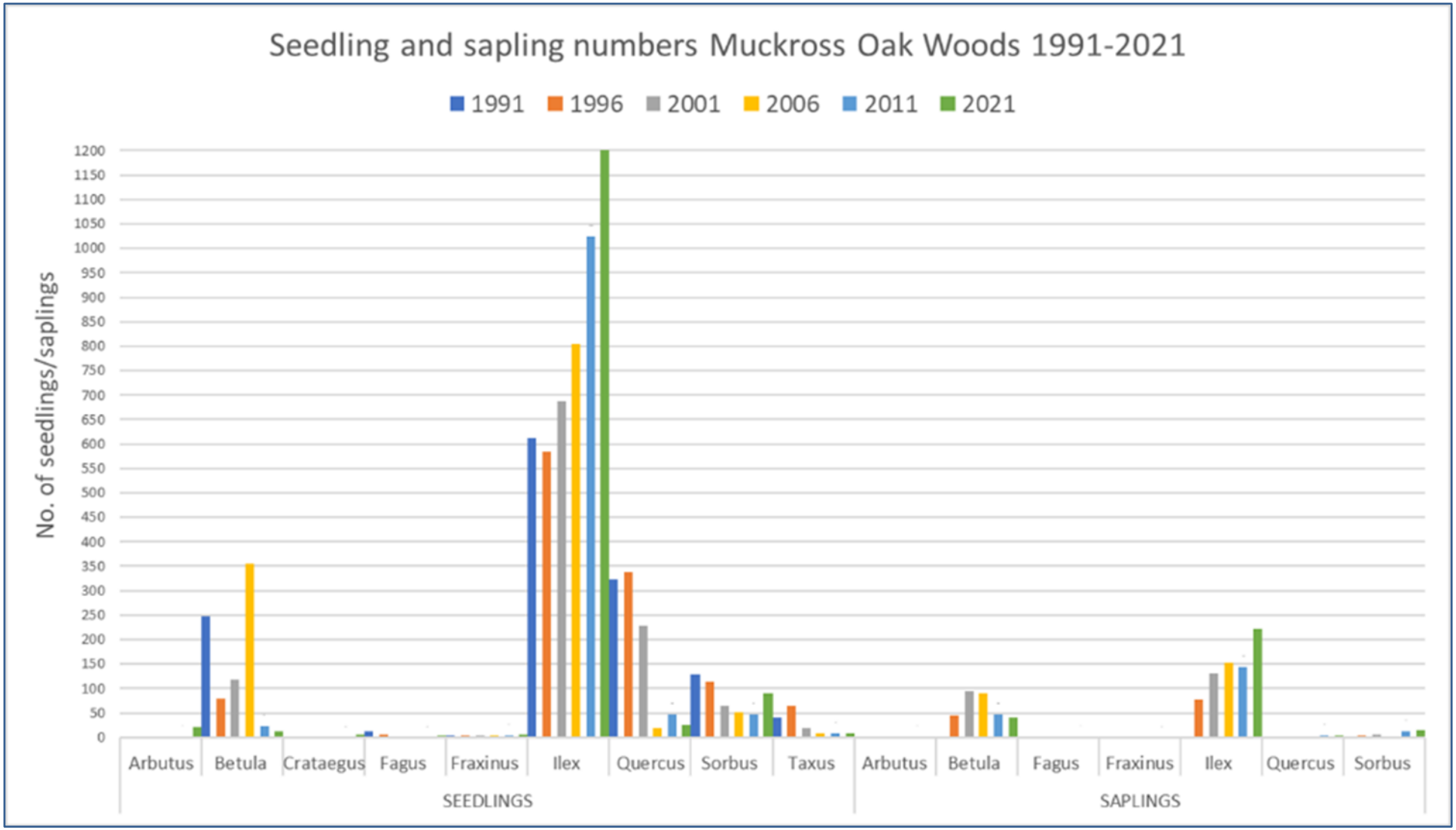

Figure 18 Muckross Oak Woods tree regeneration 1991-2021. Numbers of seedlings (S1 and S2) and saplings (S3 and S4) in 13 plots (208 m2). Full species names and numerical data are given in Table 7.

Table 7 Muckross Oak Woods tree regeneration 1991-2021

Seedling/sapling type	1991	1996	2001	2006	2011	2021
Arbutus unedo S1	0	0	0	0	1	19
Arbutus unedo S2	0	1	1	0	0	1
Arbutus unedo S3	0	0	0	0	1	1
Betula pubescens S1	146	27	79	324	14	2
Betula pubescens S2	102	53	38	32	10	11
Betula pubescens S3	0	44	94	89	46	33
Betula pubescens S4	0	0	0	0	0	7
Crataegus monogyna S1	0	0	0	0	0	1
Crataegus monogyna S2	0	2	0	0	0	0
Fagus sylvatica S1	8	1	1	0	0	0
Fagus sylvatica S2	4	5	0	2	0	3
Fagus sylvatica S3	0	0	0	0	1	0
Fagus sylvatica S4	0	0	0	0	0	1
Fraxinus excelsior S1	3	1	0	1	0	0
Fraxinus excelsior S2	0	1	0	2	1	2
Ilex aquifolium S1	353	429	342	580	886	943
Ilex aquifolium S2	258	156	346	223	138	444
Ilex aquifolium S3	0	77	131	152	144	219
Ilex aquifolium S4	0	0	0	0	0	2
Quercus petraea S1	279	323	91	2	25	2
Quercus petraea S2	45	14	136	17	21	24
Quercus petraea S3	0	0	0	1	4	3
Sorbus aucuparia S1	87	83	12	12	20	10
Sorbus aucuparia S2	41	31	52	40	27	80
Sorbus aucuparia S3	0	3	5	2	13	15
Taxus baccata S1	41	63	8	3	9	1
Taxus baccata S2	0	1	11	5	0	8

5.2.2 Glaisín na Marbh

Over the history of the project only four saplings of native trees have been recorded at Glaisín na Marbh (Figure 19). These were two S3 *Ilex aquifolium* saplings recorded in 2021 and two *Quercus petraea* saplings that were recorded in 2006 but did not manage to persist. In the 2021 survey no saplings of *Q. petraea* were recorded. Due to its remoteness, Glaisín na Marbh has had a history of high levels of grazing and of trespassing from domestic sheep. Sheep were recorded during the 2021 survey higher up in the surrounding hills (within the park bounds). Sheep wool was also recorded within and around several of the plots.

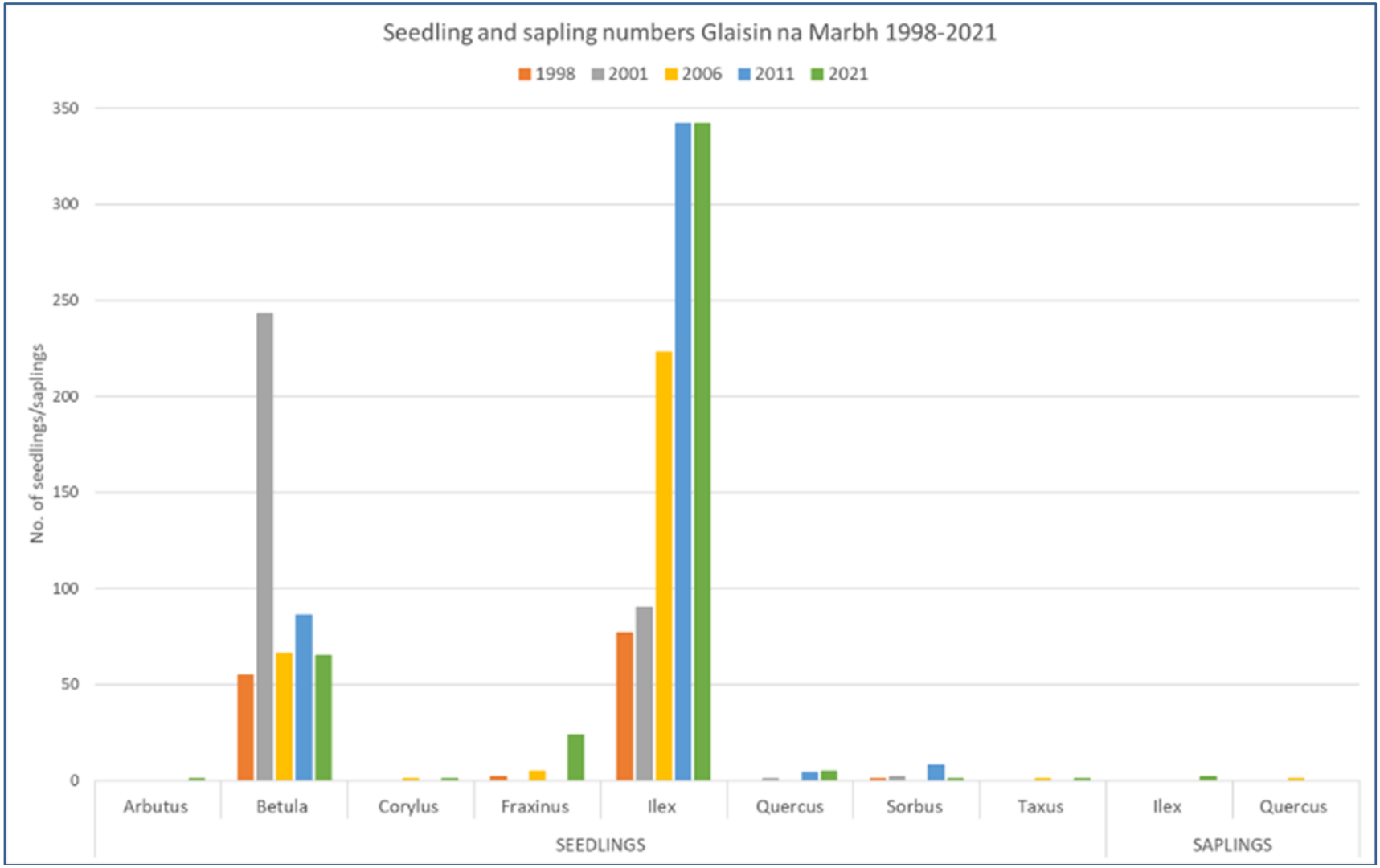

Figure 19 Glaisín na Marbh tree regeneration 1998-2021. Numbers of seedlings (S1 and S2) and saplings (S3 and S4) in 14 plots (224 m2). Full species names and numerical data are given in Table 8.

Table 8 Glaisín na Marbh tree regeneration 1998-2021

Seedling/sapling type	1998	2001	2006	2011	2021
Arbutus unedo S1	0	0	0	0	1
Betula pubescens S1	50	173	39	47	17
Betula pubescens S2	5	70	27	39	48
Corylus avellana S2	0	0	1	0	1
Fraxinus excelsior S1	1	0	2	0	4
Fraxinus excelsior S2	1	0	3	0	20
Ilex aquifolium S1	73	58	173	229	255
Ilex aquifolium S2	4	32	50	54	87
Ilex aquifolium S3	0	0	0	0	2
Quercus petraea S1	0	1	0	0	2
Quercus petraea S2	0	0	0	4	3
*Quercus petraea S*3	0	0	1	0	0
Sorbus aucuparia S1	1	0	0	2	0
Sorbus aucuparia S2	0	2	0	6	1
Taxus baccata S2	0	0	1	0	1

5.2.3 Derrycunihy

Over the course of the project, eight native tree species have been recorded regenerating within the oak woods of Derrycunihy (Figure 20). As is the case with other plots, *Ilex aquifolium* showed a high abundance of seedlings, however few seedlings have persisted into saplings; only 15 *I. aquifolium* saplings were recorded in 2021. Only three *Quercus* seedlings were recorded in 2021 and no *Quercus* saplings were recorded within any of the plots, nor in adjacent areas. A handful of saplings of *Sorbus aucuparia* and *Betula pubescens* were recorded (one and two individuals respectively).

