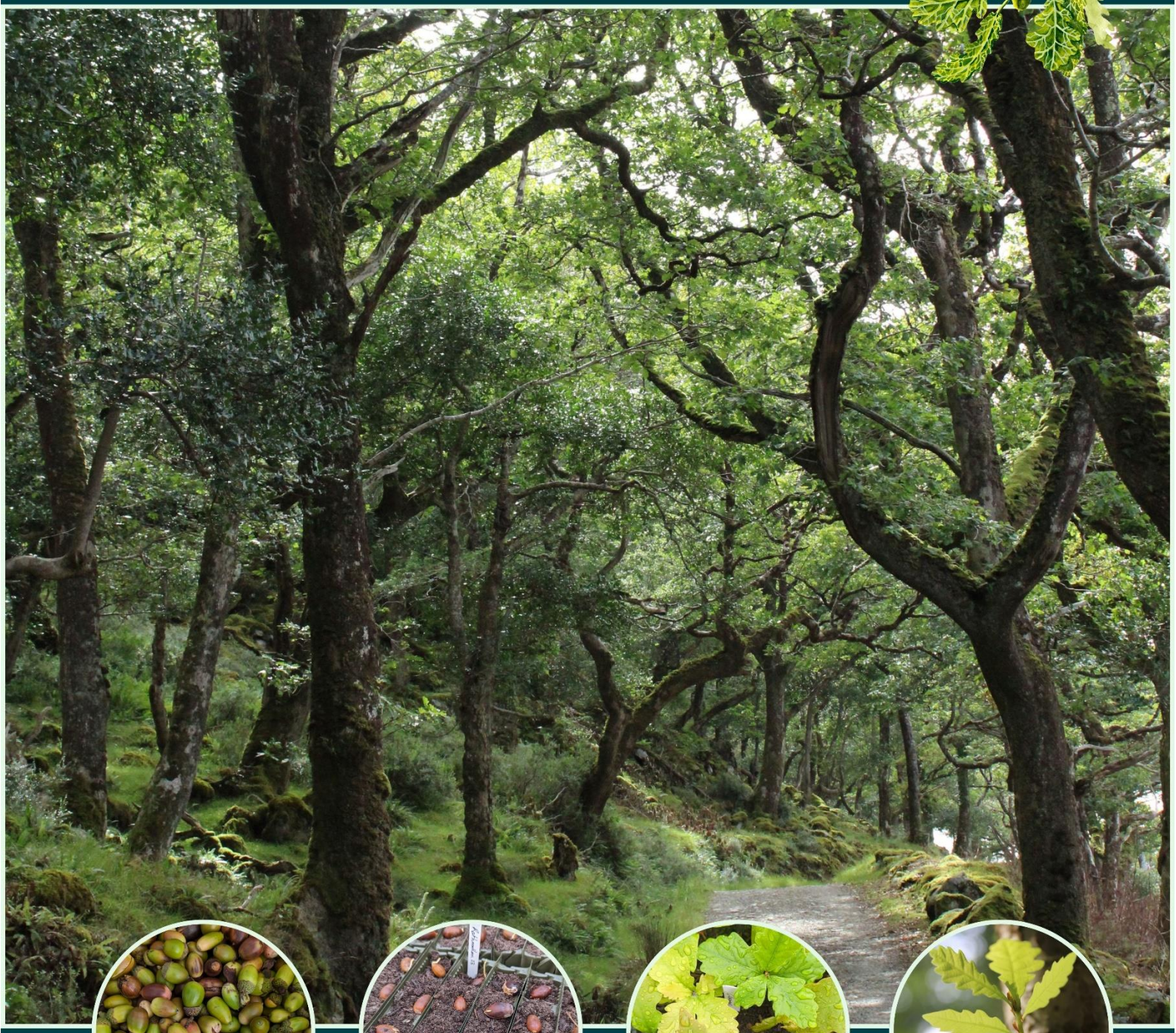
Glenveagh National Park
Woodland Management Strategy



NPWS
An tSeirbhís Páirceanna Náisiúnta agus Fiadhúlra
National Parks and Wildlife Service

An Roinn Tithíochta, Rialtais Áitiúil agus Oidhreachta
Department of Housing, Local Government and Heritage

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Contents

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Executive summary

This document sets out a Woodland Management Strategy for Glenveagh National Park. The focus of the Strategy is the woodland habitat within the Park, specifically native woodland and, as a subset of that, Annex I Old oak woodland [EU Habitat 91A0]. The main goal of the Strategy is to identify actions that will address the issues that contribute to the poor ecological condition of these internationally important woodlands and to provide a framework over which these actions can be implemented to enhance the ecological and conservation value of the woodlands.

The first part of this document sets out the Vision for the woodlands in Glenveagh National Park. The seven policies that underpin the Strategy are then outlined, together with the actions that support its implementation. A work plan is presented for each of three phases of the Strategy, from now until the year 2120.

The second part of this document sets out the context in which the Strategy has been prepared. Chapter 1 outlines the current condition of the woodlands in the Park, and why a Woodland Management Strategy is needed.

Chapter 2 reviews all available habitat and plant data pertaining to Glenveagh National Park.

Chapter 3 outlines the methodology used to address data gaps relating to the area of woodland in Glenveagh, both extant and historical (i.e., woodland that used to be present but which is now gone). Desk-based mapping was supported by fieldwork carried out in 2021, and up-to-date areas were calculated. The current extent of woodland within Glenveagh as a whole (including plantations and woodland fragments) stands at approximately 212.4 ha, with broadleaved woodland the dominant stand type. The historic map dataset indicates that 227.0 ha of the Park was wooded since c. 1830; however, these areas were not all wooded contemporaneously. Comparing the currently wooded areas in the Park with the historically wooded areas, 117.7 ha of land indicated as wooded on at least one of the historical six-inch maps is currently unwooded. These locations can be considered Potential Woodland Establishment Areas (PWEAs). This chapter also outlines desk-based research that provides strong evidence to upgrade Mullangore Wood in the Park from a Possible Ancient Woodland (PAW) to an Ancient Woodland (AW).

Chapter 4 examines the issue of invasive plant species in Glenveagh National Park. The two main problematic species are Rhododendron (*Rhododendron ponticum*) and Prickly Heath (*Gaultheria mucronata*, formerly known as *Pernettya mucronata*), but others also occur. A SWOT analysis is made of the latest Invasive Species Management Plan, and findings are used to make management recommendations with regard to bringing invasive species under control in the Park. A number of supporting measures are also outlined, including the establishment of an Invasive Species Management team.

Chapter 5 deals with the issue of deer impacts, mainly overgrazing, in the Park. Glenveagh has had a long history of deer management, dating from the mid-19th century. A lack of natural predators has led to significant impacts on the woodland ecosystem which threaten woodland continuity, e.g., by reducing the proportion of regenerating seedlings that reach maturity. Deer management is discussed in relation to fencing and culling, and other supporting measures are recommended. Foremost among these are that a comprehensive deer management strategy should be developed, and a deer management team should be established within the Park.

Chapters 6 and 7 both relate to woodland establishment and expansion. Chapter 6 concentrates on ways to support woodland that is already present, for example, by protecting existing regeneration from deer browsing, enhancing the structure of existing woodland by appropriate silvicultural techniques, maintaining stocks of dead wood, and enrichment planting where there is a lack of sufficient seed sources in the locality, or of animals that disperse seed. Chapter 7 is focused on issues surrounding the conversion of non-wooded areas to native oak and birch woodland. Considerations include licencing, commissioning Appropriate Assessments where other qualifying interests of the SAC might be affected, and determining where best to establish

new areas of woodland, based on factors such as soil type. A recommendation is made for a full habitat map of the Cloghernagore Bog and Glenveagh National Park SAC (002047) to be commissioned to support decision-making with regard to woodland creation.

Chapter 8 looks at the need for an in-house nursery for sourcing and growing up the planting material needed to service the Strategy. The importance of having properly licenced and locally sourced trees from within the Park and the north-western region is seen as key to helping to deliver the aims of the Strategy. It is also a means of conserving genetic diversity.

Chapter 9 sets out the importance of a comprehensive monitoring programme in delivering the aims of the Strategy. The points that should be considered in setting up such a programme are described, and the importance of good coordination and communication among the various management strands of the Park is emphasised.

Chapter 10 describes how initial spatial zoning has been developed for the Strategy using a Geographic Information System (GIS). Through this process each of the extant woodland blocks and the Potential Woodland Establishment Areas for which there was a specific task under the strategy are identified and zoned. As the invasive species management plan is revised the compartments developed for this will form the basis of the spatial strategy. When works are completed within a woodland block, or when additional survey work becomes available for a location, these can be recorded and entered into the GIS such that it remains up to date.

Chapter 11 sets out various initiatives that will support the actions recommended in this Strategy document. These include expanded roles in education and communication to involve local stakeholders more fully in woodland management and to promote greater appreciation of the Park and its habitats. Increasing the number and types of specialist studies that are carried out in the Park is also seen as important, contributing to a better understanding of the Park's ecology. Further avenues to explore in relation to funding these additional initiatives are presented. A number of other projects that could be carried out outside of, but close to, the Park are outlined as these will also have a beneficial effect on the habitats and species of the Park itself.

Also provided with this Strategy, as a separate file, is an Excel workbook which has been set up as a management tool to help with planning the various elements of the Strategy. It includes estimates of costs, based on a number of assumptions which can be adjusted as needed, and sets out management prescriptions for the larger areas (>1 hectare) of extant woodland and some areas of unwooded habitat that are suitable for afforestation.

Vision for Glenveagh National Park woodlands

Phase I (2020-2030): Short-term vision for native woodlands in Glenveagh:
The vision for 2030 is for native woodlands in which natural woodland processes, hitherto interrupted by overgrazing and invasive plant species, are beginning to occur again, particularly the process of native tree regeneration beyond the seedling stage of development. This will include the re-emergence of naturally regenerating native trees at a landscape level, but particularly in the main glen, outside of the existing woodland areas. This will begin to address the conservation objectives for the SAC that relate to habitat extent, including maintaining/increasing the area of Annex I Old oak woodland [91A0] and reducing fragmentation, and improving woodland structure, building up a supply of younger-stage trees (seedlings, saplings and poles) within the woodland. Some strategic planting of native trees may be required in this early phase, so a native tree nursery will have been established within Glenveagh using locally-sourced planting material that can be propagated on site and planted out as required.

While the Annex I Old oak woodland will not yet have reached favourable conservation condition, by 2030 it would be anticipated that there will be positive trends in area and structure and functions, and that the future prospects of Annex I Old oak woodland in Glenveagh will be assessed as Unfavourable-Inadequate (rather than the current assessment of Unfavourable-Bad). The effects of climate change, as demonstrated by phenomena such as increased storm severity and summer droughts, will still be experienced, but improvements in the structure, health and diversity of the woodland are expected to contribute to greater resilience in this regard.

Phase II (2030-2050): Medium-term vision for native woodlands in Glenveagh:
The vision for 2050 is for native woodlands in which natural woodland processes are continuing and in which there is a visible improvement in the overall structure of the woods, as evidenced by improved cover and diversity of bryophyte and field layers, a developing shrub layer, a cohort of new saplings, and little or no invasive plant species. The lower slopes of the main glen will be populated with a mosaic of pioneering native woodland comprised primarily of birch, but including other species such as sessile oak, holly, rowan, hazel, Scots pine, yew, aspen and willows. These will help to link up disparate blocks of woodland and reduce fragmentation.

All the Annex I Old oak woodland in Glenveagh should by now be in or very close to favourable conservation condition, and the trends in area, structure and functions, and future prospects will all be positive. The density of the shrub and understorey layers of the woodland should by now be helping to buffer taller trees from the more severe effects of stronger winds, and well-developed bryophyte mats on the ground and on trees should also help to protect plants and invertebrates in the event of drought. A wider suite of species leads to more efficient utilisation and cycling of nutrients, above and below ground, making available a wider range of resources for species to exploit, which should, in turn, lead to healthier plants that are better able to resist disease and other pressures.

Phase III (2050-2120): Long-term vision for native woodlands in Glenveagh:
The vision for 2120 is for native woodlands in which natural processes are occurring without undue human intervention, e.g., natural processes of disturbance (tree fall) and regeneration (seedling recruitment) are occurring in equilibrium, nutrient-cycling processes (such as breakdown of dead wood and carrion by invertebrates, fungi and bacteria) are operating well, and the problems of overgrazing and invasive plant species are being kept under control by sustained but non-intensive human intervention.

The woodlands now have a well-developed structure, in terms of both age (young and old trees present) and physical layering (discernible moss layer, field layer, shrub layer, understorey and canopy), with typical species present in all layers and a healthy amount of standing and fallen wood maintained with minimal human intervention. What were formerly individual blocks of woodland have coalesced into continuous corridors of wooded habitat, with better flow of species and genetic material through the wooded landscape.

The Annex I Old oak woodland should now be in favourable conservation condition, with the trends in area, structure and functions, and future prospects all positive. At least some of the woodlands established in Phase I should now be mature enough to be classed as Annex I Old oak woodland; and they should be in or approaching favourable conservation condition, with typical species having established naturally in the moss layer, field layer and upper layers of the woodland from the surrounding native woodlands, and sufficient amounts of dead wood being maintained through natural processes. By now the woodland should be resilient enough to withstand the main effects of climate change, having a multi-layered structure and a species-diverse ecosystem that is more resistant to disease and invasive species, is full-canopied and which has good understorey and shrub layers that help to maintain humidity and provide a buffer against windthrow.

Part I: Policies and Actions

Seven policies underpin this Woodland Management Strategy.

Policy 1 Invasive plant density is brought down to and maintained at a level at which invasive plants do not interfere with normal woodland ecological processes.

Policy 2 Deer density is brought down to and maintained at a level at which deer activity and grazing is compatible with normal woodland processes and functions.

Policy 3 Sensitive woodland management is employed so that natural woodland processes are supported rather than replaced.

Policy 4 Local-provenance material is used for all planting within the Park, supplied by an in-house nursery that propagates stock primarily originating from Glenveagh and northwest Ireland. An exception is made for rare genotypes for *ex situ* conservation, such as native Scots pine from Co. Clare.

Policy 5 The management team of Glenveagh National Park operates, as far as possible, a closed ecological cycle within the Park. This means retaining natural materials within the Park's natural ecological systems, including animal carcasses, dead wood and felled timber, for *in situ* decomposition and nutrient recycling.

Policy 6 The management team of Glenveagh National Park recognises the Park's importance as a focus for education and research on all aspects of woodland ecology, and continues to support educational and research initiatives in woodland ecology, especially where these contribute to policies 1 to 5 above.

Policy 7 The special place held by Glenveagh National Park in the hearts of the local community and throughout the northwest is recognised and valued. A policy of openness operates between the management team of Glenveagh National Park and the community who interact with the Park on a regular basis. The management team will continue to strive to keep local stakeholders apprised of important aspects of the woodland management taking place in Glenveagh, including the rationale, desired outcome and duration of works.

Each of the policies is supported by a number of actions.

Cross-cutting actions that support all policies:

1. Appoint additional staff, as follows:
    - Woodland management team, consisting of 1 x full-time staff member dedicated to implementation of the overall Woodland Management Strategy and all of its recommendations, plus support staff of 2 x professional staff or Full Time Equivalents (FTEs) which could include a combination of a greater number of staff with other duties. At least one of the woodland management team should have GIS expertise;
    - Invasive species management team, consisting of a minimum of 4 x full-time professional staff or FTEs which may include a combination of a greater number of staff with other duties;
    - Deer management team, consisting of a minimum of 4 x full-time professional staff or FTEs;
    - Nursery team, consisting of 1 x full-time professional staff member to administer the expanded nursery remit of the garden, plus the support of 1 x full-time operative or FTE;
    - Expand the current education and communications team at Glenveagh, including the appointment of 2 x full-time professional staff members or FTEs, to run campaign for public awareness of the Strategy and to work with volunteer groups.
2. Establish a Monitoring team from existing staff members to coordinate all aspects of monitoring the progress of the Strategy. At least one of the team should have GIS expertise.
3. Purchase necessary equipment for additional staff to carry out their duties.
4. Implement training programme for all staff members.
5. Implement a meticulous record-keeping system which incorporates a GIS-based platform.
6. Design and implement Monitoring protocols for different aspects of woodland management (e.g., invasive species control, deer management, woodland restoration and establishment).
7. Maintain good communication among all teams: woodland management, nursery, invasive plant species management and deer management.
8. Document progress and degree of success of all measures implemented as part of this Strategy, including reasons for any setbacks encountered so that these may be addressed.
9. Explore funding options, e.g., other funding avenues, identify work that is eligible for funding under public schemes, design projects around the available funding mechanisms, apply to suitable funding schemes, utilise funding as prescribed by the terms of the scheme, and produce the required reports.
10. Explore other projects that can be carried out in parallel with the Strategy which have beneficial effects on other non-woodland habitats within the Park and SAC, such as bog restoration, restoration of wet heath from conifer plantations and habitat creation.
11. Explore other projects that can be carried out in parallel with the Strategy which have beneficial effects on neighbouring areas of woodland and non-woodland habitat outside the Park.
12. Review the Strategy every 5 years:
    - Evaluate the success of the measures that are being implemented
    - reference the monitoring studies that have been carried out since work on implementing the Strategy began.

Actions to support Policy 1 (Invasive species management; see Chapter 4)

13. Agree guiding principles and realistic objectives for overall invasive species management.
14. Develop a revised strategy for Rhododendron control:
    - Set priorities;
    - Recognise that budgets and resources will vary;
    - Adopt a flexible approach - strategy needs to be adaptive such that, if priority work is not achieved in a given year, it becomes the priority for the following year.

15. Reorganise the current Invasive Species Management Plan GIS.
16. Revise and continue implementation of Invasive Species Management Plan.
17. Conduct more research on *Gaultheria mucronata*, e.g.:
    - review effectiveness of the current clearance approach;
    - build on research of Feliz (2009) on clearance methods;
    - map its extent within Glenveagh, using existing data from this Strategy, the Invasive species management plan and Feliz (2009);
    - ecological research to assess the current impact of the plant, and identifying the Annex I habitats that are most at risk.
18. Decide how other invasive plants will be prioritised in clearance regime, e.g., *Dicksonia antarctica*, *Rhododendron ciliatum* and *R. protistum*. Collect data on current extent, density, pathways of introduction into the Park; conduct research on how they should best be controlled.
19. Initiate a public information project on invasive species clearance in collaboration with the education/communications team.
20. Seek linkages with other projects and other National Parks whereby information and experiences can be shared.
21. Utilise Native Woodland Conservation Scheme to assist in invasive species management in certain woodland compartments.

Actions to support Policy 2 (Deer management; see Chapter 5)

22. Develop and commence implementation of a comprehensive deer management strategy to inform all aspects of deer management in Glenveagh.
23. Reduce deer densities such that impacts on woodland vegetation are considered acceptable. This should be a results-based operation, with success measured by woodland vegetation regeneration targets rather than by deer density.
24. Develop a deer protocol to allow for carcasses to be left on the hill to provide carrion as a food source for other organisms; initiate a PhD study (or studies) to gather local scientific data to support and optimise this policy.
25. Repair some existing deer exclosures and erect some new, small-scale ones.
26. Initiate a public information project on all aspects of deer management in collaboration with the education/communications team.
27. Collaborate with neighbouring landowners to extend the deer management area outside the park boundaries.
28. Seek linkages with other projects and other National Parks whereby information and experiences can be shared.
29. Utilise Native Woodland Conservation Scheme to assist in deer management in certain woodland compartments.

Actions to support Policy 3 (Woodland management; see Chapters 6 & 7)

30. Protect individual regenerating trees with deer tubes; research most suitable design for use in Glenveagh.
31. Carry out enrichment planting according to prescriptions set out by this Strategy.
32. Create dead wood (standing and fallen) from existing non-native trees.
33. Establish monitoring plots, in collaboration with the monitoring team.
34. Conduct or commission detailed scientific studies among other groups of species, e.g., invertebrates, birds, to monitor changes in animal ecology taking place as woodland regenerates.
35. Use close-to-nature techniques (Continuous Cover Forestry) to gradually transform non-native woodlands to natives, particularly in the wooded areas around the visitor centre and car parks which have high levels of non-native conifers present.
36. Use Forest Service Native Woodland Scheme for creation of new native woodland.
37. Target areas for proactive native woodland planting using Forest Service Afforestation Scheme to supplement natural woodland recolonisation.

38. Consider developing a designated community woodland space, specific for community involvement, close to the Visitor Centre and Derrylahan. Support funding may be available through the Native Woodland Scheme.
39. Treat or remove regeneration of non-native shrubs and trees.
40. Conduct Appropriate Assessments to address the situation where other qualifying interests of the SAC may be affected by measures recommended by this Strategy.
41. Set realistic targets for woodland expansion and establishment based on implementation of other elements of the strategy including reduced deer numbers, observed regeneration response and availability of trees for planting.
42. Finalise a plan to progress woodland establishment in areas selected based on information provided by this Strategy. Review additional potential woodland establishment areas identified by Telford (1977) for suitability.
43. Document soils / vegetation types to identify where woodland is expected / not expected to establish.
44. Create woodland in previously wooded areas, and in other suitable areas based on soil conditions, to improve habitat connectivity and increase overall woodland area.
45. Phase out non-native tree species over time in favour of natives.
46. Conifer plantations on peat in the Park and SAC as a whole should be managed in the future with the aim of benefiting other qualifying interests in the SAC. Remedial works and removal of timber from these areas needs careful consideration, particularly in sensitive Freshwater Pearl Mussel catchments.

Actions to support Policy 4 (Production of planting stock; see Chapter 8)

47. Establish nursery with capacity for raising enough native trees and shrubs of certified local provenance to use for enrichment planting in Glenveagh and the northwest region.
48. Engage fully with the Forest Service of Dept. of Agriculture, Food and the Marine regarding registering as a supplier of forest reproductive material, utilising existing seed stands at Glenveagh, registering further officially certified seed stands, and to receive other advice on forest seed and plant regulations.

Action to support Policies 5, 6 & 7 (Strategic support initiatives; see Chapter 11)

49. Commission an up-to-date habitat map of the entire Cloghernagore Bog and Glenveagh National Park SAC
50. Utilise national and international ecological expertise to research different components of the woodland ecology at Glenveagh, e.g., commission baseline and follow-up specialist studies in other plant, animal and fungal groups, deadwood, nutrient cycling processes and genetic studies.
51. Devise programmes suitable for a range of volunteer groups with different interests and abilities to help in implementing some woodland management measures of the Strategy.
52. Establish links with third-level educational establishments.
53. Disseminate and share woodland management information to interested parties in NPWS and elsewhere.
54. Design a Public Awareness Campaign in relation to the Strategy and what it hopes to achieve. The campaign should address:
    - the vision for the woodlands at Glenveagh and the steps that will be needed to bring it about
    - awareness-raising in relation to the more controversial aspects of the Strategy
    - demonstrate progress made on the strategy through a Virtual Reality display
    - the long-term nature of the measures proposed by the Strategy.

Work plan for Phase I (2020-2030)

Phase I (2020-2030): Short-term vision for native woodlands in Glenveagh:

The vision for 2030 is for native woodlands in which natural woodland processes, hitherto interrupted by overgrazing and invasive plant species, are beginning to occur again, particularly the process of native tree regeneration beyond the seedling stage of development. This will include the re-emergence of naturally regenerating native trees at a landscape level, but particularly in the main glen, outside of the existing woodland areas. This will begin to address the conservation objectives for the SAC that relate to habitat extent, including maintaining/increasing the area of Annex I Old oak woodland [91A0] and reducing fragmentation, and improving woodland structure, building up a supply of younger-stage trees (seedlings, saplings and poles) within the woodland. Some strategic planting of native trees may be required in this early phase, so a native tree nursery will have been established within Glenveagh using locally-sourced planting material that can be propagated on site and planted out as required.

While the Annex I Old oak woodland will not yet have reached favourable conservation condition, by 2030 it would be anticipated that there will be positive trends in area and structure and functions, and that the future prospects of Annex I Old oak woodland in Glenveagh will be assessed as Unfavourable-Inadequate (rather than the current assessment of Unfavourable-Bad). The effects of climate change, as demonstrated by phenomena such as increased storm severity and summer droughts, will still be experienced, but improvements in the structure, health and diversity of the woodland are expected to contribute to greater resilience in this regard.

At the end of Phase I (i.e., by 2030), what do we want to see? (Objectives)

- Foundations being laid for the sustained management of woodland in the Park that will lead to improvements in its area, ecological health and conservation status.
- Establishment of key operations teams within the Park: woodland management, invasive species management, deer management, nursery and monitoring.
- Initiation of practices that will start to bring the problems of overgrazing and invasive species under control.
- Initiation of practices that will start to improve the chances of success of native tree seedlings in reaching maturity.
- An increase in the area of newly developing native woodland, brought about mainly by greater success in natural regeneration but supported by additional planting of locally sourced planting material.
- An up-to-date habitat map for Cloghernagore Bog and Glenveagh National Park SAC, which will provide support for decisions made in relation to woodland creation targets that may conflict with other qualifying interests of the SAC, such as Annex I Wet heath.
- For Annex I Old oak woodlands, improvement in the trends in Area, Structure and functions and overall conservation status, and improvement in Future prospects for the habitat, brought about by implementation of the measures recommended by the Strategy.
- Comprehensive review of the Strategy to determine what measures have worked best, what need adjustment, what measures simply have not worked, and what should be done instead.
- In terms of woodland area, the objective is to work towards creating an additional 110 ha of immature (developing) woodland within the focus area around the Lough Beagh glen to offset historical woodland losses quantified by mapping for this project.

How will this be achieved? (Actions)

Action #	Action	Target	Time frame	Cost (€)
1	Appoint Woodland Manager to administer Strategy, plus support team	3 x staff appointed	2023	240,000 per annum*
1	Appoint staff for invasive species management team	4 x staff appointed	2023-2024	320,000 per annum*
1	Appoint staff for deer management team	4 x staff appointed	2023	320,000 per annum*
3	Purchase equipment	Equipment purchased	2023-2030	See Excel Workbook
4	Training provided to staff (e.g., specialist operations, GIS, record-keeping)	Fully-trained staff	Ongoing	TBC
5,8	Design GIS-linked system to help administer all aspects of the Strategy; provide training to management on how to use it	System set up, staff trained up	2023-2024	0**
13-15	Develop an agreed Invasive Species Management Plan (ISMP) or reconfigure the existing plan	Invasive species management plan developed/updated	2023	TBC
22	Develop an agreed Deer Management Plan (DMP)	Deer management plan produced	2023	TBC
13-21	Commence/resume implementation of ISMP	Clearance targets set out in ISMP reached	2023	See Excel Workbook
22-29	Commence implementation of DMP	Deer impact assessment targets set out in DMP reached	2023	See Excel Workbook
1	Appoint nursery manager to oversee all matters in relation to nursery establishment, appoint support staff to assist	2 x staff appointed	2023	160,000 per annum*
47-48	Establish in-house nursery to develop capacity for licensed, certified native tree production to meet planting requirements of the Strategy	Nursery established	2023	29,000
49	Commission up-to-date habitat map of the SAC	Habitat map created	2023-2024	TBC
25, 30, 31	Strategic additional small-scale planting of native woodland on mineral soils using deer exclosures and deer tubes (specified in Excel workbook supplied to managers of this Strategy)	Work to have begun in all areas specified in Excel workbook	2023-2030	Neutral: Use Forest Service (FS) schemes
30-32, 35-39, 43-44	Strategic implementation of prescribed management in existing woodlands > 1 ha (specified in Excel workbook supplied to managers of this Strategy)	Work to have begun in all polygons >1 ha	2023-2030	Offset by FS Native Woodland Conservation Scheme
1	Appoint additional staff in Education/Communications team to handle additional communications and volunteer liaison required for the Strategy	2 x staff appointed	2023-2024	160,000 per annum*
47-48	Begin production of locally sourced, certified planting material for use within the Park and throughout the northwest	Build up to 20,000 seedlings per annum	2023-2030	15,000 per annum
54	Develop an education and communication strategy to inform members of the public of the vision for the woodland and the steps that will be needed to bring it about.	Display of the main aims of the Strategy in Visitor Centre. Explanation of rationale for decisions to be made.	2023-2024	0**
2	Establish monitoring team	Team established	2023	0: From existing staff
6, 33	Design Monitoring protocols, including establishment of network of monitoring plots	Monitoring protocols and network of plots established	2023-2024	0**

Action #	Action	Target	Time frame	Cost (€)
6, 33	Conduct baseline surveys as part of monitoring; Monitor annually for first 7 years	Baseline surveys completed; Annual monitoring completed, data analysed	2023 2024-2030	TBC
10, 34, 50, 52	Establish / collaborate on research projects that support the overall woodland management plan and that also help inform future policy development, both locally and nationally.	At least 6 research projects established across a range of disciplines	2023-2030	0**
20, 28	Establish linkages with other similar projects in Ireland and beyond, to promote better exchange of shared knowledge for mutual benefit.	Make contact with all managers of similar projects noted in Chapter 5	2023-2030	0**
32	Increase dead wood throughout the Park by ring-barking and felling to waste non-native trees.	Gradual increase in dead wood volumes of 1-5% per year	2025, 2030	See Excel Workbook
12	Review the Strategy		2028	0**

Total estimated costs: €1,310,000 *per annum*, not including costs associated with commissioning of updated invasive species and deer management plans, and conducting monitoring surveys.

*Based on assumptions set out in Excel Workbook provided to management of this Strategy
** Assuming this is carried out by in-house staff, using materials already available in-house
TBC: Unknown at present; dependent on factors such as whether actions are carried out in-house or by contractors

Work plan for Phase 2 (2030-2050)

Phase II (2030-2050): Medium-term vision for native woodlands in Glenveagh:

The vision for 2050 is for native woodlands in which natural woodland processes are continuing and in which there is a visible improvement in the overall structure of the woods, as evidenced by improved cover and diversity of bryophyte and field layers, a developing shrub layer, a cohort of new saplings, and little or no invasive plant species. The lower slopes of the main glen will be populated with a mosaic of pioneering native woodland comprised primarily of birch, but including other species such as sessile oak, holly, rowan, hazel, Scots pine, yew, aspen and willows. These will help to link up disparate blocks of woodland and reduce fragmentation.

All the Annex I Old oak woodland in Glenveagh should by now be in or very close to favourable conservation condition, and the trends in area, structure and functions, and future prospects will all be positive. The density of the shrub and understorey layers of the woodland should by now be helping to buffer taller trees from the more severe effects of stronger winds, and well-developed bryophyte mats on the ground and on trees should also help to protect plants and invertebrates in the event of drought. A wider suite of species leads to more efficient utilisation and cycling of nutrients, above and below ground, making available a wider range of resources for species to exploit, which should, in turn, lead to healthier plants that are better able to resist disease and other pressures.

At the end of Phase II (i.e., by 2050), what do we want to see? (Objectives)

- Continuation of the successful measures that were initiated in Phase I.
- Initiation of new measures as a result of the Strategy review process.
- Continuation of monitoring of Strategy progress.
- Measurable decreases in invasive species cover, as determined by monitoring plots and wider observation.
- Measurable decreases in deer impact to mature trees and seedlings, as determined by monitoring plots and wider observation.
- Measurable improvements in cover, height and diversity of native species in bryophyte layer, field layer and shrub layer, as determined by monitoring plots and wider observation.
- Continued development of the areas of immature native woodland. Deer guards will have been removed from Phase I areas, but new guards may be required elsewhere; fences will have been repositioned.
- Reduction in woodland fragmentation.
- Further improvement in the conservation status of Annex I woodlands, to be achieved through positive trends and improved assessment results for Area, Structure & functions and Future prospects.
- Continued production of planting material by the Park nursery. Sufficient material is being produced to supply all of the Park requirements as well as the wider SAC and the northwest region of Ireland.
- Continued local support for the ongoing conservation work in Glenveagh, with the Education and Communications teams continuing to inform the public on the ongoing work, and liaising with volunteer groups to help implement some of the measures.
- In terms of woodland area, the objective is to continue to expand native woodland cover in the Park as a whole, increasing total native woodland cover to around 600 ha, with good progress made to developing a minimum of 3 x 30 ha blocks of native woodland in Glenveagh.

How will this be achieved? (Actions)

Action #	Action	Target	Time frame
16	Review and update the Invasive Species Management Plan and continue to implement it.	There is no longer a need for intensive clearance operations as infestations have lessened in severity. A better-developed field layer in the woodlands (from lower levels of infestation and sustainable levels of grazing) means there is less opportunity for invasive species to establish.	Review every 5-10 years
6, 33	Continue to monitor for existing and emerging invasive species	By now, these should be absent or no more than occasional, but vigilance should be maintained for any reinfestations.	Ongoing
22-29	Review and update the Deer Management Plan and continue to implement it.	Deer numbers have reduced to a level such that woodland structure (layering, diverse age structure) can fully develop, and ecological processes, such as regeneration, recruitment, seed production and senescence) are operating normally.	Review every 5-10 years
6, 33	Continue to monitor the efficacy of the various woodland management measures	Monitoring plots show healthy metrics in all attributes being assessed, such as good numbers of seedlings, saplings and poles; good representation of full range of woodland layers; diverse suite of typical species, including bryophytes, and other criteria checked by woodland monitoring plots	Ongoing
30-35, 37, 39, 45-46	Continue to implement woodland management measures that enhance woodland condition	Results of monitoring assessment should be improved from Unfavourable-Bad to Unfavourable-Inadequate, or even be Favourable. This will be measured by increases in woodland area (Area); increases in the number of adult trees in younger tree size/age classes, cover of invasive species and evidence of overgrazing should be low or absent, fragmentation is reduced (Structure and functions). Future prospects will be favourable by now as all parameter trends will be positive, active conservation measures are in place to control impacts and are having a positive impact, and steps are being taken to continue to increase the future area of the habitat and to decrease fragmentation.	Ongoing
30-46	Continue to implement woodland management measures that increase woodland area	By now, birch trees should be over 8 m high and producing seed, with a viable population of sessile oak and other species developing. The immature woodlands should be developing a suitable native ground flora and bryophyte community. Natural processes of regeneration will be occurring around the edges of the woodland on site types that are receptive to tree growth, and the complement of dead wood should be increasing through natural thinning of saplings as the canopy continues to develop and light levels under the canopy decrease.	Ongoing
6, 32	Continue to monitor the dead wood supply and maintain, only if necessary, by ring-barking or felling to waste non-native trees at a sustainable level.	The woodland is maintaining a good volume of dead wood, mainly through natural processes.	Every 5 years
47-48	Continue production of locally sourced, certified planting material for use within the Park and throughout the northwest	20,000 seedlings per annum being maintained in Glenveagh nursery	Ongoing
51, 53-54	Continue to develop and evolve an education and communication strategy that informs members of the public of the vision for the woodland and the steps that are being taken to bring it about.	The public are fully informed and engaged with how the woodland has developed over the years of the Strategy. Volunteers are helping annually to carry out some of the less specialised tasks to implement the strategy. VR display of progress over time.	Ongoing

Action #	Action	Target	Time frame
10, 34, 50, 52	Continue to facilitate research projects on all aspects of the Park's ecology and incorporate the results into ongoing management; this may include, for example, monitoring populations of invertebrates, birds or bats to examine how other species are reacting to the implementation of the Strategy.	Glenveagh is home to at least 20 wide-ranging research projects that support the Strategy by examining different aspects of the Park's ecology, encompassing animals, plants, fungi and nutrient cycling.	Ongoing

Work plan for Phase 3 (2050-2120)

Phase III (2050-2120): Long-term vision for native woodlands in Glenveagh:

The vision for 2120 is for native woodlands in which natural processes are occurring without undue human intervention, e.g., natural processes of disturbance (tree fall) and regeneration (seedling recruitment) are occurring in equilibrium, nutrient-cycling processes (such as breakdown of dead wood and carrion by invertebrates, fungi and bacteria) are operating well, and the problems of overgrazing and invasive plant species are being kept under control by sustained but non-intensive human intervention.

The woodlands now have a well-developed structure, in terms of both age (young and old trees present) and physical layering (discernible moss layer, field layer, shrub layer, understorey and canopy), with typical species present in all layers and a healthy amount of standing and fallen wood maintained with minimal human intervention. What were formerly individual blocks of woodland have coalesced into continuous corridors of wooded habitat, with better flow of species and genetic material through the wooded landscape.

The Annex I Old oak woodland should now be in favourable conservation condition, with the trends in area, structure and functions, and future prospects all positive. At least some of the woodlands established in Phase I should now be mature enough to be classed as Annex I Old oak woodland; and they should be in or approaching favourable conservation condition, with typical species having established naturally in the moss layer, field layer and upper layers of the woodland from the surrounding native woodlands, and sufficient amounts of dead wood being maintained through natural processes. By now the woodland should be resilient enough to withstand the main effects of climate change, having a multi-layered structure and a species-diverse ecosystem that is more resistant to disease and invasive species, is full-canopied and which has good understorey and shrub layers that help to maintain humidity and provide a buffer against windthrow.

At the end of Phase III (i.e., by 2120), what do we want to see? (Objectives)

- Fully mature native woodland which has developed from that established in Phase I and Phase II.
- Native woodland with a good complement of typical species, good age class diversity (young and old trees), good physical structure (bryophyte layer, field layer, shrub layer, understorey and canopy).
- All natural woodland processes of regeneration, growth, senescence and decomposition occurring at a sustainable level.
- Woodland fragments have been reconnected, with more than 10 woodlands now 30 ha or more.
- Invasive species are being maintained at a level that does not interfere with native woodland ecology.
- Deer impacts are being maintained at a level that does not interfere with native woodland ecology.
- Annex I Old oak woodland in favourable conservation condition, i.e., Area, Structure & functions and Future prospects will all be favourable.
- Continued production of planting material by the Park nursery. Sufficient material is being produced to supply all of the Park requirements as well as the wider SAC and the northwest region of Ireland. The Park is now an important *ex situ* location for conservation of other rare genotypes in Ireland.
- Continued local support for the ongoing conservation work in Glenveagh, with the Education and Communications teams continuing to inform the public on the ongoing work, and liaising with volunteer groups to help implement some of the measures.
- In terms of woodland area, the objective is to continue gradually to increase wooded habitat (including scrub and immature woodland) to a sustainable level of 600-1,000 ha

across the focus area of the Park as a whole. Native woodland will establish naturally, subject to natural conditions and processes beyond ungulate grazing.

- Other non-woodland habitats and species have also benefited from the policies adopted as part of this Strategy, including the retention of natural resources (such as dead animals and trees) for nutrient recycling within the Park to benefit a wide range of organisms.

