Hedgerow typology and condition analysis to inform greenway design in rural landscapes

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2 authors:

Julien Carlier
Galway-Mayo Institute of Technology

James Moran
Atlantic Technological University

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Authors names and affiliations: Julien CARLIER[a], James MORAN[a,b]

[a]*Institute of Technology Sligo, Sligo, County Sligo, Ireland;*

[b]*Galway-Mayo Institute of Technology, Old Dublin Rd, Galway, Ireland.*

Corresponding Author: Julien Carlier [julien_carlier18@hotmail.com]

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1 Abstract

Over the past decades, Western European hedgerows have been declining as a result of land use change. Disused infrastructure corridors such as railways and tramways can host a range of existing and returning semi-natural habitats, including extensive hedgerow networks. However, long term corridor abandonment can result in network deterioration to gappy hedgerows, lines of trees and eventually individual scrub features. The loss of hedgerows results in the loss of many ecosystem services, habitat for species and landscape connectivity. This highlights an increasing need to find innovative solutions to recognise and appropriately maintain these hedgerow networks. European Greenways typically 'upcycle' disused infrastructure transport corridors for multi- use, non- motorised recreational public infrastructure. The potential for European greenways to maintain and restore hedgerows is of interest as a novel planning mechanism for enhancing green infrastructure in general. The aim of this study is to inform Greenway design and management through the evaluation of hedgerow significance (historical, ecological and landscape), condition and composition within a rural European Greenway landscape context. 81 hedgerows were sampled along a 70 kilometre proposed Greenway route traversing a range of extensive and intensive landscapes. Hedgerows were surveyed using a rapid field score sheet which enabled significance and condition scoring. A hedgerow typology was subsequently developed based on species composition assemblages. Hedgerows were found to be highly ecologically significant and species rich throughout the route. On-going land use intensification was evident as significant sections of the former railway corridor were subsumed into intensive agriculture and afforestation. Management recommendations need to be adapted to the particular hedgerow group and surrounding landscape context, and take into account the varied requirements of different taxonomic groups. The study findings show Greenways have the potential to act as multi-functional green infrastructure (accomplishing both ecological and recreational objectives) through informed design to reinforce their nature conservation role and recognising hedgerows as integral landscape feature of Greenway corridor, at local level and as part of a wider European network.

Keywords: Hedgerow, Greenway, Agri- environment, Management, Connectivity, Land Use Change.

2 Introduction

Hedgerows in Western Europe have evolved over centuries, originating as residuals of natural woodlands shaped through traditional rural landscape management or established in response to an increasing need for enclosure of land into private parcels. Hedgerows have historically been and in some instances are still associated with the provision of services such as production of wood and drainage of land (Burel and Baudry, 1995). The onset of changing land use and intensive management practices has consequently changed the need and purpose of hedgerows, and although considered highly valuable ecologically and culturally (Burel *et al.*, 1998; Baudry *et al.*, 2000(a)), hedgerow networks are threatened by abandonment and removal (Burel *et al.*, 1998). Hedgerows are generally protected by national legislations, the EU Habitats (1992) and Birds (1979) Directives, agri- environmental schemes and good farming practice (EC Council Regulation 2078/1992 and 1257/1999), however this does not guarantee them protection from inappropriate management or removal (Foulkes *et al.*, 2013).

Many ecosystem services are provided both directly and indirectly by hedgerows; control of soil erosion, windbreak, habitat, fuel; (Burel and Baudry, 1994), nutrient buffering (Benhamou *et al.*, 2013) and pollination (Morandin and Kremen, 2013). Hedgerows play an important role providing species habitat, transit and survival within the wider landscape (Burel, 1992; Burel and Baudry 1994, 1995; Bennet, 1999; Foulkes *et al.*, 2013). The ability of hedgerows to sustain woodland species diversity has been noted to increase with time and connectivity to adjacent woodland and also other hedgerow networks (Roy and de Blois, 2006; Wehling and Diekmann, 2009; Bani *et al.*, 2018). Within predominant agricultural landscape with little forest habitat, hedgerows play an important function as potential dispersal corridors for many of the forest plant species (Wehling and Diekmann, 2009).

Hedgerows can represent not only ecological corridors, but also suitable habitats for multiple small mammals (Gelling *et al.*, 2007), arboreal rodents (Wolton, 2009; Hernández, 2014; Dondina *et al.*, 2018(b)) mustelids (Šálek *et al.*, 2009; Červinka *et al.*, 2013), bats (Boughy *et al.*, 2011) and badgers (O'Brien *et al.*, 2016). Studies examining badger habitat found most setts to be located within proximity to hedgerows and treelines, while avoiding areas of land-use intensification (Smal, 1995; Lara-Romero, 2012; Chiatante, 2017; Dondina *et al.*, 2018 (a)) and similarly hedgerows can serve as preferred foraging and orientation corridor habitat for bats (Verboom and Huitema, 1997; Downs and Racey, 2006; Zeale *et al.*, 2012; Haceková *et al.*, 2014). Several studies found hedgerows within agricultural landscapes as attractive habitats for native bees and butterflies, owing to their diversity of ground and shrub flora (Hannon and Sisk, 2009; Luppi *et al.*, 2018) and can act as a net exporter of the species to adjacent land (Morandin and Kremen, 2013). Some studies conducted in European countries showed the importance of hedgerows, lines of trees, and residual vegetation of agro ecosystems providing habitat for many bird species, and halting the loss of these should become conservation prioritiy (Mortelliti *et al.*, 2010; Morelli, 2013; Dondina *et al.*, 2017). Many woodland bird species find habitat, sources of foraging and various degrees of connectivity within the wider landscape associated with hedgerows (Davies and Pullin, 2007), but they can also have negative effects for species requiring open farmland (Hinsley and Bellamy 2000) and therefor measures for optimizing a hedgerow- grassland balance should be considered at a landscape scale (Besnard and Secondi 2014).

With the extensive and crucial roles hedgerows play within the wider countryside and yet the current trend of loss, there remains an increasing need to find solutions for the appropriate conservation of ecologically significant hedgerow networks. The conservation of hedgerows requires management based on an appraisal of the existing condition, interpreting the information obtained and informed actions (Faiers and Bailey, 2005; Foulkes *et al.*, 2013). Hedgerows that are well-structured and in good condition will host higher amounts of associated ground flora, invertebrates and bird species (Pollard *et al.*, 1974; Merckx *et al.*, 2012; Graham *et al.*, 2018).

Surveying hedgerows provides baseline information that can help inform management and conservation decisions, and focus actions towards notably important hedgerows (Defra, 2007; Foulkes *et al.*, 2013). Several hedgerow condition and significance scoring systems are available to the British Isles, notably Hedgerow Evaluation and Grading System (HEGS) (Clements and Tofts, 1992), The Hedgerow Survey Handbook (Defra, 2007), A Hedgerow Survey Methodology for Ireland (Foulkes and Murray, 2006) and Hedgerow Appraisal System (Foulkes *et al.*, 2013).

Vegetation edges along infrastructures such as railways, roads and canals can be considered as hedgerows that form important habitat and very long corridors for biodiversity (Faiers and Bailey, 2005; Morelli *et al.*, 2014; Vandevelde *et al.*, 2014). Studies on rural trackways bounded either side with hedges found significantly higher pollinator abundance when compared to surrounding field margins (Croxton *et al.*, 2002; 2005). In Europe, Greenways typically re-design disused transport routes such as railways, canal towpaths and low traffic routes into multi- use public recreational infrastructure (European Greenways Association, 1998; Toccolini *et al.*, 2006). Such disused infrastructure corridors can host a range of existing and returning semi-natural habitats, including extensive hedgerow networks. There is therefor potential for European Greenways to be innovatively designed to provide multiple synergistic conservation and recreational benefits, providing a solution towards maintain well-managed, ecologically significant hedgerows and their associated ecosystem services. In this study, hedgerow significance and condition are examined through field studies along a disused Irish railway corridor using a field scoring system. Furthermore, hedgerow species composition is examined using multivariate analysis resulting in a typology of distinct species groups for the first time. The aims of the study are to inform Greenway design through i) the evaluation of Greenway route hedgerow characteristics through field surveys using a hedgerow condition and significance scoring system and ii) the classification of hedgerow types based on species composition groups that exist along the route to inform further replanting actions. The resulting data is further examined within the context of available landscape and ecological connectivity data to take account of the surrounding Greenway landscape matrix and woodland ecosystem connectivity. The evaluation of the importance and composition of an existing hedgerow network within the context of a pre-developed Greenway can enable an informed approach towards maintaining and enhancing them in a multifunctional biodiverse and recreational corridor.

