Grassland Vegetation at Dunsany Estate, County Meath

Trinity College Dublin
The University of Dublin

Clare Lynn - 17323013

Declaration

I, Clare Lynn declare that this thesis is my own work except where stated through references or in the Acknowledgements and that it is 5940 words in length.

Clare Lynn, 13/08/21

Abstract

A quantitative vegetation analysis was carried out on six fields of Dunsany Estate, in Co Meath. The goal was to examine the vegetation structures and communities present and analyse these grasslands in terms of a conservation and rewilding program. The data was collected through 72 1 x 1m2 random quadrats. Then further analysed through software programmes such as PC-ord and ERICA. There were found to be six relatively distinct groups.

The majority was found to be of poor conservation value as semi-natural grassland. Methods to increase the biodiversity and conservation value of semi-natural grassland is further discussed.

A survey was also conducted to examine the level of succession taking place in the grassland. 100 x 4m2 was inspected for tree encroachment and presence of *rubus fruticosus*. Only one of the six surveyed fields demonstrated any progression towards shrubland or tree encroachment. The single field had majority *Salix* spp. with some *Betula* spp. The possible reasons for the singular field showing succession is discussed.

Finally, a non-random survey was conducted to analyse an area of *Populus alba.* The dense growth from root suckers was compared to the more successional growth occurring in the field mentioned above.

Acknowledgements

I would like to thank Dr. Stephen Waldren as my tutor for his time in guidance and help throughout this endeavor. Randal Plunkett for graciously allowing the use of his land and his dedication to conservation and biodiversity. Finally, all the staff and student members of the Botany Department of Trinity College Dublin who have all contributed their time and efforts during this difficult year.

Introduction

Dunsany Estate

The Dunsany estate located in County Meath approximately 35km northwest from Dublin city centre, was established in the 11th century (Fig 1.1). The land has historically been used for agricultural purposes (rewildingeurope.com). In 2014 a rewilding project was established with 300 hectares dedicated to ecology restoration (Walsh 2020). Approximately 200 hectares of this is forest and the remaining one third of this is grassland. The grassland is divided into several fields of various sizes. The ones used in this study are colloquially referred to as, crop field (CF), Durhams field (DF), cricket pitch (CP), rosegarden (RG), front lawn (FL) and front lawn flooded (FLF) (figure 1.2). As of when the surveying took place, no direct action had been taken to influence the rewilding direction of the grasslands in this study. The Skane river runs through the land which approximately 10km long and is a tributary of the Boyne. provides ecosystem services such as erosion control, maintenance of floodplain fertility and a role in nutrient cycling (Yeakley et al 2016). The area is extremely flat with the entire estate has an elevation of under 90m (en-ie.topographic-map.com). The land is comprised of a mixture of woodland, previously used farmland, and marsh.

Fig 1.1. Satellite image of the Dunsany Estate where the field work took place. (Google maps 2021)

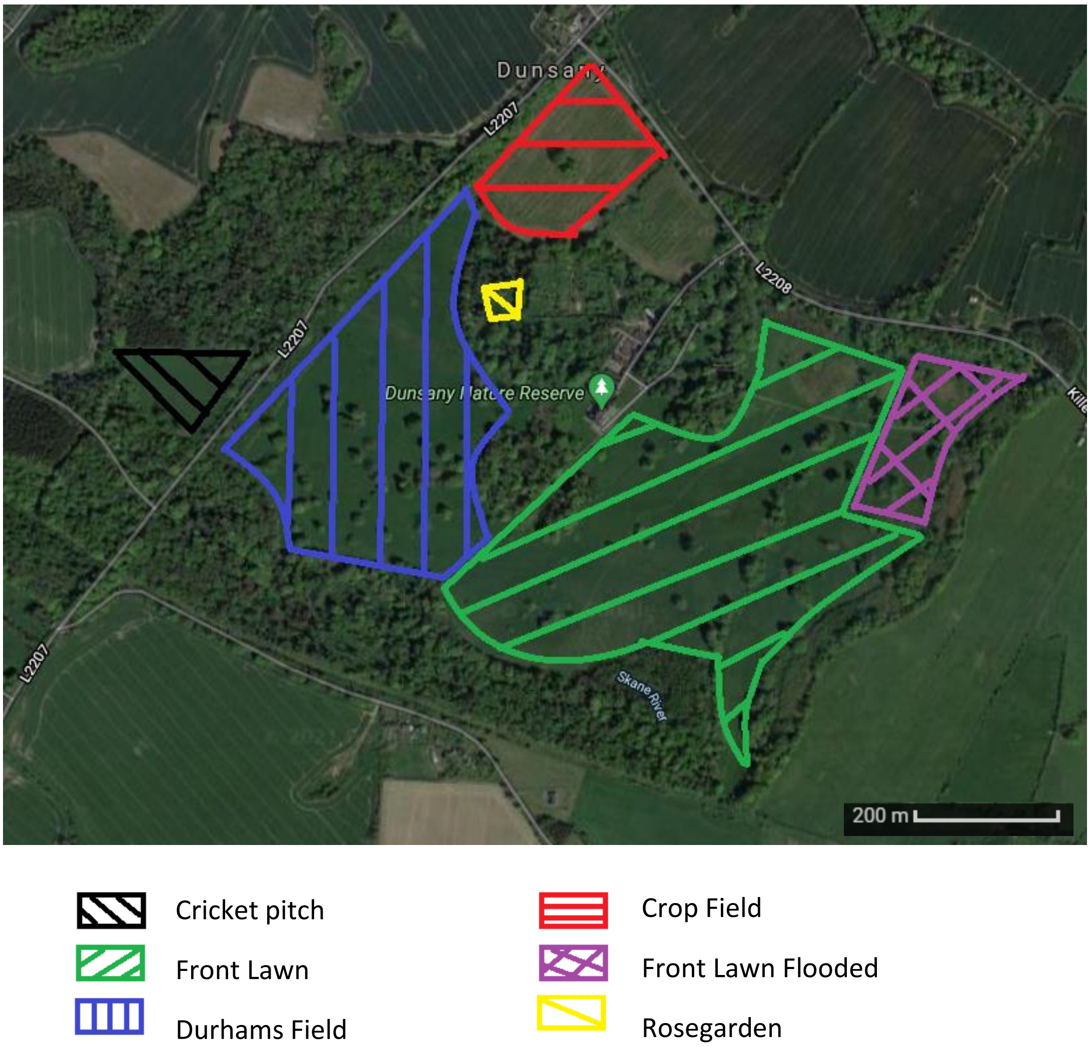


Fig 1.2. Map of Dunsany Estate, with the surveyed fields marked and named.

Vegetation and Grassland

Vegetation is a general term for the assemblage of different species that grow together; it refers to the ground cover provided by plants, and is, by far, the most abundant biotic element of the biosphere (Kent 2012). Vegetation serves many critical functions in the biosphere, at all possible spatial scales. Vegetation converts solar energy into biomass and forms the base of all food chains. Vegetation forms natural units and these units are formed on the basis of interactions of individual plants of various species with the environment (Tansley 1920).

Vegetation regulates the flow of numerous biogeochemical cycles, most critically those of water, carbon, and nitrogen. The vegetation of an area responds to the environment and environmental gradients in evolutionary terms, but they are also natural engineers in terms of how they influence their environment (Austin 1999). Their presence alters the ecosystem e.g. trees are a habitat for animals, fungi and other plants in the living or dead tissue thus, the species composition can also be an informative part of biodiversity studies (Austin 1999). Furthermore, natural vegetation provides a fully developed habitat for wildlife. The plant types growing in an area can provide other information on the ecosystem present such as the as the soil type etc. This is because an area's vegetation responds to the environment in not only evolutionary terms but also ecologically. The knowledge of vegetation structure and community is fundamental for assessing the current ecological characteristics of a natural area and for assessing future changes (Kent 2012., Chytrý et al 2011). Long term monitoring of plants can reveal changes in the habitat of a specific area and by extension, how that habitat is likely to support different animals (Kent 2012). Vegetation can be described and mapped, and therefore can be used to: monitor changes in cover, plant species distributions/composition, and environmental controls due to natural or human-influenced events, set conservation and habitat management goals (Kent 2012., Chytrý et al 2011).

Vegetation analysis is quantitative plant ecology, where the structure of plant communities and species composition are studied based on samples taken of the species abundance and composition (Schröter & Kirchner 1886–1902; Warming 1895; Clements 1905). It is not a new science and the most common aim was to define vegetation units by grouping plots that have a similar species composition and then further arranging these groups (Chytrý et al 2011). It allows for the monitoring of management practices or to provide the basis for predictions of possible changes in plant species distribution which also allows for informed decision making and conservation planning (Kent 2012., Chytrý et al 2011). This baseline is also key to examine the succession and vegetation dynamics that may take place over time (Kent 2012).

Grasslands

Grasslands are defined as herbaceous vegetation types that are dominated by a perennial sward of fine-leaved flora belonging to the Poaceae family and to a lesser extent the families Juncaceae and Cyperaceae (Roukos et al 2012). There also may be a significant percentage of the vegetation composition with broadleaved herbs. The most dominant grassland type in Europe is secondary or semi-natural grasslands. This type of vegetation is possible because the criteria for forest vegetation is not met due to human management such as mowing, or livestock grazing (Roukos et al 2012).

Grazing is an integral biological attribute of a grassland ecosystem (Roukos et al 2012). It obviously benefits humans through the provisioning of ecosystem services and the facilitation of farming (Roukos et al 2012). It is estimated that grasslands store approximately 34% of the global stock in terrestrial ecosystems (European Commission 2008) but furthermore it forms numerous habitat types, which allows elements of biodiversity to thrive (Reynolds and Frame 2005). They provide forage for wild fauna, combat some of the negative impacts from pesticides and fertilizers and provide support to insects that play vital roles of control and pollination within the ecosystem (Reynolds and Frame 2005).

Grassland is the dominant land-use option in Ireland as the Irish agricultural industry is primarily grass based (McGrath and Zhang 2003). The grass fields in Dunsany were unsurprisingly used for grazing livestock and cropping in the years before beginning the rewilding process (Walsh 2020). Grassland accounted for 58.4% of the land use in Ireland in 2018 (cso.ie). The current thought is that if a semi-natural grassland (a grassland that has not been re-seeded with high producing species or treated with fertiliser) is completely abandoned the grassland will progress to scrub land and then ultimately a woodland or closed canopy system (O'Neill et al 2013) (Mitchell 2005). Each of these stages can have a high conservation value (Mortimer et al 2000). Similar to the predominately woodland cover of the land in pre-Neolithic times. This closed canopy was widespread across Europe after glaciation (Mitchell 2005). Human activity has altered the landscape of Ireland c. 5500 BP (O'Connell 1987). Namely in that while Ireland is not capable of supporting natural grassland, there are now categories of semi-natural Irish grassland that is species rich, biodiverse and semi-natural that have been described (O'Neill et al 2013). There is a high conservation value assigned to species-rich grasslands which support a diverse range of floral and faunal communities (Pywell et al 2004).