How will this be achieved? (Actions)

Action #	Action	Target	Time frame
6, 16	Maintain vigilance in relation to invasive plant species	Any new occurrences of invasive plants are quickly detected and removed.	Ongoing
22-29	Review and update the Deer Management Plan and continue to implement it.	Deer impact remains at a level that enhances rather than damages woodland ecological processes, as determined by monitoring and general observation	Review every 5-10 years
6	Continue to monitor expansion of woodland area; implement woodland management measures only if needed	Regeneration is visible around the edges of mature woodlands established in earlier phases. Establishment of herbaceous and bryophyte species from adjacent woodland is occurring as layers develop. GIS mapping shows measurable increases in woodland area.	Ongoing
6	Continue to monitor woodland condition; implement woodland management measures only if needed.	Natural tree regeneration occurs in light gaps formed by mature tree fall, in the interior of the woodland. Viable populations have been established of mature native oak, birch, rowan and holly, producing seed, and a viable population of other associated species (such as hazel, whitebeams, willows and aspen) has also developed.	Ongoing
6	Continue to monitor woodland condition for Article 17 reporting.	Condition assessment results are Favourable for all parameters. This is measured by increases in woodland area (Area); increases in the number of adult trees in younger tree size/age classes, cover of invasive species and appropriate grazing levels are being maintained; more stringent bryophyte targets are being met; fragmentation is reduced (Structure and functions). Future prospects are favourable now as all parameter trends will be positive, active conservation measures are in place to control impacts and are having a positive impact, and steps are being taken to continue to increase the future area of the habitat and to decrease fragmentation. No significant threats exist to the future of the woodlands, and their continued viability is assured.	6-12-year periods
6	Continue to monitor the dead wood supply	The woodland is maintaining a good volume of dead wood, mainly through its own natural processes.	Every 5 years
47-48	Continue production of locally sourced, certified planting material for use within the Park and throughout the northwest	20,000 seedlings per annum being maintained in Glenveagh nursery	Ongoing
51, 53-54	Continue to inform members of the public of the importance of the woodland and the success of the measures that have been taken to achieve the aims of the Strategy.	The public are fully informed and engaged with how the woodland has developed over the years of the Strategy. Volunteers continue to be a useful source of assistance in implementing the Strategy. VR display shows progression from unwooded to wooded landscape over 50+ years	Ongoing
10, 34, 50, 52	Continue to facilitate research projects on all aspects of the Park's ecology and incorporate the results into ongoing management	Glenveagh is home to a wide range of past and present research projects (>100 since 2022) that support the Strategy by examining different aspects of the Park's ecology, encompassing animals, plants, fungi and nutrient cycling.	Ongoing

Part II: Context for a new Woodland Management Strategy

Chapter 1 Introduction

1.1 Site context

Glenveagh (in Irish *Gleann Bheatha* = "the valley of the birches") National Park is located in northwest Donegal (Fig. 1). It is the second-largest of Ireland's six national parks, encompassing approximately 16,000 ha of bog, heath, woodland and lake habitats. The Park originally comprised just the Glenveagh Estate and deer forest but was later extended to include the An Taisce-owned block to the west around Crocknafarragh and Glenfornan Lough, the hinterland of the Lough Barra Bog and Meenachullion nature reserves, and the area southwest of Errigal Mountain to Dunlewy Lough. Throughout this document, the name "Glenveagh" or "the Park" will be used to refer to the entirety of Glenveagh National Park.

Glenveagh is just one component of the Cloghernagore Bog and Glenveagh National Park Special Area of Conservation (SAC; site code 002047), which contains an additional 17,500 ha of mainly upland habitat, primarily heath and bog. Glenveagh also overlaps the Derryveagh and Glendowan Mountains Special Protection Area for birds (SPA; site code 004039) (Fig. 1). The site synopsis for the SAC is reproduced in Appendix 1, and for the SPA in Appendix 2. Site-specific conservation objectives have been compiled for the nine EU Habitats Directive Annex I habitats and four Annex II species in the SAC (Appendix 3). NPWS (2017) states: "*A site-specific conservation objective aims to define favourable conservation condition for a particular habitat or species at that site. The maintenance of habitats and species within Natura 2000 sites at favourable conservation condition will contribute to the overall maintenance of favourable conservation status of those habitats and species at a national level.*" Generic conservation objectives have been drawn up for the SPA (Appendix 4).

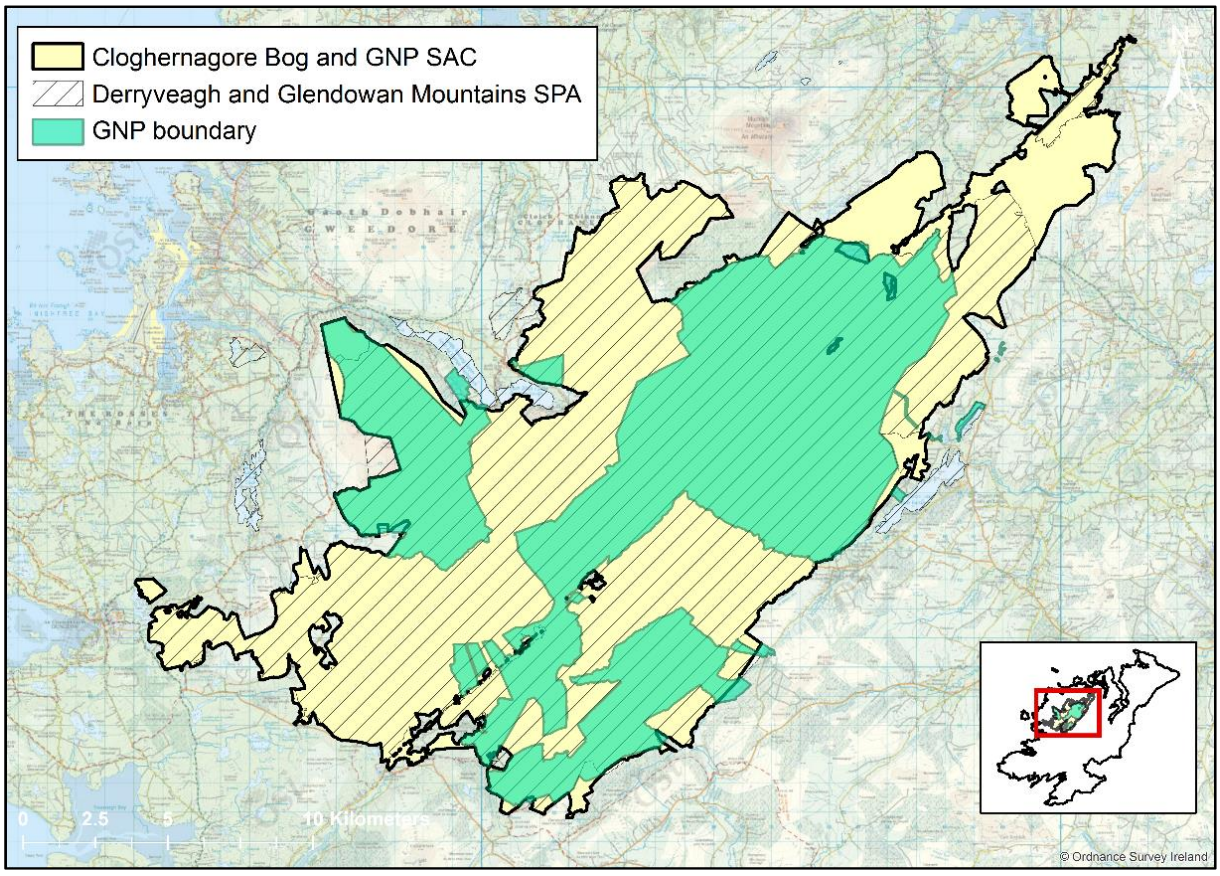

Figure 1. Location of Glenveagh National Park in relation to overlapping Natura 2000 sites. Ordnance Survey Ireland Licence No OSI-NMA-014. © Ordnance Survey Ireland Government of Ireland.

In the northeast of Glenveagh is Lough Beagh (also known as Lough Veagh), a long and narrow lake, measuring about 5.5 km in length and just over 700 m in width at its widest point. It is situated in a U-shaped glaciated valley that runs in a northeast / southwest direction. One of the Annex I habitats for which the SAC was designated is "Old sessile oak woods with *Ilex* and *Blechnum* in the British Isles [EU habitat code 91A0]" (hereafter referred to as Old oak woodland). The best examples of this habitat are found in the wettest parts of Ireland and Britain where the mild and humid climate along the western coasts has allowed the establishment of high-diversity woodland communities in which mosses and liverworts make up a significant proportion of the species. The multi-layered structure of the woodlands, where canopy and understorey trees each form a layer over shrubs and ground flora, helps to maintain this high humidity and, hence, diversity.

In Glenveagh, this habitat is concentrated within the Lough Beagh glen, with the greatest density of woodland being attained on the steep slopes beside the southeast shore of Lough Beagh in an area known as Mullangore Wood (*Maol na nGabhar* = "the hill of the goats"). This has been identified as the largest and longest-established block of woodland in Glenveagh, having been mapped on the first edition Ordnance Survey maps dating back to 1840, and is thought by several sources to be possible ancient woodland (Telford, 1977; Perrin & Daly, 2010). This possibility is discussed further in section 3.4. Other smaller areas of native woodland exist within the Park, some of which are also deemed to be Annex I Old oak woodland (Perrin *et al*., 2008; O'Neill & Barron, 2013; Daly *et al.*, 2023). The amount of woodland in the Park has fluctuated over the years. Based on mapping and field surveys carried out in 2021, the current extent of broadleaved woodland in Glenveagh is put at 123.2 ha; further details are presented in section 3.2.

1.2 Current condition of the Glenveagh woodlands (2022) and the need for a woodland management strategy

A healthy woodland should have a diverse, multi-layered structure, containing trees, shrubs, herbs, grasses, sedges and bryophytes. It should also contain a cohort of young trees – as seedlings, saplings and poles – that will eventually replace older trees in the canopy when these reach their end of life. A good supply of dead wood from these dead or moribund trees is another factor in a healthy woodland, as it provides a valuable habitat for invertebrates and fungi, which are themselves an important component of the food webs of many animals. All of these factors add up to a well-functioning, resilient ecosystem in which all components are interconnected and nutrients move efficiently around the system, from soil to plants to animals, and back to the soil.

Currently the native woodlands of Glenveagh are beset by a number of problems, primarily overgrazing and invasive plant species. These issues have interrupted natural processes such as tree regeneration which are essential for the continued viability of the woodlands. This has resulted in woodlands which are less diverse – in terms of both structure and species – and which lack the means to maintain a healthy canopy and a well-functioning ecosystem. These problems have resulted in woodland habitat that was judged to be in "Unfavourable-Bad" condition by assessments carried out in 2018 as part of monitoring surveys for EU Article 17 reporting (Daly et al., 2023; NPWS, 2019).

The consequences of climate change are also being experienced more acutely, with phenomena such as greater storm severity, increased rainfall, drought and rising average temperatures having a negative impact on woodlands. These impacts may manifest in a number of forms including windthrow, water stress, phenological changes, and disruption of relationships (whether positive or negative) with other plant, bird, mammal and invertebrate species. A woodland that is compromised in terms of its structural integrity and species diversity is more vulnerable to these effects, for example by lacking species that protect against drought (such as mosses), or containing unhealthy trees that are less able to withstand attack by insects or fungal pathogens, and is slower to recover.

It has become clear, therefore, that the woodlands in Glenveagh are not resilient enough at the present time to withstand these problems. There is a real prospect that, without targeted

intervention, regeneration will continue to fail, dead trees – especially oaks – will not be replaced, and the woodlands will not survive in the long term. This Woodland Management Strategy for Glenveagh has been prepared with the aim of identifying actions that will address the issues that contribute to the poor ecological condition of these internationally important woodlands, and providing a framework over which these actions can be implemented to enhance the ecological and conservation value of the woodlands.

1.3 Focus of the Glenveagh National Park Woodland Management Strategy

The focus of the Glenveagh Woodland Management Strategy (hereafter referred to as the Strategy) is the woodland habitat within Glenveagh, specifically native woodland and, as a subset of that, Annex I Old oak woodland. A focus area has been defined in which the majority of the native woodland in the Park is located, around the main Lough Beagh glen. The location of this focus area is shown in Fig. 2.

A number of specific points were examined during the preparation of the Strategy:

- *Woodland quality*: Can the ecological quality of the existing native woodland be improved (e.g., species assemblages, proportion of native trees, amount of dead wood).
- *Woodland quantity*: Can additional areas of native woodland be created? If so, where and how much, and what resources are required?
- *Annex I Old oak woodland*: What defines Annex I Old oak woodland? And what are the main reasons for it continuing to fail to reach favourable conservation condition in Glenveagh?

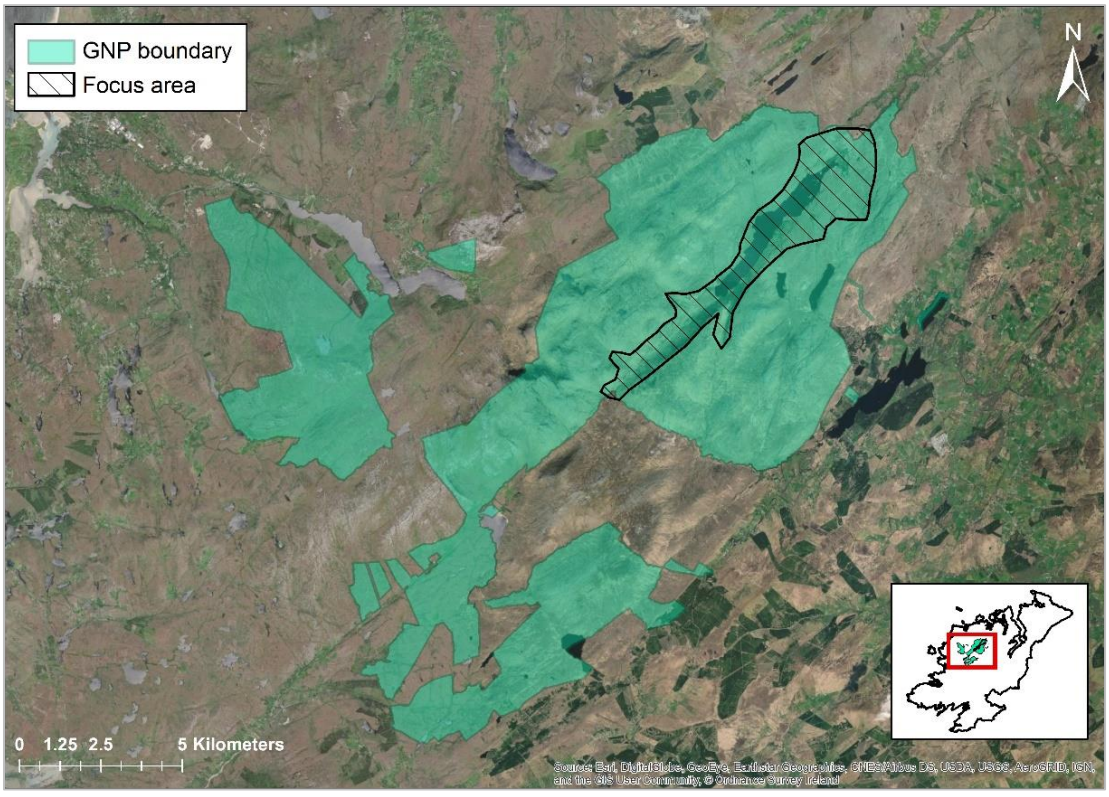

Figure 2. Location of woodland focus area within Glenveagh National Park.

1.4 Main issues to be addressed

Invasive plant species and overgrazing, primarily by deer, are intricately linked to each of the three focus points above. The success of any attempts to improve woodland quality and increase native woodland area (and hence improve the results of Annex I Old oak woodland in assessments) will be largely dependent on how well these two problems are managed. Dealing with these two issues forms a significant part of the Strategy. It is recognised that, while the Strategy focuses on deer as the main problem grazer, other grazers such as sheep and cattle are

present in peripheral areas of the Park, linked to long-standing grazing rights. While these areas may not contain core woodlands, it should be borne in mind that measures to establish woodland or improve woodland condition there should also take into account the effects of these grazers on regeneration.

Climate change is another impact that is becoming increasingly significant. Scientific evidence has mounted to show that ongoing human-induced changes to our climate will have long-term effects on our atmospheric, terrestrial, hydrological and ocean environments, manifesting as higher air and soil temperatures, fewer cold snaps and frost days, extended heat-waves, increased rainfall, soil moisture deficits, more frequent extreme weather events, and changes to global air and ocean circulation patterns (Desmond *et al*., 2009). These have consequences for all ecosystems, including woodlands and forestry. Desmond *et al*. (2017) noted, for example, that rising air temperatures could result in greater threats from exotic pests and pathogens, while heat-waves and extended dry periods lead to stress due to soil moisture deficits, and greater risk of peatland fires. Higher temperatures and fewer frost days could alter the phenology (developmental timing) of some species, changing the date of leaf emergence of trees, for example, with the decrease in the number of frost days projected to be greatest in the north of the country (Nolan, 2015, cited in Desmond *et al*., 2017). This could also lead to mis-alignments between life-cycles of interdependent species, such as birds and insects. While climate change itself cannot be directly addressed by this Strategy, the focus should be on building more resilient woodland ecosystems that are able to cope better with the effects of climate change in Donegal.

Chapter 2 Review of existing data and information

A review of all available habitat and plant data pertaining to Glenveagh was carried out. This comprised a literature review of studies carried out in Glenveagh woodland and a review of all spatial data (in the form of shapefiles) that included habitat data for the Park. The data sources are generally described below from earliest to most recent, with datasets that span a range of years described at the end.

Telford (1977):

A number of ecological surveys have been conducted in Glenveagh, the first of which was by Michael Telford for his PhD research. Telford's research had three main aims: to provide a detailed record of the vegetational history of Glenveagh, to provide a detailed account of the present vegetation in Glenveagh, and to study the effects of grazing on the woodland by the Park's red deer population.

Using pollen data, Telford built up a picture of vegetation succession in Glenveagh, from the late-glacial period (describing assemblages characterised successively by *Rumex-Salix*, *Juniperus-Empetrum*, Gramineae, *Artemisia-Empetrum*, Gramineae-*Rumex* and *Juniperus-Filipendula*) to post-glacial times, identifying wooded communities characterised by fluctuations in the levels of pollen of *Betula, Corylus, Ulmus, Pinus, Alnus* and *Quercus*, up to more recent times where herbs and shrubs became more prominent.

Telford recorded a number of relevés in Glenveagh, both in woodland and in heath/bog habitats. He recorded 32 plots in woodland, each measuring 100 m^2, and included in his analysis a further five Glenveagh woodland plots, each measuring 200 m^2, recorded by Kelly (1975).

Using available historical records and anecdotal information from locals and long-term employees of the Park, Telford pieced together the historical context of the deer herd in the Park, and carried out the first deer exclosure studies in Glenveagh to assess the effects of deer grazing on the vegetation.

Van Doorslaer & O'Sullivan (1987):

A resurvey of Telford's exclosures took place 12 years after they were initially set up.

Weekes (1990):

In 1989 Lynda Weekes carried out a vegetation survey of Glenveagh for her Masters research, to include areas previously unsurveyed by Telford (1977), to further characterise the vegetation, and to locate the different vegetation types in Telford's study areas. She drew up a comprehensive habitat map of what comprised the entire National Park at that time, as well as an additional area owned by An Taisce which has since been brought into the Park. The original field maps were later digitised by NPWS, and some habitats were cross-walked to the Heritage Council habitat codes of Fossitt (2000) and Annex I habitats, although this was evidently not possible for woodland and Rhododendron habitats. Although the mapping is now over 30 years old, it remains important as it is the most comprehensive mapping exercise carried out within Glenveagh.

Bleasdale & Conaghan (1996):

Bleasdale & Conaghan (1996) resurveyed a number of areas first surveyed by Telford (1977) and Van Doorslaer & O'Sullivan (1987), and also set up new permanent quadrats for subsequent resurvey, emphasising the value of such plots in long-term studies of vegetation and succession, particularly in the context of grazing by large herbivores such as deer. They noted the balance that must be struck between protecting woodland from overgrazing by deer so that tree regeneration can resume, and mitigating the negative effects that can result from a complete lack of grazing. They also noted that areas recently cleared of Rhododendron may need protection from grazing

animals for a period of time – acknowledged to be not fully known at that stage but a duration of 15-20 years was suggested – to allow suitable vegetation to develop.

National Survey of Native Woodlands (2006):

The woodlands at Mullangore (site no. 1423), Derrybeg (site no. 1424) and Derrylahan (site no. 1426; in some documentation referred to as Sruhannacullia wood, after the stream that flows through it) were surveyed in 2006 as part of the National Survey of Native Woodlands (NSNW; Perrin *et al*., 2008). Two relevés were recorded in Mullangore, and one each in Derrybeg and Derrylahan. The lower of the two relevés in Mullangore and the relevé in Derrybeg were classified as Annex I Old oak woodland; the other two areas were birch-dominated non-Annex woodland.

Höna (2009):

A study of the impacts of deer on the regeneration of native tree species was undertaken in Glenveagh by Seppi Höna for his M.Sc. He carried out sampling in four separate areas of woodland in the Park – two northwest of Lough Beagh: Derrybeg (effectively fenced in 1988 to exclude deer) and Derrylahan (nearby but unfenced); and two southeast of the lough: Mullangore (less effectively fenced in 1984) and NE Mullangore (nearby but unfenced). His research concluded that regeneration of juvenile trees was good in many parts of Glenveagh (although universally poor for oak), but that the effects of browsing were limiting the chances for trees to grow from juveniles to mature trees.

Feliz (2009):

A study on the invasive shrub *Gaultheria mucronata* (prickly heath; previously named *Pernettya mucronata*) was conducted by Julia Feliz as part of her M.Sc. research to characterise the ecology and distribution of the species in Glenveagh. This species, native to South America, covers extensive areas in the more open areas of the Park. Feliz's research found, among other things, that, in addition to the plant being able to reproduce from seed, regeneration could also arise via vegetative reproduction by two methods: suckering, and regeneration from fragments. Regeneration of fragments of the plant produced by strimming was put forward as one reason for the dense growth of *Gaultheria mucronata* in Glenveagh along paths, tracks and roads which are typically maintained by strimming.

A provisional inventory of ancient and long-established woodland in Ireland (Perrin & Daly, 2010):

This NPWS-commissioned study developed a protocol for the identification of ancient woodland and initialised a national Ancient and Long-established Woodland Inventory. The survey identified and mapped Mullangore as a Possible Ancient Woodland (PAW).

Woodland Monitoring Surveys (2011 and 2018):

After the NSNW, Mullangore was surveyed on two further occasions for the national Woodland Monitoring Surveys (WMS), once in 2011 and once in 2018. Full plots were not recorded; instead, data to assess a number of monitoring criteria were recorded (see Appendix 5). The monitoring plot were not placed in the same location as the NSNW plots; however, the same plot location was used in both WMS surveys.

In both years the overall assessment result for the Mullangore Annex I Old oak woodland was Unfavourable-Bad. This was largely due to the impacts of severe deer overgrazing and Rhododendron infestation, which negatively affected a number of aspects of the woodland, including structural diversity, species diversity, and cover of field layer and shrub layer. Poor assessment results for these aspects of the woodland's ecology led to the Unfavourable-Bad result for its structure and functions assessment, and the persistence of overgrazing and invasive Rhododendron meant that the future prospects of the woodland were also bad.

Newman (2013) and Newman *et al*. (2014b):

Miles Newman carried out PhD research on the effects of large herbivore grazing in oak woodlands, including the Glenveagh woodlands. He revisited two Glenveagh exclosures, one established by Telford in 1975 and the other fenced in 1988 and subsequently surveyed by Bleasdale & Conaghan (1996).

The following extract from Newman (2013) is relevant to Glenveagh:

> "The density and impact of large herbivores is not constant over time in natural ecosystems (Vera, 2000) but the intervention of herbivore management tends to focus on targets that maintain consistent herbivore densities. This research has demonstrated that, in a temperate woodland ecosystem, grazing and browsing impacts do not have a unified effect on vegetation community composition, life-forms, structure, or tree regeneration. Consequently, when herbivore densities are being managed, the targets should be tailored to achieve specific aims dictated by the regenerative cycle of the ecosystem, for example, this may be to promote tree regeneration or enhance bryophyte biodiversity. However, the promotion of low grazing impact as optimal for conservation purposes may still be the most appropriate management option, if a balance between ground flora and tree regeneration is to be met."

Turf-cutting impact review and management system surveys (Daly *et al*., 2015):

Habitat mapping was conducted at three blanket bog-dominated sites within Glenveagh as part of a turf-cutting impact review and management system survey in 2015. Sites surveyed comprised Kingarrow (51.8 ha), Devlin (136.9 ha) and Lough Nadourcon (229.6 ha). Small areas of woodland were mapped during these surveys.

Invasive Species Management Plan 2017-2026 (Aulino Wann & Associates, 2017):

An Invasive Species Management Plan was written for Glenveagh by Aulino Wann & Associates in 2017. This is addressed further in Chapter 4.

Deer population density study and Deer management plan (Burkitt 2017, 2018):

Tim Burkitt conducted studies into deer numbers at Glenveagh (Burkitt, 2017) and subsequently produced a deer management plan for the Park (Burkitt, 2018), which was valid for the period 2018-2021, with an annual review. The latest version of the plan, dated September 2018, was due for review in February 2019.

Conservation objective spatial data (NPWS, 2017):

Conservation objective spatial data for the Cloghernagore Bog and Glenveagh National Park SAC were checked and found to correspond to polygons digitised by Perrin *et al.* (2008).

Forest cover datasets from the Forest Service:

Since 1995 the Forest Service has produced spatial datasets detailing the extent of the forest estate in Ireland. The original dataset was known as FIPS95. This dataset was created through a combination of satellite imagery dated 1993-1997, ortho-rectified panchromatic aerial photographs taken in 1995, and the OSI 25" map series. There have been several updates to the original dataset, being succeeded by FIPS98 and more recently by PrivateForests2020. Information in these datasets includes land use type (e.g., Broadleaf, Mixed, Conifer, Felled), species composition, planting year and ownership.

Historical Ordnance Survey (OS) maps:

The first edition six-inch maps and third edition six-inch maps were consulted to investigate past woodland cover within the Park. According to TCD Map Library Holdings, dates for Donegal maps are as follows:

First edition:1834-6
Second edition: 1848 (partial)
Third edition: 1900-5
Later revisions: 1948-54 (partial)

These maps have specific symbols for broadleaf trees, conifer trees and brushwood. Mixed woodland is denoted by a mixture of broadleaf and conifer symbols.

Coillte datasets:

Coillte spatial datasets, comprising sub-compartment maps with forest type, species composition and planting year information, along with the Coillte Biodiversity Area datasets were reviewed.

National Conservation Assessment spatial datasets (NPWS, 2019):

Annex I habitat national distribution datasets from the Article 17 reporting period 2013-2018 were used to assess the extent of Annex I habitats within Glenveagh including Annex I woodland. This incorporates several of the sources referred to above.

Plate 1. View across southwestern end of Lough Beagh to woodland at Derrybeg. Photo by Orla Daly.

Chapter 3 Mapping and data collation

3.1 Introduction

One of the data gaps that was identified by NPWS, before the commissioning of this Strategy, was an up-to-date figure for the area of extant woodland in Glenveagh. Another gap was an estimate of the area of historical woodland, i.e., woodland that was mapped as present on 1st and 3rd edition six-inch maps, and whether or not those areas remain wooded. While it was generally acknowledged that woodland loss had occurred, the extent was not known, nor was it known where these previously wooded areas had existed. Finally, another topic to explore was the antiquity of the extant woodland, that is, how long the areas of woodland had been established. Continuity of woodland cover is an important facet of woodland ecology, with specialist woodland species (animals and fungi as well as plants) requiring continuous cover of woodland for their life cycles to complete. Addressing these data gaps was deemed to be an important step in the Strategy, with the information gleaned seen as key to planning future woodland establishment targets to counteract former losses.

This chapter describes the procedures that were carried out to fill these gaps. The methods used cover a broad base, including as they do GIS techniques, satellite imagery and aerial photograph interpretation (API), consultation of historical Ordnance Survey (OS) six-inch maps, combing through historical documents and non-OS maps, and using other pointers to historical land-cover, such as place names. These data contribute to knowledge of woodland cover, and also give clues to the woodland's antiquity.

3.2 Mapping extant woodland

3.2.1 Methodology for desk-based mapping of extant woodland

The first element of the process of mapping the extant woodland was the identification of woodland parcels using existing datasets and aerial images. This was completed in November 2020, as follows:

1. A baseline map of woodland parcels within Glenveagh was produced using existing datasets. GIS datasets used to create the baseline map were as follows:

   - National Conservation Assessment spatial datasets (NPWS, 2019)
   - NSNW (Perrin *et al.,* 2008)
   - Turf-cutting impact review and management system surveys (Daly *et al.,* 2015)
   - PrivateForests2016
   - Coillte spatial datasets
   - Weekes (1990)

   Where two or more datasets overlapped, the most up-to-date or accurate layer superseded the less accurate layer (for example, field-surveyed datasets superseded datasets that were surveyed remotely). Once the original baseline map was compiled, it was clipped to the Glenveagh site boundary.

2. Step 2 involved a systematic review of satellite imagery to identify any remaining unmapped woodland parcels. For review purposes, the Glenveagh site boundary was intersected with a 1 km grid, each grid was then systematically reviewed using up-to-date satellite imagery and any previously undetected woodland parcels were digitised in ArcGIS v. 9.3. An inclusive approach was taken while digitising woodland parcels, with linear strips, woodland fragments within ravines, developing tree scrub and/or smaller tree groups considered 'woodland' for the purpose of this study.

   This combined dataset from both of the above operations was labelled *Extant_woodland_GNP.shp*. Information contained within the dataset includes:

- the name of the original data source and/or whether it was a new woodland parcel digitised using aerial photograph interpretation (API);
- woodland type, using three broad categories: broadleaved woodland, mixed woodland and conifer plantation. This information was derived from the original data source, where available, or by API if the area was newly digitised. Where additional habitat information such as Fossitt habitat or Annex I habitat was available, this was also included;
- any target notes and information pertaining to the polygons as derived from the original dataset and/or observations while digitising.

3.2.2 Mapping updates following ground-truthing fieldwork

A sub-set of 94 extant woodland polygons contained within the provisional *Extant_woodland_GNP.shp* were visited in June 2021. Habitat information, such as Fossitt (2000) or Annex I habitat type, was recorded in the field and this was used to update the shapefile. Polygons in the draft dataset were validated, assigned to a Fossitt (2000) habitat category and, where appropriate, an Annex I habitat type.

3.2.3 Findings from extant woodland mapping

The following section describes the findings in relation to Glenveagh as a whole, and in relation to the sub-set of the Park centred on the main Lough Beagh glen, referred to in section 1.3 as the focus area, which measures 1,591 ha. This will be the main focus for woodland conservation and restoration works; however, the Strategy addresses the whole of the National Park. For comparison purposes, the woodland statistics for both areas are presented in the same tables.

Glenveagh National Park

The dataset indicates that there are approximately 212.4 ha of woodland/plantation within Glenveagh (Table 1), representing 1.4% of its total area. The dominant stand type is broadleaved woodland at 123.2 ha (58.0%), followed by conifer plantation at 74.9 ha (35.3%) and mixed woodland at 14.4 ha (6.8 %). Distribution maps of woodland/plantations within the Park are presented in Figs. 3-6.

Table 1. Summary of extant of woodland/plantation cover within Glenveagh National Park and the focus area.

	Glenveagh		Focus area	
Woodland type	Area (ha)	% of woodland	Area (ha)	% of woodland
Broadleaved woodland	123.2	58.0	106.3	82.0
Conifer plantation	74.8	35.2	10.1	7.8
Mixed woodland	14.4	6.8	13.3	10.3
Total	**212.4**	**100.0**	**129.7**	**100.0**

The main block of broadleaved woodland, mostly comprising oak woodland, is located within the main glen, with only fragments within ravines and/or smaller tree groups remaining towards the south of the glen around Poll Garbh. Linear woodland parcels, mostly containing scrubby willow, birch and oak, are found on the northern boundary of the Park along the Calabber River. Southeast of the main glen, broadleaved woodland occurs along the shores of Lough Akibbon, Lough Nacally, Gartan Lough, the Cammane River, Bullaba River and in a ravine below Ardaturr Mountain. In the west of the Park, the limited amount of broadleaved woodland present is confined to roadsides or along rivers.

Conifer plantations, mostly of Scots pine, surround the Visitor Centre and Glenveagh Castle. Along the southern boundary of the Park, conifer plantations occur on peatlands at Gubbin Hill, south of Lough Muck and at Ardachrin. Recommendations will be made in relation to these conifer plantations on peat. This is likely to require engagement with Coillte and potentially with the Wild Atlantic Nature LIFE project.

Mixed woodlands surround the Visitor Centre and Glenveagh Castle, with small amounts in the lower part of the main glen. This woodland type has only a minor presence elsewhere along roadside and/or adjacent to houses.

Focus area (Lough Beagh glen)

The dataset indicates that there are 129.7 ha of woodland/plantation within the focus area in the main glen (Table 1), comprising 8.2% of the focus area. The majority of this, 106.3 ha (82.0%), is broadleaved woodland, mostly oak, followed by mixed woodland at 13.3 ha (10.3%) and conifer plantation at 10.1 ha (7.8%). Maps of the woodland and plantations within the focus area are presented in Figs. 7-8.

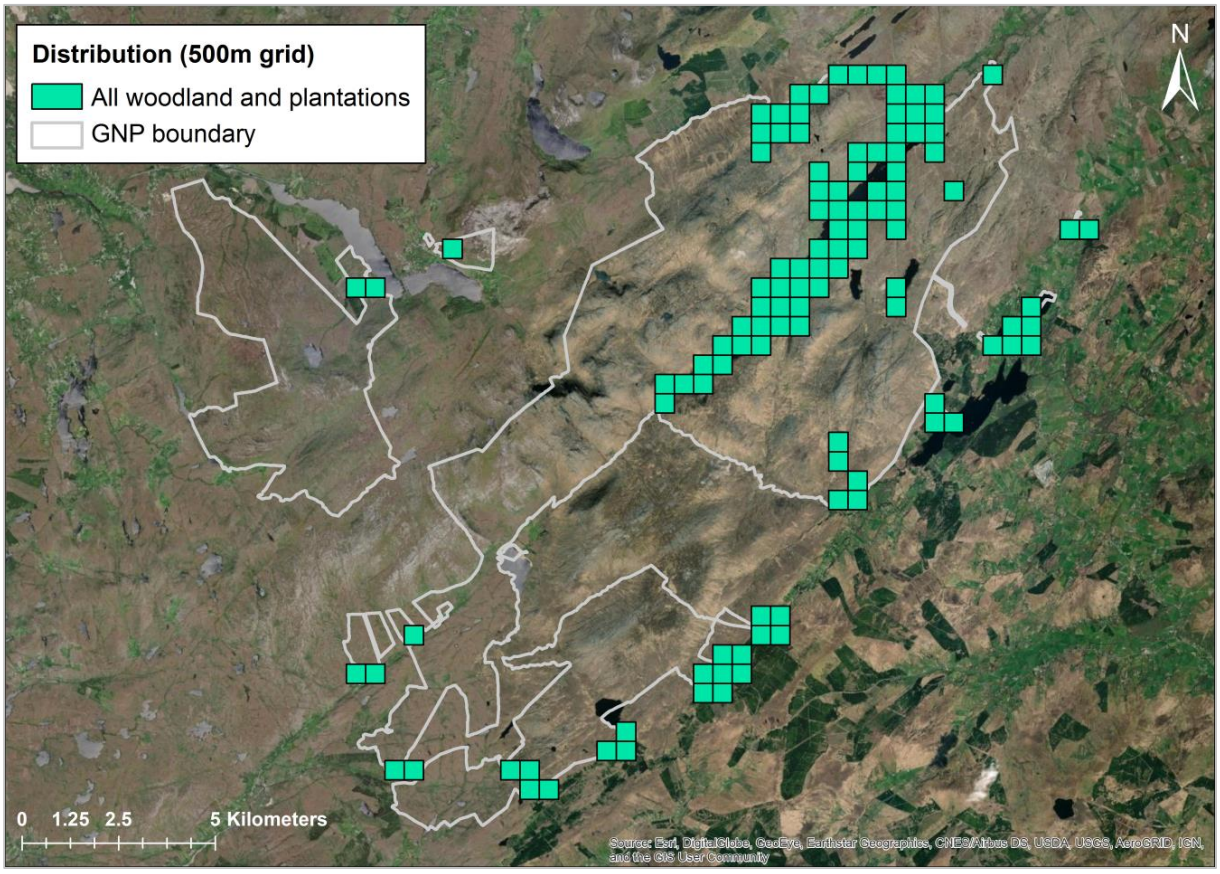

Figure 3. Distribution of all woodland and plantations within Glenveagh. The distribution displayed was derived by intersecting a 500m grid with the draft Glenveagh extant-woodland polygon shapefile.

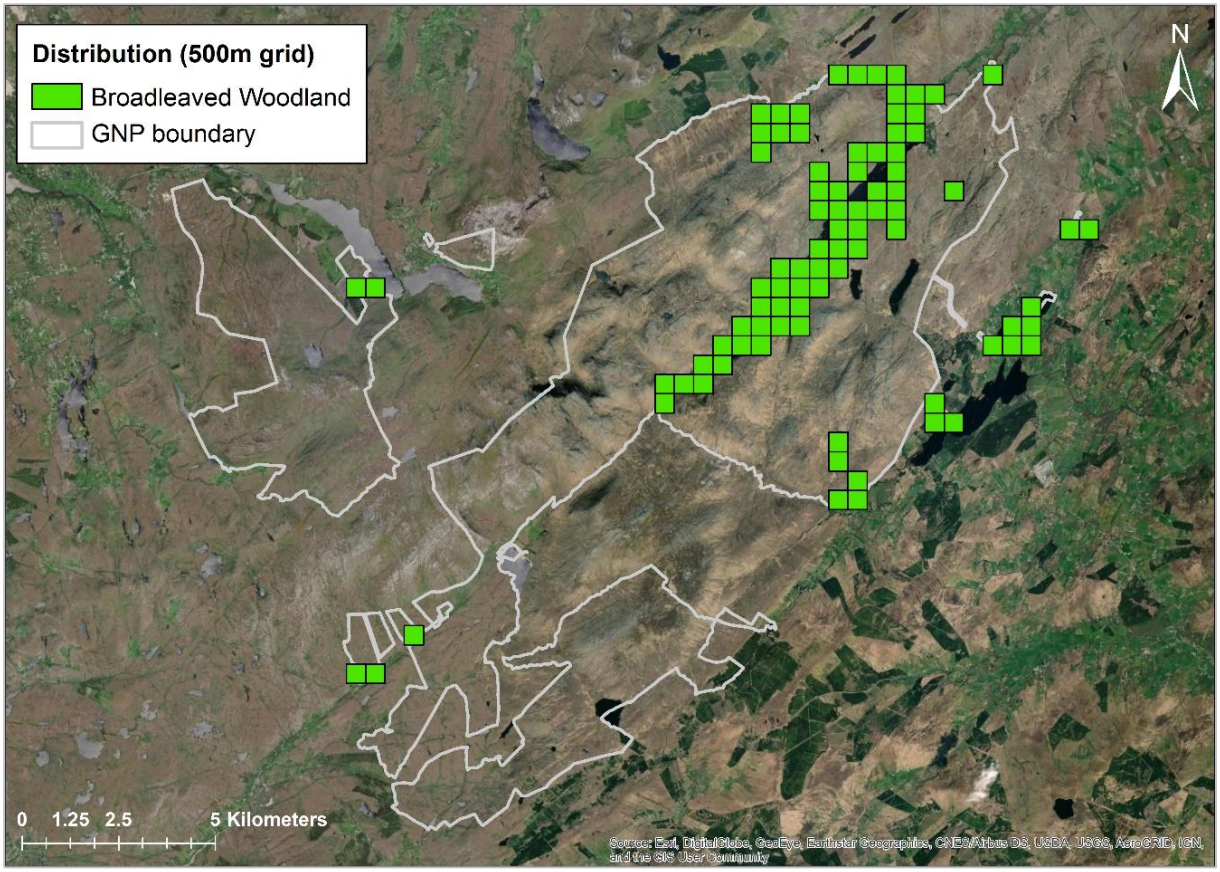

Figure 4. Distribution of broadleaved woodland within Glenveagh. The distribution displayed was derived by intersecting a 500m grid with the draft Glenveagh extant-woodland polygon shapefile.