3 Methods

The main steps taken in this study involved surveying hedgerows along a proposed Greenway route using an adapted field survey sheet and scoring system to evaluate the ecological significance and condition of the Greenway hedgerow network. Hedgerow species data was then ordinated in a multivariate classification to develop a typology of main species group assemblages. Hedgerow significance, condition and types were examined within the context of landscape ecosystem structural connectivity to evaluate and inform targeted management of the Greenway hedgerow network (Fig. 1.).

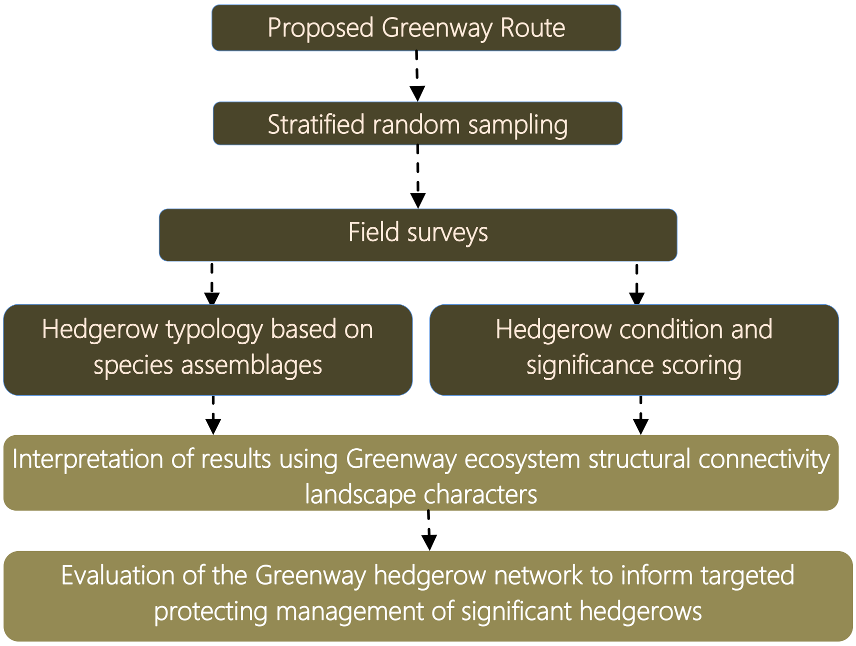

Fig. 1. Schematic outline of the main steps taken to evaluate Greenway hedgerows

3.1 Greenway study area

A 70 km^2 study area follows a former railway that is currently a proposed Greenway in the North West of Ireland (Atlantic European Biogeographical Region). The study area is 70 km long by 1 km wide (500 m either side of the route) and is cross-border, covering four counties: Sligo, Leitrim, Cavan (Republic of Ireland) and Fermanagh (United Kingdom) (see Fig. 2). The study area lies predominantly in lowland settings (22 m to 200 m above sea level). The distinctive landscape is a mix of improved agricultural grasslands, undulating drumlin farmlands of predominantly rushy pastures and wet grasslands enclosed by hedgerows and treelines typical of High Nature Value farmland landscapes (Sullivan *et al.*, 2017) and similar to 'Bocages' style landscapes in England and France (Baudry *et al.*, 2000(b)). Small pockets of semi- natural woodlands (principally wet- willow alder ash woodland) and mixed broadleaf woodlands (mean patch size 0.005 km^2) are found throughout the study area (Carlier and Moran, 2018). Further spatial arrangement information of woodland ecosystems in this region is discussed in Carlier and Moran (2019). Annual average precipitation in the region varies from 1200 to 2000mm and annual average temperature is 10 °C (1981 to 2010 mean) (Walsh, 2012). The underlying geology is mainly of limestone, shale and sandstone formations (Geological Survey of Ireland, 2004).

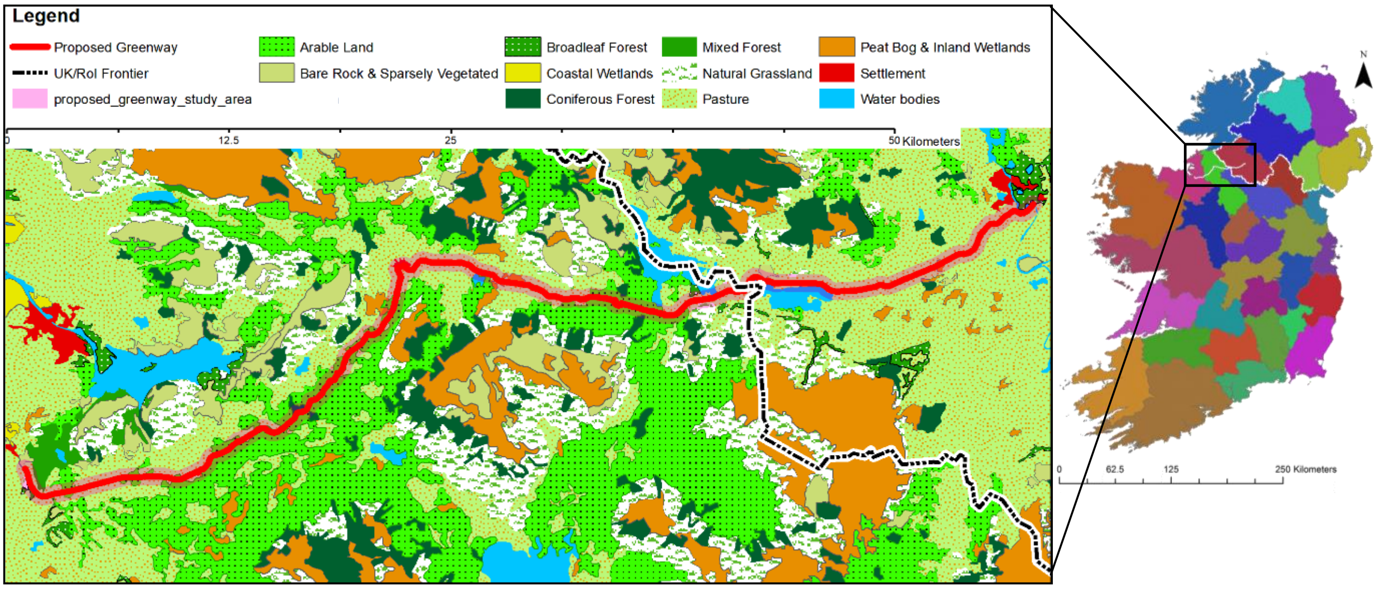

Fig. 2. Study Area location and overlay of surrounding Corine Land Cover (2012) in the Republic of Ireland and Northern Ireland (United Kingdom).

3.2 Sampling strategy

Hedgerow sampling was carried out within 35 stratified random sampling sites (320 m diameter) along the proposed Greenway route. This provided a 5% representation of the overall study area, centred on the infrastructure route to keep the hedgerow sampling within immediate vicinity of greenway. Stratification was performed using an overlay of three national Landscape Types (Valleys and Lowlands; Lakelands; Uplands) for the region (Gelogical Survey of Ireland, 2004) and a representative number of sites randomly selected within each Landscape Type using ArcGIS. Hedgerows within the 320 m diameter sample site perimeter that bounded either side of the railway corridor and stemmed off the railway corridor into the surrounding landscape (see Fig. 3) were selected for surveying. Hedgerows starting within a sample site and extending outside the site perimeter were sampled in their entirety until an end point was reached. Start and end-points of hedgerows were determined as recommended by Foulkes *et al.*, (2013): *Field corners; Nodal intersection with another hedgerow or boundary feature; Hedgerow gaps greater than 20 m.*

Fig. 3. Example areal image of a typical sampling site(white) illustrating mapped hedgerows (green) and highlighting the surveyed hedgerows (red) that bound or stem off the proposed Greenway route (yellow).

3.3 Hedgerow surveying

The scoring system and field survey sheets from the Hedgerow Appraisal System (Foulkes *et al.*,2013) and Foulkes and Murray (2006) were amalgamated into one field survey sheet and used to collect data and determine hedgerow condition and overall significance (see Appendix 1). A field survey sheet from Foulkes and Murray (2006) was re-designed and only the recording parameters relevant to the scoring system in Foulkes *et al.*, (2013) (Tables 1, 2 and 3) were retained. *Rubus fruticosus* agg. was added to the favourable woody species list (currently missing with Foulkes *at al.*, 2013). The hedgerow survey sheet design enabled a rapid on- site survey by ticking the relevant criteria of the recording parameters during fieldwork. Hedgerow parameters surveyed included:

Hedgerow length; Historical significance; Structure, Construction and Associated Features; Bank/ Wall Degradation; Habitat Connectivity; Landscape Significance; Structural Variables; Continuity –Gaps; Continuity -Individual Gaps; Margin Condition; Basal Density/ Porosity to Light of Woody Shrubs; Species Diversity Presence–Shrubs and Trees (per 30 m strip); Hedgerow Ground Flora Presence (per 30 m strip, extending 1m either side of hedge base); Unfavourable sp. (percent composition of woody growth volume); Entire Hedge Base/ Ground (unfavourable conditions).

