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# An assessment of plant species diversity and habitat composition at Mill Lakes, Bestwood Village

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**Abstract**
This study assessed the floristic diversity and vegetation structure of Mill Lakes, Bestwood Village, Nottinghamshire, using field-based quadrat surveys and spatial analysis. Thirty-one 3 × 3 m quadrats, covering a total sampled area of 279 m², were surveyed across woodland edges, grassland and wetland habitats. A total of 73 plant taxa were recorded, with substantial variation in species composition and abundance between quadrats. *Urtica dioica* was the most frequently recorded species, occurring in 29% of quadrats, followed by *Rubus armeniacus* at 26%. Most recorded taxa occurred in only one or two quadrats, indicating considerable small-scale spatial heterogeneity. QGIS analysis further identified a landscape dominated by woodland (approximately 38%), grassland (27%) and water (12%), with urban land accounting for approximately 23%. The integration of quadrat and spatial data demonstrates that Mill Lakes supports a heterogeneous vegetation mosaic with considerable ecological value.

**Keywords:** Floral diversity, Mill Lakes, ecotone, lichen, species

## Introduction

Mill Lakes is a freshwater lake complex located within Bestwood Country Park, in Nottinghamshire, England (Charsley *et al*., 2015) [1]. The site represents an important example of a restored post-industrial landscape, where former mining and agricultural land has undergone ecological succession to become a mosaic of freshwater, wetland, woodland, and grassland habitats (Broughton *et al*., 2020) [2]. Mill Lakes receives water primarily from the River Leen and local surface water drainage, forming interconnected freshwater ecosystems that support aquatic and riparian habitats (Sayer, 2014) [3]. The interface between open water, reedbeds, wet woodland, grassland, and mature deciduous woodland creates high habitat heterogeneity, which is one of the principal factors contributing to the site's biodiversity (Neumann etal. 2016) [4]. These diverse habitats provide breeding, feeding, and refuge opportunities for numerous species of birds, mammals, amphibians, invertebrates, fungi, and vascular plants (Neumann etal. 2016) [4]. From an ecological perspective, Mill Lakes functions as an important urban green infrastructure asset (Aksoy, 2016) [5]. Wetland habitats contribute to ecosystem services including water retention, natural filtration of surface runoff, carbon sequestration, nutrient cycling, and local climate regulation (Mitsch *et al*., 2015) [6]. Woodland communities support pollinating insects, decomposer organisms, and woodland bird assemblages, while aquatic environments sustain fish populations and a diverse macroinvertebrate community that forms the foundation of freshwater food webs (Mitsch *et al*., 2015) [6].

## Methodology

### Field Surveys and Vegetation Assessment

### Quadrat Surveys

A series of quadrat-based vegetation surveys was conducted at Mill Lakes, Bestwood Village, to assess the composition, diversity, and distribution of plant species across the study area. Sampling was undertaken at multiple locations within the north-western, western, north-eastern, and eastern sections of the site. Sampling locations were selected in an unbiased manner along accessible walking trails and associated habitat paths, with the intention of obtaining observations from a range of environmental conditions and vegetation communities. survey 1 consisted of a 20-minute quadrat survey conducted at three sampling locations within the north-western section of Mill Lakes. The sampling points were selected without deliberate preference for particular vegetation communities. The survey formed part of a broader assessment of floral diversity within the site. Weather conditions were overcast, with a cool breeze and an ambient temperature of approximately 20 °C. The use of three sampling locations provided observations from different portions of the surveyed area and enabled comparison of floral composition between sampling points. Survey 2 consisted of a 10-minute quadrat survey conducted at a single sampling location within the north-western section of Mill Lakes. The sampling location was situated along a small pathway leading towards the lake and was selected without deliberate bias along the available trail. The survey was conducted under clear-sky conditions at an ambient temperature of approximately 35 °C. Although the survey duration and number of sampling locations were more limited than in the other surveys, the observations contributed to the overall assessment of vegetation composition within the study area. survey 3 involved a 1-hour-and-30-minute quadrat survey undertaken across a series of sampling locations within the western and north-western sections of Mill Lakes. The survey was conducted under overcast conditions at an ambient temperature of approximately 25 °C. Sampling encompassed a heterogeneous range of habitats, including grassland, woodland/forest, and marsh or wetland environments. This broader habitat coverage allowed plant composition to be examined across contrasting vegetation communities and provided a more comprehensive assessment of local floral diversity. survey 4 consisted of a 1-hour quadrat survey conducted across a series of sampling locations within the eastern and north-eastern sections of Mill Lakes. The survey was undertaken under clear-sky conditions at an ambient temperature of approximately 19 °C. Sampling locations encompassed several habitat types, including grassland, woodland/forest, and marsh or wetland areas. The inclusion of multiple habitat types enabled assessment of differences in plant composition and vegetation structure across the eastern portion of the site.