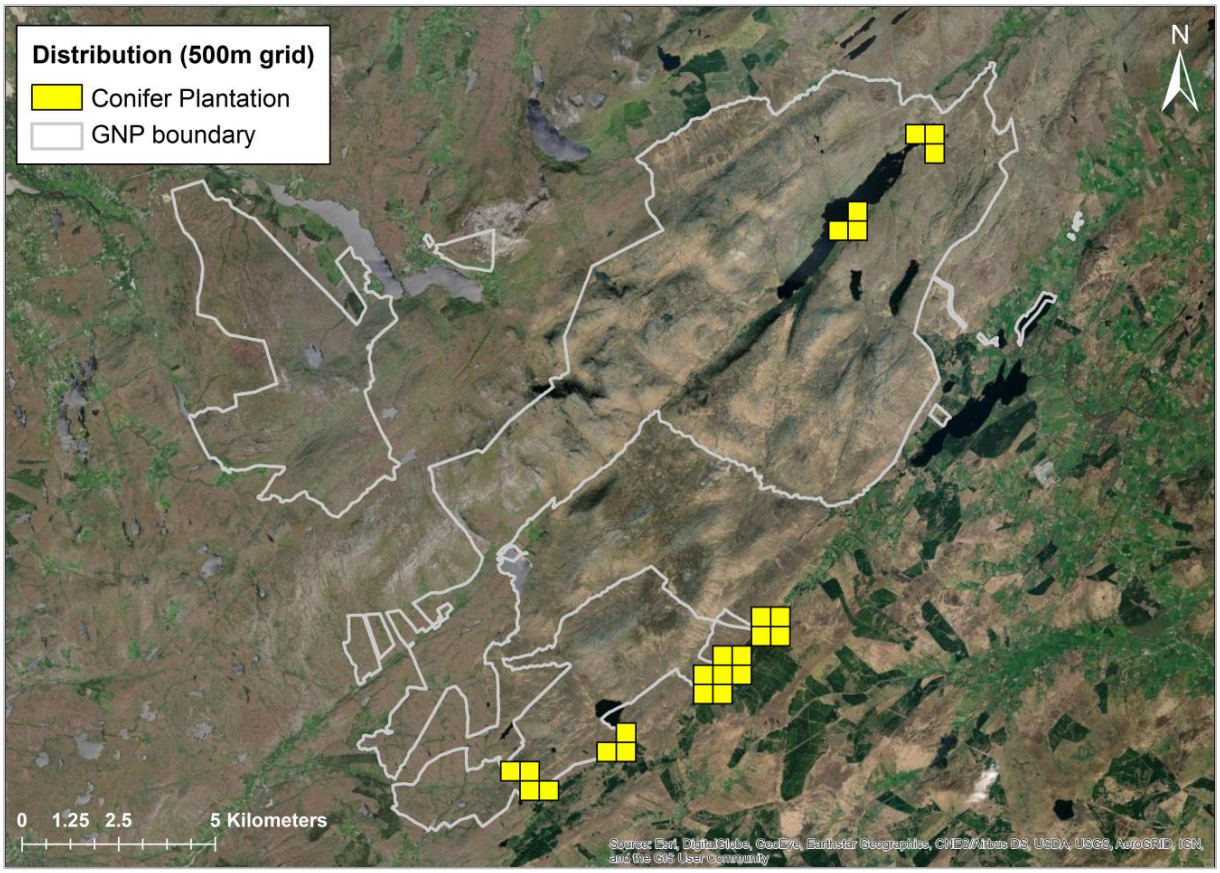

Figure 5. Distribution of conifer plantation within Glenveagh. The distribution displayed was derived by intersecting a 500m grid with the draft Glenveagh extant-woodland polygon shapefile.

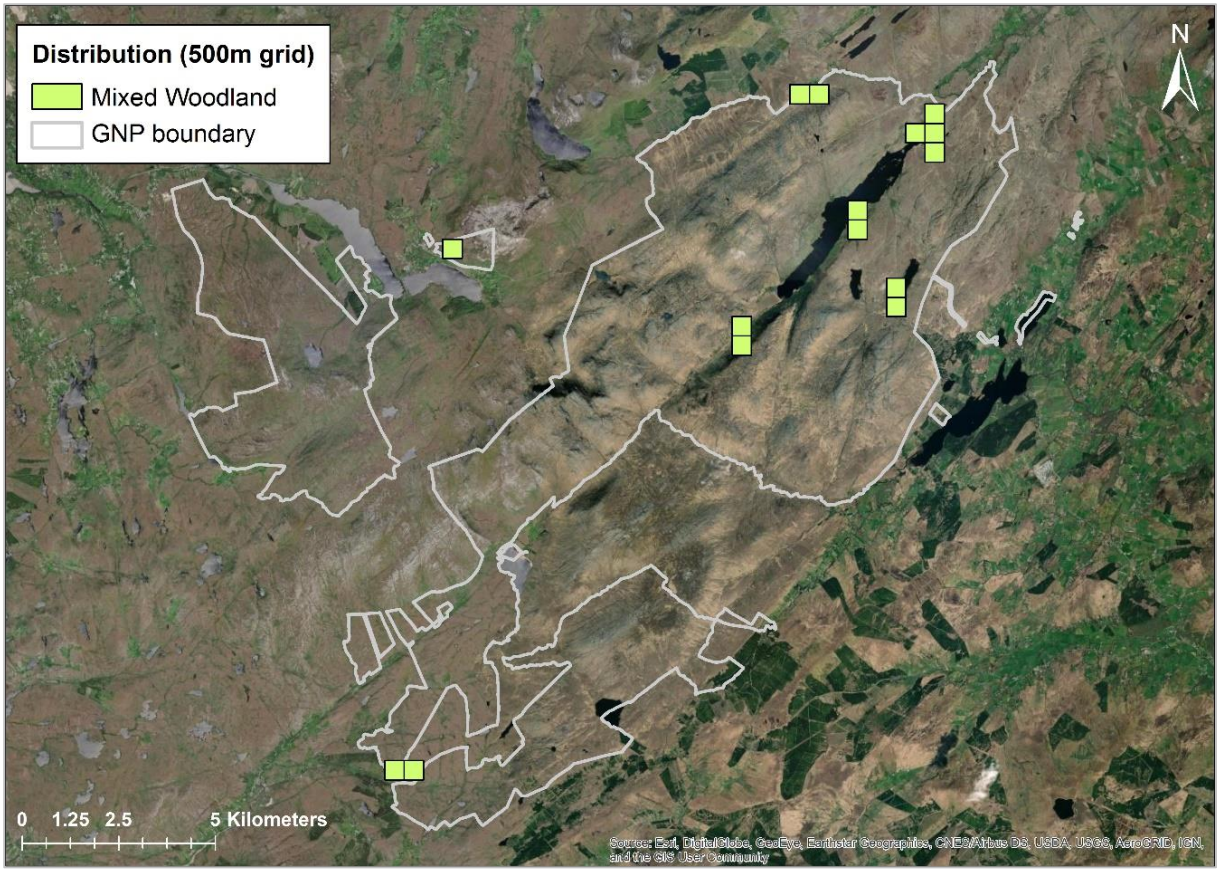

Figure 6. Distribution of mixed woodland within Glenveagh. The distribution displayed was derived by intersecting a 500m grid with the draft Glenveagh extant-woodland polygon shapefile.

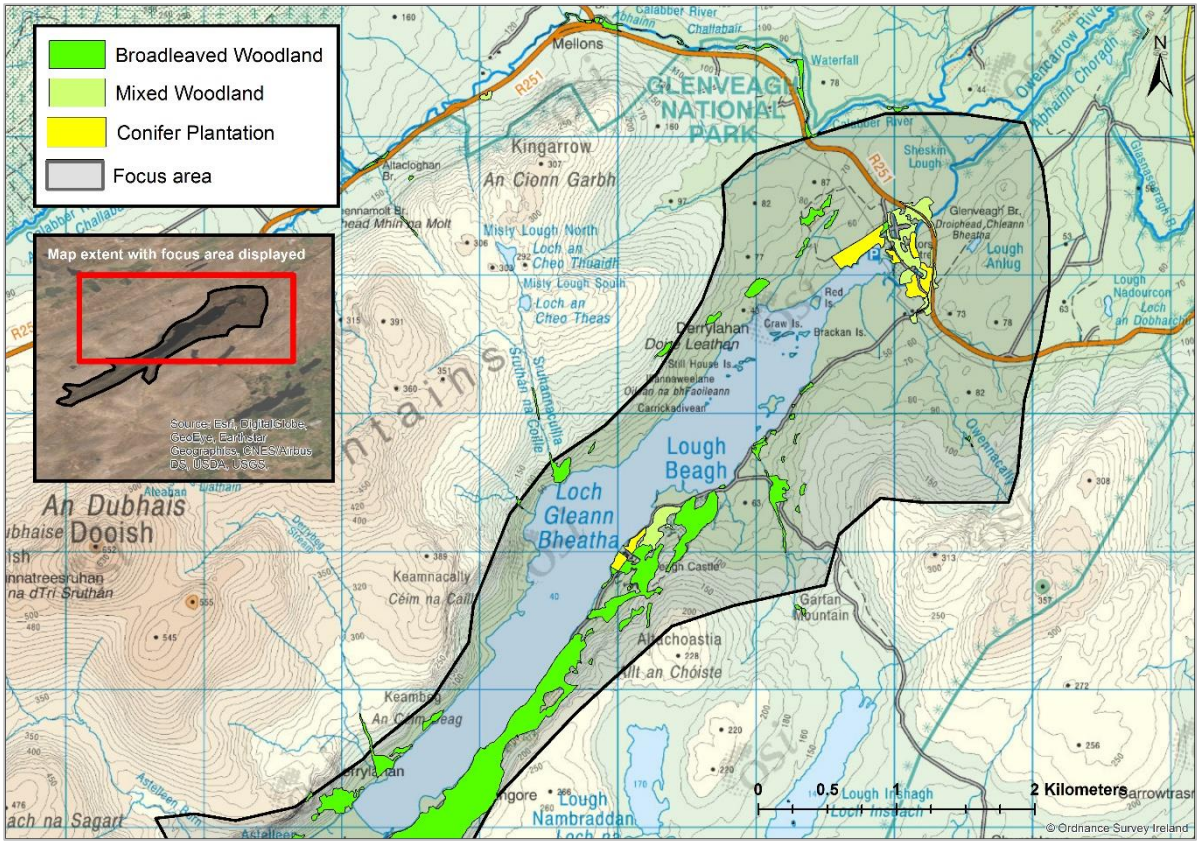

Figure 7. Extant broadleaved woodland, mixed woodland and conifer plantations in the northern section of the focus area. Ordnance Survey Ireland Licence No OSI-NMA-014. © Ordnance Survey Ireland Government of Ireland.

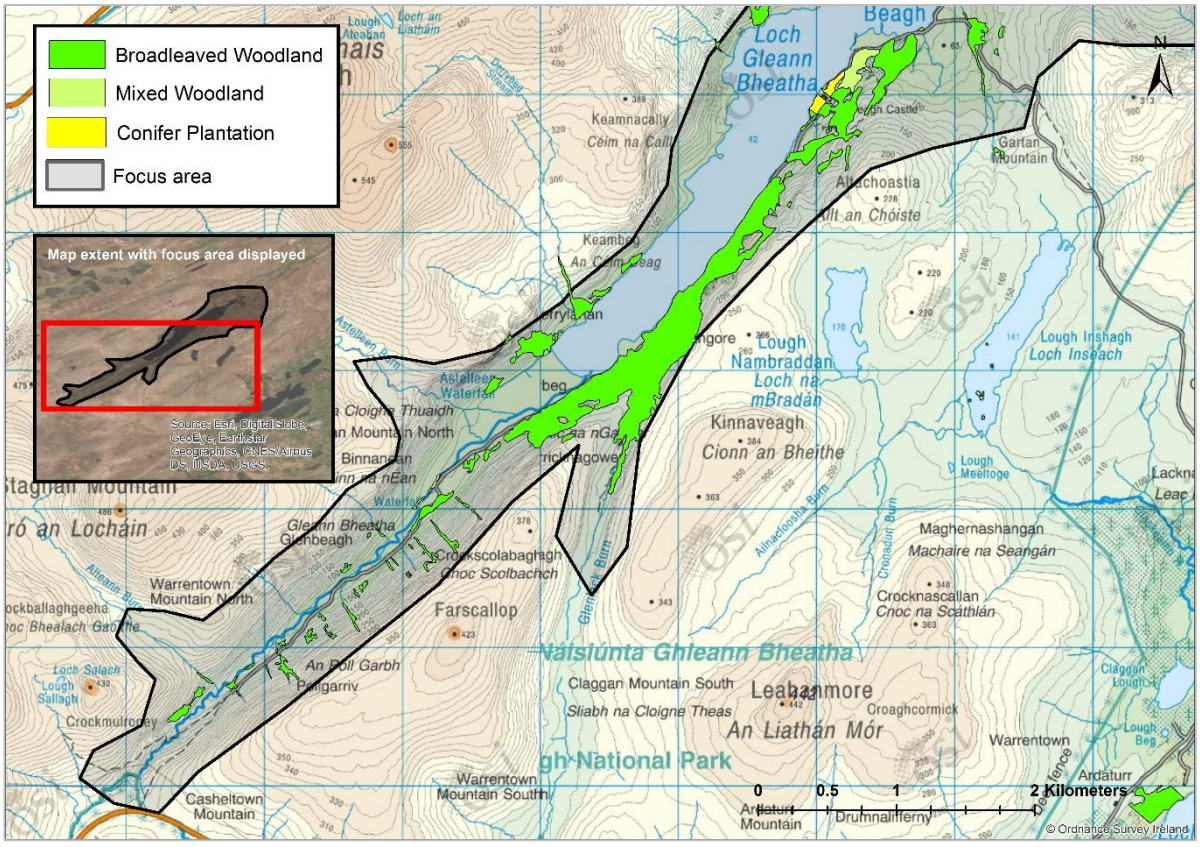

Figure 8. Extant broadleaved woodland, mixed woodland and conifer plantations in the southern section of the focus area. Ordnance Survey Ireland Licence No OSI-NMA-014. © Ordnance Survey Ireland Government of Ireland.

3.3 Mapping historical woodland

The mapping of historical woodland within Glenveagh National Park was completed in November 2020 (see section 3.3.1 below). This created a GIS dataset of all woodland that was mapped as present on the first edition or third edition six-inch maps, or both, regardless of whether or not the woodland is still extant. This dataset can therefore provide the historical context of extant woodland, and can also be used to identify Potential Woodland Establishment Areas (PWEAs), comprising locations that were formerly under woodland but which are no longer wooded.

There is a caveat attached to the six-inch mapping. There is a possibility that some areas of woodland in Glenveagh were not included in the first edition maps, or were mapped as smaller than they were in reality. Telford (1977) expressed reservations as to the accuracy of the mapping, noting that, for example, the Glenlack area had not been recorded as being wooded on the first edition maps, despite almost certainly having been so at that time.

For the purposes of comparing the first edition and third edition six-inch maps, however, the assumption is made that the historical mapping accurately reflected the situation on the ground at the time.

3.3.1 Methodology for mapping historical woodland

1. Historical Ordnance Survey (OS) maps comprising the first edition six-inch maps (1834-1836) and third edition six-inch maps (1900-1905) were used to create this spatial database.

2. The first step was to intersect the Glenveagh National Park boundary with a 1 km grid and then overlay the six-inch maps with the intersected grid. Each 1 km square was then systematically reviewed for the presence of woodland on the first edition and third edition six-inch maps. Woodland parcels were digitised if present on the first edition or third edition six-inch maps.

3. The resulting dataset has been labelled *Six_inch_woodland_GNP.shp*. Information contained within the dataset includes:
   - Woodland type present on the first edition six-inch map. Categories used were broadleaf woodland (B), mixed woodland (M), conifer plantation (C), brushwood (BW), and None. The last category indicates that no woodland was present in this location on the first edition map, but that woodland developed in this location sometime after c. 1830.
   - Woodland type present on the third edition six-inch map. Categories used were broadleaf woodland (B), mixed woodland (M), conifer plantation (C), brushwood (BW), and None. The last category indicates that woodland was present in this location c. 1830 according to the first edition six-inch map, but was no longer present in the early 20th century, according to the third edition map.
   - Digitisation notes, with these typically pertaining to any difficulties in the interpretation of woodland symbols on the six-inch maps.
   - A summary field with three categories as follows: 'On both 1st and 3rd edition six-inch maps', 'On 1st edition six-inch map only' and 'On 3rd edition six-inch map only'.

3.3.2 Findings from historical woodland mapping

Glenveagh National Park

The historic map dataset indicates that 227.0 ha of the Park was wooded since c. 1830, representing 1.5% of its total area. However, these 227.0 ha were not all wooded contemporaneously. Table 2 shows that 22.9 ha were mapped on the first edition six-inch map only. Of the remaining 204.1 ha of historical woodland mapped, the majority (132.9 ha) was present on the third edition map only, and 71.2 ha was mapped on both the first and third edition maps. Telford (1977) noted that the greater amount of woodland on the third edition OS maps

may be partly accounted for by the 1861 Derryveagh evictions and associated grazing pressure reduction from domestic stock.

Table 2. Summary of woodland history within Glenveagh and the focus area.

Woodland history	Glenveagh		Focus area	
	Area (ha)	% Percentage	Area (ha)	% Percentage
On both 1st and 3rd edition six-inch maps	71.2	31.4	68.9	32.1
On 1st edition six-inch map only	22.9	10.1	21.3	10.0
On 3rd edition six-inch maps only	132.9	58.6	124.3	57.9
Total	**227.0**	**100.0**	**214.5**	**100.0**

Table 3 shows the composition of these historical woodlands, with the majority of woodland documented on the first edition six-inch maps being broadleaved woodland (96.2%), with some brushwood (3.8%). No mixed woodland or conifer plantations were mapped as present in the Park at this time. Broadleaved woodland continues to be the dominant stand type (89.0% of all woodland) on the third edition six-inch maps, with smaller amounts of conifer plantation (4.9%), mixed woodland (3.8%) and brushwood (2.3%) occurring.

Table 3 also shows that the area of mapped woodland in Glenveagh more than doubled between the first and third edition six-inch maps, from 94.1 to 204.1 ha; this was mostly driven by a doubling of mapped broadleaved woodland from 90.5 to 181.7 ha, although mixed and conifer woodland also appeared in the intervening period. As was shown in Table 1, the GIS dataset indicates that the current extent of woodland within Glenveagh as a whole (including plantations and woodland fragments) stands at approximately 212.4 ha, with broadleaved woodland the dominant stand type (123.2 ha), followed by smaller amounts of conifer plantation (74.9 ha) and mixed woodland (14.4 ha). Thus, the amount of conifer and mixed woodland appears to have increased at the expense of broadleaved woodland, although not necessarily in the same location.

Table 3. Composition of historical woodland within Glenveagh and the focus area.

Woodland type	Glenveagh				Focus area			
	First edition six-inch maps		Third edition six-inch maps		First edition six-inch maps		Third edition six-inch maps	
	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%
Broadleaf woodland (B)	90.5	96.2	181.7	89.0	90.2	100.0	172.0	89.0
Mixed woodland (M)	-	-	7.7	3.8	-	-	7.7	4.0
Conifer plantation (C)	-	-	10.0	4.9	-	-	10.0	5.2
Brushwood (BW)	3.6	3.8	4.7	2.3	-	-	3.5	1.8
Total area (ha)	**94.1**	**100**	**204.1**	**100**	**90.2**	**100**	**193.1**	**100**

Focus area (Lough Beagh glen)

A total of 214.5 ha of the focus area was mapped as wooded in the past (Table 2). The total area of historical woodland for the whole of Glenveagh is 227.0 ha, indicating that the majority of historical woodland occurs within the focus area. Therefore, the observations made above in the context of Glenveagh also broadly apply to the focus area.

A comparison of the area of extant woodland within the focus area with the historical extent of woodland (see Table 4 and Figs. 9-10) indicates that:

- 56.2 ha (43.3%) of extant woodland has been continuously present since the first edition maps c. 1830;
- 4.0 ha (3.1%) of extant woodland was present on the first edition maps c. 1830 but absent from the third edition six-inch maps;
- 44.1 ha (34.0%) of extant woodland was absent from the first edition c. 1830 but present on the third edition six-inch maps; and

- 25.4 ha (19.6%) of extant woodland was absent from both first and third edition six-inch maps.

Table 4. Summary of woodland history within Glenveagh and the focus area with a breakdown of contemporary woodland status.

	Contemporary woodland status			
	Glenveagh		**Focus area**	
Woodland history	**Extant (ha)**	**Currently unwooded (ha)**	**Extant (ha)**	**Currently unwooded (ha)**
On both 1st and 3rd edition six-inch maps	58.5	12.7	56.2	12.7
On 1st edition six-inch map only	5.2	17.7	4.0	17.4
On 3rd edition six-inch maps only	45.6	87.3	44.1	80.1
Absent from six-inch maps	103.1	n/a	25.4	n/a
Total (ha)	**212.4**	**117.7**	**129.7**	**110.2**

On comparing the currently wooded areas with the historically wooded areas, they indicate that, within the focus area, 110.2 ha of land indicated as wooded on at least one of the historical six-inch maps is currently unwooded (Table 4). This breaks down as follows:

- 12.7 ha (11.5%) were present on both the first and third edition six-inch maps
- 17.4 ha (15.8%) were on the first edition six-inch map only
- 80.1 ha (72.8%) were on the third edition six-inch map only

These locations can be considered Potential Woodland Establishment Areas (PWEAs). Maps of PWEAs based on the historical extent of woodland, as well as further discussion of PWEAs, are presented in Chapter 7 of this report.

An approximate annual rate of woodland loss can therefore be calculated for Glenveagh, based on the area of woodland that was present on the third edition six-inch map but that is no longer extant. Assuming a time period of 120 years (1900 to 2020), and given that there are 12.7 + 87.3 = 100 ha of woodland mapped on the third edition maps that are no longer extant, this gives an average annual rate of loss of 0.83 ha per annum loss of woodland, or 8.3 hectares per decade, throughout the Park as a whole. This figure is approximate and the losses likely did not happen at a constant rate throughout, but it does indicate the level of deforestation that has taken place in Glenveagh since the beginning of the last century.

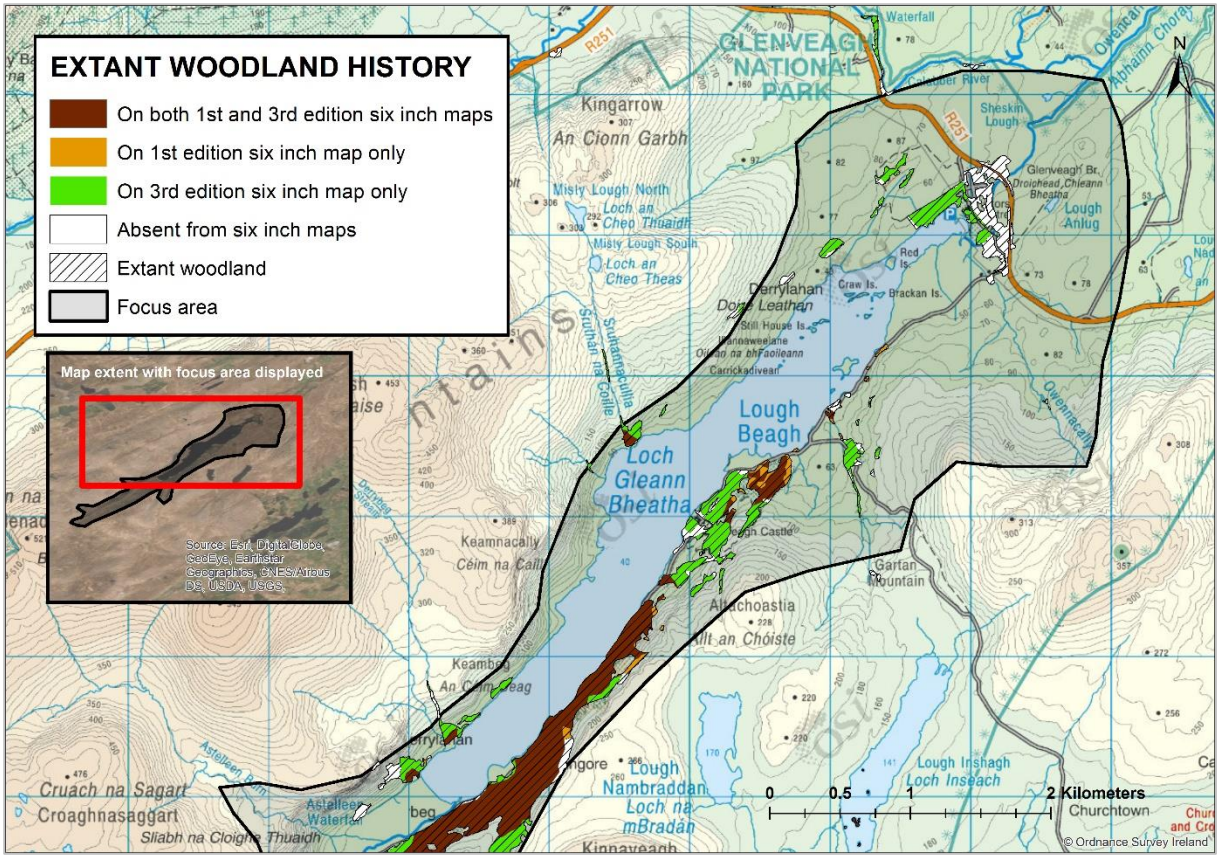

Figure 9. History of extant woodland in the northern section of the focus area. Ordnance Survey Ireland Licence No OSI-NMA-014. © Ordnance Survey Ireland Government of Ireland.

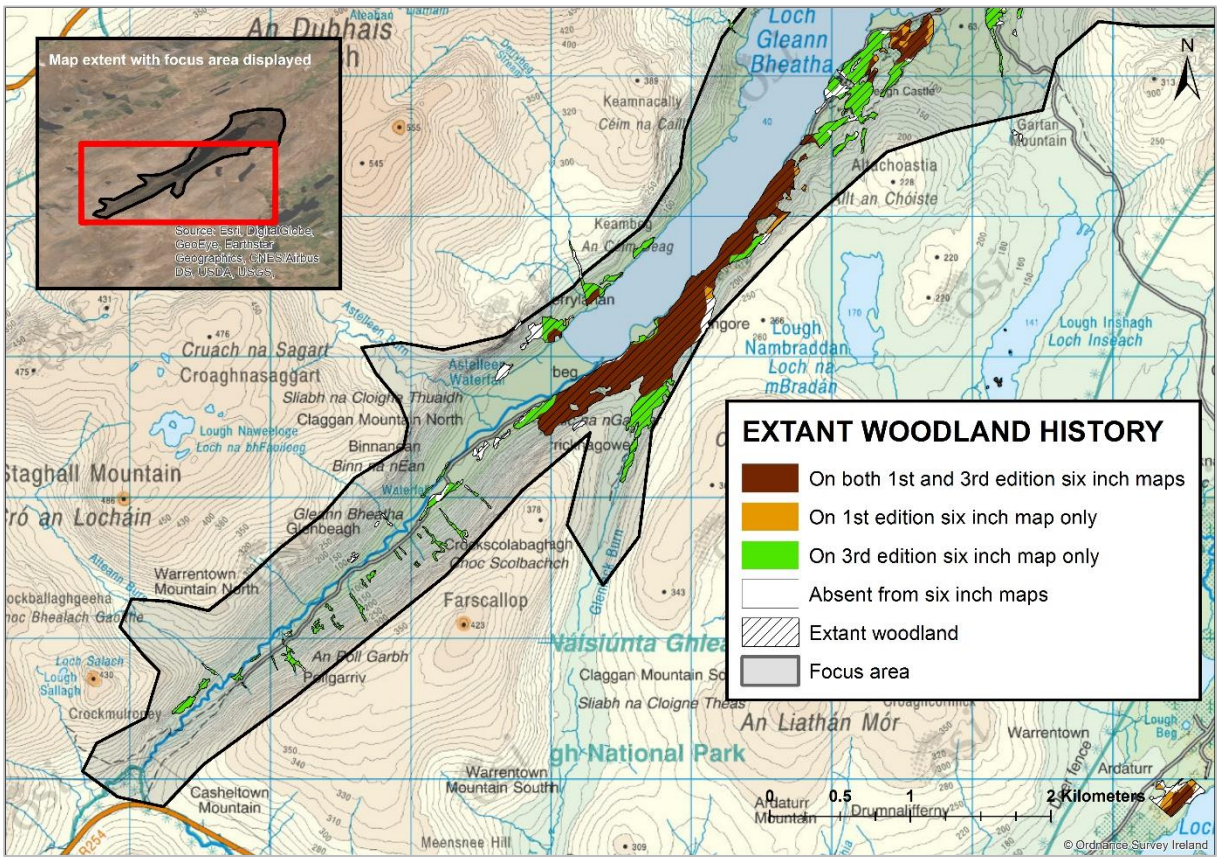

Figure 10. History of extant woodland in the southern section of the focus area. Ordnance Survey Ireland Licence No OSI-NMA-014. © Ordnance Survey Ireland Government of Ireland.

3.4 Further desk-based research on woodland antiquity

As part of the work for this Strategy, research into Glenveagh woodland antiquity was conducted. The Provisional Inventory of Ancient and Long-established Woodland in Ireland (Perrin & Daly, 2010) labelled Mullangore Wood a Possible Ancient Woodland (PAW), indicating that the woodland has likely been present since at least 1660. Perrin & Daly (2010) cited Telford (1977) as providing palynological evidence of antiquity for Mullangore Wood; they also make reference to Little (1994), who noted that there are written records dating back to 1608 that stated the woods were large enough to conceal a whole army.

Perrin & Daly (2010) recommend a multidisciplinary approach to the study of ancient woodlands that incorporates evidence from a variety of sources including historical maps, documents, toponymical research and field-based evidence such as ancient woodland indicators and archaeological evidence.

Overview of methods used

- Following Perrin & Daly (2010), extant woodland polygons that have remained continuously wooded since c. 1830 were identified (i.e., extant woodland present on both the first and third edition six-inch maps).
- Desk-based research: a review of available historical documents was conducted comprising surveys, written accounts, historical maps (section 3.4.1 and Appendix 7) and toponymical research (section 3.4.2).
- ALEW status: Woodland age status according to Perrin & Daly (2010) was assigned to extant woodland polygons following a review of the desk-based research and after considering some field-based indicators of antiquity (Section 3.4.3).

3.4.1 Historical documents and maps

While conducting historical research, the Placenames Database of Ireland (www.logainm.ie) and the Trinity College Dublin Historical Landowner Database (www.downsurvey.tcd.ie) were referenced to decipher the locations of townlands in historical documents and maps. Placenames in historical documents can differ considerably in their spelling from contemporary names as they are usually based on phonetic description and may since have been anglicised. Also, there may be differences in old and new boundaries, due in part to legislation changes in the 18th century which permitted the splitting of baronies.

Appendix 7 details the specific references to the Glenveagh area that were gleaned from consulting historical mapping and documents, most from the 1600s. Among the sources referenced were the *Civil Survey of Ireland (1654-1656),* the *Down Survey (1655-1657)*, other written accounts such as poems retelling old folk tales from the 1600s, and various later accounts such as travelogues and topographical accounts from the 1800s.

3.4.2 Toponymical research

Toponymy is the study of placenames including their origins and meanings. Rackham (1995) suggested using placenames as a means to complement map and documentary evidence of a woodland's antiquity. There are several placenames associated with the focus area that allude to woodland (Table 5).

Another aspect of toponymical research is assessing whether woodland names are present on historical maps. Rackham (1995) proposed that woodlands with their own name on historic maps or in documents are more likely to be ancient, hypothesising that woodlands with their own names on old maps had an established cultural identity at that time. The name 'Mullangore Wood' is depicted on both the first and third edition six-inch maps. No other woodland block within the Lough Beagh glen has a name on these maps.

Table 5. Placenames associated with Glenveagh that allude to woodland.

English	Irish	Meaning	Location
Derrybeg	*Doire Bheag*	Small (oak)wood	Townland on the southeast-facing slopes of the Lough Beagh glen
Derrylahan	*Doire Leathan*	Broad (oak)wood	Townland on the southeast-facing slopes of the Lough Beagh glen
Glenbeagh	*Gleann Bheatha*	Glen of Birch	Townland that comprises the upper part of the Lough Beagh glen including the southeast- and northwest-facing slopes
Derryveagh	*Doire Bheatha*	Woodland of birch	Mountain range in which the Lough Beagh glen occurs
Glenveagh	*Ghleann Bheatha*	Glen of birch	Glenveagh as a unit of landscape and place name refers to a strip of land that extends from the southern end of Lough Veagh (Beagh) following the Owenveagh river southwest to its source on the R254 road and Park boundary (Ó Gaoithín, 2021)
Lough Beagh / Veagh	*Loch Bheatha*	Lake of the birchwood	
Sruhannacullia	*Sruthán na Coille*	Stream of the wood	Watercourse on southeast-facing slopes of the Lough Beagh glen; it runs through NSNW site 1426 Derrylahan (known locally as Sruhannacullia wood)

Note: Translations by Mr. McGiolla-Easpig of the Ordnance Survey.

3.4.3 Summary of woodland antiquity

From reviewing the above information, there appears to be strong evidence to upgrade Mullangore Wood from a Possible Ancient Woodland (PAW) to an Ancient Woodland (AW). This is supported by field-based evidence, in the form of plants which serve as ancient woodland indicators. The National Survey of Native Woodlands (Perrin *et al*., 2008) recorded 11 ancient woodland vascular plant indicators in 2006, and a twelfth was recorded in the course of fieldwork for the monitoring assessments in 2018 (Daly *et al*., 2023). While Perrin & Daly (2010) recommend at least 16 indicators in larger woods such as Mullangore, many of these ancient woodland indicators are more associated with less acidic woodland habitats (for example, Wood Speedwell *Veronica montana*), so it may be that 12 indicator species are sufficient for acid oak woodlands. In addition, the 2006 survey was carried out in late June, and the 2018 survey recorded a limited range of species (confined to 91A0 indicator species), so it is possible that those surveys could have missed some early-flowering indicators of ancient status.

Evidence of antiquity is less strong for woodland on the southeast-facing slopes, with weak documentary evidence of tree cover in the 17th century (e.g., Civil Survey). By the 19th century, we know the slopes were mostly bare, except for a few small, fragmented blocks of woodland. Toponymical research, with its earlier origins, however, paints an image of a richly wooded hillside, with all townlands occupying the southeast-facing slopes and a watercourse in this location having a reference to 'oak', 'birch' or woodland in their placenames. It is proposed that the extant remnant blocks of woodland on the southeast-facing slopes (that are also present on the first and third edition six-inch maps) are assigned Possible Ancient Woodland (PAW) status based on the evidence presented. Field-based evidence of antiquity, such as ancient woodland indicators, should be collected in these woodlands to provide a complementary source of evidence. During the National Survey of Native Woodlands (Perrin *et al*., 2008), six ancient woodland indicators were recorded in Derrybeg woodland and seven at Derrylahan (Sruhannacullia wood) in 2006. However, those surveys took place in late September, thus missing any early-flowering indicator species, and a more specific field survey would possibly yield more records.

The locations of AW, PAW and Long-Established Woodland (LEW) within Glenveagh are displayed in Figs. 11-12. A shapefile has also been created (*ALEW_GNP.shp*). It is recommended that this dataset be integrated into the *National Inventory of Ancient and Long-established Woodlands* as held by the NPWS.

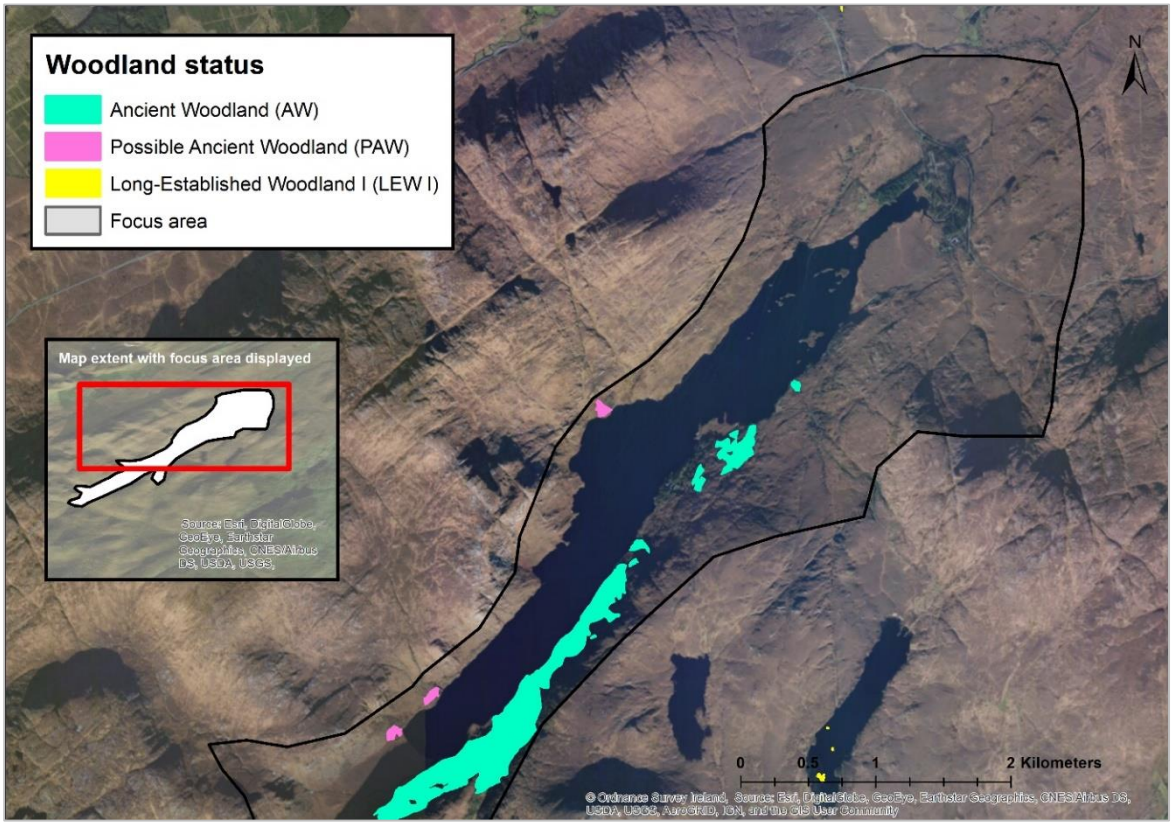

Figure 11. Antiquity of extant woodland in the northern section of the focus area.