While the grassland on the Dunsany estate experiences grazing the from a Red Deer (*Cervus elaphus* L.) population. *C. elaphus* can have an intermediate diet of both grass and sedges and concentrate food items such as tree and shrub leaves, seeds and fruits (Gebert and Verheyden-Tixier 2008). These depend on the habitat type which determines the food type that is available (Gebert and Verheyden-Tixier 2008). the pollen record indicates that herbivore grazing will not affect the end result of the succession that may be taking place (Mitchell 2005).

Soils

Figure. 1.3. Map of the soil types of county Meath (Finch et al 1983).

The soils of Dunsany are Limestone lowlands with Namurian and Silurian shale hills (Finch et al 1983) (Fig 1.3). An analysis of 566 acres, the soil was found to be filled with marl and alluvium due to the old glacial lakes that were dammed by the retreating ice. This soil is classified as a poorly drained Gley, with poor drainage across the area (Synge 1951) (Finch et al 1983). The parent material is alluvium of sandstone origin, Carboniferous limestone, and Namurian shale (Finch et al 1983).

The soil has a weak structure, heavy texture and a high watertable. The characteristics of the soil profile is the dark brown surface horizon composed of clay to clay loam texture. It has a weak coarse subangular blocky structure. From a farming perspective it was suggested that this soil was suitable for grazing livestock (Finch et al 1983). When the soils of semi-natural vegetation was collected and compared to soils from arable land and improved grassland soils, it was found that the level of extractable phosphorous was lower (Gough and Marrs 1990). This means the restoration of semi-natural grasslands can be limited if there is a high availability of readily extractable phosphorous (Pywell el al., 2007., Gough and Marrs 1990).

Rewilding

"Ecological restoration is the process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed" – Society for Ecological Restoration.

Rewilding is a form of conservation aimed at restoring and protecting natural processes and core wilderness areas, possibly providing connectivity between "wild" habitats, and protecting or reintroducing apex predators and keystone species (Jepson and Schepers 2016). It is future orientated, and the ultimate goal of rewilding efforts is generally to create ecosystems requiring passive management by limiting human control of ecosystems to allow dynamic natural processes to produce the conservation outcomes (Jepson and Schepers 2016). A key aim for any rewilding project is to promote biodiversity and not human preferred eco-system functions (Jepson and Schepers 2016). Natural vegetation recovery is a complex process (Hobbs and Cramer 2007). This generally occurs with a reduction in land use intensity often the alleviation of agriculture-use (Stoate et al. 2009). There is difficulty of course in determining the historical levels of biodiversity we should be aiming for and even the types of biodiversity. It is acknowledged that the pollen record (Roberts et al. 2018, Zanon et al. 2018) and beetle remains (Smith et al. 2018, Whitehouse & Smith 2010) both indicate there was approximately 20 to 40% open land across Europe.

Grazing can have benefits for semi-natural grasslands (Riesch et al 2020), but if the deer population is allowed to over graze there's a potential for negative effects. The herbivore density does not dictate the forest or open landscape structure. The land structure dictates the carrying capacity of herbivores (Mitchell 2005, Mitchell, In Press).

The goal of rewilding once farmed land with aim of restoring or increasing the level of biodiversity is a relatively new topic and field of research (Jepson and Schepers 2016).

The rewilding of the grasslands in the Dunsany Nature Reserve is largely unrestricted and undisturbed (Walsh 2020) (Some *Jacobaea vulgaris* was removed in the beginning but there is still some present on the site).

This approach is considered to generally be considerably slower (Isbell et al 2019), and prone to more trial and error then a more hands-on approach. However, without intervention the plant productivity and biodiversity of land may still lack in comparison to fields which have never been ploughed for up to a century after agricultural use (Isbell et al 2019). Unmanaged rewilding is considered to be more resilient, and inexpensive.

The restoration of land from an intensive agriculture setting to a species rich, diverse grassland has many difficulties. These include high residual soil fertility from intensive farming (Walker et al 2004). Competition from space and resources (Bullock 1996). A lack of suitable spots for germination (Bullock 2000) and furthermore, a lack of seed/ propagules from desirable species

(Pywell et al 2002a). solutions are present for all these, depending on the level of effort that's willing to be extended.

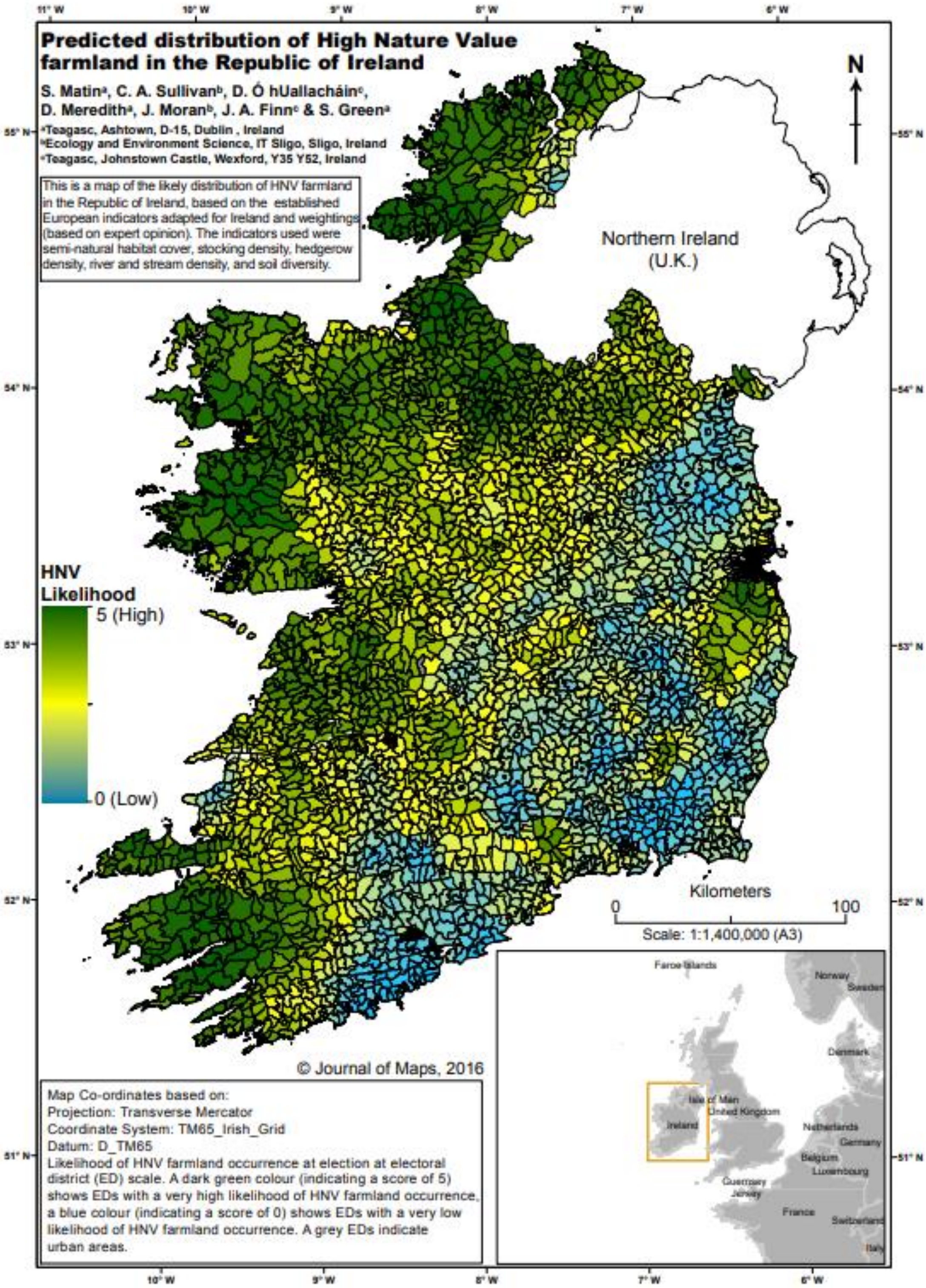


Figure. 1.4. Map of the likelihood of the occurrence of some High Nature Value farmland across the Republic of Ireland (Matin et al 2016)

Meath experiences a high rate of intensively managed farmland, or in other words there is a likelihood for a lack of high nature value farmland (Matin et al 2016). This increases the importance of Dunsany estate as a potential habitat for species due to their isolation and that these fragments are remnants that otherwise would have been much more widespread (fig 1.4).

Succession

Succession is non-seasonal cumulative changes in the plant species in an area. Succession involves the immigration and extinction of species together with their relative abundances (Kent 2012). Secondary succession on abandoned farmland is considered to fall into a general pattern (though disturbance would interrupt this) where i) land is recolonized by spontaneous vegetation ii) progresses from a herbaceous phase to a shrub-dominant phase iii) and finally a climax community of forest is established (Benjamin et al 2005).

A study of secondary succession was conducted by Keever in 1950. Plant succession was characterized in an old field after agricultural use had ceased (Keever 1950). It was found that competitive interactions among species, allelopathy, seed dispersal, and life history strategies of individual species, led to this predictable pattern of succession (Keever 1950). Multiple mechanisms operate during the process of succession, making somewhat unpredictable (Keever 1950). Restoration ecology can be viewed as an attempt to speed successional processes to reach a desired climax community. Passive rewilding involves succession where the spontaneous development of ecosystems occurs without direct human development (Meli et al 2017) (Corlett 2016). A study in England found that 23 years post-abandonment, the woody vegetation had covered 86% of the abandoned land (Broughton 2021). However, that area had different grazing pressures including, brown hares *Lepus europaeus*, grey squirrels *Sciurus carolinensis*, European rabbits *Oryctolagus cuniculus*, Reeves' muntjac *Muntiacus reevesi* and Roe deer *Capreolus capreolus* (Broughton 2021). The *C. elaphus* in Dunsany can help maintain semi-natural grasslands and without them the conservation value would decrease (Riesch et al 2020).

The potential climax community has been outlined by Cross (1997) (Fig 1.5). Meath is described largely as Pedunculate oak-ash forests with hazel and *Circaea luetiana* (unit 5) which grades into Alder-pedunculate oak-ash forests with *Salix cinerea ssp. oleifolia* (unit 9) (Fig 1.5). Other factors might affect this outcome such as introduced species that can result in novel ecosystems.