Collectively, the four surveys provided observations from different geographical sections and habitat types within Mill Lakes. The variation in survey duration and spatial coverage reflects the exploratory nature of the fieldwork and allowed plant species occurring in grassland, woodland, and wetland environments to be documented. The quadrat surveys therefore provided the primary field-based dataset for evaluating floristic composition and habitat-associated patterns in vegetation.

**Vegetation Cover Assessment**

In addition to the field-based quadrat surveys, Geographic Information System (GIS) analysis was undertaken using spatial systems to assess the spatial distribution and extent of vegetation cover across Mill Lakes. The Spatial systems component complemented the quadrat observations by providing a spatial perspective on vegetation distribution rather than relying solely on individual sampling points (Heunneke *et al*. 2001). Vegetation-covered areas were identified and assessed using spatial mapping techniques, allowing the distribution of vegetated habitats to be examined across the study area (Kopecka *et al*. 2017). The resulting spatial assessment was used to characterise the extent and arrangement of vegetation cover and to provide additional context for interpreting the plant species recorded during the quadrat surveys (Kopecka *et al*., 2017). The combination of ground-based quadrat sampling and GIS-based spatial analysis provided two complementary approaches to vegetation assessment (Kopecka *et al*. 2017). Quadrat sampling enabled direct observation and recording of plant species and local vegetation communities, whereas GIS analysis allowed the broader spatial distribution of vegetation to be examined (Gill etal, 1997). Together, these methods provided a more comprehensive assessment of the floristic diversity, habitat heterogeneity, and vegetation structure of Mill Lakes, Bestwood Village.

**Results and Discussion**

**Tree Cover in Mill Lakes**

The tree cover density maps indicate that Mill Lakes is characterised by a heterogeneous woodland structure, with tree cover concentrated primarily around the lake margins, the River Leen corridor, and adjoining woodland blocks, while open water, reedbeds, and grassland maintain areas of lower canopy cover. As the density threshold increases from >10% to >75% tree cover, the spatial distribution of woodland becomes increasingly restricted, demonstrating that although trees are widespread throughout the landscape, only selected areas support dense and mature woodland stands (Steel *et al*.,2023) [10]. At the lower thresholds (>10–20%), a continuous network of trees is visible around much of the lake system, reflecting fragmented woodland, scattered trees, riparian vegetation, hedgerows, and young secondary growth (Fig 1) (Little,2018) [11]. This broad canopy distribution is ecologically significant because it increases habitat connectivity, allowing the movement of birds, mammals, insects, and other wildlife between woodland patches while reducing habitat fragmentation (Farina, 2006) [12]. Intermediate thresholds (>25–50%) reveal that the majority of woodland surrounding Mill Lakes consists of moderately dense canopy cover, particularly along the western margins of the lakes and within established woodland compartments (Little,2018) [11]. These areas are likely to support higher structural complexity, including multiple vegetation layers comprising canopy trees, sub-canopy species, shrubs, and a well-developed ground flora (Little,2018) [11] (Farina,2006) [12].

