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Distribution of woodland areas and floral diversity in Duffield

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Abstract
Woodland ecosystems within the Duffield landscape, Derbyshire, represent an important component of the southern Peak District ecological network, providing essential ecosystem services while supporting a diverse assemblage of native flora. This study investigated woodland distribution and floral diversity by integrating remote sensing analysis with a field-based botanical survey. Tree cover patterns were assessed using the Global Forest Change dataset across multiple canopy cover thresholds (>10–75%) to evaluate woodland structure, connectivity, and recent woodland gain between 2000 and 2020. A total of 20 vascular plant species were recorded, representing woodland, grassland, wetland, and ecotonal habitats. The flora was dominated by native species, including *Prunella vulgaris*, *Achillea millefolium*, *Lotus corniculatus*, *Digitalis purpurea*, and two orchid species (*Anacamptis pyramidalis* and *Dactylorhiza fuchsii*), indicating relatively diverse semi-natural habitats. Woodland mapping demonstrated that lower canopy thresholds captured fragmented woodland, hedgerows, and riparian vegetation, whereas higher thresholds identified mature woodland concentrated along valley slopes. Woodland gain adjacent to existing forests suggested ongoing natural regeneration and improved habitat connectivity. The occurrence of numerous nectar-rich and nitrogen-fixing species highlights the ecological importance of the landscape for pollinators, nutrient cycling, and ecosystem resilience, while the presence of the invasive *Impatiens glandulifera* emphasises the need for continued management. Overall, the study demonstrates that Duffield supports a heterogeneous woodland ecosystem of considerable biodiversity value, underscoring the importance of protecting mature woodland, maintaining ecological connectivity, controlling invasive species, and promoting long-term biodiversity monitoring and habitat conservation.

Keywords: Woodland biodiversity, floral diversity, remote sensing, habitat connectivity, species

Introduction

Duffield is a large village in the borough of Amber Valley, Derbyshire, England, situated at the southern foothills of the Peak District National Park (Bull J.,2026) [1]. Positioned within the valley of the River Derwent, the village forms part of a transitional landscape where the upland environments of the Peak District merge with the lowland agricultural and urban landscapes of the East Midlands (Bull J.,2026) [1]. This geographical setting has created a mosaic of habitats, including ancient and secondary woodlands, riparian corridors, species-rich hedgerows, grasslands, wetlands, and agricultural land, making the area ecologically diverse and regionally significant (Bull J.,2026) [1].

The ecological importance of Duffield is further enhanced by its proximity to the Derwent Valley, an internationally recognized landscape that supports a wide range of terrestrial and aquatic ecosystems (Bull J.,2026) [1]. Woodland habitats surrounding Duffield provide essential ecosystem services, including carbon sequestration, soil stabilization, nutrient cycling, flood mitigation, and the regulation of local microclimates (Malhi et.al.,2022) [2]. These habitats also function as ecological corridors, facilitating the movement of wildlife and maintaining landscape connectivity between fragmented natural habitats (Dixon, M.D.2007) [3]. Such connectivity is increasingly important in maintaining biodiversity and enhancing ecosystem resilience in the face of habitat loss and climate change (Dixon, M.D.2007) [3].

An important feature of the surrounding landscape is the Cromford Canal, which extends through the Derwent Valley and supports a variety of freshwater and riparian habitats (Goulder R.,2014) [4]. The canal and its associated wetlands, woodland margins, and grasslands contribute substantially to the ecological integrity of the region by providing habitat for aquatic plants, invertebrates, birds, mammals, and amphibians (Goulder R.,2014) [4]. Together with the River Derwent and adjacent woodland patches, these habitats create interconnected ecological networks that sustain high levels of biodiversity and support numerous species of conservation importance (Goulder R.,2014) [4].

The woodlands within and around Duffield comprise a mixture of ancient semi-natural woodland, secondary woodland, and managed plantations (Fuentes-Montemayor, E. et. al,2017). Ancient woodlands are particularly valuable because they have persisted for centuries and support characteristic woodland flora, including ancient woodland indicator species that are often absent from recently established forests (Fuentes-Montemayor, E. et. al,2017) [5]. Woodland plant communities contribute significantly to ecosystem functioning by supporting pollinators, herbivores, decomposers, and higher trophic levels while maintaining ecological processes essential for long-term habitat stability (Fuentes-Montemayor, E. et. al,2017) [5].