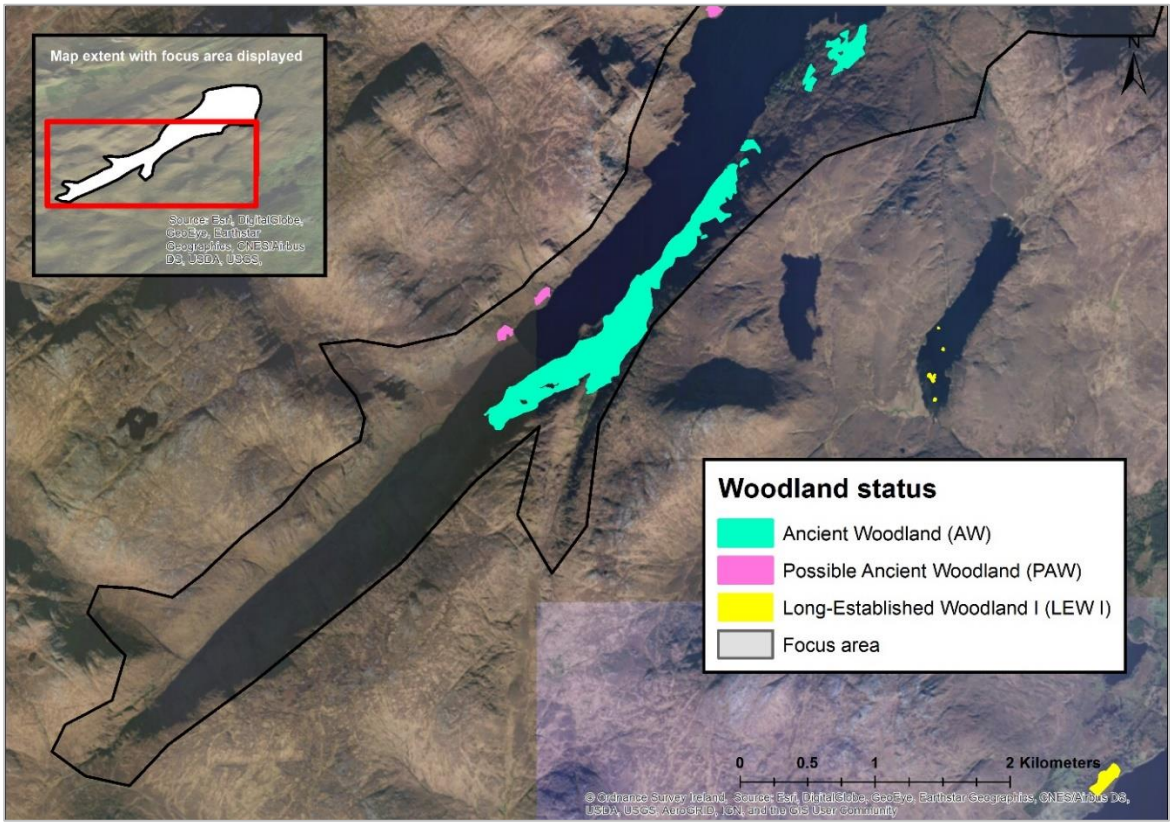

Figure 12. Antiquity of extant woodland in the southern section of the focus area.

Chapter 4 Invasive species management

4.1 Introduction

Woodlands in Glenveagh, in common with many around the country, suffer from the impacts of invasive plant species. Rhododendron (*Rhododendron ponticum*) is the main problem species, with prickly heath (*Gaultheria mucronata*) also invasive, though favouring woodland edges and more open heath areas over woodland. More recently, other problem species have emerged, including *Rhododendron ciliatum*, *R. protistum* and *Dicksonia antarctica*, among others.

Invasive species management works have been on-going within Glenveagh, to a greater or lesser degree, since the late 1970s (Aulino Wann & Associates, 2017). The level of activity has varied in response to funding availability, with the intensity of work generally reflecting the budget allocation at a given time. There has therefore been inconsistency in its implementation over time. Specifically, in the early 2000s it is understood that invasive plants were largely under control, with practically all flowering plants eliminated. However, between 2007 and 2017 little work was carried out on stump regrowth or removal of seedlings, which has resulted in significant re-infestation of areas which had previously been cleared (James McGinley, pers. comm.).

A draft Invasive Species Management Plan 2017-2026 (Aulino Wann & Associates, 2017) was prepared following fieldwork conducted in selected parts of Glenveagh National Park between September 2016 and January 2017. The report is a 51-page document plus Appendices and an associated GIS. The Invasive Species Management Plan was intended to run from 2017 to 2026 but ran into operational difficulties early in the timeframe, with low numbers of experienced contractors available to tender for advertised contracts. As such the Work Strategy given in the Invasive Species Management Plan has not been implemented as it was anticipated. Though there has been a divergence in approach, the Invasive Species Management Plan is the most recent and comprehensive record of policy in relation to invasive species, so it does warrant review as part of the Strategy.

The Invasive Species Management Plan and associated GIS have been reviewed specifically with a view to incorporating the objectives of the Invasive Species Management Plan into the Strategy and also to identify and address any shortcomings or misalignments of the existing plan.

The objectives of the Invasive Species Management Plan are reproduced in Box 1.

Box 1: Objectives of the Glenveagh National Park Invasive Species Management Plan

1. Eradicate *Rhododendron ponticum* and *Gaultheria mucronata* and other minor invasive species from the Park over a 10-year period through careful choice of the most appropriate control options
2. Prevent the further spread of invasive species within and outside the Park through liaising with neighbouring landowners
3. Monitor the Park in the long term for renewed contamination with invasive species
4. Maintain the internationally and nationally important habitats and species in the Park in favourable condition through best practice conservation management techniques such as fencing from deer grazing, management of deer numbers, and the planting of appropriate canopy and understorey species, as well as the encouragement of typical field and ground layer native species
5. Create awareness of the adverse impacts of invasive species amongst the general public through appropriate signage and interpretative displays in the Education and Visitor centres

The first of these objectives, though desirable, appears ambitious in the context of the invasive species management works which have been on-going within Glenveagh for a number of decades. This is based on the assumption that 'eradication' means the elimination of all invasive plants, i.e.,

flowering plants, non-flowering plants and seedlings of all recognised invasive species. In relation to the 10-year timeframe, Snowdonia National Park Authority (SNPA, 2008) estimated clearance of Rhododendron from a given area to take a minimum of 10 years; this allowed for just one maintenance sweep and would likely be applicable to relatively light infestation. With a 10-year timeframe for eradication of all invasive species in Glenveagh, it would be necessary to commence clearance in every part of the Park at around the same time and to apply a rather condensed monitoring / maintenance programme if eradication of all invasives were to be achieved within the given period. This is unlikely to be realistic or successful. Undoubtedly it would be a significant achievement to have all areas of Glenveagh under effective invasive species management in the medium term, and given the correct resources and commitment this is achievable. The woodland strategy will have a long-term timeframe (100 years) and the management of invasive species within the early part of this timeframe would certainly be a primary objective. As such this objective is desirable but, in the light of past experiences, the timeframe may need further consideration before it is incorporated into the Strategy.

The second and third objectives of preventing invasive plants from re-invading Glenveagh National Park and monitoring the Park in the long term are eminently sensible and the means of achieving this should be incorporated into the Strategy. However, the Invasive Species Management Plan does not provide a coherent strategy for follow-up work (i.e., monitoring / maintenance works) to the initial clearance that is proposed, with the suggestion that all compartments will be searched annually. Regardless of the success or otherwise of the invasive species management in the short-to-medium term, there is no reason to assume that vigilance in relation to the reinvasion by the current invasive species and potential new invasives within Glenveagh would not continue to be a requirement 100 years from now.

Objective 4, maintaining the important habitats and species within the National Park in favourable condition, is a fundamental element of the Strategy. As the Invasive Species Management Plan objective is stated, there is an assumption made that these habitats and species are currently in favourable condition. An objective of 'improving', rather than maintaining, the conservation condition of important habitats and species within the National Park would be more appropriate, with the ultimate aim of restoring favourable conservation status. The subsequent references to conservation management practices in relation to deer management and habitat enhancement are touched on within the Invasive Species Management Plan and are objectives which can be aligned with the overall Strategy.

Finally, raising awareness of invasive species is another desirable objective to be incorporated into the Strategy and this is likely best achieved through a working education strategy.

In conclusion, the objectives of the Invasive Species Management Plan are desirable and can be aligned with the Woodland Management Strategy. Indeed, some of the objectives given lend themselves more to inclusion within the Strategy than the Invasive Species Management Plan. Further consideration should be given to the first objective of the Invasive Species Management Plan, with a practical, attainable target being set or clarification given as to the terminology being used. Also, the strategy and timing of works after the 5-year initial clearance phase should be developed to tackle any missed plants and the seedlings which will grow from the seedbank. Incorporating a workable approach to invasive species management will be fundamental to the development of the Strategy.

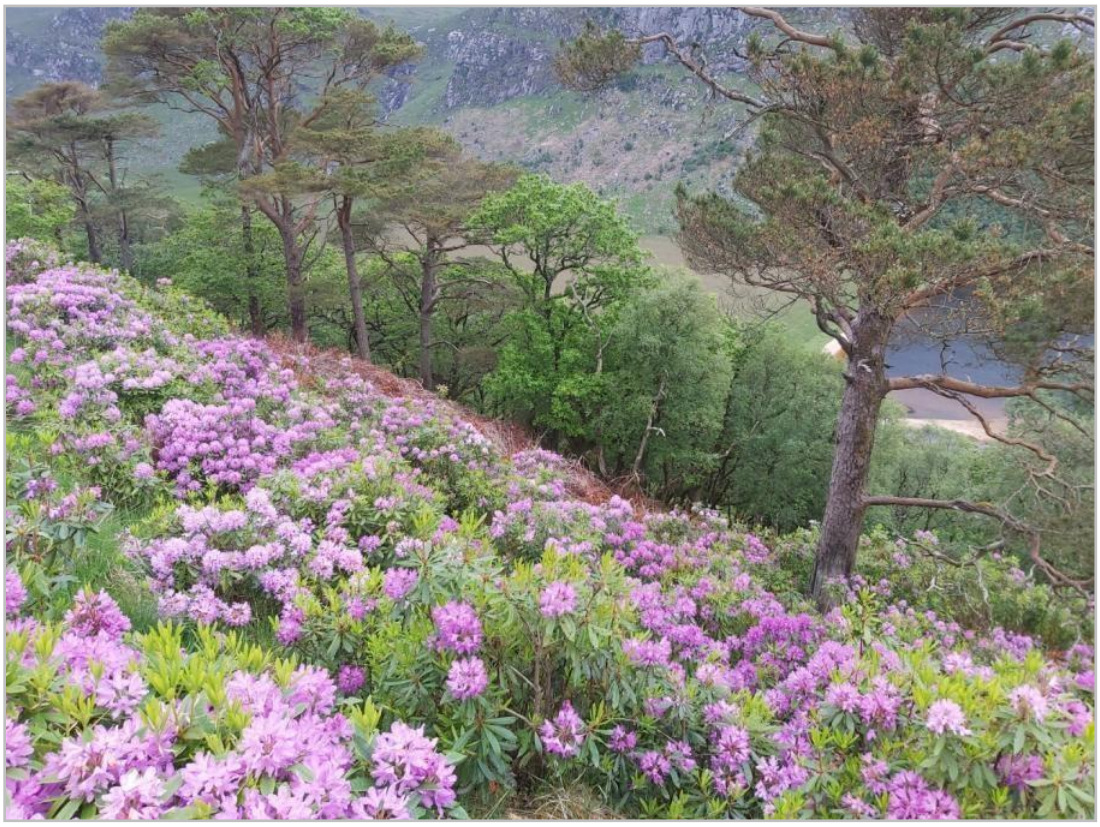

Plate 2. Open heath with *Rhododendron ponticum*: a ready source of re-infestation to surrounding woodland. Photo by Simon Barron.

Plate 3. Prickly heath (*Gaultheria mucronata*) (white-flowered dwarf shrub in fore- and middle-ground) invading edge of Annex I Old oak woodland. Photo by Fionnuala O'Neill.

Plate 4. The invasive species Giant-rhubarb (*Gunnera tinctoria*) in scrub 1 km northeast of Glenveagh Castle gardens. Photo by Simon Barron.

Plate 5. Tree fern (*Dicksonia antarctica*) and *Rhododendron ciliatum* (right foreground) invading woodland behind Glenveagh Castle gardens. Photo by Simon Barron.

Plate 6. The invasive Piri-piri burr (*Acaena novae-zelandiae*). Photo by Fionnuala O'Neill.

4.2 SWOT analysis of the Invasive Species Management Plan

Following review of the Invasive Species Management Plan, a SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis of the plan was conducted with a view to identifying shortcomings of the plan that may need attention, as well as intentions and proposals that can be incorporated into the Strategy. The analysis is summarised in Box 2 and discussed further below.

The Glenveagh Invasive Species Management Plan had a number of strengths, mainly stemming from the extensive fieldwork and detailed digital recording of invasive plants that was conducted. The fieldwork provided a comprehensive overview of the invasive species situation in 2016. The Invasive Species Management Plan included the objective of eradication of all invasive species, not only the two main issues of *Rhododendron ponticum* and *Gaultheria mucronata.* It provided a comprehensive overview of the ecology and methods of controlling *Rhododendron ponticum* and presented a position of zero tolerance of *Rhododendron ponticum*. This is important if infestation levels are going to be brought to acceptable levels.

There were also some weaknesses identified in the Invasive Species Management Plan. There was an assumption that the methods developed for the control of *Rhododendron ponticum* would be suitable for all the other invasive species. It is accepted that *Rhododendron ponticum* and *Gaultheria mucronata* are the main species of concern in Glenveagh, but the other invasive plants were given only passing reference and the tailored approaches which may be needed for these species were not considered. In the GIS there were errors in the digitisation, overlapping polygons and gaps in the data, and the non-standard organisation of the GIS made it unsuitable for anything other than the presentation of maps. The Invasive Species Management Plan work strategy recommended work to commence in 11 compartments in Year 1 and in the remaining 15 compartments by Year 4. This was overly ambitious and, due to issues such as low numbers of available contractors and high clearance costs, was not achieved. The Invasive Species Management Plan had no mechanism to adapt to this scenario and has therefore become out of date.

Box 2: SWOT Analysis of the Glenveagh National Park Invasive Species Management Plan

Strengths

- Included a remit for eradication of all invasive plants, not only *Rhododendron ponticum* and *Gaultheria mucronata*
- Stated the adoption of zero tolerance of *Rhododendron ponticum*
- Provided a good account of the ecology and methods for controlling *Rhododendron ponticum*
- The field survey work conducted covered significant areas of Glenveagh National Park
- Provided a comprehensive overview of the invasive species situation in 2016

Weaknesses

- Only passing reference was given to other 'minor invasive species'
- There was an assumption that management methods developed for *Rhododendron ponticum* will be equally applicable for other invasive species
- Recent escapes (e.g., *Dicksonia antarctica*) present a particular concern but insufficient consideration of the potential impact or required management approaches for these was given
- The GIS has extensive digitisation and organisational errors
- Compartment maps contain too much detail and are difficult to interpret
- Though GIS was used to present data, not having this form part of a record-keeping process is a missed opportunity
- Compartment divisions are arbitrary in places, cutting across infestation polygons
- The Invasive Species Management Plan Work Strategy set the extremely ambitious target of commencing initial clearance work in 11 of the 26 compartments in Year 1 and in all remaining compartments by Year 4
- There was no detail provided on the approach for monitoring / maintenance work other than annual searches. As such the Invasive Species Management Plan only represents initial clearance and initial follow up work
- The Invasive Species Management Plan had no adaptive mechanism, so when scenarios developed of low interest among contractors and varying budgets, the given Work Schedule became redundant

Opportunities

- The plan presented the opportunity for meaningful control of invasive plant species to be conducted
- Successful implementation of the plan would contribute to the enhancement of the conservation condition of Annex I habitats in the SAC and nationally
- The successful eradication of invasive species from Glenveagh would be a significant landmark in conservation management in Ireland
- Invasive species management provides opportunity for local employment

Threats

- Though a difficult desk-based task, the plan is uncosted
- There was no guarantee that budgets would be made available each year
- The objective of eradicating all invasive plants from Glenveagh within 10 years was overly ambitious and not achieving this can undermine the commitment that is needed to succeed in invasive species management
- There has been a divergence between the Invasive Species Management Plan work strategy and the invasive species management that has actually been enacted and achieved since 2017. This can contribute to the perception that there is no functioning invasive species management plan, which can overshadow the work that is being achieved
- There was an assumption that there would be sufficient numbers of contractors available to complete the Invasive species work strategy, which has not proved to be the case
- Previous invasive species management records, which can influence the decision-making process when setting priorities for work, were not available and were not incorporated into the Invasive Species Management Plan

Although the plan had weaknesses, the Invasive Species Management Plan did present an opportunity for the meaningful control of invasive species to be conducted within the Park, and consideration was given as to what would be required for initial clearance of the compartments. The Invasive Species Management Plan formed a comprehensive review of invasive species within Glenveagh and its successful implementation would contribute to the enhancement of the conservation condition of Annex I habitats within Cloghernagore Bog and Glenveagh National Park SAC, particularly Old oak woodland and Wet heaths [EU habitat code 4010]. This in turn would contribute to the enhancement of the conservation status of these habitats at a national level. The successful eradication of invasive species from Glenveagh would be a significant landmark in conservation management in Ireland. The eradication programme can provide employment to the local area both through contractors and dedicated staff within NPWS.

There were a number of external factors (threats) which affected the implementation of the Invasive Species Management Plan. The plan was uncosted, and there was no guarantee that budgets would become available, with these being set on an annual basis and subject to broader departmental demands. A failure to achieve the ambitious objective of eradicating all invasive plants from Glenveagh within 10 years could undermine the commitment that is needed to succeed in invasive species management. And could overshadow the work that is being achieved. The Invasive Species Management Plan work strategy was based on the assumption that there would be a sufficient number of suitably skilled and experienced contractors available to complete the work and this was found not to be the case. Previous management records were not available for incorporation into the Invasive Species Management Plan so it is not evident if the required work is clearance of initial infestation, follow-up on previously cut stumps, or clearance of re-infestation.

4.3 Invasive species field survey

Survey work for this Strategy included visiting woodland polygons, making notes on the habitats and recording the occurrence of invasives species. The level of the infestation was recorded on a polygon basis for Rhododendron as per Table 6, and for other invasive plant species according to Table 7.

Table 6. Classification of Rhododendron infestation (adapted from Cross, 1981 & 1982)

Description	Score
None Present	1
Plants scattered, small, none having flowered	2
Plants frequent, but not clumping. Some flowering, many seedlings	3
Plants abundant forming clumps, many seedlings	4
Plants forming dense thickets with very little ground flora below	5

Table 7. Classification of other invasives (excluding Rhododendron)

Level of Infestation	Score
None present	1
Plants scattered, not dominating any area	2
Plants dominating small areas, <20% of polygon	3
Plants dominating larger areas, 20-50% of polygon	4
Plants forming dense thickets (or carpets) over more than half the polygon	5

The results of fieldwork were incorporated into the GIS shapefiles that form part of the spatial delivery of this project, and were used to create the infestation heat maps in Figs. 13-16.

4.4 Invasive Species Management recommendations

In addition to Rhododendron and *Gaultheria mucronata*, the following invasive plant species were recorded: Piri-piri burr (*Acaena novae-zelandiae*), Montbretia (*Crocosmia* x *crocosmiiflora*), Giant-rhubarb (*Gunnera tinctoria*), Shallon (*Gaultheria shallon*) and Three-cornered Garlic (*Allium triquetrum*). The distribution and levels of infestation of Rhododendron and *Gaultheria mucronata* can be seen in Figures 13-16. Collecting these data has added to the understanding of the issue of invasive species within Glenveagh and adds to data collected for the Invasive Species Management Plan.

Invasive species management, particularly on the scale of Glenveagh, must be dynamic, adaptive and based on accurate mapping, with detailed record keeping. As such, a revised invasive species management strategy is likely required. The fieldwork from the Invasive Species Management Plan will form the basis of this, but the fundamental timeframes of the Invasive Species Management Plan and the lack of a coherent approach to monitoring / maintenance following the initial clearance and initial follow-up work need to be addressed. For the management of Rhododendron, it is likely that the approach and timeframes developed by Snowdonia National Park Authority (see SNPA, 2008) would be the most appropriate template for a site the size of Glenveagh. It is noteworthy that SNPA (2008) considered control of Rhododendron in Snowdonia National Park to be feasible in the long term.

The steps recommended for consideration in relation to invasive species are:

- Guiding principles for invasive species management should be agreed upon.
  Considerations should include:
  - establishing a general approach to clearance, such as working from the outside of the Park towards the centre, or from south to north;
  - establishing accepted terminology and definitions for the different management phases; prioritising high-value habitats in relatively good condition over other areas;
  - giving lower priority to heavily infested areas which will not deteriorate further in the short-medium term, or giving high priority to these areas in order to remove them as a seed source;
  - whether to work towards initial clearance of all compartments in the short-term, entering all areas into the monitoring / maintenance phase at around the same time with the potential for budgets and staff becoming limiting factors, or to clear fewer compartments but to be able to maintain these as cleared; and
  - prioritising monitoring / maintenance phase work in order to maintain cleared areas free of reinfestation, or to bring additional areas up to the monitoring / maintenance phase.

  Regardless of the prioritisation decisions that are made and implemented, the objectives developed must be realistic and achievable.

- Develop a revised strategy for Rhododendron control based on a phased approach such as that given in SNPA (2008) and in the NPWS Irish Wildlife Manual *Rhododendron ponticum: A guide to management on nature conservation sites* (Higgins, 2008). Achievable targets of invasive species control should be set such that a sense of progress and achievement can be obtained. Priorities will need to be set and these must be cognisant of the fact that budgets will vary and that it may not be possible to achieve everything that is desirable in a given year. the strategy needs to be adaptive such that, if priority work is not achieved in a given year, it becomes the priority for the following year.

- Reorganise the Invasive Species Management Plan GIS in a more conventional way. This will remove organisational flaws, overlapping polygons, gaps and missing data and will allow it to be used as an adaptive database, rather than simply a means of presenting maps. Consideration should be given to redrawing compartment boundaries and, where necessary, sub-dividing them, taking account of the woodland parcels now mapped and the prescriptions devised as part of this Strategy and made available to management as an

Excel Workbook. Also, where possible, compartments should follow features that can be identified on the ground such that they are of practical use to those working on site. The GIS can be used to record details of the management actions conducted within each sub-compartment. It also forms a safeguard against loss of institutional knowledge through staff movement. The GIS can be used to produce maps indicating the status of invasive species control within a polygon at any given time with, for example, maps produced on an annual basis recording the work that has been done and indicating that which is prioritised for the coming years. If any areas deteriorate, an active GIS can be updated to reflect this. The nature of state-funded organisations is that there will be fluctuations in available budgets, so an approach that is able to adapt to this is required.

- Revise the Invasive Species Management Plan based on the above recommendations and recommence implementing it.
- Unlike Rhododendron, the clearance methods for tackling *Gaultheria mucronata* are not well documented. It is understood that *Gaultheria mucronata* is currently included within the Rhododendron clearance contracts and a review of the effectiveness of this approach should be considered. Research on clearance methods for *Gaultheria mucronata* was initiated within the Park in 2021 and, building on the M.Sc. research of Feliz (2009), this will aid in the management of this particular species. The extent of *Gaultheria mucronata* within Glenveagh should be mapped using information from the Invasive Species Management Plan, Feliz (2009), records from the Strategy fieldwork in 2021, and through dedicated survey work. Through this, it will be possible to assess the current impact of the plant, whether it has a role in suppressing woodland regeneration, and identifying which Annex I habitats are currently impacted and which are most prone to infestation.
- Consideration should be given to the prioritisation of clearance of other invasive plants, such as *Dicksonia antarctica*, *Rhododendron ciliatum* and *R. protistum,* before these species become issues of a much larger scale. At the very least, the extent and density of these plants must be monitored to ascertain if they are increasing. Possible pathways of introduction may need to be researched; for example, are they and others being introduced from within Glenveagh, or are they coming in from outside? Research into the management of these species should be conducted. Experience gained in the Azores when tackling *Dicksonia antarctica* as an invasive may be of assistance (Arosa *et al*., 2012). The Rhododendron species are likely to respond to cutting and spraying techniques as used for *Rhododendron ponticum*, but again some background research and record-keeping of the extent of plants and the methods used during management will be of assistance if methods need to be adapted or applied elsewhere.
- In the invasive species issues outlined above, good record-keeping is fundamental and as it is a spatial issue this should be GIS-based. If there is not the GIS expertise among the NPWS Regional Staff or if there is a possibility that this expertise may not be a continual resource, then out-sourcing of the invasive species GIS data management for Glenveagh should be considered. If an invasive species strategy is to be adaptive then someone needs to be assigned responsibility for making the required adaptations and implementing the changes.
- Establish a structured monitoring protocol, in collaboration with the monitoring team (see Chapter 9), to help determine what methods work best, what needs adjustment, and what areas require more sustained clearance works.
- Initiate a public information project on invasive species clearance in collaboration with the education/communications team.
- Seek linkages with other projects and other National Parks whereby information and experiences can be shared.
- As one of the two main management issues at Glenveagh, consideration should be given to developing a core team of personnel dedicated to invasive species management. Though contractors have a role in clearing areas of high-density infestation, they are likely less

suited to tackling lower-density infestation, monitoring / maintenance work and, possibly, to the clearance of *Gaultheria mucronata*. Areas that have been cleared through 5-year contracts will require monitoring / maintenance in the coming years. A means of dealing with these issues needs to be in place and it is unlikely that such work would lend itself to contract staff. Successful clearance of invasive species requires long-term commitment, dedication and investment. Dedicated personnel will ensure consistency of resources and the knowledge and experience gained by a dedicated team would build additional capacity that will remain available to NPWS in the long-term.

- A dedicated invasive species management team should be established within the Park, to be made up of a minimum of 4 x full-time professional staff or Full-Time Equivalents (FTEs).

4.5 Invasive species summary

The presence of invasive species impacts the conservation status of Annex I Old oak woodland. When assessing the structure and functions of Annex I woodland, a number of assessment criteria are considered at a plot level, including the presence of negative indicator species. If the plot has a cover of 10% negative species it results in a plot failing the assessment. A further criterion is failed if there is any regeneration of negative indicator species within the plot, which would include invasive species. The presence of invasive species will also impact the Future prospects element of the conservation status assessment, with the pressures and threats presented by invasive species negatively influencing the Future prospects of a site. It should also be noted that evidence of conservation measures which are tackling the issues of invasive species would be considered as positive in relation to the Future prospects of a site. Addressing the issues presented by invasive species will therefore be fundamental to the success of the Strategy.

The aim of this review was to consider the objectives of the Invasive Species Management Plan with a view to incorporating these into the Strategy and to identify and address shortcomings or misalignments of the existing plan. The objectives of the Invasive Species Management Plan, though desirable, have proven to be overly ambitious and there has been a divergence between what was set out in the Invasive Species Management Plan work strategy and the work that has subsequently been conducted. As detailed above, a revised, adaptive strategy to invasive species control is likely required for Glenveagh which establishes achievable and measurable objectives over a suitable time-frame. Four additional members of staff are estimated to be required to carry out invasive species management tasks.

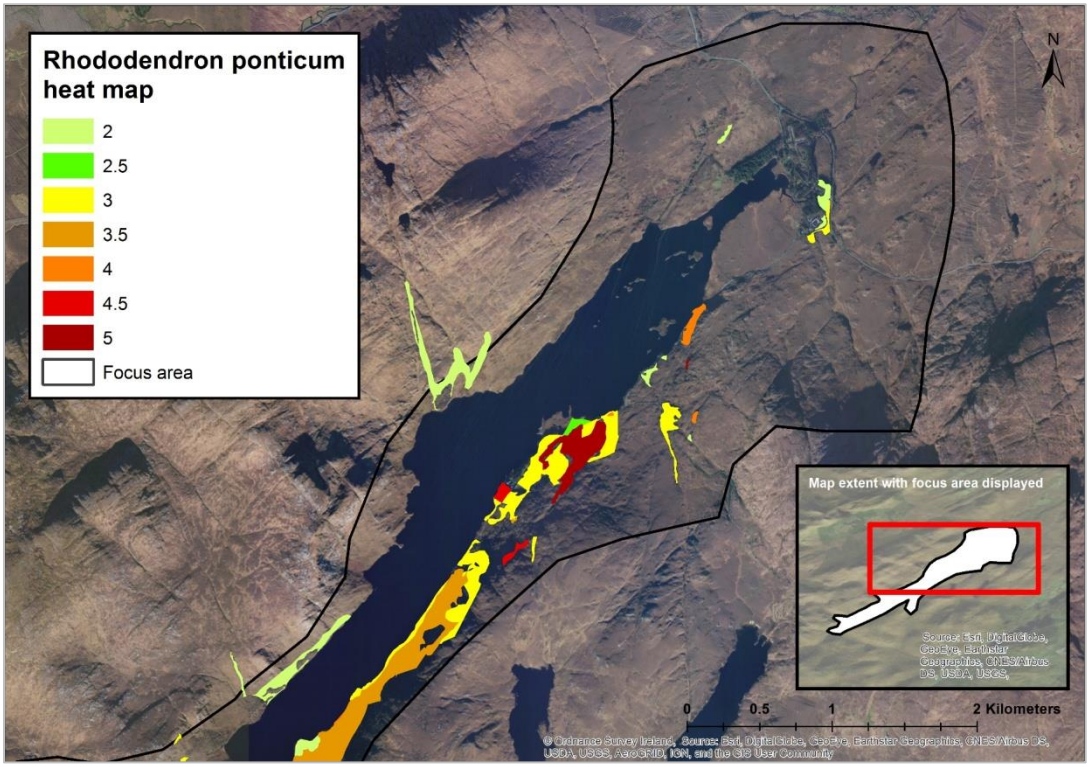

Figure 13. Level of infestation by Rhododendron (northern half of Lough Beagh). Only polygons surveyed in June 2021 have been scored; other areas of infestation occur, especially in unwooded areas northwest of the Lough.

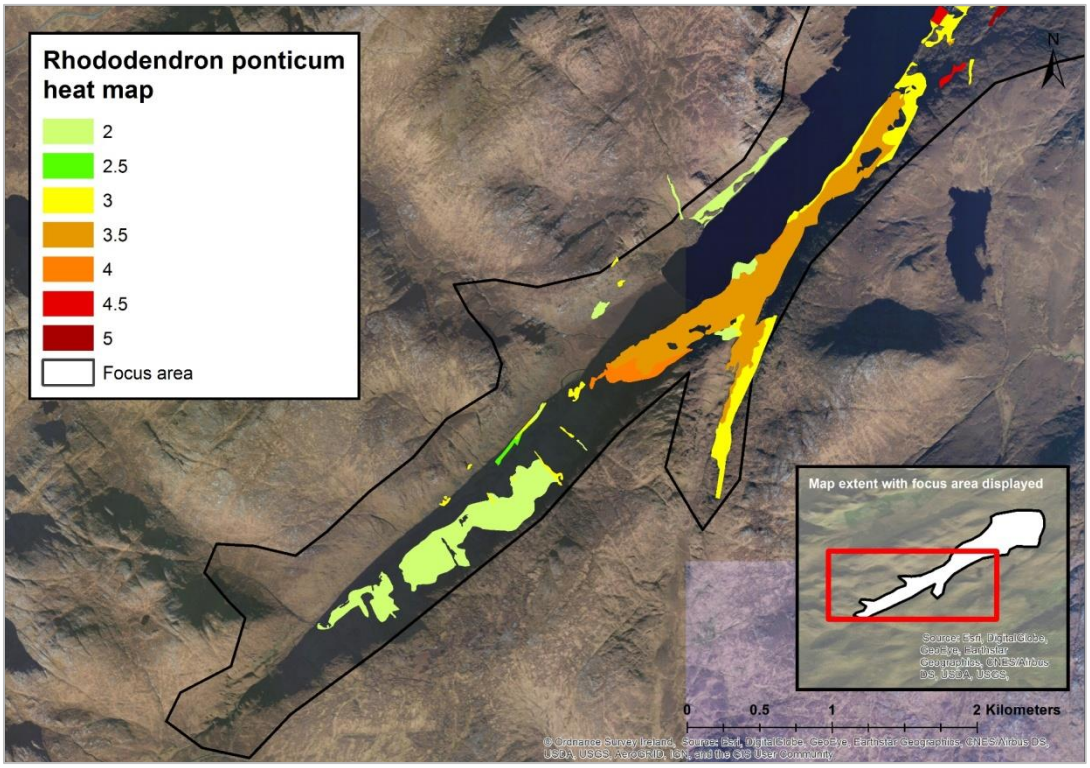

Figure 14. Level of infestation by Rhododendron (southern half of Lough Beagh). Only polygons surveyed in June 2021 have been scored.

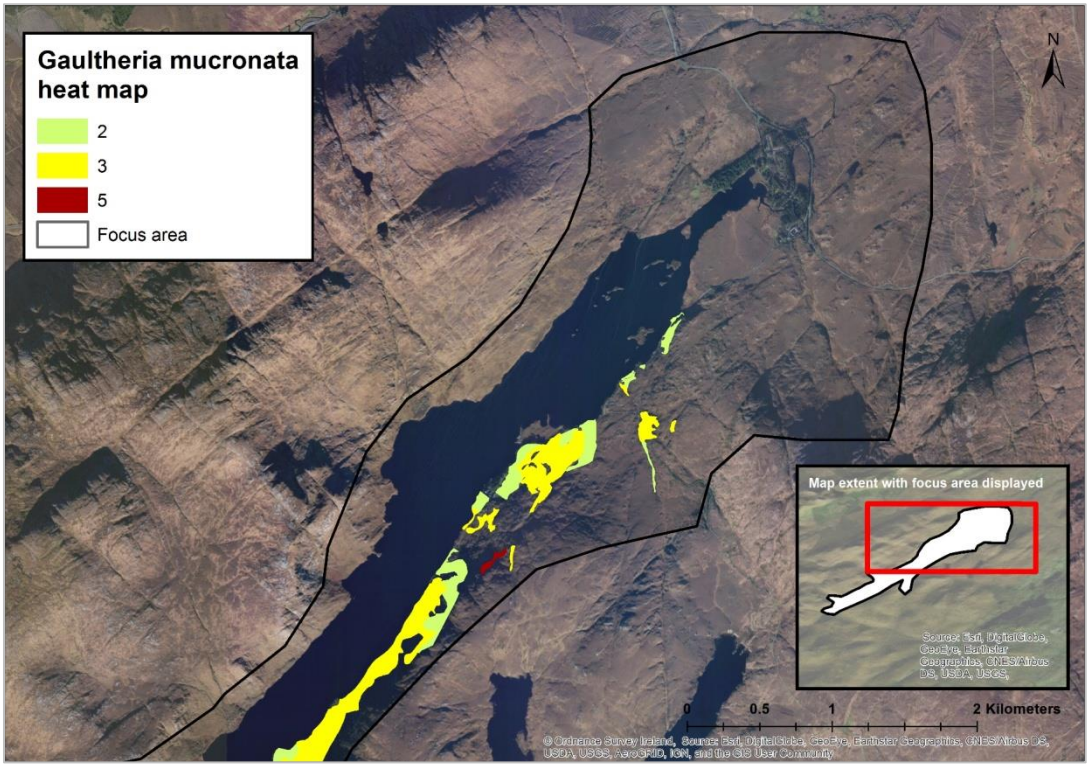

Figure 15. Level of infestation by *Gaultheria mucronata* (northern half of Lough Beagh). Only polygons surveyed in June 2021 have been scored; other areas of infestation may occur, especially along main track.

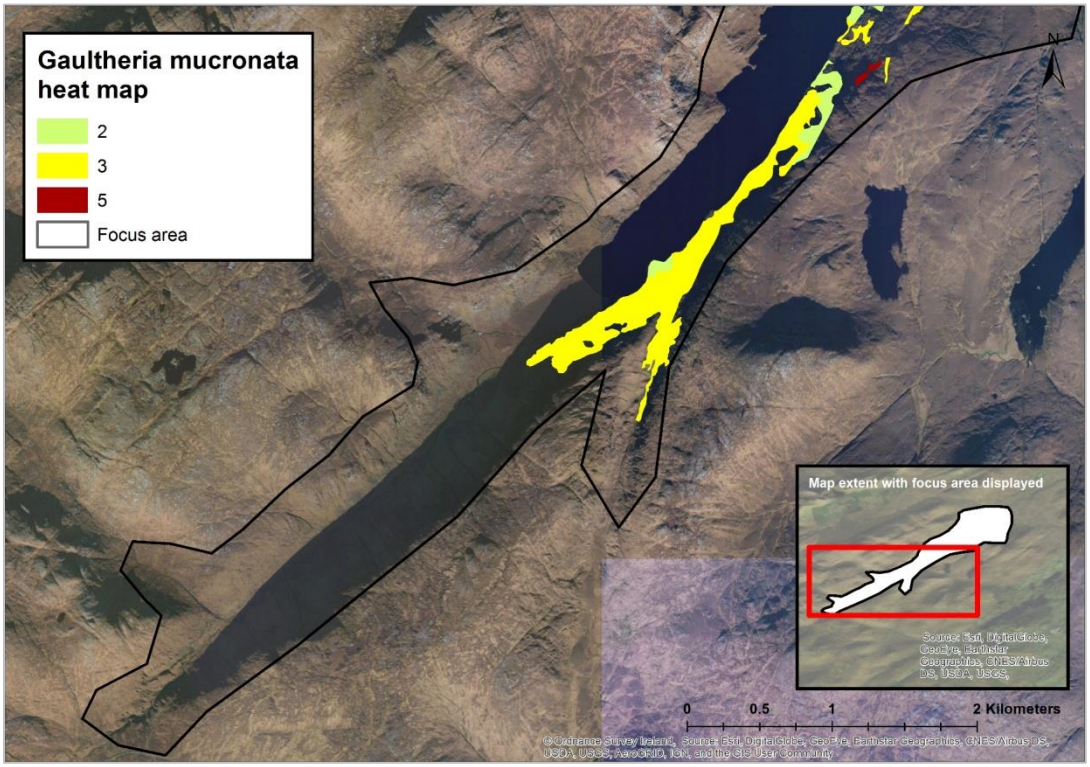

Figure 16. Level of infestation by *Gaultheria mucronata* (southern half of Lough Beagh). Only polygons surveyed in June 2021 have been scored; other areas of infestation may occur, especially along main track.

Chapter 5 Deer management

5.1 History of deer management at Glenveagh

Deer management at Glenveagh began with various introductions of red deer (*Cervus elaphus*) from different European sources in the mid- to late 19th century. A deer fence was erected around the perimeter of the estate in the late 19th century and this is largely still in place, although since the dissolution of the dedicated fencing team (early-mid 2000s) it has become ineffective, with multiple breach points along its 45 km length. Historically, deer management has been associated with sporting rather than ecological interests, although a series of woodland exclosures have been erected over the last 50 years with the intention of excluding deer from areas of woodland (see Fig. 17). While many of these fences are still largely in place, they have all been breached and are in various stages of disrepair due to a variety of causes including rotting of stakes, falling of branches, deer pressure and snow drift, and require ongoing management, which has been entirely lacking in the past 15-20 years.

5.2 The need for deer control

There are no longer any natural predators for deer in Ireland due to an absence of apex predators such as wolves, lynx and bears. This has led to an increase in the number of deer ranging through the Park, and the development of behaviour and feeding patterns that are damaging to the woodlands, such as animals spending longer periods browsing in one place. There is therefore a requirement for humans to take on a role that mimics the actions of predators. This takes the form of directly controlling population numbers by culling, or of influencing where and how quickly individuals and herds move through areas of woodland, using methods such as fencing (to limit access to some areas) or non-lethal hunting (to keep animals on the move to reduce browsing time).