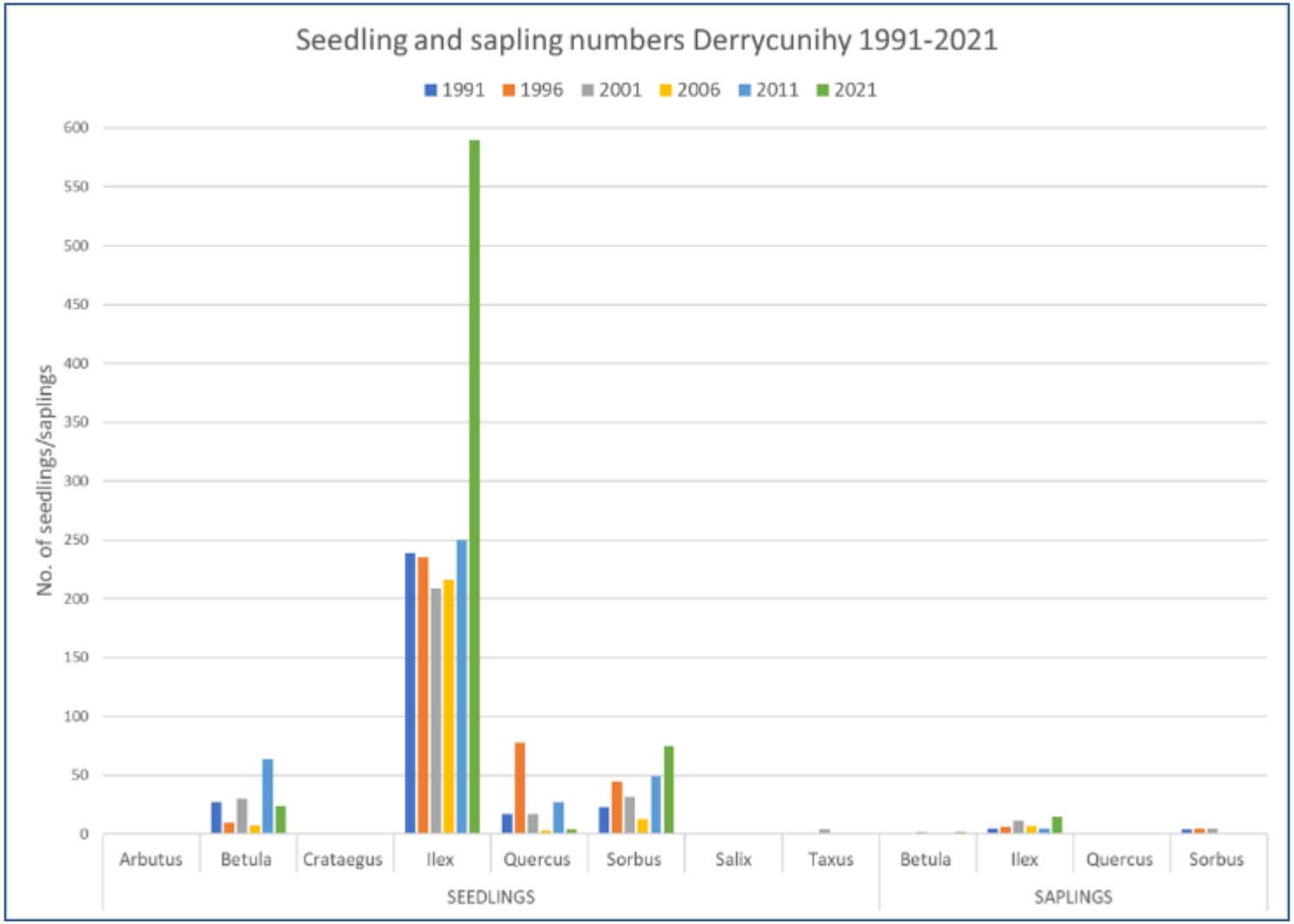

Figure 20 Derrycunihy: tree regeneration 1991-2021. Numbers of seedlings (S1 and S2) and saplings (S3 and S4) in 12 plots (192 m2). Full species names and numerical data are given in Table 9.

Although grazing pressure is high throughout the woods, where vegetation is above reach of browsers (e.g. on high rocks/clefts), the reduced pressure allows the herb/field layer to grow. Species like *Vaccinium myrtillus* were notably taller in these areas compared to more heavily grazed areas. Deer were recorded regularly within the woods, both from their tracks and visual sightings including a Sika deer (*Cervus nippon*) hind which walked through a plot while it was being surveyed (Figure 21). *Calluna vulgaris* was observed to exhibit a "topiary" effect (closely-pruned shape) caused by consistent browsing by herbivores (Figure 22).

Figure 21 Female Sika deer in Derrycunihy, unfazed by the presence of the surveyors. Photograph Jessica Hamilton.

Table 9 Derrycunihy oak wood seedling and sapling numbers recorded between 1991-2021

Seedling/sapling type	1991	1996	2001	2006	2011	2021
Arbutus unedo S2	0	0	1	0	0	0
Betula pubescens S1	19	2	13	4	34	4
Betula pubescens S2	8	8	17	4	30	20
Betula pubescens S3`	1	0	2	0	0	2
Crataegus monogyna S2	0	0	0	0	0	1
Ilex aquifolium S1	207	208	149	181	221	458
Ilex aquifolium S2	32	27	60	35	29	132
Ilex aquifolium S3	5	6	11	7	5	15
Quercus petraea S1	14	55	7	2	22	0
Quercus petraea S2	3	23	10	1	5	4
Quercus petraea S3	0	0	0	1	0	0
Sorbus aucuparia S1	15	30	6	2	40	15
Sorbus aucuparia S2	8	15	26	11	9	60
Sorbus aucuparia S3	4	5	5	0	0	1
Salix cinerea S2	0	0	1	0	0	0
Taxus baccata S1	0	0	3	0	1	0
Taxus baccata S2	0	0	1	0	0	0

Figure 22 *Calluna vulgaris* at Derrycunihy, showing topiary effect (closely-pruned shape caused by consistent browsing from herbivores). Photograph Jessica Hamilton.

5.2.4 Tomies Wood

Tomies Wood has a very high level of grazing, and signs of over-grazing were noted throughout (stunted saplings, bark stripping and topiary effect). This is reflected in the low number of surviving saplings within the woods (Figure 23). No saplings of *Q. petraea* were recorded in 2021, and over the course of the study, only one oak sapling has been recorded within the plots (2001). *Ilex aquifolium* were the only saplings recorded in the 2021 survey, with nine recorded, an increase from 2011, however all saplings were notably browsed (see Figure 24).

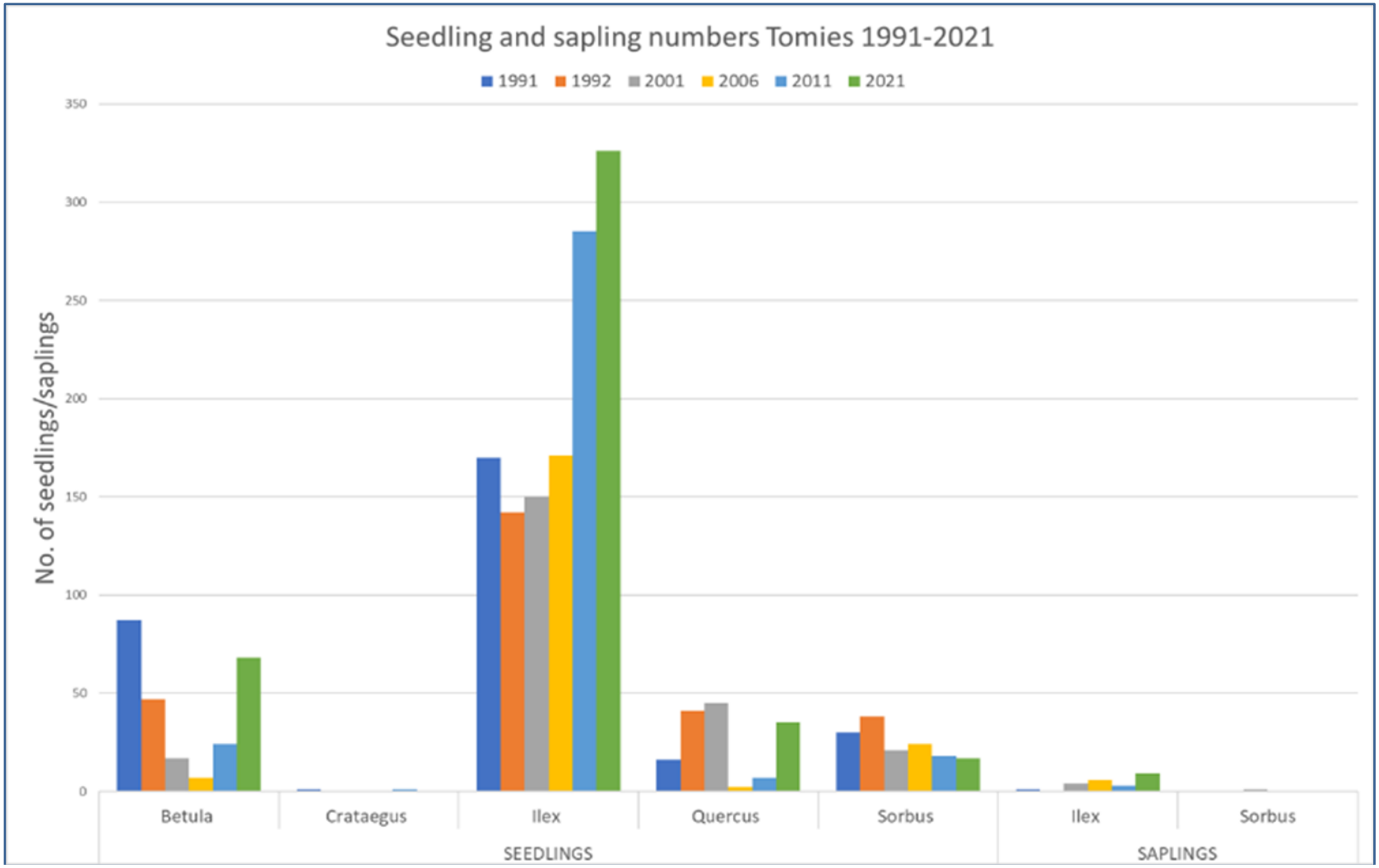

Figure 23 Tomies Wood tree regeneration 1991-2021. Numbers of seedlings (S1 and S2) and saplings (S3 and S4) in 12 plots (192 m2). Full species names and numerical data are given in Table 10.

Table 10 Tomies Wood seedling and sapling numbers recorded between 1991-2021

Seedling/sapling type	1991	1996	2001	2006	2011	2021
Betula pubescens S1	48	25	7	5	5	4
Betula pubescens S2	39	22	10	2	19	64
Crataegus monogyna S1	0	1	0	0	0	1
Ilex aquifolium S1	137	125	125	141	240	211
Ilex aquifolium S2	33	17	25	30	45	115
Ilex aquifolium S3	1	0	4	6	3	9
Quercus petraea S1	13	39	17	1	1	24
Quercus petraea S2	3	2	28	1	6	11
Sorbus aucuparia S1	9	14	1	2	0	0
Sorbus aucuparia S2	21	24	20	22	18	17
Sorbus aucuparia S3	0	0	1	0	0	0
Malus sp.	0	1	0	0	0	0

Figure 24 Deer damage was frequently seen throughout the woods in various forms. The left-hand image shows *Ilex* suckers which have been vigorously browsed and damaged. On the right-hand side, bark stripping on a mature *Ilex* is shown. Photographs Jessica Hamilton.

5.2.5 Coomclachan

The old, open woodlands of Coomclachan have consistently had a low level of sapling persistence, with 1996 being the last year when any saplings were recorded (Figure 25). In 2021 this scenario continued, and no saplings were recorded of any species, neither within the plots nor across the wood (from our general observations). Grazing impact was notably high across the woodland, with a strong browse-line. Both Red and Sika deer were regularly seen in the general areas surrounding the woods.

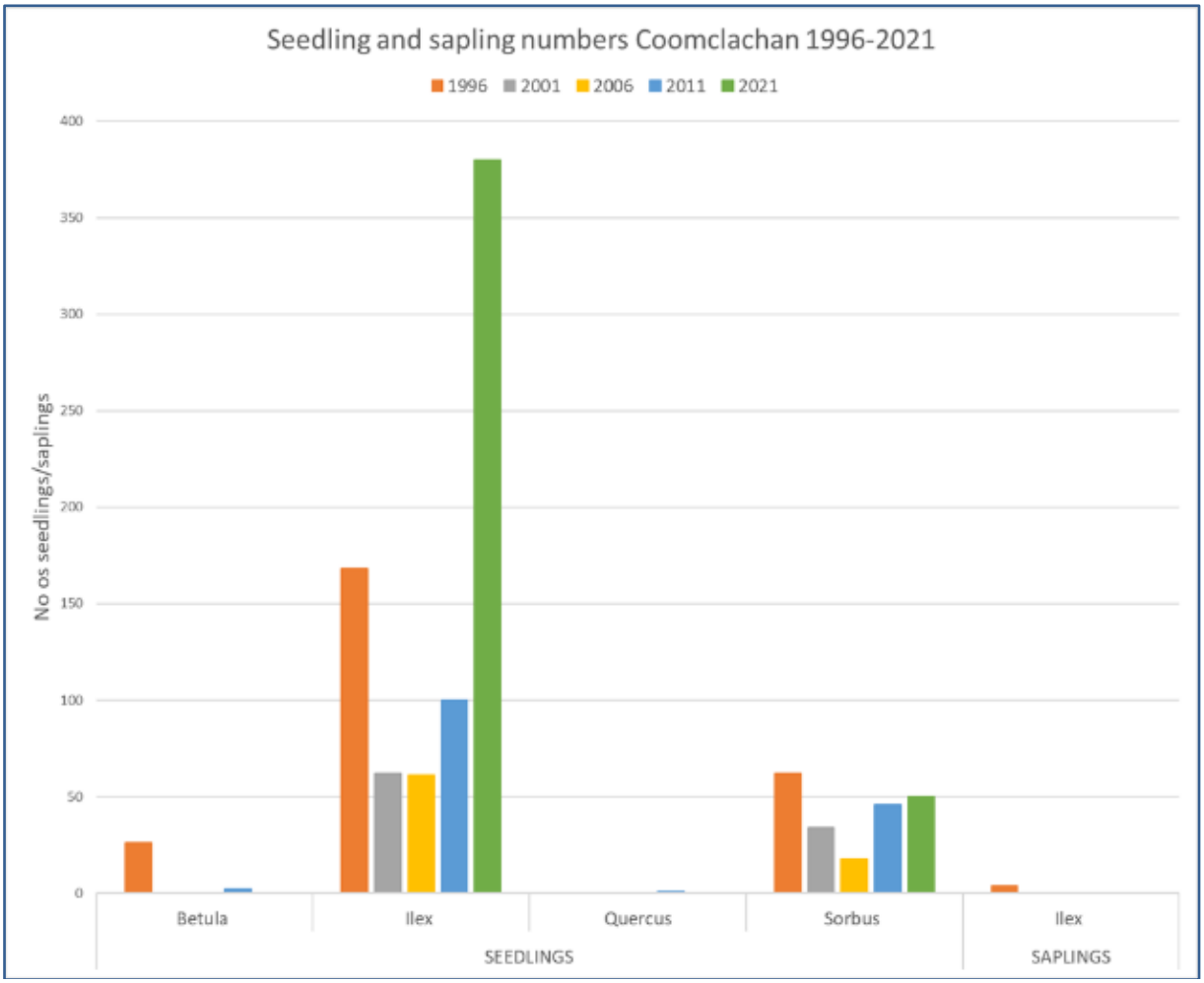

Figure 25 Coomclachan tree regeneration 1996-2021. Numbers of seedlings (S1 and S2) and saplings (S3 and S4) in six plots (96 m2). Full species names and numerical data are given in Table 11.

