A Baseline Study of Bird Diversity on the Rewilding Reserve of Dunsany Castle Estate, County Meath

Thomas Buckley

Student Number: 16307320

Word Count:12,207

MSc. (Mod) Environmental Science Dissertation 2021

School of Natural Sciences

University of Dublin

Trinity College

Supervisor: Stephen Waldren

Declaration:

I declare that this thesis has not been submitted as an exercise for a degree at this or any other university and it is entirely my own work.

I agree to deposit this thesis in the University's open access institutional repository or allow the Library to do so on my behalf, subject to Irish Copyright Legislation and Trinity College Library conditions of use and acknowledgement.

I consent / do not consent to the examiner retaining a copy of the thesis beyond the examining period, should they so wish (EU GDPR May 2018).

In the case of a thesis for which the work has been carried out jointly; the declaration must have a statement that it includes the unpublished and/or published work of others, duly acknowledged in the text wherever included.

Signed: Thomas Buckley

Thomas Buckley

Acknowledgements:

I would like to thank my supervisor, Dr. Stephen Waldren for his guidance, support and his forbearance throughout the last few months. Thank you for everything.

I want to thank my wife Catherine for all her hard work and endeavour and for all her love and support for the past six years.

I want to thank my mother Marie and sister Andrea for all their support and love throughout the year.

I want to thank my children for all their support and kind words Anna, Thomas, Edward, Dean, Shannen and Sarah.

I want to thank Pierce Casey who has been by my side since our days back in Maynooth, thank you for your support when things have looked bleak.

I want to thank Randal Plunkett for the opportunity to and the permission to conduct this study on his property.

I want to thank Hugh Kenny who set me on this journey.

For you Da.

Abstract

Dunsany Estate in County Meath became the first Irish member of the European Rewilding Network in 2020. The estate has done away with livestock farming and 300 hectares is now being rewilded through passive rewilding. The estate is made up of fragmented woodland and grasslands and is surrounded by arable farmland. Management of the estate requires a number of surveys to be carried out so that future conservation measures can be ascertained.

An initial baseline study of bird diversity was carried out as birds are an important indicator species of ecological and biodiversity balance that have been used in many studies globally. This study will look at the species richness, abundances and habitats of bird communities on the estate.

Line transects and point count sampling were carried out over an 8-week period in June and July in a mixture of grassland and woodland habitats. Non-metric Multidimensional Scaling (NMS) and Cluster Analysis was carried out on the transect and point data to ascertain similar assemblages of birds and to note habitat differences between communities.

Total abundances for transects was 482 and for points was 195. There was a 2:1 ratio between woodland and grassland abundances in both point and transect counts. The dominant species throughout the study was *Columba palumbus.*

The communities were grouped into 4 groups in both point and transect cluster analysis, there was a distinct separation between grassland and woodland groups in most cases, but close associations caused group anomalies.

The findings in this study may guide management in future research into community associations and how they interact.

Key Words

Birds, Rewilding, Cluster Analysis, Indicator Species, Woodland, Grassland

Table of Contents

Contents

1 Introduction

1.1 Rewilding

Dunsany Castle Estate is a medium sized estate of c.650 hectares, located in the heart of livestock and arable farmland in South Co. Meath (Fig.1). The castle was built c.1180-1200 AD for the Norman warlord Hugh de Lacy, as a towered fortification and the four main towers form part of the current structure, which is c.3 times the original size. In 1401 Sir Christopher Plunket married the heiress to Killeen and Dunsany, Joan Cusack. In 1439 under Henry VI the Barony of Dunsany was created with the current estates remaining in the Plunket family, making it the oldest ownership continuity in Ireland (Silke, 2014; Moore, 2019). The current owner, Randal Plunkett is the 21st Baron of the estate.

Figure 1a and b: - Dunsany Estate, showing its location in County Meath, Republic of Ireland and the estate perimeter showing research sites. Maps made in Google Earth.

1.2 Concepts, history

Seven years ago, an awareness of climate change and environmental degradation led to a decision to forego grazing of sheep and cattle on the Dunsany estate and to rewild 300 of the 650 hectares. The term rewilding owes its origins to the conservation biologist Michael Soulé and environmentalist David Foreman who coined the phrase in the 1980s following the creation of the wildlands project (Lorimer et al., 2015).

The first time rewilding was used in print, was in the magazine 'Wild Earth in 1991', which was connected to The Wildlands Project (Jørgensen, 2015). Early development of this idea envisaged restoration of large predators into areas of connected wild spaces across north America, in an attempt to restore the apex predator in trophic food webs. There were three features that characterized rewilding at this time. 1) large, protected core reserves, 2) interconnected corridors between reserves and 3) reintroduction of keystone predatory species, known as the three C's: Cores, Corridors and Carnivores (Soule and Noss, 1998). A study by

Svenning et al, (2016) referred to this rewilding as "trophic rewilding" and highlighted the ecological roles and impacts that these large carnivores and herbivores can have in an ecosystem. For example, large adult herbivores (>1,000kg) due to size and abundance can strongly impact vegetation and ecosystems, while carnivores (i.e. wolves) can for example control and limit deer densities. An often-used example of this rewilding is the reintroduction of wolves into Yellowstone national park, where predation of elk caused a cascading effect on the parks ecology due to shifts in elk grazing patterns in exposed areas (i.e. river valleys), preventing over grazing (Lennon, 2016). This facilitated willow regeneration in riparian areas, causing river changes such as silting and realignment which regenerated habitat. This predation and fear of predation caused shifts in herbivore feeding patterns and ultimately facilitated increases in local biodiversity.

Other definitions of rewilding have since emerged and can be broadly distinguished into three other main concepts, passive rewilding, ecological rewilding and Pleistocene rewilding (which is the restoration of large megafauna, to recreate lost Pleistocene interactions and will not be covered in this study).

1.2.1 Passive rewilding

Passive rewilding reduces intervention in ecosystems and sees former cultivated lands abandoned with nature allowed to flourish and develop of its own accord. The influence of humans is reduced and often a key consequence of this type of rewilding is the reestablishment of forest areas and vegetative succession. Scrubland and woodland expansion due to natural succession are often the result of abandoned farmland and pastures and can regenerate as much woodland as active planting (Conti and Fagarazzi, 2005; Rey Benayas and Bullock, 2012). Vegetation succession can take anywhere from 15 to 30 years to approach equilibrium with the old vegetation state but displaying upper levels of species richness and mid successional species of trees (Cramer et al., 2008).

1.2.2 Rewilding examples in Ireland

Wild Nephin in County Mayo announced in 2013 is one of the most well know and aims to combine the Ballycroy National Park with Nephin forest to create around 4,000 hectares of wilderness. The project was to be the first of its kind in Ireland but in recent years has begun to be heavily criticised for inaction and continued recent felling and logging activities. Other activities such as sheep grazing and a large-scale rhododendron eradication programme have also continued throughout the site.

1.2.3 Changes, plans and progress to date

The use of fertiliser, pesticides, the felling of trees were all discontinued. Hunting practices on Dunsany lands were also abolished. Just over 300 hectares around the estate have been reassigned as a nature reserve and a herd of red deer (Cervus elaphus Linnaeus 1758) are now the sole large grazer and browser on the estate. 200 hectares of the reserve are made up of woodland and 100 hectares are grassland. The woodlands consist of native and non-native broadleaf and conifers and are fragmented throughout the estate, but they are connected through grassland corridors. The grasslands are former grazing areas and old crop fields that have been abandoned to facilitate natural regeneration of habitats. The Dunsany rewilding project has been in effect for less than ten years and has yet to reach the original vegetation state. Farmland abandonment for rewilding purposes can have a variety of impacts on animals in the vicinity, through the concept of winners and losers, (Russo, 2007). Rewilding can determine community composition with species either declining (losers) or increasing (winners) as vegetation and soil change as they no longer have an anthropogenic input (Navarro and Pereira, 2015). Shifting practices can have impacts on bird species, with loss of breeding habitats and food sources for some, while other species receive a positive feedback (Pointereau et al., 2008). Species of bird that can benefit from farmland abandonment include treecreepers, woodpeckers and tits (Navarro and Pereira, 2015). Passive rewilding as practised in Dunsany, relies on the evolutionary response of species in situ which generates its own problems in the conservation of a complex system as one species may become dominant (Gillson et al., 2011).

There are several springs and streams flowing through marshy areas throughout the estate with the Skane River the main water feature. The land not wooded or being used for rewilding is used for arable farming to grow crops, as the soil here is very fertile; rewilding is supported by incomes generated by agriculture and other commercial interests.

The first ever record of woodpeckers breeding in Co Meath was in 2008 (Coombes and Wilson, 2015) and last year (2020) a pair of great-spotted woodpeckers (Dendrocopos major) bred on the Dunsany estate, this was the first breeding pair of woodpeckers ever recorded in Dunsany (Walsh, 2020).

1.2.3 Challenges

There have also been sightings of hares, stoats, otters, pine martin, red kite, barn owl, snipe, numerous insects (Appendix 2) and there appears to be more small birds (Walsh, 2020). Some noted pests have also appeared such as mink (which have been recently sighted) and illegal poaching has been reported.

Other challenges faced by the estate include the planned extension of a railway line from Dunshaughlin that would cut through the reserve, through woodland that the woodpeckers are nesting in.

It is planned to allow the reserve to regulate itself as a natural ecosystem with a noted reduction in flooding (other than recent torrential downpours), as the land has not been harrowed and compressed, therefore drainage inhibition has lessened (Spagnoli Gabardi, 2019).

There are plans to plant numerous native Irish species of tree throughout the estate. As a private reserve the estate does not, as of yet receive funding but with its inclusion in the ERN this may change (Donohoe; 2019). Human footfall on the reserve has been reduced to negligible amounts, with most human activity centred around the castle. As a private reserve, public access is limited to invitation only and no trespassing is allowed. Old pathways through the woods and grasslands have been reclaimed by the natural vegetation, creating a vast array of habitat types for wildlife.

Rewilding is considered another form of conservation, with the introduction of large herbivores or carnivores, used to restore ecosystem services being the end goal (Root-Bernstein et al., 2017; Root-Bernstein et al., 2018). Dunsany management are considering the reintroduction of large grazers as the meadows have become overgrown and are in need of some control measures that are in the spirit of the rewilding process (R. Plunket, personal communication, July 16th, 2021).

Cataloguing the diversity on the estate is important, to note any changes in that diversity in the future and to note any area or species that may be protected under current legislation. Baseline studies are an essential part of environmental management processes and they are needed to inform of any impacts over the lifetime of a project (Gullison et al., 2015). The information gathered from these studies can help guide management to best practice. Already there has been a ground beetle (Carabidae) baseline study conducted on the estate by Shields

(2020). This project has conducted a baseline study of bird diversity in the different woodland and grassland areas and of Dunsany as a whole.

1.3 The importance of Farmland Birds

The overall trend of bird populations in Europe shows a downward trend due to habitat loss, illegal hunting and pesticides (Gross, 2015). Agricultural intensification in the latter part of the 20th century and the loss of habitat have been implicated in the collapse of some of Europe's bird populations (Donald *et al.*, 2001). Common farmland birds have declined in Europe over a 20-year period, but woodland species have not (Gregory et al., 2005). Common farmland bird numbers have fallen by almost a half, a few species have increased in number, some species have remained stable, but most species have declined, and the biomass of farmland birds has more than halved over a 27-year period (Vorisek *et al.*, 2010). There are major gaps in biodiversity data across Europe (including Ireland) and although birds are the most extensively monitored taxonomic group, there are still major gaps in their known abundance and distribution, partly due to bird's ability to rapidly change their range (Wetzel *et al.*, 2017). The Wetzel report also notes that these gaps can lead to misleading baseline biodiversity status evaluations, which shows the importance of data availability for continuous monitoring and research. These gaps may lead to a biased view in conservation assessments and may incorrectly influence policy makers. Baseline studies of populations are needed for future determination through monitoring the health or fitness of a community and to recognize the need for conservation of habitat, to strengthen or preserve species that are under pressure from anthropogenic activity (Mihoub *et al*., 2017). Mihoub also goes on to indicate that 'Temporal Baseline Studies' are required to fill in changes that can occur over time. In Ireland lowland farmland provides suitable habitat for 120 bird species of European Conservation Concern, which rely on it for wintering habitat, breeding or both, and this constitutes the greatest numerical dependency of any habitat for birds in Ireland (McMahon, 2007). Thirteen of the 18 species of bird that are of high conservation concern are linked to agricultural habitats. In Ireland a lack of baseline data to provide comparative study on both breeding and wintering bird populations have failed to show any significant impacts of the Rural Environment Protection Scheme (REPS) on farms taking part in the scheme (Copland et al., 2011).

A long-term analysis of bird's conservation status in Ireland began after the publication of the Irish Red Data Book in 1993 which led to the first BoCCI (birds of conservation concern in Ireland) list and was undertaken in 1999 by Newton *et al*. (Calhoun and Cummins, 2013). Intensification of farming in Ireland has been attributed to the reduction of invertebrate food that many species rely on and species such as Yellowhammer (*Emberiza citronella*) have declined by c.90% across Ireland over a 20-year period. These are representative of other amber list farmland species that have declined in Ireland such as stock dove (*Columba oenas*), skylark (*Alauda arvensis*), tree sparrow (*Passer montanus*) and linnet (*Linaria cannabina*) (Lynas et al., 2007). Concern has also been raised over the status of wintering waterbirds, breeding waders and lowland farmland birds. The IUCN a species that decreases by 80% over a 10-year period or over three generations (whichever is longer) to be critically endangered, endangered if it declines 50–79% over the same period, and vulnerable if it declines by 20–49% (IUCN, 2001; Bled *et al*., 2013). Baseline studies and continuous updating of data will show population fluctuations and the need to intervene with conservation measures before a point is reached when a species numbers decline. In Ireland red-listed species are the species of highest conservation priority, species of lesser priority are amber listed and green listed species are those of least concern. Passerine additions to the Red list such as grey wagtail (*Motacilla cinerea*) and meadow pipit (*Anthus pratensis*) due to significant declines of fifty percent or more over a 13-year period has been notable in recent years and other species could be suffering the same fate, whereas little egrets (*Egretta garzetta*) have increased in number and distribution (Colhoun and Cummins, 2013). Currently, conservation has become a topic of interest in Ireland with concern over peatland degradation, bird decline, habitat destruction, water quality and so on. Birds are found in many different terrestrial and aquatic habitats and the habitat in which it lives is based on the geo-physical and vegetational topographies that occur there (Crick, 1992). Classification of species by habitat association, although helpful, can be misleading, as many species use more than one defined habitat type (farmland, woodland, marshland, etc) at different times of the year, choosing the optimal available habitat and may be absent at the time of data collection (Fuller et al., 2004; Wiens, 1992; Hilden, 1965). Birds as a group are easily repeatedly observed and as one of the most studied organisms play an important role as bioindicators and can act as an early warning system of environmental changes such as chemical contamination, marine pollution, environmental fragmentation and climate change (Becker, 2003).

1.4 Birds as biodiversity and ecological indicators

Species richness may be ascertained by the occurrence of indicator species where a small set of species presence or absence can be representative of a larger cluster of species (Fleishman *et al*., 2005). Ecological indicators are used as early warning signals to ascertain change to the environment, to gauge the condition of the environment and to diagnose the cause (Dale and Beyeler, 2001). Birds as biodiversity indicators is not as straightforward as it may first appear as cause-and-effect relationships may take time to manifest, site fidelity can also produce time lags to any changes in their environments (Temple and Wiens, 1989). Changes to their environments can be naturally occurring or anthropogenically induced. Some of the natural disturbance can come in the form of fires, drought or food shortages and anthropogenic pressures such as acid rain, introduced species, urbanization, air pollution and land use change, and all can cause an ecological response (Niemi and McDonald, 2004). Birds have been used to indicate the presence of heavy metals and other endocrine disrupting chemicals (EDCs) which can have serious adverse impacts on the human system. The study looked at birds, as they represent a similar form of exposure to xenobiotics as humans and could prove to be a good bioindicator of contaminated areas (Carere *et al.*, 2010). The decline of bird populations can be used as an indicator for conservation measures that need to be undertaken, however characteristics of species need to be considered, and detailed evaluation is required to note species at risk (Dunn, 2002).

1.5 Baseline Studies

1.6 What are they?

Baseline studies are needed as a comparison point of changes that may occur over time but they may also uncover environmental factors that may impact a particular study (Wall & Horak, 2007). Impacts by anthropogenic activity are often overlooked in ecosystems due to a lack of baseline studies and monitoring (Ashton et al., 2003). The impacts of humans through deviations from the baseline results allows an understanding of effective management of natural resources (Arcese & Sinclair, 1997).

Climate change is having an impact on a number of ecosystems and their inhabitants and a phenological study by Bell *et al*. (2019) found that baseline studies with both geographical and temporal factors were better able to explain phenological shifts in birds than a model with a single factor such as habitat without spatial factors. A baseline study of bird diversity at Dunsany is to guide management in the future who can access change by using repeatable methododology. This is an important reason to create baseline studies across all areas to close any gaps in the data.

This could also show that the lack of data is impacting on the outcomes of studies through incorrect estimations of breeding populations as there is a deficiency in continued monitoring. Monitoring needs to be continuous to support management and directed by a number of questions: "Why monitor? What should be monitored? How should monitoring be carried out?" (Yoccoz et al., 2001). A study of population changes in Heronries in the UK used an older set of estimated data as a baseline for subsequent changes in population (Reynolds, 1979). When no actual baseline figures are available, this may be the only alternative. Elliott and Image (2018) depict a baseline study of grassland habitat types for birds in Ireland, with baseline scores on measures of success for species requirements and noted a mix of desirable and undesirable sward types, Chough (*Pyrrhocorax pyrrhocorax*), Grey partridge (*Perdix perdix*), the family Anatidae scored well but Hen Harrier and wader sites were considered too improved with denser than desirable vegetation, whilst Corncrake (Crex crex) sites had insufficient coverage of nettles (*Urtica dioica*), herbs (such as the family Apiaceae or Umbelliferae) and rushes (Juncaceae) (Elliott and Image, 2018). Failings in habitat conservation or incorrect restoration is leading to the demise of numerous species in Ireland and needs to be addressed by more directed scientific research. There are still major gaps in some rural areas as they are overlooked in preference to the more accessible research projects of peatlands, national parks, agreeable landowners, and government allocated projects. There is a greater need to access the corridors between these projects and to construct a current accessible baseline dataset.

1.7 Research Questions

The design of an inventory or monitoring project needs clearly defined objectives and once they are defined, specific areas to be inventoried or monitored need to be selected (Silsbee and Peterson 1991). This research project was an inductive evaluation of the birdlife in Dunsany Demesne compiling a baseline list of species present on the estate, although this was only for eight weeks of the annual cycle, c.June 8th until August 4th. The study aimed to provide a quantitative measure of species abundance on the estate. The aimed of the list, other than serving as a catalogue, are to help guide with the management of habitats and more importantly to point out conspicuous absences or presence of expected species.

A baseline study compiling the current bird diversity on site can be used in the future to note any decline in bird population diversity.

The study is showed the differences in the communities between habitats, with some species numerically dominating and it was hoped to show that keystone species are present. The baseline study has helped identify species present on site and provided data for management that can be used in their upkeep. Differing habitat use were noted with an aim for future studies to point out diminishment or growth of populations within each of the communities. The study also aimed to show if there is an affinity of species for their preferred habitat, and management efforts for such species will be most effective if they are directed towards the species observed locations rather than the locations that the species are believed to be associated with.

1.6.1 The Questions

The overarching aim of the study was to catalogue the bird diversity at Dunsany Demesne by listing all species found and in what habitat, and to answer the following questions:

- • What species are present on the estate and the abundances of species?
- • Are there significant species richness differences between habitat communities?
- • What is the evenness of each community?
- • What indicator species occur on site?

Point and transect counts were used to calculate populations but enough bird counts needed to be accumulated to ensure good estimations of birds present in the area per (Marsden, 1999).

The study

Line transects and point counts are the most widely used methods for bird count surveys but there are others, such as spot mapping and the catch and release (Bibby *et al*.,2000). This study used both point and line transects during the survey

Purpose and Scope

The concern over the apparent decline of birds across Europe has created the need to conduct baseline studies in areas that have been overlooked in the past. As Dunsany is in the process of rewilding it may show that these projects help promote biodiversity recovery. It is hoped that the data collated will complement any future baseline studies done in Dunsany and will give a more complete picture of the health and biodiversity make-up of the area.

2. Materials and Methods

2.1 Site Details

Dunsany Castle Estate (53°32'32.62" N, 6°37'20.70" W) and is mainly surrounded by agricultural land with Killeen castle c.3.5 km to the west. A pilot qualitative study of the estate was carried out with a visit to the estate on Monday the 26/4/21 to gain familiarity with the different habitat types on the estate. A further remote sensing study of the estate's grounds was carried out using Google Earth to assist with land cover classification, similar to a study by Li *et al*. (2020) but at a much smaller scale. The study itself was carried out over a ten-week period starting 8th June until the first week in August with the full co-operation of the landowner. Land use changes were also looked at (R. Plunket, personal communication, July 16th, 2021).

The three most widely used survey methods to conduct bird counts to ascertain diversity are spot-mapping, point counts and line transects (Bibby *et al.*, 2000). This study utilized point counts and line transects, as spot-mapping would have required multiple quadrats in wooded or forested areas leading to inconsistent replication. Line transects have been found to be more effective in denser environments than point counts, with point counts more effective in open environments (Wilson *et al.*, 2000).

Passive survey methods were carried out using guidelines set out by Buckland *et al.*, 2005 and Buckland *et al.*, 2015. When the need arose, a range finder was used to estimate distance and a phone app was used in the identification of species song (Collin's Bird Guide, 2020). In both point counts and line transects, birds were noted when observed visually or aurally and the corresponding habitat and location they were observed in. Weather was categorized as follows: cloud cover was measured in octals (0-7) 0 no cloud cover and 7 as no sky visible, brightness was on a scale of 0-6 (6 sunny, 5 bright,…1 dull and 0 was dark) temperature was measured in °C with min and max noted, rainfall (0-6) with 6 as torrential downpour, wind was based using the Beaufort scale 0-12. Rain had an impact on the decision to carry out observances as birds were kept down when rain became more than a drizzle. Sampling was carried out on three separate occasions for all transect and observation points.

Table 1:Transect names and their abbreviations, dominant habitat type and GPS start and finish points.