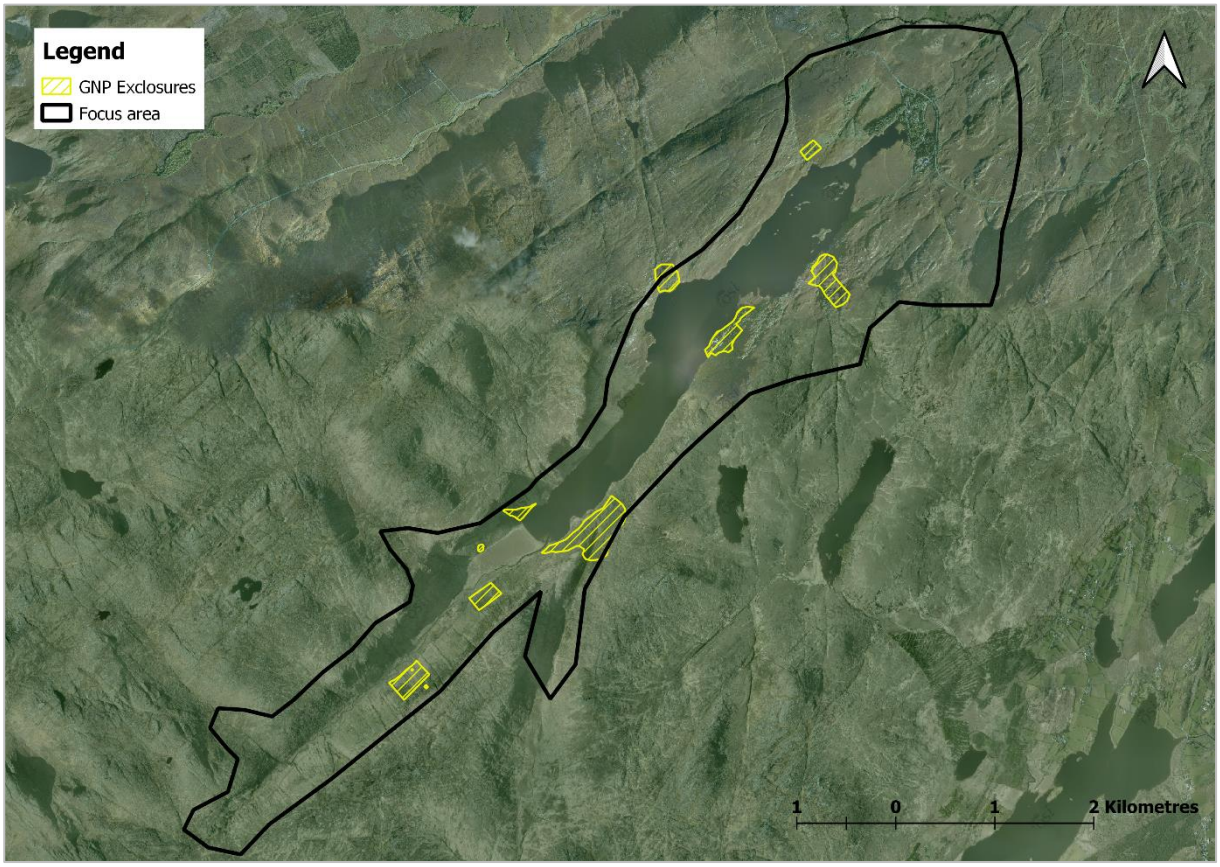

Figure 17. Existing exclosures in Glenveagh National Park. Ordnance Survey Ireland Licence No OSI-NMA-014. © Ordnance Survey Ireland Government of Ireland.

A recent study and deer management plan for Glenveagh (Burkitt, 2017, 2018) reports deer densities of approximately 5.0–6.0 / km^2 (range of 2.55 to 8.99 / km^2). Notwithstanding these low estimates there is widespread evidence throughout the Park of significant deer impacts which are rendering the existing woodlands unsustainable in the long term. There are very few areas or cases of woodland regeneration surviving the browsing impact of deer except where deer have been excluded by fences or by natural topography such as steep gullies or by occasional orientations of fallen timber. These provide direct evidence of the impact deer are having on the ecology of the National Park. Further evidence is provided from assessments within historic exclosures where there are cohorts of natural regeneration that were afforded temporary protection from deer and that have progressed to thicket and semi-mature stages as a result of that period of protection (Höna, 2009; pers. obs., June 2021). New woodland establishment and, potentially, expansion of existing woodland (for example, by higher levels of tree regeneration at woodland margins) will achieve greater success with an implemented deer management plan.

5.3 Points to consider with regard to deer fencing

The historic perimeter fence is not proposed as a viable resource for deer management in the Strategy. Evidence from Glenveagh's 100 years of deer fence management, and other similar estates worldwide, indicates that large fenced areas neither effectively exclude deer nor prevent their escape. Additionally, large fenced areas are not cost effective and resources are more efficiently deployed when they are focused on smaller fenced areas and active management (such as culling) over a larger area, rather than passive infrastructure (fencing). This also simulates a more natural environment with regard to deer use of cover in response to hunting pressures. Indeed, open range control of deer is considered closer to natural processes and more effective over a wider landscape where change is to be effected through natural regeneration. Newman *et al*. (2014b) recommend that large-scale, long-term fencing of oak woodlands be replaced by large herbivore management programmes, in order to ensure the conservation of diverse native woodland ecosystems, monitoring and adjusting large herbivore impacts through localised culling, to achieve specific long-term management objectives.

Ultimately, it is the level of grazing impact that is important in determining the sustainability of the woodlands at Glenveagh rather than deer density or numbers. From the survey work completed as part of this Strategy (unpublished results) it is evident that current impact levels are locally high, that woodland condition is generally poor, and that the woods are in an unsustainable state. The successful implementation of a revised deer management strategy, whereby deer densities are significantly reduced, will allow much of the natural tree regeneration to progress. The gradual release of currently regenerating native trees over a 10 to 20-year period would leave a legacy for 100 to 200 years. As such, the deer management element of this plan is one of the most important aspects of the proposed woodland management strategy.

5.4 Deer management strategy

It is recommended that significant action be taken at Glenveagh to implement a new deer management regime. The first step in such a regime would be to develop a comprehensive deer management strategy to inform all aspects of management of the deer herd to allow the development of self-sustaining, naturally functioning and expanding woodland. The strategy should address a diverse suite of elements. Below are given some of the main issues to be considered, but other issues would likely be identified in the course of preparing such a strategy.

- A dedicated deer management team should be established within the Park with the sole purpose of implementing deer management, and having duties such as culling, monitoring, and maintaining fences. This should be made up of a minimum of 4 x full-time professional staff or Full-Time Equivalents (FTEs) which may include a combination of a greater number of staff with other duties.

- Deer densities require significant reduction to a point where impacts from grazing are considered low. As such, the target should not be to achieve a specific deer density but rather to achieve a level of impact from grazers that is acceptable and allows woodland

recovery and, ultimately, expansion. Once this is achieved, deer densities then require maintenance at that level through continued culling and monitoring. A certain level of grazing in woodlands has been shown to be beneficial (Newman *et al*., 2014b) and prevents homogenisation of vegetation.

- Deer management staff time and resources should be dedicated to reducing deer densities. In this regard it should not be a requirement to remove all carcasses from the hill. This decision should be part of a wider long-term objective to operate as closed an ecological cycle within Glenveagh as possible. This concept is in keeping with the IUCN class of National Park that Ireland aims to manage Glenveagh as (CAT II), whereby there are no removals of natural materials from the Park's natural ecological system (Emmett Johnston, pers. comm.); this would also include other materials such as dead wood, felled timber and fish. To facilitate this, a Deer Protocol should be developed to allow for carcasses to be left on the hill to provide carrion as a food source for invertebrates and fungi, as well as larger scavengers such as golden eagles, ravens, foxes and badgers. This will also save staff significant time otherwise spent carrying / dragging animals off the mountain. The protocol will be clear as to when and where it is acceptable (or not) to leave a carcass for natural decomposition; for example, not to do so next to a stream or lake.

  It is recommended that a PhD study be initiated that would build on the existing body of international evidence (e.g., Flueck, 2009; Wolf *et al*., 2013; van Klink *et al*., 2020) and gather local scientific data to support this policy development and allow it to be implemented on a phased basis over time. This would include a system of labelling carcasses left on the hill and analysing, for example, decomposition time-frames, scavenger populations, changes in nutrient flow between trophic layers and the distribution patterns of seed as a result of the policy.

- Some of the existing deer exclosures should be repaired and some new, small-scale ones erected (see woodland conservation measures in Chapter 6).

- Monitoring of progress is important and should be conducted and documented. Monitoring protocols should be developed through the deer management strategy, and in association with the monitoring team at Glenveagh (see Chapter 9). A series of permanent deer impact assessment plots (suggested size of 20 m x 20 m) should be introduced across the property in areas inside and outside of deer fences, within or adjacent to woodland or areas of tree cover. The areas should have current regenerating trees present (albeit browsed) or should be areas suitable for woodland. Data recorded in these plots should include:
  - Number of seedlings, saplings and poles[1] present
  - Diversity of seedlings, saplings and poles present
  - Presence or absence of recent browsing
  - Presence or absence of other stem damage
  - Height and stem diameter records of selected (tagged) trees in each plot
  - Other condition indicators (to be determined by the deer management strategy)

  Many of the above data are recorded as part of the Annex I woodland monitoring surveys periodically carried out in Mullangore (see Appendix 5). As such, both sets of monitoring data are complementary.

- A public information project should be initiated which explains the importance of creating and maintaining a balance between the deer population and woodland ecology, and outlining the rationale behind the treatment of deer carcasses. The data from the deer impact assessment plots will be an important component of this project, including the visual evidence that will come from the Woodland and Tree Regeneration Management

[1] The term "seedling" in this report describes a young regenerating tree with DBH (diameter at breast height, i.e. at 1.3 m) <7 cm and height ≤25 cm. "Sapling" in this report is a young regenerating tree with DBH <7 cm and height 26-200 cm. "Pole" refers to young trees with DBH <7 cm and height >200 cm.

proposals set out below in Chapter 6. This function should be fulfilled by the education team at Glenveagh. In addition to this, any research roles that are filled to support this Strategy should also have a communication function whereby their work and findings are clearly accessible and communicated to the public and conservation sectors.

- Deer management is best practised at a landscape scale and agreements should be reached with neighbouring landowners to extend the deer management area outside the Park boundaries. This is in the interest of similar deer management objectives and practices being followed on neighbouring properties, whether farmed, under forestry or another land-use category.

- Linkages with other projects and other National Parks with similar issues should be sought whereby information and experiences can be shared. Some suggested projects include:
    - Baronscourt Estate, Co. Tyrone
    - Trees for Life (NGO) in Scotland
    - Wicklow Mountains National Park
    - Killarney National Park
    - Mar Lodge Estate, Cairngorms National Park, Scotland (see Rao, 2017)
    - Carrifran Wildwood Project, Scotland (see Ashmole & Ashmole, 2009)

Plate 7. Clockwise from bottom left: Heavily browsed birch and holly, rowan, aspen and oak – all unable to progress past the surrounding vegetation height. Photos by Paddy Purser.

Chapter 6 Woodland conservation and regeneration

6.1 Target woodland type

The main type of woodland that this Strategy aims to protect, enhance and recreate is Annex I Old oak woodland, including the intermediate stages in its development that may not yet conform to the definition of the Annex I habitat. Annex I Old oak woodland was described in some detail by Daly *et al*. (2023), and the description is reproduced in full in Box 3 at the end of this chapter.

Improving the ecological health of woodlands requires tackling on a number of fronts, including addressing the woodland structure (in terms of both age profile and physical layering), species diversity, area and degree of fragmentation. Measures proposed to control invasive species and grazing (primarily by deer) have been described in Chapters 4 and 5 respectively, and these will yield positive results for all of these aspects of woodland ecology. This chapter describes other management techniques, such as tree planting and the protection of regenerating seedlings and saplings, which will complement and support the measures that address the problems of overgrazing and invasive species. Chapter 7 deals specifically with measures that will help to increase the extent of woodland, either by creating entirely new areas of wooded habitat, or by facilitating the expansion of existing woodland. There is some overlap between the measures employed for both situations.

To assist woodland managers who will be tasked with implementing this Strategy, a set of management prescriptions have been developed for woodland polygons greater than 1 ha in size and made available to the management team as an Excel Workbook. Woodland polygons were mapped as per the methodology described in sections 3.2 and 3.3 and were then sampled on the ground. Their current status informs many of the prescriptions presented in the Workbook. It is important to state that these mapped areas or polygons are far from being homogeneous in terms of site type and condition as there is much internal site variation associated with topography and soils. The sections below describe the context in which the various prescriptions have been developed.

6.2 Woodland and tree regeneration management

In many parts of Glenveagh, both within existing woodland areas and outside of them, there are significant levels of natural regeneration of native trees that are unable to develop, due principally to high levels of browsing by deer. This means that in general terms there are good conditions already in play for seed production, dispersal and germination of many species. This is likely to continue for as long as the core woodland areas are present. As noted in Chapter 5, the successful implementation of the deer management strategy, whereby deer densities and grazing pressure are significantly reduced, will be key as it will allow much of this regeneration to progress to older age cohorts. This will be at a landscape level and will be transformative for the Park. However, it is anticipated that the deer management strategy will require a considerable number of years to achieve the required densities, and so, while bearing in mind the assertion of Newman *et al*. (2014b) regarding the greater efficacy of large herbivore management programmes, compared to permanent fencing, in the conservation of diverse native woodland ecosystems, it is recommended that interim action also be taken with regard to protecting existing regeneration and allowing it to develop past the seedling stage.

The preferred method of woodland expansion at Glenveagh is by protecting existing natural regeneration from local seed sources that has successfully germinated and adapted to local site conditions. While planting of nursery-grown trees has a role to play, this role should generally be regarded as supportive rather than leading. The role of planting is discussed separately below in section 6.4. The restoration and expansion of existing woodland through the use of natural regeneration can be achieved using a number of different methods:

1. Repair of existing deer fences

There are 11 deer fence exclosures throughout Glenveagh (Fig. 17), encompassing an area of approximately 60 ha. All of these are in various states of disrepair. It is clear from the stage of development of native trees within them that, for varying periods of time, these were effective at excluding deer. Inevitably, though, these get damaged over time (Plate 8) and require ongoing management, which has hitherto been lacking. However, the periodic success of some of these fences provides an indication of the impact deer are having on natural succession and colonisation of woodland. They also show that, notwithstanding the fact that effectiveness has been temporary, they can be a useful measure in restoring woodland and in releasing a new generation of woodland from seedling stage to thicket stage and further.

Within these fences are areas where browsing has become impactful again and there is value in repairing some of these (after first ensuring that no deer remain inside). The repair should include provision for deer to exit exclosures via ramps or other features that facilitate jumping out of, but not into, exclosures. In general terms, smaller exclosures are more effective as they are both less attractive for deer to enter and easier to monitor and maintain. Specific prescriptions in this regard are provided to management in an Excel Workbook with this Strategy (see notes Appendix 8). It is not proposed to restore the 45 km deer fence that was erected in the late 19th century as this is considered both impractical and ineffective.

Plate 8. Damaged fence with deer tracks in and out of same – Derrylahan. Photo by Paddy Purser.

2. Erection of new, small-scale deer exclosures

In addition to the existing exclosures referred to above, it is recommended that a series of smaller exclosures be used to protect existing regeneration from browsing. These are to be used in conjunction with the individual tree protective measures discussed in point 3 below. These new exclosures will be small in dimension (no larger than 40 m x 40 m) and erected in areas where there are good levels of existing regeneration and where topography allows. The dimensions will be dictated by practical considerations associated with topography and

access. Fences may be constructed conventionally using driven strainers and posts, or using the A-Frame "sit on top" system (see Appendix 6 for a draft specification).

The purpose of these exclosures is to facilitate the progression of existing, heavily browsed regeneration to thicket stage woodland and beyond; i.e., to a stage where trees are above browsing height and where deer damage to stems through fraying and stripping is unlikely to result in tree death. Some degree of follow-up maintenance in these areas will be required in the three or four seasons after erection of the exclosures. This will include monitoring of the fence line itself, to ensure that it is still secure, and also manual cleaning around emerging trees, particularly of bracken. Any invasive species occurring in these exclosures will be removed through the invasive species management conducted for the various woodland compartments.

Note that a number of new larger exclosures are also recommended, and these are discussed separately in point 4 below, as it will be possible to get Forest Service funding for these under either the Afforestation Scheme or the Woodland Creation on Public Lands Scheme.

Newman *et al*. (2014a) noted that plant community homogenisation (particularly in relation to Greater Wood-rush *Luzula sylvatica* and Bracken *Pteridium aquilinum*) may take place after 12 years of large herbivore exclusion, so the vegetation within the exclosures should be monitored with a view to determining not only the efficacy of the fencing in promoting regeneration, but also if / when the fencing should be removed to prevent such homogenisation from occurring. Monitoring is discussed in detail in Chapter 9.

3. Protection of individual regenerating trees

As previously discussed, there are significant levels of natural regeneration of native trees at Glenveagh that are currently unable to develop due to high levels of browsing by deer. It is recommended that an annual programme for individual tree protection be put in place. Specific compartments where this is appropriate are identified in the Excel Workbook being provided to managers of this Strategy. In general, this measure can be utilised in areas where current regeneration is sporadic or in small clumps, or in areas such as gullies and stream sides where deer fencing is not practical. This measure should be undertaken in three phases as follows:

Phase 1:

- Identify naturally regenerated trees that are struggling to emerge above the ground vegetation
- Install a short tree guard (approximately 60-80 cm in height) over the regenerated tree and secure the guard using either inserted bamboo cane(s) or a driven stake. Different tube suppliers will recommend different methods of securing the tube. Tubes can be of varying diameter but should have a minimum diameter of 10 cm
- Keep a record of the number of tubes installed per compartment per species
- Survey these tubes annually for a 1 to 3-year period and fix / replace any tubes that have become ineffective

Phase 2:

- Survey the Phase 1 work and for those trees that have developed to the top of, or are emerging out of the Phase 1 tube, remove the tube without damaging the tree
- Re-use or recycle the Phase 1 tubes
- Install a new, longer and wider tube over the tree (minimum tube height of 1.5 m, minimum tube diameter of 12 cm) and secure it with a robust driven stake
- Keep a record of the number of tubes installed per area per species
- Survey these tubes annually for a 1 to 3-year period and fix / replace any tubes that have become ineffective

Phase 3:

- Remove tube and stake once the tree has emerged from the top and is considered to be robust enough to be free standing
- Re-use or recycle the Phase 2 tubes

The purpose of the three phases is to facilitate hardier tree development and to avoid rapid growth in a tall tube used in a single phase that will not be hardy / sturdy / viable once the tube is removed. Apart from the physical protection of these trees, this measure will also help to fulfil an important educational function as it will clearly illustrate where trees / forests want to develop in the Park. For the duration of this work, the tubes will be visible in the landscape[2].

This is a measure that could potentially be implemented with the assistance of volunteers, particularly the Phase 1 work of finding regenerating seedlings and installing the shorter tubes. They could also assist with the careful removal of tubes in Phase 3. A short training exercise would be needed but this work is relatively safe, logical and hard to get wrong.

4. Utilisation of Forest Service scheme for new native woodland creation

A small number of larger areas with potential for afforestation using a combination of natural regeneration and planting have been identified as part of this plan, and appropriate prescriptions have been provided in the Excel Workbook provided to managers of this Strategy (see notes Appendix 8). These are predominantly bracken-dominated areas and are proposed for new deer-fenced exclosures. They have been selected in areas that meet the vegetative / soils criteria the Forest Service use for grant-aided native woodland establishment. It is recommended that applications be made to the Forest Service under either the Afforestation Scheme (Native Woodland Categories – GPC 9/10) or the Woodland Creation on Public Lands Scheme.

6.3 Conservation of existing native woodland

Strategic use of the Forest Service Native Woodland Conservation Scheme should be made to assist in the implementation of prescribed management in certain existing woodlands. This will significantly overlap with other aspects of this plan – deer management and invasive species management in particular. The Native Woodland Conservation Scheme can be used as a funding mechanism for these measures in circumstances where they are impacting on existing woodland areas, but additional conservation measures can also be utilised in existing woodland and funded by the scheme, such as:

- Enrichment planting – see section 6.4 below.
- Creation of dead wood (standing and fallen) from existing non-native trees – this is not a short-term priority (with the exception of Derrylahan Wood and some of the woods around the car park / visitor centre) but non-native beech (*Fagus sylvatica*) and European silver fir (*Abies alba*) in Mullangore wood could become more invasive as a result of more intensive deer management, and measures may be required to remove seed sources through dead-wooding / ring-barking in the medium to longer term.
- Establishment of monitoring plots – this measure is discussed fully in Chapter 9.

For each application to the Native Woodland Conservation Scheme, a specific plan must be prepared in which a set of measures will be prescribed for the area covered by the application. These measures will largely be drawn from those set out in this Strategy.

[2] Note that if this is considered inappropriate from a landscape perspective, then it may be appropriate to commission the production of wire tree guards that do not stand out in the landscape yet perform the same function as currently commercially available tree guards. If this measure is fully implemented, then there will be significant numbers of these guards required and a specific "Glenveagh Guard" could be commissioned. NPWS staff in the Wicklow Mountains National Park have developed a guard in conjunction with Luggala Estate in County Wicklow and it is being deployed with considerable success. The use of such a guard, while more costly initially, could result in the amalgamation of phases 1 and 2 above. These wire mesh guards are also invisible in the landscape, which is a significant advantage.

In addition to the use of the Native Woodland Conservation Scheme, native woodland conservation at Glenveagh should be supported by detailed scientific studies, as outlined in Chapter 11.

6.4 Enrichment planting

In certain circumstances it is recommended that "enrichment planting" be used as a measure in native woodland restoration and expansion. This is where nursery-grown stock is planted into areas where that species is not successfully regenerating but where it belongs as a component of the native woodland mix. Such circumstances would include:

- lack of sufficient seed sources in the locality
- insufficient shelter available for non-pioneering species to survive – enrichment planting is used in existing woodland once shelter starts to develop
- lack of birds or mammals that would normally disperse seed

Such planting will be in small groups with the purpose of diversifying woodlands and restoring native species composition. It is recommended that trees for enrichment planting be raised in the Glenveagh Castle gardens; this is discussed separately in Chapter 8.

6.5 Management of existing forest stands in car park / north end of lake

These areas are characterised by having a relatively high proportion of non-native tree species. It is recommended that these areas be transitioned slowly to native woodland using a range of close-to-nature forest management techniques. This will be achieved over an undefined number of interventions at approximately 6-year intervals over a 30- to 40-year period. At each intervention, the stands should be professionally marked for thinning, with the thinning entirely dedicated to the promotion of native species, the restructuring of the canopy and the development of appropriate ground cover, including the release of native regeneration. This strategy is obviously dependent on the successful implementation of the overall deer management strategy whereby deer densities are reduced to levels that allow regeneration of native seedlings and their recruitment into the forest canopy structure. It is also dependent on the successful implementation of the overall invasive species management plan, such that opportunities created for native regeneration are not seized by invasive species.

Consideration should also be given to developing a designated community woodland space, specific for community involvement, close to the Visitor Centre and Derrylahan. Developing these areas as a nature walk for visitors would build on what has already been done in other parts of the wood. Support funding may be available through the Native Woodland Scheme.

The interventions mentioned above will be non-commercial, and thinnings will generally be left as either standing or fallen deadwood in the forest. Marking will indicate the kind of treatment that is appropriate for each tree marked. These will include:

- **Felling to Waste** – the simple felling of non-native trees to:
    - improve light conditions for regeneration
    - release native species that are being dominated
    - reduce the production of non-native seed in the forest
    - provide fallen deadwood – fallen trees can either be left with branches on, which will help provide thicket conditions and in some cases provide local protection from deer browsing, or they can be de-limbed and cross-cut to facilitate easier access through the wood for the public.

Plate 9. Conifer woodland at north end of lake where windblow has occurred and fallen stems have excluded deer, resulting in native woodland developing in the improved light and browse-free conditions. Photo by Paddy Purser.

- **Dead-wooding** – the "ring-barking" to result in the death of the tree while still standing. This can be carried out in order to:
    - Provide standing deadwood and future habitat for a range of fungi and invertebrates and therefore support for the wider food chain
    - Avoid damaging native trees in situations where felling would inevitably cause such damage
    - Improve light conditions for regeneration

  Note that dead-wooding is not an appropriate measure in areas adjacent to public paths or in other areas of high public footfall, although the surgical topping of trees in such areas can make them safe and become an educational feature for visitors.

- **Halo Thinning** – the felling / dead-wooding of trees around a particular tree or group of trees to be favoured (Plate 10). This is done in order to:
    - Allow crown development of the favoured tree(s)
    - Provide greater opportunities for seed production and dispersal from favoured trees
    - Improve light conditions for regeneration

In addition to the thinning interventions, there will be a requirement for other management interventions, which will include:

- Treatment or removal of non-native regeneration of shrubs and trees. In the case of newly regenerating non-native trees, these can generally be manually pulled and left lying *in situ*.
- Enrichment planting whereby native species are introduced through planting in areas where:
    - regeneration has not been / is unlikely to be successful.
    - There is no local seed source for the desired species

  Enrichment planting can also be incorporated into education programmes / volunteer workshops.

6.6 Appointment of a Woodland Manager for Glenveagh

It is recommended that a full-time staff member be appointed at Glenveagh dedicated to implementation of the woodland management Strategy and all of the recommendations above. This person would require the support of two professional staff or Full Time Equivalents (FTEs) which could include a combination of a greater number of staff with other duties.

Plate 10. Oak amongst lodgepole pine with a light understorey of holly – a situation where halo thinning around the oak would be used to good effect. Photo by Paddy Purser.

Box 3. Description of Annex I Old oak woodland (91A0) from Daly *et al.* (2023)

The acidophilous *Quercus petraea* woods that conform to Annex I habitat 91A0 in the interpretation manual of European Union habitats (CEC, 2013) primarily correspond to the WL1 *Quercus petraea – Luzula sylvatica* group described in the Irish Vegetation Classification (IVC; Perrin, 2016). All vegetation communities in this group have an affinity to the Annex I habitat: WL1A *Quercus robur – Luzula sylvatica* woodland (78.7% affinity), WL1B *Quercus petraea – Luzula sylvatica* woodland (97.9% affinity), WL1C *Quercus petraea – Corylus avellana* woodland (66.3% affinity) and WL1D *Quercus petraea – Vaccinium myrtillus* woodland (98.7% affinity). The interpretation manual gives little information on the habitat beyond describing it as having "many ferns, mosses, lichens and evergreen bushes … including *Arbutus unedo*", and only lists three indicative taxa: *Quercus petraea, Ilex aquifolium* and *Blechnum* ssp. (*sic*). Due to frequent planting of other *Quercus* species into Irish sessile oak woods, a broader interpretation of the habitat has been taken for the assessment reported here to include woods with *Quercus* x *rosacea* (hybrid between *Q. petraea* and *Q. robur*) and, in a small number of cases, *Quercus robur*, provided the ground flora is acidic in nature; ideally, however, *Q. petraea* should also be present. Effectively, all three sub-associations of the Blechno-Quercetum petraeae association are regarded as the Annex I habitat: sub-association typicum, sub-association scapanietosum and sub-association coryletosum.

An old sessile oak wood is characterised by a number of diverse elements coming together in a fully functioning system. The soil is usually acidic, often a podzol, brown earth or grey-brown podzol, and generally well drained. This supports a characteristic flora. The woodland itself is typically multi-layered, with well-developed sessile oak woods having a canopy, understorey, shrub, dwarf shrub, field and ground layers. A good proportion of the canopy should be composed of *Quercus petraea* or the hybrid *Quercus* x *rosacea*, although other native species such as *Betula* spp. And *Sorbus aucuparia* also occur.

The understorey and shrub layers, if present, are generally made up of shorter and/or younger individuals of the above species, with *Ilex aquifolium* and *Corylus avellana* generally frequent in the shrub layer. A dwarf shrub layer of low woody species such as *Vaccinium myrtillus* and *Calluna vulgaris* often occurs. In Ireland, a field layer of ferns such as *Blechnum spicant*, *Polypodium* spp. And *Dryopteris* spp., and flowering plants such as *Luzula sylvatica* and *Oxalis acetosella* are typical. *Hyacinthoides non-scripta* may be present on more nutrient-rich soils. The ground (bryophyte) layer is usually well developed, consisting of a diverse range of mosses, including *Rhytidiadelphus* spp., *Dicranum* spp., *Polytrichum formosum, Hylocomium brevirostre, Mnium hornum, Plagiothecium undulatum, Pseudotaxiphyllum elegans*, and liverworts such as *Diplophyllum albicans, Saccogyna viticulosa* and *Scapania* spp. Other liverwort species, such as *Calypogeia* spp., *Frullania* spp. *Plagiochila* spp., *Lepidozia* spp. And *Bazzania trilobata*, may also occur, particularly in western sessile oak woodlands, where epiphytes are typically abundant. Lichens present may include *Lobaria* spp., *Pannaria* spp., *Thelotrema lepadinum* and *Normandina pulchella* (James *et al.,* 1977; JNCC, 2019).

An oak wood should be structurally diverse, that is, it should have a range of age classes, ideally including seedlings, saplings, poles, young, old and senescent trees. Conditions suitable for the regeneration of the main tree species should be present, including canopy gaps for oak regeneration. Structural diversity is also provided by the tree species themselves, which vary from smooth-barked species such as *Ilex aquifolium* to rough-barked species such as *Quercus petraea*; this diversity in substrate is important for epiphytic lichen and bryophyte species, and for invertebrates.

A well-functioning oak wood will generally have a good quantity of dead wood and a range of dead wood types, including coarse and fine, standing and fallen, which provide a variety of niches for animals (both vertebrates and invertebrates), fungi and epiphytes. Oak woods also provide habitat for grazers and browsers, and the large amounts of seeds, berries and nuts are a valuable source of food. An appropriate level of grazing is essential to maintain a proper species balance so that no single species becomes dominant. However, too much or too little grazing can disrupt the system and may have unwanted consequences such as a reduction in tree regeneration or proliferation of ground-covering species such as brambles or bracken.

Chapter 7 Woodland conversion and establishment

7.1 Points to consider

Chapter 6 addressed the conservation and enhancement of existing woodland by a combination of methods such as reducing deer numbers, deer fencing, protecting *in situ* seedlings from grazing with deer guards, and enrichment planting. Many of these methods will also be employed for woodland conversion (e.g., from non-native to native woodland) and woodland establishment (afforestation of currently unwooded areas). However, there may be additional issues pertinent to these approaches that will need careful consideration, particularly where woodland establishment is planned. They are listed below.

- Appropriate Assessments will likely be required to address the situation where other qualifying interests (QIs) of the Cloghernagore Bog and Glenveagh National Park SAC (002047) and Derryveagh and Glendowan Mountains SPA (004039) may be affected by measures recommended by this Strategy. For example, woodland may naturally establish on Annex I Wet heath, thus reducing its extent; or clearance of Rhododendron has the potent to impact on Killarney fern habitat. Such gains and losses would be viewed in the context of the SAC as a whole, not just within the Park. To ensure that the site-specific conservation objectives for all QIs within the SAC and SPA are met, an Appropriate Assessment will help to determine if the measure will be permitted to go ahead, or if mitigation measures (such as habitat recreation elsewhere) will be required to ensure that the conservation objectives for the habitat or species at Glenveagh is not adversely affected. A habitat map of the SAC would assist in putting any potential negative impacts on habitats into the context of the overall habitat resource within the SAC.
- It is strongly recommended that an up-to-date habitat map for the entirety of the Cloghernagore Bog and Glenveagh National Park SAC (002047) be commissioned. The most recent comprehensive habitat mapping exercise at Glenveagh was carried out in 1989 (Weekes, 1990) and covered most of what is now within the National Park boundary, but not the wider SAC. Habitat areas that may be subject to change from the implementation of the measures recommended in this Strategy require a baseline, particularly where other non-woodland QIs may be affected. This information will also be needed to update the Natura 2000 data forms for the SAC.
- Woodland expansion targets may be set, such as a certain area of habitat to be rewooded over a certain number of years, but flexibility may be required depending on the rate at which this occurs.
- Landscape level changes will result from deer management and invasive species management. This will require adaptability in decision-making with relation to proposed planting areas.
- Descriptions will be required of soils / vegetation types where woodland is expected / not expected to populate.[3]
- Target areas for proactive native woodland planting using the Forest Service Afforestation Scheme, i.e., areas that would be readily assessed by the Forest Service as suitable for woodland and that can be deer-fenced and planted to quickly increase the footprint of native woodland, providing both shelter and seed source for future landscape level regeneration. The aim of such proactive planting would be to kick-start the process of woodland establishment and would supplement, rather than replace, natural woodland recolonisation that would occur over a longer period of time. Material used should be of local provenance, ideally originating from with the Park. The establishment of an in-house nursery to support this is discussed in Chapter 8.
- Develop plans for transformation to native woodland of areas around the visitor centre and car parks which currently have high levels of non-native conifers present

[3] The Excel workbook supplied as part of this project describes soil characteristics of a number of areas proposed for planting

- Utilise the Native Woodland Conservation Scheme to assist in deer management / invasive species management in certain woodland compartments.
- Phase out non-native tree species (e.g., beech, European larch and European Silver fir) over time in favour of natives, allowing the non-native trees to contribute to the woodland ecosystem as either standing or fallen deadwood, helping to enrich the site.
- As well as the potential woodland establishment areas identified in section 3.3, further woodland creation will be needed to join these up and improve habitat connectivity.
- Future management of conifer plantations on peat within the Park must be considered. Restoration of these to blanket bog will likely be the most suitable option, if soil conditions allow; replanting with native broadleaves may be an option if this is not the case. Replanting with conifers should not be considered. Conifer plantations at Kingarrow, Ardachrin and Meenadohan should be high priority for restoration.
- State-owned lands, such as Coillte, bordering the Park should be considered for conversion away from conifer plantations to nature conservation.
- Removal of any timber from these areas, and any subsequent works such as drain blocking and habitat rehabilitation, will need careful consideration, particularly in relation to Freshwater Pearl Mussel. A number of catchments for the species occur within the Park and the greater SAC, including the Glaskeelan catchment, which is one of the top Freshwater Pearl Mussel sites in the country.

7.2 Historical woodland: Potential Woodland Establishment Areas (PWEAs)

In Chapter 3 of this report, it was shown that 110.2 ha of the study area were formerly wooded on the historical six-inch OS maps. These areas represent Potential Woodland Establishment Areas (PWEAs). An overview of PWEAs in the study area is presented in Figs. 18-19. Based on an analysis of the historical data, the following PWEAs have been provisionally identified:

On the southeast-facing slopes of the main glen, there appears to be scope to:

- extend and link up the extant woodland fragments at Derrylahan;
- extend the extant woodland that currently straddles the Sruhannacullia River at Derrylahan;
- link up the extant woodland blocks and fragments on the hillsides around Derrybeg/Keambeg (i.e., the location of NSNW site 1424 Derrybeg; Perrin *et al*., 2008);
- link the fragmented stands on the lower slopes of Crockmulroney.

On the northwest-facing slopes of the main glen, there is scope to:

- expand the woodlands around Glenveagh Castle, in particular the open area to the northeast of the Castle gardens and extending the woodland northwards in general;
- extend Mullangore woodland at the northern end and link it with the woodlands that surround Glenveagh Castle;
- extend Mullangore woodland into Glenlack, focusing on the northwest-facing slopes of the Glenlack valley;
- extend Mullangore woodland at the southern end, particularly upslope of the extant stand;
- reinstate the extensive woodland as it appears on third edition six-inch maps at Poll Garbh.

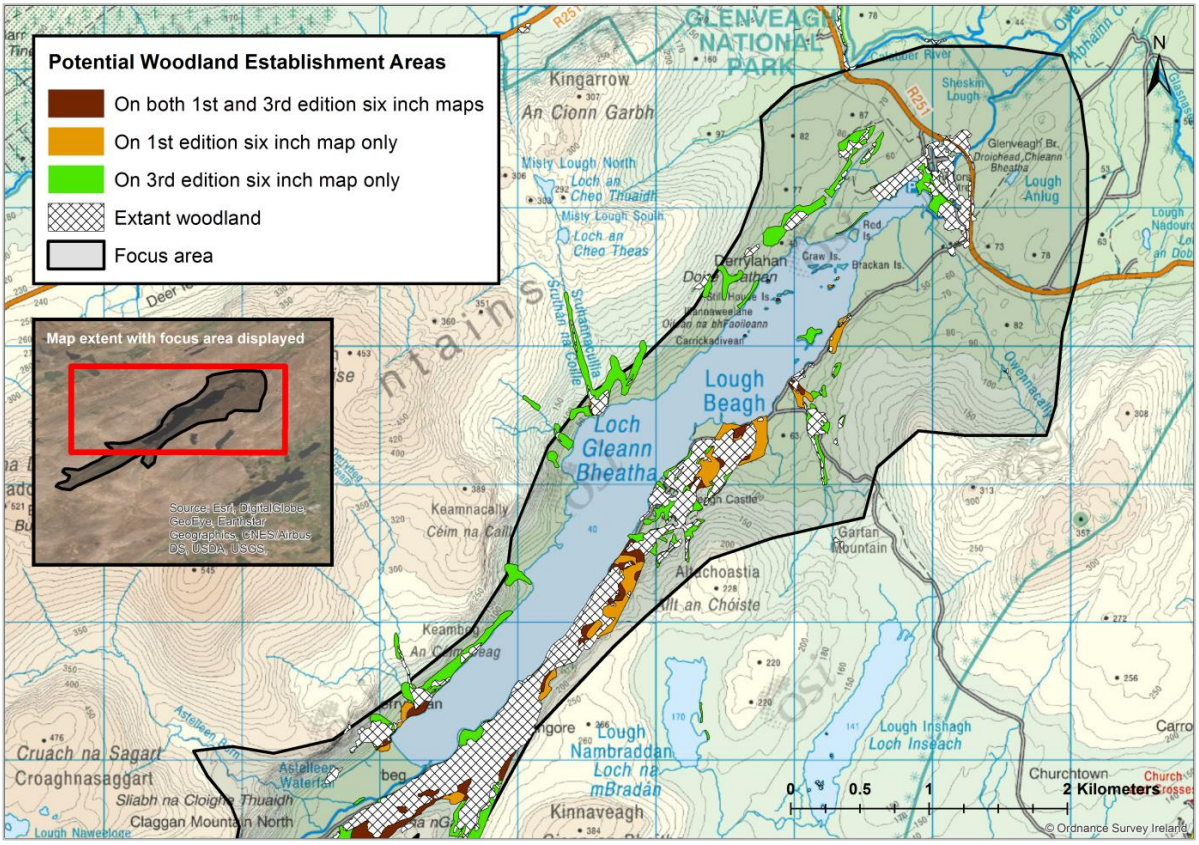

Figure 18. Potential woodland establishment areas (PWEAs) derived from historical six-inch OS maps in the northern section of the focus area. Extant woodland is also displayed. Ordnance Survey Ireland Licence No OSI-NMA-014. © Ordnance Survey Ireland Government of Ireland.