Table 11 Coomclachan seedling and sapling numbers recorded between 1996-2021

Seeding/sapling type	1996	2001	2006	2011	2021
Betula pubescens S1	26	0	0	2	0
Ilex aquifolium S1	162	60	40	99	365
Ilex aquifolium S2	6	2	21	1	15
Ilex aquifolium S3	4	0	0	0	0
Quercus petraea S2	0	0	0	1	0
Sorbus aucuparia S1	48	16	0	10	1
Sorbus aucuparia S2	14	18	18	36	49

5.2.6 Reenadinna

Over the course of the project twelve tree species have been recorded regenerating within the yew woodland plots. All of these are native except for *Fagus sylvatica* which has continued to persist and is dealt with further in section 5.5.1. The most frequent species seen regenerating are *Fraxinus excelsior* and *Ilex aquifolium* (Figure 26). Although *Taxus baccata* seedlings (S1 and S2) were recorded in 2021 (n=30), no saplings of *T. baccata* have been recorded in any of the plots since 1996.

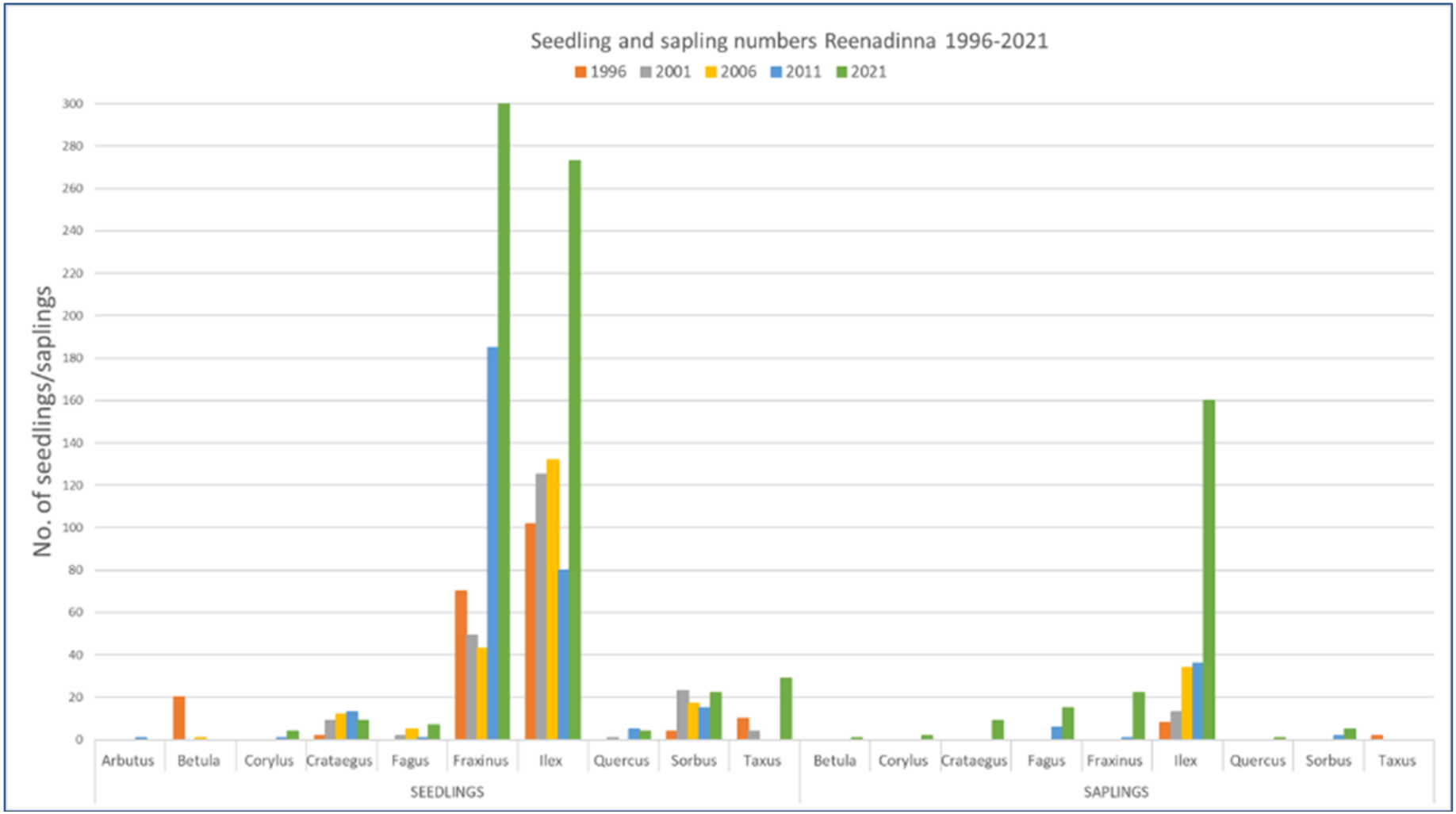

Figure 26 Reenadinna: tree regeneration 1996-2021. Numbers of seedlings (S1 and S2) and saplings (S3 and S4) in 10 plots (160 m2). Full species names and numerical data are given in Table 12.

Table 12 Reenadinna seedling and sapling numbers recorded between 1996-2021

Seedling/sapling type	1996	2001	2006	2011	2021
Arbutus unedo S2	0	0	0	1	0
Betula pubescens S1	20	0	1	0	0
Betula pubescens S3	0	0	0	0	1
Corylus avellana S2	0	0	0	1	4
Corylus avellana S3	0	0	0	0	2
Crataegus monogyna S1	1	1	0	9	1
Crataegus monogyna S2	2	8	12	4	8
Crataegus monogyna S3	0	0	0	0	9
Fagus sylvatica S1	0	0	1	0	0
Fagus sylvatica S2	0	2	4	1	7
Fagus sylvatica S3	0	0	0	6	12
Fagus sylvatica S4	0	0	0	0	5
Fraxinus excelsior S1	6	8	1	23	100
Fraxinus excelsior S2	64	41	42	162	204
Fraxinus excelsior S3	0	0	0	1	22
Ilex aquifolium S1	22	9	23	2	98
Ilex aquifolium S2	80	116	109	78	175
Ilex aquifolium S3	8	13	34	36	160
Quercus petraea S1	0	1	0	0	0
Quercus petraea S2	0	0	0	5	4
Quercus petraea S3	0	0	0	0	1
Prunus avium S3	0	0	0	1	0
Pinus sylvestris S1	1	0	0	0	0
Sorbus aucuparia S1	0	0	0	0	5
Sorbus aucuparia S2	4	23	17	15	17
Sorbus aucuparia S3	0	0	0	2	5
Taxus baccata S1	5	4	0	0	26
Taxus baccata S2	5	0	0	0	3
Taxus baccata S3	2	0	0	0	0

5.3 *Rhododendron* change

5.3.1 *Rhododendron* in the general plot network

Figure 27 illustrates the changes in *Rhododendron* across the oak woodland plots. The fluctuations in *Rhododendron* cover reflect varying management/removal activities in the different woods over the years. It is clearly evident that despite removal from some plots, *Rhododendron* continues to re-invade. It should be noted that the percentage covers plotted in Figure 27 are mean values across all the plots, many of which had no *Rhododendron* present. The Glaisín na Marbh plots show the heaviest level of reinfestation, with vigorous regrowth noted in several plots as well as in their environs (Figures 28 and 29). No *Rhododendron* has been recorded at any stage in the Reenadinna Yew Wood plots, and no *Rhododendron* has been recorded at any stage in the Coomclachan Holly Wood.

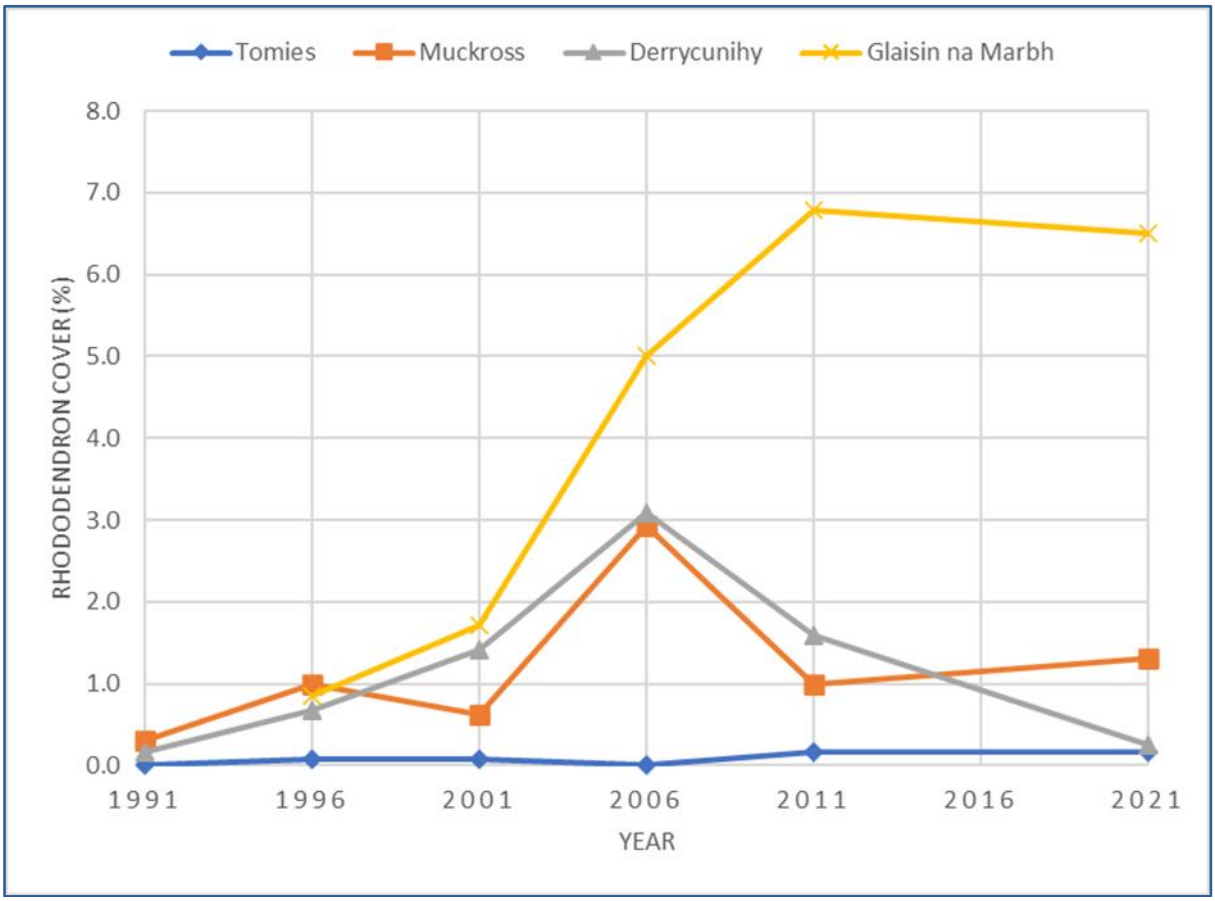

Figure 27 Change in *Rhododendron* across the oak wook plots

One issue that presented itself was the apparent clearance of *Rhododendron* from within one of the permanent plots and its immediate environs. A large area of *Rhododendron* had been recently partially cleared (numerous fresh saplings hanging from tree branches, and vegetation disturbance) in the immediate environs of one of the plots at Glaisín na Marbh. Clearing of *Rhododendron* from the Killarney oak woods is an imperative matter but the removal of any vegetation from the permanent plots and their immediate vicinity will skew data and provide an untrue reflection of the wider levels of *Rhododendron* infestation.

This can be addressed by maintaining a detailed record of all *Rhododendron* management activities, including the casual removal of individual plants, by staff or contract workers within,

or in the vicinity of, the permanent plots. *Rhododendron* data from the permanent plots can then be considered alongside the available data on *Rhododendron* management.

Figure 28 Glaisín na Marbh, plot GG8 in 2011. Photograph Miles Newman.

Figure 29 Glaisín na Marbh, plot GG8 in 2021. Photograph Jessica Hamilton.

5.3.2 The Rhododendron plots

In total there are seventeen extant *Rhododendron* plots spread across the four oak woodlands. These consist of plots where *Rhododendron* has previously been cleared or has had a continuous level of infestation. Data from these plots are not included in Figure 27 above.

Data from the *Rhododendron* plots over the 2021 monitoring period are presented in Figure 30. Of the four most heavily infested plots, TRC1, TRC2, G11 and G12, each has a cover of *Rhododendron* that is between 95-100% (see Figures 31 and 32). Beneath them the ground is virtually devoid of plant life, and the plot species richness is correspondingly negligible. The only herb species recorded included a very scanty cover of *Hymenophyllum* sp. A handful of leggy S1 seedlings of *I. aquifolium* were noted, along with three saplings of the same species across three of the plots, but they were straggly and unlikely to persist. Both the seedlings and saplings showed high levels of browsing.

