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Proliferation and ecological impact of Cow Parsley (*Anthriscus sylvestris*) in temperate woodland ecosystems

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Abstract
Cow Parsley (*Anthriscus sylvestris*) is a widespread biennial herb that exerts significant influence on British woodland ecosystems. Its early phenology, rapid spring growth, and high nectar production support pollinators and enhance understorey structure, yet these same traits can lead to competitive dominance. Dense stands frequently suppress slower-growing woodland specialists, alter soil chemistry through allelopathic compounds, and shift successional trajectories, particularly in nutrient-enriched or poorly managed sites. This study highlights Cow Parsley's dual ecological role—as both facilitator and antagonist—and emphasises the need for context sensitive woodland management aimed at balancing its ecological benefits with the conservation of native woodland biodiversity.

Keywords: Herb, invasive species, competition, phytochemicals, ecology

Introduction

Cow Parsley (*Anthriscus sylvestris* (L.) Hoffm.) is a common and widespread biennial herb belonging to the Apiaceae (Umbelliferae) family, well known for its early-season emergence and conspicuous white umbels. Native to Europe and parts of Asia, A. sylvestris has become emblematic of the British springtime landscape, frequently dominating roadside verges, field margins, woodland edges, and hedgerows (Stace, 2019) [17]. Its ecological ubiquity, rapid phenological development, and capacity to colonise disturbed habitats have sparked both interest and concern among ecologists, particularly regarding its influence on woodland biodiversity, plant community dynamics, and habitat structure.

Cow Parsley typically germinates in late summer or early autumn, forming a basal rosette of finely dissected leaves during its first year. In its second year, the plant rapidly sends up flowering stalks, often exceeding 1.5 metres in height, culminating in characteristic compound umbels of small, white, five-petalled flowers (Rose & O'Reilly, 2006) [15]. Flowering typically occurs from April through June, coinciding with a temporal niche in which few other species of comparable size and cover are active in the woodland understorey. This phenological advantage allows A. sylvestris to outcompete other species for light and space, particularly in semi-open environments where canopy closure is incomplete or seasonally delayed (Grime *et al*., 2007) [4]. Its dominance in early spring ground flora has led to speculation about its role as a keystone species in lowland temperate ecosystems. Cow Parsley is a notable attractant for a wide range of pollinators, including bees, hoverflies, beetles, and parasitic wasps (Hicks *et al*., 2016) [5]. As a generalist nectar and pollen source, it serves an important ecological function during a period when floral resources are relatively scarce. This provisioning role may benefit early season pollinator communities and, by extension, the reproductive success of co-occurring plant species that rely on the same functional pollinator groups (Bates *et al*., 2020). Furthermore, the plant contributes to soil structure and moisture retention, offering habitat and microclimatic niches for invertebrates and small vertebrates alike. However, this positive ecological image is not without contest. Concerns have been raised about the competitive dominance of A. sylvestris in certain contexts, particularly in disturbed or semi-natural woodlands where management regimes have changed or ceased. Its ability to establish dense monospecific stands can suppress the regeneration of shade-intolerant herbaceous plants and woody seedlings (Mountford et.al., 2003) [11]. Such competitive exclusion may reduce local species richness and alter successional trajectories, particularly in ancient woodlands or conservation areas with sensitive flora. This has led some to classify Cow Parsley as a "native invader" in regions where its abundance has been amplified by anthropogenic change (Maskell *et al*., 2006) [10].

Discussion

One of the ecological paradoxes of Cow Parsley lies in its dual response to disturbance and stability. While it thrives in nutrient-rich, semi-disturbed soils—a hallmark of ruderal species—it also persists in relatively stable environments, provided that light levels remain adequate and disturbance does not reach a threshold that would favour more aggressive competitors such as Urtica dioica or Heracleum sphondylium (Rodwell, 1998) [14]. Its success is therefore strongly mediated by factors such as canopy cover, soil fertility, light availability, and grazing pressure. Studies by Smart *et al*. (2004) [16] have demonstrated that elevated nitrogen deposition across the UK has facilitated the spread of nitrophilous species like A. sylvestris, contributing to compositional shifts in woodland ground flora communities. In traditional woodland management systems, such as coppice-with-standards, the patchy light environment created by rotational cutting supported a dynamic and heterogeneous understorey flora. However, the decline of these systems has resulted in increasingly uniform and shaded woodland interiors, punctuated by edge habitats and rides where light-loving species, including Cow Parsley, may proliferate (Kirby *et al*., 2005) [8]. In these ecotones, the plant plays a significant role in defining community

composition and ecosystem function. It is also in these zones that its competitive effects on regenerating tree seedlings and woodland herbs may be most pronounced (Rackham, 2003) [12].

In addition to its ecological effects, A. sylvestris has cultural and aesthetic significance in Britain. Its frothy white umbels are frequently celebrated in rural folklore and nature writing as heralds of spring, and the plant has featured in traditional hedgerow medicine, although its usage is now minimal (Grieve, 1931) [3]. Despite its benign appearance, accurate identification is important, as Cow Parsley bears morphological resemblance to several toxic members of the Apiaceae family, such as Hemlock (Conium maculatum) and Fool's Parsley (Aethusa cynapium), which can pose a risk to foragers and livestock. From a conservation perspective, understanding the ecological role of Cow Parsley is vital to woodland management and restoration strategies. Its presence in indicator species lists for ancient woodland is ambivalent; while it is not considered diagnostic of ancient woodland status, its co occurrence with other species may inform assessments of habitat quality or successional stage (Goldberg et.al., 2007) [7]. Moreover, its temporal dominance in spring makes it a critical species for studying phenological shifts in response to climate change. Earlier flowering times have been documented across the UK, and species such as A. sylvestris serve as useful bioindicators of environmental change (Fitter & Fitter, 2002) [2].