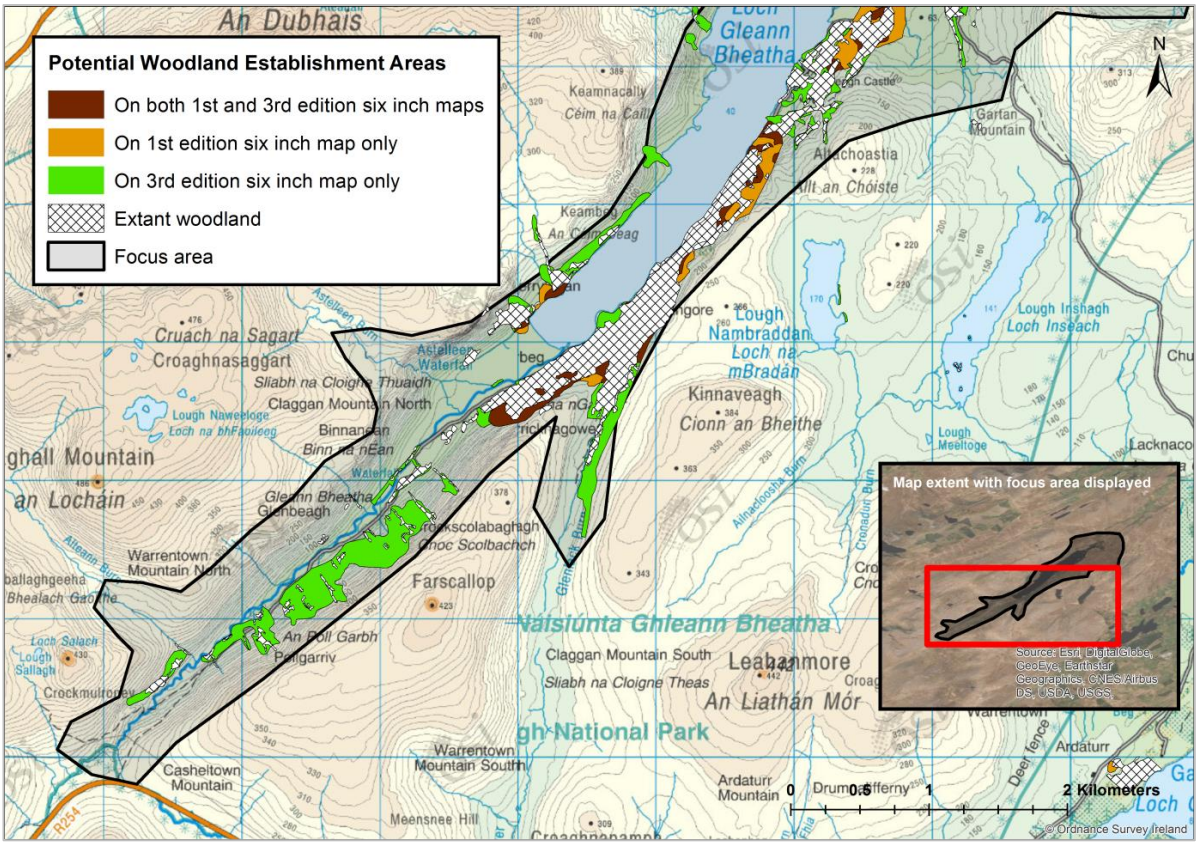

Figure 19. Potential woodland establishment areas (PWEAs) derived from historical six-inch OS maps in the southern section of the focus area. Extant woodland is also displayed. Ordnance Survey Ireland Licence No OSI-NMA-014. © Ordnance Survey Ireland Government of Ireland.

7.3 Further research on Potential Woodland Establishment Areas

The Potential Woodland Establishment Areas (PWEAs) identified and discussed in Chapter 3 were assessed in the field in June 2021. Surveyors recorded the current habitats present according to Fossitt (2000) and, where applicable, Annex I habitat type. Level of infestation by invasive species was also scored. Preliminary analysis indicates that most PWEAs were Annex I Wet heath. However, other areas with dense bracken may be more suitable as the presence of bracken indicates deeper mineral soil.

Research on antiquity (Chapter 3) also highlighted that the Potential Woodland Establishment Areas (PWEAs) solely derived from the historic OS six-inch maps should not be the only areas considered for new plantings, with all evidence indicating that the extent of the woodland was much greater during the Middle Ages.

Chapter 8 Acorn to tree, nursery and seed stands

8.1 Planting material and genetic conservation

In addition to the specific woodland management measures associated with different locations within Glenveagh, a number of other initiatives are recommended to support the overall strategy. These mainly relate to the provision of sufficient planting material of local provenance to support the objectives of native woodland establishment in the Park. Developing an "acorn-to-tree" approach to conserving, propagating and establishing native trees, particularly locally sourced trees from within the Park and the north-western region, was identified early on as being a key factor in helping to deliver the aims of the Strategy. This initiative can also be regarded as a means of conserving genetic diversity, both from within Glenveagh and from Donegal as a whole. Provision has already been made in Glenveagh for conserving the genotype of the rare native Scots pine from Co. Clare.

Establishing an on-site nursery will ensure a permanent supply of locally sourced woodland plants for planting up as required. Further recommendations regarding planting are provided in Chapter 6. As plant material becomes available in the nursery, selected material can be dedicated to the establishment of conservation plantations of key major species such as oak and birch, and key minor species such as juniper, yew, aspen and rock whitebeam (*Sorbus rupicola*). Some of the space in the nursery could be used for seed orcharding. There are already healthy 15-year-old specimens of rock whitebeam and Irish whitebeam (*Sorbus hibernica*) in cultivation in the Glenveagh Castle gardens which are reliable sources of seed, and the Castle gardens currently act as a seed orchard for other minor species such as guelder rose, aspen, hawthorn, spindle and bird cherry (S. Ó Gaoithín, pers. comm).

8.2 Issues to be considered in establishing a tree nursery

Work is ongoing regarding licensing issues to allow collection and registration of suitable material from approved seed stands. There are currently five registered oak (*Quercus petraea*) seed stands in Co. Donegal from which material may be gathered by licensed collectors: Mullangore, Rathmullan, Derk More, Ballyarr and Greenan (Ardnamona), and new additions can be proposed to the Department of Agriculture, Food and the Marine (DAFM), which is the organisation responsible for maintaining the register (B. Clifford, DAFM, pers. comm.).

Some of the issues to consider in relation to establishing a nursery of stock for use within the Park (and potentially its hinterland) include:

- Seed stand(s) used for collection – Local provenance from within Glenveagh is preferable for material to be planted within the Park, but the other Donegal woodlands may be more suitable for use outside the Park. Genetic studies may further inform this decision, and research is currently ongoing on elucidating the genetic diversity and origins of Glenveagh oak (Colin Kelleher, pers. comm.).
- Propagation – Currently some propagation is carried out at Glenveagh Castle gardens, including some 2,000 individuals of native Scots pine from Rockforest in Co. Clare. However, given the amount of material that will be required, both for serving Glenveagh itself and the wider area, a larger space will be needed. Work is already well under way on identifying a suitable area for use as additional nursery space and scoping out its requirements.
- Planting out – There may be other requirements in relation to planting out, whether in Glenveagh or elsewhere in Donegal, using material propagated in Glenveagh. Appropriate licensing and assessment protocols will be followed.
- Regulation of seed collection is required in registered seed stands in the wider seed source catchment area for the Strategy, e.g., on a permit basis (as in Rockforest for native Scots pine), where only registered collectors for commercial purposes are allowed to collect seed and the permission of the landowner (in this case, NPWS) is required. A protocol on seed collection is required to assist regional staff in managing the activity.

8.3 Key functions of a new Glenveagh nursery

Glenveagh Castle gardens should develop capacity for raising native trees that can be used for enrichment planting in the wider Glenveagh area. Box 4 outlines a proposed schedule by which this could be achieved (devised by Seán Ó Gaoithín, pers. comm).

The focus should be on the less successfully regenerating species in the woodlands and Glenveagh area, such as oak (locally sourced oak is not currently available commercially), Scots pine, aspen, yew, juniper (for wider planting / re-establishment outside of the woodlands) and whitebeam (*Sorbus hibernica*).

The nursery's remit should include the collection of locally sourced seed / cuttings to ensure, where possible, that local provenances are utilised. There is a strong likelihood that seedlings produced will be required for grant-aided work at Glenveagh, in which case Official Certificates of Provenance will be required.

Engagement with the Forest Service of DAFM, as the regulator of such activities, is essential to:

- Register as a supplier of forest reproductive material (both as seed collectors and nursery producers / suppliers)
- Utilise existing seed stands at Glenveagh and potentially register further seed stands where seed is collected and can be traced through Official Certificates of Provenance
- Receive other advice on forest seed and plant regulations

This work will require a dedicated resource within the Glenveagh Castle garden, so it is recommended that 1 x full-time professional staff member, supported by a full-time operative (or FTE), be appointed to develop the native tree (and other flora if appropriate) elements of the garden with the specific tasks of sourcing appropriate seed stock from both within and beyond Glenveagh, growing it in the Glenveagh garden / nursery and subsequently providing trees for enrichment planting in Glenveagh.

Plate 11. Scots pine seedlings from native Co. Clare population *in situ* in Glenveagh Castle gardens. Photo by Orla Daly.

Box 4: Proposed plant production schedule for new plant nursery in Glenveagh (Devised by Seán Ó Gaoithín)

Years 1 and 2

- Hire dedicated staff to run the nursery, develop a collecting strategy, maintain accessioning records for all plant material, establish seed sources, collect and propagate seed and cuttings, establish a permanent collection in the nursery, and expand production of key species. Begin to transplant native stock to woodland locations, continue to expand production.

Years 3 to 5

- Full capacity production reached. Up to 17,000 - 20,000 trees in production per annum. Continue to transplant native material to woodlands, and deal with any reinvasion of exotic species.

Years 5 to 10

- Establish a closed canopy of native material in all designated woodlands

Seasonal Tasks

- Autumn (August to October): main season for seed collection, seed cleaning, seed treatment, cuttings, pest control (mice), accession records (6 weeks), nursery soil preparation (2 weeks), weed control and nursery transplanting (4 weeks)
- Winter (November to January): transplanting bare root trees (4 weeks), control of invasive species (6 weeks), pest and disease control in nursery, labelling (2 weeks)
- Spring (February to April): seed sowing, propagation, watering, weed control record keeping, (4 weeks), transplant seedlings (4 weeks), control of invasives (4 weeks)
- Summer (May to July): weed control around newly planted trees (2 weeks), seed collecting, propagation (2 weeks), control of invasive species (8 weeks)

Chapter 9 Monitoring

9.1 The need for monitoring

On-going monitoring is regarded as essential to the success of this Strategy, and should be carried out not just as a task in itself but with the recognition that the results of monitoring may require flexibility and adaptability in relation to the operation of the Strategy. Monitoring is needed to ascertain if the measures being implemented are having the desired result. For example, if monitoring clearly indicates that the condition of Annex I woodland habitat is not improving with the current management prescriptions, the reason for this should be investigated and the management practices should be adjusted as appropriate to bring about the required improvement. Timely monitoring and documentation of findings ensures that measures are optimised so that the objectives of the Strategy will be achieved.

Monitoring is also required to ensure that the implementation of the Strategy will not adversely affect non-target (i.e., non-woodland) habitats or species, particularly where these are qualifying interests of the SAC or SPA. This should be assessed with reference to the site-specific conservation objectives for the SAC and SPA. Appropriate assessments will likely be required to address the situation where other qualifying interests of the SAC may be affected by measures carried out for this Strategy, such as the establishment of new young woodland on Annex I Wet heath, or clearance of Rhododendron in areas of Killarney fern habitat. However, longer-term monitoring may also be required, particularly in situations where mitigation measures for non-woodland habitats and species have been implemented.

For every measure being implemented, each has its own set of targets to be met. However, while the measures may be diverse, the targets are often complementary; for example, reducing grazing and controlling invasive species may both lead to increased numbers of saplings and native tree cover expansion. For each conservation measure being carried out, the desired outcome of a particular measure must be clearly defined, and should have measurable criteria and targets that indicate success. A comprehensive monitoring programme will assess whether or not these targets have been met.

A monitoring team should be established, made up of existing staff members, who will have the responsibility of designing and implementing a coordinated monitoring programme that tracks all aspects of woodland recovery occurring as part of the implementation of this Strategy.

9.2 Monitoring required as part of this Strategy

Monitoring for specific purposes is already taking place in Glenveagh:

- Assessment of Annex I Old oak woodland for Article 17 reporting
    - This is a specific monitoring programme that assesses the conservation status of Annex I woodland at a sub-sample of sites throughout the country, one of these sites being Mullangore, Glenveagh. Further information on this assessment process is given in Appendix 5, including the assessment results achieved by Mullangore in the most recent assessment, carried out in 2018.
- Invasive species
    - Areas treated for invasive rhododendron are checked to verify if they remain clear of infestation.

These monitoring programmes will continue regardless of this Strategy, and the results can be integrated into the overall Strategy monitoring programme. However, a wider monitoring programme is needed to assess the effectiveness of individual components of the Strategy, including (but not necessarily limited to) monitoring of the following:

- Invasive species levels in conjunction with a revised invasive species strategy
- Impact of deer on seedlings and saplings in conjunction with increased culling
- Integrity of deer guards and replacement of these as necessary

- Integrity of fence lines to ensure that any breaches are identified and repaired, with no deer on the inside
- Assessment of the conservation status of Annex I Old oak woodland throughout the entire SAC, not just in Mullangore
- Expansion of existing woodland
- Establishment of new woodland
- Efficacy of messaging provided by the education/communication group
- Impacts of climate change on woodland
- Scientific research projects taking place in Glenveagh

9.3 Points to consider for plot-based monitoring

The four monitoring plots periodically revisited in Mullangore are not, on their own, adequate to assess the woodland improvements which this Strategy aims to bring about. However, their findings can be incorporated into the Strategy's monitoring programme. Monitoring the efficacy of the various conservation measures will require the establishment of a network of woodland monitoring plots, additional to those already established in Mullangore. The number of plots must be sufficient to assess the area of target habitat adequately. The larger the area to be assessed overall, the larger the number of plots. An initial figure of 16-20 plots seems reasonable to begin with, but use of paired plots may require a larger number, and more plots may be required as measures are rolled out.

Baseline data must be recorded at the monitoring plots before the measures are implemented. The monitoring team will decide the nature of the baseline data to be collected at each plot, e.g., whether to record full relevés, with a comprehensive list of all species and their percentage covers, or whether it will suffice to record a sub-set of data that will provide an adequate basis for comparisons in later years.

Monitoring data at the plots should then be recorded on an annual or 3-yearly basis, or at a frequency to be determined by the monitoring team. A monitoring plot size of 20 m x 20 m is suggested, to allow compatibility with the existing Mullangore assessment plots, but other sizes may be more appropriate in other situations, e.g., the entire area of a small fenced enclosure.

Monitoring should take account of the aim of the measure. This should be clearly defined at the outset. A number of scenarios are presented below as examples of how to determine what monitoring is appropriate, but many others will exist.

Scenario 1:

- Measure: Erect small exclosures outside woodland
- Measure aim: Protect seedlings from grazers and aid woodland establishment in unwooded areas
- Purpose of monitoring: Examine the effectiveness of the exclosures by comparing numbers of seedlings inside and outside the exclosures,
- Requirement: Monitoring plots both inside and outside of exclosures to compare numbers of seedlings in grazed and ungrazed areas in addition to year-on-year changes within the monitoring plots.

Scenario 2:

- Measure: Erect large exclosures in wooded areas
- Measure aim: Protect woodland against overgrazing and improve structure of existing woodland
- Purpose of monitoring: Examine the effectiveness of the exclosures by comparing diversity of field and shrub layers inside and outside the exclosures, and by comparing seedling/sapling numbers inside and outside the exclosures

- Requirement: Monitoring plots both inside and outside of exclosures in addition to year-on-year changes within the monitoring plots to compare field and shrub cover and diversity, and seedling/sapling numbers, in grazed and ungrazed woodland.

Scenario 3:

- Measure: Control deer numbers by culling
- Measure aim: Promote woodland expansion
- Purpose of monitoring: Examine if deer control is leading to expansion at woodland edges through development of scrub and tree seedlings at the woodland edge
- Requirement: Monitoring plots at edge of woodland to monitor the progress of woodland expansion over time, by estimating cover of scrub and counting new tree/shrub seedlings in successive years.

A similar step-by-step rationale should be employed for all measures. As the desired outcome of different measures may be similar, monitoring plots may be used to examine the progress of several measures at once. The data recorded as part of the Article 17 assessment process could be used as a template, as the information gathered is comprehensive and covers many of the aspects needed for monitoring progress of the Strategy measures. More details of the data recorded for that project are supplied in Appendix 5, and an in-depth discussion is provided in Daly *et al*. (2023).

Currently, four plots measuring 20 m x 20 m are used in the Mullangore assessments. This size would be suitable for the Deer Impact Assessment plots mentioned in Chapter 5, and for tracking the success of woodland establishment and woodland expansion. It would also allow Annex I Old oak woodland in the greater Park area, outside Mullangore, to be assessed in the same way as Mullangore, thereby facilitating two-way data flow between monitoring for the Strategy and for Article 17 reporting.

The number of additional monitoring plots should be calculated based on the area of habitat that is being assessed, taking account of whether or not comparison plots are required, such as in scenarios 1 and 2 above, where comparisons between grazed and ungrazed areas are required. It is recommended that baseline monitoring plots be established as soon as possible, ideally 2023. The frequency of monitoring after baseline surveys should be determined by the monitoring team, and is likely to change as the measures take effect. For example, annual monitoring might be required in the early years of the Strategy while measures are being fine-tuned. After that, frequency might be decreased, with 6-yearly monitoring coinciding with the Article 17 reporting phases, or 2 to 3-yearly monitoring being required for invasive species monitoring.

Fixed point photography has been used to good effect in other woodland regeneration studies in Ireland such as the resurveys of the People's Millennium Forests (see Perrin 2004; Perrin *et al*., 2009; Daly *et al*., 2019). Good-quality photographs from a standard vantage point (and if possible, from a standard camera type) across a number of years offer invaluable information on the progress of regeneration and woodland recovery. They are also invaluable when communicating the changes resulting from the Strategy to a wider audience. Progress could be tracked across a swathe of habitat, such as a 5m or 10m-wide transect, as was used in the study initiated by Perrin (2004). One way to ensure consistency across years would be to erect permanent photography posts such that a photograph is taken from a set height and location, with the direction of view established on the post either by a cradle for the camera or a direction marker.

A further variation on this approach would be to take 360° photos from a fixed point. These provide new opportunities to create a wholly objective record of woodland structure and vegetation at a particular time and place. These cameras are becoming more common and affordable and even when viewed in cheap cardboard devices can give an immersive experience of standing in the middle of woodland, allowing the viewer to look at the vegetation at their feet, in the shrub layer and also in the canopy. This could be used initially to present woodland views in different seasons. When comparing views from different years, the changes following removal

of invasive species, the growth of native woodland planting and the development of the ground flora and shrub layer as grazers are reduced will be evident. Such views would be an irreplaceable record of the changes resulting from the Strategy and, with a Virtual Reality display in the visitor centre, could be viewed throughout the lifetime of the Strategy and beyond.

Over the years during which the Strategy operates, monitoring and assessment of the woodlands at Glenveagh will continue, primarily to assess the effectiveness of the Strategy, but also as part of our obligations with relation to Article 17 of the EU Habitats Directive. The aim of the Strategy monitoring programme is to track how the condition of the woodland is improving as a result of the conservation efforts being made, particularly in relation to the control of deer and invasive species, and to see how improvements may be effected in the future: it is not merely a question of going through the motions of the process. While it is true that implementing any of the actions proposed in this strategy will improve the conservation assessment results that feed into the Article 17 report (even if only by improving the site's future prospects), it is the effects on the structure and processes of the woodland – such as improvements in tree regeneration, age structure and connectivity between woodland blocks – that should be the main concern.

Chapter 10 Spatial zoning

Initial spatial zoning has been developed for the Strategy using a Geographic Information System (GIS). Through this process, each of the extant woodland blocks and the Potential Woodland Establishment Areas for which there was a specific task under the Strategy are identified and zoned. The spatial zoning and the invasive species management require an integrated approach, so the framework builds on the management compartments devised for the draft Invasive Species Management Plan 2017-2026 (Aulino Wann & Associates, 2017) and also incorporates the Deer Management Units from Burkitt (2017).

As noted in Chapter 4, the GIS for the Invasive Species Management Plan is organised in a non-standard way, so some revision of the shapefile containing the compartments was conducted such that it could be utilised. An interim shapefile was created (*Interim_ISM_Compartments_GNP.shp*) which:

- Removes overlapping polygons,
- Removes gaps and slivers,
- Extends some compartments to incorporate all extant woodland in the main valley,
- Realigns compartment boundaries to, where possible, avoid splitting woodland blocks between compartments,
- Introduces an extra sub-compartment where part of the main Mullangore woodland was included in a large mainly unwooded compartment (Compartment 21),
- Removes the compartments outside the Woodland Strategy focus area.

It was not possible to remove all instances where woodland blocks straddled compartment boundaries but these were limited to the main woodland block of Mullangore, sections around the Castle garden, and a woodland block which is bisected by the road toward Lough Inshagh. Additionally some of the Potential Woodland Establishment Areas extend across the interim invasive species management compartments.

Management of invasive species is one of the fundamental tenets of the Woodland Strategy and a revised approach is recommended in Chapter 4. Part of this revision would be the development of workable invasive species management compartments. These should take into account the extant woodland areas that have been identified through this Strategy and wherever possible should avoid splitting these between compartments. Other factors to consider are the location of the potential woodland establishment areas and the deer fences which are to be retained. The revision of the compartments presented with this Strategy should be viewed as an interim measure created to demonstrate the process of generating spatial zoning.

The *Management_prescriptions_GNP.shp* shapefile was viewed and the Invasive Species Management compartments within which each occurred were added to the attributes table (parentheses were used where only a small overlap occurred). A similar addition was made to indicate the location of the polygons in relation to the Deer Management Units. As the Invasive Species Management Plan is revised, the compartments developed for this will form the basis of the spatial strategy. Each of the extant woodland polygons, potential woodland establishment areas and exclosures can be brought into the compartments which are developed. When works are completed within a woodland block, or when additional survey work becomes available for a location, these can be recorded and entered into the GIS such that it remains up to date. In this way, works completed and planned works can be regularly displayed graphically. The remaining non-wooded habitat within the Park should also be assigned spatial zoning codes such that works occurring within these can be documented.

Chapter 11 Strategic Support Initiatives

11.1 Education / Communication

To effectively communicate the role and importance of woodland in Glenveagh's ecosystems to the public requires all communications staff and Park staff to deliver consistent, positive messaging. In this regard, the dedicated education team already in Glenveagh has a core function in the successful delivery of the Strategy in that they will have responsibility for the management of communications, training of staff and keeping visitors informed as the Strategy is rolled out.

The Communication / Education team would therefore have a wide remit:

- Education of the public (e.g., via displays in the visitor centre) to emphasise the international importance of the woods, and how they are threatened (these are already in place).
- Designing a Public Awareness Campaign in relation to the Strategy and what it hopes to achieve:
    - inform members of the public of the vision for the woodlands at Glenveagh and the steps that will be needed to bring it about.
    - include awareness-raising in relation to the more controversial aspects of the Strategy such as deer culling (including handling of carcasses), clearing invasives using herbicides, and fencing.
    - Introduce a Virtual Reality display utilising the 360° monitoring photography to demonstrate progress made on the Strategy.
    - emphasise the long-term nature of the measures proposed by the Strategy, acknowledging that it may take many decades for their full effect to become apparent.
- Developing a volunteer programme to help with woodland work (e.g., tree planting, invasives clearance, positioning of deer guards around tree seedlings). This will have a role in keeping costs down but its main function will be to give stakeholders an opportunity to participate in some management activities and to learn first-hand the issues involved. It is envisaged that there will be a wide range of volunteers such as schoolchildren, corporate social responsibility groups, university students and environmental NGOs, and programmes would need to be developed to match the type of groups / individuals involved. The input of the Park's education team will be vital in setting up suitable programmes and initiatives that communicate the aims and methods of implementation of the Strategy to the many people who interact with Glenveagh on a regular basis. Consideration should be given to employing a dedicated volunteer liaison working with volunteer groups, devising programmes suitable for a range of volunteer groups with different interests and abilities.
- Establishing links with third-level educational establishments such that students from a variety of disciplines can obtain valuable work experience in a range of woodland management skills.
- Dissemination of knowledge: to other NWPS departments, to other interested groups outside the Park for capacity building in the northwest region, among other Irish National Parks, other areas overseen by NPWS, or nationally.

In-house communication and knowledge transfer within Glenveagh is also crucially important so that valuable knowledge gained during the implementation of specific aspects of the Strategy are not lost in the event of staff changes. Points to consider here include the following:

- Implement training programmes for in-house knowledge transfer. This could include training of staff in support skills such as GIS, file management and record-keeping, documenting standard operating procedures, and more. If staff members change in the Park, this should facilitate an efficient handover, with documented procedures and standard protocols to follow, instructions on where documentation is held, and a clear

indication of what tasks are next in the schedule. New staff members would then have clarity regarding work that has been done or is due to be done, and how this is achieved.
- Communication between the different operational teams (e.g. deer management, invasive species management, monitoring) should be structured rather than *ad hoc*, and regular liaison between the teams should take place so that groups do not work in isolation but are fully aware of issues and successes in areas other than their own.

With the diverse range of disciplines that will be required to implement the Strategy fully – deer management, invasive species eradication, ecological knowledge, forestry, to name a few – it is imperative that woodland management expertise gained is retained in-house to serve Glenveagh's needs. The ultimate aim should be for the Park to become a training centre and Centre of Excellence for techniques in key aspects of woodland management such as continuous cover forestry in native woodlands, woodland re-establishment, deer management and control, and control of invasive species. This expertise can then be shared with other National Parks in Ireland, and other interested groups grappling with similar management issues.

11.2 Detailed specialist studies

It is recognised that there is ecological expertise available, both nationally and internationally, for many different components of the woodlands at Glenveagh. A series of baseline studies should be commissioned or continued, to capture the status of these components with a view to repeat studies being carried out periodically over time. This should be used as a form of monitoring of the success or otherwise of the Strategy, but also as a means of informing aspects of its implementation which may require adjustment for specific interests in certain circumstances. Such studies could also have a role in influencing national policies on native woodland management. They also will be useful in the selection and design of future research studies, which Glenveagh has hosted over the years and should continue to encourage. If there are NPWS staff members with relevant expertise, then some of these studies could be conducted in-house.

Specialist studies would include (but not be limited to) the following:

- Closed Ecological Cycle – leaving deer carcasses on the hill and related studies
- Scavengers, food chains and nutrient cycling – this could be subdivided further
- Entomology – this could be subdivided further
- Birds and bats
- Deadwood volumes and condition
- Mycology
- Lichens and other cryptogams
- Range of *Salix* species
- Tree provenance studies
- Genetic studies

It is strongly recommended that an up-to-date habitat map for the entirety of the Park be commissioned first, to help target studies where they are most relevant.

11.3 Prospective Funding Avenues

Some external funding sources that could support the implementation of WMS actions are outlined below. These include various DAFM woodland schemes, cross-border funding initiatives and European programmes.

- *Native Woodland Conservation Scheme*: Native Woodland Scheme (NWS) funding for restoration of existing native woodland (e.g., protective fencing, non-native/exotic removal), the conversion of conifer forests to native wood through planting and/or natural regeneration, and the management of existing emergent scrub (e.g., protective fencing, non-native/exotic removal, and respacing).

- *Woodland Creation on Public Lands Scheme*: Funding for public bodies for the establishment of new native woodlands on suitable bare lands.
- *NeighbourWood (NBR) Scheme:* Available to public landowners working in partnership with local communities to support the development of woods for public use and enjoyment. The scheme comprises 'NBR Establishment' which funds woodland establishment on open greenfield sites, 'NBR Enhancement' which funds silvicultural enhancements of existing NBR woods or proposed NBR woods, and 'NBR Facilities' which funds the installation and/or upgrade to recreational facilities within NRB sites. The latter element can also be combined with Native Woodland Conservation Scheme works.
- *Seed Stand and Seed Orchard Scheme:* This DAFM scheme supports the conservation and development of Ireland's forest genetic resource. Element 1 'Seed Stands' aims to improve the management and conservation of existing, registered Seed Stands included on the National List of Basic Material. Element 2 'Seed Orchard' supports the establishment of new seed orchards, both clonal and seedling, both indoor and outdoor.
- *Shared Island Initiative:* Through its Shared Island Initiative, the Irish Government has made €500 million available for capital funding between 2021-25 for investments in North/South projects. Shared Island funds are available for biodiversity-related projects.
- *PEACEPLUS Programme:* PEACEPLUS (2021-27) is a new EU funding programme designed to support peace and prosperity across Northern Ireland and the border counties of Ireland. Under this programme, €40 million has been ring-fenced for 'biodiversity, nature recovery and resilience' projects.
- *EU LIFE:* The LIFE Nature and Biodiversity sub-programme supports projects that contribute to the implementation of the EU Birds and Habitats Directives, and in particular, the development and management of the Natura 2000 network and the IAS Regulation.
- *INTERREG Europe programme:* INTERREG is financed through the European Regional Development Fund (ERDF) with a budget to help local, regional and national governments across Europe to share solutions and good practice. Funding is available for biodiversity projects under this programme.

11.4 Parallel projects

11.4.1 Gartan Lough

There is another area of woodland near Gartan Lough which is at the southeast edge of Glenveagh National Park but is within a different SAC, the Leannan River SAC (site code 002176), which does not list Annex I Old oak woodland as a qualifying interest. Even though this area is some distance from the core area of the Park and is not in the Cloghernagore Bog and Glenveagh National Park SAC, woodland establishment is to be welcomed anywhere in the vicinity of Glenveagh. Therefore, this and other outlying areas can still be managed in parallel with the core areas of the Park in a manner that positively contributes to the Strategy and supports the achievement of its overall/wider objectives. As part of fieldwork in 2021, this area was visited and found to be generally suitable for woodland expansion through planting. It is recommended that this area be explored further with regard to woodland establishment and expansion. There is Annex I Old oak woodland close by, southeast of this potential planting area, which appears to be in reasonable condition and would seem to require little more than control of beech and deer to improve its conservation condition.

11.4.2 Coillte-owned conifer woodland on bog

Although not a core objective of the Strategy, the issue of non-native commercial forestry on peatland within the National Park should be addressed. Towards the south of the Park, 64.8 ha of forestry occur on peatlands at Gubbin Hill, south of Lough Muck and at Ardachrin. Approximately 50 ha of these are Coillte-owned plantations, so discussion and engagement with Coillte will be required. Among the negative impacts of these conifer plantations are the fact that the trees could be acting as a seed source; also, the large drains required for coniferous forestry act to dry out adjoining areas of bog and heathland, not just the planted area. A possible solution might be for

Coillte to bring these plantations into their biodiversity areas and to enhance their biodiversity value by removing the trees and restoring hydrology through the blocking of drains.

A similar discussion has already taken place between NPWS and Coillte with regard to a conifer plantation adjacent to the eastern boundary of the Park, in the Glaskeelan catchment near Lough Gartan (Emmett Johnston, pers. comm.). This is one of the top Freshwater Pearl Mussel catchments in the country, and as such is a highly sensitive area. The area in question is not within the Park but is within the Cloghernagore Bog and Glenveagh National Park SAC. Agreement has been reached between the two organisations to remove an area of conifer plantation and restore it to bog and heath. Creation of habitat such as this presents opportunity for balancing of some of the perceived habitat losses which may result through the woodland expansion proposed through this Strategy.

11.4.3 Potential other collaborations

NPWS and the staff at Glenveagh are open to working with other State bodies and local communities to develop partnerships around woodlands, including supporting the development of neighbouring woodlands in areas adjacent to the Park. In such scenarios NPWS can offer training, advice and support regarding the above, particularly once expertise on these areas has been consolidated among Park staff members.

Chapter 12 Future considerations within the lifetime of the Strategy

No plan is fully future-proof. In all plans and strategies there is a need to continually revisit and review; for example, to check if progress is being made according to the agreed schedule, or to examine if any parameters have changed. One hundred years is a considerable period of time for a plan to cover, and while all efforts are made to identify all of the issues at the time of writing this Strategy, the natural world is never static, and neither are national economics.

It is recommended that the Strategy be reviewed every 5 years until at least 2042 (i.e. for the first 20 years), after which it may be reviewed every 10 years. The following factors should be considered in any review:

- Climate change – is it worsening and adversely affecting achieving the aims of the Strategy? If so, what adjustments need to be made to the Strategy to stay on track?
- Has new environmental or ecological legislation come into effect since the previous review?
- Are there tie-ins with Ireland's Climate Action Plan? For example, can the carbon capture of addition woodland be accounted and projected?
- Progress (speed and success) of deer control.
- Progress (speed and success) of invasive species control.
- Progress (speed and success) of natural woodland regeneration.
- New invasive species.
- New pathogens and pests; e.g., Oak processionary moth, new fungal diseases of oak.
- Are all actions of the Strategy being carried out? If not, why not?
- Costs – are some actions costing more/less than planned? If less, can resources be reallocated to where they are most needed?
- Are current staffing levels adequate? If not, what additional resources are required?
- Are there any actions that are simply not working? If so, what actions should be carried out instead?
- Are any other novel approaches coming on stream that may be applicable to further the aims of the Strategy, e.g., reintroduction of large predators? This is currently controversial, but there may be more research on this in the future on how to manage small populations safely, using techniques such as no-fence GPS collars to keep them within a specific area, to protect domestic livestock and allay the public's concerns.

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Appendix 1 Site synopsis for Cloghernagore Bog and Glenveagh National Park SAC

Site Name: Cloghernagore Bog and Glenveagh National Park SAC
Site Code: 002047

Cloghernagore Bog and Glenveagh National Park SAC is an exceptionally large inland site located in the centre of northwest Donegal. It includes a rich diversity of habitats and landscape features, including mountains, exposed rock and scree, blanket bogs, dry, wet and alpine heath, upland grassland, wet grassland, rivers, lakes, scrub and woodland. The Gweebarra fault bisects the area forming a long valley, orientated northeast to southwest, in which Lough Barra and Lough Veagh (Beagh) are situated. The area is generally mountainous, taking in most of the Derryveagh and Glendowan ranges and including the two highest mountains in Donegal, Errigal (751 m) and Slieve Snaght (678 m). Towards the centre-west of the site are the fine ice-carved cliffs of the Poisoned Glen and Bingorms, which contrast dramatically with the gently undulating expanses of blanket bog in the southwest and northeast of the site. The underlying rock is predominantly granite, with a few intrusive dykes. However, around Errigal the geology is more complex with bands of schists, quartzite, granodiorite and limestone occurring.

The site is a Special Area of Conservation (SAC) selected for the following habitats and/or species listed on Annex I / II of the E.U. Habitats Directive (* = priority; numbers in brackets are Natura 2000 codes):

- [3110] Oligotrophic Waters containing very few minerals
- [3260] Floating River Vegetation
- [4010] Wet Heath
- [4030] Dry Heath
- [4060] Alpine and Subalpine Heaths
- [6410] *Molinia* Meadows
- [7130] Blanket Bogs (* if active bog)
- [7150] Rhynchosporion Vegetation
- [91A0] Old oak woodland

- [1029] Freshwater Pearl Mussel (*Margaritifera margaritifera*)
- [1106] Atlantic Salmon (*Salmo salar*)
- [1355] Otter (*Lutra lutra*)
- [1421] Killarney Fern (*Trichomanes speciosum*)

Atlantic blanket bog is the dominant habitat of interest, with much of it being relatively unspoilt. Indeed, the area around Cloghernagore constitutes the most extensive blanket bog system remaining in the northwest of Ireland. Overall, there are excellent examples of several types of blanket bog including Highland Bog (Cashelnagor and Dunlewy Far), Lowland Bog (Cloghernagore and Glenveagh Bridge), Domed Valley Bog (Derrybeg and Calabber Valley), Headwater Bog (Crockastoller and Carrickatimpan Mountain) and blanket bog apparently in the early stages of formation (Attinadague).

The blanket bog vegetation is relatively uniform and typically dominated by Purple Moor-grass (*Molinia caerulea*), Heather (*Calluna vulgaris*), Black Bog-rush (*Schoenus nigricans*), Deergrass (*Scirpus cespitosus*) and Common Cottongrass (*Eriophorum angustifolium*), with areas of Bog-myrtle (*Myrica gale*) also occurring.

A number of features indicative of well-developed blanket bog are found at the site. The pool systems found are typically colonised by bog moss species such as *Sphagnum auriculatum* and *S. cuspidatum*, Lesser Bladderwort (*Utricularia minor*), Bogbean (*Menyanthes trifoliata*) and sedges (e.g., *Carex panicea* and *C. limosa*), with Great Sundew (*Drosera anglica*) occurring around the margins. Hummocks of *Sphagnum* species (including *S. capillifolium, S. imbricatum* and *S. papillosum*) and other mosses such as *Leucobryum glaucum* and *Racomitrium lanuginosum* are

found, as are flushed areas with *Sphagnum* species such as *S. auriculatum* var. *inundatum* and *S. magellanicum*), Common Reed (*Phragmites australis*), rushes (*Juncus acutiflorus* and *J. effusus*) or sedges (*Carex echinata, C. rostrata* and *C. demissa*). There are also quaking flats of mosses (*Campylopus atrovirens, C. brevipilus, Pleurozia purpurea* and *Sphagnum* spp.) with sedges (e.g., *Carex lasiocarpa*), and shallow, infilling lakes with associated *Sphagnum* scraws and sedge swards. The vegetation described for the pool areas and wet quaking flats is representative of Rhynchosporion vegetation.

A number of scarce or only locally-occurring vascular plant species have been recorded from bogs on the site. These include a hybrid Sundew, *Drosera anglica* x *D. rotundifolia* (*Drosera* x *obovata*), Whorled Caraway (*Carum verticillatum*), Bearberry (*Arctostaphylos uva-ursi*), Cranberry (*Vaccinium oxycoccos*) and, in a gorge, Cowberry (*Vaccinium vitis-idaea*). Lower plants of note include several mosses (*Sphagnum fuscum, S. contortum, S. recurvum* var. *tenue*, *S. molle, Calliergon stramineum* and *Polytrichum longisetum*) and lichens (*Cladonia parasitica, C. gracilis, C. bellidiflora, C. cervicornis* subsp. *verticillata*, *C. digitata, Peltigera hymenea, Sphaerophorus fragilis, Usnea fragilescens* and *Umbilicaria polyrrhiza*).

Wet heath occurs at this site in an intimate mosaic with blanket bog, and the vegetation of the two habitat types intergrades. This occurs particularly on the lower slopes of hills, where deep lowland blanket peat meets shallower peat on the flanks of hills. Dry heath occurs at this site on slopes above 300 m. Heather and Bell Heather (*Erica cinerea*) are common, while species such as Gorse (*Ulex europaeus*) and Western Gorse (*U. gallii*) are thought to be relatively uncommon. Other species present include Common Bent (*Agrostis capillaris*), Velvet Bent (*A. canina*), Heath-grass (*Danthonia decumbens*) and Sheep's-fescue (*Festuca ovina*).