Across the remaining 13 *Rhododendron* plots, reinfestation was recorded in three plots. Where there was no reinfestation, the number of seedlings varied somewhat, but high numbers of *I. aquifolium* were recorded in several of the plots; MRC1 MRC2, MRC3, DRC2 and DRC1 each contained hundreds of seedlings of *I. aquifolium*. The plot DR02 contained 478 seedlings of *B. pubescens*. Very few species, however, were persisting to saplings, with no *B. pubescens* saplings recorded across any of the 13 plots, despite the high number of seedlings recorded. Indeed, sapling numbers were overall low, with the exception of MRC1 and MRC2; these contained 22 and 45 saplings respectively, of two main species, *S. aucuparia* and *I. aquifolium*. Less than five saplings were recorded from the remaining eight plots. It is evident from these data that *Rhododendron* infestation is having significant negative impacts on tree regeneration as well as species richness.

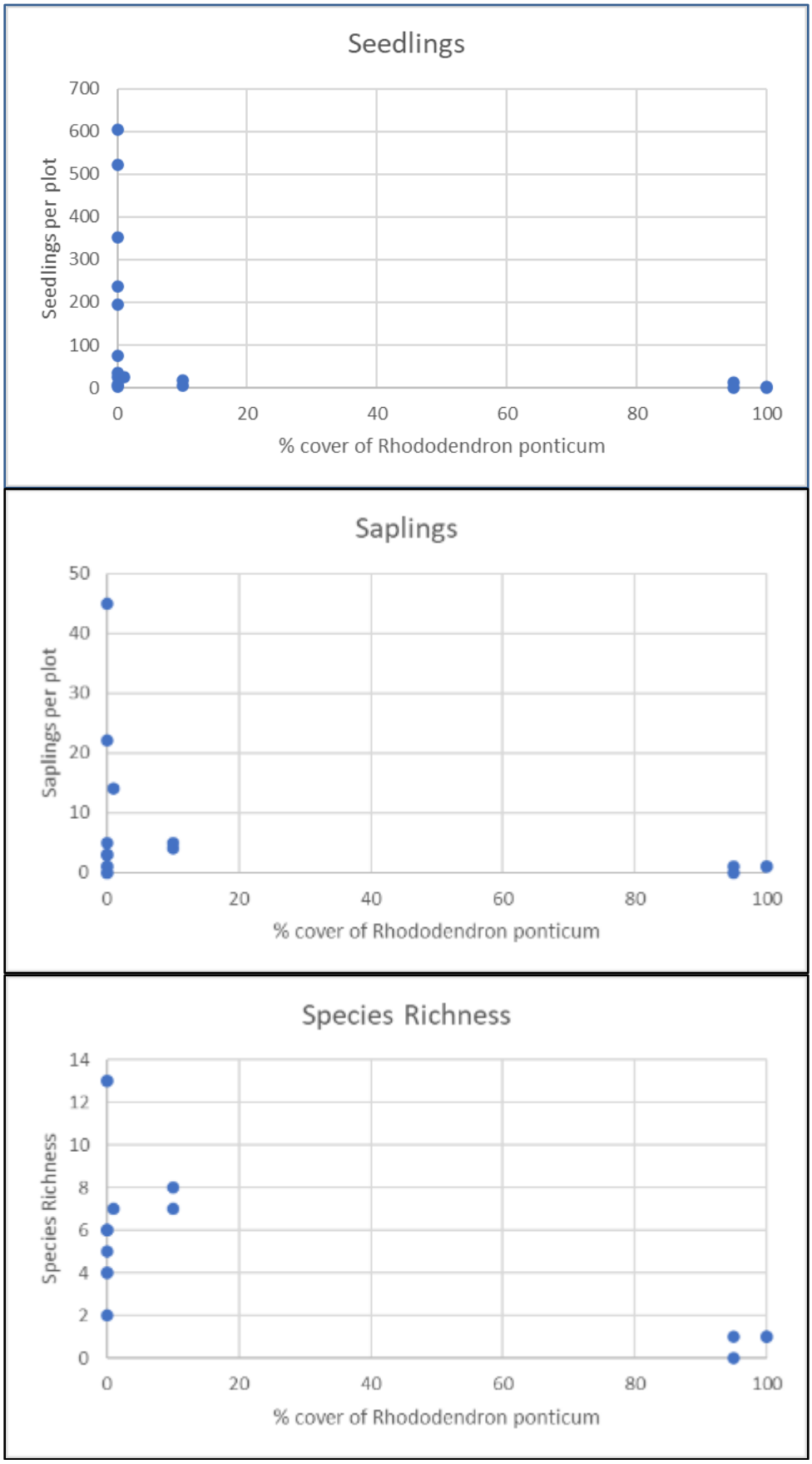

Figure 30 2021 data from *Rhododendron* plots: *Rhododendron* cover vs numbers of tree seedlings, numbers of tree saplings and total vascular plant species richness.

Figure 31 Tomies Wood, Plot TRC1 in 2011. Photograph Miles Newman.

Figure 32 Tomies Wood, Plot TRC2 in 2021. *Rhododendron* cover 95-100%. Photograph Jessica Hamilton.

5.4 2021 Burnt plots

The 2021 monitoring commenced approximately eight weeks after the fire of late April of 2021. Figure 33 below shows basic environmental data that were collected from the five burnt plots. Low woody species, as expected, had very low to non-existent cover as any such species (*e.g*. *Calluna vulgaris*) had been burnt beyond recognition. Herb cover was relatively high across the plots; more details are given below (Figure 34). Bryophyte cover was scanty, nearly all had been burnt off. Bryophyte cover was slightly higher in plot GG5 as that plot was only approximately 50% burnt over. Litter across all five plots in this instance refers to burnt debris as any dry/dead vegetation from previous years was burnt off in the fire. Bare ground refers to where the fire had burnt and exposed bare soil.

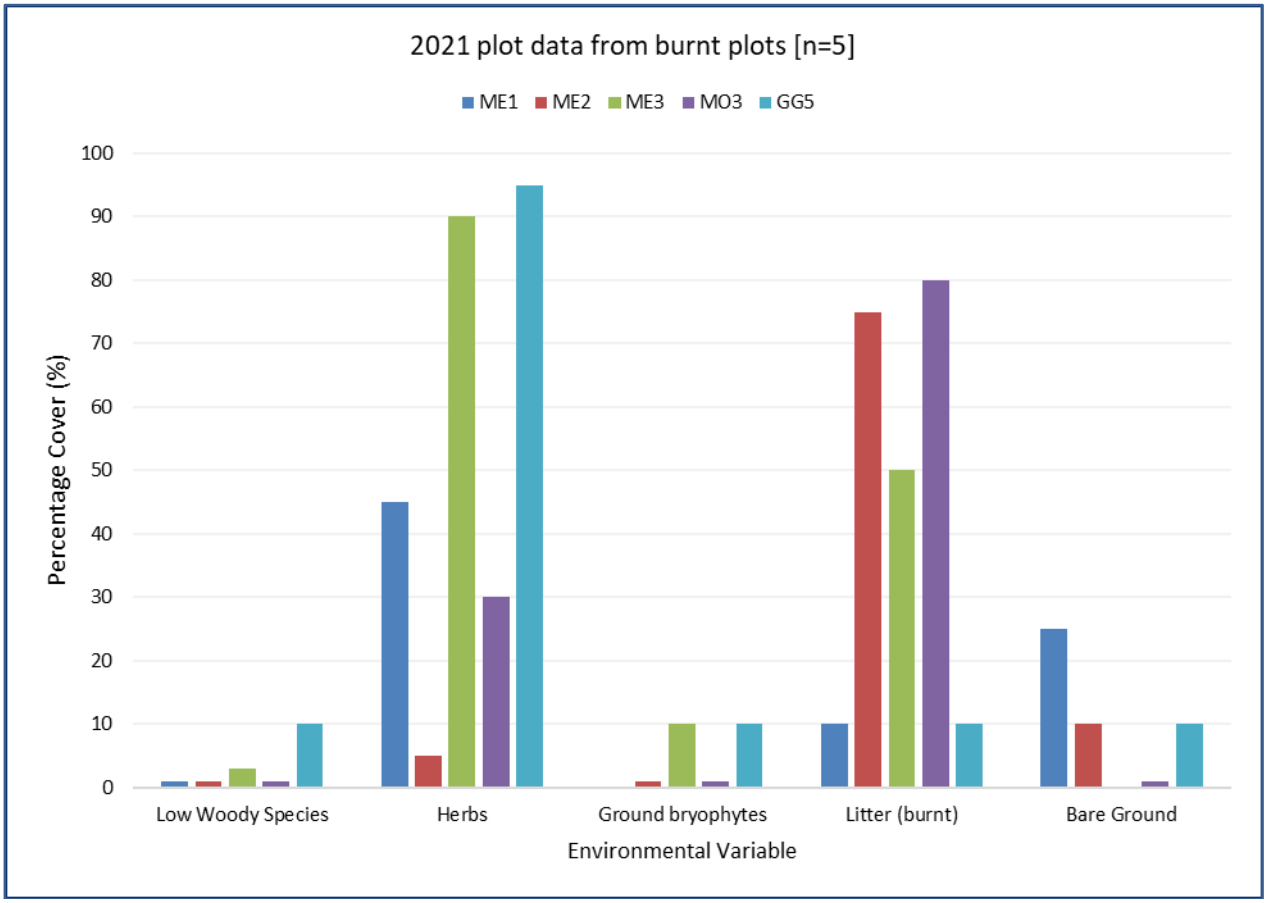

Figure 33 Environmental data collected from the five plots burnt in the 2021 fires.

Across the five plots that were burnt, four species of native tree were noted to be regenerating in the form of S1 seedlings. *Betula pubescens* was the most frequently recorded species and occurred at least once in all five of the plots (Figure 35). Examples of the damaged caused can be seen in Figures 36 and 37.

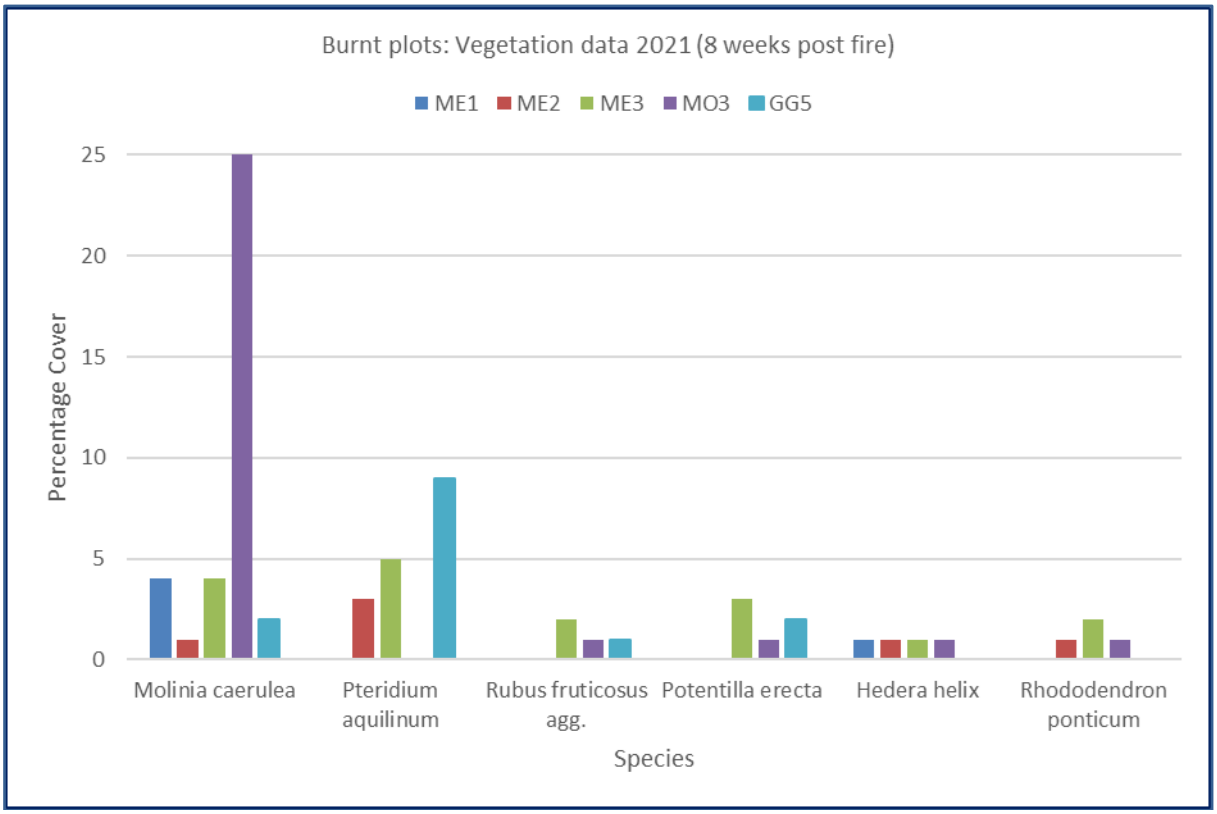

Figure 34 Most common herbs and low woody species recorded within the five burnt plots.