Floristic recordings were carried out along the entire length of hedgerows up to 60 m in length. Two random 30 m floristic recording strips were generated for hedgerows greater than 60 m in length.

Hedgerows were surveyed during the fieldwork season of May to September 2015. The entire length and both sides of the hedgerow were surveyed for the parameters listed on the survey sheet, and distances (meters) were paced to determine the locations of the random 30 meter strips. Vegetation nomenclatures follows that used in 'Collins Tree Guide' (Johnson, 2004), 'The Wildflower Key' (Rose and O'Reilly, 2006) and 'Grasses, Sedges, Rushes and Ferns of Britain and Northern Europe' (Fitter, Fitter and Farrer, 1984). Average heights, widths, gaps, degradation and basal densities were measured using a field tape measure or estimated when structural conditions were unfavourable. All structural and floristic recordings were extracted into a database and individual species frequency and average hedgerow length was calculated per site.

Further characterisation of the Greenway route was carried out in 2018 and is available in Carlier and Moran (2019). Results from the significance and condition scoring, and species composition were examined within the context of the six Landscape Characters (LC) areas identified in this study and illustrated using photography from the study area (Fig. 4a-f).

Fig. 4. Photographs taken from the proposed Greenway route to help visualisation of the six various landscape characters within the study area.(a) LC 1: Diverse landscape high in semi- natural woodland; (b) LC 2: Intermediate, semi-improved landscape; (c) LC 3: Semi-natural grassland delineated by hedgerows and wet ditches; (d) LC 4: Semi-natural grassland and mixed woodland landscape; (e) LC 5: Semi- improved grasslands and lakelands; (f) LC 6: Intensive agricultural grassland landscape with high hedgerow density treelines.

3.4 Scoring hedgerow significance and condition.

Scores were compiled for each hedgerow with reference to the assessment criteria tables available in (Foulkes *et al.*, 2013; pages 14-19). Overall significance assessment is based on ranking the significance of hedges on a scale of 0-4 (0 being lowest) in five categories: historical significance, species diversity significance, structure, construction and associated features, habitat connectivity significance and landscape significance. Condition assessment is based on ranking from 0-3 (0- unfavourable; 3- highly favourable) in three categories representing structural variables, continuity and other negative indicators (as defined in Foulkes *et al.*, (2013)). These scoring tables were synthesised and included on the back of the survey sheet (see Appendix 1) to assist the scoring of each hedgerow surveyed.

Criteria for determining if hedgerows were in favourable condition for wildlife were obtained from Sullivan *et al.*,(2013), adapted from the British Hedgerow Survey Handbook (DEFRA, 2007): Threshold for favourable condition for wildlife (all criteria must be met): *Average height at least 2 m; Average width at least 1.5 m; Less than 10% gaps, with no individual gap wider than 5 m; Base of woody component closer than 5 0cm to the ground; Less than 10% introduced non-native species; At least 2 m of undisturbed (uncultivated) ground from hedge.*

3.5 Hedgerow typology

Multivariate data analysis was performed using PCORD v. 7.01 (McCune and Mefford, 2016). Classification of hedgerow types was carried out using a combination of Non-metric Multidimensional Scaling (NMS) of woody species frequencies to seek pattern in species compositions of hedgerows within sample sites. NMS was used as an ordination tool based on its suitability for species count datasets (McCune and Grace, 2002; Peck, 2016). A Sørensen distance measure was applied due to the zero- rich and heterogeneous nature of count data. The resulting ordination axes served as a data reduction process, producing summary 'synthetic responses' to guide a hierarchal polythetic Cluster Analysis (CA). Euclidean distance was used as distance measure and Wards group linkage method was selected accordingly following data skewness assessment. A multi-response permutation procedure (MRPP) provided an *A* -value of within group agreement other than expected by chance, and not requiring equal sample sizes (Peck, 2016).

Eighteen quantitative explanatory variables were compiled into second matrix for overlay analysis to determine relationships between hedgerow species groups, hedgerow structure and species richness and sample site habitat characteristics (see Table 1). Areal and linear habitat data was obtained from Carlier and Moran (2018) and species richness was calculated in PCORD.

Table 1. Summary of explanatory landscape variables compiled for multivariate analyses

	Variable	Description	Format
Areal Habitats	Semi-Nat. Grass	Semi- natural grassland	% of site area
	Imp. Grass	Improved grassland	% of site area
	Spruce	Conifer plantation	% of site area
	Broadleaf	Semi- natural and mixed broadleaved woodland	% of site area
	Lakes	Freshwater lakes and ponds	% of site area
	Built	Built land	% of site area
	Peatland	Cutover bog*	% of site area
Linear Habitats	Linear woodlands**	Total linear woodlands density	km/site
	Total Linear features***	Total linear features density	km/site
Hedgerow Structure	Condition	Median hedgerow condition	Score 0 - 4
	Length	Average length of hedgerows	km/site
	Height	Average height of hedgerows	m/site
	Width	Average width of hedgerows	m/site
	Boxed	Percent of hedgerows that were boxed- profile	%/site
	Overgrown	Percent of hedgerows that were overgrown	%/site
	Remnant	Percent of hedgerows that were remnant	%/site
Species Richness	Woody Species	Woody layer species richness of hedgerows	Sp.R/site
	Herb Species	Herb layer species richness of hedgerows	Sp.R/site

* 'cutover bog' habitat was the only type of peatland present within study area; the habitat was mostly regenerating back into heath and bog woodland with occasional and localised turf cutting **linear woodlands refers to the combination of treelines and hedgerows ***total linear features refer to the combination of all mapped linear features [*stone walls*, *earth banks*, *farm tracks*, *drainage ditches*, *streams*, *hedgerows and treelines*]

4 Results

4.1 Survey results

Of the 35 sampling sites, 24 contained hedgerows which were alongside and stemmed off the railway corridor. Six sites had no hedgerows along the route or stemming off it, two had a gap greater than 20 m between the route and hedge start and three had all hedgerows removed prior to surveying. In total 14 hedgerows were removed over seven sites from the date of aerial image production (7th November 2011) to the fieldwork season (May-September 2015). A total number of 81 hedgerows were sampled with an overall length of 10.75 km. The average hedgerow length surveyed was 134.75 m (±116.30).

A total of 71 hedgerow species were recorded over the 24 sites. Three classes of vegetation (woody, herbaceous and pteridophyte) were recorded (species frequencies are listed in Appendix 2).

Woody plant layer: 36 woody plant species were recorded. The average number of woody plant species present per hedgerow was 7 (±2.24) with a maximum of 12 recorded. 77 of the 81 hedgerows surveyed (95%) were considered species rich (containing four or more native woody plant species, Foulkes and Murray (2006)).

Herbaceous plant layer: 24 herbaceous plant species were recorded. The average number of herbaceous plants species per hedgerow was 5 (±1.63), with a maximum diversity of 11 species recorded.

Pteridophyte layer: 12 ferns and allies species presence were recorded during surveying. The average number of species presence recorded per hedgerow was 3.09 (±1.57). A maximum diversity of six species per hedgerow was recorded

4.2 Hedgerow significance and condition

23.75% of hedgerows were determined as being in unfavourable condition, due to continuity issues; individual gap(s) greater than 5 m and total hedge gaps greater than 10%. Adequate, favourable and highly favourable condition scores returned 1.25%, 41.25% and 32.5% respectively. 84% of hedgerows bounding the proposed Greenway and 83% of hedgerows stemming off the railway route scored 'highly significant'.

73.75% of hedgerows were in favourable condition for wildlife. The reason for hedgerows not meeting the criteria for favourable condition for wildlife was principally on account of gap issues within the hedgerow structures. The percent of hedgerows which met the various criteria used for determining favourable wildlife condition are listed in Table 2.

Table 2. Criteria for hedgerows to be considered favourable for wildlife (Sullivan *et al.*, 2013). Table shows percent of sampled hedgerows within study area meeting individual and all criteria

Criteria for favourable conditions for Wildlife	Favourable hedgerows (%)
Average height at least 2 m	97.5
Average width at least 1.5 m	100
Less than 10% gaps, with no individual gap wider than 5 m	76.25
Base of woody component closer than 50 cm to the ground*	92.5
Less than 10% introduced non-native species	100
At least 2 m of undisturbed (uncultivated) ground from hedge**	100
Meeting all Criteria	73.75

*measured as basal density parameter on survey sheet; any criteria other than 'open' **measured as margin condition parameter on survey sheet as '2 m+ grassy margin' or '2 m+ grassy margin (double)'

Hedgerow condition, overall significance and species diversity within the six Landscape Characters (LC) are listed in Table 3. LC 1, LC 3 and LC 4 had the highest hedgerow significance, LC 3 had the highest woody plant diversity, and LC 2 had the highest un- favourable hedgerow condition. LC 6 also had high hedgerow significance values, and LC 5 had the highest favourable hedgerow condition.