Subalpine heath is found at this site on very thin, peaty soils with some bare rock evident. The community is typically dominated by Heather and Bilberry (*Vaccinium myrtillus*). Crowberry (*Empetrum nigrum*) is also found on some of the higher mountain slopes. Other species of note in this habitat are Tormentil (*Potentilla erecta*) and the moss *Racomitrium lanuginosum*. Juniper (*Juniperus communis*) and Bearberry are occasional on mountain summits.

The site includes many rivers and streams, containing, or fringed by plants such as Water Horsetail (*Equisetum fluviatile*), Lesser Spearwort (*Ranunculus flammula*), pondweeds (*Potamogeton natans, P. polygonifolius*), sedges (*Carex* spp.) and rushes (*Juncus* spp). By one river the locally-occurring Lemon-scented Fern (*Oreopteris limbosperma*) is found. In some areas gorges have been cut by streams, and here fragments of deciduous woodland remain. These are characterised by Aspen (*Populus tremula*), Rowan (*Sorbus aucuparia*), oak (*Quercus petraea* and *Q. robur*) and willow (*Salix* spp.).

An area of semi-natural deciduous woodland occurs on the steeply sloping eastern side of Glenveagh. The dominant trees are Sessile Oak (*Quercus petraea*), Downy Birch (*Betula pubescens*) and Rowan, with Hazel (*Corylus avellana*) occurring frequently. Holly (*Ilex aquifolium*) occurs in the understorey. Rhododendron (*Rhododendron ponticum*) has invaded much of the woodland and adjacent hillsides. Other species present include Yew (*Taxus baccata*), Juniper and, near Lough Veagh, the scarce Rock Whitebeam (*Sorbus rupicola*). Within the woodland the lower plant community is well-developed with liverworts, including *Frullania tamarisci*, growing on the tree trunks. This is replaced as an epiphyte in damper areas by Wilson's Filmy-fern (*Hymenophyllum wilsonii*). Of particular note is the presence of the scarcer Tonbridge Filmy-fern (*H. tunbrigense*). The woodlands are also notable for the presence of two rare species of Myxomycete fungus, namely *Licea gloeoderma* and *Physarum vernum*, the former in its only known Irish site.

Molinia meadow at the site is characterised by a co-dominance of Purple Moor-grass, Soft Rush (*Juncus effusus*), Sharp-flowered Rush (*J. acutiflorus*) and Conglomerate Rush (*J. conglomeratus*). The habitat occurs in areas that are subject to occasional flooding. Other species recorded include Water Horsetail, Marsh Speedwell (*Veronica scutellata*), Silverweed (*Potentilla anserina*), Marsh Ragwort (*Senecio aquaticus*), Cuckooflower (*Cardamine pratensis*), Marsh Cinquefoil (*Potentilla palustris*) and Marsh Pennywort (*Hydrocotyle vulgaris*).

There are several large oligotrophic lakes on the site, including Lough Barra, Lough Veagh and Lough Altan. Aquatic plant species found include Water Lobelia (*Lobelia dortmanna*), Shoreweed

(*Littorella uniflora*) and Bulbous Rush (*Juncus bulbosus*). Lough Veagh also contains two quillwort species (*Isoetes lacustris* and *I. echinospora*), the latter of which is a locally-occurring species. Some of the smaller lakes also contain the scarce species Pipewort (*Eriocaulon aquaticum*).

Many scarce plants have been recorded from cliffs and gullies, mainly around Slieve Snaght and the Poisoned Glen. These include Brittle Bladder-fern (*Cystopteris fragilis*), Alpine Clubmoss (*Diphasiastrum alpinum*), Stiff Sedge (*Carex bigelowii*), Mountain Sorrel (*Oxyria digyna*) and Irish Spurge (*Euphorbia hyberna*). Purple Saxifrage (*Saxifraga oppositifolia*) and Alpine Saw-wort (*Saussurea alpina*) have also been recorded from this area, along with a more recent sighting of Killarney Fern (*Trichomanes speciosum*). These are all rare species which are listed in the Irish Red Data Book, the latter also being legally protected under the Flora (Protection) Order, 1999, and listed on Annex II of the E.U. Habitats Directive.

Three other rare Red Data Book plant species have been recorded within the site: Bird Cherry (*Prunus padus*), Small-white Orchid (*Pseudorchis albida*) and Heath Cudweed (*Omalotheca sylvatica*). The two last-named are legally protected under the Flora (Protection) Order, 1999.

The area is also of considerable zoological value. Mammal interest includes the largest herd of Red Deer in Ireland, along with Badgers, Otters, Irish Hares and Stoats.

Lough Veagh contains Arctic Char, a fish species that was once widespread but is now rare in most places. It is listed as vulnerable in the Irish Red Data Book. The Owencarrow and Lackagh River systems support a good population of Atlantic Salmon, a species listed on Annex II of the E.U. Habitats Directive. Brown Trout also occur. Common Lizard has been recorded from the site. The site supports populations of Freshwater Pearl Mussel, a rare species that is listed on Annex II of the E.U. Habitats Directive.

A number of important bird species are represented at this site, with several which are listed in the Red Data Book, and a number listed on Annex I of the E.U. Birds Directive. Those which breed within the area include Red-throated Diver, Golden Plover, Merlin and Peregrine. A small flock of Greenland White-fronted Goose, also listed on Annex I of the E.U. Birds Directive, feed on some of the bogs in winter. The Red Data Book species Goosander and Wood Warbler both breed on the site. Generally, the woodlands are favoured by Siskin, Tree Creepers and Redstarts, while Meadow Pipits, Red Grouse, Ravens, Snipe and Dunlin are among the birds found on the moorland.

One of the major land uses at this site is conservation management. The site contains the whole of the Glenveagh National Park along with two Statutory Nature Reserves, Lough Barra Bog and Meenachullion Bog. Grazing by sheep and deer is common and in a few places the bogs have suffered from over-grazing and poaching. Grazing has also prevented woodland regeneration. Annual deer culls take place to control numbers and the main herd is kept within the confines of the National Park by a 45 km-long deer fence. Invasion by Rhododendron has been a particular problem within the National Park, where it has choked areas of woodland and covered adjacent hillsides. A removal programme is in progress and the threat from this species has been considerably reduced. Peat cutting, both by hand and machine, has caused damage to some bogs in the site. Turbary and afforestation are the main threats to this habitat, with erosion and burning also having an impact.

The site is of great scientific and conservation value, particularly for the large areas of excellent, little-damaged blanket bog it contains, including the largest intact area of blanket bog in north-west Ireland. It also includes good quality examples of semi-natural deciduous woodland, heath, oligotrophic lakes and inland cliffs. The importance of the site is increased by the presence of a wide range of plant and animal species, including many rare or threatened Red Data Book species, and several that are listed on Annex II of the E.U. Habitats Directive or Annex I of the E.U. Birds Directive.

Appendix 2 Site synopsis and qualifying interests for Derryveagh and Glendowan Mountains SPA

Qualifying interests for SPA 004039:

- Red-throated Diver (*Gavia stellata*) [A001]
- Merlin (*Falco columbarius*) [A098]
- Peregrine (*Falco peregrinus*) [A103]
- Golden Plover (*Pluvialis apricaria*) [A140]
- Dunlin (*Calidris alpina schinzii*) [A466]

SITE NAME: DERRYVEAGH AND GLENDOWAN MOUNTAINS SPA
SITE CODE: 004039

Derryveagh and Glendowan Mountains SPA is an extensive upland site in north-west Co. Donegal, comprising Glenveagh National Park, a substantial part of the Derryveagh and Glendowan Mountains and a number of the surrounding lakes. Much of the site is over 300 m above sea level, rising to a peak of 678 m at Slieve Snaght. The solid geology is predominantly quartzite. The substrate over much of site is peat, with blanket bog and heath comprising the principal habitats.

The site is a Special Protection Area (SPA) under the E.U. Birds Directive, of special conservation interest for the following species: Red-throated Diver, Merlin, Peregrine, Golden Plover and Dunlin.

This site is one of only a few locations where Red-throated Diver breed in Ireland and the birds also use a number of lakes within the site for feeding. A survey in 2010 recorded 6 pairs at the site. The extensive bog and heath habitats provide excellent foraging habitat for both Peregrine (5-6 pairs in 2002) and Merlin (estimated 6-11 pairs). Peregrine nest on the crags and cliffs, whilst Merlin nest in the heather or in old crows' nests in trees. The site is very important for breeding Golden Plover and Dunlin (subsp. *schinzii*) with 18 and 5 pairs respectively recorded in 2002.

Red Grouse is also widespread on the bogs and Ring Ouzel, a rare species of the uplands, breeds sparingly, with at least 2 pairs recorded in a 2002 survey. Several pairs of Whinchat, a scarce Irish species, breed within the site. Goosander is also a regular visitor to the lakes, though breeding within the site has not been proved. Snowy Owl has also attempted to breed within the site - a clutch of eggs was laid but these did not hatch. Wood Warbler is present annually, with perhaps three pairs occurring. Redstart has bred on at least one occasion but there have been few sightings in recent years and it is not known if breeding occurs regularly.

Glenveagh National Park is the central location for the Golden Eagle re-introduction programme, which commenced in 2000. With time, this species may become successfully re-established as a breeding species in Ireland.

The site is of high ornithological importance with nationally important breeding populations of five species. Of particular note is that five of the species that occur regularly are listed on Annex I of the E.U. Birds Directive, i.e. Red-throated Diver, Peregrine, Merlin, Golden Plover and Dunlin (subsp. *schinzii*). A large proportion of Lough Barra Bog, a Ramsar Convention site and a Statutory Nature Reserve, is within the Derryveagh and Glendowan Mountains SPA.

7.7.2014

Appendix 3 Conservation Objectives for Cloghernagore Bog and Glenveagh National Park SAC (002047) (abbreviated)

The site-specific conservation objectives for Cloghernagore Bog and Glenveagh National Park SAC set out the circumstances in which all the Annex I habitats and Annex II species listed as qualifying interests for the SAC achieve favourable conservation status (NPWS, 2017). The following extracts of text and tables are taken from NPWS (2017). The tables refer to habitats and species that are most likely to be affected during the implementation of the Strategy.

NPWS (2017) states:

The favourable conservation status of a habitat is achieved when:

- its natural range, and area it covers within that range, are stable or increasing, and
- the specific structure and functions which are necessary for its long-term maintenance exist and are likely to continue to exist for the foreseeable future, and
- the conservation status of its typical species is favourable.

The favourable conservation status of a species is achieved when:

- population dynamics data on the species concerned indicate that it is maintaining itself on a long-term basis as a viable component of its natural habitats, and
- the natural range of the species is neither being reduced nor is likely to be reduced for the foreseeable future, and
- there is, and will probably continue to be, a sufficiently large habitat to maintain its populations on a long-term basis.

The overall aim of the Habitats Directive is to maintain or restore the favourable conservation status of habitats and species of community interest. These habitats and species are listed in the Habitats and Birds Directives and Special Areas of Conservation and Special Protection Areas are designated to afford protection to the most vulnerable of them. These two designations are collectively known as the Natura 2000 network.

The maintenance of habitats and species within Natura 2000 sites at favourable conservation condition will contribute to the overall maintenance of favourable conservation status of those habitats and species at a national level.

1. The targets given in these conservation objectives are based on best available information at the time of writing. As more information becomes available, targets for attributes may change. These will be updated periodically, as necessary.

2. An appropriate assessment based on these conservation objectives will remain valid even if the targets are subsequently updated, providing they were the most recent objectives available when the assessment was carried out. It is essential that the date and version are included when objectives are cited.

3. Assessments cannot consider an attribute in isolation from the others listed for that habitat or species, or for other habitats and species listed for that site. A plan or project with an apparently small impact on one attribute may have a significant impact on another.

4. Please note that the maps included in this document do not necessarily show the entire extent of the habitats and species for which the site is listed. This should be borne in mind when appropriate assessments are being carried out.

5. When using these objectives, it is essential that the relevant backing/supporting documents are consulted, particularly where instructed in the targets or notes for a particular attribute.

91A0 Old sessile oak woods with Ilex and Blechnum in the British Isles

To restore the favourable conservation condition of Old sessile oak woods with *Ilex* and *Blechnum* in the British Isles in Cloghernagore Bog and Glenveagh National Park SAC, which is defined by the following list of attributes and targets:

Attribute	Measure	Target	Notes
Habitat area	Hectares	Area stable or increasing, subject to natural processes; at least 37.3ha, for the sub-sites (Mullangore Wood, NSNW site code 1423; Derry Beg, NSNW site code 1424) surveyed. See map 4 for surveyed areas	The main area of old oak woodland in Cloghernagore Bog and Glenveagh National Park SAC is Mullangore Wood, on the south-eastern side of Lough Veagh; other areas include Sruhanacullia Wood, Brogan's Wood, Derrybeg Wood, Upper Glen Wood and Garman Wood (Bleasdale and Conaghan, 1996; NPWS internal files). Two sites within the SAC were surveyed by Perrin et al. (2008) as part of the National Survey of Native Woodlands (NSNW): Mullangore Wood (NSNW site code 1423) and Derry Beg (NSNW site code 1424). Mullangore Wood (1423) was also included in a national monitoring survey (O'Neill and Barron, 2013). Map 4 shows the surveyed woodlands classified as 91A0 (37.3ha) by the NSNW. NB further unsurveyed areas are present within the SAC
Habitat distribution	Occurrence	No decline, subject to natural processes. Surveyed woodland locations are shown on map 4	Distribution based on Perrin et al. (2008). It is important to note that there are additional areas of woodland, which were not mapped by the NSNW, present within this SAC
Woodland size	Hectares	Area stable or increasing. Where topographically possible, "large" woods at least 25ha in size and "small" woods at least 3ha in size.	The target areas for individual woodlands aim to reduce habitat fragmentation and benefit those species requiring 'deep' woodland conditions (Peterken, 2002). In some cases, topographical constraints may restrict expansion
Woodland structure: cover and height	Percentage and metres	Diverse structure with a relatively closed canopy containing mature trees; subcanopy layer with semi-mature trees and shrubs; and well-developed herb layer	Described in Perrin et al. (2008) and NPWS internal files
Woodland structure: community diversity and extent	Hectares	Maintain diversity and extent of community types	Described in Perrin et al. (2008) and NPWS internal files
Woodland structure: natural regeneration	Seedling:sapling:pole ratio	Seedlings, saplings and pole age-classes occur in adequate proportions to ensure survival of woodland canopy	Oak (*Quercus petraea*) generally regenerates poorly. In suitable sites, ash (*Fraxinus excelsior*) can regenerate in large numbers although few seedlings reach pole size
Woodland structure: dead wood	m^3 per hectare; number per hectare	At least $30m^3$/ha of fallen timber greater than 10cm diameter; 30 snags/ha; both categories should include stems greater than 40cm diameter	Dead wood is a valuable resource and an integral part of a healthy, functioning woodland ecosystem
Woodland structure: veteran trees	Number per hectare	No decline	Mature and veteran trees are important habitats for bryophytes, lichens, saproxylic organisms and some bird species. Their retention is important to ensure continuity of habitats/niches and propagule sources

91A0 Old sessile oak woods with Ilex and Blechnum in the British Isles (ctd.)

Woodland structure: indicators of local disctinctiveness	Occurrence	No decline	Includes ancient or long-established woodlands, archaeological and geological features as well as red-data and other rare or localised species. Perrin and Daly (2010) identified Mullangore Wood (NSNW site code 1423) as "possible ancient woodland". The Near Threatened beech fern (*Phegopteris connectilis*) (Wyse Jackson et al., 2016) and the Annex V listed fir clubmoss (*Huperzia selago*) are present in Mullangore Wood (Perrin et al., 2008)
Vegetation composition: native tree cover	Percentage	No decline. Native tree cover not less than 95%	Species reported in Perrin et al. (2008) and NPWS internal files
Vegetation composition: typical species	Occurrence	A variety of typical native species present, depending on woodland type, including oak (*Quercus petraea*) and birch (*Betula pubescens*)	Species reported in Perrin et al. (2008) and NPWS internal files
Vegetation composition: negative indicator species	Occurrence	Negative indicator species, particularly non-native invasive species, absent or under control	Rhododendron (*Rhododendron ponticum*) infestation is a problem within this habitat in the SAC, although an extensive clearance programme is on-going (Perrin et al., 2008; NPWS internal files)

1421 Killarney Fern *Trichomanes speciosum*

To maintain the favourable conservation condition of Killarney Fern in Cloghernagore Bog and Glenveagh National Park SAC, which is defined by the following list of attributes and targets:

Attribute	Measure	Target	Notes
Distribution	Occurrence	No loss in geographical spread of populations, subject to natural processes	Killarney fern (*Trichomanes speciosum*) is currently known from one location in Cloghernagore Bog and Glenveagh National Park SAC, within hectad B91. The exact location is not mapped here on account of the threat posed by illegal collecting. The species has also been recorded from a second location in the SAC but not, apparently, since 1955; recent searches of the second location have failed to record the species and it is considered likely to be no longer extant there. Based on Ní Dhúill et al. (2015), NPWS (2013) and NPWS internal files
Populations	Number	No decline, subject to natural processes	One population of the species is known from the SAC. It was first recorded here in 1961 and subsequently in 1976, 1993, 1995 and 2011. Based on Ní Dhúill et al. (2015), NPWS (2013) and NPWS internal files
Colonies	Number	No decline, subject to natural processes	The sole population of Killarney fern known from the SAC comprises a single colony. Based on Ní Dhúill et al. (2015), NPWS (2013) and NPWS internal files
Population: life-cycle stage	Type (sporophyte or gametophyte)	Maintain life-cycle stage composition of populations, subject to natural processes	The single colony of the species known from the SAC comprises a mixture of sporophytes (frond stage) and gametophytes (filamentous stage). Based on Ní Dhúill et al. (2015), NPWS (2013) and NPWS internal files
Population size: area of occupancy	Square metres	No decline, subject to natural processes	The area of occupancy was recorded as 0.33 square metres in 2011. Based on Ní Dhúill et al. (2015), NPWS (2013) and NPWS internal files
Population size: living sporophyte fronds	Number	No decline, subject to natural processes	38 fronds were recorded in 2011. Based on Ní Dhúill et al. (2015), NPWS (2013) and NPWS internal files
Population structure: young and unfurling fronds	Occurrence	Young (not fully expanded) and/or unfurling (crozier) fronds present in populations previously observed to have these, subject to natural processes	Young and/or unfurling fronds have been recorded from the SAC. Based on Ní Dhúill et al. (2015), NPWS (2013) and NPWS internal files
Population structure: fertile fronds	Occurrence	Fertile fronds present in populations previously observed to have these, subject to natural processes	Fertile fronds have not been recorded from the SAC to date. Based on Ní Dhúill et al. (2015), NPWS (2013) and NPWS internal files
Population structure: juvenile sporophyte fronds emerging from gametophytes	Number	No decline, subject to natural processes	Juvenile sporophyte fronds emerging from gametophytes have not been recorded from the SAC to date. Based on Ní Dhúill et al. (2015), NPWS (2013) and NPWS internal files
Habitat extent	Hectares	No loss of suitable habitat, subject to natural processes	The species grows in deeply shaded, humid situations - dripping caves, overhangs and crevices on cliffs, rocky slopes, by waterfalls, in stream ravines and gullies, on rock or soil banks in woodlands and, occasionally, under fallen trees and on the floor of damp woodlands. Whilst also occurring in these habitats, the gametophyte (filamentous) stage can grow in drier areas that do not suit the sporophyte. Based on Ní Dhúill et al. (2015), NPWS (2013) and NPWS internal files

1421 Killarney fern *Trichomanes speciosum* (ctd.)

Hydrological conditions: wet/damp microhabitats	Occurrence	Maintain hydrological conditions at the locations of known populations - visible water source, with dripping or seeping water present and/or substrate wet/damp to touch, subject to natural processes	Based on Ní Dhúill et al. (2015), NPWS (2013) and NPWS internal files
Hydrological conditions: relative humidity	Percentage	Maintain relative humidity levels at known colonies at not less than 80%, subject to natural processes	Based on Ní Dhúill et al. (2015), NPWS (2013) and NPWS internal files
Hydrological conditions: desiccated fronds	Number	No increase, subject to natural processes	Presence of desiccated sporophyte fronds and gametophyte mats is indicative of unsuitable conditions. Based on Ní Dhúill et al. (2015), NPWS (2013) and NPWS internal files
Light levels: shading	Shade index score	At least 4 for woodland sporophyte-only and mixed colonies; at least 5 for open upland sporophyte-only and mixed colonies; at least 6 for gametophyte-only colonies, subject to natural processes	Shade Index: 4. Moderate shade, e.g. light-medium deciduous canopy with sun flecks. 5. Permanently shaded from direct sunlight but otherwise open to sky. 6. Deep woodland (e.g. coniferous or in ravine) shade, no sun flecks. 7. Perpetual deep shade, e.g. cave entrance, beneath boulder. Woodland colonies have not been recorded from the SAC to date. Based on Ní Dhúill et al. (2015), NPWS (2013) and NPWS internal files
Woodland canopy cover	Percentage	No loss of woodland canopy at, or in the vicinity of, location of population and canopy cover here maintained at more than 33%, subject to natural processes	Woodland management at or near to locations of known populations of the species to take account of its habitat requirements, in particular, with regard to maintenance of sufficient canopy cover. Woodland colonies have not been recorded from the SAC to date. Based on Ní Dhúill et al. (2015), NPWS (2013) and NPWS internal files
Invasive species	Occurrence	Maintain absence of invasive non-native and vigorous native plant species at the locations of known populations or, if present, maintain vegetation cover of these at less than 10%, taking into account the habitat requirements of *T. speciosum*	In order to avoid negative impacts on *Trichomanes speciosum*, its habitat requirements (site hydrology, relative humidity, canopy cover, shading levels, etc.) must be taken into account in locations that are subject to or proposed for management actions to control invasive non-native and/or vigorous native plant species. Based on Ní Dhúill et al. (2015), NPWS (2013) and NPWS internal files

4010 Northern Atlantic wet heaths with Erica tetralix

To restore the favourable conservation condition of Northern Atlantic wet heaths with *Erica tetralix* in Cloghernagore Bog and Glenveagh National Park SAC, which is defined by the following list of attributes and targets:

Attribute	Measure	Target	Notes
Habitat area	Hectares	Area stable or increasing, subject to natural processes	Northern Atlantic wet heaths with *Erica tetralix* has not been mapped in detail for Cloghernagore Bog and Glenveagh National Park SAC, but from current available data the total area of the qualifying habitat is estimated to be approximately 3,396ha, covering 10% of the SAC (NPWS internal files). Further details on this and the following attributes can be found in the Cloghernagore Bog and Glenveagh National Park SAC conservation objectives supporting document for blanket bogs and associated habitats
Habitat distribution	Occurrence	No decline, subject to natural processes	The habitat occurs in an intimate mosaic with blanket bog particularly on the lower slopes of hills, where peat is shallower. Good examples of wet heath can be found on the south-eastern slopes of Errigal and in the area around Croangar (NPWS internal files). Further information can be found within NPWS internal files and the blanket bogs and associated habitats supporting document
Ecosystem function: soil nutrients	Soil pH and appropriate nutrient levels at a representative number of monitoring stops	Maintain soil nutrient status within natural range	See the blanket bogs and associated habitats supporting document for further details
Community diversity	Abundance of variety of vegetation communities	Maintain variety of vegetation communities, subject to natural processes	A variety of wet heath vegetation communities have been recorded in this SAC (Douglas et al., 1990; NPWS internal files; R. Hodd, pers. comm.), four of which correspond to communities recorded in the National Survey of Upland Habitats and listed in the provisional list of vegetation communities described in Perrin et al. (2014). Further information on vegetation communities associated with this habitat is presented in Perrin et al. (2014)
Vegetation composition: cross-leaved heath	Occurrence within 20m of a representative number of monitoring stops	Cross-leaved heath (*Erica tetralix*) present within a 20m radius of each monitoring stop	Attribute and target based on Perrin et al. (2014)
Vegetation composition: positive indicator species	Percentage cover at a representative number of 2m x 2m monitoring stops	Cover of positive indicator species at least 50%	Attribute and target based on Perrin et al. (2014), where the list of positive indicator species for this habitat is also presented
Vegetation composition: lichens and bryophytes	Percentage cover at a representative number of 2m x 2m monitoring stops	Total cover of *Cladonia* and *Sphagnum* species, *Racomitrium lanuginosum* and pleurocarpous mosses at least 10%	Attribute and target based on Perrin et al. (2014)
Vegetation composition: ericoid species and crowberry	Percentage cover at a representative number of 2m x 2m monitoring stops	Cover of ericoid species and crowberry (*Empetrum nigrum*) at least 15%	Attribute and target based on Perrin et al. (2014)
Vegetation composition: dwarf shrub species	Percentage cover at a representative number of 2m x 2m monitoring stops	Cover of dwarf shrubs less than 75%	Attribute and target based on Perrin et al. (2014)
Vegetation composition: negative indicator species	Percentage cover at a representative number of 2m x 2m monitoring stops	Total cover of negative indicator species less than 1%	Attribute and target based on Perrin et al. (2014), where the list of negative indicator species for this habitat is also presented

4010 Northern Atlantic wet heaths with Erica tetralix (ctd.)

Vegetation composition: non-native species	Percentage cover at, and in local vicinity of, a representative number of 2m x 2m monitoring stops	Cover of non-native species less than 1%	Attribute and target based on Perrin et al. (2014). Pirri-pirri-bur (*Acaena novae-zelandiae*) (R. Hodd, pers. comm.) and rhododendron (*Rhododendron ponticum*) (NPWS internal files) are present within wet heaths in the SAC
Vegetation composition: native trees and shrubs	Percentage cover in local vicinity of a representative number of monitoring stops	Cover of scattered native trees and shrubs less than 20%	Attribute and target based on Perrin et al. (2014)
Vegetation composition: bracken	Percentage cover in local vicinity of a representative number of monitoring stops	Cover of bracken (*Pteridium aquilinum*) less than 10%	Attribute and target based on Perrin et al. (2014)
Vegetation composition: soft rush	Percentage cover in local vicinity of a representative number of monitoring stops	Cover of soft rush (*Juncus effusus*) less than 10%	Attribute and target based on Perrin et al. (2014)
Vegetation structure: *Sphagnum* condition	Condition at a representative number of 2m x 2m monitoring stops	Less than 10% of the *Sphagnum* cover is crushed, broken and/or pulled up	Attribute and target based on Perrin et al. (2014)
Vegetation structure: signs of browsing	Percentage of shoots browsed at a representative number of 2m x 2m monitoring stops	Less than 33% collectively of the last complete growing season's shoots of ericoids, crowberry (*Empetrum nigrum*) and bog-myrtle (*Myrica gale*)	Attribute and target based on Perrin et al. (2014)
Vegetation structure: burning	Occurrence in local vicinity of a representative number of monitoring stops	No signs of burning in sensitive areas, into the moss, liverwort or lichen layer or exposure of peat surface due to burning	Attribute and target based on Perrin et al. (2014), where the list of sensitive areas for this habitat is also presented
Physical structure: disturbed bare ground	Percentage cover at, and in local vicinity of, a representative number of 2m x 2m monitoring stops	Cover of disturbed bare ground less than 10%	Attribute and target based on Perrin et al. (2014)
Physical structure: drainage	Percentage area in local vicinity of a representative number of monitoring stops	Area showing signs of drainage from heavy trampling, tracking or ditches less than 10%	Attribute and target based on Perrin et al. (2014)
Indicators of local distinctiveness	Occurrence and population size	No decline in distribution or population sizes of rare, threatened or scarce species associated with the habitat and no decline in status of hepatic mats associated with this habitat	This includes species listed in the Flora (Protection) Order, 2015 (FPO) and/or the red data lists (Lockhart et al., 2012; Wyse Jackson et al., 2016). The FPO listed and Vulnerable liverworts *Scapania ornithopodioides* and *Bazzania pearsonii* (Lockhart et al., 2012) are present within hepatic mats associated with this habitat in the SAC (R. Hodd, pers. comm.)

1029 Freshwater Pearl Mussel *Margaritifera margaritifera*

To restore the favourable conservation condition of Freshwater Pearl Mussel in Cloghernagore Bog and Glenveagh National Park SAC, which is defined by the following list of attributes and targets:

Attribute	Measure	Target	Notes
Distribution	Kilometres	See targets below and see map 5	The conservation objective applies to the Glaskeelan and Owencarrow freshwater pearl mussel (*Margaritifera margaritifera*) populations, which are listed on the European Communities Environmental Objectives (Freshwater Pearl Mussel) Regulations 2009 (SI No. 296 of 2009). The target is for the species to be sufficiently widespread to maintain itself on a long-term basis as a viable component of the Glaskeelan and Owencarrow systems (see further information below). The Glaskeelan, owing to the relatively few pressures in the catchment, is one of eight Irish populations prioritised for conservation action. This SAC covers much of the Glaskeelan and Owencarrow catchments. It also covers upper parts of the Clady catchment, while the Glaskeelan is a sub-catchment of the Leannan (see map 5). Conservation objectives for the Clady and Leannan freshwater pearl mussel populations are detailed for SACs 000140 and 002176, respectively
Distribution: Glaskeelan	Kilometres	Maintain Glaskeelan distribution at 3.17km	As noted above, the Glaskeelan freshwater pearl mussel population is one of eight Irish populations prioritised for conservation action (Moorkens, 2010; NPWS, 2010). Information on the distribution of the freshwater pearl mussel in the Glaskeelan comes from Moorkens (1995, 1996, 2007, 2009). Mussels have been found from just downstream of the national park boundary to the mouth of the river at Gartan Lough; however, most of the population occurs between a 'large rock' at C04873 17424 and the lake. Further survey is required of the stretches from the national park boundary downstream to the 'large rock'. The target is for the species to be sufficiently widespread to maintain itself on a long-term basis as a viable component of the Glaskeelan system. See NPWS (2010) for further information
Distribution: Owencarrow	Kilometres	Maintain Owencarrow distribution at 7.3km	The distribution of the freshwater pearl mussel is poorly known for the Owencarrow system, but is considered to be from the outflow from Lough Beagh to the New Bridge (N56) (based on records from: Beasley, 1996; Moorkens, 1995, 1996, 2007, 2009). Further survey is required of the distribution, abundance and condition of the species and its habitat in the Owencarrow. The target is for the species to be sufficiently widespread to maintain itself on a long-term basis as a viable component of the Owencarrow system. See NPWS (2010) for further information

1029 Freshwater Pearl Mussel *Margaritifera margaritifera* (ctd.)

Population size	Number of adult mussels	Restore populations to at least: 10,000 adult mussels in the Glaskeelan and 10,000 in the Owencarrow	The 2009 population estimate for the Glaskeelan was a maximum of 10,000 (Moorkens, 2009; NPWS, 2010). NPWS (2010) provided a population estimate of 15,000 for the Owencarrow, however Moorkens (2010) considered it more likely to be less than 10,000. Pearl fishing appears to have contributed significantly to the Owencarrow population decline (Beasley, 1996; Moorkens, 2009; NPWS, 2010) and the available mussel habitat is below capacity for mussels (Moorkens, 2009). Further survey of both systems is required to provide more robust population targets. NPWS (2013) assumed the Glaskeelan, like other priority populations, had declined at a rate of 1% per year and the Owencarrow at 3% per year. Moorkens (2017), however, found that one stretch of the Glaskeelan had declined by 82% in 4 years. The target is for the species to be sufficiently abundant to maintain itself on a long-term basis as a viable component of the Glaskeelan and Owencarrow systems
Population structure: recruitment	Percentage per size class	Restore to at least 20% of each population no more than 65mm in length; and at least 5% of each population no more than 30mm in length	Mussels of no more than 65mm are considered 'young mussels' and may be found buried in the substratum and/or beneath adult mussels. Mussels of no more than 30mm are 'juvenile mussels' and are always buried in the substratum. See the European Communities Environmental Objectives (Freshwater Pearl Mussel) Regulations 2009. Beasley (1996) conducted age studies of Glaskeelan and Owencarrow mussels. In 2009, the smallest Glaskeelan mussel was 26mm, but it failed both targets with only 6.6% ≤65mm and 1.3% ≤30mm (Moorkens, 2009). No juvenile or young mussels were found in the Glaskeelan in 2012 or 2016 (Moorkens, 2012, 2017). No juveniles or young mussels were found in the Owencarrow in 2009 (Moorkens, 2009; NPWS, 2010). Both populations are unsustainable owing to lack of survival of juvenile mussels. The target is for sufficient juvenile recruitment to allow the species to maintain itself on a long-term basis as a viable component of the Glaskeelan and Owencarrow systems
Population structure: adult mortality	Percentage	No more than 5% decline from previous number of live adults counted; dead shells less than 1% of the adult population and scattered in distribution	5% is considered the cut-off between the combined errors associated with natural fluctuations and sampling methods and evidence of true population decline. 1% of dead shells is considered to be indicative of natural losses. The Glaskeelan was assumed to pass both targets in 2009 and again in 2012, when the absence of baseline data made assessment of changes in live adults difficult (Moorkens, 2009, 2012; NPWS, 2010). In 2016, a severe decline was recorded, with an 82% drop in adults between 2012-16 in one stretch, the highest density was 3 mussels/m² and the 8 mussels tested by tongs were found to be 'Stressed'. The Owencarrow failed both targets in 2009, when more dead shells (more than 145) than large, live adults (c.110) were counted (Moorkens, 2009, 2010). The target is for sufficient survival of adults to allow the species to maintain itself on a long-term basis as a viable component of the Glaskeelan and Owencarrow systems

1029 Freshwater Pearl Mussel *Margaritifera margaritifera* (ctd.)

Suitable habitat: extent	Kilometres	See targets below	The habitat is a combination of 1) the area of habitat adult and juvenile mussels can occupy; 2) the area of spawning and nursery habitats host fish can occupy. Fish nursery habitat typically overlaps with mussel habitat. Fish spawning habitat is generally adjacent to mussel habitat, but may lie upstream of the generalised mussel distribution. Only spawning areas that can regularly contribute juvenile fish to adult mussel habitat should be considered. Availability of mussel and fish habitat is determined by flow and substratum conditions. It is highly sensitive to hydromorphological changes, sedimentation and nutrient enrichment. Pressures throughout the catchment (map 5) contribute to such impacts. Habitat in the Glaskeelan and Owencarrow is unsuitable for juvenile recruitment (NPWS, 2010). The target is for sufficient habitat in favourable condition to allow the species to maintain itself on a long-term basis as a viable component of the Glaskeelan and Owencarrow systems. See below
Suitable habitat: extent - Glaskeelan	Kilometres	Restore suitable habitat in more than 3.17km in the Glaskeelan system and any additional stretches necessary for salmonid spawning	The extent of the mussel habitat in the Glaskeelan, in correspondence with the species' distribution, is considered to be from just downstream of the National Park boundary to the mouth of the river at Gartan Lough (Moorkens, 1995, 1996, 2007, 2009). As noted above, however, further survey is required, particularly of the more upstream stretches, to confirm the habitat extent. Most of the mussel habitat is considered to be under carrying capacity and mussel density is particularly poor in some patches (Moorkens, 2009, 2017; NPWS, 2010). Sedimentation and organic enrichment are the key impacts on the Glaskeelan mussel habitat. The target is for sufficient habitat in favourable condition to allow the species to maintain itself on a long-term basis as a viable component of the Glaskeelan system
Suitable habitat: extent - Owencarrow	Kilometres	Restore suitable habitat in more than 5.0km in the Owencarrow system and any additional stretches necessary for salmonid spawning	Further survey is required to accurately map the extent of mussel habitat in the Owencarrow system. The habitat polyline is likely to underestimate habitat extent downstream of Owencarrow Bridge and overestimate it above that bridge. Suitable habitat was patchy and limited in extent in the stretches surveyed in 2007 and 2009, and where found was below carrying capacity for mussels (Moorkens, 2007, 2009). Sedimentation and nutrient enrichment are impacting on the condition of the Owencarrow mussel habitat. The target is for sufficient habitat in favourable condition to allow the species to maintain itself on a long-term basis as a viable component of the Owencarrow system
Water quality: macroinvertebrate and phytobenthos (diatoms)	Ecological quality ratio (EQR)	Restore water quality - macroinvertebrates: EQR greater than 0.90 (Q4-5 or Q5); phytobenthos: EQR greater than 0.93	The EQR targets correspond to high ecological status for these two Water Framework Directive (WFD) biological quality elements. They represent high water quality with very low nutrient concentrations (oligotrophic conditions). In 2009, the habitat in both the Glaskeelan and Owencarrow systems failed the macroinvertebrate target, but passed the diatom target (Ní Chatháin, 2009; Williams, 2009; NPWS, 2010). See also The European Communities Environmental Objectives (Surface Waters) Regulations 2009. The target is for sufficient habitat in favourable condition to allow the species to maintain itself on a long-term basis as a viable component of the Glaskeelan and Owencarrow systems

1029 Freshwater Pearl Mussel *Margaritifera margaritifera* (ctd.)

Substratum quality: filamentous algae (macroalgae); macrophytes (rooted higher plants)	Percentage	Restore substratum quality - filamentous algae: absent or trace (less than 5%); macrophytes: absent or trace (less than 5%)	Both the Glaskeelan and Owencarrow systems failed the macroalgal target in 2009, but (marginally) passed the macrophyte target (NPWS, 2010). Macroalgal cover of 60% and 70% was recorded in the Glaskeelan during macroinvertebrate surveys (Williams, 2009; NPWS, 2010). The macrophyte *Potamogeton* was more abundant than expected in the Glaskeelan mussel habitat (Moorkens, 2009, 2017; NPWS, 2010). *Littorella* was also abundant in 2016 (Moorkens, 2017). Bacterial and fungal growth requires further investigation in the Glaskeelan given the loading of organic matter that has entered the river (see Moorkens, 2012). Algal cover varied spatially and temporally in the Owencarrow mussel habitat, but was greatest (60%) at the bridge near the Glenveagh visitor centre (Williams, 2009; NPWS, 2010). The target is for sufficient habitat in favourable condition to allow the species to maintain itself on a long-term basis as a viable component of the Glaskeelan and Owencarrow systems
Substratum quality: sediment	Occurrence	Restore substratum quality - stable cobble and gravel substrate with very little fine material; no artificially elevated levels of fine sediment	The Glaskeelan failed the target for the Sub-basin Management Plan, having strong silt plumes (Moorkens, 2009; Williams, 2009; NPWS, 2010). There was a clear relationship between heavy siltation and higher macrophyte cover abundance. It failed again in 2012 (high/increased silt cover (drape) and substantial silt plumes when agitated) and in 2016 (silt infiltration on all transects) (Moorkens, 2012, 2017). The Owencarrow failed the target in 2009, with slight to moderate silt plumes in mussel habitat (Williams, 2009; NPWS, 2010). Sufficient survival of juvenile mussels is being prevented by the poor condition of the river substratum in both systems. The target is for sufficient habitat in favourable condition to allow the species to maintain itself on a long-term basis as a viable component of the Glaskeelan and Owencarrow systems
Substratum quality: oxygen availability	Redox potential	Restore to no more than 20% decline from water column to 5cm depth in substrate	Differences in redox potential between the water column and the substrate correlate with differences in oxygen levels. Juvenile mussels require full oxygenation while buried in gravel. In suitable habitat, there should be very little loss of redox potential between the water column and underlying gravels. The Glaskeelan failed the redox target in 2009, with an average loss of 21.3% redox potential at 5cm (range 11-27.5%) (Moorkens, 2009; NPWS, 2010). In 2012, average redox was 30.6% and substratum condition had deteriorated significantly throughout the Glaskeelan (Moorkens, 2012). It failed again in 2016 (average of 24.9%, all readings at lower sites over 20%) (Moorkens, 2017). The Owencarrow failed the target in 2009, with average redox of 24.1% (Moorkens, 2009; NPWS, 2010). The target is for sufficient habitat in favourable condition to allow the species to maintain itself on a long-term basis as a viable component of the Glaskeelan and Owencarrow systems

1029 Freshwater Pearl Mussel *Margaritifera margaritifera* (ctd.)

Hydrological regime: flow variability	Metres per second	Restore appropriate hydrological regimes	The availability of suitable freshwater pearl mussel habitat is largely determined by flow (catchment geology being the other important factor). In order to restore the habitat for the species, flow variability over the annual cycle must be such that: 1) high flows can wash fine sediments from the substratum; 2) high flows are not artificially increased so as to cause excessive scour of mussel habitat; 3) low flows do not exacerbate the deposition of fine sediment or growth of algae/macrophytes and 4) low flows do not cause stress to mussels in terms of exposure, water temperatures, food availability or aspects of the reproductive cycle; see Moorkens and Killeen (2014). Groundwater inflow to the substratum also contributes to water-cycling and favourable habitat condition. The target is for sufficient habitat in favourable condition to allow the species to maintain itself on a long-term basis as a viable component of the Glaskeelan and Owencarrow systems
Host fish	Number	Maintain sufficient juvenile salmonids to host glochidial larvae	Salmonid fish are host to the larval stage of the freshwater pearl mussel and thus are essential to completion of the life cycle. 0+ and 1+ fish are typically used, both because of habitat overlaps and the development of immunity with age in fish. Fish presence is considered sufficient, as higher fish density and biomass is indicative of enriched conditions in mussel rivers. Geist et al. (2006) found that higher densities of host fish coincided with eutrophication, poor substrate quality for mussels and a lack of mussel recruitment, while significantly lower densities and biomass of host fish were associated with high juvenile mussel numbers. Fish movements must be such that 0+ fish remain in the mussel habitat until their 1+ summer. No fish stocking should occur within the mussel habitat, nor any works that may change the salmonid balance or residency time. In the Glaskeelan and Owencarrow, neither salmon nor trout were encysted with glochidia in May 2009 (Johnston, 2009; NPWS, 2010)
Fringing habitats: area and condition	Hectares	Maintain the area and condition of fringing habitats necessary to support the population	Riparian habitats, including those along lake fringes, particularly natural/semi-natural woodlands and wetlands, even where they do not form part of a natural floodplain, are an integral part of the structure and functioning of river systems. Fringing habitats aid in the settlement of fine suspended material, protect banks from erosion, contribute to nutrient cycling and to the aquatic food web (e.g. allochthonous matter) and provide habitat (refuge and resources) for certain life-stages of fish, birds and aquatic invertebrates. Shade may also be important in suppressing algal and macrophyte growth in enriched rivers and moderating temperatures. Equally, fringing habitats are dependent on rivers/lakes, particularly their water levels, and support wetland communities and species of conservation concern. The target is for sufficient habitat in favourable condition to allow the species to maintain itself on a long-term basis as a viable component of the Glaskeelan and Owencarrow systems

Appendix 4 Conservation Objectives for Derryveagh and Glendowan Mountains SPA (004039)

The overall aim of the Habitats Directive is to maintain or restore the favourable conservation status of habitats and species of community interest. These habitats and species are listed in the Habitats and Birds Directives and Special Areas of Conservation and Special Protection Areas are designated to afford protection to the most vulnerable of them. These two designations are collectively known as the Natura 2000 network.