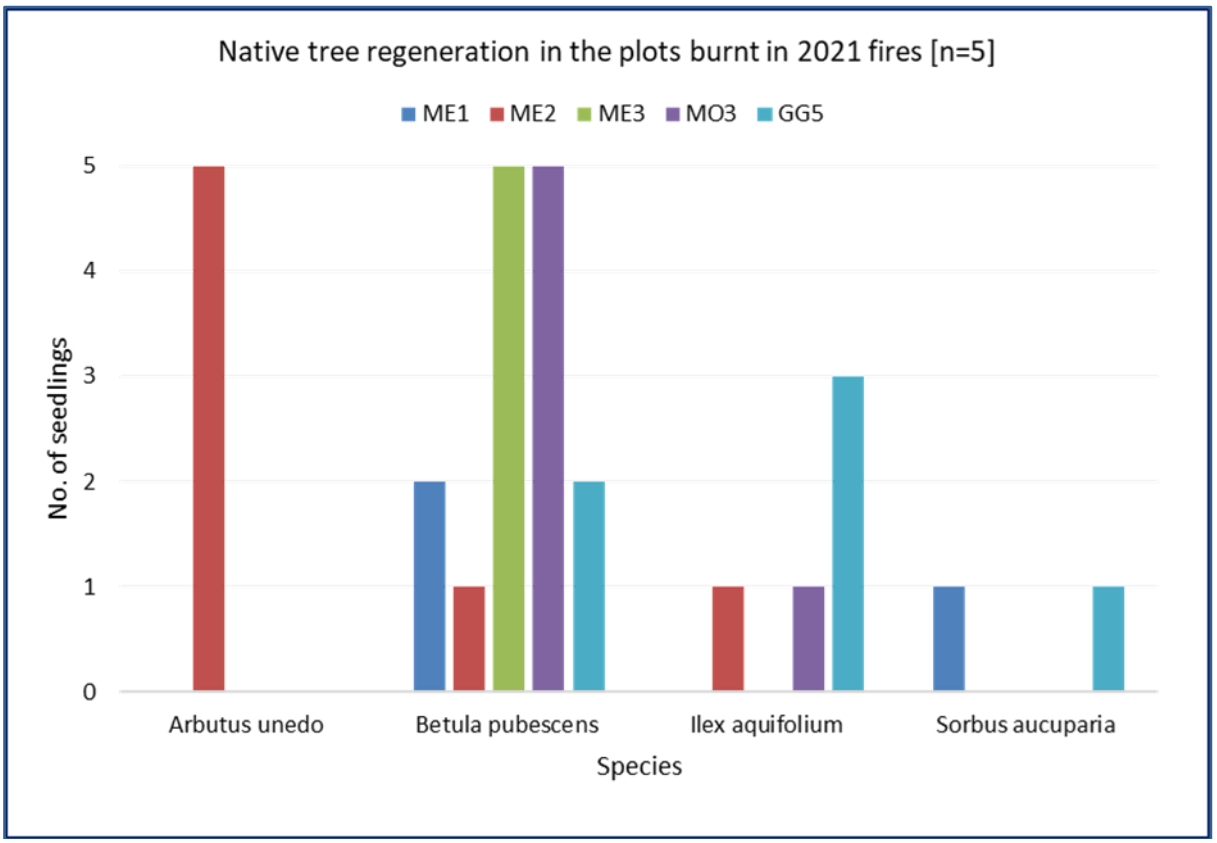

Figure 35 Native tree species that were noted to be regenerating within the burnt plots.

Figure 36 Plot ME1 which was completely burnt over in the 2021 fire. Photograph Jessica Hamilton.

Figure 37 Plot MO3 which was burnt over in the 2021 fire. Photograph Jessica Hamilton.

5.5 Other invasive/problematic species

5.5.1 *Fagus sylvatica* (Beech)

Fagus sylvatica is a non-native species that is shade tolerant and able to regenerate in low light conditions (even under the dense, evergreen canopy of *Taxus baccata*). The monitoring of woodland plots in the yew wood commenced in 1996 and *F. sylvatica* was not recorded in the first round of monitoring (1996). It has since been recorded in two gap plots (RG1 and RG2) with every subsequent round of monitoring. The plot data over time have shown that the seedlings in RG1 have been able to persist and the total cover of *F. sylvatica* in the plot has soared, increasing from 6% in 2011 to over 20% in 2021. Several saplings were recorded that were more than 2 m high. Figure 38 below shows the apparently accelerating increase of *F. sylvatica* over the past 25 years. Figures 39 and 40 below show plot RG1 in 2011 vs 2021 which highlights the dramatic increase of Beech within the Yew woodland plot RG1.

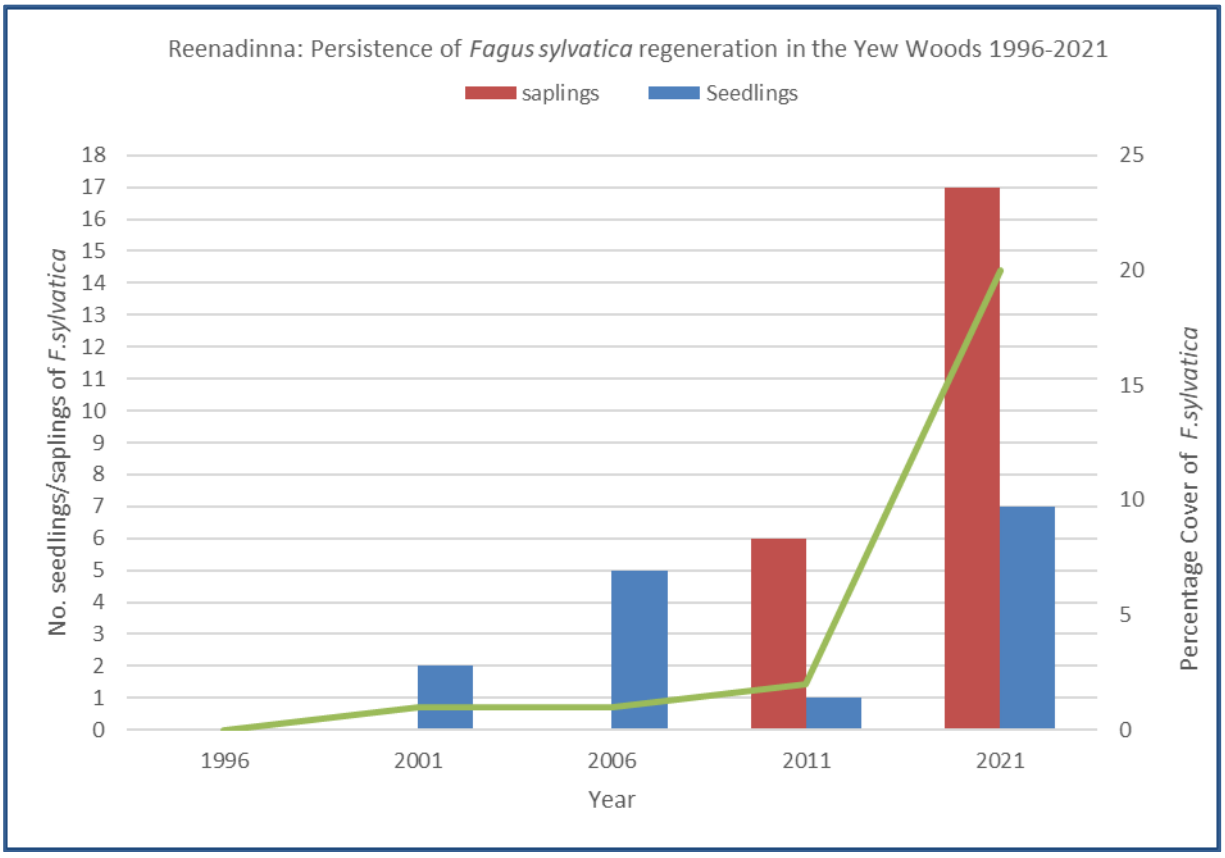

Figure 38 Persistence of *Fagus sylvatica* in the Yew woodland plots.

Figure 39 Reenadinna plot RG1 in 2011. Photograph Miles Newman

Figure 40 Reenadinna plot RG1 in 2021 showing vigorous growth of *Fagus sylvatica*. Photograph Jessica Hamilton.

5.5.2 *Luma apiculata* (Chilean Myrtle)

Luma apiculata is a member of the Myrtaceae (Myrtle family) and is native to South America (Stace, 2019). During the 2021 survey period, *Luma apiculata* was recorded in the yew woods for the first time (Figure 41). It has also been noted to occur in the more highly modified woodlands closer to Muckross House and Gardens (J.J.H. personal observation). Several plants of various ages were present in/around Reenadinna. Where possible, small plants were removed and disposed of appropriately. Larger plants with more extensive roots systems were grid-referenced, tagged and their location data passed on to the Park Rangers. As they were accidental encounters, it is likely there are several other specimens remaining undetected in the yew wood. *Luma apiculata* is not (yet) classified or listed as an invasive species, however it has already become problematic in other wooded areas in Kerry and West Cork, especially in the Glengarriff area (cf. Reynolds 2002).

Figure 41 Alien species *Luma apiculata*. Top: larger specimen tagged for removal, bottom: upper sides of leaves (right) and undersides (left). Photographs Jessica Hamilton.

5.5.3 *Cotoneaster* spp.

Several species of *Cotoneaster* have become naturalised within Killarney National Park, the largest extent being *Cotoneaster cf. integrifolius* on the Muckross Peninsula. (*C. integrifolius* and *C. microphyllus* have been much confused with each other, and their identification often causes debate (Dickoré & Kasperek, 2010; Fryer & Hylmö, 2009). Other species that have naturalised on the peninsula, and in other woodlands (*e.g*. Derrycunihy) include *C. horizontalis*, *C. simonsii* and more rarely *C. franchetii* (Figure 42). Although only *C. simonsii* was recorded within the monitoring plots, the other *Cotoneaster* species were observed and appear to be spreading. For the first time, *C. horizontalis* was recorded within a yew woodland plot (RG5). As well as the seedling recorded in the plot, *C. horizontalis* was plentiful in the immediate environs, growing vigorously to the north, east and west of the plot. *Cotoneasters*, especially *C. integrifolius*, are regarded as negative indicator species on limestone pavement habitats due to their vigorous growth habit and ability to compete with native flora (Cooper *et al*., 2012; Willis, 2011).

Figure 42 L-R: *Cotoneaster simonsii*, *C. horizontalis*, and *Cotoneaster* cf. *integrifolius*. Photographs Jessica Hamilton.

5.6 Notable/new species recorded during the survey

Trichomanes speciosum **(Killarney Fern)** A new sporophyte colony was recorded in oak woodland (outside the monitoring plots) in a wood that had not previously had any sporophyte records (Figure 43). In addition, a gametophyte population of the species was recorded in one of the monitoring plots, occurring amongst luxuriant growth of *Hymenophyllum* spp. *T. speciosum* is a protected species under the Flora (Protection) Order, 2015. The sporophyte population is assessed as Vulnerable (Jackson, *et al*., 2016; Ní Dhúill *et al.,* 2015).

***Neottia cordata* (Lesser Twayblade)** was recorded in several monitoring plots for the first time (Figure 43). Often the only evidence of its presence post-flowering are the paired basal leaves. Due to its diminutive size and inconspicuousness, it is possible that this species may have been missed in previous surveys.

***Botrychium lunaria* (Moonwort)** was recorded in the yew wood (outside the monitoring plots). An uncommon species that has been previously recorded in the vicinity (Figure 43). It is currently classified as 'Near Threatened' on the Irish Red List of Vascular Plants (Jackson, *et al*., 2016)

***Luzula pilosa* (Hairy Wood-rush)** was recorded within one of the yew woodland plots for the first time (Figure 43). *L. pilosa* was subsequently recorded in several locations around Derrycunihy Wood, where it had not been previously recorded. *L. pilosa* is a rare species in Kerry, being more common in the north and south-east of the country.

Other species that were recorded in the plots for the first time during the 2021 monitoring period include *Ficaria verna* (Lesser Celandine), *Cynosurus cristatus* (Crested Dog's-tail), *Jacobaea vulgaris* (Common Ragwort) and *Deschampsia cespitosa* (Tufted Hairgrass).

Figure 43 Clockwise: *Botrychium lunaria, Neottia cordata*, sporophyte of *Trichomanes speciosum* and *Luzula pilosa*. Photographs Jessica Hamilton.

6. Discussion and Recommendations

6.1 Discussion

As highlighted in section 5, there is little or no sustained regeneration of the principal native tree species across any of the woodlands. This is an issue that has been consistently highlighted in previous reports on this study and is a key theme of discussion across the literature (Kelly, 1981; Higgins *et al.,* 2001; Newman *et al.,* 2014a)

In areas of woodland where successful regeneration might be expected (*e.g*. gaps), the situation is no different from that under the woodland canopy: seedlings are not persisting to develop into saplings. This finding highlights that light levels are not the principal factor restricting regeneration. Ample evidence from observations in the field points to grazing as the principal cause of the failure of regeneration. While grazing is an integral element of woodland ecology (Mitchell & Kirby, 1990; Newman *et al.*, 2014b), the level of grazing across the Killarney woodlands continues to exceed sustainable levels.

Across all the woodlands, over the course of the 2021 monitoring period, a total of 527 saplings (S3 and S4), were recorded, of which over half were recorded within plots on the Muckross Peninsula. Out of this total, only four were *Q. petraea*, representing less than 1% of all saplings. The majority of saplings were *Ilex aquifolium*, many of which were, however, stunted from being consistently browsed; very few showed no signs of browsing.

The grazing animals in the woodland show a preference for certain species with *Quercus petraea, Ilex aquifolium, Sorbus aucuparia, Fraxinus excelsior* and *Taxus baccata* being more heavily grazed in comparison to other species such as *Corylus avellana* or the non-natives which are largely untouched. This gives non-native species such as *Fagus sylvatica* and *Rhododendron ponticum* a distinct advantage as they are avoided by browsing animals. The saplings of *F. sylvatica* are extremely shade-tolerant which further improves their competitive advantage.

The graphs and tabulated data for each of the woodlands have shown that the abundance of S1 and S2 seedlings recorded do not reflect the numbers that will persist and become saplings. This is particularly true for species such as *Ilex aquifolium* which produce many hundreds of S1 seedlings, of which only a miniscule fraction will become saplings. Therefore, as indicated by Newman *et al.* (2014a) the S3 saplings provide a truer reflection of the state of tree regeneration within the plots.