Despite the recognised ecological value of the wider Derwent Valley, relatively little attention has been given to synthesising the available information on woodland distribution and floral diversity specifically within Duffield (Cruickshank, S. 2017) [6]. Existing information is dispersed across botanical surveys, conservation reports, woodland inventories, and academic literature, making it difficult to develop a comprehensive understanding of the area's woodland resources and plant biodiversity (Cruickshank, S.

2017) [21]. A critical review of the available evidence is therefore necessary to consolidate current knowledge, identify patterns in woodland distribution and species composition, evaluate conservation significance, and highlight gaps requiring further investigation (Whittaker et.al,2005) [7].

Results

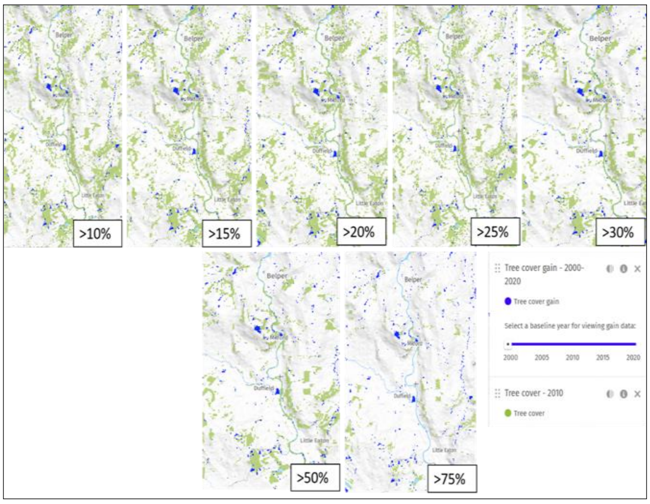

Fig 1: Spatial distribution of tree cover across the Duffield landscape under different canopy cover thresholds (>10%, >15%, >20%, >25%, >30%, >50%, and >75%), derived from the Global Forest Change dataset (Hansen *et al*., 2013) [8]. Existing tree cover is represented in green, while areas of tree cover gain between 2000 and 2020 are shown in blue. The figure illustrates the progressive reduction in mapped woodland extent with increasing canopy cover thresholds, highlighting the distribution of dense woodland patches and recent forest regeneration within the Duffield region.

Figure 1 illustrates the spatial distribution of tree cover within and around Duffield using a series of canopy cover thresholds ranging from >10% to >75% (Bellamy C.,2024) [9]. Tree cover is displayed in green, whereas areas of tree cover gain recorded between 2000 and 2020 are shown in blue (Thonfeld, et.al.,2022). The application of multiple canopy cover thresholds enables the differentiation of sparse woodland, scattered tree cover, and dense forest stands, providing a more comprehensive representation of woodland structure across the landscape (Zellweger et.al.,2013) [11].

At lower canopy cover thresholds (>10–20%), woodland appears relatively extensive and includes fragmented woodland patches, hedgerows, riparian vegetation, and scattered trees distributed throughout the Derwent Valley (Staley et.al.,2024) [12]. As the threshold increases (>30–75%), only areas characterised by dense and continuous canopy remain, indicating the core woodland habitats that likely represent mature or well-established forests (Spies et.al.,2014). These higher-density woodland patches are concentrated along the valley slopes and surrounding upland areas, reflecting the influence of topography and land use on woodland persistence (Hahm et.al,2019) [14].

The distribution of tree cover, gain between 2000 and 2020 demonstrates localized woodland expansion and regeneration, particularly adjacent to existing woodland patches (Staddon, et.al.,2021) [15]. Such patterns suggest ongoing natural succession and woodland establishment, contributing to increased habitat connectivity within the landscape (Norden et.al.,2014) [16]. Overall, the figure highlights the heterogeneous nature of woodland distribution in Duffield and provides an important spatial framework for assessing floral diversity, ecological connectivity, and woodland conservation priorities within this ecologically significant region (Cork et.al,2026) [17].