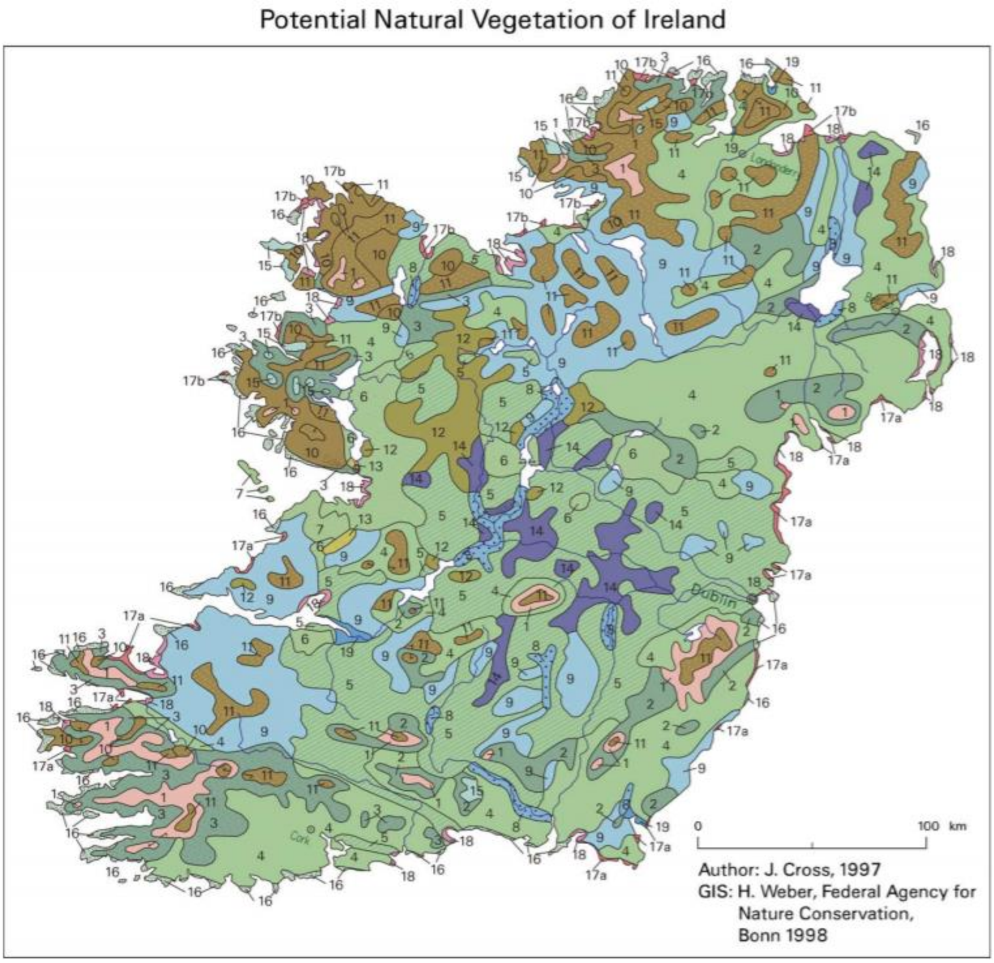


Fig. 1— The potential natural vegetation of Ireland compiled at a scale of 1:1.25m.

Figure. 1.5. Diagram of the potential vegetation of Ireland. The potential vegetation is based on factors such as vegetation history, soil type, climate amongst other biotic factors (Cross 1997).

Aims

This project aims to provide a more detailed understanding of the current biodiversity of the grasslands in Dunsany rewilding project through analysis of the vegetation present on the sites. To do this a detailed description of the current vegetation is needed as well as a comparison to other Irish semi-natural grasslands. By establishing this baseline, the value of the biodiversity and conservation of the grassland sites can be critically analysed. Should there be an effort to maintain the grasslands or would they have better value as the woodland. Would passive rewilding to woodland be more feasible than the maintenance required for a semi-natural grassland? Furthermore, the level of succession taking place in these grasslands is to be examined by monitoring the bramble and presence of trees saplings. These will be achieved through data collection in situ and then further statistical analysis of the vegetation communities present.

Methods

The method for sampling the vegetation and biodiversity of the grasslands involved taking a total of 72 random 1 x 1m quadrat samples across five fields on the Dunsany estate. The sampling recorded the presence and a visual estimate of the vascular plant species. In the larger fields the more quadrat samples that would be taken. A quadrat size of 1 x 1m was utilised as an appropriate size for sampling the herbaceous vegetation of a grassland (Coulloudon et al 1999). This ensures adequate size to capture the variety while keeping it small to allow for accurate data collection. The sampling method is based on Perrin (et al 2014). The data collection took place between the 13th of the 8th 2020 and 2nd of the 10th 2020.

The fields sampled in this report are, front lawn (14 quadrats), front lawn flooded (8 quadrats), crop field (14 quadrats), cricket pitch (14 quadrats), Durham's field (14 quadrats) and rose garden (8 quadrats). Front lawn was split into the two separate parts based on the noticeable change in water content and vegetation. A percentage cover of each species (or genus if it was not possible to identify to a species level) present was recorded. Species identification was based on An Irish Flora (Curtis and Parnell 2012), Grasses (Hubbard 1984) and Willows and Poplars by (Meikle 1984). Due to the inaccuracies of mobile phone GPS the locations of the quadrats were not recorded.

The percentage cover of all vascular plant species present in the quadrat was recorded in-situ and if not readily identified, a sample was taken and persevered in a plant press until identification could be made (Perrin et al 2014). The percentage cover was kept to 5% intervals, if the cover was less than 10% where smaller 1% intervals were used (Perrin et al 2014).

To examine for tree species establishment two 100m line transect on the large sites (front lawn, Durhams field, crop field, and cricket pitch) or 24m line transect on the smaller sites (rose garden and flooded, front lawn) was placed. On this transect every 4 meters was counted as different “block”. The tree species and height within 50cm ranges (<50cm, 50-100cm, 100-150cm and 150+cm) are again recorded in-situ in the 4 x 4 meter “blocks” they were found in. The presence or absence of Rubus fruiticous was also recorded as there is evidence this can protect seedlings against grazing damage by deer (Harmer et al 2010) thus allowing the seedling to become established. The starting and finishing point of each line transect was recorded using the internal GPS of a Samsung Galaxy J5 2016 with Google maps version 10.49.2 (Google, 2020).

Populus alba was present in Durhams field. This is a tree can form dense colonies as sucker shoots are produced from the parent tree and these can produce several offspring (Meikle 1984). To monitor a potential colony additional 56m line transects were set up in T-shape to examine the growth around the parent tree on this site while ensuring to not over survey an area. The height of *P.alba* was recorded in 4 groups (<50cm, 51-100cm, 101-150cm and 150+cm). Furthermore, damage of these trees from deer grazing were recorded. To be counted as damage there had to be snapping/break of the main trunk that would influence the measure of the tree height. The frequency of the tree and then the density per m^2 was calculated.

The data gathered was inputted and formatted in spreadsheets using the software Microsoft Excel. Due to difficulty in identifying Rumex in the latter stage of the growing season and its low frequency and cover within the quadrats this was only recorded to genus level.

Then further analysis took place in PC-ORD for windows, version 5 (McCune and Mefford 1999). The data for each of the fields, was run through a Non-metric Mutidimensional Scaling (NMS) analysis. The data was edited to ensure a final stress value lower than 20. Then was analysed again to through a slow and steady option which uses 250 real data iterations and 250 randomized data iterations (Monte-Carlo test). This calculates from a 1 dimensional to a 6-dimensional solution. The solution present was then graphed using PC-ORD.

A cluster analysis was run based on Lance and Williams flexible beta clustering. The beta was set to -0.25. A suitable group membership level was found to be … The dendrogram produced was graphed on PC-ORD. The groupings that were selected from the dendrogram were plotted on the NMS graphs for clarity.

Indicator Species analysis

To calculated the indicator species a Monte Carlo test was run based on the cluster analysis data that was run above, the data was clustered from 2 to 70 each of these clusters was put through 4999 randomized runs and then the number of significant indicators was noted and the mean probability of the indicators from the outputs of the clusters from 2 to 70 was calculated. For the higher number of clusters there was the need to remove the groups that only contain a single quadrat within them. The cluster number was plotted against the mean probability and the number of indicators. The appropriate number of clusters was determined from the highest number of indicators and lowest probability.

relative abundance, relative frequency and indicator values for this number of clusters to help describe the vegetation in these groups of quadrats.

Two-way cluster analysis

A two-way cluster analysis was set up in PC-ORD 5 to compare the dendrogram to the groupings of species. This allows the importance species for defining the different groups of quadrats to be analysised. The parameters were set up as Sorenson (Bray-Curtis) for the distance and the flexible beta (again set to -0.25) as the group linkage method.

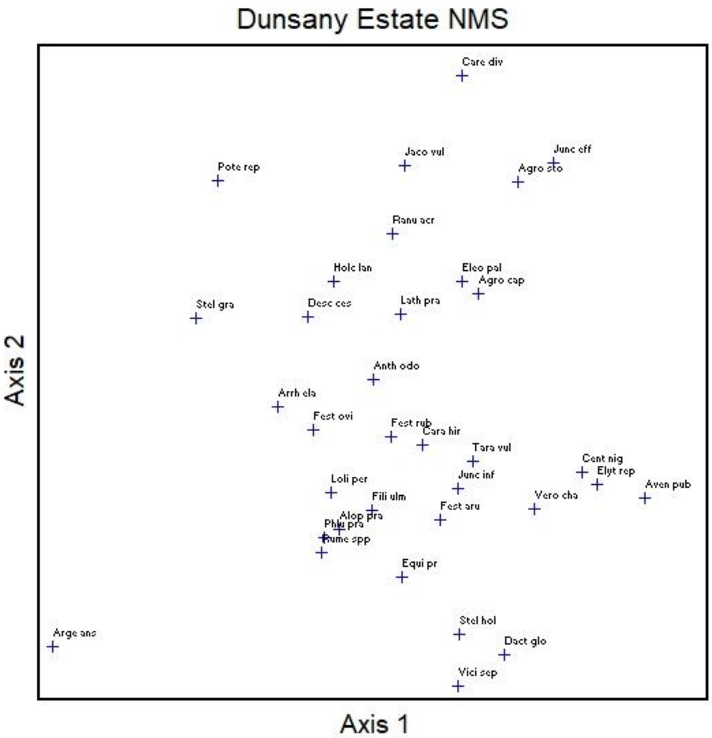
The densities of the line transects

ERICA

The data was analysed through ERICA web application (https://www.biodiversityireland.ie/). It allows the data collected to be defined by the Irish Vegetation Classification. This can be used to assess the conservation value of the land. The results for Erica have gaps as this software is set to analysis data that's identified to a species level. This was not full possible as some (Rumex, a Salix tree) were only identified to genus level. Erica doesn't have all Irish communities incorporated as of yet, but the data collected on grasslands was suitable for the web application. The software was used to group the various quadrats into the classifications as described according to the Irish Vegetation Classification. It will also differentiate between transitional and assigned communities. In addition ERICA also gives a value for the Simpsons evenness and Simpsons diversity for all the quadrats.