Table 3. Average significance, overall condition, favourable wildlife condition, and species diversity results of hedgerows surveyed within the context of each of the Landscape Characters (see Table 2, section 3.3) of the study area

	Landscape Character (LC)					
Hedgerow Parameter	1	2	3	4	5	6
N of hedgerows surveyed	1	15	10	4	19	32
Highly Significant (%)	100	60	90	100	78.95	87.5
Highly Favourable Condition (%)	0	0	10	25	73.68	25
Favourable Condition (%)	100	33.33	50	25	5.26	62.5
Adequate Condition (%)	0	0	0	0	5.26	0
Un-Favourable Condition (%)	0	66.66	40	50	15.79	12.5
Favourable Condition For Wildlife (%)	100	33	10	25	73.68	71.87
$\bar{x}$ Wood Species Diversity (*N* of Sp)	7	5.6 (±2.38)	7.1 (±2.38)	6.25 (±1.89)	7.58 (±1.95)	7.78 (±2.11)
$\bar{x}$ Herb Species Diversity (*N* of Sp)	4	5 (±2.16)	5.1 (±1.52)	4.25 (±0.96)	5.05 (±1.31)	4.22 (±1.3)
$\bar{x}$ Pteridophyte Species Diversity (*N* of Sp)	0	2.93 (±1.71)	2.8 (±1.48)	3.5 (±0.58)	3.26 (±1.88)	3.16 (±1.39)

4.3 Hedgerow typology

A three dimensional ordination was recommended post data testing for non-metric multidimensional scaling (NMS) of woody hedgerow species frequency. A final stress of 11.29 with a final instability of 0 was obtained. The resulting ordination allows the graphic display of sample site groupings based on hedgerow species composition and the overlay of explanatory variables (Fig. 5). Peatland and Woody Species Richness had the highest correlation with Axis 1 (negative). Spruce and Broadleaf had a negative correlation with Axis 2, while positive correlations were observed for hedge boxed and both Woody and Herb Species Richness. Axis 3 was negatively correlated with Herb Species Richness (see Table of ordination axes in Appendix 3).

Four interpretable hedgerow groups were determined in Cluster Analysis (CA) with 13.9% chaining. A multi-response permutation procedure (MRPP) A -value of 0.43 indicated a large within group agreement effect other than expected by chance (Peck, 2016). The resulting groups were added as an explanatory variable and used as a grouping variable to examine the NMS ordination axes and explanatory variable relationships from the overlay (see Fig. 5). The main differences between the groups can be explained by differences in woody species frequency and species richness in Table 4.

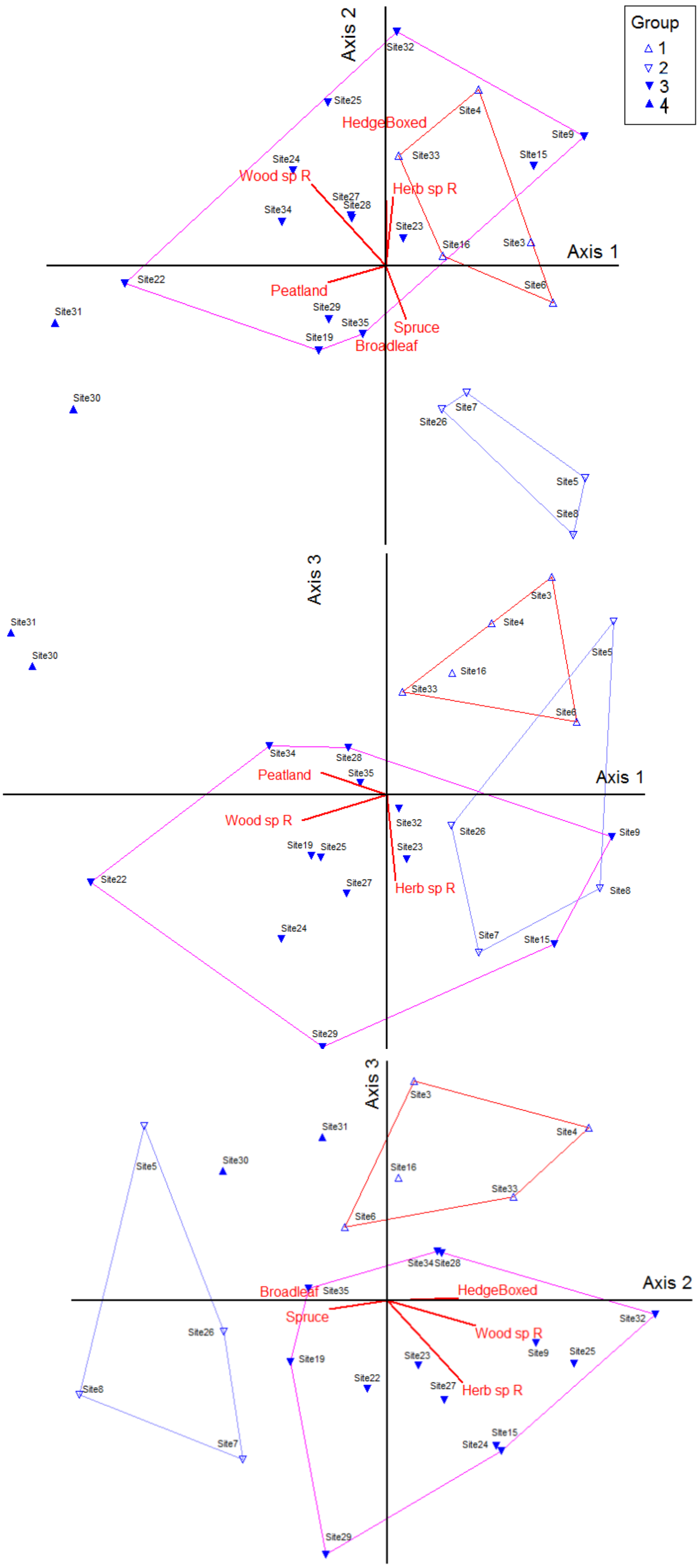

Fig. 5. NMS ordinations of axes 1-3 showing CA groups and explanatory variables overlaid

Table 4. Summary Table of average frequencies (sd) of species occurring within the four groups of hedgerows in Cluster Analysis

Hedgerow Species		Group1 *N* of sites=5	Group 2 *N* of sites=4	Group 3 *N* of sites=13	Group 4 *N* of sites=2
		Frequency (%)	Frequency (%)	Frequency (%)	Frequency (%)
Trees	*A. glutinosa*	0	40 (±49)	37.6 (±33.2)	0
	Betula spp	0	0	9 (±16.1)	100 (±0)
	C. avellana	0	0	25.1 (±29.8)	0
	C. monogyna	100 (±0)	100 (±0)	91.3 (±14.6)	100 (±0)
	F. excelsior	82.6 (±16.6)	43.3 (±41.7)	88.8 (±11.3)	75 (±35.4)
	I. aquifolium	46 (±26.8)	0	60.4 (±29.4)	100 (±0)
	P. nigra	0	0.6 (±0.9)	4.4 (±13.8)	0
	P. avium	0	0	2.2 (±6)	25 (±35.4)
	P. spinosa	42.6 (±37.1)	10 (±20)	63.7 (±29)	0 (±0)
	P. padus	0	5 (±10)	0.5 (±1.9)	0
	Salix spp.	17.5 (±24.4)	81.8 (±21.3)	78.2 (±28.3)	100 (±0)
	S. nigra	5 (±11.2)	0	2.2 (±5.3)	0
	S. aria	10 (±22.4)	0	0	0
	S. aucuaria	0	0	5.5 (±14.6)	100 (±0)
	T. bacatta	10 (±22.4)	0	0	0
Shrubs	*L. vulgare*	12.2 (±3.6)	8.25 (±16.5)	6.6 (±15.3)	0
	L. periclymenum	16.6 (±15.5)	10 (±20)	45.6 (±30)	100 (±0)
	M. gale	0	0	3.9 (±13.9)	0
	R. idaeus	0	0	10.2 (±19.9)	50 (±70.7)
	U. europaeus	0	0	0	50 (±70.7)
	V. opulus	0	0	14.3 (±24.9)	0
Climbers	*H. helix*	90 (±22.4)	100 (±0)	93.8 (±11.6)	100 (±0)
	R. fruticosus agg	100 (±0)	77.5 (±26.3)	87.5 (±28)	100 (±0)
	Rosa spp.	53.4 (±19.2)	65 (±47.3)	72.5 (±34.2)	25 (±35.4)
	S. dolcamara	0	0	1.3 (±4.7)	0
Sp. Richness	Woody layer	8.2	7	11.9	11
	Herb layer	9.8	10	14.5	5
MRPP *A*-value (4 groups): 0.4289					

All hedgerow classification groups featured a high frequency of *C. monogyna*, *H. helix* and *R. fruticosus* agg. Both groups one (dry hedgerow) and two (species poor willow-alder hedgerow) had lower woody species richness, but group one had a higher frequency of *F.excelsior* and *P. spinosa* compared to group two which had a higher frequency of *Salix* spp. Group three species rich willow-alder hedgerow) was most common, with the highest woody and herb layer species richness and appeared to contain a majority of hedgerow species. Group four (birch-holly hedgerow) occurred the least, had the lowest herb layer species richness and featured a high frequency of several woody species not present in other groups. Group one occurred principally within the intermediate, semi-improved landscape (LC 2); group two occurred principally within the semi-natural grassland and mixed woodland landscape (LC 4), group three occurred across all LCs apart from LC 4, and group four occurred solely within the intensive agricultural grassland landscape (LC 6).