Transect	Abbreviation	Dominant Habitat Type	Start	Finish
Athronan Wood	AW	Woodland	53.545433, -6.630719	53.541748, -6.634775
Mixed Woodland	MWL	Woodland	53.532973, -6.635953	53.533984, -6.634479
Cricket Field & Wood	CF&W	Grassland	53.535396, -6.632072	53.537542, -6.638437
Duckpond Wood 1	DPW 1	Woodland	53.537739, -6.629243	53.538168, -6.630959
Duckpond Wood 2	DPW 2	Woodland	53.536925, -6.630537	53.539188, -6.637308
Railway Wood West	RWW	Woodland	53.534067, -6.631574	53.532466, -6.625827
Railway Wood East	RWE	Woodland	53.531179, -6.619078	53.531242, -6.624876
Alder Plantation	AP/2	Woodland	53.539983, -6.623751	53.536210, -6.629364
West Meadow	WM	Grassland	53.537914, -6.625225	53.533892, -6.628699
Main Garden Lawn	MGL	Grassland	53.534221, -6.626037	53.533798, -6.617710
Castle Grounds East	CG1	Woodland	53.535271, -6.618064	53.537972, -6.621687
Castle Grounds West	CG2	Woodland	53.538047, -6.623630	53.533774, -6.622190
Old Crop Fields	OCF	Grassland	53.538978, -6.623045	53.538081, -6.618024
Marsh Area	MA	Grassland	53.536594, -6.616338	53.535653, -6.610261
East Meadow	EM	Grassland	53.534127, -6.613124	53.529780, -6.616949

Table 2:Observation point names and their abbreviations, dominant habitat type and GPS location

Observation Point	Abbreviation	Dominant Habitat Type	Location (GPS)
Athronan Wood	AW_P1	Woodland	53.543394, -6.632414
Duckpond Wood	DPW_P1	Woodland	53.538506, -6.629611
Duckpond Wood 2	DPW_P2	Woodland	53.537945, -6.633709
Cricket Field and Wood	CF&W_P1	Grassland	53.536174, -6.635201
Mixed Woodland	MWL_P1	Woodland	53.534179, -6.636011
Alder Plantation	AP/2_P1	Woodland	53.538675, -6.625766
Railway Wood West	RWW_P1	Woodland	53.532485, -6.629052
Railway Wood East	RWE_P1	Woodland	53.530417, -6.620178
Old Crop Fields	OCF_P1	Grassland	53.538982, -6.620154
Marsh Area	MA_P1	Grassland	53.536168, -6.612952
East Meadow	EM_P1	Grassland	53.532413, -6.614645
Castle Grounds East	CG1_P	Woodland	53.537204, -6.619048
Castle Grounds West	CG2_P	Woodland	53.535774, -6.622852
West Meadow	WM_P1	Grassland	53.535654, -6.627501
Main Garden Lawn	MGL_P1	Grassland	53.532412, -6.622722

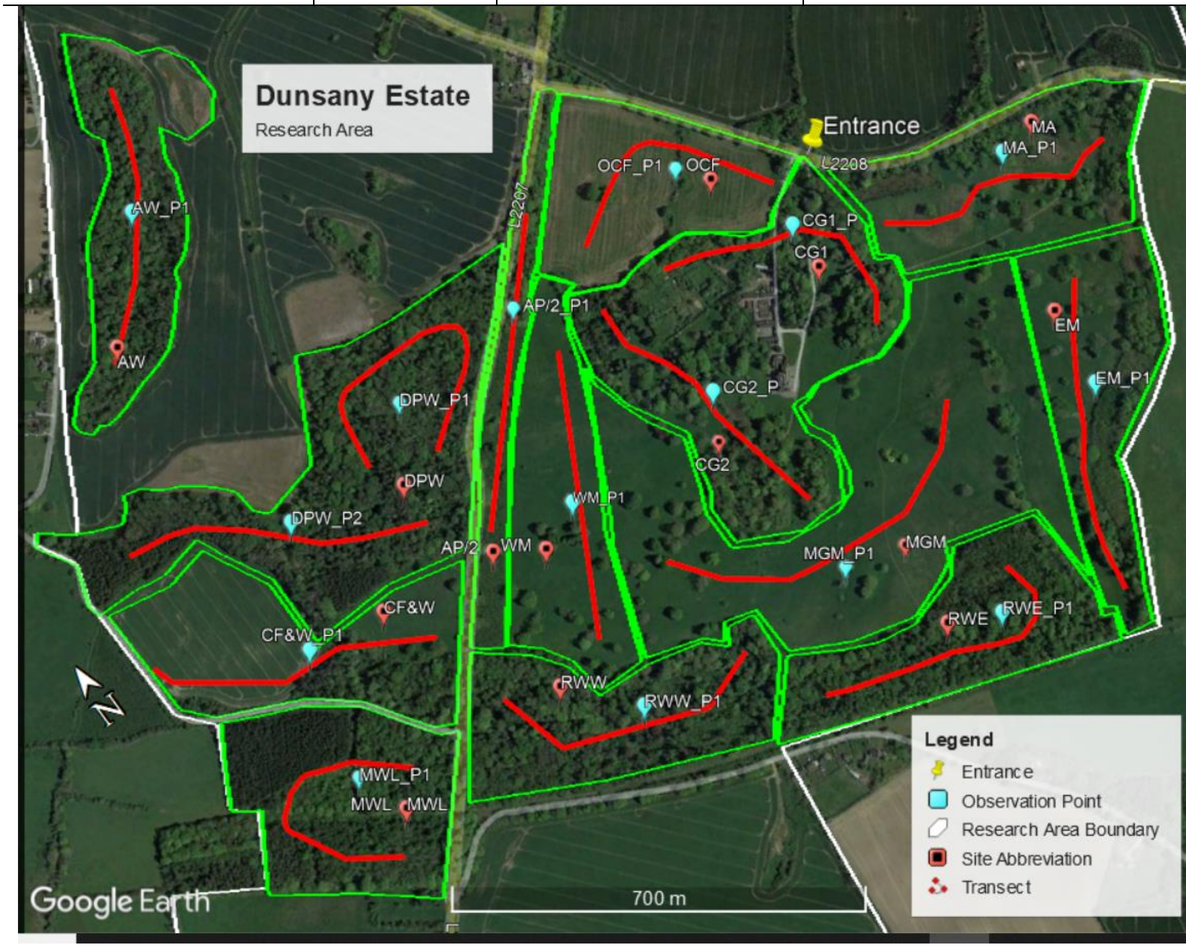

Figure 2: - Study Area with Transect and Point Abbreviations

2.1.1 Grasslands

Cricket Field & Wood (CF&W)

The Cricket Field is one of the oldest rewilded sites on the estate and was originally used as a crop field for cattle and sheep until approximately ten years ago. The field is bordered by the Dunsany Road and by the Mixed Woodland to the south-west and DPW to the north-east, with a large crop field at the western end. The field has a deep ditch along three of its sides with the Skane river along the crop field end. There are a number of large oak (*Quercus sp.*) trees within the field and a copse of horse chestnut (*Aesculus hippocastanum*) and hawthorn (*Crataegus monogyna*) along the Skane. The Cricket Field has the most diverse composition of grasses on the estate and this year the crop field has been left fallow but has had a large number of thistle (*Cirsium vulgare* and *Cirsium arvense (Appendix 3)*) and nettle (*Urtica dioica*) patches grow in place of a crop.

The transect here starts in the south-east corner of the Cricket Field and close to the Dunsany Road, traverses along the wood to the south-west, crossing the Skane into the crop field and continuing along edge and around to the end of the Duckpond Wood. The point observations CF&W_P1 were conducted from the end of the cricket field beside the Skane.

West Meadow (WM)

The WM also known as Black Lawn runs from the Old Crop Fields, alongside the Alder Plantation and Castle Grounds West and continues down to Railway Wood West and was originally used to graze sheep. The meadow mainly consists of tall grass species with some vetch (*Vicia sativa*) species and *Juncus spp.* denoting wet conditions in lower depressions in the middle of the meadow. The southern end of the meadow is dotted with *Quercus sp.*, *Betula sp*., and cherry laurel (*Prunus laurocerasus).*

Main Garden Meadow (MGM)

The Main Garden Meadow runs from the Southern End of the West Meadow along the Railway Wood, the Castle Grounds, the East Meadow and ends in the Marsh Area. This is the largest grassland in the research area and was originally used for grazing and silage. The meadow is divided in the centre by a separation fence that was used to keep cattle on one side of the pasture or the other. The grass is long and dense on the western side of the fence and around to the front of the Castle. There are large beds of *Cirsium vulgare* and *Urtica dioica* along the fence, the Railway Wood and under the trees which the deer use for refuge and hiding their fawns during the day. The eastern side of the meadow drops into a hollow area that was initially waterlogged and formed a shallow water feature. This area was composed of shorter grass and Juncus spp. early in the research but with the rising temperatures, dried out and was eventually composed of the same surrounding vegetation. There are several small copses of beech trees (*Fagus sylvatica*) with some copper beech (*Fagus sylvatica Atropunicea*), *Quercus sp., Acer pseudoplatanus* and *Betula sp.* scattered throughout the meadow.

Old Crop Fields (OCF)

Locally known as Durham's Field, OCF were originally used for arable crops, as late as 2015 and the tillage lines can still be seen on the Google Earth 2021 image (Fig.2). The area is sided by the Entrance Road to the north, the Castle Grounds to the south and the northern end of the Alder Plantation along the western side. The ground is very uneven as the drills have yet to settle completely. The grass content is less here in comparison to the other areas and there is a much higher coverage of *Juncus spp.* and large patches of ragwort (*Jacobaea vulgaris*) with the perimeter covered in deep beds of *Urtica dioica*. The field is split in two with a ditch running across the centre, the eastern end appears to be wetter ground judging by the vegetation.

Although the area has a high coverage of wetland plant species it also has the greatest number of young trees in comparison to any other site. Mature trees here include a copse of *Quercus sp*. in the eastern field. There are *Betula pubescens, Quercus sp*., Ash (*Fraxinus excelsior*), *Prunus laurocerasus* and some *Salix alba* (white willow).

Marsh Area (MA)

This region is sided by woodland on three sides and the Main Garden Meadow to the south. This section has a number of furrows that hold significant amounts of water, there is also a deep trench running through the eastern end of the zone. Although grass is the main vegetation type with about 60% cover, other vegetation here includes include wetland species such as *Juncus spp*., yellow iris (*Iris pseudacorus*) and a good percentage of meadowsweet (*Filipendula ulmaria*). Trees in this zone include *Quercus sp., Fagus sylvatica* and Atropunicea**,** *Crataegus monogyna* and with some black poplar (*Populus nigra*).

East Meadow (EM)

This is a long narrow undulating meadow sided by a small woodland along its eastern boundary and a large crop field beyond the wood, the meadow narrows to a point as it joins RWE. The meadow appears to be a transient point for deer as they move about the estate, the area here is criss-crossed with deer trails creating a number of open areas where common lizards (*Zootoca vivipara*) were observed. Outside the woods, trees include *Fraxinus excelsior,* sycamore (*Acer pseudoplatanus*), *Quercus sp*. (some dead) and a small fir (*Abies sp*.) plantation. This is one of the driest areas on the estate with the gradient running towards the River Skane at the southern end.

2.1.2 Woodlands

Athronan Wood (AW)

Locally known as Moore's Wood, this is a long narrow wood surrounded by a large crop-field and has a small marsh area at the north eastern end consisting of *Juncus sp. and Iris pseudacorus*. The woodland floor undulates throughout the length of the wood and has a number of dells that are quite deep. The woodland consists of *Fagus sylvatica*, *Acer pseudoplatanus, Fraxinus excelsior* and a large quantity of *Ulmus glabra*. The canopy is quite open throughout and the understorey consists of elderberry (*Sambucus nigra*) and *Prunus laurocerasus*. The floor has a number of bramble (*Rubus fruticosus*) thickets, some ivy (*Hedera helix*) and a covering of numerous herbaceous plants. There is a noticeable gradient that falls from south-east to north-west which creates an elevated and lower level, with the lower level having a greater density of vegetation. Overall, this is the most open woodland on the estate and has at least two badger (*Meles meles)* setts, a noticeable herd of *Cervus elaphus* and the scat of pine marten (*Martes martes*) was observed.

Mixed Woodland (MWL)

Locally known as Toomey's Wood this is one of the more confined woodlands on the estate with roads on two sides and arable cropland on the others. The woodland is a mix of broadleaf and conifers with the conifers (part of an old plantation) fully matured and confined to the northwest of the area. The conifers have a closed canopy with little or no understorey, the ground cover is composed of a thick layer of needles denoting the longevity of the plantation. The main canopy of broadleaf trees consists of *Fagus sylvatica* which are complimented by scots pine (*Pinus sylvestris*), *Acer pseudoplatanus* and *Aesculus hippocastanum*. This woodland has one of the most open canopies on the eastate. The understorey consists of a number of saplings with stands of holly (*Ilex aquifolium*), hazel (*Corylus avellana*), hawthorn (*Crataegus monogyna*) and a small number of elm (*Ulmus glabra*). The large amount of light boosts a significant herbaceous ground layer.

Duckpond Wood (DPW1, DPW2)

This is the largest woodland in the study, covering more than 20 hectares. The name comes from a pond at the north east end of the wood, the pond was covered with algal mats during the period of the study and the surrounding area had a number of umbellifers species including Wild Angelica (*Angelica sylvestris*) and hogweed (*Heracleum sphondylium*). Due to its large size the wood was split into two, Transect 1 and Point 1 (DPW_P1) were on the northern side of the wood, a 10 hectare section that was accessed from the north east corner. The transect here was horseshoe shaped and observation point 1 (DPW_P1) was in an open area under a full canopy of *Acer pseudoplatanus* in the centre of the zone. The second transect was in the south east end of the wood, beside the Cricket Field and started at the Dunsany road, continued to the south-west along the arm of the wood, crossing the Skane and continuing to the Athronan road end. DPW_P2 was situated at the start of the arm, between a small plantation of Douglas Fir (*Pseudotsuga menziesii*) and the deciduous woodland just before the River Skane and in an open area that was accessed by crossing a small bridge from the Cricket Field. The canopy at the northern side of the Skane conssits of a mixture of *Acer pseudoplatanus, Aesculus hippocastanum*, *Fagus sylvatica* and *Pinus sylvestris*, while the understorey from the north east end and up to the CF&W was dominated in large part by *Prunus laurocerasus* which was so impenetrable that it prevented any herbaceous layer from forming in this area. The western side of the transect was more open and has a diverse herbaceous layer and an understorey of *Ilex aquifolium*, *Corylus avellana*, *Crataegus monogyna* and *Rubus fruticosus*. Across the River Skane the canopy initially consisted of more *Fagus sylvatica* with some *Quercus sp.*, *Fraxinus excelsior* and *Acer pseudoplatanus*. There was a reasonable herbaceous layer suplemented by deciduous leaf litter. The River Skane partially ran throuh this part of the wood creating a fork at one point that had to be circumvented. The wood beyond this point was more open and generally had a lower canopy consisting of hawthorn (*Crataegus monogyna*), hazel (*Corylus avellana*),   holly (*Ilex aquifolium*) a number of young *Fraxinus excelsior* trees. Fern species including Hart's tonguefern (*Asplenium scolopendrium*) became more abundant as the ground became more waterlogged before draining into a sream in the northwest corner beside the road.

Railway Wood (RWW, RWE)

The Skane River also runs through this woodland, effectively cutting it in two, with the MGM on one side and a road on the other beside cropland and a few residential properties. The Railway Wood West (RWW) can be accessed from MWL by the Dunsany Road underpass. The RWW woodland is a continuation of the MWL although it is separated by the road, the underpass and separated from the estate by the River Skane, relieving it from a lot of foot traffic. Although undisturbed by human activity the woodland here is very open. Deer tracks abound here due to passage back and forth from the river. The woodland beside the river has well-spaced stands of *Fagus sylvatica* and *Acer pseudoplatanus.* Fallen trees block some paths and one that had fallen across the river creating a risky crossing point. The floor here was a mix of grass in the more open areas and a reasonable herbaceous layer elsewhere, with fern species throughout. Further from the river and towards the road smaller trees dominated, with the most profuse being *Prunus laurocerasus* and a scattering of *Ilex aquifolium*, *Taxus baccata, Corylus avellana*, *Crataegus monogyna* and *Rubus fruticosus* creating a shrub layer. A semi-established thicket of Himalayan knotweed (*Persicaria wallichii*) was found 50m from the river and reported to the landowner. The transect ran centrally through the woodland and close to the course of the Skane. Point observation (RWW_P1) was in an open area just past the remnants of an iron bridge that crossed the Skane. RWE was accessed from the south east of MGM and the EM. The woodland here initially comprises of a mix of deciduous trees and a high number of conifers before reaching the path along the Skane where *Fagus sylvatica* dominated but was complimented by some *Acer pseudoplatanus, Pinus sylvestri* with some and *Fraxinus excelsior*. The understorey is comprised mainly of common boxwood (*Buxus sempervirens*) with little or no herbaceous layer. The transect commences at the eastern MGM side of the wood and then follows the course of the Skane. RWE_P1 was in a small stand along the Skane with conifers and *Buxus sempervirens* on the periphery.

Alder Plantation (AP/2)

The Alder (*Alnus glutinosa*) plantation was the narrowest woodland in the study (less than 50m wide in parts), and was adjacent to the Dunsany Road and consists of two different woodland types. The first ran from RWW and along WM and stops at OCF and the second (separated from the first by a deep drainage ditch and a track to an old entrance gate) continued along the OCF and up to the entrance Road. The first woodland mostly consisted of a young plantation of *Alnus glutinosa* but there were a number of mature *Fagus sylvatica* and *Quercus sp.* in the centre of the plantation. There was little understorey other than some brambles along the road and the woodland floor was a mix of grass and a minimal herbaceous layer. The northern end was a more mature woodland and had a good mix of deciduous and coniferous trees with a light canopy. Trees included *Fagus sylvatica*, *Quercus sp.*, *Acer pseudoplatanus* with stands of *Ilex aquifolium*, *Corylus avellana* and *Crataegus monogyna.* The shrub layer had a small quantity of *Buxus sempervirens* and *Rubus fruticosus* and there is a minimal herbaceous layer due to a dense detritus layer of deciduous leaf litter. The first half of the transect began in the plantation but the ditch has to be circumvented by returning to WM and returning to the second half via the entrance gate track. AP/2_P1 was located at the entrance gate between a mature *Fagus sylvatica* and *Quercus sp.*

Castle Grounds (CG1, CG2)

The Castle Grounds had been split into two separate line transects and two observation points. The first CG1 started in the east of MGL in front of the castle. After crossing a drainage ditch the area consisted of a steep mound with a mix of conifers, Quercus sp. and some *Acer pseudoplatanus*, there was a minimal herbaceous layer on the mound. There was an open area beside the Old Dunsany Church before entering into a dense stand of *Prunus laurocerasus* with little or no herbaceous layer. The road was bypassed by using a small culvert that went under the road. The *Prunus laurocerasus* stand opened up onto a farm track between the castle and the woodland creating an open area with a mix of *Ilex aquifolium*, *Taxus baccata, Crataegus monogyna* and *Rubus fruticosus* with the transect finishing just before the Rose Garden Wood. The second area CG2 began in the Rose Garden which was a mix of non-native ornamental trees and shrubs with a minimal herbaceous layer. A small grassland was crossed to a stand of *Pinus sylvestris, Abies sp.*, *Taxus baccata* and a number of *Acer pseudoplatanus* on the periphery. The understorey consisted of grasses, *Rubus fruticosus* , *Urtica dioica, Cirsium spp.* and there was number of felled trees due to their proximity to the residence. Another small grassland separateed the Rose Garden area from the Bluebell Wood. The Bluebell Wood had a mix of trees including *Fagus sylvatica, Fraxinus excelsior, Acer pseudoplatanus* and some conifers. The understorey had a notable herbaceous layer. This was an area of the grounds that had a significant amount of human footfall with a small amenity area and a pathway for farm machinery running through the wood.

2.2 Field survey methods

2.2.1 Line Transect Sampling

Line transects were measured by pacing out an approximately 500m continuous length of each woodland and grassland transect line, circumventing obstacles to keep the line as straight as possible and to keep equality between transects. Transect names and their acronyms, dominant habitat type and GPS start and finish points were mapped and tabulated (Table1 and Fig.2). The transects were traversed, stopping every 100m for 1 minute and listening for calls or song and also noting any visual observations. Observations were also noted for any individuals heard or seen while walking between stopping points, noting their exact location in an attempt to avoid multiple counting. The density or abundance of species was estimated from detected individuals (Buckland et al., 2015). Counting the starting point as point 1 gave six stopping points over a 500m line transect. Birds beyond 80m from the line were not counted as they were classed as part of other transects. Birds outside the transect dimension that were flushed ahead of the observer were noted and classed as the ability to move on or off the transect area could not be controlled and the observer may have been the cause for flight (Bibby *et al.*, 1992). Observations at the boundary cause some upward bias in estimates as some birds may be outside, but these are cancelled out by a matching bias in the effectiveness of the plot size resulting in minimal bias in abundance estimates (Buckland *et al*., 2015). Birds identified at boundaries were counted as they were deemed part of the transect as their mobility allowed them to enter or leave the site as they foraged.

2.2.2 Point count sampling

Observation points were set as close to the centre of transects as possible to prevent contamination of counts by birds from other sites. Each point count location was visited for a set period c.20 minutes and counted observed individuals for the first 5 minutes as anything beyond this can have replicated counts (pseudoreplication), then only new species detected were counted in the remaining minutes. The first 5 minutes has been found to be 3 times higher for detection of new species during a 15-minute count and detection of species declined by more than 60% over the 3 hours after sunrise (Ralph et al., 1995). Point counts will be based on visual and auditory observances from central points within each habitat location. Observation point names and their acronyms, dominant habitat type and GPS location were tabulated and mapped (Table 2 and Fig.2). Observed birds, either auditory or visually will similarly to line transect observances be noted in a comparable manner.

2.2.3 Nocturnal Observations

Owl observations followed guidelines by Takats *et al*. (2001). Weather, especially rain is not conducive to owl flight and there were no observations carried out during wet conditions. Roads and paths were used as transects throughout the estate and observances were carried out for c.90 minutes from sunset by listening for calling owls every 200m for 2-3 minutes. Clear skies or overcast conditions were noted. As transect counts proved to be ineffective playback observations were used using barn owl and long-eared owl calls. These calls were played every c.400m along the transects. Point counts were also used, using the point position of daytime point count locations and listening for 30 minutes intervals before using the playback option. Observations were only carried out on four occasions in July and were found to be inadequate and so were discontinued. Barn owls (*Tyto alba*) and long-eared owls (*Asio otus*) had been seen on the estate earlier in the year during nesting season and this may be a project that could be carried out at another time.

2.3 Data Analysis

Each of the 15 transect and observation points were visited 3 times and all observations were noted. Data were collated into an excel file and a mean value was calculated for each species observations across Dunsany and a mean value for total abundance was also calculated for the 3 observations for both transect and points (Table 3 and Table 4).

2.3.1 Non-metric Multidimensional Scaling (NMS) and Cluster Analysis

PC-Ord 5 was used and using Sorenson (Bray-Curtis) distance measure the data for transects and points were analysed separately by a non-metric multidimensional scaling (NMS). This was done to find similar compositions of birds which were visualised using ordination plots depicting sites with similar bird assemblages (Fig. 3 and 4). The results file had a Monte Carlo test result that compares real data with randomized data after 250 runs for each, the final stress value is then recorded. Cluster analysis was then run using Sorenson (Bray-Curtis) distance and using flexible data method (Lance and Williams, 1967) beta was set at -0.25 (McCune and Grace, 2002) and groups were set at 4. Indicator species analysis was run using a Monte Carlo randomization procedure (Dufrene and Legendre, 1997) to achieve maximum indicator values. Results were then uploaded into an (word file first) excel file for analysis.

Data Analysis

Graphs were constructed in Excel from the collated data and data analysis was conducted using a number of tests from Krebs (1999, 2015):

- Abundance was calculated by the mean of the three observations for both total abundance and the abundance of each species (Table 3 and Table 4).
- Total abundance was measured for each transect, point and Dunsany.
- The number of species was used to calculate species richness comparisons between sites.

Diversity was measured using Shannon's and Simpson's indices, The Shannon diversity index uses number of species and number of individuals of each species (but can also use place occupied by individuals) to calculate species diversity, whereas Simpson's diversity index is a similarity index, the closer to 1 the lower the diversity (Krebs, 2015).

Evenness measured using Simpson's measures of evenness. Evenness will show which habitat has equal or unequal abundances of different species.

flushed birds were discounted so as not to count again. The cost of traveling to the site over a six-week period

Samples consisted of collections of transect and observation point data and were collated as separate collections of data and treated as such, although analysis of each was identical. Species diversity and evenness were calculated using Shannon's and Simpson's indices then tabulated in Excel.

3.Results

The study was conducted over an eight-week period, across Dunsany with a total of 2031 individual observations, 1445 and 586 individuals were observed along transects and observation points respectively (Table 3 and Table 4). 41species of birds were noted and listed with their authority (Table 5.) and woodpigeons (*Columba palumbus*) were the most common species noted and were observed on all transects and count points but were more abundant in woodland areas.

Table 3: Transects total observations, total abundance, relative abundance, species richness and relative species richness across Dunsany. Observations were carried out on three separate occasions for each site (mean totals were rounded up).

Scientific Name	AW	DPW	DPW2	CF&W	MWL	AP/2	RWW	RWE	OCF	MA	EM	CG1	CG2	WM	MGL	Total Obs.	Mean Total
Turdus merula	14	10	8	3	11	9	10	4	2	9	1	6	8	-	1	96	32
Sylvia atricapilla	11	10	7	8	11	5	4	5	3	5	-	9	6	-	-	84	28
Cyanistes caeruleus	4	6	9	-	-	-	3	-	-	8	9	5	1	-	-	45	15
Pyrrhula pyrrhula	-	3	-	-	3	-	-	-	-	-	-	1	-	-	-	7	3
Buteo buteo	4	7	-	3	-	10	-	2	4	2	5	2	-	5	5	49	17
Fringilla coelebs	6	5	7	5	4	6	4	2	5	5	-	5	7	1	3	65	22
Phylloscopus collybita	-	-	-	-	1	-	-	-	-	-	-	1	-	-	-	2	1
Periparus ater	-	-	9	-	-	-	2	1	-	5	5	5	1	-	-	28	10
Cuculus canorus	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1	1
Prunella modularis	2	1	5	-	1	2	3	1	-	2	-	2	-	-	-	19	7
Regulus regulus	2	1	1	-	3	1	-	2	-	-	-	1	3	-	-	14	5
Dendrocopos Major	-	-	1	1	2	-	-	-	-	1	-	-	1	-	-	6	2
Parus major	2	5	-	1	4	-	1	-	-	2	-	7	8	-	-	30	10
Larus argentatus	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1	1
Corvus cornix	1	-	-	1	4	3	1	4	3	-	-	-	1	1	1	20	7
Delichon urbicum	-	-	-	-	-	-	-	-	-	2	7	-	-	-	15	24	8
Corvus monedula	-	-	-	-	-	-	-	-	-	-	-	6	-	-	11	17	6
Garrulus glandarius	6	5	9	-	11	3	7	8	-	1	1	-	2	1	2	56	19
Falco tinnunculus	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1	1
Larus fuscus	-	-	-	-	-	-	-	-	3	6	-	-	-	-	-	9	3
Aegithalos caudatus	-	-	2	-	-	-	-	-	-	-	7	-	-	-	-	9	3
Anas platyrhynchos	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	1
Pica pica	-	-	-	-	1	-	-	-	-	-	2	-	-	-	2	5	2
Turdus viscivorus	1	7	-	-	1	-	-	-	1	21	4	18	1	-	9	63	21
Phasianus colchicus	1	-	2	-	-	-	-	-	-	-	-	-	-	-	-	3	1
Corvus corax	-	1	2	13	2	1	1	-	2	1	-	1	-	-	-	24	8
Emberiza schoeniclus	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	3	1
Erithacus rubecula	5	4	4	2	7	6	4	6	-	-	1	4	2	-	1	46	16
Corvus frugilegus	2	5	2	2	-	-	2	-	2	11	-	4	4	-	2	36	12
Riparia riparia	-	-	-	-	-	-	-	3	-	-	6	-	-	-	3	12	4
Turdus philomelos	6	7	5	2	3	10	4	2	-	2	-	4	6	-	1	52	18
Accipiter nisus	-	1	-	-	-	1	2	4	-	1	-	-	-	1	1	11	4
Muscicapa striata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	1
Columba oenas	3	7	2	-	10	-	2	1	-	1	-	6	-	-	-	32	11
Hirundo rustica	-	-	-	-	2	-	-	-	1	7	20	1	-	2	19	52	18
Apus apus	-	-	-	-	-	-	-	-	-	2	10	1	-	-	2	15	5
Certhia familiaris	-	-	-	-	1	-	-	-	1	-	-	-	1	-	-	3	1
Columba palumbus	17	15	23	8	32	17	18	18	44	25	9	80	47	6	13	372	124
Troglodytes troglodytes	12	16	10	7	14	14	11	9	4	4	2	12	9	2	3	129	43
Emberiza citrinella	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	2	1
Species Richness	18	19	18	13	22	14	17	16	17	22	15	23	17	8	19	40	40
Relative Species Richness	45.0	47.5	45.0	32.5	55.0	35.0	42.5	40.0	42.5	55.0	37.5	57.5	42.5	20.0	47.5	100.0	100.0
Total Observations	99	116	108	56	129	88	79	72	82	123	89	182	108	19	95	1445	1445
Total Abundance	33	39	36	19	43	29	26	24	27	41	30	61	36	6	32	482	493
Relative Abundance	6.9	8.0	7.5	3.9	8.9	6.1	5.5	5.0	5.7	8.5	6.2	12.6	7.5	1.3	6.6	100.0	100.0

Table 4: Points total observations, total abundance, relative abundance, species richness and relative species richness across Dunsany. Observations were carried out on three separate occasions for each site (mean totals were rounded up).