Results

The final stress value for the NMS analysis was 19.57 for a 3-dimensional solution which is between the acceptable range of 10 to 20. The final instability was 0.00178. The P value for the stress in relation to dimensionality for a 3-dimensional solution was 0.0040, a statistically significant result.



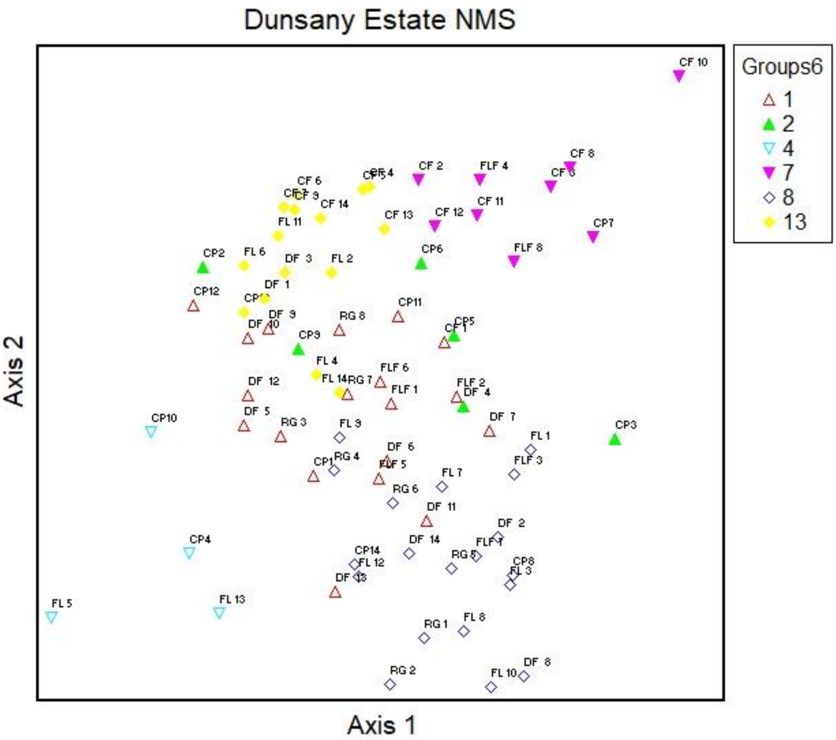
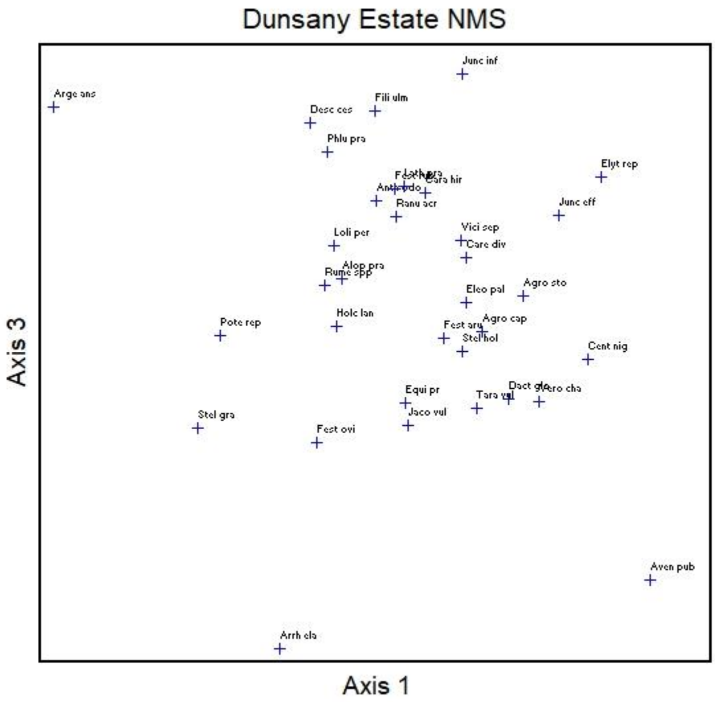


Figure 2.1 NMS ordination 44 plant species for axis 2-1 (right) and Figure 2.2 NMS ordination for 72 quadrats clustered by 6 plant communities for axis 2-1 (left).



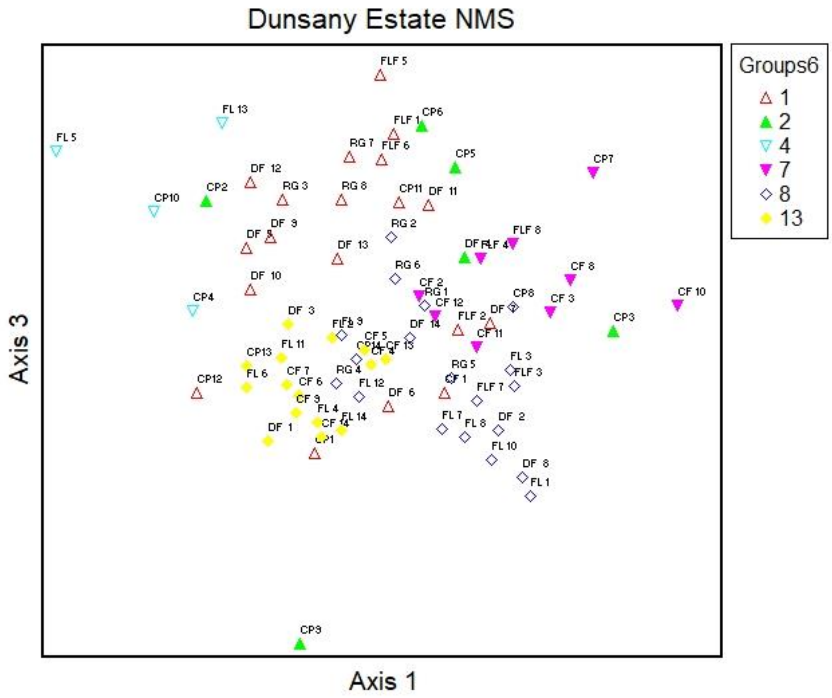
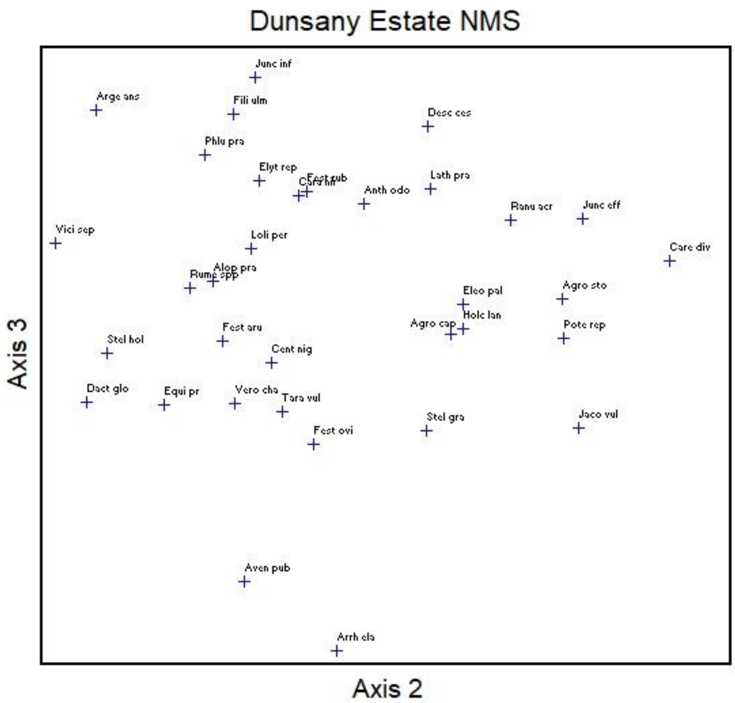


Figure 2.3. NMS ordination of 44 plant species for axis 3-1 (right) and Figure 2.4. 72 quadrats clustered by 6 plant communities for axis 3-1 (left).



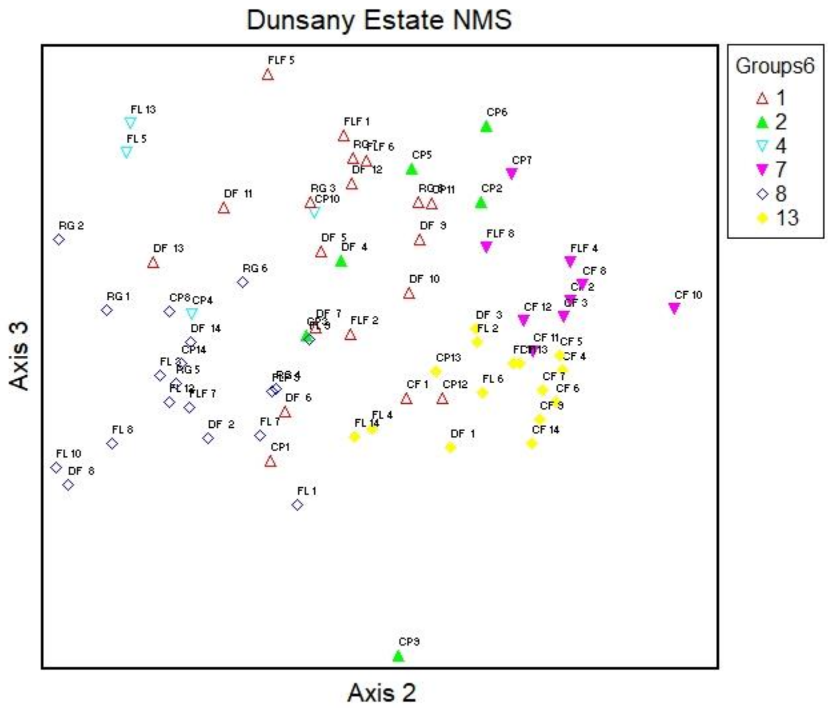


Figure 2.5 NMS ordination of 44 plant species for axis 3-2 (right) and Figure 2.6. NMS ordination of 72 quadrats clustered by 6 plant communities for axis 3-2 (left).