European and national legislation places a collective obligation on Ireland and its citizens to maintain habitats and species in the Natura 2000 network at favourable conservation condition. The Government and its agencies are responsible for the implementation and enforcement of regulations that will ensure the ecological integrity of these sites.

The maintenance of habitats and species within Natura 2000 sites at favourable conservation condition will contribute to the overall maintenance of favourable conservation status of those habitats and species at a national level.

Favourable conservation status of a habitat is achieved when:

- its natural range, and area it covers within that range, are stable or increasing, and
- the specific structure and functions which are necessary for its long-term maintenance exist and are likely to continue to exist for the foreseeable future, and
- the conservation status of its typical species is favourable.

The favourable conservation status of a species is achieved when:

- population dynamics data on the species concerned indicate that it is maintaining itself on a long-term basis as a viable component of its natural habitats, and
- the natural range of the species is neither being reduced nor is likely to be reduced for the foreseeable future, and
- there is, and will probably continue to be, a sufficiently large habitat to maintain its populations on a long-term basis.

Objective: To maintain or restore the favourable conservation condition of the bird species listed as Special Conservation Interests for this SPA:

Bird Code	Common Name	Scientific Name
A001	Red-throated Diver	*Gavia stellata*
A098	Merlin	*Falco columbarius*
A103	Peregrine	*Falco peregrinus*
A140	Golden Plover	*Pluvialis apricaria*
A466	Dunlin	*Calidris alpina schinzii*

For more information please go to: www.npws.ie/protected-sites/conservation-management-planning

Appendix 5 Article 17 monitoring and assessment results for Mullangore, Glenveagh

A5.1 Woodland assessment at Mullangore

Mullangore Wood in Glenveagh was surveyed as part of the Woodland Monitoring Surveys of 2011-12 (O'Neill & Barron, 2013) and 2017-18 (Daly *et al*., 2023). These monitoring surveys are commissioned by NPWS at intervals to inform the 6-yearly reports to the EU on the status of Annex I habitats, which are a requirement under Article 17 of the EU Habitats Directive. The aim of the surveys is to assess a sub-sample of the national resource of Annex I Old oak woodland, to get a nationwide evaluation of the conservation status of the Annex I woodland by means of three parameters: Area, Structure & functions, and Future prospects. They also inform a fourth parameter, Range, which is assessed across the entire national distribution of the habitat.

The Area parameter examines the change in extent of the Annex I habitat. In Glenveagh, this parameter will be favourably affected by any attempts to increase woodland area.

The Structure & functions parameter examines characteristics of the physical structure of the habitat (including the presence of typical species) and how the habitat functions ecologically. In Glenveagh, appropriate measures that improve structural diversity, increase species diversity or increase success of tree regeneration beyond the seedling stage will have a positive effect on the Structure & functions assessment.

The Future prospects parameter assesses the long-term viability of the Annex I habitat, in terms of its area, structure, ecological functioning, current pressures and future threats. A more favourable assessment will be obtained for Glenveagh if there is a reduction in pressures on the habitat (e.g. control of overgrazing and reduction in invasive plant species infestation levels) and if various conservation measures are implemented to enhance the woodland's condition, such as temporary fencing.

A5.2 2018 Assessment results for Annex I Old oak woodland at Mullangore (Daly *et al*., 2023)

A5.2.1 Area assessment

The Area parameter was assessed in the field, taking note of any recent losses in the monitoring polygon evident during the survey. Any area losses were marked on the field maps and then mapped digitally in the office. Area loss was calculated as a percentage of the original (pre-loss) area as follows:

(Current area / (Current area + area lost)) x 100.

This was then divided by the number of years since the site was surveyed in the baseline monitoring survey to derive the equivalent annual percentage loss in area as required for assessing Conservation Status. No area loss was recorded at Mullangore, so the Area parameter for the site was assessed as **Green**.

A5.2.2 Structure & functions assessment

The Structure & functions assessment procedure is based around four monitoring plots of 20 m x 20 m each. Some criteria are measured within the monitoring plot ('individual-plot level'); others are assessed across all four plots ('four-plot level').

The Structure & functions assessment criteria presented in Tables A5.1 to A5.4 below are those used by Daly *et al*. (2023) in the assessment of Old oak woodland for the latest Article 17 reports (NPWS, 2019). It is important to note that these assessment criteria are only used for assessment purposes: they are not used to determine Annex I status. The Annex I habitat Old oak woodland, as it occurs in the Irish context, is defined in Box 3 (see Chapter 6) and the decision as to whether woodland conforms to the Annex I habitat should be made in advance of carrying out the

assessment. Table A5.1 presents the positive indicator species used for criterion 1. Tables A5.2 and A5.3 list the individual-plot and four-plot (respectively) Structure & functions criteria.

Table A5.1 List of positive indicator species

Target species	*Quercus petraea, Quercus* x *rosacea*
Other woody species	*Betula pubescens, Corylus avellana, Ilex aquifolium, Lonicera periclymenum, Sorbus aucuparia, Vaccinium myrtillus*
Herbs & fern	*Blechnum spicant, Luzula sylvatica, Oxalis acetosella, Hyacinthoides non-scripta, Polypodium* sp.
Mosses & liverworts	*Dicranum scoparium/D. majus, Diplophyllum albicans, Hylocomium brevirostre, Mnium hornum, Plagiothecium undulatum, Polytrichum formosum, Pseudotaxiphyllum elegans, Rhytidiadelphus loreus, Saccogyna viticulosa, Scapania gracilis*

Table A5.2 Assessment criteria at the individual-plot level for 91A0 woodlands.

	Assessment criterion	**91A0 target for pass**
1	Positive indicator species	At least 1 target species
		≥6 positive species, of which at least 2 must be bryophytes
2	Negative species cover	≤10% cover of plot
3	Negative species regeneration	Absent
4	Median canopy height	≥11 m
5	Total canopy cover	≥30% of plot
6	Proportion of target species in canopy	≥50% of canopy
7	Native shrub layer cover	10 - 75% of plot
8	Native dwarf shrub/field layer	≥20% of plot, height ≥20 cm
9	Bryophyte cover	≥4%
10	Grazing pressure	All 4 indicators absent

Table A5.3 Assessment criteria at the four-plot level for 91A0 woodlands.

	Criterion	**Target for pass**
1	Target species size class distribution	At least 1 of each size class present over all 4 plots
2	Target species regeneration	At least 1 sapling ≥2m tall over all 4 plots
3	Other native tree regeneration	At least 1 sapling ≥2m tall in 2 or more plots
4	Old trees & dead wood	At least 3 from any category (DBH ≥20 cm)

Table A5.4 Summary of conditions required for Structure and Functions assessment results at the individual-plot, four-plot and polygon levels.

Level	No. of criteria assessed	Required for pass	Best result	Worse result
1-plot	10	Passes in ≥8 criteria	Four Passes	Four Fails
4-plot	4	Passes in ≥3 criteria	Pass	Fail
Polygon	Four 1-plot results + one 4-plot result	Various - see below	Green	Red

No. of 1-plot passes	4-plot result	Polygon S&F assessment result
4	Pass	Green
3	Pass	Amber
4	Fail	Amber
<3	Pass	Red
<4	Fail	Red

Mullangore failed several of the Structure & functions criteria in the 2018 assessment. The results below are from Daly *et al*. (2023) and incorporate some general unpublished data gathered as part of the assessment. Most of the failures were linked either to the presence of negative (non-native) species such as *Rhododendron ponticum*, or to overgrazing by deer, causing negative consequences to the field layer and shrub layer.

Tables A5.5 and A5.6 present the individual-plot and four-plot (respectively) Structure & functions results for Mullangore. On the basis of the plot assessments, the Structure & functions parameter was assessed as **Red**.

Table A5.5 Individual-plot-level Structure & functions criteria and results for Mullangore

	1-plot-level Assessment Criterion	Plot 1	Plot 2	Plot 3	Plot 4
1	Positive indicator species	Pass	Pass	Pass	Pass
2	Negative species cover (%)	Fail	Pass	Pass	Fail
3	Negative species regeneration	Fail	Fail	Fail	Fail
4	Median canopy height	Fail	Pass	Pass	Fail
5	Total canopy cover	Pass	Pass	Pass	Pass
6	Proportion of target species in canopy	Pass	Pass	Pass	Pass
7	Native shrub layer cover	Pass	Pass	Pass	Pass
8	Native dwarf shrub/field layer	Pass	Fail	Pass	Pass
9	Bryophyte cover	Pass	Pass	Pass	Pass
10	Grazing pressure	Fail	Fail	Fail	Fail
Overall	**1-plot level result**	**Fail**	**Fail**	**Pass**	**Fail**

Table A5.6 Four-plot-level S&F criteria and results for Mullangore

	4-plot-level Assessment Criterion	Result across 4 plots
1	Target species size class distribution	Pass
2	Target species regeneration	Fail
3	Other native tree regeneration	Pass
4	Old trees & dead wood	Pass
Overall	**4-plot level result**	**Pass**

A5.2.3 Future prospects assessment

Future Prospects were assessed at Mullangore by evaluating the future expected trend of Area and Structure & functions at the site, and examining the current pressures, future threats and beneficial management practices operating on the habitat. Negative impacts from overgrazing and invasive non-native shrubs were considered to cast serious doubts on the future viability of the woodland, and the future expected trend of Structure & functions was also evaluated as bad. These two results in combination gave a Future prospects assessment of **Red**.

A5.2.4 Overall condition assessment

The combination of Red Structure & functions and Red Future prospects assessments for the Old oak woodland habitat at Mullangore resulted in the habitat receiving an overall condition assessment of **Red**. The results are summarised in Table A5.7.

Table A5.7 Overall condition assessment for Mullangore achieved by combining the assessment results of Area, Structure & functions and Future prospects.

Site name	Area	S&F	FP	Overall Conservation Status
Mullangore Wood	Green	Red	Red	**Red**

Appendix 6 Draft A-frame fence specification

The specification provided here is an unpublished draft specification from NPWS. It is recommended that this specification be finalised and circulated among NPWS staff as appropriate.

B Timber Standard and Treatment

B.1 Timber Standard:

Timber used in deer fencing shall meet the requirements of IS436/IS437, as and from 1st March 2008 and be certified as such by the NSAI or equivalent Body (e.g. BSI).

B.1.1 Permitted species

Timber used in fencing shall be chosen from species in accordance with Table 1.

Table 1 — Permitted species

Species	Post	A-Frame Pylon
Douglas fir – Pseudotsuga menziesii	Permitted	Permitted
Larch – Larix spp.	Permitted	Permitted
Lodgepole pine – Pinus contorta	Permitted	Permitted
Scots pine – Pinus sylvestris	Permitted	Permitted
Oak – Quercus spp.	Permitted	Permitted
Spruce – Picea sitchensis, Pinus abies	Permitted	Permitted

B.1.2 Grading

Timber posts shall meet the requirements in Table 2A and Table 2B and Figure 1 when graded in accordance with I.S 127.

Table 2A — Grading requirements

Characteristics	Permissible limits
Knots	Total Knot Area Ratio (KAR) not greater than ½
Slope of grain	Not exceeding 1 in 6
Wane	Up to ¼ of face or edge over full length and can be up to ⅓ in any 300 mm length for Horse fencing timbers. For deer, sheep and goat fencing timbers the wane shall not exceed 1/3 of face or edge over full length (rectangular sections only)
Sapstain	Permitted
Decay	Not permitted
Active insect attack	Not permitted
Surface condition	Free from extraneous matter for example water, mud, dirt and largely free from inner or outer bark.

B.1.3 Moisture content

After drying and immediately prior to preservative treatment, the moisture content of posts and timbers shall not exceed 26%, when measured in accordance with **I.S. 436 or I.S. 437**.

Table 2B— Additional requirements for Deer fencing timbers

Characteristics	Permissible limits
End splits	Not longer than 150 mm
Fissures	Total depth of fissure not greater than ½ the thickness
Distortion	See Figure 1
Bow	Maximum 25 mm over 3000 mm
Spring	Maximum 15 mm over 3000 mm
Twist	Maximum 20 mm over 3000 mm
Cup	Not greater than $^1/_{25}$ of the width

B.1.4 Preservation of timber pieces

Oak may be used untreated, but, if so, shall be free of sapwood. For all other permitted species, pieces of the correct moisture content and dimensions, shall be treated in accordance with I.S. 436 or I.S. 437, and as and from 1st March 2008 shall be certified to be in compliance with the relevant standard by the NSAI.
Brush on treatment of any preservative is not acceptable.

B.1.5 Marking

B.1.5.1 Intermediate posts

Intermediate posts shall be labelled by the bale. Each bale shall be labelled with the label containing the following information at a minimum:

Manufacturer's details, bale number, number of pieces in bale, piece dimensions, date of labelling, verification of final inspection, Irish Standard number.

B.1.5.2 Straining Posts

Straining posts shall be individually marked with a unique number, which can be fully traced back to the manufacturer. Each bale of straining posts shall also be labelled as for intermediate posts.

B.1.5.3 Certificate for Stakes

A fencing stake certificate (in Appendix A) shall be completed for all stake applications for grant aid. Section A is to be completed by the stake manufacturer. Section B is to be completed by the supplier of the stake to the farmer. The farmer shall submit the completed certificate together with the standard paperwork for grant aid.

E.2 Non-tensile suspended Fence

In areas where conventional high-tensile wire cannot be effectively constructed, Non-tensile suspended deer fencing (A-Frame fencing) shall be utilised. Fencing of this type is highly suited to fencing of small coupes on undulating or uneven terrain, shallow soils, and non- arable land types. Owing to the unstressed nature of the suspended non-tensile fence, it is important that the fence route should be designed to preclude turns of 90 ° or more. Best fence performance is achieved using gradual shallow curves as opposed to acute angles.

Where this type of fencing may be used in proximity to cattle, it must be supplemented by appropriate stock fencing to S148 (2008) standard.

Non-tensile suspended deer fencing shall be constructed using rectangular wire mesh as specified in clause D.2.4 above. Chain link mesh (D.2.7), suitably strengthened, may also be used.

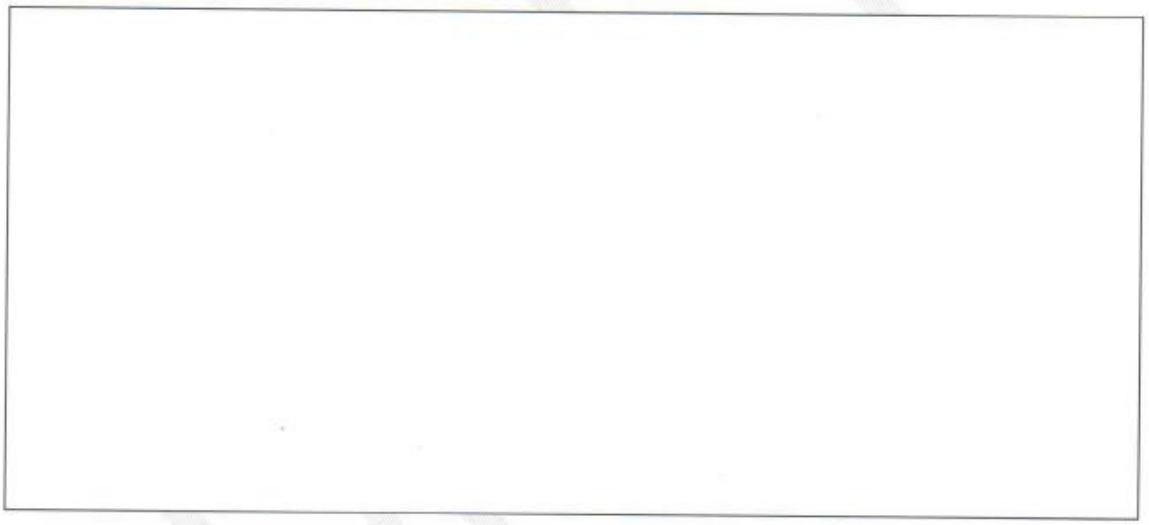

Fig. E.2 Non tensile Suspended deer fence

E.2.1 Perimeter Fencing

Perimeter fencing using rectangular locking joint wire mesh shall be a minimum of 1.9m high formed of 13, 17 or 18 horizontal wires, with suitably graded spaces becoming smaller nearer the ground. There shall be a maximum space of 150mm between the vertical wires.

E2.1 A-frame Pylons

Wire fencing is suspended from treated timber pylons at 4-6m intervals. Pylons to consist of either 3000mm by 105mm half round stakes, or similarly dimensioned timber, treated in accordance with S.I 436/S.I 437. Pylons will be assembled using a single 100mm nail driven through parallel to the direction of the wire netting. The stakes should pass through the fence under the top horizontal strand. The lowermost portion of fencing should be

secured flat to the ground at the second horizontal strand of netting to the ground, using 200mm treated pegs and staples, at appropriate intervals.

E.1.3.4 Straining non-tensile suspended fencing

Owing to the unstressed nature of the suspended non-tensile fence, the fence route should be designed to preclude turns of 90 ° or more. Instead, gradual shallow curves should be used. Where acute turns cannot be avoided, a robust tripod arrangement should be used to support the fence, consisting of a standard A – frame pylon fixed to a suitable straining post. The posts used shall be not less than 3 metres long, with a diameter of not less than 225mm and driven l000mm into the ground or placed in an augered hole at the position of the bend.

A.1.1 Gates

Gates shall be medium-duty type of galvanised steel suitably constructed and braced. They shall be at least 3m wide and 1.9m high. If they are also used as entrance gates from a public road they shall be at least 3.6m wide and shall open inwards.
PHOTO CONOR DALY GATE

A.1.1.1 Steel Gates

Steel gates shall be formed of fully galvanised tubular steel with an outside diameter of 33.7x3mm. Tubular steel should preferably be bent at each corner and welded to form the frame. Alternatively, welded mitred square joints at corner may be used.

Gates may be constructed using an infill of rectangular wire mesh or chain link mesh exactly as specified for perimeter fencing per section A above. In this case, the gate shall be diagonally braced as shown in Figure E1.2 and E1.3, using 32mm tubular steel. Gates may also be formed with an infill of rigid galvanised steel mesh. Spaces between the mesh shall not be greater than specified for perimeter fencing.

A.1.1.2 Timber Gates

Timber gates shall be formed of treated timbers. Frame and bracing timbers shall be at least 100mm x 38mm. Diagonal bracing shall be as in Figure E1.3.

Gates may be constructed using an infill of rectangular wire mesh or chain link mesh exactly as specified for perimeter fencing per A above. The gates (with the same bracing) may also be constructed using laths, horizontal timber laths at least 75mm x 25mm with a maximum space of 75mm between the laths.

A.1.1.3 Gate Posts

Gateposts shall either be the outer post of an H-frame or a straining post as previously specified. All hinges, sockets, and sliding bolts shall be fully galvanised.

Plate 12. A-frame fencing in the Blackwater Catchment, Kenmare, Co. Kerry – note how it can "sit on top of" and "ride over" sensitive areas or difficult terrain. Photo by Paddy Purser.

Plate 13. A-frame fencing detail showing pegging of mesh and stay to ground. Photo by Paddy Purser.

Appendix 7 Historical records to support woodland antiquity

The Civil Survey of Ireland (1654-1656)

This survey was established to profile the Irish lands that were due to be confiscated and redistributed to the English under the Act of Settlement, 1652. The Civil Survey was dependent upon the Irish citizens testifying to their possessions under oath before the Courts of Survey.

The text under Gartan Parish that potentially relates to the focus area (Lough Beagh glen) includes:

> *"Losson one quarter, Losson temple, one Quarter, Tryhena, one qrter, Killmore one qrter, Being in all foure quarters of Land"*

These four quarters of Gartan were described as comprising 536 plantation acres of which 86 acres were "*Shrubby Wood and Mountany Wood*". These townlands are listed as owned by James Knox (on lease from the See of Rapho).

Placename database research indicates *Losson temple* is an old name for Gartan Mountain. *Losson* and *Killmore* refer to the modern-day townlands, Losset and Kilmore, with the exact location of the old townland *Tryhena* remaining unknown. The following locational information is presented for these townlands in the Civil Survey:

> *"the sd fower quarters of Land is bounded-on the East wth Bryan Litter, Sowth wth Loughbae, West wth Derrveagh, And North wth the River of Callebber."*

Note: Loughbae is likely a reference to Gartan Lough (rather than Lough Beagh), *Derryveagh* likely refers to Derryveagh Mountain and the *River of Callebber* refers to the Calabber River. The eastern boundary reference for *Bryan Litter* remains unknown.

The grouping of townlands means the exact location of the 86 plantation acres of "*Shrubby Wood and Mountany Wood"* cannot be deciphered (e.g., if it occurred within the Lough Beagh glen or the lands to the east). However, this record represents a potential reference to woodland on the northwest-facing slopes of the glen.

Glendon and Derriveagh (2 quarters) was described as comprising 300 plantation acres of which 24 acres were "*Shrubby Wood*". These townlands are listed as owned by Sir William Gore. Placename database research indicates the names *Glendon* may refer to either Glendowanbeg townland or the Glendown Mountain area. *Derriveagh* likely refers to Derryveagh Mountains or the general Derryveagh district. The following locational information is presented:

> *"The above menconed two Quarters of Glendone and Deriveagh belonging to Sr. Wm. Gore, are bounded on the East wth the fower Quarters of Gartan, South wth Loghbue, West wth the Barrony of Boylagh and Banagh, North wth Muckill Hill in the parish of Clandehorka".*

Note: The *fower Quarters of Gartan* refers to the four quarters of Gartan (Gartan Mountain, Losset, Kilmore and the old townland *Tryhena*), *Loghbue* is likely a reference to Gartan Lough but could also be an old name for a lake at the southern edge of Gartan Parish (Lough Barra?), *Barrony of Boylagh and Banagh* refers the Boylagh Barony boundary and *Muckill Hill* is a reference to Muckish Mountain in the Clondahorky Parish.

The exact location of the 24 plantation acres of woodland is not given. However, this record represents a potential reference to woodland on the southeast-facing slopes and/or the northwest-facing slopes at the top of the glen.

The Down Survey (1655-1657)

The Down Survey sought to measure all the land to be forfeited by the Catholic Irish in order to facilitate its redistribution to English soldiers and adventurers. It was carried out under the direction of Sir William Petty and comprises a series of barony and parish maps of confiscated Irish lands. The maps are accompanied by a series of 'terriers', books that provide written descriptions of both barony and parish boundaries along with the land quality of each townland.

The written description for Kilmacrenan Barony does not mention woodland and there are no tree symbols on the barony map. The barony maps show that much of the Lough Beagh glen is mapped as 'unfortified land' with very little map detail displayed, except mountains (the Down Survey only focused on fortified lands). Details for part of Gartan Parish are shown comprising the areas owned by James Knox. Here, lakes including Lough Gartan are displayed (labelled *Lough Reagh*) along with Gartan Mountain townland (labelled *Lesson Temple*), Losset (labelled *Lesson*), Kilmore (labelled *Killmore*) and an unknown townland (labelled *Tuckeny* but referred to as *Triheny* in the parish text; referred to as *Tryhena* by the Civil Survey). Source link: http://downsurvey.tcd.ie/down-survey-maps.php#bm=Killmacreenan&c=Donegal

The written description of the fortified land in Gartan Parish does not mention woodland; similarly there are no tree symbols depicted on the parish map. Source link: http://downsurvey.tcd.ie/down-survey-maps.php#bm=Killmacreenan&c=Donegal&p=Garton

Other 17th century written accounts

The Ballad of Turlough Óg is a poem by Donegal poet Niall MacGiolla Bhríde, who was born in 1861. He grew up in Creeslough, in the shadow of Doe Castle, and the story he put in the poem was already a famous folk tale at the time (Conliffe, 2021). The poem details a tragic love story set in the 1600s of Aileen MacSweeney, daughter of Maolmuire of Doe, and her lover Turlough Óg O'Boyle. The poem refers to a 'dark Glenveagh' that was regarded as a hunting ground for deer.

> *"Wild are thy hills, O Donegal, that growing darkly rise as if to greet the mist that falls upon them from the skies; Dark, dark thy hills and darker still thy mountain torrents flow, But darker still Maolmuire's heart in his Castle Hall at Doe..."*
>
> *"Stout are thy oaks, O Donegal, and straight thy ashen tree, and swift and strong thy sons so tall thy country's pride to see; But oak or ash or young men all that sprung from Irish soil..."*
>
> ***"With ringing cheer to hunt the deer from his haunts in dark Glenveagh..."***

One of the most notable early records of woodland within the Lough Beagh glen was a reference by O'Sullivan quoted by John O'Donovan in his 1835 Ordnance Survey letters about the Cahir O'Doherty revolt in 1608.

> *"O'Dogherty considering his own unequal to the forces of his enemies,* ***concealed himself with much riches in the wood of Gleann Beatha*** *leading to which there are only three passages through which the enemy could come to attack him..."*

Telford (1977) notes that, for the woods to be able to conceal an army, and for there to only be three possible routes through which passage could be made, this suggested that the woodlands were more extensive and likely denser at that time.

19th century written accounts

Although the 19th century is late for assigning antiquity, travelogues and other topographical accounts from that period can provide descriptive information about the landscape. Otway's travelogue in 1822 describes the tree composition of the woodlands on the northwest-facing slopes and mentions the wooded islands. He omits any reference to woodland on the southeast-facing slopes.

The Protestant clergyman, Caesar Otway, travelogue 1822
"*On the right hand side of the lake the mountain rises like a steep wall out of the water, lofty and precipitous, for a thousand feet; and this cliff is the secure eyrie of the eagle and jer-falcon. On the other side the shore was lofty also, and mountainous;* ***but still there was room for oak and the birch, the rowan and alder, to strike out their roots amidst the rocks, and clothe the ravines and hollows with ornamental copse-wood. The lake was studded with wet woody islands…*** *"*

John O'Donovan's Ordnance Survey letters in 1835 indicate that he viewed Lough Beagh glen as a much-reduced, denuded landscape, conveying the idea that much of the woodland had been destroyed prior to his visit.

John O'Donovan Ordnance Survey letter 1835
"Gleann Bheatha, anglicized Glenveagh, ***is a grand and picturesque glen which presents all the appearance of its having once been a forest and Mullangore wood yet adorns its north-eastern extremity****…"*

The topographical dictionary of Ireland by Samuel Lewis published in 1837 makes references to the industries in the area that may have contributed to a reduction of woodland cover.

A topographical dictionary of Ireland by Samuel Lewis 1837
"*As* ***long as fuel could be procured from the forests*** *of Donegal,* ***Derryveagh****, Slievedoon and Kilmacrenan, the mines were wrought and the ore smelted.*"
The text for Gartan Parish states:
"A silver and lead mine was worked here in 1835, in the townland of Warrenstown, but has been discontinued*."*

John O'Hagan's travelogue details his arduous hike around Lough Veagh (Beagh) in 1845. The author makes references to the "*remains of old forests*" and "*primeval thickets*". These phrases indicate he thought the woodlands were in existence for a long time prior to his visit (at least the 17th century or beyond). The phrase "*remains of old forests*" also indicate the author's belief that the woods were once more extensive. O'Hagan also makes reference to the bareness of the southeast-facing slopes.

John O'Hagan travelogue - Ulster in the Summer of 1845
The following are excerpts from his walk around Lough Veagh (Beagh)
"***The hill on one side bare, on the other a good deal of the remains of old forests****. We saw on the far side, part of a road, which, there was every reason to believe extended through the wood, all along the lake*"
"*Here was this beautiful lake, looking by moonlight as lovely a scene as one could wish to set eyes on, yet not a boat on it, not a house near it, no road on either side, but a dangerous path on one side* ***and no path at all but primeval thickets on the other.***"

The Memoirs of the Geological Survey for northwest and central Donegal, dated 1891, remarks on the low tree cover in the region, with the exception being the 'considerable' native forests of Glenveagh, which occupy the northwest-facing slopes from the lake verge to the edge of the tableland. Source link: http://www.geologicalmaps.net/IrishHistMapsDownload/B02008.pdf.

Memoirs of the Geological Survey 1891
*"**Except in the neighbourhood of Glenbeagh Castle trees are scarce, but here the sterile aspect of the region is relieved by a considerable forest, of native trees, which covers the banks from the margin of the lough to the edge of the table-lands. These woods and mountain solitudes were the last, refuge of the red deer in county Donegal, down to a time well within the present century**."* *"On the western side, near its centre, the lake is bounded by naked cliffs of granite, rising almost vertically from the water. The opposite side, however, **is extensively clothed with a natural forest of oak, mountain ash, hazel, and holly**, surmounted by cliff of granite, from which enormous blocks have fallen to the margin of the lake."*

The great botanical historian, Eileen McCracken, with reference to the Memoirs of the Geological Survey wrote the following about Donegal woodland cover:

"*Donegal, much of it mountain or covered with poor boulder strewn soil, does not appear to have carried very extensive or thick woods. This lack of timber is emphasised by the fact that seventeenth-century planters in Donegal and Tyrone were granted wood from county Londonderry.*
The woods of oak, hazel, holly and mountain ash which clothed the slopes of the Derryveagh mountains were the last refuge of the red deer in Donegal in the late nineteenth century as they were the refuge of the woodkerne after the O'Dogherty rising of 1608" (McCracken, 1959).

Other historical maps

Woodland was depicted in the general location of Glenveagh on John Norden's map of Ulster (1609) and Nicolas Sanson's map (c. mid-1600s).

17th Century
Map title: Ulster British Library identifier: 001COTAUGI00002U00044000 Publication date: 1609 Creator: John Norden Description: This is a map of the six 'escheated' counties of Ulster. It dates from 1609 and may be by John Norden, though likely to be based on the barony maps of Josias Bodley and William Parsons. **Within Kilmacrenan Barony tree symbols are depicted in the general vicinity of Glenveagh. A river coming from a central mountainous area flows into Sheephaven Bay near Doe Castle. This river is flanked by tree symbols. The exaggerated large lake in the Kilmacrenan Barony appears to represent Gartan Lough given its association with the River Leannan and Lough Fern. Tree symbols are shown within mountainous regions to the north and west of Gartan Lough corresponding with the general location of Glenveagh.** Link: https://britishlibrary.georeferencer.com/maps/328dd139-35fa-5a57-b3a9-2fb339cff1b4/
Map title: Royaume D'Irlande David Rumsey identifier: 12178.037 Publication date: 1708 Creator: Nicolas Sanson (1600-1667) Description: **Within Kilmacrenan Barony tree symbols are depicted in the general vicinity of Glenveagh (i.e., northwest of Gartan Lough).** Link: https://davidrumsey.georeferencer.com/maps/f968c474-58e7-56a8-aff6-739fd62e6c53/

Appendix 8 Excel Prescriptions Workbook

An Excel Workbook has been prepared and supplied with this report that sets out prescriptions for all compartments / polygons greater than 1 hectare in size, the costs associated with implementing these prescriptions over the first 5 years of the plan, and overall costs for implementing this Strategy. The workbook is organised with five different sheets as described below. Its purpose is to provide NPWS with an ongoing dynamic tool where the assumptions can be changed and updated to reflect actual costs as they become known. In this regard, the Excel Workbook is meant as a support tool for NPWS staff in planning and managing the implementation of the Woodland Management Strategy.

Worksheet name	Notes
Full Details (All Polygons)	This contains details for all Compartments (polygons) at Glenveagh. There are 127 of these, covering 214 hectares. The spreadsheet contains details per compartment of current habitat types (Fossitt), Annex I habitats, Percentage of oak and other canopy tree species, Understorey species, Regeneration, Degree of Invasive Plant species, Grazing Pressure, Woodland Type, Field Notes and Compartment Area & Perimeter. For compartments greater than 1 hectare in area, management prescriptions are recorded.
Assumptions	This sets out cost assumptions for a number of items such as repairing existing deer fences, installing new exclosures, enrichment planting, individual tree protection (whether new planting or regeneration) and marking & thinning. It also includes cost assumptions for Full Time Equivalent (FTE) professional staff.
Costs for Compartments > 1 ha.	Of the 127 compartments, 86 of them are less than 1 hectare in area and considered too small for specific prescriptions. Instead, these compartments will be affected by the overarching strategy of deer density reductions and invasive species management. The remaining 41 compartments, making up 182 ha (85% of the total area), are identified in this spreadsheet and prescriptions are costed based on the assumptions in the "Assumptions" spreadsheet. These costs are totalled per operation but are also scaled up (*pro rata*) to the full 214 hectares covered by all compartments.
Cost Summary Table	This spreadsheet presents a summary of costs as calculated in the "Costs for Compartments > 1 ha." spreadsheet with further costs associated with developing the woodland management, invasive species management and deer management teams at Glenveagh. The costs are presented on an annual basis and for the operational costs it assumes these are spread evenly over the first 5 years of the plan. Based on the assumptions, the implementation cost of the plan is estimated at an average of €1,310,000 *per annum* for the first 5 years.
Costs Background (leave)	This sheet includes calculations in the background and should not be edited.

Appendix 9 Additional photographs

A9 Plate 1. *Rhododendron ponticum and Gaultheria mucronata* in an open woodland setting, northeast of Glenveagh Castle. Photo: Orla Daly.

A9 Plate 2. Wooded landscape interspersed with invasive plants, northeast of Glenveagh Castle. Photo: Orla Daly.

A9 Plate 3. Invasive plants including *Dicksonia antarctica* in the Castle Garden Woods. Photo: Orla Daly.

A9 Plate 4. View of Mullangore wood and Lough Beagh from the castle grounds. Photo: Orla Daly.

A9 Plate 5. View of Mullangore wood and Lough Beagh from the hillside above the woodland. *Rhododendron ponticum* is present in the wet heath habitat here. Photo: Simon Barron.

A9 Plate 6. The difference in tree regeneration inside and outside the deer fence at Mullangore wood. Photo: Orla Daly.

A9 Plate 7. *Rhododendron ponticum* infestations within the Glenlack valley. Photo: Orla Daly.

A9 Plate 8. View of the woodlands at Derrybeg. Photo: Orla Daly.

A9 Plate 9. View of the woodlands at Derrybeg and Derrylahan (known locally as Sruhannacullia wood). Photo: Orla Daly.

A9 Plate 10. A block of moribund oak wood (known locally as Foxes wood) with no structure or tree regeneration. Photo: Paddy Purser.

A9 Plate 11. A block of mature oak and birch (known locally as Badger's wood), with poor understorey and structure. Photo: Paddy Purser.

A9 Plate 12. Recently treated *Rhododendron ponticum* amongst remnant oak and birch on steep slopes north of Owenveagh River. Photo: Paddy Purser.

A9 Plate 13. Steep-sided stream valley containing woodland at Poll Garbh. Photo: Orla Daly.

A9 Plate 14. A thin scattering of remnant rowan and birch amongst wet heath habitat at Poll Garbh. Photo: Orla Daly.

A9 Plate 15. Stunted holly regeneration at Poll Garbh. Photo: Orla Daly.

A9 Plate 16. A small grazing exclosure visible in the centre and a thin scattering of trees elsewhere, Poll Garbh. Photo: Orla Daly.

A9 Plate 17. Woodland species, honeysuckle and aspen, clinging on in a steep cliff area above the lake (inaccessible to deer). Photo: Paddy Purser.

A9 Plate 18. Leafy liverworts, mosses and filmy ferns, typical of humid Old oak woodland, at Glenveagh. Photo: Fionnuala O'Neill.

A9 Plate 19. Woodland species, wood anemone, bluebell and wood sorrel, growing in the open near scattered woodland. Photo: Orla Daly.

A9 Plate 20. Remnant woodland in ravine on southeast-facing slopes, southwest of Lough Beagh. Photo: Simon Barron.

A9 Plate 21. EU Annex V species *Huperzia selago* (Fir clubmoss) growing in wet heath. Photo: Simon Barron.

Notes:

NPWS
An tSeirbhís Páirceanna
Náisiúnta agus Fiadhúlra
National Parks and Wildlife
Service

An Roinn Tithíochta,
Rialtais Áitiúil agus Oidhreachta
Department of Housing,
Local Government and Heritage