Species	AW_P	DPW_P	DPW2_P	CF&W_P	MWL_P	AP/2_P	RWW_P	RWE_P	OCF_P	MA_P	EM_P	CG1_P	CG2_P	WM_P	MGL_P	Total Obs	Mean Total
Turdus merula	3	5	2	1	4	2	4	1	1	3	1	3	1	-	1	32	11
Sylvia atricapilla	3	7	4	2	3	2	3	2	1	1	-	6	1	-	2	37	13
Cyanistes caeruleus	4	2	3	-	2	-	2	-	-	-	2	8	-	-	1	24	8
Pyrrhula pyrrhula	-	2	1	-	1	-	-	-	-	-	-	-	-	-	-	4	2
Buteo buteo	3	5	3	3	1	10	-	1	4	4	1	-	3	5	5	48	16
Fringilla coelebs	1	2	3	2	2	2	2	-	1	3	-	2	3	1	1	25	9
Phylloscopus collybita	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	1
Periparus ater	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	2	1
Prunella modularis	3	1	2	-	1	-	-	-	-	1	-	1	1	-	-	10	4
Dendrocopos Major	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	1
Parus major	4	3	1	-	1	2	3	2	-	-	-	3	1	-	-	20	7
Ardea cinerea	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1	1
Corvus cornix	-	-	-	1	1	-	-	2	1	1	-	-	-	3	5	14	5
Delichon urbicum	-	-	-	-	-	-	-	-	-	3	4	-	-	-	4	11	4
Corvus monedula	-	-	-	-	-	-	-	-	-	-	-	3	1	-	6	10	4
Garrulus glandarius	4	4	4	-	7	1	4	1	-	-	1	-	3	-	-	29	10
Falco tinnunculus	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1	1
Larus fuscus	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	2	1
Pica pica	-	-	-	-	-	-	-	-	-	-	1	4	-	-	-	5	2
Turdus viscivorus	-	2	-	-	-	-	-	-	1	1	1	1	2	3	4	15	5
Corvus corax	-	1	-	1	1	1	-	-	2	-	-	-	-	-	-	6	2
Erithacus rubecula	1	2	2	-	2	1	3	2	-	-	-	2	-	-	-	15	5
Corvus frugilegus	-	2	2	-	-	-	-	-	-	3	-	8	-	2	-	17	6
Riparia riparia	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	2	1
Turdus philomelos	2	7	1	-	1	2	2	3	-	1	-	2	1	-	1	23	8
Accipiter nisus	-	1	-	-	2	2	1	3	-	-	-	-	-	-	-	9	3
Columba oenas	-	3	1	-	4	-	1	-	-	-	-	3	-	-	-	12	4
Hirundo rustica	-	-	-	-	-	-	-	-	-	9	16	-	-	-	5	30	10
Apus apus	-	-	-	-	-	-	-	-	-	1	8	1	-	-	-	10	4
Certhia familiaris	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1	1
Columba palumbus	6	12	10	5	7	8	7	9	11	9	8	16	7	5	7	127	43
Troglodytes troglodytes	3	5	5	2	4	3	3	3	1	3	1	4	4	-	-	41	14
Emberiza citrinella	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1	1
Species Richness	12	18	15	8	17	12	12	12	12	15	12	18	13	6	12	33	33
Relative Species Richness	36	55	45	24	52	36	36	36	36	45	36	55	39	18	36	100	100
Total Observations	37	66	44	17	44	36	35	30	26	45	46	70	29	19	42	586	586
Total Abundance	13	22	15	6	15	12	12	10	9	15	16	24	10	7	14	196	208
Relative Abundance	6	11	8	3	8	6	6	5	4	8	8	12	5	3	7	100	100

3.1 PC-Ord Non-metric Multidimensional Scaling (NMS) and Cluster Analysis to Visualise Levels of Similarity

A 2-dimensional solution was used in both line transect and point counts to illustrate the data in an ordination plot. The finals stress value for transect data was 9.65 which was significantly lower than the Monte Carlo randomisation stress value of 19.84, with a P value of 0.0096 across six axes. The final stress value for point count data was 7.75 which was also significantly lower than the Monte Carlo randomisation stress value, which was 15.35, with a P value of 0.0040 across six axes.

3.1.1 Ordination Plots with sites clustered as similar bird species assemblages

The ordination plot of transect sites showed all woodland to have a high axis1 (>85) value in comparison to grassland where only CFW had high value, however axis2 showed a more even distribution of sites except for WM which appears as an outlier (Fig. 3). Clusters of sites can be seen with most woodland together and a close association with CF&W (grassland). OCF, CG1, CG2 and possibly MA forming a loose cluster, EM and MGL are closely linked although separate from other clusters, with WM isolated.

Although the pattern found in the ordination plot of point sites has grassland at the higher values on Axis1 and woodland the higher values on Axis 2, grassland and woodland are noticeably separate in the main (Fig.4). Woodland cluster of sites can be seen with MWL_P, RWW_P, AW_P, DPW2_P and DPW_P, forming one and RWE_P, AP/2_P, CG2_P another, with CG1_P isolated. Grassland clusters of MA_P and MG1_P, with WM_P and EM_P isolated.

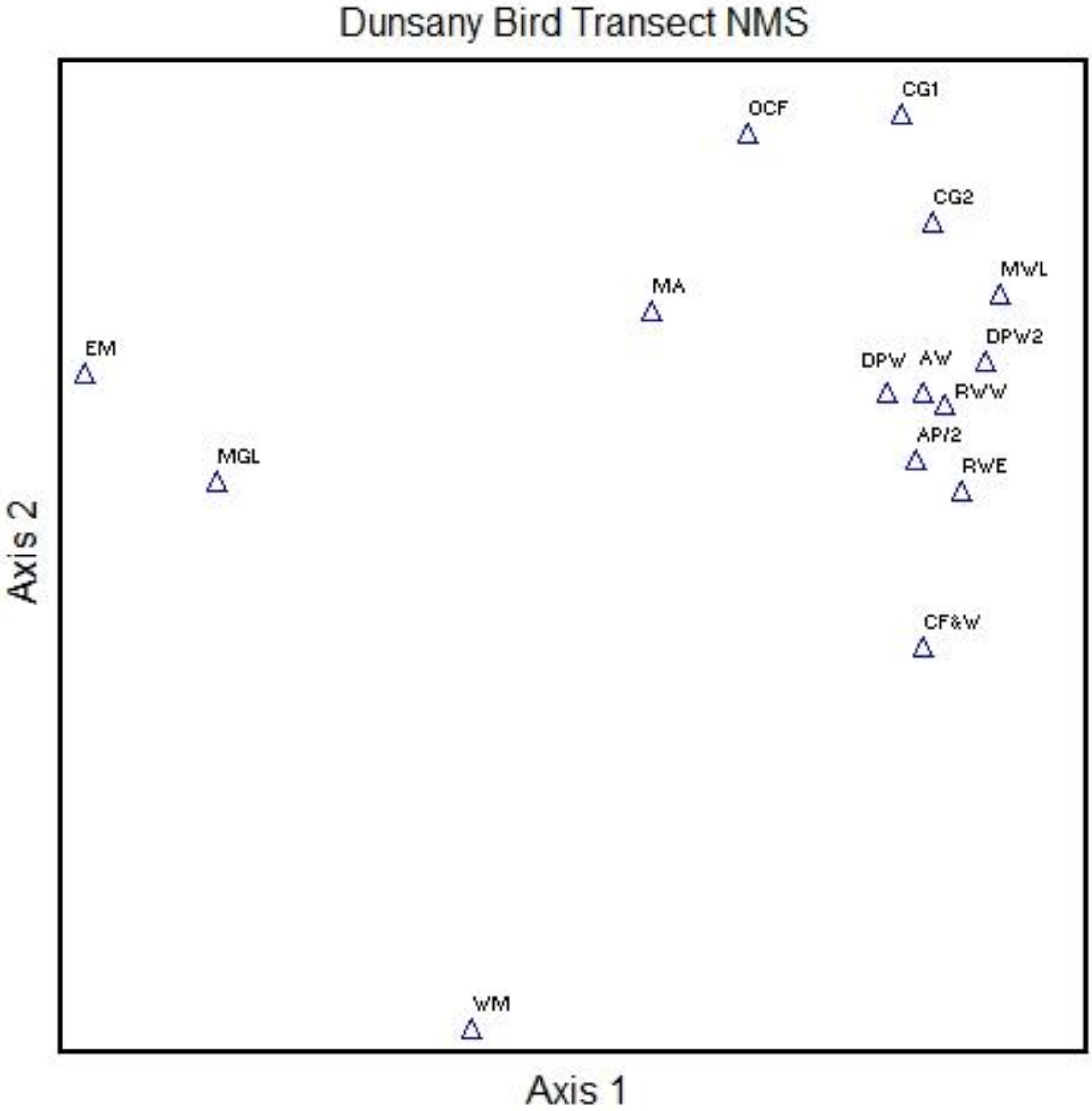

Figure 3: - NMS Ordination of line transects for bird observations in Dunsany. Habitat type and abbreviations can be found in Table1. Clusters show similar species compositions with different compositions isolated and appearing as outliers.

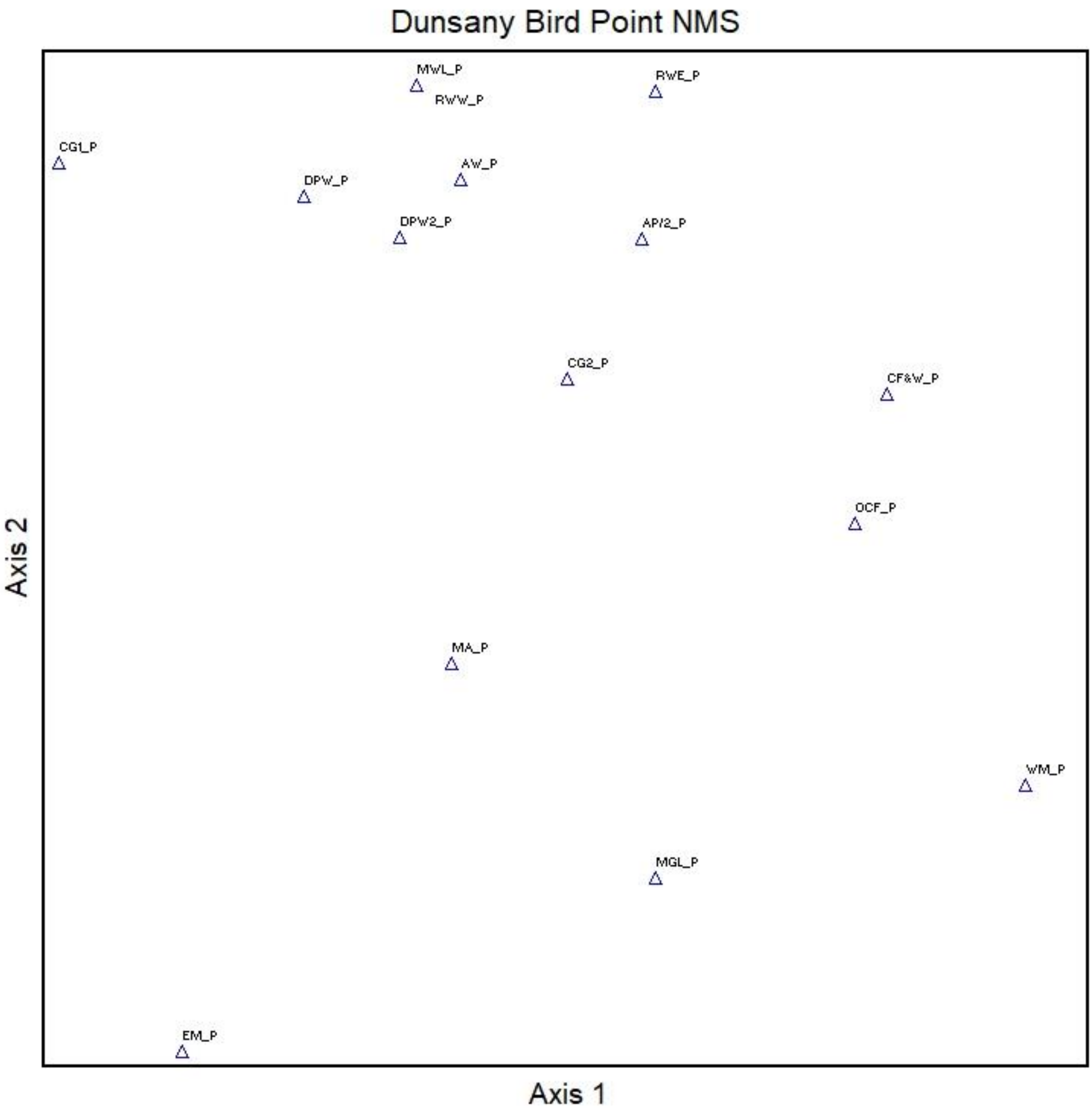

Figure 4: - NMS Ordination of count points for bird observations in Dunsany. Habitat type and abbreviations can be found in Table2. Clusters show similar species compositions with different compositions isolated and appearing as outliers.

The species ordination plots reflect differences in habitat types, with higher species numbers clustered in woodland habitat as seen in the biplots, with species richness indicating an increase towards woodland in both point and transects (Fig.5 & Fig.6). A combined list of species observed along transects and count points with common name, scientific name with authority and abbreviations for species scientific names (Table 5). This trend is further supported by species dominance percentages as seen in Tables 6 & 7.

Table 5: Bird species r A combined list of species observed along transects and count points with common name, scientific name with authority and abbreviations for species scientific names.

Common Name	Scientific Name	Abbreviation
Blackbird	*Turdus merula* (Linnaeus, 1758)	Turd mer
Blackcap	*Sylvia atricapilla* (Linnaeus, 1758)	Sylv atr
Blue Tit	*Cyanistes caeruleus* (Linnaeus, 1758)	Cyan cae
Bullfinch	*Pyrrhula pyrrhula* (Linnaeus, 1758)	Pyrr pyr
Buzzard	*Buteo buteo* (Linnaeus, 1758)	Bute but
Chaffinch	*Fringilla coelebs* (Linnaeus, 1758)	Frin coe
Chiffchaff	*Phylloscopus collybita* (Vieillot, 1817)	Phyl col
Coal Tit	*Periparus ater* (Linnaeus, 1758)	Peri ate
Cuckoo	*Cuculus canorus* (Linnaeus, 1758)	Cucu can
Dunnock	*Prunella modularis* (Linnaeus, 1758)	Prun mod
Goldcrest	*Regulus regulus* (Linnaeus, 1758)	Regu reg
Great Spotted Woodpecker	*Dendrocopos Major* (Linneus, 1758)	Dend Maj
Great Tit	*Parus major* (Linnaeus, 1758)	Paru maj
Grey Heron	*Ardea cinerea* (Linnaeus, 1758)	Arde cin
Herring Gull	*Larus argentatus* (Pontoppidan, 1763)	Laru arg
Hooded Crow	*Corvus cornix* (Linnaeus, 1758)	Corv cor
House Marten	*Delichon urbicum* (Linnaeus, 1758)	Deli urb
Jackdaw	*Corvus monedula* (Linnaeus, 1758)	Corv mon
Jay	*Garrulus glandarius* (Linnaeus, 1758)	Garr gla
Kestrel	*Falco tinnunculus* (Linnaeus, 1758)	Falc tin
Lesser Black-backed Gull	*Larus fuscus* (Linnaeus, 1758)	Laru fus
Long-tailed Tit	*Aegithalos caudatus* (Linnaeus, 1758)	Aegi cau
Mallard	*Anas platyrhynchos* (Linnaeus, 1758)	Anas pla
Magpie	*Pica pica* (Linnaeus, 1758)	Pica pic
Mistle Thrush	*Turdus viscivorus* (Linnaeus, 1758)	Turd vis
Pheasant	*Phasianus colchicus* (Linnaeus, 1758)	Phas col
Raven	*Corvus corax* (Linnaeus, 1758)	Corv cor
Reed Bunting	*Emberiza schoeniclus* (Linnaeus, 1758)	Embe sch
Robin	*Erithacus rubecula* (Linnaeus, 1758)	Erit rub
Rook	*Corvus frugilegus* (Linnaeus, 1758)	Corv fru
Sand Marten	*Riparia riparia* (Linnaeus, 1758)	Ripa rip
Song Thrush	*Turdus philomelos* (Brehm, 1831)	Turd phi
Sparrowhawk	*Accipiter nisus* (Linnaeus, 1758)	Acci nis
Spotted Flycatcher	*Muscicapa striata* (Pallas, 1764)	Musc str
Stock Dove	*Columba oenas* (Linnaeus, 1758)	Colu oen
Swallow	*Hirundo rustica* (Linnaeus, 1758)	Hiru rus
Swift	*Apus apus* (Linnaeus, 1758)	Apus apu
Treecreeper	*Certhia familiaris* (Linnaeus, 1758)	Cert fam
Woodpigeon	*Columba palumbus* (Linnaeus, 1758)	Colu pal
Wren	*Troglodytes troglodytes* (Linnaeus, 1758)	Trog tro
Yellowhammer	*Emberiza citrinella* (Linnaeus, 1758)	Embe cit

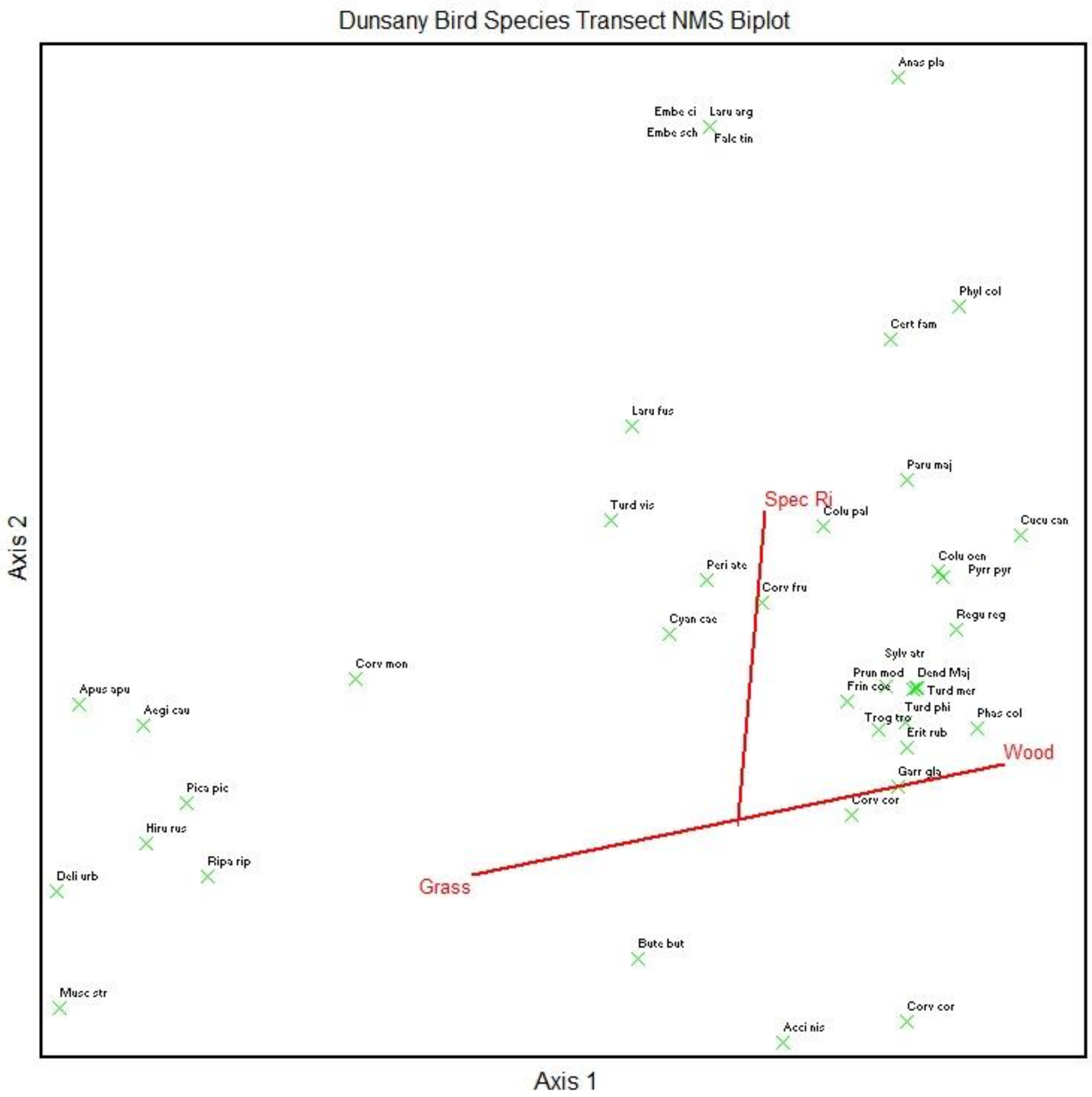

Figure 5: - NMS Ordination of line transects for bird observations in Dunsany. Species scientific names and their abbreviations can be found in Table 3. The vectors identify the habitat types as grassland (Grass), woodland (Wood) and species richness (Spec Ri) is indicated as higher in woodland.

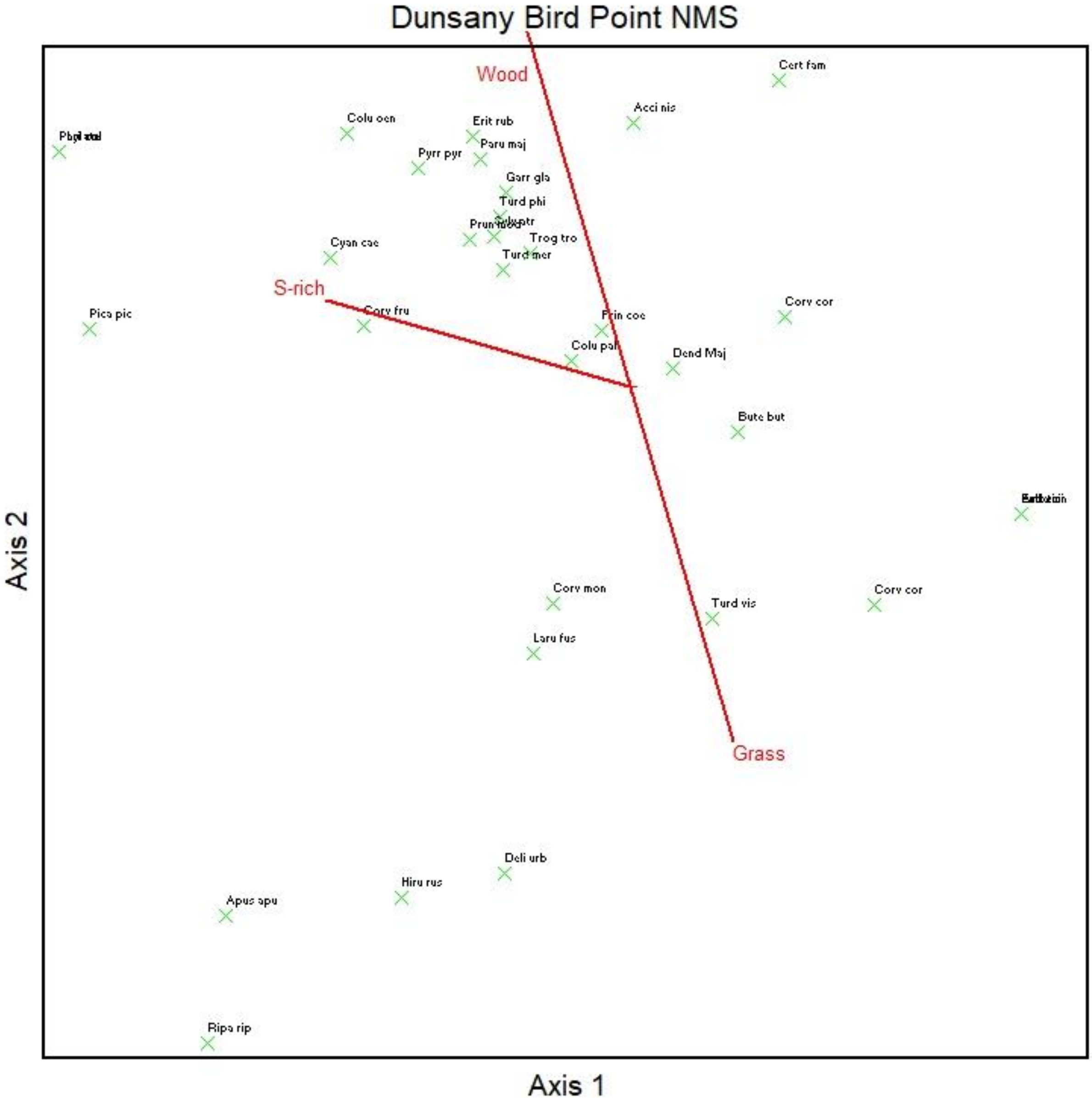

Figure 6: NMS Ordination of count points for bird observations in Dunsany. Species scientific names and their abbreviations can be found in Table 3. The vectors identify the habitat types as grassland (Grass), woodland (Wood) and species richness (Spec Ri) is indicated as higher in woodland.