The NMS plots show some communities which are more distinct and more which show intergradation between the communities. The NMS figures are presented with the species (Fig 2.1, Fig 2.3 and Fig 2.5) and the quadrats (Fig 2.2, Fig 2.4, and Fig 2.6) next to each other. The cluster analysis produces a dendrogram which allows the quadrats to be grouped into clusters based on how similar they are (Fig 2.7). The dendrogram shows the distinctions between the communites. This Dendrogram has split the group here into 6 different groups refered to as red, green, light blue, dark blue, pink and yellow. In the 6 communities plotted based on the results from the dendrogram (Fig 2.7). *Holcus lanatus* is by far the most dominant species. It's is present in every one of the 6 groups. The pink group can be mostly distinguished by the presence of *Juncus effusus*, but as there is overlap the red and green group also have *J.effusus* present (Fig. 2.8). The similarities between red and green can be seen in all the axis of the NMS analysis (Fig 2.2, Fig 2.4, and Fig 2.6). However, red is the most "spread out" group when examining the NMS figures. When comparing to the two-way cluster analysis we can see that the red also has the most spread-out presence and absence chart. Dark blue has *Dactylis glomerata* present in every quadrat and the light blue has *Argentina anseria* (Fig 2.8). These communities are more distinct then the red and green as can be seen in the NMS figures. In Fig 2.2 light blue is quite separate, as is dark blue in fig. 2.2 and 2.6. The yellow group does appear distinct in the NMS analysis with some overlap with red (Fig 2.2, Fig 2.4, and Fig 2.6). It is the sparest group of the 6 (Fig 2.8).

This analysis is useful to get a general idea but when an indicator species analysis was run, none of the P values were significant (None were ≤ 0.05) (Fig 2.10).

Another way to classify vegetation communities is based on the Irish Vegetation Classification (Fig 2.9). The vegetation in Dunsany currently does not fit neatly into the classification system, as over half is transitional (less then a 50% match). The majority of the plots matched best with the GL2C community. Surprisingly, there was also communities which mapped best with a saltmarsh classification, this is probably from the heavy gley soils with poor drainage. Furthermore there were plots which didn't match with any currently identified Irish Vegetation Classification.

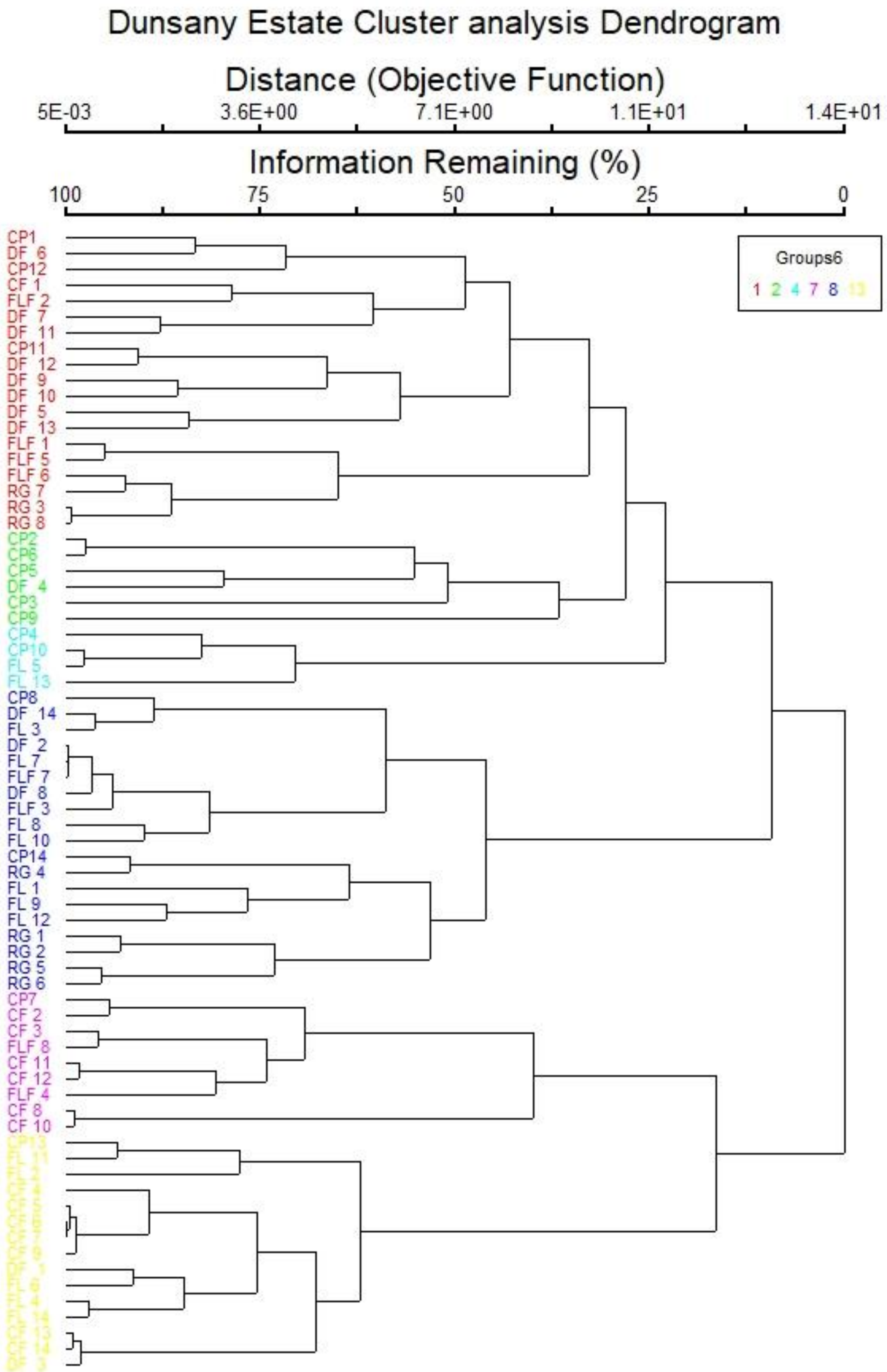


Figure 2.7. A dendrogram which has split the quadrats into 6 groups. The branching points shows the level of similarity amongst the different quadrats and groups. The information Remaining (%) line shows how alike the groups or quadrats are based on where they branch along that like.

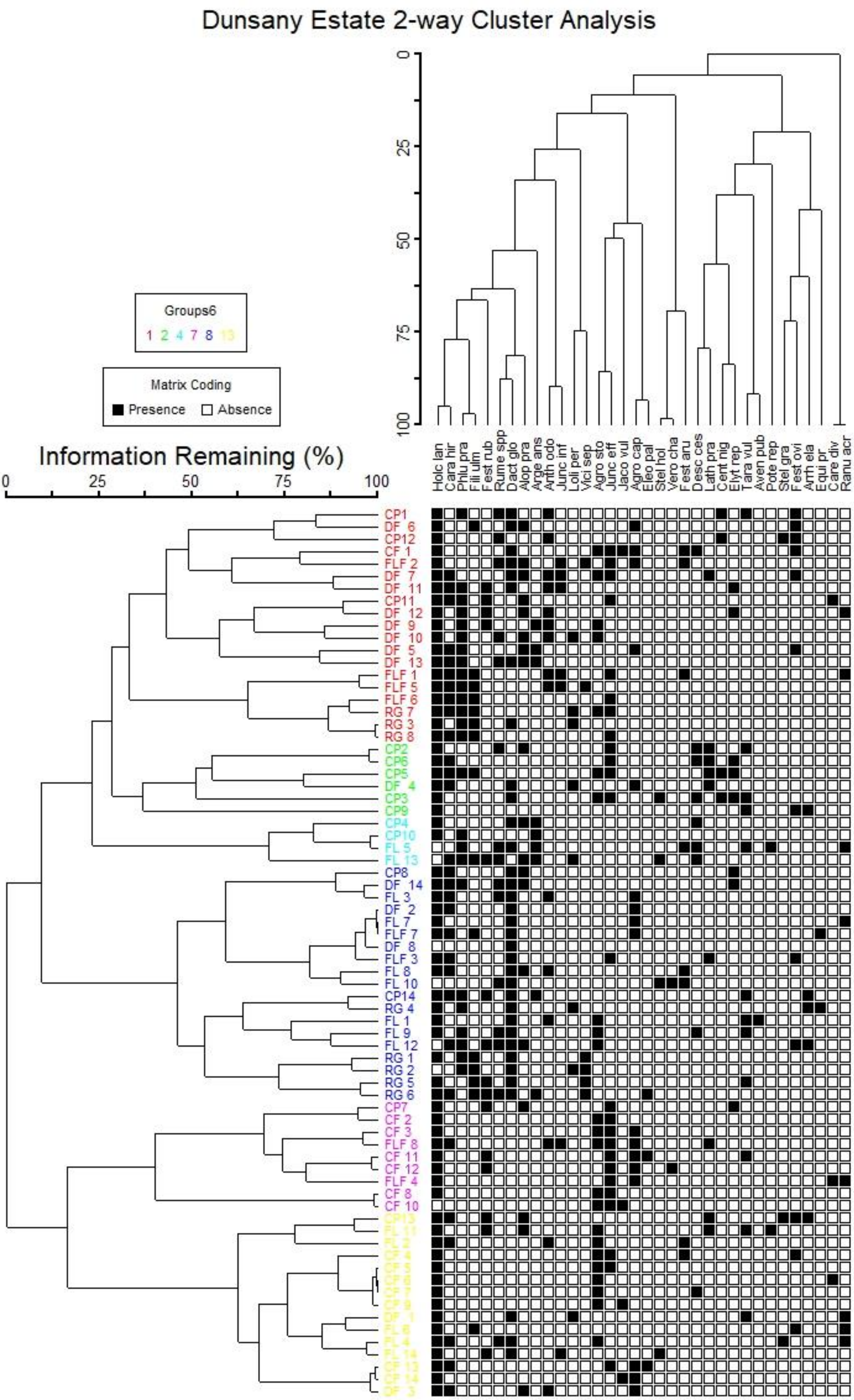

Dunsany Estate 2-way Cluster Analysis
Groups6
1 2 4 7 8 13
Matrix Coding
Presence
Absence
Information Remaining (%)
0
25
50
75
100
Holc lan
Cara hir
Philu pra
Fili ulm
Fest rub
Rume spp
Dact glo
Alop pra
Arge ans
Arth odo
Junc inf
Loli per
Vici sep
Agro sto
Junc eff
Jaco vul
Agro cap
Eleo pal
Stel hol
Vero cha
Fest aru
Desc ces
Lath pra
Cent nig
Elyt rep
Tara vul
Aven pub
Pote rep
Stel gra
Fest ovi
Arrh ela
Equi pr
Care div
Ranu acr
CP1
DF 6
CP12
CF 1
FLF 2
DF 7
DF 11
CP11
DF 12
DF 9
DF 10
DF 5
DF 13
FLF 1
FLF 5
FLF 6
RG 7
RG 3
RG 8
CP2
CP6
CP5
DF 4
CP3
CP9
CP4
CP10
FL 5
FL 13
CP8
DF 14
FL 3
DF 2
FL 7
FLF 7
DF 8
FLF 3
FL 8
FL 10
CP14
RG 4
FL 1
FL 9
FL 12
RG 1
RG 2
RG 5
RG 6
CP7
CF 2
CF 3
FLF 8
CF 11
CF 12
FLF 4
CF 8
CF 10