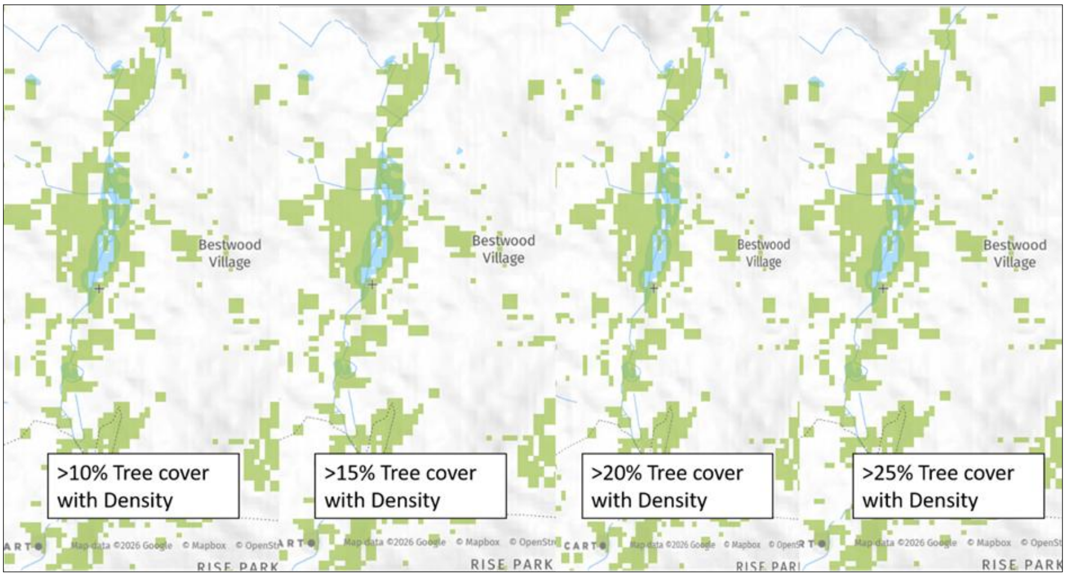


**Fig 1:** Vegetation Cover of Mill Lakes between 10% to 25%

At the highest density threshold (>75%), only a limited number of woodland patches remain visible, indicating the presence of mature woodland cores with closed canopies (Fig 2) (Mountford *et al*., 2006) [13]. These high-density woodland areas are particularly valuable from a conservation perspective because they provide stable microclimatic conditions, including reduced temperature fluctuations, higher humidity, and protection from wind exposure. Such conditions favour shade-tolerant vascular plants, bryophytes, lichens, saproxylic invertebrates, woodland fungi, and cavity-nesting birds (Mountford *et al*., 2006) [13].