5 Discussion

Hedgerow densities vary greatly across European landscapes, from occasional occurrence as shelterbelts in open 'prairie' to a dominant feature within 'bocage' pastoral landscapes (Baudry *et al.*, 2000(b); Barr and Gillespie, 2000). Hedgerows are considered a typical landscape feature in the British Isles and Western Europe (Barr and Gillespie, 2000); a network of up to 300,000 km remains in Ireland- many of which are considered 'heritage' hedgerows due to their ancient periods of establishment and their make-up of mixed native species (Smal, 1995; Foulkes *et al.*, 2013; Bullock and Hawe, 2013). Habitat mapping (see Carlier and Moran (2018) of the rail corridor study area used in the present study identified over nine kilometres of hedgerow per km^2. This is significantly higher than the UK average of 2.9 km / km^2 (Barr *et al.*, 1993) but lower compared to the high-density hedgerow network (bocage) landscapes of 27.3 km / km^2 in Brittany (Baudry *et al.*, 2000(a)). Linear boundary features established as part of early rail (c.19th Century) and canal (end 17th Century) infrastructure in Europe means many remaining hedgerows may be of heritage significance or ancient; implying hedgerows that are likely species-rich (Barr and Gillespie, 2000). European Greenways, through their use of former infrastructure corridors and their linear nature, have the potential to host large densities of heritage and new hedgerows within landscapes that are facing increasing land use change. However, a Greenway can also present threats and pressures to such hedgerow networks; for example removal during trail development, damage during trail maintenance, inappropriate or lack of management, and inappropriate replanting schemes. The potential for European greenways to maintain and restore hedgerows is therefor of interest as a novel planning mechanism for enhancing green infrastructure. The integration and safeguarding of important natural heritage features along with cultural and industrial heritage, such as in the upcycling of disused transport infrastructure into Greenways, is likely to become increasingly important in the context of sustainable development and green infrastructure.

The wide standard deviation of average sampled hedgerow length suggests a large variance in land parcel boundary size; reflecting changing landscape characters across the study area from the Republic of Ireland into the United Kingdom (Carlier and Moran, 2018; 2019). Significant land use change from small- scale extensive farming is evident from the removal of hedgerows in almost one in three sample sites, typically within 'marginal' landscape characters- LC 3 (semi-natural grassland delineated by hedgerows and wet ditches) and LC 4 (semi- natural grassland and mixed woodland) (see Carlier and Moran, 2019). Greenway development has been noted to provide excellent opportunities to preserve cultural and natural heritage (Fabos, 1995; Ryan *et al.*, 2004). In this case the current hedgerow network could be effectively preserved from further fragmentation and removal by recognising hedgerows as an integral part of the corridor infrastructure and further enhancing the network by re-establishing favourable hedgerow conditions, applying appropriate hedgerow species composition groups where necessary.

A high proportion of hedgerows bounding the proposed route and those stemming off into adjacent land were highly significant. This high overall significance observed was principally on account of hedgerow structure and species diversity, and this is reflected with 73.75% of hedgerows supporting favourable conditions for wildlife (also based on hedgerow species diversity and structure). Favourable hedgerow structural conditions such as increased width and tree height result in an increase in habitat volume used for small mammals (Hilty and Merenlender, 2004; Gelling *et al.*, 2007). It increases nesting and territory posts for farmland birds (Sparks *et al.*, 1996; Walker *et al* 2005) while mature growth in hedgerows is beneficial to invertebrate and bat species (Graham *et al.*, 2018). Hedgerows have been found to promote woodland species dispersal (Corbit *et al.*, 1999; Roy and de Blois, 2006) and with appropriate management, can serve as ecological corridors to mitigate the effects of fragmentation within agricultural landscapes (Davies and Pullin, 2007; Dondina *et al.*, 2016; Chiatante *et al.*, 2017). This effect may be particularly important for hedgerows with low woody species richness such as in hedgerow group two. Unfavourable hedgerow continuity issues may indicate a trend of decreasing need for hedgerows to act as boundaries along the proposed Greenway route, particularly as the former railway is abandoned or frequently used as hard-stand for supplementary livestock feeding and as an access route. However, even small gaps can potentially have negative consequences on small mammals (Bright, 1998; Gelling *et al.*, 2007), and the maintenance and enhancement of hedgerow spatial continuity along Greenways should be encouraged.

Nearly all (95%) of hedgerows surveyed were determined 'species rich' (containing four or more woody species). This finding is significant from a land management context; increased intensity of adjacent land use decreases hedgerow species richness (Closset-Kopp *et al.*, 2016) and past studies in the UK have found a decrease in species richness in hedgerows (Barr and Gillespie, 2000; Garbutt and Sparks, 2001). Species- rich hedgerows are also associated with structural diversity (Graham *et al.*, 2018). It is likely that Greenway corridors (prior to development) host important hedgerow species diversity, though further research on a range of other pre- Greenway corridors is needed to confirm this. The high species rich values recorded may also be in part due to the 'Green lane' effect of the former railway route (Fig. 6). Green lanes (un-bound farm tracks flanked either side by hedgerows) have been reputed to contain a higher diversity of species than other agricultural linear boundaries due to their corridor and sheltered effect from adjacent land management and environmental impacts (Croxton *et al.*, 2002; Croxton *et al.*, 2005; Walker *et al.*, 2005). Hedgerows considered to be in favourable condition have a better chance of increasing plant species diversity (DEFRA, 2007), while increased hedgerow plant diversity can increase essential food biomass resources promoting wildlife (Staley *et al.*, 2012).

Fig. 6. Green lane effect; picture shows former railway flanked either side by hedgerows and trees- promoting woodland species richness

The highest woody species frequency observed was *C. monogyna* and *F. excelsior*, common to European hedgerows (Sullivan *et al.*, 2013; Graham *et al.*, 2018) and typical of hedgerows occurring within drumlin physiographic zones (Doogue and Kelly, 2006). Positive associations have been observed between a high occurrence of *C. monogyna* and the number of bird species presence within hedgerows (Walker *et al.*, 2005) and berry yields can be significantly increased through appropriate hedgerow management (Croxton *et al.*, 2002; Staley *et al.*, 2012). In contrast the frequency of *H. helix* was slightly higher than *R. fruticosus* agg woody climbers more commonly observed in other hedgerow studies (e.g. Sullivan *et al.*, 2013), possibly due to the high frequency of high (over two meters) hedgerows and the abundant presence of mature trees providing canopy shade.

All hedgerow groups had a common presence of *C. monogyna*, *H. helix* and *Rubus* spp. agg., each group classification returned distinctive separation based on large variations of other common species presence. The relatively low presence of *Salix* spp. and absence of *A. glutinosa* in group one (dry hedgerow) suggests hedgerows growing in drier soil conditions. Hedgerow group two (species poor willow-alder hedgerow) appears to represent opposite hedgerow conditions to group one, with the highest presence of *Salix* spp. and *A. glutinosa* indicating hedgerows found in wetter soil conditions. This group appeared to be related to a broadleaf and conifer habitat and was also found principally within LC 4; a wet grassland dominated mosaic with a mixture of conifer and broadleaved woodland. Wet pastures are considered marginal from an agricultural production perspective, and often commercial afforestation predominantly targets marginal agricultural land in Ireland (Department of Agriculture, Food and the Marine, 2015). This highlights hedgerows in this group may therefore be threatened from further land use change, depending on the design of afforestation programs. Group three (species rich willow-alder hedgerow) was most common hedgerow type across five of the LCs, suggesting that species rich hedgerows occur throughout the Greenway route. This indicates that suitable conditions exist for the preservation and enhancement of species rich hedgerows throughout the route. The 100% presence of *Betula* spp., *S. aucuparia* and *I. aquifolium* in group four (birch-holly hedgerow) indicates hedgerows growing in predominantly acidic soil conditions. Group four was only present LC 6 which contains the highest area of peatland bogs within the study area.