Figure 2.8. A two-way cluster dendrogram comparing plant species (top) against the quadrats (right). Displaying 6 plant communities. (Sørensen 1948)

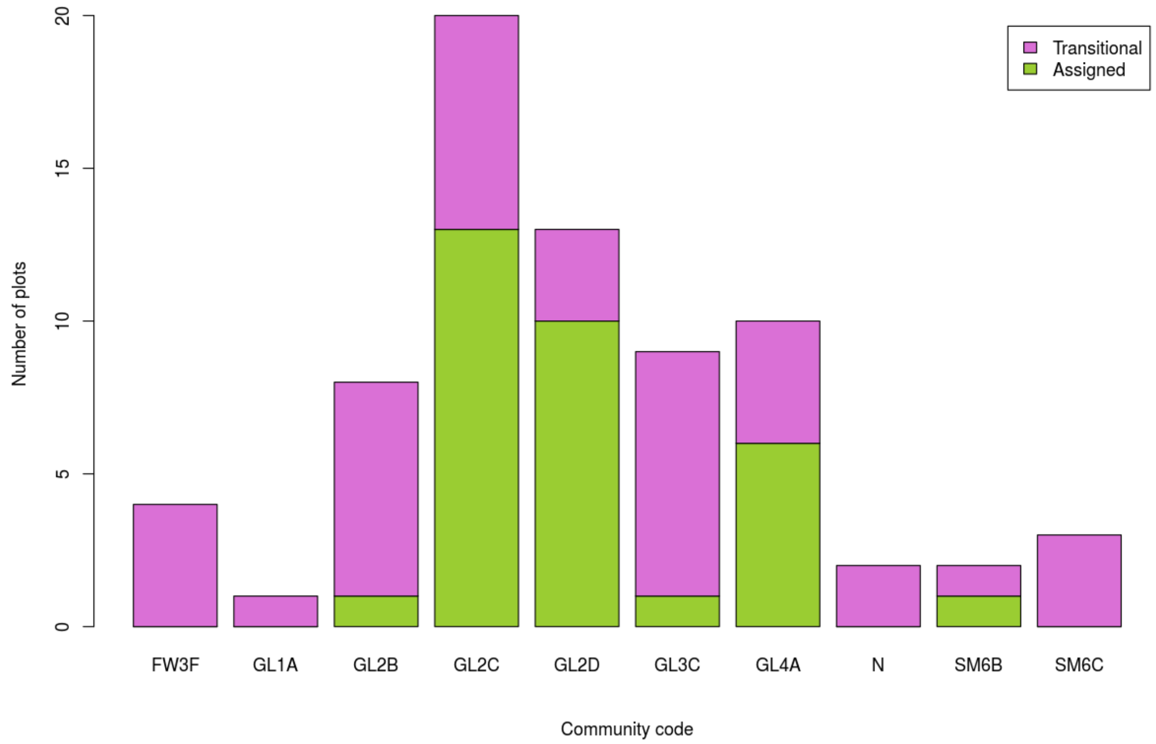


Figure 2.9. A bar graph of the communities present at Dunsany based on the Irish Vegetation Classification.

MONTE CARLO test of significance of observed maximum
indicator value for species
4999 permutations.
Random number seed: 4574

Column	Maxgrp	Observed Indicator Value (IV)	IV from randomized groups Mean	S.Dev	p *
1 Agro sto	70	24.4	17.5	8.62	0.1496
2 Phlu pra	25	13.6	16.3	6.87	0.5643
3 Fili ulm	15	20.9	16.2	8.53	0.1978
4 Rume spp	0	13.5	15.9	8.59	0.5057
5 Alop pra	5	12.9	16.6	8.33	0.5813
6 Junc eff	30	21.4	16.9	7.72	0.2162
7 Desc ces	70	8.6	18.5	11.36	0.8668
8 Anth odo	35	34.2	16.1	8.52	0.0584
9 Stel hol	55	17.8	18.5	10.87	0.4249
10 Stel gra	35	27.8	18.7	12.20	0.1730
11 Cara hir	15	14.2	15.8	5.86	0.5261
12 Cent nig	35	16.5	19.1	12.19	0.4839
13 Lath pra	45	19.3	16.9	9.49	0.3109
14 Arge ans	0	13.6	18.6	10.55	0.6215
15 Fest ovi	35	15.3	18.0	10.60	0.5109
16 Dact glo	10	16.9	16.2	5.65	0.3917
17 Arrh ela	45	21.3	18.3	12.15	0.2817
18 Care div	70	33.9	19.1	12.41	0.1256
19 Tara vul	10	10.8	17.4	9.39	0.7712
20 Fest rub	20	6.8	16.8	9.38	0.9624
21 Elyt rep	5	12.3	17.8	10.58	0.6471
22 Vero cha	30	15.9	18.9	12.22	0.5301
23 Fest aru	35	19.0	17.2	9.79	0.3177
24 Agro cap	50	20.1	16.1	8.43	0.2226
25 Eleo pal	50	18.9	18.2	10.85	0.4613
26 Jaco vul	60	14.6	18.4	10.77	0.5993
27 Ranu acr	45	13.0	18.5	11.55	0.6473
28 Junc inf	10	15.8	17.7	10.51	0.4921
29 Loli per	60	15.4	17.3	9.92	0.4459
30 Pote rep	50	32.6	19.3	13.29	0.1966
31 Aven pub	5	12.5	18.2	12.10	0.6795
32 Vici sep	0	4.5	17.4	9.94	0.9810
33 Equi pr	30	21.7	18.7	12.30	0.3579

* proportion of randomized trials with indicator value
equal to or exceeding the observed indicator value.
p = (1 + number of runs >= observed)/(1 + number of randomized runs)
Maxgrp = Group identifier for group with maximum observed IV

Figure. 2.10. Indicator Species Analysis

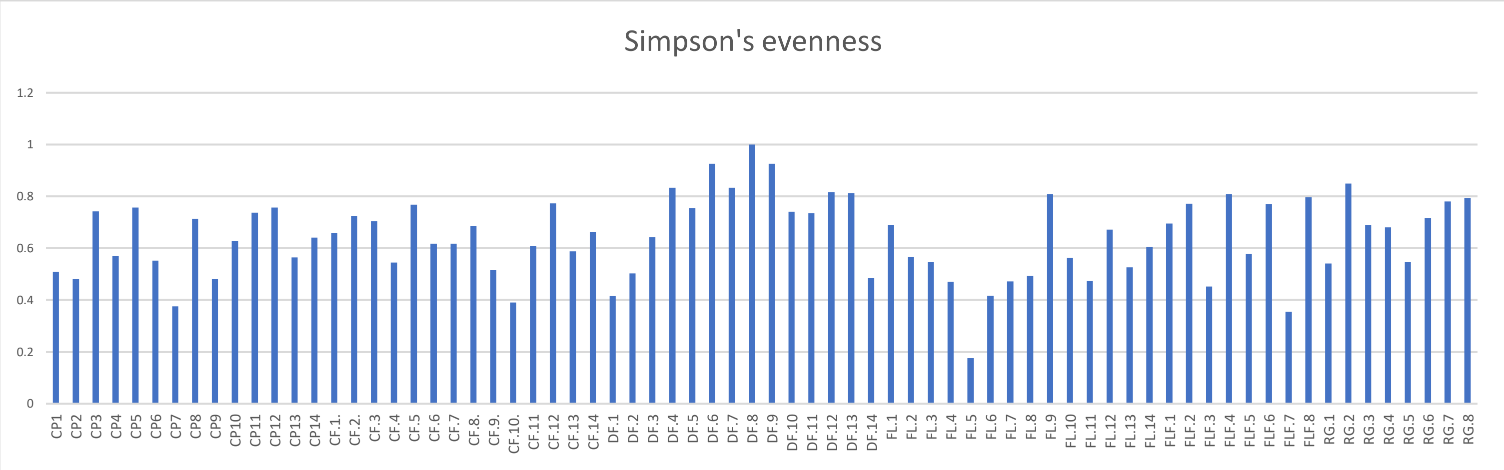


Figure 2.11 Bar chart of Simpsons evenness. The evenness value is on the left and the quadrat is along the bottom.

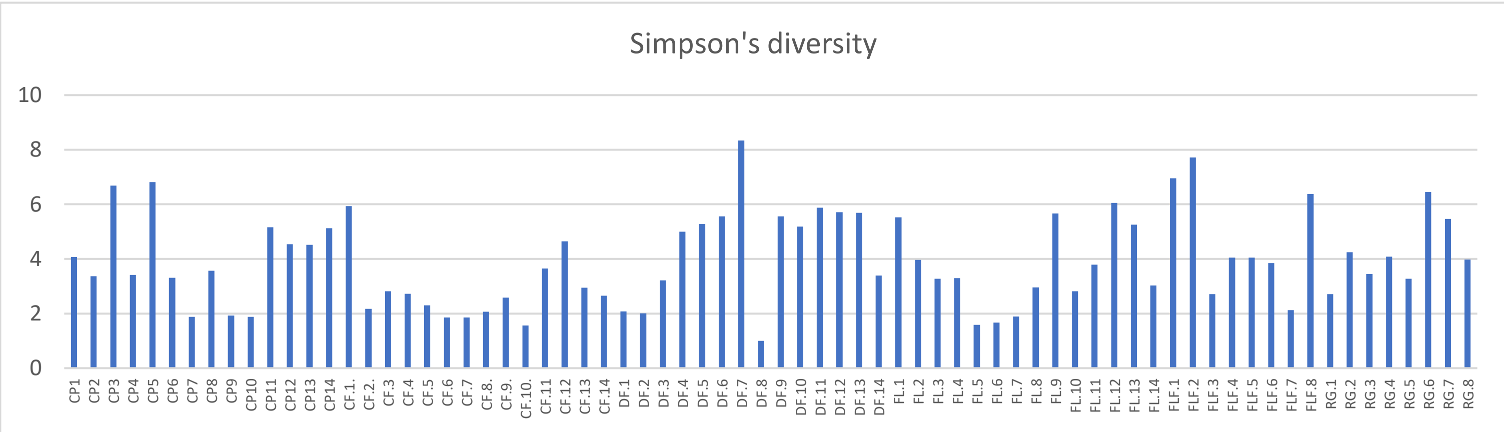


Figure 2.12. Bar chart of Simpsons diversity. The diversity value is on the left and the quadrat is along the bottom.