The woodland with the highest number of saplings was Muckross with 281 saplings (both S3 and S4) – however, only three of these were *Quercus petraea*. The Muckross Oak Woods have had higher levels of deer culling over the past decade or so, and the increased numbers of saplings within these woods, compared to more remote woodlands, is likely a reflection of reduction in deer numbers. These results indicate that sustained regeneration of native species can occur if the grazing pressure is reduced. This is further emphasized by the fact that the Muckross Oak Woods were the only woods to contain S4 saplings of native species.

The spread of invasive non-native species, principally *Rhododendron ponticum*, remains the other major threat to the ecological integrity of these woodlands. Much work has been done in combatting the invasion of this species, some of it with impressive results, but there have been setbacks as well as advances. Some parts of the oak woodlands have been cleared of *Rhododendron* and have since been kept more or less *Rhododendron*-free (*e.g.* much of Camillan Wood). Other areas were cleared of *Rhododendron* but have subsequently been reinvaded. The 2021 results from Glaisín na Marbh are particularly alarming. This is an area that had been very largely cleared of *Rhododendron* (mainly by volunteers) in the period from 1984 to early 2000s; yet the 2021 resurvey records vigorous regrowth in several of the plots as well as in the surrounding areas.

6.2 Recommendations

The following recommendations are made:

Continual successive monitoring

- The long-term data collected in this study now represent an important asset for both research and management and include 30 years' worth of data from 1991-2021. It is important that this monitoring continues and familiarity with all the plots and their locations are maintained.
- The next survey should take place in 2026 and be followed with the five-year intervals currently used.
- All the data will be fully digitised and archived for future use; they should be updated and built on over the coming years.

Plot Markers

- Where possible all plots should have markers replaced to ensure that every plot has four permanent markers. At Coomclachan, several plots have wooden markers, several of which have rotted, at least partially so. These should be replaced with aluminium markers to ensure longevity.
- It is important that staff and contract workers working in the Park are aware of the plots and their locations so that disturbance can be minimised.

Photographing of plots

- Photographs should continue to be taken at the same compass bearing over the years for consistency and to document a visual representation of the changes within each plot. Some photographs are ambiguous due to the angle they are taken at, so extra photographs should be taken of distinctive features to aid future location of these plots.

Recording of environmental data

- Some environmental data have not been consistently recorded over the successive monitoring periods. The variable 'rock' for example has been recorded over the years EITHER as the percentage cover of 'exposed rock directly visible within a plot' (which may or may not include microlichens) OR as the percentage cover of 'rock that is not soil-covered but is covered by a growth of mosses, liverworts or macrolichens'. This has caused anomalies in the data set which hinder data analysis. In future surveys, rock should be consistently recorded using one or other definition, or both.

Management of *Rhododendron ponticum*

- *Rhododendron ponticum* remains an enormous threat to the future of the Killarney oak woods. The available evidence demonstrates that once a continuous cover of mature *Rhododendron* has taken hold of an area, the biodiversity value of the area has plummeted. The upsurge of *Rhododendron* over the past two decades in the Glaisín na Marbh area (Figures 27-29) highlights the alarming situation in the western, less accessible parts of the Park. We urge that direct interventions to mitigate the spread and establishment of *Rhododendron* in the Park are intensified, and targeted on the areas of highest importance in terms of conservation and biodiversity value.

- The data gathered from the permanent plots can contribute vital scientific data on the invasion process and impacts of *Rhododendron* but this can only be achieved if records are kept of *Rhododendron* management within and around the permanent plots. We thus request that all management activities, including the casual removal of individual *Rhododendron* plants, by staff or contract workers within, or in the vicinity of, the permanent plots are recorded and that the records are made available to future permanent plot monitoring teams.

Management of other invasive species

- Results for 2021 provide the first quantitative evidence of accelerating *Fagus sylvatica* regeneration in Reenadinna Yew Wood. *Fagus* is already regenerating and competing with the native plant community in the oak woods of Killarney National Park, notably at Rossnahowgarry (near Torc Waterfall) (Owens, 2011). *Fagus* combines unpalatability to herbivores such as deer and hares (Higgins, 2001) with tolerance of deep shade. We recommend that control of *Fagus* should be a priority in the management of Reenadinna Yew Wood. Control/management of the other identified alien invasive species should also be undertaken.

Grazing Pressure

- Reduction in grazing pressure is essential, all of the woodlands mentioned in this report are overgrazed to varying levels, with no woodlands showing any significant regeneration. Where significant culling has taken place (*e.g.* in the past in Muckross Peninsula), there has been an increase in the number of saplings.

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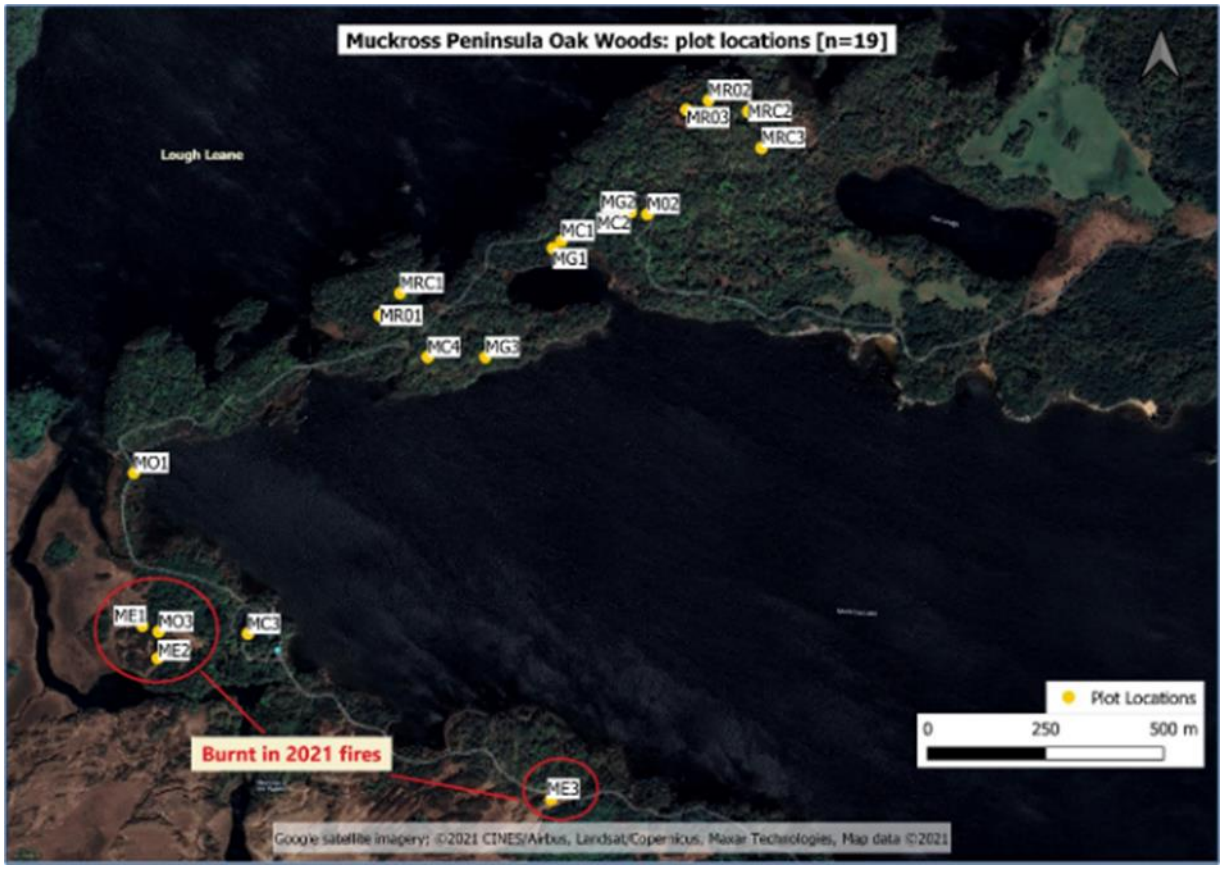
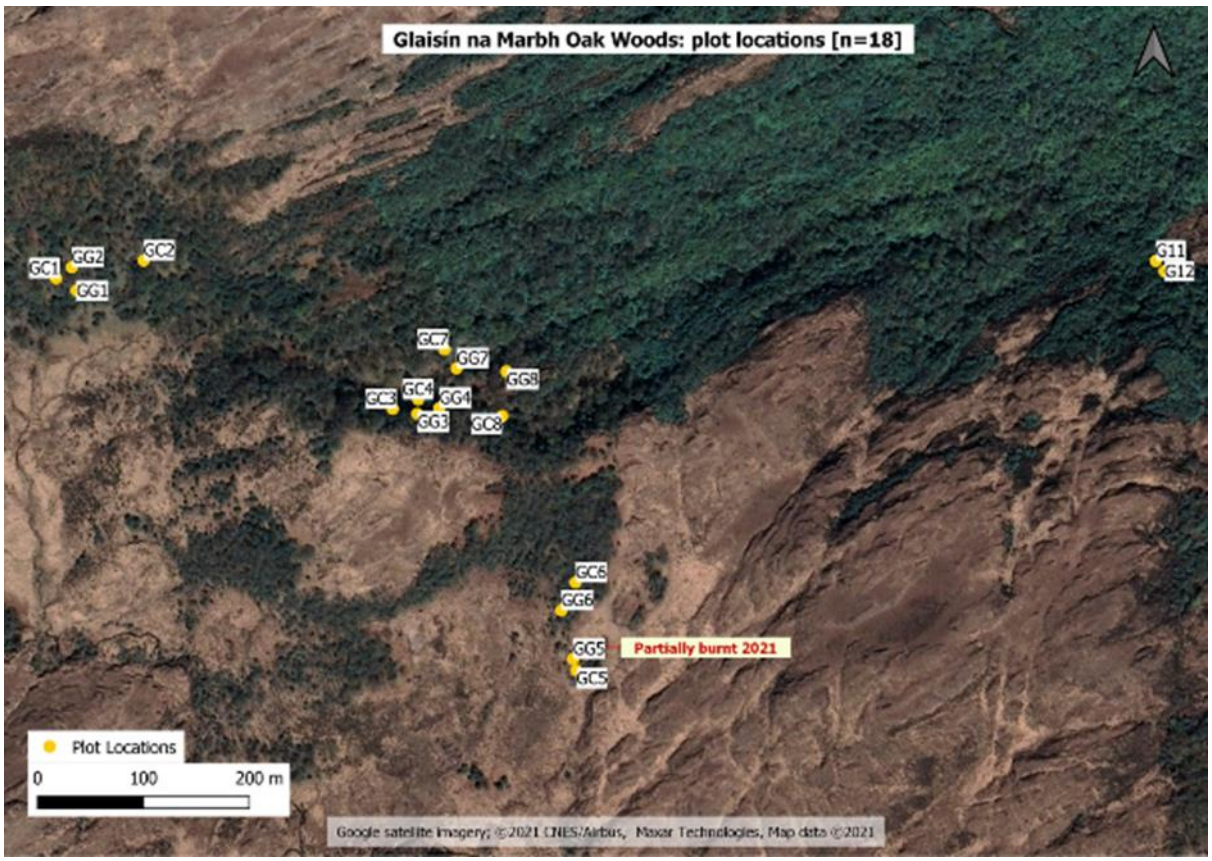
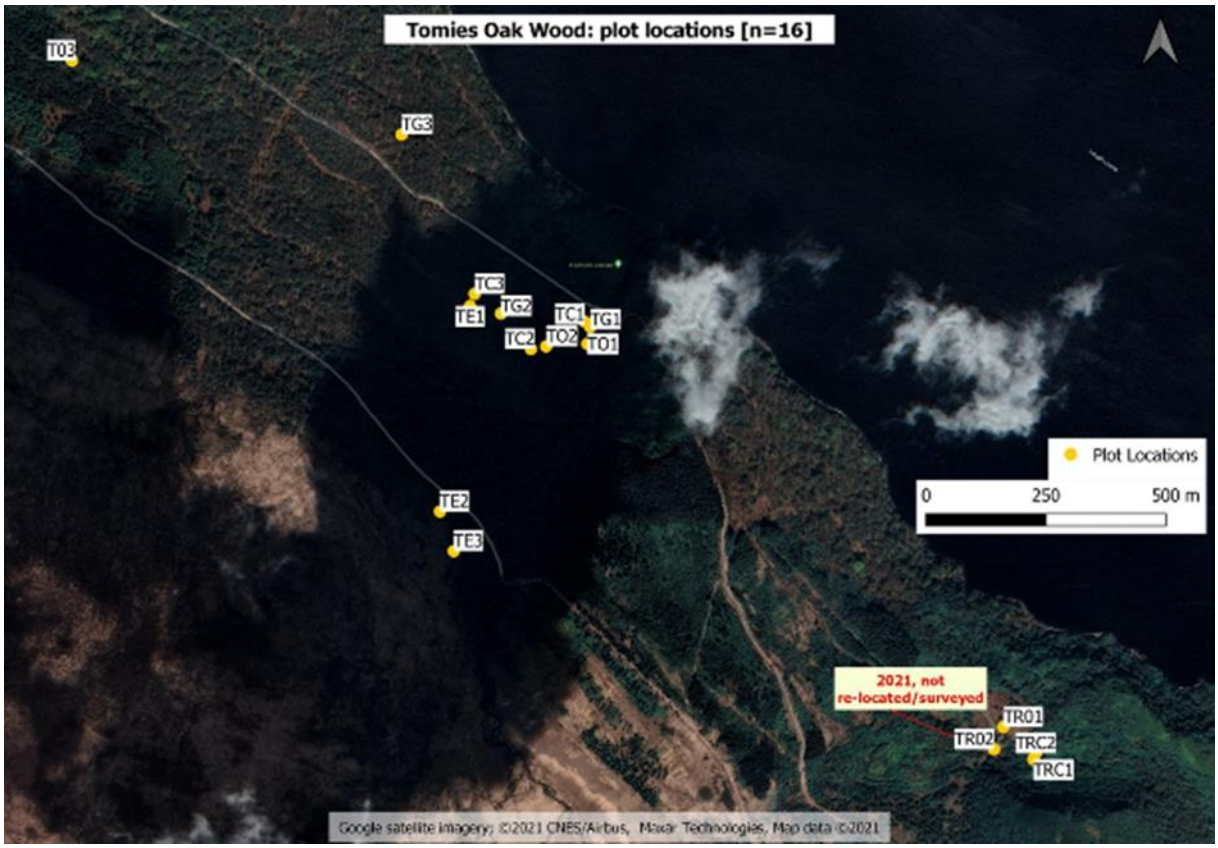
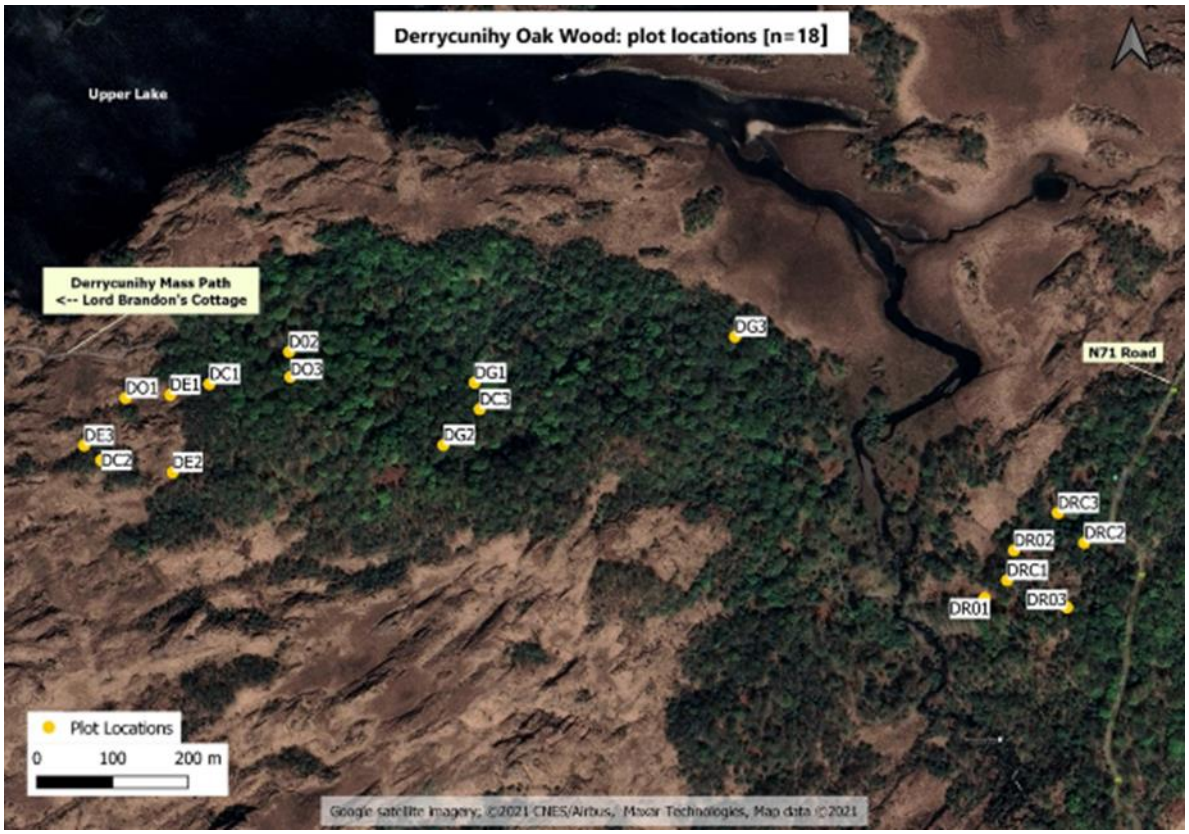
Appendix 1: Maps of woods and their plot locations