The results of hedgerow group classification, significance and condition in respect to landscape characters can be used to develop recommendations for preserving and enhancing the hedgerow network of the proposed Greenway route (Carlier and Moran, 2019). LC 2 (an intermediate, semi-improved grassland landscape) is typically characterised as having the highest abundance of fragmented linear woodland, and in this study had the lowest hedgerow significance, (60%), 67% of hedgerows were in un- favourable condition and 33% were in favourable condition for wildlife. This is due to large gaps and overall gappiness, and therefor highlights the need to address this problem in hedges along these sections of the Greenway. Species characteristic of the particular hedgerow and of local providence should be used when infilling gaps. Gap issues in hedges along Greenways and in the surrounding landscape could be addressed through targeted Agri – Environment schemes or Rural Development programmes (planting, laying and in-filling of gaps of existing hedgerows). Appropriate hedgerow management should be included in Greenway maintenance protocols considering common hedgerow management techniques suggested for specific species targets- for example Hinsley and Bellamy (2000) (farmland birds); Dondina *et al.*,2016 (mammal species); Staley *et al.*,(2016) (moths) Carlier *et al.*, (2019) (bats) and Graham *et al.*,(2018) for general wildlife habitat provision.

Hedgerows present in LC 1, LC 5 and LC 6 host the ideal combinations of a high occurrence of highly significant hedgerows, low occurrence of un-favourable condition, a high occurrence of favourable conditions for wildlife and highest species richness. Despite the predominant association with intensified agriculture (an increasing land use in Europe), LC 6 hosted a high degree of linear woodland connectivity and the ideal existing hedgerow conditions potentially provide an important biodiversity network (Dondina *et al.*, 2016; Heath *et al.*, 2017; Bani *et al.*, 2017). However, with areal woodland cover under 5%, the high linear woodland structural connectivity in this intensified landscape may fail to provide the necessary core habitat for small arboreal mammals (Mortelliti *et al.*, 2011). In this instance, allowing boundary hedgerows to mature into complete canopy cover of the Greenway corridor to enhance woodland core habitat could be essential and also benefit bat species (Carlier *et al.*, 2019). Additional supplementary planting of hedgerows or trees within peatlands should take reference from the typical hedgerow species listed under group four. LC 2, LC 3 and LC 4 had the lowest favourable conditions for wildlife and overall hedgerow conditions were mostly un- favourable, mainly due to gap related issues. These landscapes are typically associated with marginal agriculture, and due to increased abandonment or land use change, hedgerows as field boundaries are being neglected (Burel *et al.*, 1998), returning to treelines and becoming fragmented. Although the negative gappy conditions prevail in these landscape characters, certain species may not benefit from increased hedgerow cover and length, especially in the case of open grassland bird species (Besnard and Secondi, 2014) and the existing balance of grassland to hedgerows needs to be informed by biodiversity targets. In the case of very gappy hedgerows in these landscapes, a more cost effective solution may be the conversion to clumps of bushes spaced by wildflowering banks or seedy grass verges as suggested by Hinsley and Bellamy (2000). Although considered species rich, only one hedgerow was sampled within LC 1, due to this character having the lowest linear woodland density. The surveyed hedgerow represented the longest of all hedgerows at over half a kilometre in length. However, with a lack of other hedgerow samples it was not possible to determine a general profile within this diverse landscape character.

Summary recommendations:

- 'Green Lane' conditions, where they exist prior to Greenway development, must be retained. Further efforts should examine where these can be extended to benefit biodiversity, ecosystem services, and cultural and historical heritage;
- Greenways should play a vital role for landscape-scale conservation of hedgerows; maintaining extensive railway hedgerow networks of high natural and cultural significance. This includes the incorporation of appropriate replanting and maintenance schemes;
- One size does not fit all; new hedgerow replanting species composition should be informed by specific group assemblages from hedgerow typologies;
- In concurrence with Dondina *et al.*, (2018 (a) & (b)), Carlier and Moran (2019) and Carlier *et al.*, (2019), targeted planting locations should be informed by woodland ecosystem connectivity enhancement opportunities identified in landscape structural and functional connectivity analyses to maximally benefit Greenway ecosystem connectivity;
- Hedgerow maintenance must consider conservation objectives, such as structures associated with increased bat activity, woodland core effects for small arboreal mammals, widths and density associated with increased biomass, infilling with hedgerow species appropriate to the surrounding species compositions. Maintenance protocols must nonetheless remain complementary to conventional management for the purpose of maintaining access and the safety of Greenway users. Without a demand for accessible recreational Greenways, these potential conservation synergies could be lost.

6 Conclusion

As shown through this study, extensive knowledge exists regarding the relevant management of hedgerows in order to maintain and enhance the ecosystem services they provide within rural landscapes. The challenge however, exists in targeting and applying management and enhancement actions where they will most benefit the surrounding landscape composition and structure, including re-establishment of hedgerow boundaries and connecting links where deemed necessary and appropriate. As shown in this study, the structure and species composition of hedgerows vary greatly along infrastructure corridors of significant landscape scale and thus a prescribed 'one size fits all' approach to managing and establishing hedges along Greenways is not suitable. Worryingly, the European trend of diminishing use of hedges for their extensive functions and their appropriate management was observed along the disused railway and increasing agricultural intensification means the associated 'green lane' corridor effect is gradually being lost. In many instances landowners of the proposed route corridor have maintained their hedgerows to various extents and past land use management has delivered species rich, dense and well-connected networks. The future of linear woodlands remains uncertain with changing farming practices, associated management costs, scale and an uncoordinated approach to deliver currently undistinguished objectives. The delivery of a Greenway infrastructure to upcycle disused infrastructure corridors potentially adds increasing pressures to already threatened hedgerow networks, but also presents opportunities. Existing hedgerows should be recognised as an integral component of European Greenway corridors and thus preserved. While this study had a predominant ecological focus, it is recommended further research should take account of Greenway hedgerow landscape and cultural significance. Finally, the development of a Greenway infrastructure presents opportunities towards a long- term coordinated approach to large scale targeted management that can be tailored to specific wildlife and heritage objectives. This in turn can help the realisation of European Greenways as truly multifunctional and sustainable green infrastructure.

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9 Appendix 1

Fig. 1. Field card (front) for scoring hedgerow condition and significance using Hedgerow Appraisal System (HAS) (Foulkes *et al.,* 2013). See Fig. 2. for reverse side of card.

Hedgerow Field Recordings for Significance and Condition Assessments

Site Name/no.		Hedgerow no.
Hedgerow Length (m):	Altitude (m) (most Northerly point):	Date:
Random Sample Distances (m): (x-30m-y-30m-z)		Surveyor:

Historical Significance	
Recent	
Internal Field Boundary	
Roadside/Rail/Canal/Farm Boundaries	
Boundary on 1st Ed O.S.	
Townland/County Boundary, Woodland Link (on 1st.ED O.S.), Link with feature listed on Sites and Monuments	
Past Evidence of Laying or Coppicing	
Non Linear (exc. Roadside)	

Structure, Construction & Associated Features			
No Wall/ Bank		Wall/ Bank <0.5m	
Wall/Bank 0.5 – 1m			
Wall/ Bank >1m			
Double Ditch		Dry Ditch	
Wet Ditch/ Drain		Stream/ River	
Badger Sett		Green Lane	

Bank/ Wall Degradation							
>20%		<20%		Minor		None	

Habitat Connectivity	
No link with Semi- Natural Habitat	
Single link with Semi- Nat. Hab. Inc. Hedge	
Multiple links with Semi- Nat. Hab. Inc. Hedges	
Links with Woodland/ Forest Habitat	
Link with Designated Area	

Landscape Significance	
Wind Shaped	
Mature Hedgerow Trees	
Landscape Conservation & Amenity Area Orders, TPO	

Structural Variables			
Height <1.5m		Width <1m	
Height 1.5- 2.5m		Width 1- 2m	
Height 2.5- 4m		Width2- 3m	
Height >4m		Width >3m	
Remnant/ Derelict			
Wind Shaped; Loosing Base Structure			
Boxed/ A- Shaped; Straight Sided			
Overgrown; Top heavy/ Undercut; Basal Overgrowths			

Continuity -Gaps (m)				Continuity -Individual Gaps			
>10%		5- 10%		>5m		<5m	
<5%		0		None			

Margin Condition			
Ploughing/erosion/poaching at Base of Hedge			
2m+Grassy Margin		2m+Grassy Margin (double)	

Basal Density/ Porosity to Light of Woody Shrubs			
Open		Semi- Translucent	
Semi- Opaque		Opaque/ Dense	