When looking at Figure 2.11 and 2.12 it’s noticeable the low level of diversity found in CF. The yellow group is dominated by CF plots, with some in the pink group too. This matches the rather sparse values seen in Fig 2.8.

Line transects

The random line transects had the surprising result where only the crop field had any tree seedlings/saplings found within the line transect. Some tree growth was seen in the other fields, notably there was a tree with growth of over 1.5m just outside of the line transect in the front lawn flooded.

Crop Field line transects	**Occurance**	**Density (occurrence/m²)**
Rubus fruiticous	15	0.075
Betula pendula <50cm	3	0.015
Betula pendula 50 – 100cm	5	0.025
Salix aurita hybrid <50cm	1	0.005
Salix aurita hybrid 50 – 100cm	4	0.02
Salix aurita less then 50cm	2	0.01
Salix cinerea ssp. atrocinerea <50cm	1	0.005
Salix cinerea ssp. atrocinerea 50-100cm	2	0.01
Salix atrocinertea <50cm	1	0.005
Salix atrocinertea 50-100cm	5	0.025
Salix atrocinertea 100-150cm	1	0.005
Betula pubescens 50-100cm	8	0.04
Betula pubescens <50cm	13	0.065
Salix caprea <50cm	1	0.005
Total (excluding Rubus)	47	0.235

Table 2.1 Frequency and density table of tree encroachment in Crop field (GPS 53.539262,-6.621771 to 53.538892,-6.623162)

Salix was the most frequently occurring sapling in the crop field. The only trees present were in the genus Salix or Betula.

Poplar sampling

While the randomly placed line transects of Durhams field had no growth, there was a dense colony of *Populas alba* shoots. The line transects were placed deliberately and non-randomly to sample this colony.

Populus line transects	**Occurance**	**Density (Occurance/m^2)**
Populus alba <50cm	8	0.071
Populus alba 50-100cm	14	0.125
Populus alba 100-150cm	9	0.08
Populus alba >150 m	2	0.018
Populus alba damaged <50cm	3	0.027
Populus alba damaged 50-100cm	2	0.018
Populus alba damaged 100-150cm	2	0.018
Total	**40**	**0.357**

Table 2.2. Non-random frequency and density table of *P.alba* taken in Durhams Field. (GPS 53.535205,-6.624994 to 53.535194,-6.625846 and GPS 53.535395,-6.626052 to 53.534933,-6.625776).

The Populus have a density of 0.357 trees per m^2. 0.122 more trees per m^2 then the CF. There was no damage found on the tree species in the CF, while 17.5% of the trees in DF had damage.

Discussion

Quadrats

The NMS results show some level of separation but also a high amount of overlap. With this level of intergradation, it is harder to logically define the communities present. This is somewhat expected as the sites surveyed were all closely linked fields. Throughout all the groups *Holcus lanatus* is by far the most common species. Some of the communities are quite different for example light blue and pink are quite distinct from each other, whereas red and green seem to have a lot more overlap.

The National Biodiversity Data Centre has classified the grasslands of Ireland into various communities. The vegetation communities found on Dunsany estate includes FW3F (*Filipendula ulmaria – Phragmites australis* tall-herb swamp), GL1A (*Juncus acutiflorus – Holcus lanatus* grassland), GL2B (*Juncus effusus – Holcus lanatus* grassland), GL2C (*Holcus lanatus – Lolium perenne* grassland), GL2D (*Juncus effusus – Rumex acetosa* grassland), GL3C *(Festuca rubra – Plantago lanceolata* grassland), GL4A (*Agrostis capillaris – Trifolium repens* grassland), N (no community), SM6B (*Agrostis stolonifera – Triglochin maritimum* saltmarsh) and SM6C *grostis stolonifera – Potentilla anserina* saltmarsh). These are mostly of poor conservation value, with the exception of FW3F and GL3C. FW3F is considered to be species rich compared to other swamp types. GL3C is a community with a medium to high species richness and can have importance for pollinators.

The majority of the plots were not firmly in a classified Irish Vegetation community. There were 38 plots determined to be transitional whereas there were 34 that were assigned into a distinct vegetation group. The largest of the groups was GL2C.

The grassland surveying took place between the 13th of the 8th 2020 and 2nd of the 10th 2020 this is outside of the growing season for many grass species, and it should be acknowledged that if the surveying was to take place earlier in the season the overall results could have been slightly different.

Line transects

From the line transects it would appear that succession was largely not occurring with the exception of crop field. The crop field had a high presence of *Rubus fruticosus* and 47 trees found*.* Not a single other field had an occurrence within the randomly surveyed boundary. The reason for this is unclear. It should be noted that boundary of the crop field was the most exposed to the road. This may have worked as a deterrent to the *C. elaphus* present on the estate. This site also was the only one with the presence of *R.fruticosus* within the surveyed area. Crop field also had plants that show disturbance (e.g. *Chamaenerion angustifolium*). The zero values for other five fields demonstrate that there is currently no tree encroachment.

Poplar sampling

In the non-random sampling of the *P.alba* shoots in Durhams field also showed a dense growth rate. However, there was a notable amount that were significantly damage by deer (17.5%). Compare this to the crop field where there was no breakage found. It's noteworthy that the field which had no damage by deer and had no eyewitness account of deer was the only field to show succession with the presence of shrub and tree encroachment. Will the dense shoots of *P.alba* outnumber the deer and allow succession in DF?

CF also had some of the lowest biodiversity rates, along with FLF. These seem to be places the deer avoided. The lack of grazing pressure could be reducing the biodiversity.

Rewilding goals

The future of the semi-natural grasslands in Dunsany could take several directions. At this current point it is generally of low conservation value. It could be left completely alone and be allowed to passively rewild. The outcome of this is uncertain, especially due to lack of shrub land and tree encroachment currently found on the land. This is the cheapest and easiest option.

If a more active management role is taken to increase biodiversity and the conservation value of the semi-natural grassland, there are several options. Ecologically desirable and adapted species could be deliberately introduced (Pywell et al. 2002a). There is a difficulty in this as there are dominant species in grasslands that block out germination areas, and they out-compete for space and resources (Bullock 2000, Bullock 1996). As a solution to this *Rhinanthus minor,* a hemiparasitic plant could be sown. This would have the result of causing a decrease in productivity and biomass which allows the local species richness to increase (Pywell et al. 2004). Aiming to reduce competition by reducing the soil fertility has had limited success when compared to the introduction of *R.minor* (Marrs *et al.* 1998; Pywell *et al.* 2002a). This treatment could be combined with a later sowing of desirable species, which was found to have very beneficial effect on the grassland structure and the survival of introduced species (Pywell et al. 2004). This is more expensive and labour intensive then passive rewilding.

It is generally thought that after many years of agricultural use. There needs to be some human assistance to restore to a highly biodiverse level.

Future Work

It would be interesting for future work to be carried out on the grassland of Dunsany. Changes in the vegetation communities could be tracked as well as monitoring to assess the succession (if there is any) of the area. The experiment could be replicated in the same area at the same time of year to establish a baseline to monitor the restoration and re-wilding management. There is the possibility of grasslands “grading up” from their current conservation value. For the further work, it would be ideal to track the plots surveyed using a GPS system.

Bird surveying could also yield valuable insights. For instance, *Garrulus glandarius* has a symbiotic relationship with *Quercus* spp (Bossema 1979). As *G.glandarius* enhances the reproductive success of *Quercus* through dispersing of acorns and the acorns in turn increase the *G.glandarius* odds of survival in the winter food scarcities.

References

Austin, M. (1999). The Potential Contribution of Vegetation Ecology to Biodiversity Research. Ecography, 22(5), 465-484. Retrieved August 12, 2021, from http://www.jstor.org/stable/3683139

Belanger et al (2003) https://acsess.onlinelibrary.wiley.com/doi/epdf/10.2135/cropsci2003.2400

Benjamin, K., Domon, G. and Bouchard, A. (2005) Vegetation Composition and Succession of Abandoned Farmland: Effects of Ecological, Historical and Spatial Factors. Landscape Ecol 20, 627–647. https://doi.org/10.1007/s10980-005-0068-2

Bossema, I. (1979). Jays and oaks: an eco-ethological study of a symbiosis. Behaviour, 70(1-2), 1-116.

Broughton RK, Bullock JM, George C, Hill RA, Hinsley SA, Maziarz M, et al. (2021) Long-term woodland restoration on lowland farmland through passive rewilding. PLoS ONE 16(6): e0252466. https://doi.org/10.1371/journal.pone.0252466

Burke, M.J.W. and Grime, P.J. (1996) An experimental study of plant community invisibility. Ecology, 77, 776–790.

Bullock J.M (1996) The Ecology and Management of Grazing SystemsThe Ecology and Management of Grazing Systems, 69-100, 1996

Bullock, J.M. (2000) Gaps and seedling colonization. Seeds: The Ecology of Regeneration in Plant Communities, 2nd edn (ed. M. Fenner), pp. 375–395 . CAB International, Wallingford, UK.

Chytrý, M., Schaminée, J.H.J., Schwabe, A. 2011. Vegetation survey: a new focus for Applied Vegetation Science Applied Vegetation ScienceVolume 14, Issue 4 p. 435-439.

Clements, F.E. 1905. Research methods in ecology. University Publishing Company, Lincoln, NE, US.

Corlett, R. T. (2016). Restoration, reintroduction, and rewilding in a changing world. Trends in ecology and evolution, 31(6), 453-462.

Coulloudon, B., Podborny. P., (1999) Sampling Vegetation Attributes. U.S. Department of Agriculture: Natural Resource Cobservation Service Grazing Land Technology Institute https://extension.arizona.edu/sites/extension.arizona.edu/files/attachment/InteragencyTechGuideSampleVeg_0.pdf

Cramer V.A and Hobbs R.J, Editors, Old Fields. Dynamics and Restoration of Abandoned Farmland (2009) Basic and Applied Ecology 10(6):579 DOI:10.1016/j.baae.2009.01.003

Cross, J. R. (2006). The potential natural vegetation of Ireland. In Biology and Environment: Proceedings of the Royal Irish Academy (pp. 65-116). Royal Irish Academy.

https://www.cso.ie/en/releasesandpublications/ep/p-eii/environmentalindicatorsireland2020/landuse/ (Accessed 9th March 2021)

European Commission, Environment Directorate-General, 2008. Life and Europe's grasslands: restoring a forgotten habitat. http://www.wri.org/publication/content/8272.