3.1.2 Cluster analysis of bird species assemblages divided into site groups

Cluster analysis was used to produce dendrograms of group associations, a 4 group analysis was used for both transect and point analysis. The 15 sites for both transect and point sampling were grouped into 8 communities, 4 for points and 4 for transects, indicating differences in habitat and species composition within each of the 4 groups.

The initial transects dendrogram (Fig.7) split, grouped woodland together with CF&W (a grassland) although this was a distant relationship in the habitat ordinance map. Grasslands associated with woodland were grouped together with woodland surrounded by grassland, CG1 and CG2, Castle Grounds which are in part surrounded by grassland and OCF and MA which are adjacent to woodland. Grasslands EM and MGL are grouped together with WM by an association node, these three sites are bodily connected.

The point dendrogram (Fig.8) preliminary split grouped most woodland together except for CG1_P which was isolated. Grassland formed two groups containing CF&W_P, OCF_P, with WM_P, and grouped MA_P, MGL_P with EM_P together. The groups are associated with species compilations to form the clusters and are visualised in ordination plots with communities of similar birds dictating the clustering of sites and habitat types (Fig. 9 and Fig.10). The most abundant species at these sites are listed as dominant in both transects and points (Table 6 and 7 respectively).

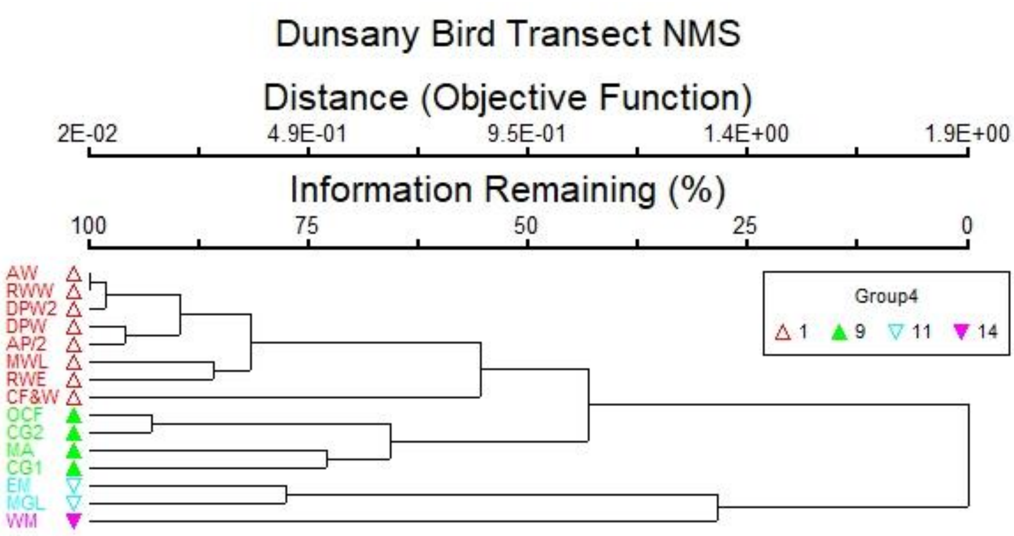

Figure 7: - Cluster analysis dendrogram of Dunsany transects sites. Site names, abbreviations and habitat type can be found in Table.1.

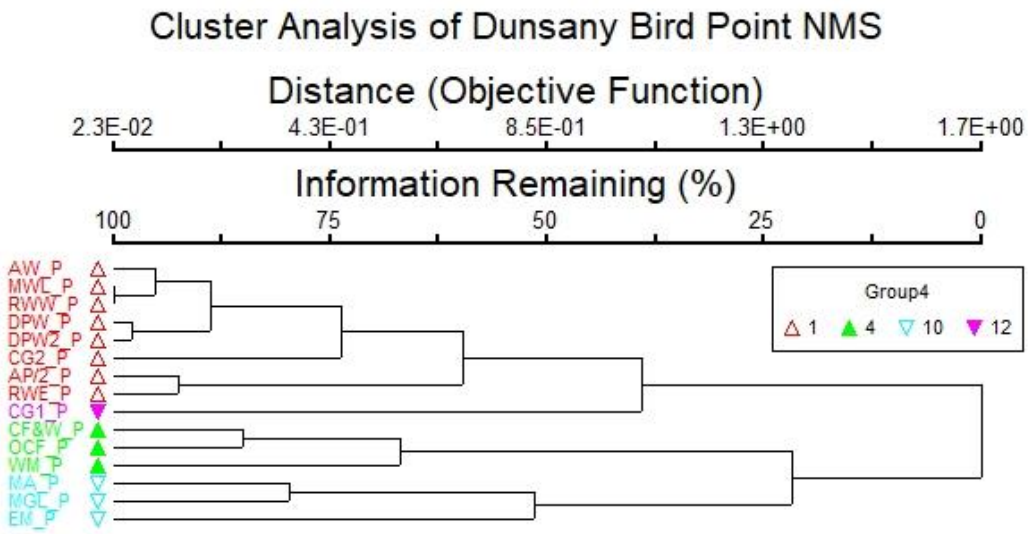

Figure 8: - Cluster analysis dendrogram of Dunsany count points. Site names, abbreviations and habitat type can be found in Table.1.

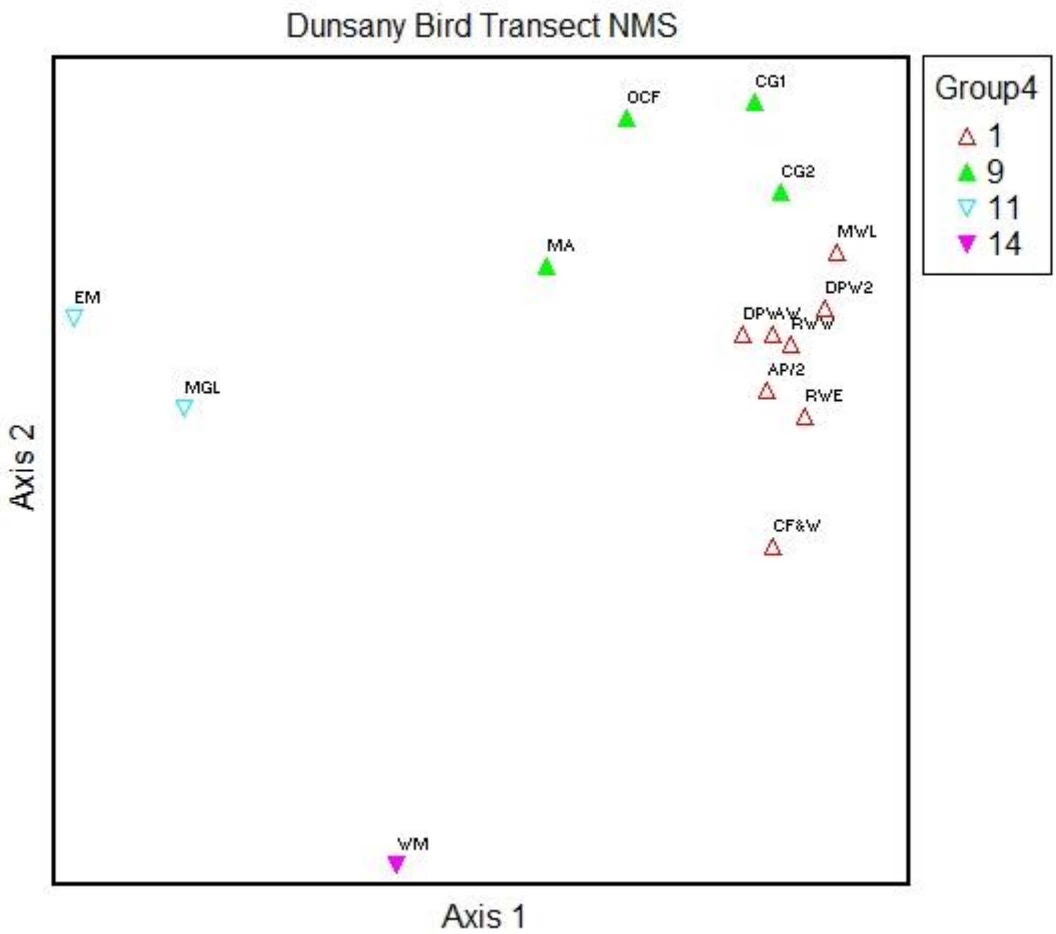

Figure 9: Ordination plot overlayed with cluster analysis showing 4 different cluster groupings of transects that have similar bird community compositions. Abbreviations for transect names as in Table 3.

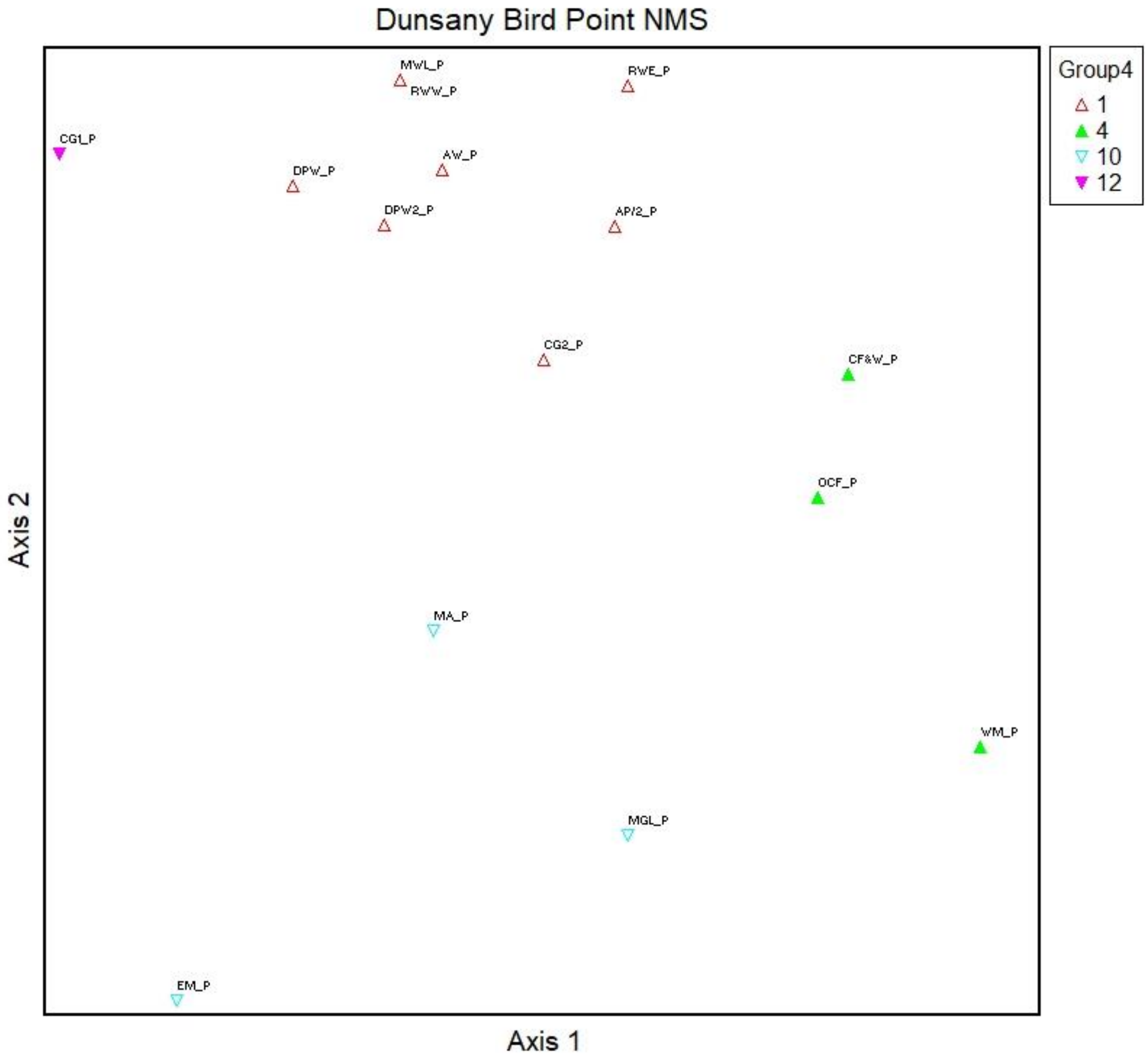

Figure 10: Ordination plot overlayed with cluster analysis showing 4 different cluster groupings of point sampling areas that have similar bird community compositions. Abbreviations for transect names as in Table 3.

The dendrograms were grouped in the following order with species dominance taken from Tables 6 and 7.

Transects groups were numbered 1, 9, 11 and 14 on the dendrogram (Fig.7).

Group 1: A community of mainly woodland consisting of Athronan Wood, Railway Wood West, Railway Wood East, Duckpond Wood 2, Duckpond Wood, Alder Plantation. Mixed Woodland and Cricket Field & Wood. *Columba palumbus* and *Troglodytes troglodytes* have high percentage associations with each of these sites.

Group 9: This group is a community mixed with Woodland surrounded by grassland and grassland adjacent to woodland. Geographically the sites are in close proximity to each other, Old Crop Fields and Castle Grounds West are geographically adjacent as are Castle Grounds East and Marsh Area, they are also associated on the dendrogram at connecting nodes. Although all sites have strong associations with *Columba palumbus,* there was a greater mix of species than in the previous group.

Group 11: This group consists of two connected grassland sites, East Meadow and Main Garden Lawn, these two grasslands are also geographically connected. The dominant species on these sites was *Hirundo rustica* which is associated with open areas.

Group 14: This group had a solitary member with West Meadow as the only site. *Columba palumbus* was again the dominant species and *Buteo buteo* was the next most dominant species.

Point Groups were numbered 1, 4, 10 and 12 on the dendrogram (Fig.8).

Group 1: This group consisted of a community of eight woodland sites, Athronan Wood Point, Mixed Woodland Point, Railway Wood West Point, Duckpond Wood Point, Duckpond Wood 2 Point, Castle Grounds West Point, Alder Plantation Point and Railway Wood East Point.

Group 4: This group is a community of grasslands that have some water features Old Crop Field Point, West Meadow Point and Cricket Field & Woodland Point. *Columba palumbus* was the dominant species with *Buteo buteo* the second most dominant in all three sites.

Group 10: This grouping was also a community of grasslands, Marsh Area Point, Main Garden Lawn Point and East Meadow Point. All three grasslands had a high dominance proportion of *Columba palumbus* and *Hirundo rustica.*

Group 12: This was a solitary site group, and the only site was Castle Grounds East Point. This was the only group that *Cyanistes caeruleus* and *Corvus frugilegus* strongly featured in.

Table 6:Cluster analysis group allocation showing the 5 most observed species along transects and across Dunsany, ranked by percentage of site abundance.

Grp.	Transects	Most Abundant Species	Percentage	2nd Most Abundant	Percentage	3rd Most Abundant	Percentage	4th Most Abundant	Percentage	5th Most Abundant	Percentage
1	AW	*Columba palumbus*	17.17	*Turdus merula*	14.14	*Troglodytes troglodytes*	12.12	*Sylvia atricapilla*	11.11	*Fringilla coelebs*	6.06
1	DPW	*Troglodytes troglodytes*	13.79	*Columba palumbus*	12.93	*Turdus merula*	8.62	*Sylvia atricapilla*	8.62	*Turdus philomelos*	6.03
1	DPW2	*Columba palumbus*	21.30	*Troglodytes troglodytes*	9.26	*Cyanistes caeruleus*	8.33	*Garrulus glandarius*	8.33	*Periparus ater*	8.33
1	CF&W	*Corvus corax*	23.21	*Columba palumbus*	14.29	*Sylvia atricapilla*	14.29	*Troglodytes troglodytes*	12.50	*Fringilla coelebs*	8.93
1	MWL	*Columba palumbus*	24.81	*Troglodytes troglodytes*	10.85	*Sylvia atricapilla*	8.53	*Turdus merula*	8.53	*Garrulus glandarius*	8.53
1	AP/2	*Columba palumbus*	19.32	*Troglodytes troglodytes*	15.91	*Turdus philomelos*	11.36	*Buteo buteo*	11.36	*Turdus merula*	10.23
1	RWW	*Columba palumbus*	22.78	*Troglodytes troglodytes*	13.92	*Turdus merula*	12.66	*Garrulus glandarius*	8.86	*Erithacus rubecula*	5.06
1	RWE	*Columba palumbus*	25.00	*Troglodytes troglodytes*	12.50	*Garrulus glandarius*	11.11	*Erithacus rubecula*	8.33	*Sylvia atricapilla*	6.94
9	OCF	*Columba palumbus*	53.66	*Fringilla coelebs*	6.10	*Troglodytes troglodytes*	4.88	*Buteo buteo*	4.88	*Sylvia atricapilla*	3.66
9	MA	*Columba palumbus*	20.33	*Turdus viscivorus*	17.07	*Corvus frugilegus*	8.94	*Turdus merula*	7.32	*Cyanistes caeruleus*	6.50
11	EM	*Hirundo rustica*	22.47	*Apus apus*	11.24	*Columba palumbus*	10.11	*Cyanistes caeruleus*	10.11	*Delichon urbicum*	7.87
9	CG1	*Columba palumbus*	43.96	*Turdus viscivorus*	9.89	*Troglodytes troglodytes*	6.59	*Sylvia atricapilla*	4.95	*Parus major*	3.85
9	CG2	*Columba palumbus*	45.32	*Troglodytes troglodytes*	8.33	*Parus major*	7.41	*Turdus merula*	7.41	*Fringilla coelebs*	6.48
14	WM	*Columba palumbus*	31.58	*Buteo buteo*	26.32	*Troglodytes troglodytes*	10.53	*Hirundo rustica*	10.53	*Fringilla coelebs*	5.26
11	MGL	*Hirundo rustica*	20.00	*Delichon urbicum*	15.79	*Columba palumbus*	13.68	*Corvus monedula*	11.58	*Turdus viscivorus*	9.47
	DUNSANY	*Columba palumbus*	25.74	*Troglodytes troglodytes*	8.93	*Turdus merula*	6.64	*Sylvia atricapilla*	5.81	*Fringilla coelebs*	4.50

Table 7: Cluster analysis group allocation showing the 5 most observed species at count points and across Dunsany, ranked by percentage of site abundance.

Grp	Points	Most Abundant Species	Percentage	2nd Most Abundant	Percentage	3rd Most Abundant	Percentage	4th Most Abundant	Percentage	5th Most Abundant	Percentage
1	AW_P	*Columba palumbus*	16.22	*Garrulus glandarius*	10.81	*Parus major*	10.81	*Cyanistes caeruleus*	10.81	*Buteo buteo*	8.11
1	DPW_P	*Columba palumbus*	10.18	*Sylvia atricapilla*	10.61	*Turdus philomelos*	10.61	*Buteo buteo*	7.58	*Troglodytes troglodytes*	7.58
1	DPW2_P	*Columba palumbus*	22.73	*Troglodytes troglodytes*	11.36	*Sylvia atricapilla*	9.09	*Garrulus glandarius*	9.09	*Buteo buteo*	6.82
4	CF&W_P	*Columba palumbus*	29.41	*Buteo buteo*	17.65	*Troglodytes troglodytes*	11.76	*Sylvia atricapilla*	11.76	*Fringilla coelebs*	11.76
1	MWL_P	*Columba palumbus*	15.91	*Garrulus glandarius*	15.91	*Troglodytes troglodytes*	9.09	*Turdus merula*	9.09	*Columba oenas*	9.09
1	AP/2_P	*Buteo buteo*	27.78	*Columba palumbus*	22.22	*Troglodytes troglodytes*	8.33	*Turdus merula*	5.56	*Sylvia atricapilla*	5.56
1	RWW_P	*Columba palumbus*	20.00	*Turdus merula*	11.43	*Garrulus glandarius*	11.43	*Troglodytes troglodytes*	8.57	*Sylvia atricapilla*	8.57
1	RWE_P	*Columba palumbus*	30.00	*Troglodytes troglodytes*	10.00	*Turdus philomelos*	10.00	*Accipiter nisus*	10.00	*Sylvia atricapilla*	6.67
4	OCF_P	*Columba palumbus*	42.31	*Buteo buteo*	15.38	*Corvus corax*	7.69	*Troglodytes troglodytes*	3.85	*Sylvia atricapilla*	3.85
10	MA_P	*Columba palumbus*	20.00	*Hirundo rustica*	20.00	*Buteo buteo*	8.89	*Troglodytes troglodytes*	6.67	*Turdus merula*	6.67
10	EM_P	*Hirundo rustica*	34.78	*Columba palumbus*	17.39	*Apus apus*	17.39	*Delichon urbicum*	8.70	*Cyanistes caeruleus*	4.35
12	CG1_P	*Columba palumbus*	22.86	*Cyanistes caeruleus*	11.43	*Corvus frugilegus*	11.43	*Sylvia atricapilla*	8.57	*Troglodytes troglodytes*	5.71
1	CG2_P	*Columba palumbus*	22.14	*Troglodytes troglodytes*	13.79	*Fringilla coelebs*	10.34	*Buteo buteo*	10.34	*Garrulus glandarius*	10.34
4	WM_P	*Columba palumbus*	26.32	*Buteo buteo*	26.32	*Turdus viscivorus*	15.79	*Corvus cornix*	15.79	*Corvus frugilegus*	10.53
10	MGL_P	*Columba palumbus*	16.67	*Corvus monedula*	14.29	*Buteo buteo*	11.90	*Corvus cornix*	11.90	*Hirundo rustica*	11.90
	DUNSANY	*Columba palumbus*	21.67	*Buteo buteo*	8.19	*Troglodytes troglodytes*	7.00	*Sylvia atricapilla*	6.31	*Turdus merula*	5.46

3.1.3 Indicator species analysis

An indicator species analysis was run in PC-Ord 5 for both points and transects and a Monte Carlo test was used to note significant indicator species. Transects were found to have 12 significant indicator species and points had 8. Transect indicator species of note were *Columba palumbus* with an indicator value (IV) of 59.5, a mean of 43.8 across the groups and a P value of 0.001, *Troglodytes troglodytes* with an IV of 57.7, a group mean of 42.2 and a P value of 0.0058, and *Turdus merula* with an IV of 61.1, a mean of 44.6 and a P value of 0.0082 (Table 8).

Table 8: Transect Monte Carlo *indicator* species analysis results with group max, indicator values, mean, S.D. and significant P value of <0.05.