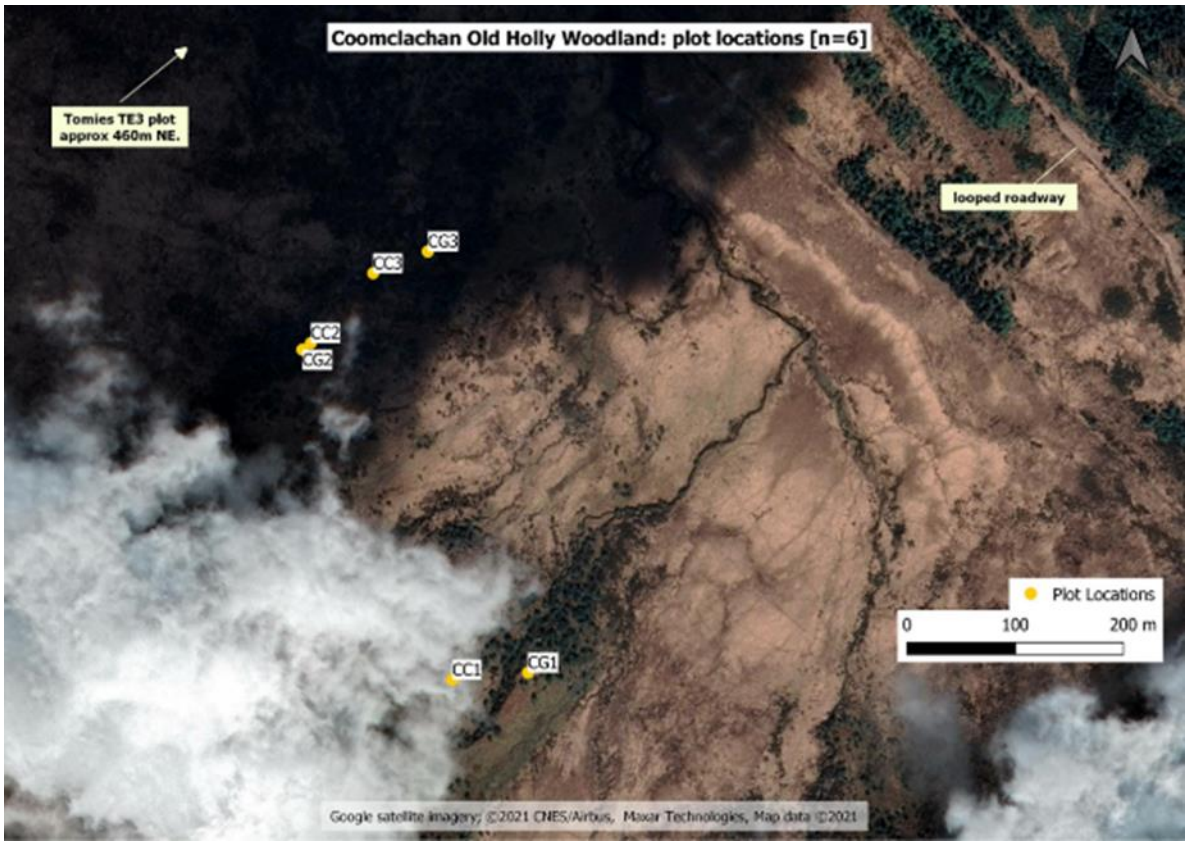
This appendix contains maps of plot locations across the six woodlands. More detailed maps have also been prepared and will be available for future surveyors.




Glaisín na Marbh Oak Woods: plot locations [n=18]
GC1
GG2
GC2
GG1
GC7
GG7
GG8
GC3
GC4
GG4
GG3
GC8
G11
G12
GC6
GG6
GG5
Partially burnt 2021
GC5
Plot Locations
0
100
200 m
Google satellite imagery; ©2021 CNES/Airbus, Maxar Technologies, Map data ©2021


Tomies Oak Wood: plot locations [n=16]
TO3
TG3
TC3
TE1
TG2
TC1
TG1
TC2
TO2
TO1
TE2
TE3
Plot Locations
0
250
500 m
2021, not re-located/surveyed
TR01
TR02
TRC2
TRC1
Google satellite imagery; ©2021 CNES/Airbus, Maxar Technologies, Map data ©2021


Derrycunihy Oak Wood: plot locations [n=18]
Upper Lake
Derrycunihy Mass Path
<-- Lord Brandon's Cottage
N71 Road
DO2
DO3
DO1
DE1
DC1
DG3
DG1
DC3
DG2
DE3
DC2
DE2
DRC3
DRC2
DR02
DRC1
DR01
DR03
Plot Locations
0
100
200 m
Google satellite imagery; ©2021 CNES/Airbus, Maxar Technologies, Map data ©2021


Coomclachan Old Holly Woodland: plot locations [n=6]
Tomies TE3 plot
approx 460m NE.
looped roadway
CG3
CC3
CC2
CG2
CC1
CG1
Plot Locations
0
100
200 m
Google satellite imagery; ©2021 CNES/Airbus, Maxar Technologies, Map data ©2021


Reenadinna Yew Wood: plot locations [n=10]
RC1
RG5
Muckross -->
RC2
2021 New Location
RG3
RG4
RC3
RG2
RG1
RC5
Arthur Young Trail
RC4
Plot Locations
0
75
150 m
<-- Dinis
Killbeg Bay
Google satellite imagery; ©2021 CNES/Airbus, Maxar Technologies, Map data ©2021

Appendix 2: Plot location data

Site Code	ITM	Comment (2021)	Direction of 2021 photos
CC1	490985587074	All 4 markers were in incorrect positions. Repositioned appropriately. *Ilex* nearby has since fallen. V strong browsing line.	30
CC2	490852587386	*Ilex* suckers well chewed, and damage on nearby *Ilex*. Plot dominated by *Pteridium*. Within a couple m of CG2, care should be taken not to confuse both plots with each other.	265
CC3	490920587450	Deer damage evident on *Ilex*. Dung abundant and trampling evident. Standing dead *Ilex*.	350
CG1	491055587079	V grassy. All seedlings showing signs of grazing, esp *Sorbus*. *Ilex* has since died and now standing dead. 3 markers, only 1 correct.	25
CG2	490861587387	Markers were 5m apart, repositioned to form 4x4m plot. Strong grazing on *Blechnum* and *Molinia*. Surrounding *Ilex* showing signs of ageing/decay. Deer damage evident. All seedlings well chewed. Plot CG2 is very close to plot CC2, care should be taken not to confuse plots with each other.	110
CG3	490971587469	Deer path running through plot. *Ilex* (NW of plot) from previous photo has fallen in recent years and has evidence of severe deer damage incl. bark stripping. 3 out of 4 markers incorrectly positioned. Repositioned appropriately. Wooden and beginning to rot. *Molinia* partially grazed, seedlings benefiting from *Molinia* as not as extensively grazed.	185
DC1	490141581343	*Quercus* seedlings scarce and well chewed. *Ilex* seedlings abundant and grazed. *Vaccinium* and *Blechnum* also chewed.	230
DC2	489996581246	4 markers present but not in correct places. Repositioned appropriately. *N. cordata* recorded.	320
DC3	490497581302	Grazing evident, dung in and beside plot.	320
DE1	490089581330	*Rhododendron* in plot. Grazing on vegetation and seedlings. *Quercus* overhanging.	295
DE2	490090581229	*Rhododendron* inside and outside plot. *Sorbus* sapling severely chewed, more like an S2. Markers were in incorrect positions. Repositioned appropriately.	80
DE3	489974581266	*Molinia* well chewed. Treated *Rhododendron* outside plot. Topiary effect on *Calluna*. Extensive bark stripping on *Ilex* outside plot.	280
DG1	490491581337	Abundant dung and grazing evident.	140
DG2	490448581256	All 4 markers present were in wrong place. Repositioned appropriately. Little regen, vegetation mostly *Pteridium*.	65
DG3	490836581390	No markers. Repositioned as close to original as possible. All seedlings and saplings well grazed.	220
DO1	490030581327	Topiary effect on *Ilex* saplings, stunted. Deer path going through plot. Dominated by *Molinia* tussocks. Dead *Ulex* in plot.	250