Finch, T.F., Gardiner, M.J., Comey, A., and Radford, T., (1983) National Soil Survey of Ireland. Soil Survey Bulletin No. 37. An Foras Taluntais, 19 Sandymount Avenue, Dublin 4V

Gebert C and Verheyden-Tixier H (2008) Variations of diet composition of Red Deer (Cervus elaphus L.) in Europe Mammal Review Volume 31, Issue 3-4 p. 189-201

Google maps (2020 – 2021) Google Maps Android Version 10.49.2 (August 29th, 2020) Mountain View, CA: Google Inc

Gough M.W., Marrs, R.H A comparison of soil fertility between semi-natural and agricultural plant communities: Implications for the creations of species-rich grassland on abondoned agricultural land Biological Conservation Volume 51, Issue 2, 1990, Pages 83-96

Hubbard, C.E., (1984) Grasses. Penguin Books, Middlesex, England, (476)

Isbell, F., Tilman, D., Reich, P. B., and Clark, A. T. (2019). Deficits of biodiversity and productivity linger a century after agricultural abandonment. Nature Ecology and Evolution, 3(11), 1533–1538. doi:10.1038/s41559-019-1012-1

Jepson, P., Schepers, F., (2016) Making Space for Rewilding: Creating an enabling policy environment https://doi.org/10.13140/RG.2.1.1783.1287

Keever, C., (1950) Causes of Succession on Old Fields of the Piedmont, North Carolina. Ecological Monographs 20:229–250.

Kent, M. (2012) Vegetation Description and Data Analysis. Wiley-Blackwell New York (428)

Long, M. (2011). Plant and snail communities in three habitat types in a limestone landscape in the west of Ireland, and the effects of exclusion of large grazing animals. Unpublished PhD Thesis, Trinity College, University of Dublin

Marrs, R. H., Snow, C. S. R., Owen, K. M., and Evans, C. E. (1998). Heathland and acid grassland creation on arable soils at Minsmere: identification of potential problems and a test of cropping to impoverish soils. Biological Conservation, 85(1-2), 69-82.

Matin, S., Sullivan, C.A., hUallacháin, D.Ó., Meredith D., Moran, J., Finn, J.A., and Green, S. (2016) Predicted distribution of High Nature Value farmland in the Republic of Ireland, Journal of Maps, 12:sup1, 373-376, DOI: 10.1080/17445647.2016.1223761

McCune, B., and Mefford, M. J.,2006. PC-ORD: Multivariate analysis of ecological data, Version 5. Gleneden Beach, OR: MjM Software. McDowall, R. M. 2002.

McGrath and Zhang (2003) Spatial distribution of soil organic carbon concentrations in grassland of Ireland Applied Geochemistry 18(10):1629-1639 DOI: 10.1016/S0883-2927(03)00045-3

Meikle, R.D., (1984) Willows and poplars. Botanical Society of the British Isles, Cromwell Road, London (198)

Meli, P., Holl, K. D., Rey Benayas, J. M., Jones, H. P., Jones, P. C., Montoya, D., and Moreno Mateos, D. (2017). A global review of past land use, climate, and active vs. passive restoration effects on forest recovery. Plos one, 12(2), e0171368.

Mitchell, F. J. G. 2005 How open were European primeval forests? Hypothesis testing using palaeoecological data. Journal of Ecology 93, 168-77.

Mitchell, F.J.G. (in press) Trees vs. grazers: who wins? The palaeoecological perspective. In: The nature of the first forests in NW Europe. Ed M. Stewart. Proceedings of the Scottish Woodland History Conference, The Native Woodlands Discussion Group, Perth.

Mortimer, S.R., Turner, A.J., Brown, V.K., Fuller, R.J., Good, J.E.G., Bell, S.A., Stevens, P.A., Norris, D., Bayfield, N. and Ward, L.K. 2000. The nature conservation value of scrub in Britain, August 2000, JNCC Report No. 308, JNCC, Peterborough, ISSN 0963-8091.

O'Connell, M., Mitchell, F.J.G., Readman, P.W., Doherty, T.J. and Murray, D.A., Palaeoecological investigations towards the reconstruction of the post-glacial environment at Lough Doo, County Mayo, Ireland, Journal of Quaternary Science, 2, 1987, p149 – 164

O'Neill, F.H., Martin, J.R., Devaney, F.M. and Perrin, P.M. (2013) The Irish semi-natural grasslands survey 2007-2012. Irish Wildlife Manuals, No. 78. National Parks and Wildlife Service, Department of Arts, Heritage and the Gaeltacht, Ireland.

Parnell, J. Curtis, T. and Cullen, E. (2012). Webb's An Irish Flora. Cork University Press. Cork (560)

Perrin, P.M., Barron, S.J., and O'Hanrahan, B. (2014). Guidelines for a national survey and conservation assessment of upland vegetation and habitats in Ireland. Version 2.0. Irish wildlife Manuals, No. 79 National Parks and Wildlife Service; Department of Arts. Heritage and the Gaeltacht, Dublin, Ireland.

Pywell R.F., Bullock J.M., Tallowin J.B., Walker K.J., Warman., E.A and Master., G 2007 Enhancing diversity of species-poor grasslands: anexperimental assessment of multiple constraints Ecological Society, Journal of Applied Ecology, 44, 81–94

Pywell, R.F., Bullock, J.M., Hopkins, A., Walker,K.J., Coulson, S.J Gregory, M.S (2004) Facilitating grassland diversification using the hemiparasitic plant Rhinanthus minor Journal of Applied Ecology Volume 41, Issue 5 p. 880-887

Pywell, R.F., Bullock, J.M., Hopkins, A., Walker, K.J., Sparks, T.H., Burke, M.J.W. and Peel, S. (2002a) Restoration of species-rich grassland on arable land: assessing the limiting processes using a multi-site experiment. Journal of Applied Ecology, 39, 294–310.

https://rewildingeurope.com/rew-project/dunsany-nature-reserve/_(Accessed 26th February 2021)

Reynolds, S.G., and Frame, J. editors (2005) Grasslands; developments, opportunities, perspectives. Food and Agricultural Organization and Science Publishers, Rome, Italy and Plymouth UK

Riesch F, Tonn B, Stroh H.G, Meißner M, Balkenhol N, Isselstein J. (2020) Grazing by wild red deer maintains characteristic vegetation of semi-natural open habitats: Evidence from a three-year exclusion experiment. Appl Veg Sci. 2020;23:522–538. https://doi.org/10.1111/avsc.12505

Roberts, N., Fyfe, R. M., Woodbridge, J., Gaillard, M. J., Davis, B. A. S., Kaplan, J. O., Marquer, L., Mazier, F., Nielsen, A. B., Sugita, S., Trondman, A. K. and Leydet, M. 2018 Europe's lost forests: a pollen-based synthesis for the last 11,000 years. Scientific Reports 8.

Riesch F, Tonn B, Stroh H.G, Meißner M, Balkenhol N, Isselstein J. 2020 Grazing by wild red deer maintains characteristic vegetation of semi-natural open habitats: Evidence from a three-year exclusion experiment. Appl Veg Sci. 2020;23:522–538. https://doi.org/10.1111/avsc.12505

Roukos, C., Chatzitheodoridis, F., Koutsoukis, C., and Sotiris, K. (2012). Dry Grasslands Management in Greece. Crucial Points and Proposals for a New Sustainable Policy: A Case Study of Epirus.

Reynolds, S.G., and Frame, J. editors (2005) Grasslands; developments, opportunities, perspectives. Food and Agricultural Organization and Science Publishers, Rome, Italy and Plymouth UK

Schröter, C. and Kirchner, O. 18861902. Die Vegetation des Bodensees. Stettner, Lindau, DE.

Smith, D., Hill, G. and Kenward, H. 2018 The development of late-Holocene farmed landscapes: Analysis of insect assemblages using a multi-period dataset. The Holocene in press, DOI: 10.1177/0959683618804645.

Sørenson, T., 1948. A method of establishing groups of equal amplitude in plant sociology based on similarity of species content, and its application to analysis of the vegetation on Danish commons. Kongelige Danske Videnskabernes Selskab, 5(1-34), 4-7.

Stoate, C and Báldi, A and Beja, P and Boatman, N and Herzon, I and Doorn, A and Snoo, G R. and Rakosy, L and Ramwell, C. (2009). Ecological Impacts of Early 21st Century Agricultural Change in Europe—A Review. Journal of environmental management. 91. 22-46. 10.1016/j.jenvman.2009.07.005.

Synge F.M (1951) The Glacial Deposits around Trim, Co. Meath Proceedings of the Royal Irish Academy. Section B: Biological, Geological, and Chemical Science Vol. 53 (1950/1951), pp. 99-110 (19 pages)

Tansley, A.G. 1920: The classification of vegetation and concept of development . Journal of Ecology 8, 118—49.

Vera, F.W.M. (2000) Grazing Ecology and Forest History. CABI, Wallingford.

Walker, K.J., Stevens, P.A., Stevens, D.P., Mountford, J.O., Manchester, S.J. and Pywell, R.F. (in press) The restoration and recreation of species-rich lowland grassland on land formerly managed for intensive agriculture in the UK. Biological Conservation, 119, 1– 18.

Walsh 2020 https://www.irishtimes.com/news/environment/how-the-baron-of-dunsany-carried-out-an-ambitious-rewilding-project-in-meath-1.4443054 (accessed 1st January 2021)

Warming, E. 1895. Plantesamfund – Grundtræk af den økologiske plantegeografi. P.G. Philipsens, København, DK.

Whitehouse, N. J. and Smith, D. 2010 How fragmented was the British Holocene wildwood? Perspectives on the "Vera" grazing debate from the fossil beetle record. Quaternary Science Reviews 29, 539-53.

Yeakley J.A, David E, Heejun C, Elise F. G, Dujon, V. Vivek S and Brown D. (2016) Ecosystem services of streams and rivers (book)

Zanon, M., Davis, B. A. S., Marquer, L., Brewer, S. and Kaplan, J. O. 2018 European Forest Cover During the Past 12,000 Years: A Palynological Reconstruction Based on Modern Analogs and Remote Sensing. Frontiers in Plant Science 9.