Table 1: Composition of the vascular flora recorded in the Duffield woodland landscape and their ecological, phytochemical, and conservation characteristics.

Common name	Scientific name	Important phytochemicals / medicinal compounds	Native or invasive in England	Conservation status in England
Great willowherb	*Epilobium hirsutum*	Flavonoids (quercetin, kaempferol), tannins, phenolic acids; traditional anti-inflammatory uses	Native	Common/ widespread
Common selfheal	*Prunella vulgaris*	Rosmarinic acid, flavonoids, tannins, triterpenes; traditionally used for wound healing, sore throat and inflammation	Native	Common/ widespread
Creeping thistle	*Cirsium arvense*	Flavonoids, phenolic acids, sesquiterpene lactones; antioxidant compounds	Native	Common; agricultural weed
Common yarrow	*Achillea millefolium*	Azulene, achillin, flavonoids, tannins, essential oils; traditional wound treatment and digestive aid	Native	Common
Common ragwort	*Jacobaea vulgaris*	Pyrrolizidine alkaloids (toxic), flavonoids; important nectar plant for insects	Native	Common; protected by ecological importance but controlled near grazing land
Bird's-foot trefoil	*Lotus corniculatus*	Flavonoids, condensed tannins, cyanogenic glycosides; nitrogen-fixing legume	Native	Common
Hogweed	*Heracleum sphondylium*	Furanocoumarins, essential oils, flavonoids; can cause skin sensitivity	Native	Common
Pyramidal orchid	*Anacamptis pyramidalis*	Orchid compounds including flavonoids and mucilage; traditional uses limited	Native	Locally common but declining in some areas
Hedge woundwort	*Stachys sylvatica*	Essential oils, iridoid glycosides, flavonoids; traditional wound-related uses	Native	Common
Fireweed (Rosebay willowherb)	*Chamaenerion angustifolium*	Flavonoids, tannins, vitamin C, phenolic compounds; used traditionally as herbal tea	Native	Common / widespread
European black	*Sambucus nigra*	Anthocyanins, flavonoids, sambunigrin, vitamin	Native	Common

elderberry		C; immune-supporting traditional medicine		
Herb Robert	*Geranium robertianum*	Geraniin, tannins, flavonoids, essential oils; traditional astringent	Native	Common
Himalayan balsam	*Impatiens glandulifera*	Flavonoids, phenolic acids, naphthoquinones; some antimicrobial compounds studied	Invasive non-native	Widespread invasive species; listed under invasive species regulations
Bull thistle	*Cirsium vulgare*	Flavonoids, phenolic acids, sesquiterpenes	Native	Common
White clover	*Trifolium repens*	Isoflavones, flavonoids, cyanogenic glycosides; nitrogen fixation	Native	Common
Common spotted orchid	*Dactylorhiza fuchsii*	Phenolic compounds, flavonoids; orchid tubers contain glucomannan-like mucilage	Native	Common but monitored due to habitat loss
Tufted vetch	*Vicia cracca*	Flavonoids, saponins, nitrogen-fixing compounds	Native	Common
Purple loosestrife	*Lythrum salicaria*	Ellagitannins, flavonoids, phenolic acids; traditional treatment for diarrhoea and inflammation	Native	Common in suitable wetlands
Purple foxglove	*Digitalis purpurea*	Cardiac glycosides (digitoxin-like compounds), flavonoids; source of heart medicines	Native	Common; locally declining in some areas
Common mallow	*Malva sylvestris*	Mucilage polysaccharides, anthocyanins, flavonoids; soothing anti-inflammatory properties	Native	Common

Discussion

Implications of Tree Cover Distribution Patterns for Woodland Biodiversity in Duffield

The spatial arrangement of dense woodland patches within Duffield suggests a strong influence of landscape topography and historical land use on woodland persistence (Bradfer et.al.,2025). The concentration of higher canopy cover areas along valley slopes and less intensively managed regions indicates that physical geography has played an important role in maintaining woodland habitats (Singh et.al, 2018) [19]. Steep slopes, riparian zones, and areas unsuitable for intensive agriculture often act as refugia where woodland ecosystems persist despite broader landscape modification habitats (Singh et.al, 2018) [19]. theseareas can function as biodiversity reservoirs, preserving native plant communities and providing source populations for species recolonisation habitats (Singh et.al, 2018) [19]. The association between woodland distribution and topographic features highlights the importance of geomorphology in shaping ecological patterns, as variations in elevation, soil moisture, drainage, and exposure influence vegetation composition and woodland development habitats (Singh et.al, 2018) [19].