Common name	Scientific Name	Max Grp	Value (IV)	Mean	S.Dev	P
Blackbird	*Turdus merula* (Linnaeus, 1758)	1	61.1	44.6	5.68	0.0082
Blackcap	*Sylvia atricapilla* (Linnaeus, 1758)	1	62.7	44.6	7.34	0.0212
Blue Tit	*Cyanistes caeruleus* (Linnaeus, 1758)	11	27.6	44.9	17.73	0.7884
Bullfinch	*Pyrrhula pyrrhula* (Linnaeus, 1758)	1	28.6	36.3	13.84	0.929
Buzzard	*Buteo buteo* (Linnaeus, 1758)	11	48.6	45.6	13.3	0.4333
Chaffinch	*Fringilla coelebs* (Linnaeus, 1758)	9	48.6	41.6	4.62	0.0754
Chiffchaff	*Phylloscopus collybita* (Vieillot, 1817)	1	14.3	27.3	17.21	1
Coal Tit	*Periparus ater* (Linnaeus, 1758)	11	26.5	45.1	18.71	0.8952
Cuckoo	*Cuculus canorus* (Linnaeus, 1758)	1	14.3	27.3	17.21	1
Dunnock	*Prunella modularis* (Linnaeus, 1758)	1	100	46.2	14.39	0.0026
Goldcrest	*Regulus regulus* (Linnaeus, 1758)	1	41.8	45.6	13.65	0.6313
Great Spotted Woodpecker	*Dendrocopos Major* (Linneus, 1758)	9	26.9	38.1	16.94	0.9466
Great Tit	*Parus major* (Linnaeus, 1758)	9	35	43.3	19.08	0.5553
Herring Gull	*Larus argentatus* (Pontoppidan, 1763)	9	50	27.3	17.18	0.3635
Hooded Crow	*Corvus cornix* (Linnaeus, 1758)	9	45.9	47.2	11.51	0.5649
House Marten	*Delichon urbicum* (Linnaeus, 1758)	11	100	35.8	13.02	0.0306
Jackdaw	*Corvus monedula* (Linnaeus, 1758)	11	50	27.3	17.19	0.3639
Jay	*Garrulus glandarius* (Linnaeus, 1758)	1	73.7	45.7	7.68	0.0026
Kestrel	*Falco tinnunculus* (Linnaeus, 1758)	9	50	27.3	17.18	0.3635
Lesser Black-backed Gull	*Larus fuscus* (Linnaeus, 1758)	9	50	27.3	17.18	0.3635
Long-tailed Tit	*Aegithalos caudatus* (Linnaeus, 1758)	11	46.2	35.3	14.78	0.2869
Magpie	*Pica pica* (Linnaeus, 1758)	11	93.3	38.3	17.02	0.024
Mistle Thrush	*Turdus viscivorus* (Linnaeus, 1758)	11	74	49.5	16.75	0.1064
Pheasant	*Phasianus colchicus* (Linnaeus, 1758)	1	28.6	36	13.79	1
Raven	*Corvus corax* (Linnaeus, 1758)	1	35.7	43.3	16.9	0.7005
Reed Bunting	*Emberiza schoeniclus* (Linnaeus, 1758)	9	50	27.3	17.18	0.3635
Robin	*Erithacus rubecula* (Linnaeus, 1758)	1	72	44.3	6.44	0.0026
Rook	*Corvus frugilegus* (Linnaeus, 1758)	9	53.8	45.4	12.78	0.3191
Sand Marten	*Riparia riparia* (Linnaeus, 1758)	11	91.3	38.2	17.15	0.0534
Song Thrush	*Turdus philomelos* (Brehm, 1831)	1	60.2	46	8.88	0.0662
Sparrowhawk	*Accipiter nisus* (Linnaeus, 1758)	1	39.8	43	18.85	0.5075
Spotted Flycatcher	*Muscicapa striata* (Pallas, 1764)	11	50	27.3	17.19	0.3639
Stock Dove	*Columba oenas* (Linnaeus, 1758)	1	85.7	46.5	17.76	0.026
Swallow	*Hirundo rustica* (Linnaeus, 1758)	11	96.1	44.6	17.48	0.024
Swift	*Apus apus* (Linnaeus, 1758)	11	100	34.4	15.51	0.0306
Treecreeper	*Certhia familiaris* (Linnaeus, 1758)	9	87.5	37.9	17.23	0.0838
Woodpigeon	*Columba palumbus* (Linnaeus, 1758)	9	59.5	43.8	4.54	0.001
Wren	*Troglodytes troglodytes* (Linneaus, 1758)	1	57.7	42.2	4.41	0.0058
Yellowhammer	*Emberiza citrinella* (Linnaeus, 1758)	9	50	27.3	17.18	0.3635
					Mean of P	0.118918
					Significant Values	12
					Mean of Significant Values	0.008905

Point indicator species of note were *Parus major* with IV of 100, group mean of 39.2 and P value of 0.0002, *Garrulus glandarius* with IV of 91.3, group mean of 39.2 nad P value of 0.001, *Troglodytes troglodytes* with an IV value of 61.6, group mean of 41.4 and P value of 0.0018, and *Columba palumbus* with an IV of 35.5, a group mean of 37.2 and a P value of 0.8192 (Table 9).

Table 9: Point Monte Carlo indicator species analysis results with group max, indicator values, mean, S.D. and significant P value of <0.05.

Common name	Scientific Name	Max Grp	Value (IV)	Mean	S.Dev	P
Blackbird	*Turdus merula* (Linnaeus, 1758)	1	54.1	43.3	6.41 0	0.0746
Blackcap	*Sylvia atricapilla* (Linnaeus, 1758)	1	61	43.2	8.11	0.0152
Blue Tit	*Cyanistes caeruleus* (Linnaeus, 1758)	1	38.7	37.1	13.05	0.3239
Bullfinch	*Pyrrhula pyrrhula* (Linnaeus, 1758)	1	37.5	27.5	15.01	0.3159
Buzzard	*Buteo buteo* (Linnaeus, 1758)	4	37.8	43.4	6.84	0.7614
Chaffinch	*Fringilla coelebs* (Linnaeus, 1758)	1	36.1	41.3	5.55	0.8308
Dunnock	*Prunella modularis* (Linnaeus, 1758)	1	46.9	35.5	14.06	0.1724
Great Spotted Woodpecker	*Dendrocopos Major* (Linneus, 1758)	1	12.5	21.7	10.35	1
Great Tit	*Parus major* (Linnaeus, 1758)	1	100	39.2	13.15	0.0002
Grey Heron	*Ardea cinerea* (Linnaeus, 1758)	4	33.3	21.4	10.31	0.4265
Hooded Crow	*Corvus cornix* (Linnaeus, 1758)	4	41.2	38.6	14.51	0.3947
House Marten	*Delichon urbicum* (Linnaeus, 1758)	10	100	27.8	15.16	0.0056
Jackdaw	*Corvus monedula* (Linnaeus, 1758)	10	31.4	25.8	13.61	0.3157
Jay	*Garrulus glandarius* (Linnaeus, 1758)	1	91.3	40.9	12.15	0.001
Kestrel	*Falco tinnunculus* (Linnaeus, 1758)	4	33.3	21.4	10.31	0.4265
Lesser Black-backed Gull	*Larus fuscus* (Linnaeus, 1758)	10	33.3	21.3	10.3	0.4245
Magpie	*Pica pica* (Linnaeus, 1758)	10	33.3	21.2	10.28	0.4189
Mistle Thrush	*Turdus viscivorus* (Linnaeus, 1758)	10	52.2	37.7	13.85	0.1422
Raven	*Corvus corax* (Linnaeus, 1758)	4	48.5	33.7	15.1	0.1534
Robin	*Erithacus rubecula* (Linnaeus, 1758)	1	87.5	37.2	13.05	0.0026
Rook	*Corvus frugilegus* (Linnaeus, 1758)	10	15.4	29.8	16.2	0.869
Sand Marten	*Riparia riparia* (Linnaeus, 1758)	10	33.3	21.2	10.28	0.4189
Song Thrush	*Turdus philomelos* (Brehm, 1831)	1	78.1	44.2	12.17	0.0036
Sparrowhawk	*Accipiter nisus* (Linnaeus, 1758)	1	62.5	33.8	15.73	0.0792
Stock Dove	*Columba oenas* (Linnaeus, 1758)	1	50	31.6	15.61	0.2022
Swallow	*Hirundo rustica* (Linnaeus, 1758)	10	100	28.7	14.86	0.0056
Swift	*Apus apus* (Linnaeus, 1758)	10	66.7	25.8	13.88	0.0658
Treecreeper	*Certhia familiaris* (Linnaeus, 1758)	1	12.5	21.4	10.3	1
Woodpigeon	*Columba palumbus* (Linnaeus, 1758)	1	35.5	37.2	2.17	0.8192
Wren	*Troglodytes troglodytes* (Linneaus, 1758)	1	61.6	41.4	5.63	0.0018
Yellowhammer	*Emberiza citrinella* (Linnaeus, 1758)	4	33.3	21.4	10.31	0.4265
					Mean of P	0.094213
					Significant Values	8
					Mean of Significant Values	0.002516

NMS ordination overlays of indicator species and their habitat association were constructed for both transect and point data with colour depicting transect group and symbol size reflecting relative abundance.

A cluster analysis graph with *Columba palumbus* ordination plot overlayed displaying distribution and abundance (Fig.11). *Columba palumbus* is well represented in Transect Group 1 (brown) and Transect Group 9 (green) and showing the highest abundance along transect CG1. Low abundances are noted in Group 11 and 14 which are grasslands but there was also a low relative abundance in CF&W which is a grassland but was in group 1.

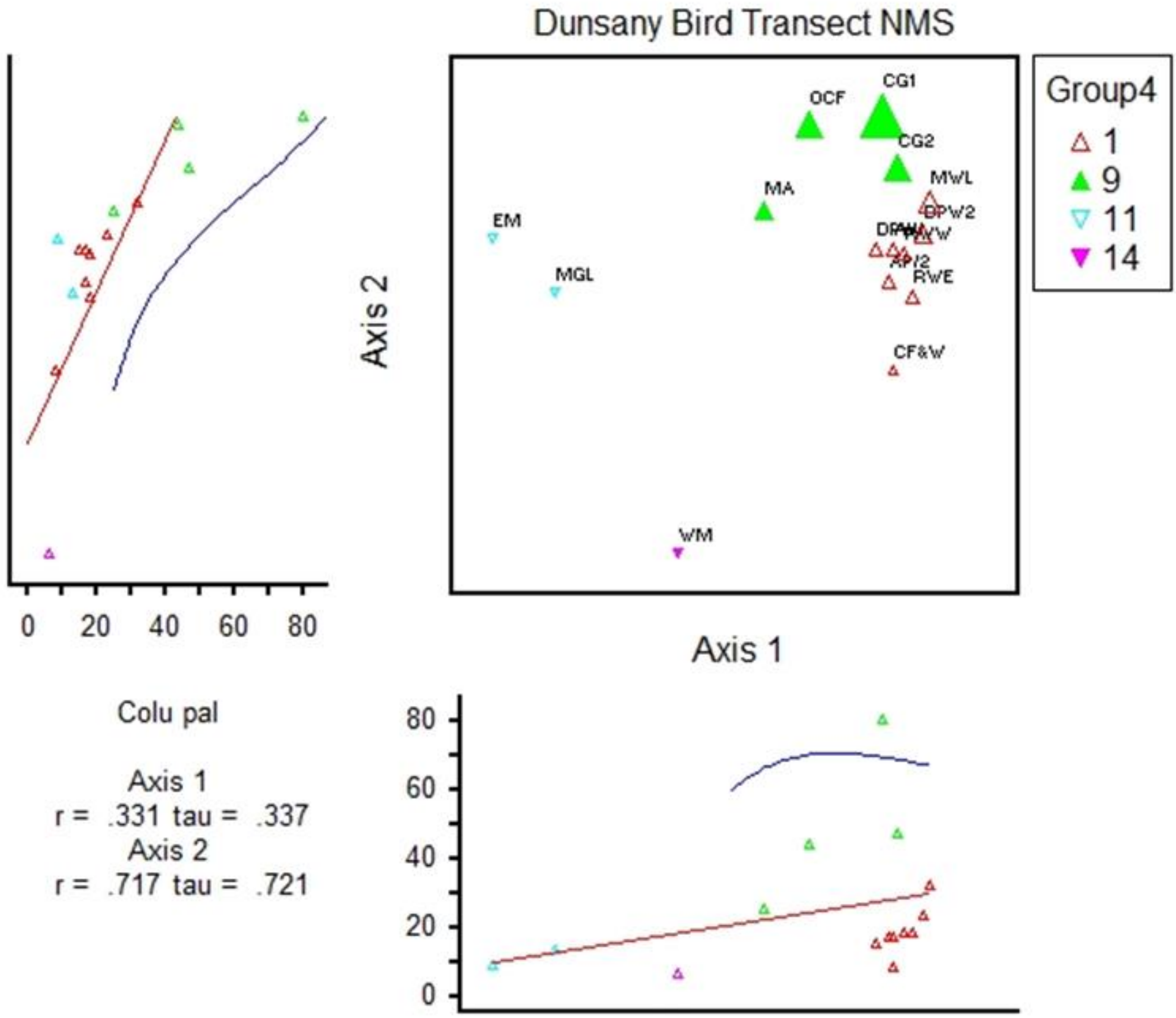

Figure 11: Ordination plot overlay of bird transects at Dunsany, with the symbols and colours used for each transect reflecting the 4 group solution from cluster analysis, and with the size of the symbols proportional to the relative abundance of Columba palumbus.

A cluster analysis graph with *Troglodytes troglodytes* ordination graph overlayed displaying distribution and abundance (Fig.12). Transect Group 1 (brown) shows the highest abundance and Transect Group 9 (green) gives mixed abundances with groups 11 and 14 having the least abundances.

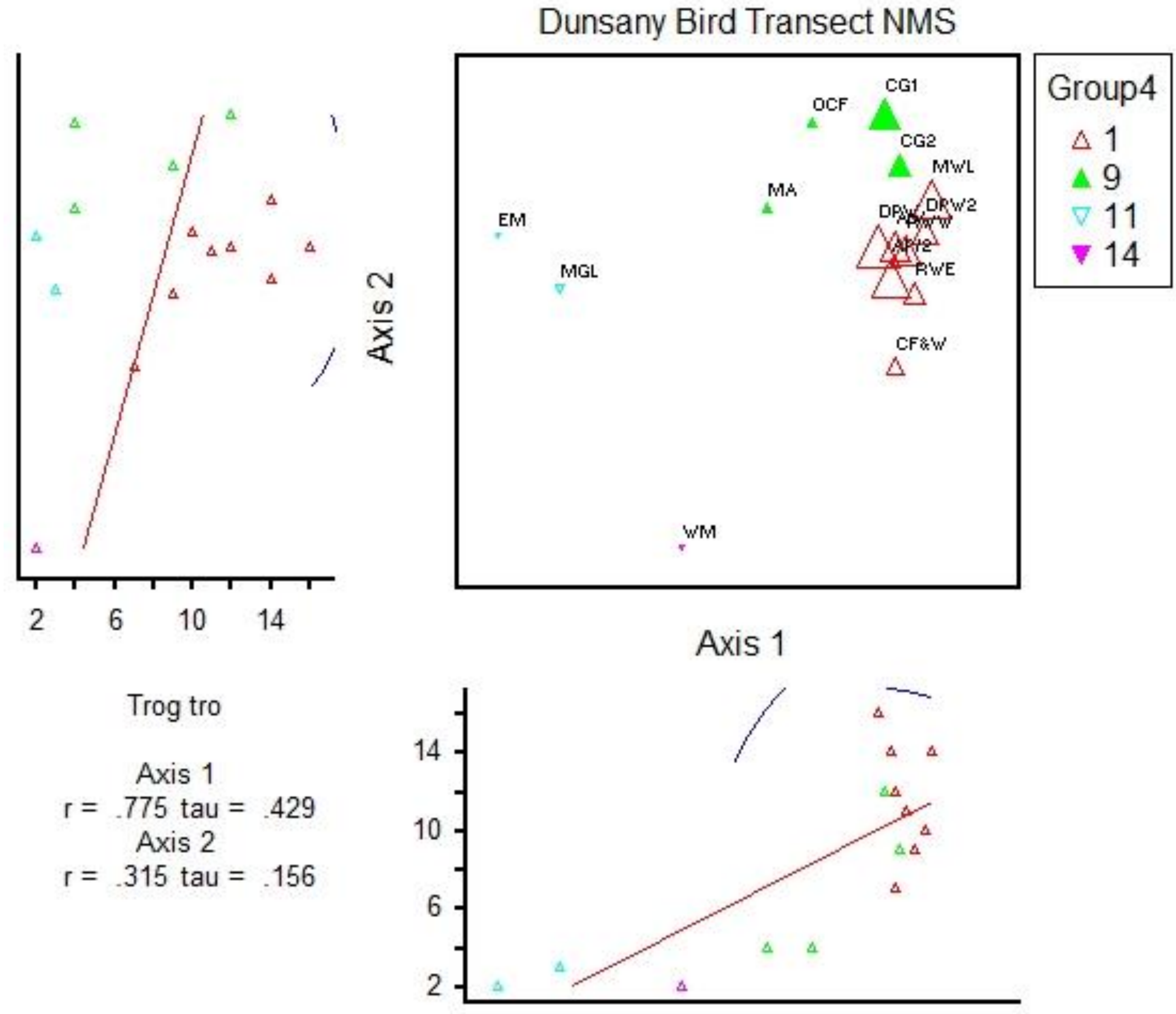

Figure 12: Ordination plot of bird transects at Dunsany, with the symbols and colours used for each transect reflecting the 4 group solution from cluster analysis, and with the size of the symbols proportional to the relative abundance of Troglodytes troglodytes.

A cluster analysis graph with *Turdus merula* ordination graph overlayed displaying distribution and abundance (Fig. 13). *Turdus merula* is well represented in Transect Group 1 (brown) and Transect Group 9 (green) with lesser abundances in the other groups particularly low in WM of group 14.

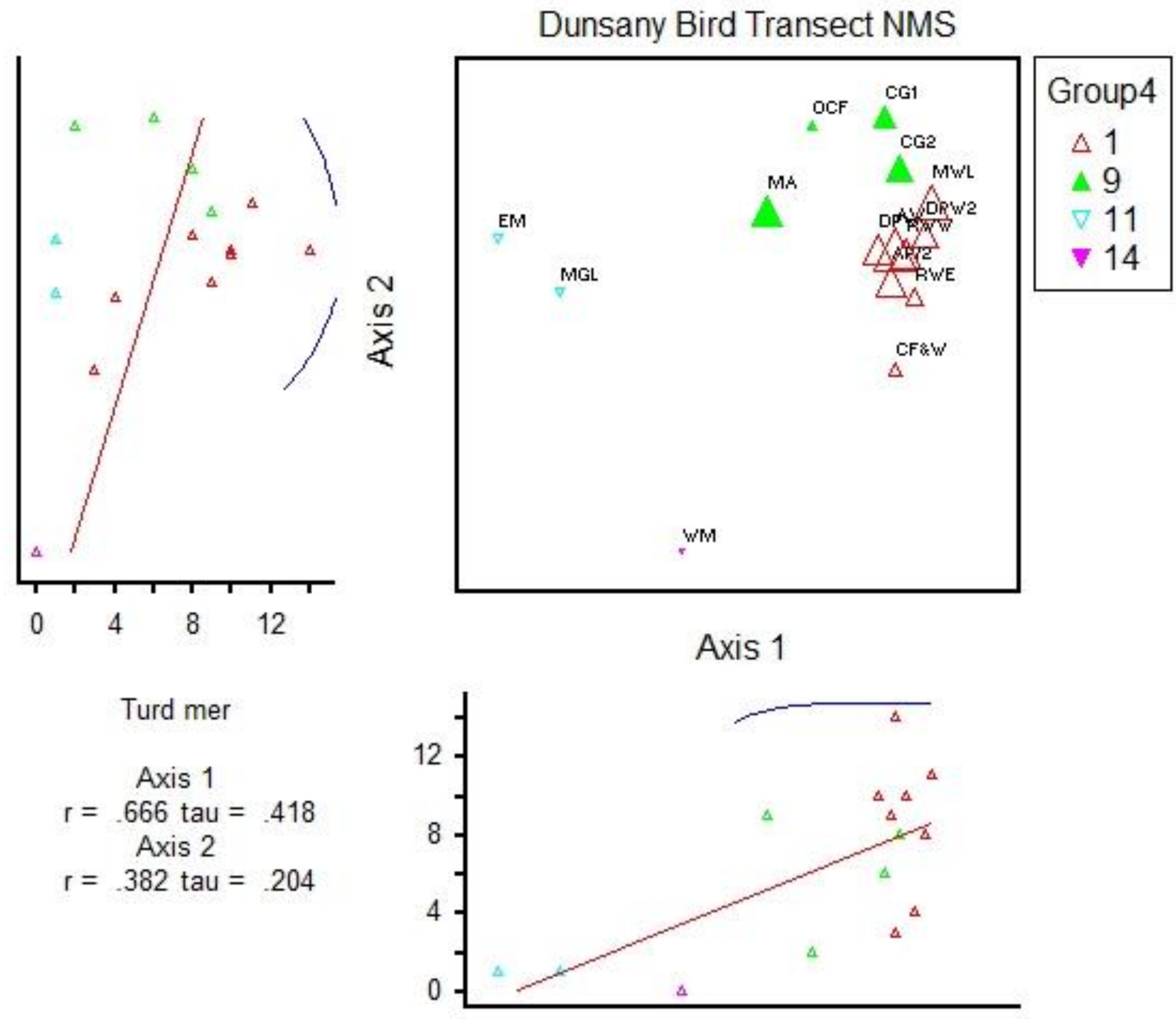

Figure 13: Ordination plot of bird transects at Dunsany, with the symbols and colours used for each transect reflecting the 4 group solution from cluster analysis, and with the size of the symbols proportional to the relative abundance of Turdus merula.

A cluster analysis graph with *Parus major* ordination graph overlayed displaying distribution and abundance (Fig. 14). *Parus major* is well represented in Point Group 1 (brown) and Point Group 12 (pink) showing high abundance in this single member group. Point Groups 4 and 10 (green and blue respectively) show very litle association with *Parus major*.

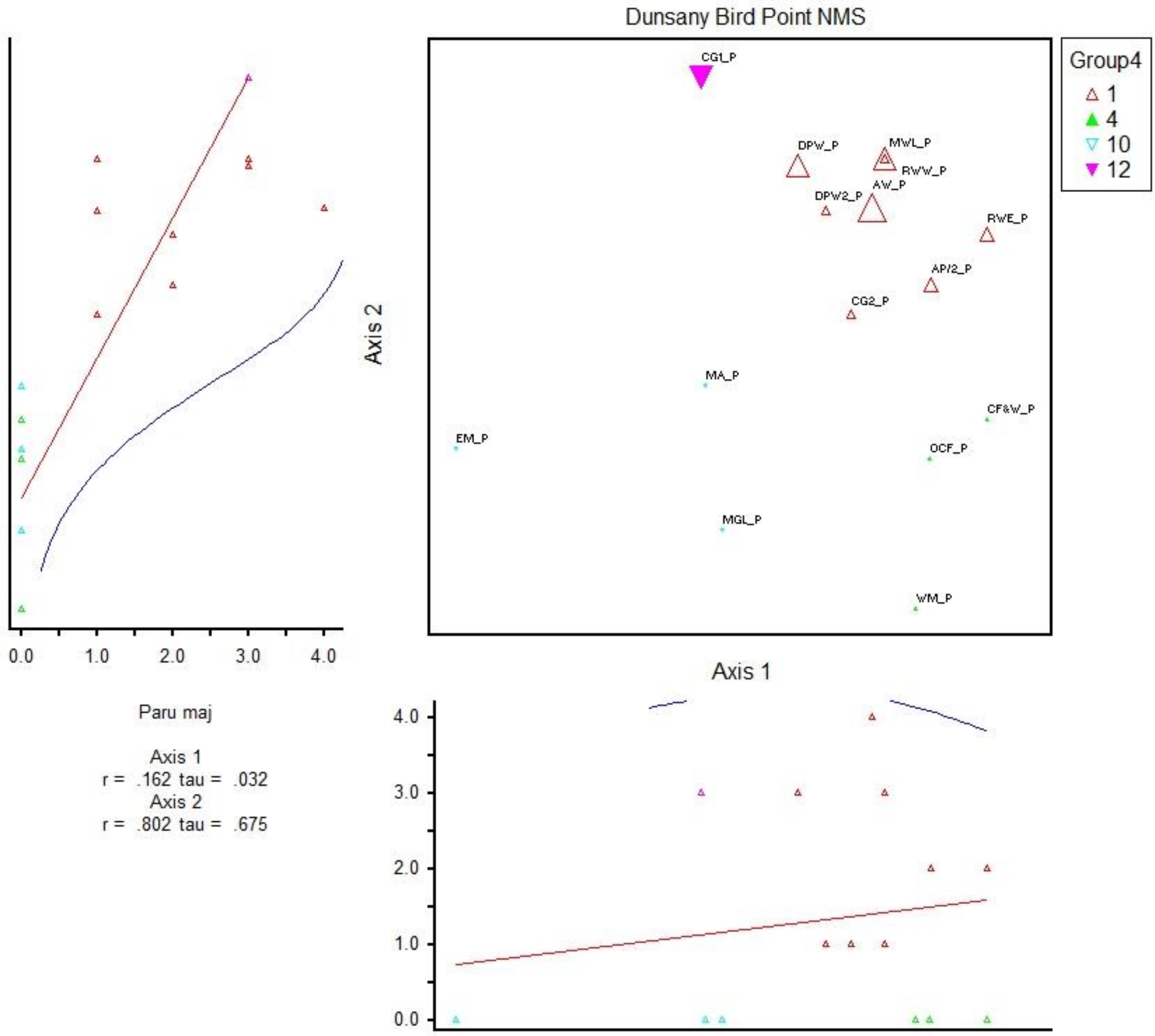

Figure 14: Ordination plot of bird count points at Dunsany, with the symbols and colours used for each transect reflecting the 4 group solution from cluster analysis, and with the size of the symbols proportional to the relative abundance of Parus major.

A Cluster analysis graph with *Garrulus glandarius* ordination graph overlayed displaying distribution and abundance (Fig. 15). Only abundant in Point Group 1 (brown), a woodland and absent or very few observations in Groups 4, 10 and 12.