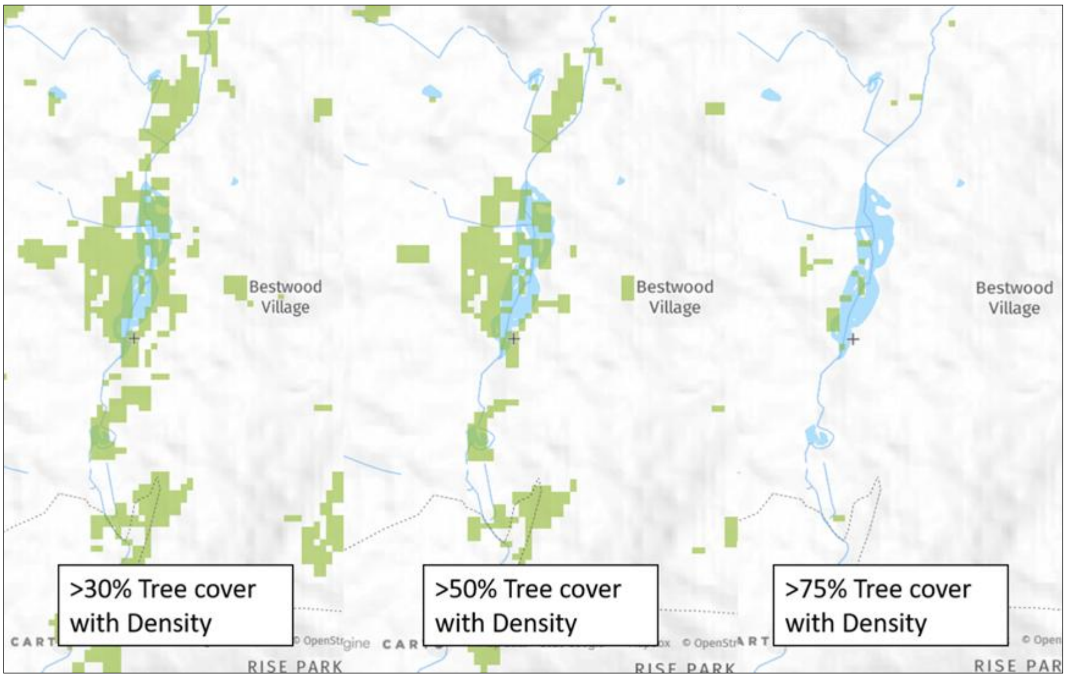


**Fig 2:** Vegetation Cover of Mill Lakes between 30% to 75%

The relatively limited extent of these dense woodland cores suggests that much of the woodland surrounding Mill Lakes comprises mixed-age secondary woodland that has naturally regenerated following landscape restoration associated with former mining activities. (Holtz, 1981) [14]. Overall, the spatial distribution of tree cover demonstrates a well-balanced landscape mosaic in which woodland, freshwater habitats, reedbeds, grassland, and open spaces coexist to maximise habitat heterogeneity (Liu, 2022). This mosaic is one of the principal drivers of the site's high biodiversity, as ecotones—the transition zones between woodland and aquatic habitats—often support greater species richness than homogeneous habitats (Ward etal., 1999) [16]. Furthermore, the woodland contributes a range of ecosystem services, including carbon sequestration, regulation of local microclimate, interception of rainfall, reduction of surface runoff and soil erosion, enhancement of water quality through riparian buffering, and provision of food and shelter for wildlife (Ward etal., 1999) [16]. Consequently, the tree cover density observed at Mill Lakes reflects not only the ecological maturity of different woodland stands but also the successful restoration and long-term development of a resilient, multifunctional landscape capable of supporting diverse biological communities and maintaining important ecosystem functions (Ward etal., 1999) [16].

**Vegetation Survey and Sampling**

Vegetation was sampled at Mill Lakes using 31 quadrats, each 3×3 m (9 m²), yielding a total sampled area of 279 m². Quadrats were placed across different habitat sections (woodland edges, open grassland and wet margins) to capture spatial variation (Carpenter, *et al*., 2012) [17]. Within each quadrat all vascular plant species were recorded and their cover or abundance estimated (Carpenter, *et al*., 2012) [17]. In practice this involved counting individuals or estimating cover for each taxon in the frame, as recommended for quantitative vegetation survey (Carpenter, *et al*., 2012) [17]. The quadrat method delimits a standard area for each sample, ensuring results are comparable between plots (Carpenter, *et al*., 2012) [17]. All data were later compiled to calculate species richness (total number of taxa) and frequency of occurrence (percentage of quadrats occupied) for each species.

- **Total sampled area:** 31 quadrats × 9 m² = 279 m².
- **Total species richness:** 73 distinct plant taxa were recorded across all quadrats.
- **Mean richness per quadrat:** ≈ 4.1 species (range 1–8 species per 9 m²).
- **Most frequent species:** *Urtica dioica* (stinging nettle) occurred in 9 of 31 quadrats (29% frequency), *Rubus armeniacus* (Armenian blackberry) in 8 quadrats (26%), and a few others (Cow parsley, Hogweed, Perennial rye-grass, etc.) in 4–5 quadrats (13–16% each).

**Species Richness and Diversity**

Across the 31 quadrats a total of about 73 plant taxa were identified (counting each named species or group once). This constitutes the floral species richness of the sampled area. Species richness is simply the count of distinct species present. Because each quadrat covers only 9 m², individual quadrats contained only a handful of species (1–8 each); collectively the larger pooled area reveals higher diversity. For standardization, species richness here is reported as the raw count (no diversity index was calculated). The observed species accumulation (73 species in 279 m²) reflects the heterogeneous habitats around Mill Lakes. Many taxa were singletons or very rare (e.g. Sycamore Maple, Great Willow Herb, Black Knapweed appeared only once or in one plot), indicating localised niches, whereas a few species were widespread (see below).

Species frequency was calculated as the percentage of quadrats in which each species was recorded. For example, a species found in 15 of 30 quadrats would have a 50% frequency. In our data, the highest frequencies were: Great Stinging Nettle (present in 9/31 quadrats, 29% frequency) and Armenian Blackberry (8/31, 26%). Several herbaceous weeds also had moderate frequencies (e.g. Cow Parsley, Hogweed, Perennial Rye-grass, Umbellifer Powdery Mildew fungus each in ~4/31 plots). In contrast, most species (about two-thirds of taxa) occurred in only one or two quadrats, yielding frequencies <7%. (By definition frequency ranges from 0–100%; here no species was in all quadrats.)