Species Diversity Significance (per strip)					
Alder			Sour Cherry		
Silver birch			Wild Plum		
Downy birch			Bird Cherry		
Spanish Chestnut			Blackthorn, sloe		
Dogwood			Wild Pear		
Hazel			Sessile oak		
Hawthorn			Pedunculate oak		
Broom Spindle-tree			Purging Buckthorn		
Ash			Wild Rose		
Ivy			Raspberry		
Holly			Eared willow		
English Walnut			Goat willow		
Wild Privet			Rusty willow		
Honeysuckle			Bay Willow		
Wild Apple			Osier		
Crab Apple			Elder		
Bog Myrtle			Bittersweet		
Scots pine			Whitebeam		
Black poplar			Rowan		
Aspen			Yew		
Wild cherry			Gorse		
Geulder Rose			Wych Elm		
Bramble			ā Strip species no.		
English Elm					

Unfavourable sp.(%vol)	
All coniferous species (except Scots pine)	
Field Maple	
Sycamore	
Horse Chestnut	
Hornbeam	
Clematis	
Beech	
Fuchsia	
Laburnum	
Japanese Privet	
Dwarf Box	
White Poplar	
Cherry laurel	
Rhododendron	
White willow	
Crack willow	
Snowberry	
Lilac	
Lime	
Wayfairing Tree	
>10% Volume of Hedge	
Ivy >25% in Canopy	

Hedgerow Ground Flora (per strip, 1m out from hedgerow edge either side)							
Bugle			Tutsan			Male Fern	
Garlic Mustard			Nipplewort			Broad Buckler Fern	
Ramsons			Toothwort			Scaly Male Fern	
Wood Anemone			Great Woodrush			Hay-scented Bucklr Fern	
Cow Parsley			Yellow Pimpernel			Narrow Buckler Fern	
Lords-and-Ladies			Birds-nest Orchid			Hart's Tongue Fern	
Opp. Leaved Golden Saxifrage			Wood Sorrel			Soft Shield Fern	
			Barren Strawberry			Polypody Fern	
Pignut			Primrose			Great Horsetail	
Foxglove			Lesser Celandine			Wood horsetail	
Broad-leaved Helleborine			Wood Sanicle			Pteridophytes no:	
			Hedge Woundwort			Entire Hedge Base/ Gound	
Wild Strawberry			Greater Stitchwort			Ruderal sp. Dominate	
Sweet Woodruff			Wood Speedwell			>20% Herbicide Use	
Herb Robert			Dog Violets			Noxious Weeds Present	
Wood Avens			ā Strip species no.			>20% Nutrient Rich sp.	
Ground Ivy			Lady Fern			Alien Invasive Species	
Bluebell			Hard Fern				

Julien Carlier,CERIS, ITSligo. Julien_carlier18@hotmail.com

Fig. 2. Field card (reverse) for scoring hedgerow condition and significance using Hedgerow Appraisal System (HAS) (Foulkes *et al.,* 2013). See Fig. 1. for front side of card.

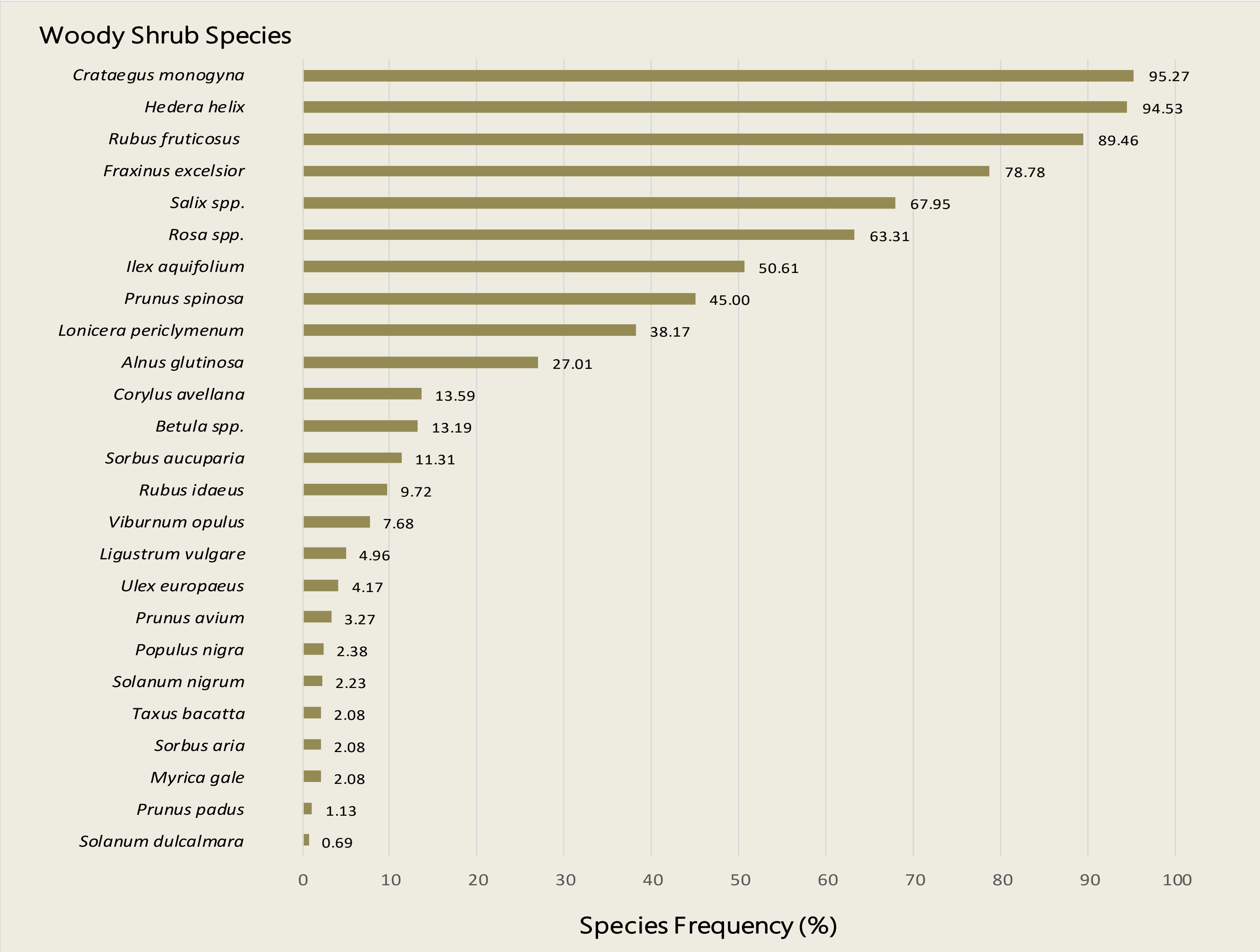
Hedgerow Significance Assessment		Hedgerow Condition Assessment	
1.Historical	**Score**	**1.Structural**	**Score**
Period of Establishment		Height	
Non Linear		Width	
Past Coppicing/ Laying		Profile	
2.Species Diversity	**Score**	Basal Density	
Tree/Shrub/Climber no. sp./30m Strip		**2.Continuity**	**Score**
Ruderal sp. Dominate		%Gaps	
No. sp./30m Strip		Specific Gaps	
No. of Pteridophytes		**3.Negative Indicators/Degradation/Viability**	**Score**
3.Structure, Construction and Associated Features	**Score**	Bank/Wall Degradation	
Wall/Bank Height or Double Ditch		Ivy >25%	
Drain/ Ditch		Unfavourable sp. >10% vol. of Hedge	
Badger Sett		>20% Herbicide Use	
Green Lane		Noxious Weeds/ >20% Nutrient Rich sp.	
4.Habitat Connectivity	**Score**	Alien Invasive Species Presence	
No link/link(s) with Semi Natural Habitats/SAC/SPA		Degraded Margin/Grassy Margin 2m+ or double	
5.Ladnscape	**Score**	Total Score (out of 24)	
Wind Shaped/ Mature Hedgerow Trees/Designation			