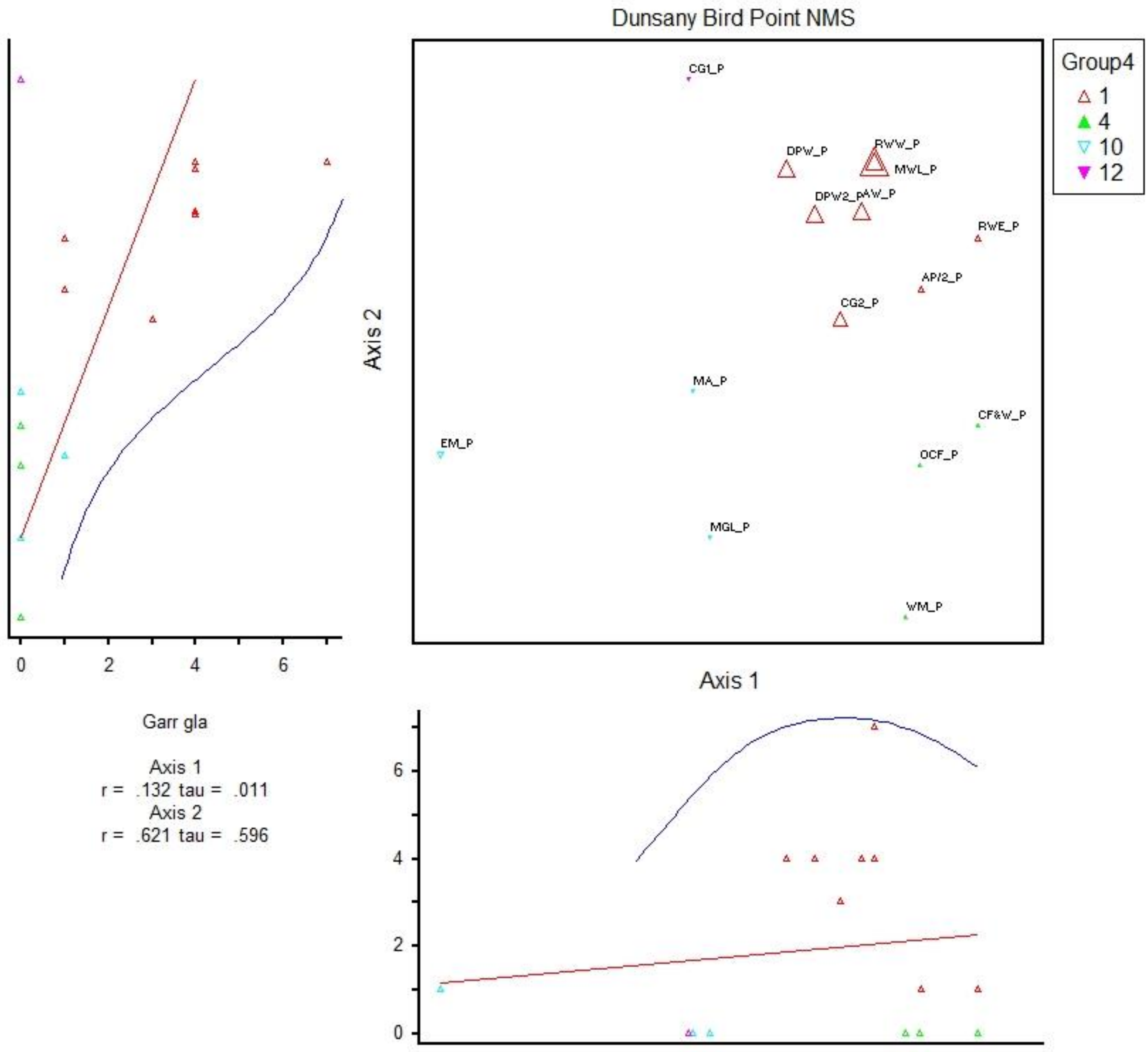

Figure 15: Ordination plot of bird count points at Dunsany, with the symbols and colours used for each transect reflecting the 4 group solution from cluster analysis, and with the size of the symbols proportional to the relative abundance of Garrulus glandarius.

A cluster analysis graph with *Troglodytes troglodytes* ordination graph overlayed displaying distribution and abundance. Point Group 1 (brown) shows the highest abundance and distribution, Point Group 12 (pink) a solitary woodland has high abundance and Point Groups 4 and 10 have mixed results.

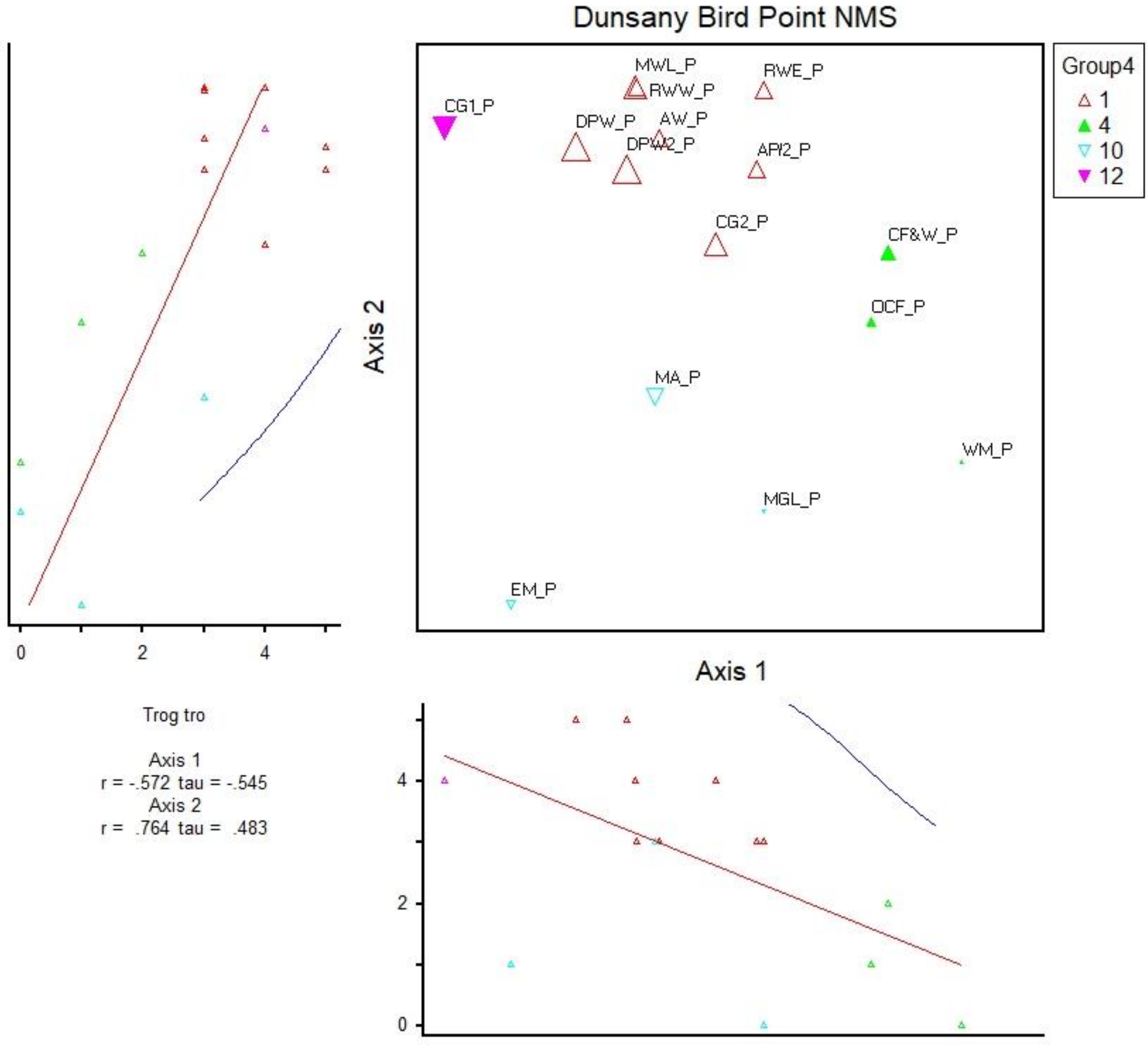

Figure 16: Ordination plot of bird count points at Dunsany, with the symbols and colours used for each transect reflecting the 4 group solution from cluster analysis, and with the size of the symbols proportional to the relative abundance of Troglodytes troglodytes.

Cluster analysis graph with *Columba palumbus* ordination graph overlayed displaying distribution and abundance. Well represented in Point Group 1 (brown) and Point Group 12 (pink) showing the highest abundance and mixed results in Point Groups 4 and 10.

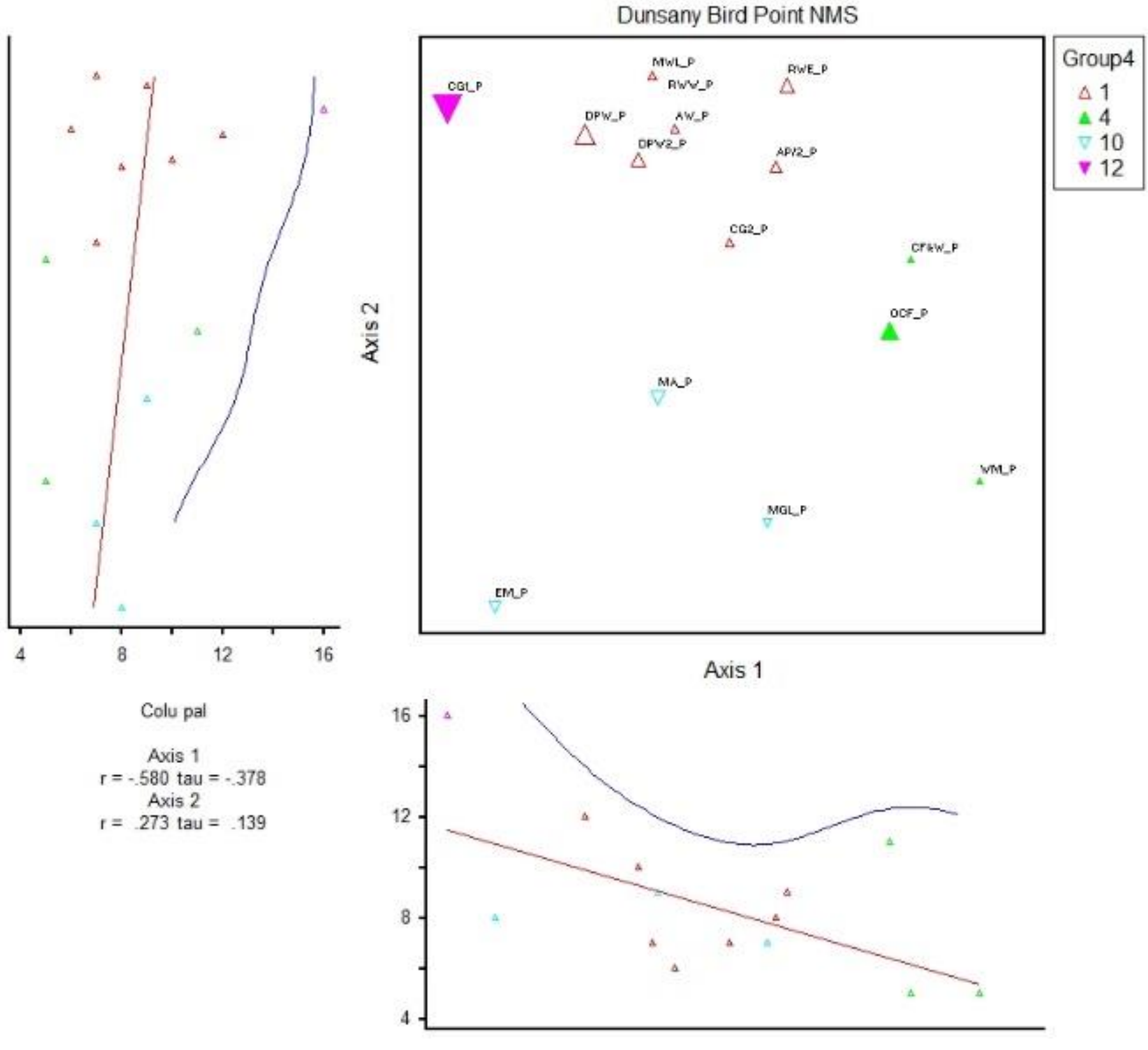

Figure 17: Ordination plot of bird count points at Dunsany, with the symbols and colours used for each transect reflecting the 4 group solution from cluster analysis, and with the size of the symbols proportional to the relative abundance of Columbus palumbus.

3.2 Species Diversity, Abundance, Richness, and Indices for each Transect and Point

The total observations of bird records for transects was 1445, with 981 observations in woodland transects and 464 found in those from grassland (Fig. 18), species richness for transects was 40 (Table 3). Total abundance was 327 in woodland and 155 in grassland. The woodland transect with the highest abundance was CG1 from Transect Group 9 and the grassland transect with the highest abundance was MA from Transect Group 9. The woodland transect with the lowest abundance was RWE from Transect Group 1 and the grassland transect with the lowest was WM from Transect Group 14.

The total observations of bird records for the point counts were 596, with 391 observations from woodland count points and 195 from grassland count points (Fig. 19), species richness for points was 33 (Table 4). Total abundance was 130 in woodland and 65 in grassland. The woodland point with the highest abundance was CG1_P from Point Group 12 and the grassland point with the highest was EM_P from Point Group 10 closely followed by MA_P from the same group. The woodland point with the lowest abundance was CG2_P from Point Group 1 and the Grassland Point with the lowest was CF&W_P from Point Group 4. Woodland generally had higher abundances and species richness in comparison to grassland along the transects (Fig. 18 & 19).

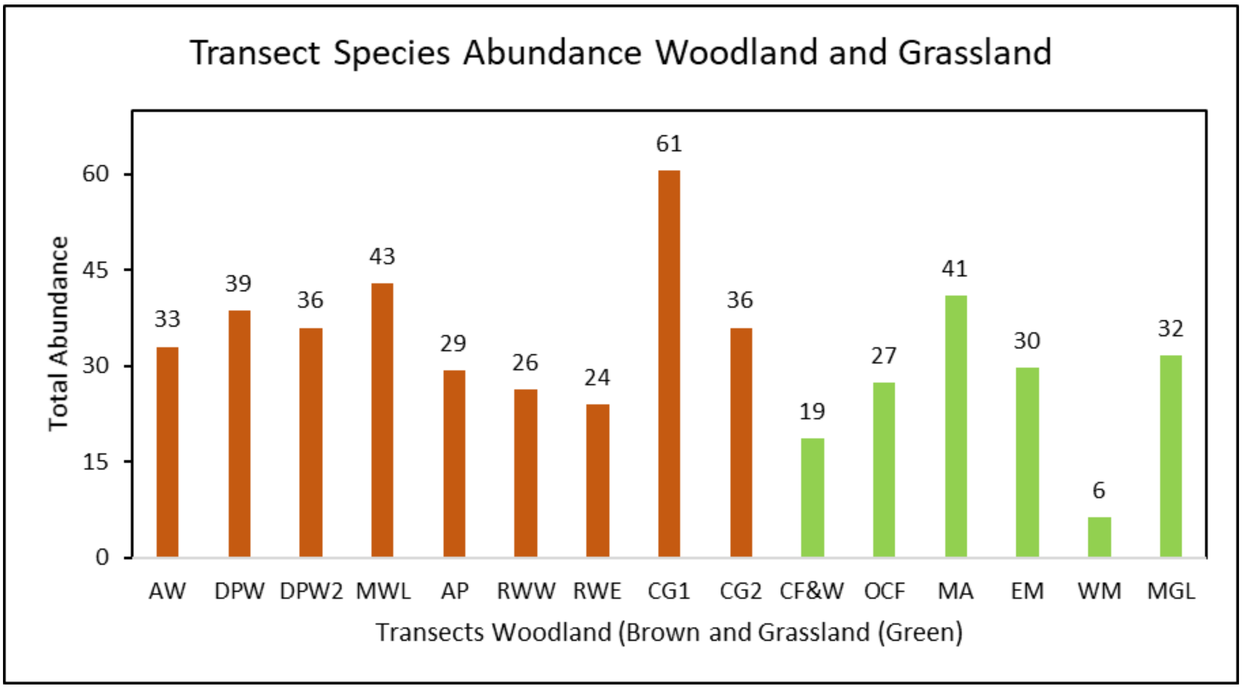

Figure 18: Total abundance of woodland vs grassland transects. Woodland is coloured brown and grasslands green. Abundances are labelled for each transect.

.

Figure 19: Species richness of Woodland and grassland transects. Woodland is coloured brown and grasslands green. Species richness is labelled for each transect.

Woodland points generally had higher abundances and species richness in comparison to grassland points (although this was not as pronounced as the abundance along transects data) other than DPW_P and CG1_P (Fig. 20). Woodland points showed a slight positive species richness relationship in comparison to grasslands points (Fig.21).

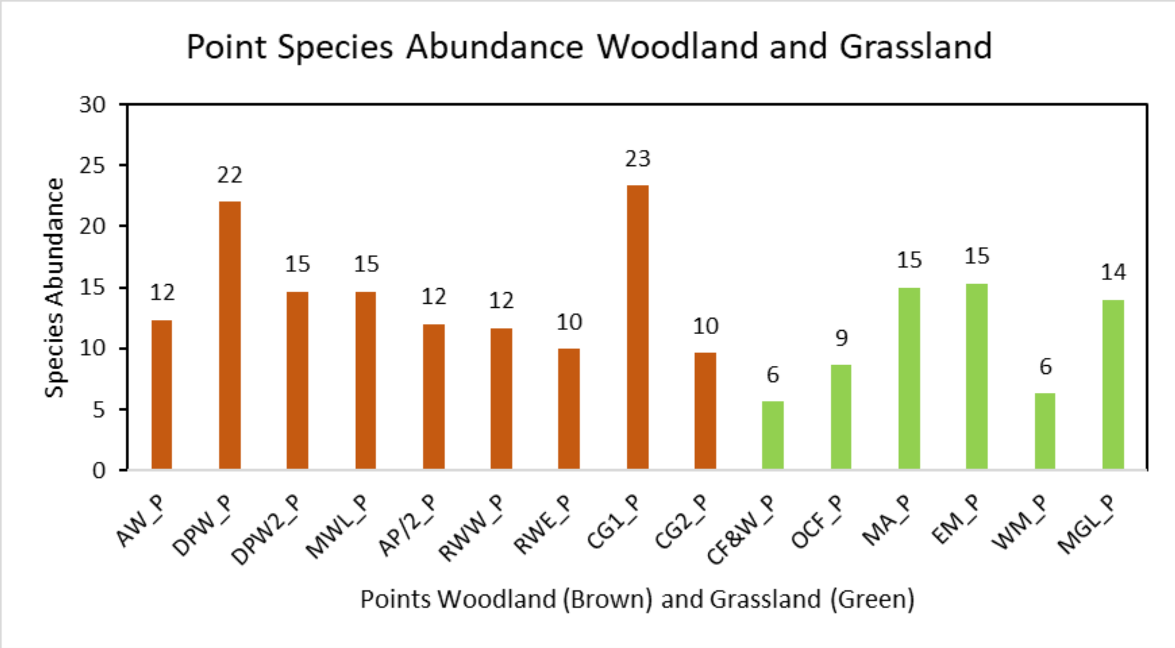

Figure 20: Total abundance of Woodland and grassland points. Woodland is coloured brown and grasslands green. Species richness is labelled for each point.

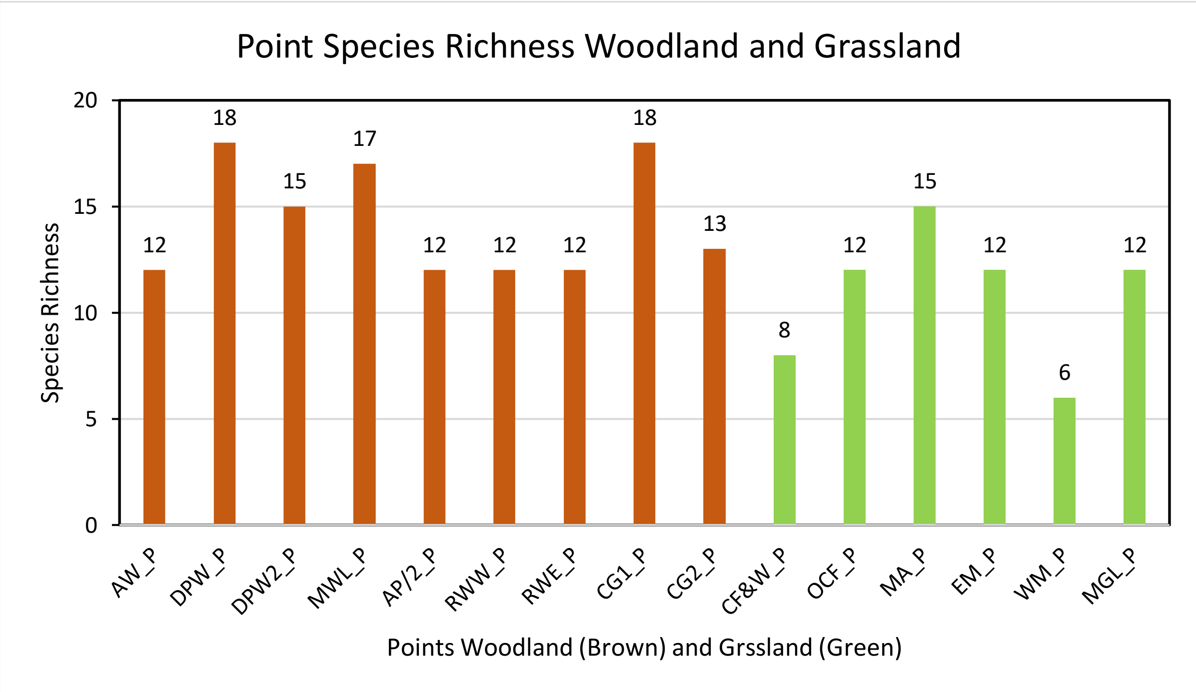

Figure 21: Species richness of woodland and grassland points. Woodland is coloured brown and grasslands green. Species richness is labelled for each point.

The most diverse transects were DPW, DPW2 and MA and the most diverse points were MWL_P, DPW_P CG1_P (Table 10). The least diverse transects were WM, OCF and CG2 and the least diverse points were WM_P, CF&W_P and EM_P.

Although transect data produced higher abundance and species richness numbers across the estate, point data produced a higher diversity index both in the Shannon Diversity Index and the Simpson's Diversity Index for Dunsany as a whole.

Table 5: Diversity indices and evenness measures for transects and points across the Dunsany Estate. Group allocation from cluster analysis is also noted.

Transects	Species Richness	Simpson's Index D	Simpsons Div. Index	Shannon Div. Index	Shannons Eveness	Grp
AW	18	0.087	0.913	2.559	0.885	1
DPW	19	0.069	0.931	2.708	0.920	1
DPW2	18	0.088	0.912	2.581	0.893	1
CF&W	13	0.113	0.887	2.257	0.880	1
MWL	22	0.103	0.897	2.578	0.834	1
AP/2	14	0.104	0.896	2.336	0.885	1
RWW	17	0.100	0.900	2.479	0.875	1
RWE	16	0.104	0.896	2.433	0.878	1
OCF	17	0.296	0.704	1.914	0.676	9
MA	22	0.094	0.906	2.621	0.848	9
EM	15	0.100	0.900	2.411	0.890	11
CG1	23	0.214	0.786	2.228	0.711	9
CG2	17	0.214	0.786	2.083	0.735	9
WM	8	0.158	0.842	1.809	0.870	14
MGL	19	0.105	0.895	2.453	0.833	11
Dunsany	40	0.096	0.904	2.905	0.787	
Points						
AW_P	12	0.074	0.926	2.388	0.961	1
DPW_P	18	0.073	0.927	2.649	0.917	1
DPW2_P	15	0.085	0.915	2.475	0.914	1
CF&W_P	8	0.118	0.882	1.921	0.924	4
MWL_P	17	0.071	0.929	2.586	0.913	1
AP/2_P	12	0.130	0.870	2.159	0.869	1
RWW_P	12	0.081	0.919	2.354	0.947	1
RWE_P	12	0.113	0.887	2.228	0.896	1
OCF_P	12	0.191	0.809	1.977	0.796	4
MA_P	15	0.095	0.905	2.408	0.889	10
EM_P	12	0.178	0.822	1.960	0.789	10
CG1_P	18	0.091	0.909	2.560	0.886	12
CG2_P	13	0.091	0.909	2.318	0.904	1
WM_P	6	0.158	0.842	1.677	0.936	4
MGL_P	12	0.092	0.908	2.286	0.920	10
Dunsany	33	0.08	0.92	2.92	0.83	

4 Discussion

The study attempted to ascertain if indicator species were present in relation to rewilding through farmland abandonment. This study also sought to investigate bird diversity at Dunsany Estate through species abundance, species richness and evenness and to ascertain if communities differed between habitats.

4.1 NMS Ordination and the Clustering Effect of Similar Communities

4.1.1

NMS Ordination in both transects and point data (Fig. 4 & 5) separated sites into similar groupings reflecting differences in habitat types. Sites that had similar bird compositions although not always geographically close were clustered closer together on the plots. Sites that had no commonality were spatially separated and appeared as outliers. Using species composition from the data, species assemblages were also clustered into their similarity groupings (Fig. 6 & 7) and the biplot vectors show denser species assemblages in woodland with the species richness vectors mirroring an increase in species richness in woodland. The cluster analysis tool grouped the sites closest in species composition together and a visual representation was produced in the form of dendrograms. The structure of woodlands can influence the species composition (Wilson et al., 2006).

Transect groups 1 and 9 were closely linked on the Transect NMS ordination plots (Fig. 10) and formed woodland or woodland associated communities respectively. Group 1 had a mix of woodland species notably *Columba palumbus* and *Troglodytes troglodytes. Columba palumbus* was the dominant species in all group 9 communities with *Troglodytes troglodytes* less evident. Other notable species in groups 1 and 9 were *Turdus merula, Sylvia atricapilla* and *Garrulus glandarius.*

The Group 1 woodlands of the transect dendrogram showed close associations between AW, RWW and DPW2 in Group 1 and all three of these woodlands had open areas beneath a full canopy and are long and narrow woods. MWL and RWE are similar in structure to the previous woodlands but are more uniform in shape which may have influenced species composition here with less edge effect. DPW and AP/2 are adjacent to each other and only separated by a road and although AP/2 is a young plantation in parts, individuals from DPW may be expanding into AP/2 as new territory giving a similarity reading. CF&W, the most *Poaceae* diverse grassland was grouped with woodlands and not grasslands as expected. This could have been due to the proximity of woodland on 3 sides (DPW, AP/2 and MWL) and species from these woodlands may have been detected during observations. Transect Group 9 is a mix of grasslands and woodland associations with OCF noticeably similar to CG2 and as both of these transects are geographically connected, species crossover is to be expected. MA and CG1 are also geographically adjacent with a similar species crossover expectation although the dendrogram implies that it is not as close an association as the last sites. The woodlands of CG2 and CG1 are dense in parts but they have open canopy areas that may influence edge species composition.