**Species Abundance and Dominance**

The abundance of each species was summed across plots (as raw count or cover units). Several taxa dominated numerically or by cover in the survey. *Stinging nettle* had the highest total count (73 "hits" across plots) and was also the most frequent species. *Perennial rye-grass* had the next highest total (63 hits, largely due to 40 in one quadrat) and occurred in four plots (often in grass-dominated sites). Armenian blackberry totaled 40 individuals (8 plots). Other abundant species included Cow Parsley (34 total), Umbellifer powdery mildew (37, a fungus on umbels), Common Dandelion (30 in one plot), Great Willow-herb (30 in one plot), Hogweed (20 total), and Greater Plantain (32 total across four plots). These totals indicate which species contributed most vegetation cover or biomass overall. In particular, species like Common Dandelion and Great Willow-herb were locally dominant in single quadrats (30 counts each in Plots 3 and 25), illustrating patchiness (i.e. some quadrats were dominated by one or two species).

Dominant species in a plant community are those with the greatest cover or biomass (Whittaker, 1965) [18]. The survey data show a classic pattern: a few species had very high abundance while many were rare (Whittaker, 1965) [18]. For example, *Urtica dioica* (common nettle) was highly abundant and often dominant; this is consistent with its ecology as a nitrogen-loving plant – "the presence of nettles may indicate … soil fertility" (Taylor, 2009) [19]. Similarly, *Rubus* (bramble) species readily colonize disturbed ground; they are "very common and adaptable… found in hedgerows, woodland, meadows, [and] waste ground" (Oleskevich etal., 1996) [20]. Thus, the local dominance of nettles, brambles, thistles, ragwort and similar weeds suggests nutrient-rich or disturbed microsites within the Mill Lakes area (Timoney, 1998) [21]. Conversely, true woodland or wetland indicator species were much less common (e.g. only one quadrat had *Sycamore Maple*, one had *White Willow*).

**Conclusion**

The floristic data reflect a mosaic of habitats around the lake (Birks, etal., 1992) [24]. Certain quadrats had composition characteristic of open, disturbed grassland or meadow. For instance, Plot 3 (north-west site) was dominated by weedy herbs (*Dandelion*, *Greater Plantain*, *Tropical Horseweed*, *Ragwort*) with sparse grasses, indicating a bare, nitrogen-rich soil (Maron etal., 1996) [25]. Similarly, Plot 25 (eastern edge) contained only *Great Willow-herb* (a tall ruderal) with 30 counts, suggesting a marshy or recently disturbed bank (Brabandere etal. 2006) [22]. In contrast, other quadrats had more woodland-edge assemblages. Plots 5–7 (western side) included shrubs and trees (*Guelder* Rose, Silver Birch, European Alder) along with forest-floor herbs (Iris sp., Plantain), indicating semi-shaded, moist conditions (Bickford etal.,1979) [23]. Plots 21–24 (north-east) featured typical scrub species (Dogwood, Hawthorn, Elderberry, Alder, Willow) mixed with nettles and brambles – consistent with a transitional woodland margin. Plot 31 (southern lawn) contained mainly Perennial Ryegrass (40 counts) and few broadleaves, reflecting a mown or parkland grass sward (Dodd etal, 2010) [26].

These patterns are ecologically meaningful (Farrant, etal. 2016) [27]. Quadrats at the lake margin or path edges tended to have nitrophilous ruderals (nettles, ragwort, dock mildews), while interior-woodland quadrats included more saplings and shade-tolerant herbs (Glaeser, 2004) [28]. The scattered presence of certain indicator species (e.g. Hedge Woundwort, Yellow Iris near water; Guelder Rose, Silver Birch in understorey) helps infer microhabitats (Glaeser,2004) [28].. Overall, the floristic composition suggests that Mill Lakes supports a mix of coarse grassland/scrub and woodland-edge communities, with local disturbances (trails, windthrow, soils) creating patches rich in ruderal species (Kelly, 1990) [29]. The data thus capture both the common "generalist" species and the patchy occurrences of others, reflecting small-scale environmental heterogeneity.

In summary, the 31-quadrat survey found moderate species richness (73 taxa) and considerable variation in vegetation structure across the site. A few species (U. dioica, R. armeniacus, Heracleum sphondylium, etc.) were frequent and abundant, while most taxa were infrequent. This dominance pattern – common weeds vs. many rare species – is typical of mixed habitats and suggests a landscape influenced by nutrient inputs and disturbance (Booth, 2003) [30]. The quantitative measures (richness, frequency, cover) therefore provide a detailed scientific description of the Mill Lakes flora, which can serve as a baseline for further ecological interpretation or monitoring.

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