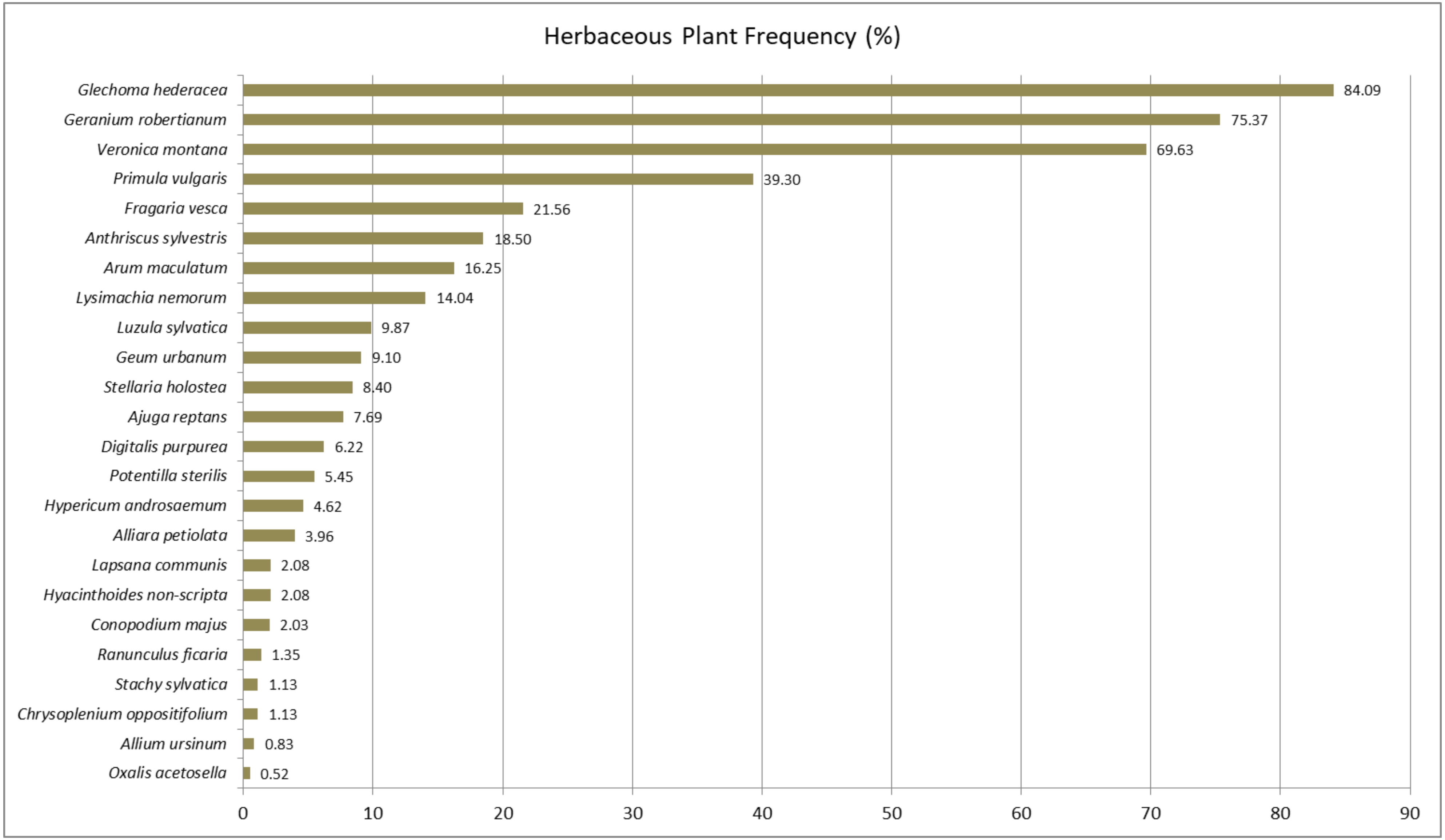
Hedgerow is Highly Significant		Overall Hedgerow Condition	
(score of 4 in any category; cumulative score of 6 or more within the category 1, 2 or 3; or a cumulative score of 16 or more over the 5 categories)		Adequate: 7- 11 (minimum favourable score= 7) Favourable: 12- 19 Highly Favourable: 20- 24 Unfavourable: any category with a score 0.	

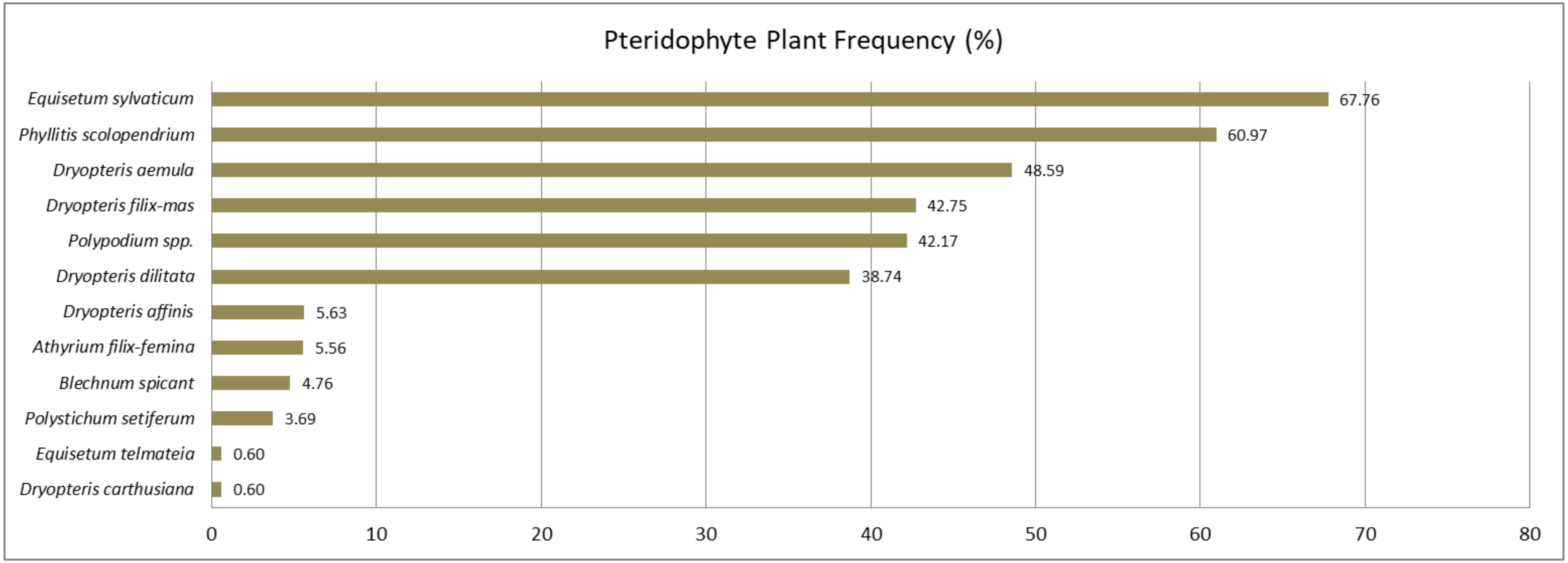
Notes

Julien Carlier,CERIS, ITSligo. Julien_carlier18@hotmail.com

10 Appendix 2




Herbaceous Plant Frequency (%)
Glechoma hederacea 84.09
Geranium robertianum 75.37
Veronica montana 69.63
Primula vulgaris 39.30
Fragaria vesca 21.56
Anthriscus sylvestris 18.50
Arum maculatum 16.25
Lysimachia nemorum 14.04
Luzula sylvatica 9.87
Geum urbanum 9.10
Stellaria holostea 8.40
Ajuga reptans 7.69
Digitalis purpurea 6.22
Potentilla sterilis 5.45
Hypericum androsaemum 4.62
Alliara petiolata 3.96
Lapsana communis 2.08
Hyacinthoides non-scripta 2.08
Conopodium majus 2.03
Ranunculus ficaria 1.35
Stachy sylvatica 1.13
Chrysoplenium oppositifolium 1.13
Allium ursinum 0.83
Oxalis acetosella 0.52
0
10
20
30
40
50
60
70
80
90


Pteridophyte Plant Frequency (%)
Equisetum sylvaticum
Phyllitis scolopendrium
Dryopteris aemula
Dryopteris filix-mas
Polypodium spp.
Dryopteris dilitata
Dryopteris affinis
Athyrium filix-femina
Blechnum spicant
Polystichum setiferum
Equisetum telmateia
Dryopteris carthusiana
67.76
60.97
48.59
42.75
42.17
38.74
5.63
5.56
4.76
3.69
0.60
0.60
0
10
20
30
40
50
60
70
80

11 Appendix 3

Table 1 : Pearsons correlation (r) with NMS ordination axes and explanatory variables

Variable	Axis 1	Axis 2	Axis 3
Built	0.298	0.047	-0.088
ImpGrass	0.081	0.315	0.08
Semi-NatGras	0.033	0.002	-0.169
Spruce	0.276	**-0.448**	-0.172
Broadleaf	0.01	**-0.486**	0.063
Lakes	-0.159	0.073	0.078
Peatland	**-0.467**	-0.246	0.271
Hedge Length	-0.024	0.155	0.154
HedgeCond	-0.324	0.233	-0.367
TotHedgKm	0.12	0.367	-0.126
TotalLinearF	0.354	0.249	-0.059
HedgeHeight	-0.12	0.01	0.059
HedgeRemnant	0.321	0.052	-0.13
HedgeBoxed	0.047	**0.496**	0.098
HedgeOvergro	0.221	-0.072	0.047
Wood Sp. R	**-0.531**	**0.554**	-0.294
Herb Sp. R	0.17	**0.511**	**-0.534**