The presence of woodland gain between 2000 and 2020 provides evidence of ongoing vegetation expansion and ecological recovery processes within Duffield (Staddon, et.al.,2021) [15]. From a biodiversity perspective, this increase in tree cover may enhance habitat connectivity by reducing isolation between woodland fragments (Norden et.al.,2014) [16]. Connectivity is particularly important in fragmented landscapes because many woodland organisms have limited dispersal capabilities and depend on continuous habitat networks for survival (Norden et.al.,2014) [16]. Expanding woodland corridors may therefore improve ecological resilience by allowing species movement in response to environmental changes, climate pressures, and habitat disturbance (Norden et.al.,2014) [16].

However, the difference between overall tree cover distribution and dense canopy distribution also highlights potential limitations in woodland quality (Hill et.al.,2010) [20]. A landscape can contain substantial tree cover while still lacking extensive areas of mature, high-quality woodland habitat (Hill et.al.,2010) [20]. Areas classified only under lower canopy thresholds may represent young plantations, isolated trees, woodland edges, or fragmented habitats that do not provide the same ecological functions as ancient or semi-natural woodland (Hill et.al.,2010) [20]. For biodiversity conservation, the quality, age structure, species composition, and ecological continuity of woodland are as important as the total amount of tree cover (Hill et.al.,2010) [20]. Therefore, the Duffield landscape should be interpreted not simply in terms of woodland quantity but through a framework incorporating habitat maturity, connectivity, and functional ecological value (Hill et.al.,2010) [20].

Ecological Significance of Recorded Plant Species and Their Conservation Importance in the Duffield Landscape

The presence of the recorded plant species within the Duffield landscape provides valuable evidence of the ecological complexity and habitat diversity present within this region. The coexistence of species such as common selfheal (*Prunella vulgaris*), common yarrow (*Achillea millefolium*), bird's-foot trefoil (*Lotus corniculatus*), white clover (*Trifolium repens*), tufted vetch (*Vicia cracca*), and common mallow (*Malva sylvestris*) indicates the presence of semi-natural grassland, roadside verges, woodland margins, and disturbed open habitats (Cliff ,2017) [21]. These flowering plants contribute significantly to ecosystem functioning by providing nectar and pollen resources for a wide range of pollinators, including bees, butterflies, hoverflies, and other insects (Ollerton ,2017) [21]. Leguminous species such as bird's-foot trefoil, white clover, and tufted vetch also perform an important ecological function through biological nitrogen fixation, where symbiotic bacteria associated with their root nodules convert atmospheric nitrogen into biologically available forms (Pinhey, 2022) [23]. This process improves soil fertility and influences plant community composition by supporting nutrient cycling within the ecosystem (Smith et.al.,2015) [24]. The occurrence of woodland-associated species such as hedge woundwort (*Stachys sylvatica*), herb Robert (*Geranium robertianum*), great willowherb (*Epilobium hirsutum*), and European black elderberry (*Sambucus nigra*) suggests the presence of structurally diverse woodland edges, hedgerows, and moist shaded environments (Wright,2016) [25]. These species are indicators of transitional habitats where woodland interacts with open landscapes, creating ecotones that often support exceptionally high biodiversity (Wright,2016) [25].

Elderberry, for example, plays a significant ecological role by producing berries consumed by numerous bird species, while its flowers provide nectar for insects (Wright,2016) [25]. Herbaceous woodland plants contribute to the complexity of the forest floor community by supporting invertebrate populations, influencing nutrient cycling through decomposition, and providing microhabitats for small organisms (Wright,2016) [25]. The presence of these species suggests that Duffield's woodland habitats are not simply areas of tree cover but functioning ecosystems with interconnected plant, animal, and microbial communities (Wright,2016) [25].