DO2	490247581383	Vegetation in plot trampled. Evidence of grazing.	140
DO3	*490248581350*	*Rhododendron* in plot. Grazing and dung, *Ilex* stunted and *Vaccinium* well chewed.	265
DRC1	491188581063	Deer tracks, grazing and dung present.	NA
DRC2	491291581110	Abundant *Ilex* seedlings	NA
DRC3	491257581150	Dominated by *Molinia* which is chewed. 1 marker present. *Quercus* has fallen since previous survey. *Betula* growing epiphytically. Grazing noted on *Betula*.	190
DRO1	491158581040	Deer tracks, grazing and droppings present.	270
DRO2	491198581102	Grazing evident, dung in and beside plot.	NA
DRO3	491266581025	GPS incorrect. Strong topiary on *Ilex*, seedlings also well chewed. *Quercus* in previous photo has since fallen. 1 marker present. *Molinia* dominated.	70
GC1	491641585118	V grassy in appearance. *Ilex* tree visible in previous photo has now fallen.	30
GC2	491724585133	Trees in previous photos have since fallen. *Blechnum* well chewed. Epicormic *Quercus* shoots extensively grazed. Deer damage on nearby *Ilex*. *Rhododendron* regen within 1m of plot.	175
GC3	49194384958	Exclosure. Fence recently replaced. *Rhododendron* in plot and abundant in surrounds of woodland. *Ilex* tree in plot fallen recently, lots of exposed bare ground as a result. All seedlings well grazed incl. *Corylus*. Plot was 5x5m, repositioned to 4x 4m. *Ilex* in excl dying, severely grazed and bark stripped.	245
GC4	491970584982	*Blechnum* chewed as well as *Corylus* suckers. *Rhododendron* in plot and abundant in surrounds.	240
GC5	492124584738	Only 1 marker in correct place, plot size was incorrect; 5x3.5m, repositioned to 4x4m. Treated *Rhododendron* in plot, with fresh regen and suckers.	310
GC6	492125584821	*Ilex* taller than *Quercus*, plot size was incorrect (5x4m), Repositioned to 4x4m. *Quercus* suckers well grazed, *Ilex* in plot had decayed more since previous *Blechnum* grazed.	320
GC7	492006585043	Fallen *Betula*, twin-stemmed *Quercus*. Seedlings well grazed and nearby *Ilex* tree well chewed. Large 'wall' of *Rhododendron* plants nearby, light is somewhat limiting their spread into woods. 1 marker present. Sheep wool in plot.	
GC8	492059584979	*Rhododendron* in plot and heavily infesting surrounding woodland. *Ilex* tree and saplings well grazed.	20
GG1	491660585106	Species-rich, c 31 species. *Fraxinus* and *Ilex* well chewed, *Corylus* not grazed. Sheep wool in plot. Lots of deer dung. Old *Quercus* and *Betula* have since fallen. 1 marker was incorrect. *Rhododendron* regen nearby.	310
GG2	491656585128	Rich in herbs/graminoids	60
GG3	491979584983	Exclosure. Fence recently replaced. Grazing in plot.	40
GG4	492000584988	Vegetation (*Juncus*) well trampled and grasses disturbed. Recently treated/pulled *Rhododendron* in surrounds and seemingly from plot. *Ilex* S3 v grazed and stunted. More like S2.	220
GG5	492121584749	Plot partially burnt. Treated *Rhododendron* in plot, with visible, stunted growth. *Rhododendron* regen all around	340

		plot. Must climb *Taxus* to take proper photo. *Pteridium* dominated.	
GG6	492111584795	Deer path going through plot, lots of dung. *Rhododendron* in plot and all-around surrounding plot areas. Dominated by *Pteridium* and *Molinia*. Old *Ilex* dead.	25
GG7	492017585025	1 marker. *Rhododendron* covering approx. 25% of plot. Photo taken at different bearing to previous as dead tree now lying and preventing access. Dead tree either side of plot. Plot located on steep slope.	275
GG8	49206585021	GPS incorrect, goes to old/unused location that has since been changed/moved. Heavily infested with *Rhododendron*, some of which has previously been treated. *Quercus*/*Ilex* seedlings well grazed. Deer path in plot. *Quercus* with large branch level with ground.	205
GI1	492679585112		20
GI2	492687585102	*Rhododendron* tunnel plot. Devoid of light and no herbs except *Hymenophyllum*. Seedlings present v straggly. 10m south of G11.	45
MC1	494322586182	*Ilex*, *Quercus* and *Sorbus* seedlings well chewed. Dead *Taxus* nearby being covered by *Calluna*. *Calluna* well grazed in plot but some tall, ungrazed *Calluna* noted nearby. Deer damage on nearby *Ilex*.	250
MC2	494460586239	Regeneration of a high no. of species, mostly seedlings.	250
MC3	493624585367	Plot dominated by S3 *Ilex*, *Cotoneaster simonsii* in plot (and noted in nearby woodland edge)	175
MC4		Several standing dead *Taxus* in vicinity. All *Ilex* saplings well chewed. *Hedera* liane on nearby *Quercus*. Plot was incorrect size (5x 5m). Repositioned to 4x4m.	5
ME1	493417585388	Plot completely burnt over.	125
ME2	493448585319	All *Calluna* burnt off, whole plot burnt. *Rhododendron* resprouting. Extant vegetation present is *Pteridium* and *Molinia*. Base of overhanging *Arbutus* singed but still alive.	225
ME3	494261584982	Burnt, but not as severely as others (close to path). *Rhododendron* in plot, vigorously resprouting. 3 markers, none were in correct place. Overhanging *Quercus* showing damage from fire with defoliation noted. *Ilex* suckering. Dominated by *Molinia* and *Pteridium*.	340
MG1	494303586167	S4 *Betula* recorded. Both *Calluna* and *Pteridium* c2m high. Plot close to *Arbutus* that has been cut. Treated standing dead *Rhododendron* nearby. 1 marker retrieved from lake!	155
MG2	494471586240	*Arbutus* S3 should be S4 but unrecognizable as a sapling due to severe grazing. *Rhododendron* spreading in plot and treated nearby. Large S4 *Fagus* (3.2m) in plot. *Sorbus* surprisingly not grazed, *Quercus* well chewed. Old *Ilex* in previous photo has now fallen.	235
MG3	494156585940	Seedlings v grazed, esp *Sorbus*. *Hedera* liane on nearby *Quercus* and many others nearby.	140
MO1	493406585711	*Rhododendron* inside and outside of plot. *Calluna* and *Ulex* v tall.	330
MO2	494505586235	*Pteridium* and *Calluna* v tall, showing no signs of grazing. No grazing on S3 *Quercus*. Some evident on *Blechnum*.	15

MO3	493451585375	Plot completely burnt over. All previous saplings/woody shrubs dead. *Rhododendron* is resprouting. New growth of *Molinia*, already grazed.	85
MRC1	493978586079	Plot was incorrect size, (5x4m), repositioned to 4x4m. All seedlings and saplings well grazed & stunted. *Rhododendron* regen abundant around plot.	225
MRC2	494723586448	*Ilex* tree in previous photo has since fallen, extensively bark stripped but still suckering. *Hedera* liane on *Betula*. Large *Betula* branch has fallen off and now lying across plot. Canopy more open compared to previous due to fallen trees and branches. Abundant *Fagus* seedlings nearby.	315
MRC3	494750586370	Grazing severe, some seedlings unrecognizable. Standing dead *Ilex* outside plot has further decayed. *Ilex* suckers with strong topiary effect. Nearby *Quercus* has since fallen.	225
MRO1	493934586033	1 marker. *Betula* in previous photo has since died. *Calluna* approx. 1.7m tall. *Ulex* c1.5m. *Rhododendron* regen in plot and from all surrounds. Not too grazed.	340
MRO2	494640586473	*Erica cinerea* c. 1m tall, *Calluna* c 1.5m. Plot near upright *Juniperus* bush. *Rhododendron* in plot & surrounds. *Ulex* is almost 2m in part.	50
MRO3	494593586454	*Ulex* is c2m high, *Calluna* is c.0.5-1m. Standing dead *Ulex* outside plot. Seedlings well chewed. No herb species.	135
RC1	495861586506	Standing dead *Taxus*, *Ilex* suckers well chewed.	320
RC2	495955586411	New plot created in 2021 to replace lost plot. Similar to previous in terms of distance from path, presence of twin stemmed *Taxus*	NA
RC3	495709586330	Lot of *Fraxinus* regen.	350
RC4	495721586264	Standing dead *Taxus*, possibly dead in previous survey. Extensive bark stripping. Field layer virtually non-existent.	5
RC5	495923586285	*Ilex* saplings well grazed, extensive damage on nearby *Fraxinus*	345
RG1	495759586305	*Sorbus* saplings well grazed. Dramatic increase in height of *Fagus* and *Ilex*. Old grazing on *Ilex*, but field layer relatively unscathed. *Luma apiculata* discovered nearby.	25
RG2	495812586320	Extensive deer damage on *Ilex* saplings, bark stripping. Standing dead specimens present. No damage on 4+m *Fagus* in plot. Sickly looking *Taxus* near plot.	40
RG3	495825586393	*Corylus* adjacent to plot has since fallen.	320
RG4	495747586348	Standing dead *Taxus*, deer path going through plot. More like a canopy plot now, canopy closing in.	175
RG5	496069586495	Human track going through plot. Two spp. of *Cotoneaster* in the immediate surrounds. *Fagus* regenerating readily close by. Rich in fern species, most nibbled.	355
TC1	491377588396	*Pteridium* chewed.	245
TC2	491263588342	Dung abundant. Seedlings well chewed	355
TC3	491148588459	Dung and grazing	270
TE1	491138588434	Dung abundant. Seedlings well chewed.	165
TE2	491066588008	Vegetation flattened, possible deer resting spot. *Ilex* well grazed	205
TE3	491093587925	*Molinia* and *Ilex* grazed with topiary effect. Deer path running through plot.	180

TG1	491388588385	Vegetation well grazed. *Rhododendron* seedlings and regen near (but not in) plot.	305
TG2	491202588417	*Quercus* has since fallen, photo taken further back at same compass bearing. *Rhododendron* in plot, showing evidence of previous treatment.	240
TG3	490971587469	Deer path N of plot. Saplings well grazed. Only 2 markers in correct place. Abundant dung.	0
TO1	491381588350	*Rhododendron* within 10m of plot. Vegetation well grazed.	NA
TO2	491295588347	*Luzula* and *Pteridium* grazed. Abundant dung. Path going through plot.	185
TO3	490305588943	4 stakes, 3 incorrect. Replaced and repositioned correctly. *Pteridium* chewed. Dying *Ilex* with suckers v grazed. Vegetation trampled.	320
TRO1	492232587534	All 4 plot markers found piled against tree c 50m away. Treated *Rhododendron* in plot with strong regrowth.	
TRO2	n/a	Not re-located/surveyed in 2021	n/a
TRC1	492292587465	1 marker found, aligned as best as possible to previous layout. Dramatic increase in *Rhododendron* since previous surveys.	
TRC2	492298587478	All 4 markers found, only 2 in correct place. Aligned as best as possible to previous layout. Dramatic increase in *Rhododendron* since previous surveys.	

Appendix 3: Recording sheet

Permanent plots KNP 2021									
Date									
Plot Code									
canopy cover %									
low woody sp. %									
herb %									
ground/bryophytes %									
litter %									
bare %									
rocks and boulders %									
Coarse Woody Debris (CWD)									
Confirmed correct location (as original survey)	.								
Tree Seedlings (No.)									
Tree Seedlings (% cover)									
Woody spp. (%)									

Ferns, Forbs & Graminoids (%)									

Appendix 4: 2021 plot species list (presence/absence)

	Reenadinna	Derrycunihy	Muckross	Tomies	Glaisín na Marbh	Coomclachan
Agrostis canina/vinealis/capillaris		X	X	X	X	X
Athyrium filix-femina	X					
Anthoxanthum odoratum		X	X	X	X	X
Asplenium scolopendrium	X					
Blechnum spicant		X	X	X	X	X
Brachypodium sylvaticum	X		X			
Cardamine hirsuita					X	X
Carex echinata				X		
Carex nigra						X
Carex pilulifera						X
Carex pulicaris					X	
Carex remota					X	
Carex sylvatica	X					
Cerastium fontanum			X			X
Cirsium palustre					X	
Cynosurus cristatus					X	
Dactylis glomerata	X				X	
Danthonia decumbens		X		X		
Deschampsia cespitosa				X		
Deschampsia flexuosa		X				
Digitalis purpurea		X	X	X	X	
Drosera rotundifolia		X				
Dryopteris aemula		X	X	X	X	
Dryopteris affinis						
Dryopteris dilatata	X	X				
Dryopteris filix-mas	X					
Epilobium brunnescens			X		X	
Euphorbia hyberna		X	X			
Festuca rubra						X
Festuca vivipara						X
Ficaria verna	X				X	
Fragaria vesca	X				X	
Galium saxatile		X	X	X	X	X
Huperzia selago		X				
Hymenophyllum tunbridgense		X	X	X	X	X
Hymenophyllum wilsonii				X		X
Hypericum androsaemum	X					
Hypericum pulchrum	X					
Hypochoeris radicata					X	
Jacobaea vulgaris	X					
Juncus bulbosus		X		X		X
Juncus conglomeratus		X				
Juncus effusus		X	X	X	X	X
Juncus squarrosus						X
Luzula multiflora		X		X	X	X

Luzula pilosa	X					
Luzula sylvatica		X	X	X	X	X
Lysimachia nemorum	X				X	
Melampyrum pratense			X		X	X
Molinia caerulea		X	X	X	X	X
Nardus stricta	X					
Narthecium ossifragum	X					
Neottia cordata		X	X		X	
Osmunda regalis			X			
Oxalis acetosella	X	X	X	X	X	X
Plantago lanceolata					X	
Polygala serpyllifolia		X			X	X
Polypodium sp.		X	X	X	X	
Polystichum setiferum	X					
Potentilla erecta		X	X	X	X	X
Potentilla sterilis	X					
Primula vulgaris					X	
Prunella vulgaris	X				X	
Pteridium aquilinum		X	X	X	X	X
Ranunculus flammula					X	
Ranunculus repens						
Rubia peregrina	X	X	X			
Sagina procumbens						X
Sanicula europea	X		X			
Stellaria media					X	X
Taraxacum sp.	X				X	X
Teucrium scorodonia	X		X			
Trichomanes speciosum (gametophyte)					X	
Trichophorum cespitosum				X		
Veronica chamaedrys			X		X	
Veronica montana	X					
Veronica officinalis					X	X
Viola riviniana/ reichenbachiana	X		X		X	
			Woody species			
Calluna vulgaris		X	X	X	X	
Erica cinerea		X	X	X	X	X
Erica tetralix		X	X	X	X	
Hedera helix	X	X	X	X	X	X
Lonicera periclymenum	X	X	X	X		X
Myrica gale			X			
Ulex europaeus/gallii		X	X	X	X	X
Rhododendron ponticum		X	X	X	X	
Rubus fruticosus agg.	X	X	X	X	X	X
Vaccinium myrtillus		X	X	X	X	

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