Transect Group 11 consists of EM and MGL and Group 14 of WM, these two groups show a loose association in the transect dendrogram although they are geographically continuous. EM and MGL are open meadows sided by woodland while WM is slightly restricted with woodland encroachment and this may have limited woodland species intrusions during observations. *Hirundo rustica* was the most observed species in Group 11 and to a lesser extent in Group 14 where *Columba palumbus* was the dominant species. *Muscicapa striata* was only observed in WM (Group 14) which was an open area with a dead tree where *Muscicapa striata* foraged from, its presence could indicate why WM was classed as an outlier.

Point groups 1 and 12 were linked on the Point NMS ordination plot and all were woodland habitats. Group 12s only member CG1_P was separated slightly from the other woodlands indicating a difference in species composition which may be due to its proximity to grassland and the many open areas within the transect. The dominant species in Point Groups 1 and 12 was *Columba palumbus*. Other species of note in these two groups are *Buteo buteo, Troglodytes troglodytes, Sylvia atricapilla, Turdus merula and Garrulus glandarius*.

The Group 1 point dendrogram shows close associations between AW_P, MWL_P and RWW_P. These three woodlands all have full canopies with more open areas where more mature broadleaf tree stands were the observation locations of the counts. MWL_P and RWW_P are geographically close separated by Dunsany Road. The DPW observation points are associated strongly and although separated by distance they are physically one woodland. CG2_P is an isolated woodland on the points dendrogram, possibly due to the location of the observation point which was in an open area of the site and may have a picked up more open habitat species. RWE_P and AP2_P have a loose association on the points dendrogram and both observation points were located in areas with a noticeable conifer content which may account for a comparable species composition. CG1_P is an isolated woodland on the dendrogram and *Corvus frugilegus* as one of the dominant species may have separated Group

12 from the other woodlands. CF&W_P, OCF_P and WM_P are three grasslands that form an almost continuous corridor through the estate with only the narrow AP as a barrier. The most observed species in all three grasslands was *Columba palumbus* with *Buteo buteo* as the second most observed. Other species of note in OCF_P and CF&W_P were *Troglodytes troglodytes*, *Sylvia atricapilla* while in WM_P were *Corvus cornix* and *Turdus viscivorus.*

4.1.2 Indicator Species Analysis

Columba palumbus was the species most frequently observed throughout the study both in grassland and woodland. They were a few exceptions, (DPW, EM, MGL and CF&W) but they were always in the top three most observed species. Other species of note were wren (*Troglodytes troglodytes*), blackbird (*Turdus merula*), blackcap (*Sylvia atricapilla*), jay (*Garrulus glandarius*), and buzzard (*Buteo buteo*).

Indicator species can represent a larger cluster of species, and species richness can be determined by their presence or absence (Fleishman *et al*., 2005). Monitoring sites and using indicator species as a measure could give a snapshot of diversity gains or losses as the rewilding project matures. The transect Monte Carlo test showed up a number of indicator species from both transect and point data. Significant indicator species for transects included *Columba palumbus*, *Troglodytes troglodytes* and *Turdus merula* and indicator species from points included *Parus major*, *Hirundo rustica* and *Troglodytes troglodytes.*

Columba palumbus is the largest member of the order Columbiformes found in Ireland and is classed as a major agricultural pest (O hUallachain and Dunne, 2013). New woodland formation could have long term impacts on the population of woodpigeons as more nesting sites will become available (Inglis et al., 1994). Woodpigeons in the British Isles have had a recent population surge and with a varied diet from cereal and grain in summer and autumn and a diet of fruit, weed leaves and clover in winter and spring they are an adaptable species (Murton et al., 1964; O'Regan, 2012). Dunsany surrounded by agricultural farmland and with woodland regeneration is prime habitat for *Columba palumbus.*

Troglodytes troglodytes is a bird associated with woodland and shrubbery. *Troglodytes troglodytes* prefer to forage and nest in younger woodland and plantations, and with farmland abandonment and the increase in scrubland and woodland this will have a positive effect on *Troglodytes troglodytes* abundance (Fuller and Green, 1998).

Hirundo Rustica is a migratory species that winters in Africa before returning to Ireland to breed when insect become a reliable food source (Huin and Sparks, 1998). *Hirundo rustica* is associated with grassland but will forage in woodland clearings, over water and wetland habitats, wherever insect prey is available particularly larger flying insects (Henderson *et al*., 2007). The presence of cattle can have a positive effect on swallow productivity in grassland as can the presence of higher hedgerows in arable landscapes (Henderson *et al.*, 2007). The grassland in Dunsany had a high aerial feeding *Hirundo rustica* contingent whereas the crop fields surrounding AW although outside the study area were noted to have tall hedgerows and a strong presence of feeding *Hirundo rustica.*

Turdus merula is a bird of both woodland and edge habitats and can be interchangeable with *Erithacus rubecula* (Butler *et al.*, 2012). *Turdus merula* nesting sites indicate that edge territory nest loss is higher than in woodland nest loss (Haatchwell *et al*., 1996). Turdus merula is used as an indicator species for niche evaluation of subterranean invertebrate resources (Butler *et al*., 2012).

Parus major rely heavily on the larvae of lepidoptera during breeding season which acts as an indicator of habitat quality and food availability for themselves and other species (Redhead *et al*., 2013). *Parus major* were observed in CG1 which although wooded gave visual access to the canopy from open areas. Other woodlands may have had greater numbers of tit species that were undetected as they fed in the upper canopy.

Other species of note include *Sylvia atricapilla* which had a very similar distribution to *Turdus merula* when Ordination plots were overlayed with species (Appendix 1. Fig22-29). This was a good example of niche separation on site as *Sylvia atricapilla* are arboreal foragers, feeding on lepidopteran and dipteran species. As the site matures and woodland becomes more expansive *Sylvia atricapilla* although migratory could become a dominant species in spring. *Dendrocopos major* a species known for its tendency to colonize abandoned farmland ((Navarro and Pereira, 2015) has successfully nested and fledged at least one brood this season on the Dunsany estate. The nest was located close to the CF&W in DPW which is a regenerating woodland with decreased footfall. *Buteo buteo* also showed in good numbers with at least 9 birds on site, adults and 3 juveniles in AP/2, a pair in AW and another pair in DPW and there may be more (Fig.).

4.2 Species Diversity, Abundance, Richness, and Indices for each Transect and Point

This study also sought to note relative abundances, species richness and the equitability between habitats.

Woodland and grassland abundances and species richness have produced skewed results that appear to favour woodland as the more diverse habitat. The methods were strictly adhered to and birds were only counted if correctly identified which left a number of detected but unidentified birds uncounted. Point counts in woodland were more difficult as the observer had to remain as still as possible to prevent flushing. There are several issues that can influence bird species diversity and in temperate regions bird diversity has a direct correlation with foliage height diversity and increases as vegetation layer count increases (MacArthur and MacArthur, 1961; MacArthur and MacArthur, 1962). Grasslands are considered one layered and woodlands can vary between two and three layers which can vary diversity between woodlands (Tramer, 1969).

The was a clear 2:1 ratio for total abundances between woodland and grassland in both transect and points abundances. Woodland with open areas and close to grassland had the highest abundances such as CG1 but grasslands MA, EM and MGL had comparable abundances to many of the woodland areas. This may have been due to their close proximity to the woodlands and each of these areas is dotted with trees. DPW, DPW2 and MWL were the woodland with the highest abundances, and it seems bird assemblages are affected more by the woodland growth stage than by tree species. RWW and RWE were the woodlands with the lowest abundances although they had comparable woodland to MWL and DPW, but this woodland was occupied by a family of *Accipiter nisus* that may have subdued other birds there. The site with the highest abundance in both point and transect counts was CG1 and the site with the lowest abundance for both point and transect counts was WM.

Species richness was highest in CG1 along transects, with WM the lowest. Species richness was highest at points CG1_P and DPW_P with the lowest at WM_P. CG1 and DPW_P are both well developed woodlands with open areas while WM_P is an open meadow with very little elevated vegetation.

Diversity indices across the estate varied with DPW as the most diverse transect and second in observation points. CG1 and CG2 were the least diverse woodlands although CG1 had the highest abundance. The most diverse grassland was MA and EM which are both in close proximity to woodland and they also had a high proportion of Hirundinidae that may have influenced the result. Observation point counts were more diverse across Dunsany than transects, the smaller sample sizes may have had less noise.

Transect evenness was best observed in DPW with OCF showing the least evenness along transects. Points evenness was best observed in AW_P with the least being EM_P followed by OCF_P.

4.3 Project limitations and changes for the future

4.3.1 Sampling Period

The timing of the sampling period gave a very restricted view of bird diversity and it would have been more appropriate to sample the area from mid-March till mid-May when breeding season and fledging normally take place. Raptors such as *Butteo buteo* and *Accipiter nisus* were more apparent as they are later breeding birds and fledge later. Although the sampling period was later in the year it was still a very short window to ascertain the diversity at Dunsany. Species such as *Emberiza citronella* and *Corvus cornix* appeared very late on in the study.

Some species were more secretive and did not call while nesting or raising young, these species had to be visually identified. Certain hedgerow species have a tendency to skulk such as the wren (*Troglodytes troglodytes*) or dunnock (*Prunella modularis*), and dunnocks had a low detection rate as they were silent for long periods. Transects and point counts may be biased against these species with an underestimated count. Transect duration varied greatly as variances in walking pace on different days, was affected by conditions and some transects were overgrown and had to be navigated. Some species were prone to flushing even with every precaution taken.

Given the size of the site and terrain, extra personnel would be needed to cover areas simultaneously thus preventing contamination from one site to another. Fatigue can be an issue when transects become waterlogged and dangerous underfoot and more personnel would increase safety for individuals.

Migratory birds such as *Sylvia atricapilla* were very prevalent in June but had all but disappeared in July, *Sylvia atricapilla* and *Phylloscopus collybita* had been heard on the pilot visit but subsequently had moved on during the sampling period.

The age of some of the sites such as AP have not reached their full potential yet and within a few years may see changes that are unexpected.

4.3.2 Future

Future studies in Dunsany with this initial baseline study as a starting point to detect changes in the bird communities within the estate over time. This baseline can be used in conjunction with baselines from other seasonal perspectives as communities may change seasonally to some degree. Yearly monitoring would be important as the site progressed into its fully rewilded state and to note positive or negative changes. Conservation of birds that appear on the red list may become part of the site's agenda. Since the previous review in 2007 by BoCCI (birds of conservation concern in Ireland), of 202 species of birds assessed, 37 were placed on the Red list (an increase of 12), 91 on the Amber list (an increase of 5) and 74 on the Green list (Colhoun and Cummins, 2013). Continuous monitoring over the next ten years will tell if species of birds change or if their abundances change as the habitat changes. Species richness and evenness between sites could change greatly as the habitat matures and changes. Will indicator species still be the same and how will woodland regeneration on site and the fragmentation between woodlands have changed?

Further studies in Dunsany in areas that were missed such as The Orchard, and more extensive studies could be carried out in the areas already covered.

Transect sampling is more thorough and had greater coverage on sites but point counts would be invaluable as quick sampling methods.

5. Conclusion

Farmland abandonment for passive rewilding has seen effective progress in the past and as Dunsany has only recently become a rewilding project it has the potential to establish a model for other Irish sites to follow. Dunsany became the first Irish rewilding project to become part of the European Rewilding Network (ERN) which is an achievement in itself and the owner is fully committed to continuing with the project. Dunsany has the potential as it evolves and as its anthropogenic footprint alleviates to become a wildlife refuge for native Irish wildlife.

This study has shown that Dunsany has a species richness of at least 41 species of birds. The study has noted the locations of species and the habitat differentiation between species namely woodland and grassland species. A number of these birds have been deemed indicator species and their abundances on site could determine if their will be a need for management to make changes so as there are no negative impacts on site. The study has also shown that species will fill niches that are available as habitats change. How Dunsany will influence others with its rewilding project, only time will tell.

7.Appendices:

7.1 Appendix 1.

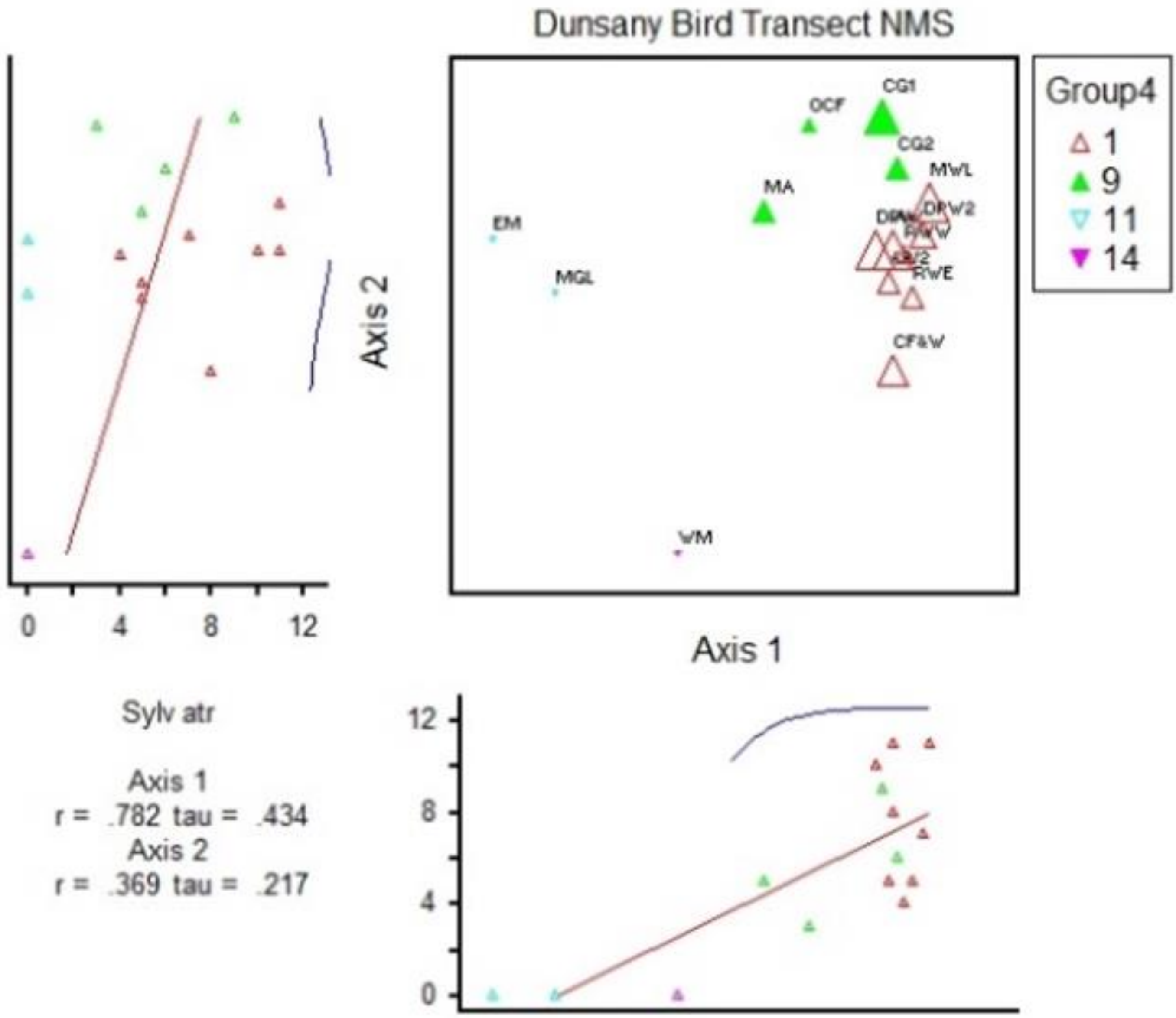

Figure 22: Ordination plot of bird transects at Dunsany, with the symbols and colours used for each transect reflecting the 4 group solution from cluster analysis, and with the size of the symbols proportional to the relative abundance of Sylvia atricapilla.

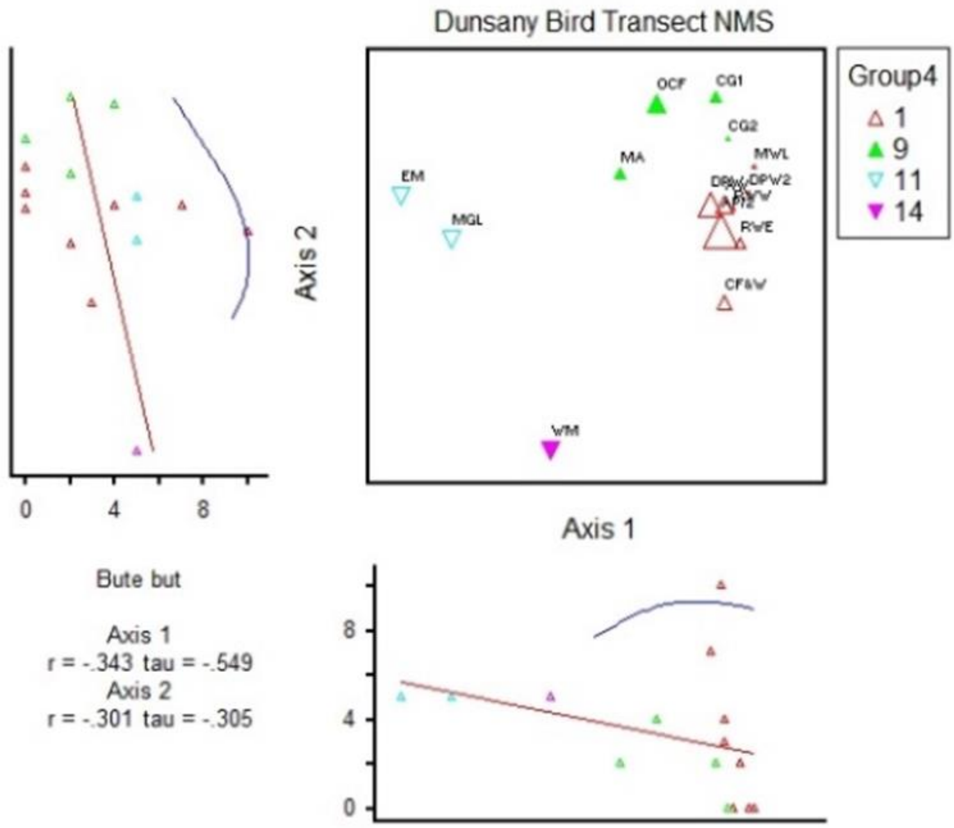

Figure 23: Ordination plot of bird transects at Dunsany, with the symbols and colours used for each transect reflecting the 4 group solution from cluster analysis, and with the size of the symbols proportional to the relative abundance of Buteo buteo.

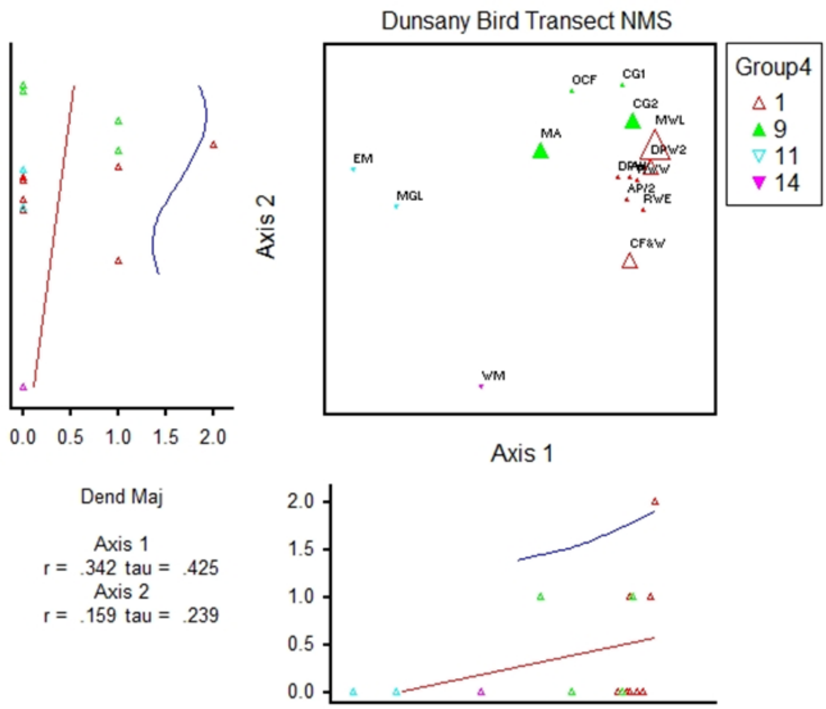

Figure 24: Ordination plot of bird transects at Dunsany, with the symbols and colours used for each transect reflecting the 4 group solution from cluster analysis, and with the size of the symbols proportional to the relative abundance of Dendrocopos major.

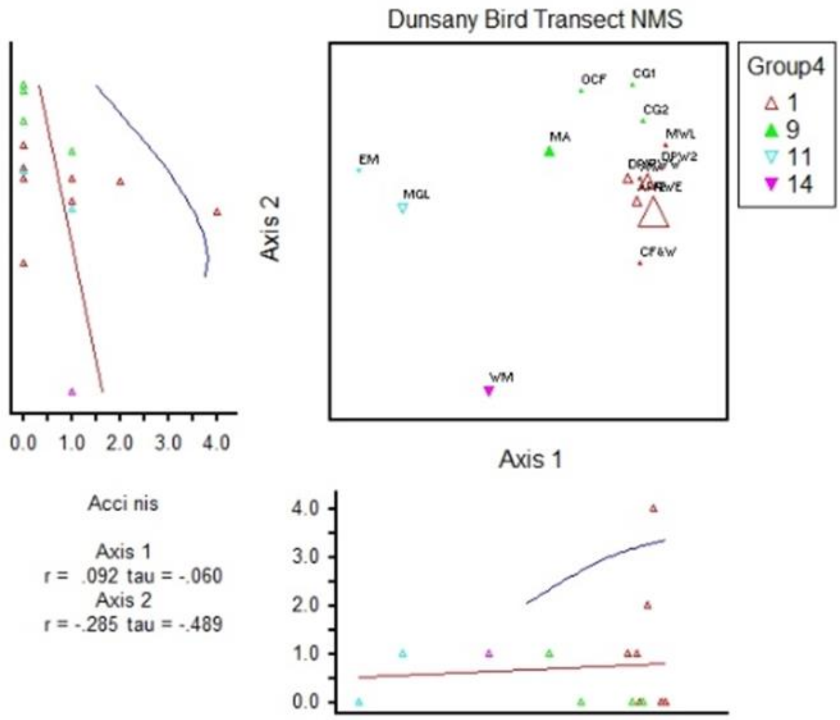

Figure 25: Ordination plot of bird transects at Dunsany, with the symbols and colours used for each transect reflecting the 4 group solution from cluster analysis, and with the size of the symbols proportional to the relative abundance of Accipiter nisus.

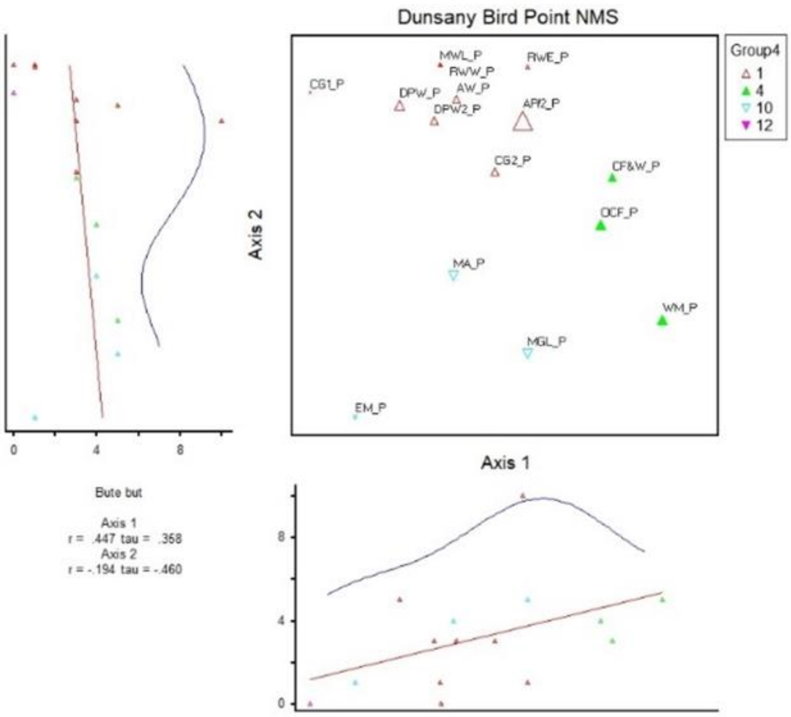

Figure 26: Ordination plot of bird count points at Dunsany, with the symbols and colours used for each transect reflecting the 4 group solution from cluster analysis, and with the size of the symbols proportional to the relative abundance of Buteo buteo.