The identification of orchid species, including pyramidal orchid (*Anacamptis pyramidalis*) and common spotted orchid (*Dactylorhiza fuchsii*), is particularly ecologically significant (Harrap, et.al.,2010) [26]. Orchids are often considered indicators of habitat quality because many species require specific soil conditions, fungal associations, and relatively stable ecological environments for successful establishment (Harrap, et.al.,2010) [26]. Their presence may indicate areas where traditional grassland management, low nutrient availability, and reduced disturbance have allowed specialised plant communities to persist (Harrap, et.al.,2010) [26]. Orchids also contribute to biodiversity by supporting specialised pollination relationships with insects, demonstrating the ecological importance of maintaining diverse flowering plant communities (Harrap, et.al.,2010) [26]. Although these orchids are not currently classified as nationally threatened in England, many orchid populations have experienced local declines due to habitat loss, agricultural intensification, drainage, and changes in land management (Harrap, et.al.,2010) [26]. Their conservation importance therefore lies not only in their legal status but also in their role as indicators of semi-natural habitat integrity (Harrap, et.al.,2010) [26].

Species such as common yarrow, ragwort (*Jacobaea vulgaris*), creeping thistle (*Cirsium arvense*), bull thistle (*Cirsium vulgare*), and purple loosestrife (*Lythrum salicaria*) demonstrate the importance of so-called "weedy" or pioneer plants within the Duffield ecosystem (Schaefer et.al,1988) [27]. Although sometimes considered undesirable by humans, these species perform essential ecological functions (Schaefer et.al,1988) [27]. Ragwort, despite containing toxic pyrrolizidine alkaloids that make it unsuitable for livestock consumption, is one of the most valuable native plants for invertebrate conservation because it supports specialised species such as the cinnabar moth (*Tyria jacobaeae*) and provides abundant nectar for pollinators (Schaefer et.al,1988) [27]. Thistles are similarly important nectar sources and support numerous insects, including butterflies and seed-feeding birds (Schaefer et.al,1988) [27]. Purple loosestrife contributes to wetland biodiversity by stabilising river margins, supporting pollinators, and providing habitat complexity in damp environments. Their presence indicates that Duffield contains a range of microhabitats capable of supporting diverse ecological interactions (Schaefer et.al,1988) [27].

However, the detection of Himalayan balsam (*Impatiens glandulifera*) represents an important conservation concern (Cockhel et.al.,2012) [28]. Unlike the other recorded species, Himalayan balsam is a non-native invasive plant introduced from the Himalayas and has become widespread across many parts of England (Cockhel et.al.,2012). Its rapid growth, high seed production, and ability to dominate riverbanks and moist woodland habitats allow it to outcompete native vegetation (Cockhel et.al.,2012). During winter, the death of its shallow root system can increase soil erosion along watercourses, potentially affecting aquatic ecosystems (Cockhel et.al.,2012). The presence of Himalayan balsam suggests that monitoring and management may be required, particularly in riparian woodland areas where maintaining native plant communities is important (Cockhel et.al.,2012). Conservation efforts should focus on preventing further spread while promoting the recovery of native wetland and woodland-edge vegetation (Cockhel et.al.,2012).

Conclusions

Overall, the plant species recorded in Duffield represent a biologically valuable assemblage that reflects a landscape containing woodland, grassland, wet habitats, and transitional ecological zones (Crick, et. al., 2020) The majority of recorded species are native and widespread in England, generally classified as Least Concern or common species, but their ecological value extends beyond individual conservation categories (Bull J.,2026) [1]. Together, these plants support pollination networks, soil nutrient cycling, food resources for wildlife, habitat formation, and ecosystem resilience (Goulder R.,2014) [4]. The presence of flowering plants, orchids, native shrubs, and woodland herbs suggests that Duffield supports a functioning ecological network rather than isolated plant populations (Bull J.,2026) [1] Conservation priorities should therefore focus on maintaining habitat connectivity, protecting mature woodland and species-rich margins, controlling invasive Himalayan balsam, and preserving the habitat conditions that allow native plant communities to persist (Cockhel et.al.,2012). The species composition provides important evidence that Duffield's woodland landscape contributes significantly to regional biodiversity conservation and represents an ecologically interconnected system requiring long-term protection and monitoring (Bull J.,2026) [1].

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