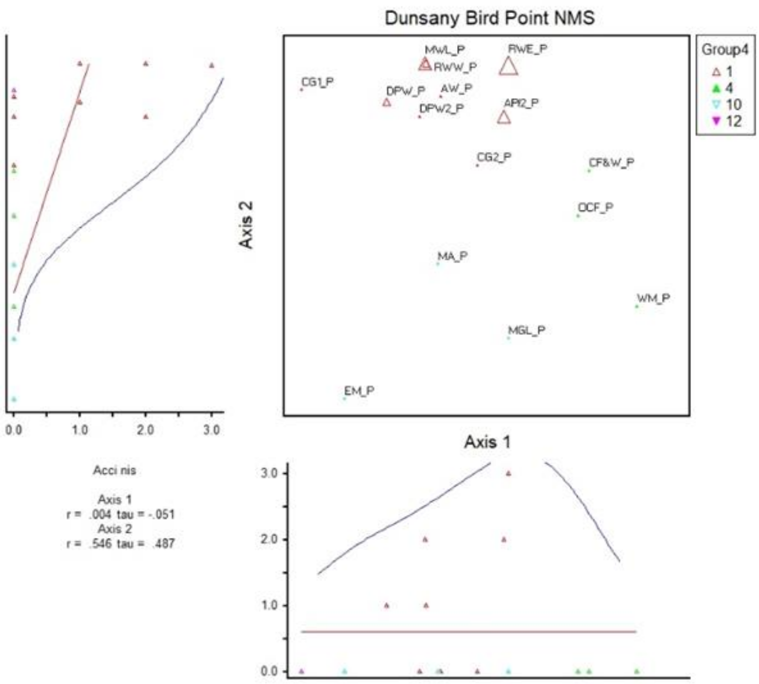

Figure 27: Ordination plot of bird count points at Dunsany, with the symbols and colours used for each transect reflecting the 4 group solution from cluster analysis, and with the size of the symbols proportional to the relative abundance of Accipiter nisus.

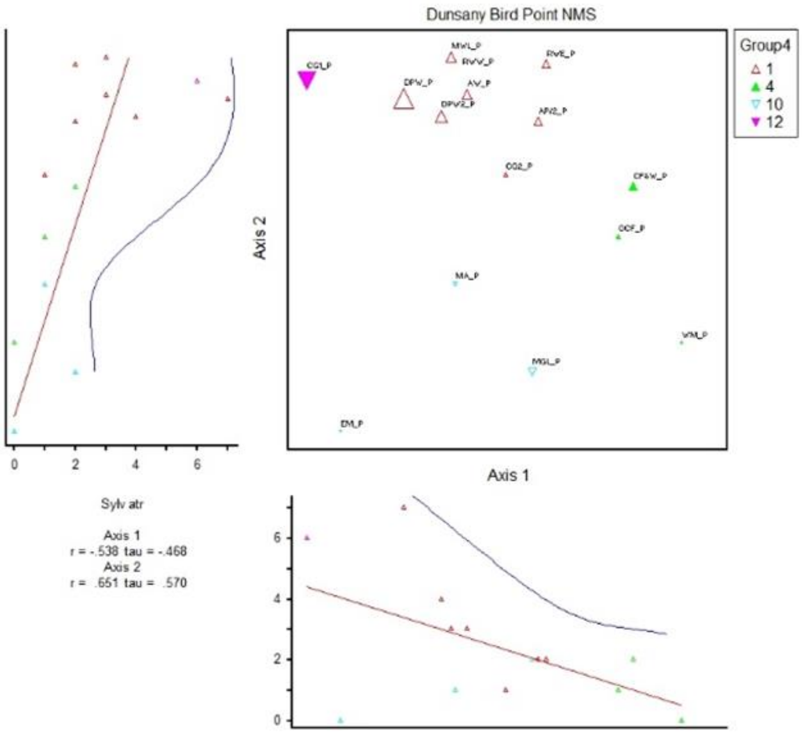

Figure 28: Ordination plot of bird count points at Dunsany, with the symbols and colours used for each transect reflecting the 4 group solution from cluster analysis, and with the size of the symbols proportional to the relative abundance of Sylvia atricapilla.

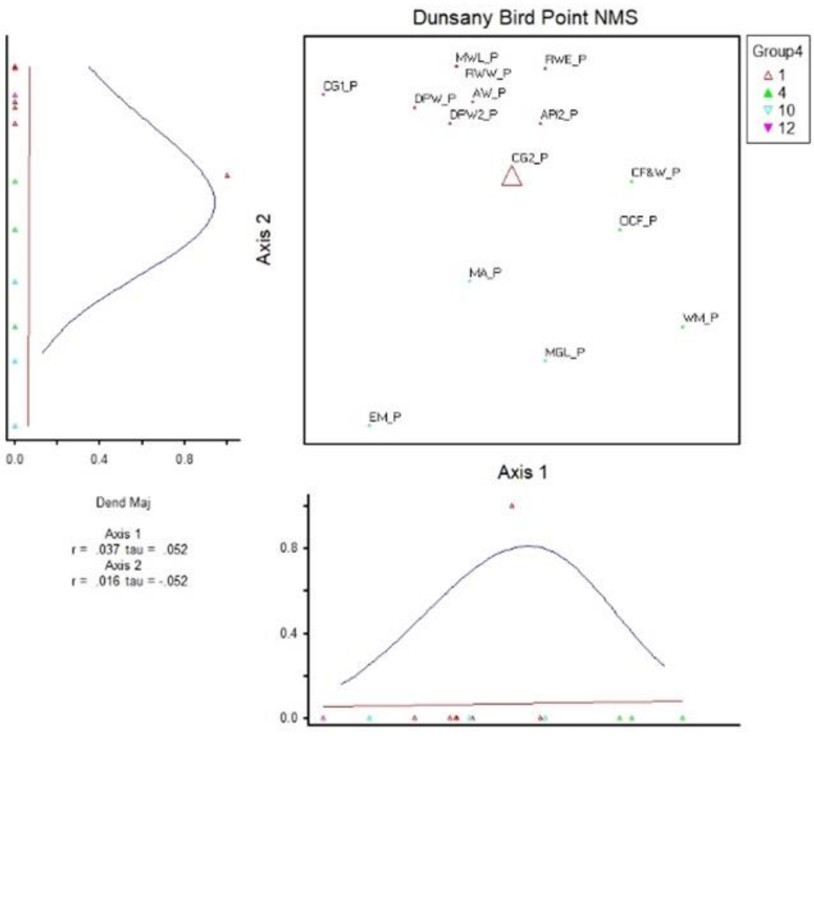

Figure 29: Ordination plot of bird count points at Dunsany, with the symbols and colours used for each transect reflecting the 4 group solution from cluster analysis, and with the size of the symbols proportional to the relative abundance of Dendrocopos major.

Appendix 2. Other species fauna seen on site. Common nsme, scientific name and authority.

Mammalia

Species	Scientific Name (L depicts Linnaeus 1758)
Pine Marten	*Martes martes* L
Red Deer	*Cervus elaphus* L
Rabbit	*Oryctolagus cuniculus* L
Hare	*Lepus timidus* L
Fox	*Vulpes vulpes* L
Badger	*Meles meles* L

Invertebrates

Lepidoptera

Butterflies

Red Admiral	*Vanessa atalanta* L.
Small Tortoiseshell	*Aglais urticae* l.
Speckled Wood	*Pararge aegeria* L.
Meadow Brown	*Maniola jurtina* L.
Ringlet	*Aphantopus hyperantus* L.
Orange Tip	*Anthocharis cardamines* L.
Silver Washed Fritillary	*Argynnis paphia* L.
Peacock	*Aglais io* L.
Large White	*Pieris brassicae* L.

Moths

Brimstone Moth	*Opisthograptis luteolata* L.
Yellow Underwing	*Noctua pronuba* L.

Odanata

Dragonflies

Four-spotted Chaser	*Libellula quadrimaculata* L.
Hairy Hawker	*Brachytron pratense* Müller, 1764.
Brown Hawker	*Aeshna grandis* L.

Damselflies

Blue-tailed Damselfly	*Ischnura elegans* Vander Linden, 1820.
Banded Damoiselle	*Calopteryx splendens* Harris, 1780.

Bees

Carder Bee	*Bombus pascuorum* Scopoli, 1763
Buff-tailed Bumblebee	*Bombus terrestris* L.
Honey Bee	*Apis mellifera* L.

Hoverfly Species

Pond Skaters	*Gerris lacustris* L.
Diving Beetle spp.	*Agabus bipustulatus* L.
Whirlygig Beetles	*Gyrinus spp.*
Ash Sawfly	*Tomostethus nigritus* Fabricius, 1804.

Reptilia

Common Lizard	*Zootoca vivipara* Lichtenstein, 1823.

Amphibians

Common Frog	*Rana temporaria* L.

Appendix 3. List of plant species

Trees

Species	Scientific Name
Beech	*Fagus sylvatica* L.
Alder	*Alnus glutinosa* (L.) Gaertn.
Scot's Pine	*Pinus sylvestris* L.
Holly	*Ilex aquifolium* L.
Oak	*Quercus Sp.* L.
Sycamore	*Acer pseudoplatanus* L.
Elm	*Ulmus glabra* Huds.
Spruce	*Picea Spp.* Mill.
Yew	*Taxus baccata ('fastigiata'?)* L.
Hazel	*Corylus avellana* L.
Ash	*Fraxinus excelsior* L.
Common Laurel	*Prunus laurocerasus* L.
Birch	*Betula pubescens* Ehrh.
Elderberry	*Sambucus nigra* L.
Hawthorn	*Crataegus monogyna* Jacq.
Blackthorn	*Prunus spinosa* L.
Sallow	*Salix spp.*
Black Poplar	*Populus nigra* L.
White Birch	*Betula pendula* Roth.

Other Plants

Bramble	*Rubus fruticosus* L.
Hogweed	*Heracleum sphondylium* L.
Fern Spp.	*Monilophyte spp.*
Hart's Tongue Fern	*Asplenium scolopendrium* L.
Nettles	*Urtica dioica* L.
Docks	*Rumex acetosa* L.
Goosegrass	*Galium aparine* L.
Thistles Spp.	*Cirisium & Carduus spp.*
Soft Rush	*Juncus effusus* L.
Hard rush	*Juncus inflexus* L.
Common Reed	*Phragmites australis*
Grasses	*Poaceae spp.*
Hairy Chervil	*Chaerophyllum hirsutum* L.
Wild Angelica	*Angelica sylvestris* L.
Common Boxwood	*Buxus sempervirens* L.
Vetch spp.	*Vicia sativa ssp.*
Meadow Sweet	*Filipendula ulmaria* (L.) Maxim.

Snowberry	*Symphoricarpos albus (L.) S.F.Blake 1914*
Ragworth	*Jacobaea vulgaris* Gaertn.
Golden Saxifrage	*Chrysosplenium oppositifolium* L.

References:

Ashton, E.C., Macintosh, D.J. and Hogarth, P.J., 2003. A baseline study of the diversity and community ecology of crab and molluscan macrofauna in the Sematan mangrove forest, Sarawak, Malaysia. *Journal of Tropical Ecology*, 19, pp.127-142.

Becker, P.H., 2003. Biomonitoring with birds. In *Trace Metals and other Contaminants in the Environment* (Vol. 6, pp. 677-736). Elsevier.

Bell, J.R., Botham, M.S., Henrys, P.A., Leech, D.I., Pearce-Higgins, J.W., Shortall, C.R., Brereton, T.M., Pickup, J. and Thackeray, S.J., 2019. Spatial and habitat variation in aphid, butterfly, moth and bird phenologies over the last half century. *Global Change Biology*, *25*(6), pp.1982-1994.

Benayas, J.M.R. and Bullock, J.M., 2012. Restoration of biodiversity and ecosystem services on agricultural land. *Ecosystems*, *15*(6), pp.883-899.

Bibby, C.J., Burgess, N.D., Hill, D.A., Hillis, D.M. and Mustoe, S., 2000. *Bird Census Techniques*. Elsevier. Academic Press, Harcourt Brace & Company, Publishers

Buckland, S.T., Rexstad, E.A., Marques, T.A. and Oedekoven, C.S., 2015. *Distance Sampling: Methods and Applications* (Vol. 431). New York, USA: Springer. pp

Buckland, S.T., Anderson, D.R., Burnham, K.P. and Laake, J.L., 2005. Distance sampling. *Encyclopedia of Biostatistics*, *2*.

Butler, S.J., Freckleton, R.P., Renwick, A.R. and Norris, K., 2012. An objective, niche-based approach to indicator species selection. *Methods in Ecology and Evolution*, *3*(2), pp.317-326.

Colhoun, K. and Cummins, S., 2013. Birds of conservation concern in Ireland. *Irish Birds*, *9*, pp.523-544.

Collins Bird Guide 2020. Version 1.54.45(287) [Mobile App] NatureGuides. Accessed 14 May 2021.

From: https://play.google.com/store/apps/details?id=com.natureguides.birdguide

Conti, G. and Fagarazzi, L., 2005. Forest expansion in mountain ecosystems:‘‘environmentalist’s dream’’or societal nightmare. *Planum*, *11*, pp.1-20.

Coombes, R.H. and Wilson, F.R., 2015. Dendrocopus major in the Republic of Ireland. *137 Black-headed Gulls Chroicocephalus ridibundus feeding on Mayfly Ephemera danica JG Greenwood 143 Reproductive output of Hen Harriers Circus cyaneus in relation to wind turbine proximity*, *10*(2), pp.183-196.

Cramer, V.A., Hobbs, R.J. and Standish, R.J., 2008. What's new about old fields? Land abandonment and ecosystem assembly. *Trends in ecology & evolution*, *23*(2), pp.104-112.

Crick, H.Q.P., 1992. A bird-habitat coding system for use in Britain and Ireland incorporating aspects of land-management and human activity. *Bird Study*, *39*(1), pp.1-12.

Dale, V.H. and Beyeler, S.C., 2001. Challenges in the development and use of ecological indicators. *Ecological indicators*, *1*(1), pp.3-10.

Donald, P.F., Green, R.E. and Heath, M.F., 2001. Agricultural intensification and the collapse of Europe's farmland bird populations. *Proceedings of the Royal Society of London. Series B: Biological Sciences*, *268*(1462), pp.25-29.

Donohoe, J., 2019. “Inspire Interview: The Nature Lord, Dunsany's Randal Plunkett”. *Meath Chronicle*, [online]. Meath. Saturday 28th December 2019.

Retrieved: - 7th August 2021

From: https://www.meathchronicle.ie/2019/12/28/inspire-interview-the-nature-lord-dunsanys-randal-plunkett/

Dufrêne, M. and Legendre, P., 1997. Species assemblages and indicator species: the need for a flexible asymmetrical approach. *Ecological monographs*, *67*(3), pp.345-366.

Dunn, E.H., 2002. Using decline in bird populations to identify needs for conservation action. *Conservation Biology*, *16*(6), pp.1632-1637.

Elliott, J. and Image, M., 2018. *Design of Agri-Environmental Schemes–evidence from the monitoring and evaluation GLAS in Ireland* (No. 2133-2018-5412). National University of Ireland, Galway.

Fleishman, E., Thomson, J.R., Mac Nally, R., Murphy, D.D. and Fay, J.P., 2005. Using indicator species to predict species richness of multiple taxonomic groups. *Conservation biology*, *19*(4), pp.1125-1137.

Fuller, R.J. and Green, G.H., 1998. Effects of woodland structure on breeding bird populations in stands of coppiced lime (Tilia cordata) in western England over a 10-year period. *Forestry: An International Journal of Forest Research*, *71*(3), pp.199-218.

Fuller, R.J., Hinsley, S.A. and Swetnam, R.D., 2004. The relevance of non-farmland habitats, uncropped areas and habitat diversity to the conservation of farmland birds. *Ibis*, *146*, pp.22-31.

Gillson, L., Ladle, R.J. and Araújo, M.B., 2011. Baselines, patterns and process. *Conservation biogeography. Oxford: Wiley-Blackwell. p*, pp.31-44.

Gregory, R.D., Van Strien, A., Vorisek, P., Gmelig Meyling, A.W., Noble, D.G., Foppen, R.P. and Gibbons, D.W., 2005. Developing indicators for European birds. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *360*(1454), pp.269-288.

Gross, M., 2015. Europe's bird populations in decline. Current Biology 25, pp.483–489.

Henderson, I., Holt, C. and Vickery, J., 2007. National and regional patterns of habitat association with foraging Barn Swallows Hirundo rustica in the UK. *Bird Study*, *54*(3), pp.371-377.

Hildén, O., 1965, January. Habitat selection in birds: a review. In *Annales Zoologici Fennici* (Vol. 2, No. 1, pp. 53-75). Finnish Zoological and Botanical Publishing Board.

Huin, N.I.C.O.L.A.S. and Sparks, T.H., 1998. Arrival and progression of the Swallow Hirundo rustica through Britain. *Bird Study*, *45*(3), pp.361-370.

Inglis, I.R., Wright, E. and Lill, J., 1994. The impact of hedges and farm woodlands on woodpigeon (Columba palumbus) nest densities. *Agriculture, ecosystems & environment*, *48*(3), pp.257-262.

International Union for Conservation of Nature, International Union for Conservation of Nature, Natural Resources. Species Survival Commission and IUCN Species Survival Commission, 2001. *IUCN Red List categories and criteria*. IUCN.

Jørgensen, D., 2015. Rethinking rewilding. *Geoforum*, *65*, pp.482-488.

Lance, G.N. and Williams, W.T., 1967. A general theory of classificatory sorting strategies: 1. Hierarchical systems. *The computer journal*, *9*(4), pp.373-380.

Lennon, M., 2019. Rewilding as rural land management: opportunities and constraints. In Scott, M., Gallent, N., Gkartzios, M.(eds.). The Routledge Companion to Rural Planning. Routledge.

Li, W., Dong, R., Fu, H., Wang, J., Yu, L. and Gong, P., 2020. Integrating Google Earth imagery with Landsat data to improve 30-m resolution land cover mapping. *Remote Sensing of Environment*, *237*, p.111563

Lorimer, J., Sandom, C., Jepson, P., Doughty, C., Barua, M. and Kirby, K.J., 2015. Rewilding: science, practice, and politics. *Annual Review of Environment and Resources*, *40*, pp.39-62.

Lynas, P., Newton, S.F. and Robinson, J.A., 2007. The status of birds in Ireland: an analysis of conservation concern 2008-2013. *Irish Birds*, *8*(2).

MacArthur, R.H. and MacArthur, J.W., 1961. On bird species diversity. *Ecology*, *42*(3), pp.594-598.

MacArthur, R.H., MacArthur, J.W. and Preer, J., 1962. On bird species diversity. II. Prediction of bird census from habitat measurements. *The American Naturalist*, *96*(888), pp.167-174.

Marsden, S.J., 1999. Estimation of parrot and hornbill densities using a point count distance sampling method. *Ibis*, *141*(3), pp.327-390.

McCune, B., Grace, J.B. and Urban, D.L., 2002. *Analysis of ecological communities* (Vol. 28). Gleneden Beach, OR: MjM software design.

Mihoub, J.B., Henle, K., Titeux, N., Brotons, L., Brummitt, N.A. and Schmeller, D.S., 2017. Setting temporal baselines for biodiversity: the limits of available monitoring data for capturing the full impact of anthropogenic pressures. *Scientific reports*, *7*(1), pp.1-13.

Moore, M., 2019. “ME01681 - DUNSANY - Castle - Anglo-Norman masonry castle”. *MeathHeritage.com, Heritage & Culture in Meath.* [online]. Meath. Wednesday 21st August 2019.

Retrieved: - 8th August 2021

From: http://www.meathheritage.com/index.php/archives/item/me01681-dunsany-castle-anglo-norman-masonry-castle

Murton, R.K., Westwood, N.J. and Isaacson, A.J., 1964. The feeding habits of the Woodpigeon Columba palumbus, Stock Dove C. oenas and Turtle Dove Streptopelia turtur. *Ibis*, *106*(2), pp.174-188.

Navarro, L.M. and Pereira, H.M., 2015. Rewilding abandoned landscapes in Europe. In *Rewilding European Landscapes* pp. 3-23. Springer, Cham.

Niemi, G.J. and McDonald, M.E., 2004. Application of ecological indicators. *Annu. Rev. Ecol. Evol. Syst.*, *35*, pp.89-111.

Ó hUallachain, D. and Dunne, J., 2013. Seasonal variation in the diet and food preference of the Woodpigeon Columba palumbus in Ireland. *Bird Study*, *60*(3), pp.417-422.

O’Regan, S.M., Flynn, D., Kelly, T.C., O’Callaghan, M.J., Pokrovskii, A.V. and Rachinskii, D., 2012. The response of the woodpigeon (Columba palumbus) to relaxation of intraspecific competition: a hybrid modelling approach. *Ecological modelling*, *224*(1), pp.54-64.

Pointereau, P., Coulon, F., Girard, P., Lambotte, M., Stuczynski, T., Sanchez Ortega, V. and Del Rio, A., 2008. Analysis of farmland abandonment and the extent and location of agricultural areas that are actually abandoned or are in risk to be abandoned. European Commission Joint Research Centre. *Institute for Environment and Sustainability* pp.99-101.

Redhead, J.W., Pywell, R.F., Bellamy, P.E., Broughton, R.K., Hill, R.A. and Hinsley, S.A., 2013. Great tits Parus major and blue tits Cyanistes caeruleus as indicators of agri-environmental habitat quality. *Agriculture, Ecosystems & Environment*, *178*, pp.31-38.

Rewilding Europe, 2020. “European Rewilding Network welcomes its first Irish rewilding initiative”.

European Rewilding Network. [Online]. Netherlands. Sunday 5th July 2020.

Retrieved: - 8th August 2021

From: https://rewildingeurope.com/news/european-rewilding-network-welcomes-its-first-irish-rewilding-initiative/

Reynolds, C.M., 1979. The heronries census: 1972–1977 population changes and a review. *Bird Study*, *26*(1), pp.7-12.

Robinson, R.A., 2010. State of bird populations in Britain and Ireland. *Silent summer: the state of wildlife in Britain and Ireland. Cambridge University Press, Cambridge*, pp.281-318.

Root-Bernstein, M., Galetti, M., & Ladle, R. J., 2017. Rewilding South America: ten key questions. *Perspectives in ecology and conservation*, *15*(4), 271-281.

Root-Bernstein, M., Gooden, J. and Boyes, A., 2018. Rewilding in practice: Projects and policy. *Geoforum*, *97*, pp.292-304.

Russo, D., 2007. Effects of land abandonment on animal species in Europe: conservation and management implications. *Integrated assessment of vulnerable ecosystems under global change in the European Union. Project report. European Commission, Community Research, Sustainable development, global change and ecosystems*, pp.1-51.

Silke, S., 2014. “Dunsany Castle”. *Dublin Places to Visit.* [online]. Dublin. Sunday 6th July 2014.

Retrieved: - 8th August 2021

From: http://www.dublinplacestovisit.com/dunsany-castle/#:~:text=The%20Castle%20was%20established%20as,chief%20seat%20was%20at%20Trim.

Silsbee, G.G. and Peterson, D.L., 1991. *Designing and implementing comprehensive long-term inventory and monitoring programs for National Park System lands.* Denver, CO: National Park Service. *Natural Resources Report NPS/NRUW/NRR-91/04*.

Soulé, M. and Noss, R., 1998. Rewilding and biodiversity: complementary goals for continental conservation. *Wild Earth*, *8*, pp.18-28.

Spagnoli Gabardi, C., 2019. “Visiting The Lord of Nature at Dunsany Castle”. *Eluxe Magazine* [online]. London. Saturday 14th September 2019.

Retrieved: - 8th August 2021

From: https://eluxemagazine.com/people/dunsany-castle/

Svenning, J.C., Pedersen, P.B., Donlan, C.J., Ejrnæs, R., Faurby, S., Galetti, M., Hansen, D.M., Sandel, B., Sandom, C.J., Terborgh, J.W. and Vera, F.W., 2016. Science for a wilder Anthropocene: Synthesis and future directions for trophic rewilding research. Proceedings of the National Academy of Sciences, 113(4), pp.898-906.

Temple, S.A. and Wiens, J.A., 1989. Bird populations and environmental changes: can birds be bio-indicators. *American Birds*, *43*(2), pp.260-270.

Tramer, E.J., 1969. Bird species diversity: components of Shannon's formula. *Ecology*, *50*(5), pp.927-929.

Voříšek, P.E.T.R., Jiguet, F., van Strien, A.R.C.O., Škorpilová, J.A.N.A., Klvaňová, A. and Gregory, R.D., 2010. Trends in abundance and biomass of widespread European farmland birds: how much have we lost. *BOU Proceedings–Lowland Farmland Birds III*, *24*.

Wall, D. and Horák, T., 2007. Using baseline studies in the investigation of test impact. *Assessment in Education*, *14*(1), pp.99-116.

Walsh, L., 2020. “How the baron of Dunsany carried out an ambitious rewilding project in Meath”. *The Irish Times.* [online]. Dublin. Saturday 26th December 2020

Retrieved: - 7th August 2021

From: https://www.irishtimes.com/news/environment/how-the-baron-of-dunsany-carried-out-an-ambitious-rewilding-project-in-meath-1.4443054

Wetzel, F.T., Bingham, H.C., Groom, Q., Haase, P., Kõljalg, U., Kuhlmann, M., Martin, C.S., Penev, L., Robertson, T., Saarenmaa, H. and Schmeller, D.S., 2018. Unlocking biodiversity data: Prioritization and filling the gaps in biodiversity observation data in Europe. *Biological conservation*, *221*, pp.78-85.

Wilson, R.R., Twedt, D.J. and Elliott, A.B., 2000. Comparison of line transects and point counts for monitoring spring migration in forested wetlands. *Journal of Field Ornithology*, *71*(2), pp.345-355.

Wilson, M.W., Pithon, J., Gittings, T., Kelly, T.C., Giller, P.S. and O'Halloran, J., 2006. Effects of growth stage and tree species composition on breeding bird assemblages of plantation forests. *Bird Study*, *53*(3), pp.225-236.

Wiens, J.A., 1992. *The ecology of bird communities* (Vol. 1). Cambridge University Press.

Retrieved: 15th August 2021

From: Link to source

Yoccoz, N.G., Nichols, J.D. and Boulinier, T., 2001. Monitoring of biological diversity in space and time. *Trends in ecology & evolution*, *16*(8), pp.446-453.