Ultimately, the question of whether Cow Parsley is a "friend or foe" to woodland biodiversity hinges on ecological context. In some environments, it may act as a facilitator—supporting pollinators, preventing soil erosion, and contributing to structural diversity. In others, particularly those with reduced management, high nutrient loading, or disrupted successional processes, it may exert suppressive effects that reduce compositional diversity and hinder natural regeneration. These dualities make it an ideal subject for examining the nuanced interplay between native flora, disturbance regimes, and biodiversity outcomes in British woodlands.



Fig 1: Cow Parsley (*Anthriscus sylvestris*) emerges early and rapidly in woodland ecosystems, often dominating the ground layer. This study examines whether it functions as a keystone ground flora—supporting pollinators and stabilizing soils—or if its dense growth suppresses native understory species. Through field surveys and ecological analysis, we explore its dual role as both facilitator and competitor in woodland biodiversity.

Ecological Benefits of Cow Parsley (*Anthriscus sylvestris*) in Woodland Ecosystems: Biodiversity Support, Phytochemical Contributions, and Evolutionary Role

Cow Parsley is among the first herbaceous plants to flower in spring, forming dense ground cover and offering critical ecological services during a resource-scarce period. Its early flowering is supported by rapid mobilisation of stored carbohydrates from the taproot, where starch reserves are hydrolysed into glucose via amylase, later converted into sucrose through sucrose-phosphate synthase. This sucrose is transported to flower tissues and secreted as nectar via the apoplastic pathway. Its abundant nectar and pollen supply support a wide guild of early pollinators including hoverflies (Syrphidae), solitary bees (Andrenidae), honeybees (Apis mellifera), and parasitoid wasps (Hicks *et al*., 2016) [5]. Nectar sucrose is further broken down by pollinators—bees enzymatically hydrolyse sucrose into glucose and fructose using midgut invertase, providing immediate energy for thermoregulation and flight. By supporting these insects, Cow Parsley indirectly contributes to the pollination success of other spring and early-summer flora in the same woodland strata, forming a mutualistic web of biotic relationships. By supporting these insects, Cow Parsley indirectly contributes to the pollination success of other spring and early-summer flora in the same woodland strata, forming a mutualistic web of biotic

relationships. Additionally, the plant's tall, hollow stems provide microhabitats for overwintering invertebrates and shelter for small mammals such as voles and shrews. This structural complexity enhances the vertical and temporal diversity of the understorey, which benefits both invertebrate predators and the species that rely on them, such as insectivorous birds and amphibians (Kirby *et al*., 2005) [8]. Cow Parsley synthesises a suite of secondary metabolites with ecological and physiological significance. These include coumarins, flavonoids, essential oils, and polyacetylenes, produced through well-characterised metabolic pathways, which have been documented for their roles in plant defence, antimicrobial activity, and allelopathic effects (Wink, 2003) [19]. For example, phenylalanine is deaminated via phenylalanine ammonia-lyase (PAL) to form cinnamic acid, which is converted through the phenylpropanoid pathway into umbelliferone and scopoletin, key coumarins with defensive and allelopathic properties. Flavonoids originate from acetyl-CoA and malonyl-CoA condensation reactions catalysed by chalcone synthase, while polyacetylenes derive from fatty-acid desaturation and elongation reactions. Coumarins such as umbelliferone and scopoletin are known to inhibit germination and root elongation of competing plants, partly by interfering with auxin (IAA) transport proteins and reducing peroxidase activity required for cell wall loosening (Reigosa *et al*., 2006) [13]. In exposed root tips of neighbouring plants, these compounds may trigger reactive oxygen species (ROS) formation, leading to oxidative stress and growth suppression. While such allelochemicals may contribute to A. sylvestris' competitive advantage, they also have ecological benefits. The phytochemicals may inhibit pathogenic fungi in the rhizosphere by disrupting ergosterol synthesis and deter herbivory by generalist invertebrates, thus maintaining the plant's role in stabilising early ground flora communities (Inderjit & Duke, 2003) [6].

Cow Parsley's extensive fibrous root system helps bind topsoil, reducing erosion in woodland edge habitats and paths subjected to trampling or runoff. As a biennial, its leaf litter decomposes rapidly, contributing organic matter and nutrients to the soil. Decomposer fungi and bacteria accelerate breakdown of tissues through cellulase mediated hydrolysis of cellulose to glucose and laccase/peroxidase oxidation of lignin. The nitrogen-rich detritus promotes microbial activity through ammonification (organic nitrogen $\rightarrow NH_4^+$), followed by nitrification ($NH_4^+ \rightarrow NO_2^- \rightarrow NO_3^-$), providing a pulse of plant-available nitrogen timed to early growth stages of other woodland species. This synchronises nutrient cycling with seasonal community dynamics (Grime *et al*., 2007) [4]. Furthermore, Cow Parsley supports a diverse mycorrhizal community, fostering indirect associations with other woodland plants through shared fungal networks. Mycorrhizal fungi mobilise phosphorus via acid phosphatase mediated cleavage of organic P compounds and transfer inorganic phosphate (Pi) directly to A. sylvestris roots. Nitrogen exchanged through the symbiosis is processed by the plant through nitrate reductase and nitrite reductase reactions ($NO_3^- \rightarrow NO_2^- \rightarrow NH_4^+$), enabling incorporation into amino acids via the GS-GOGAT pathway. This microbial connectivity potentially enhances nutrient exchange, stress tolerance, and community resilience in species-rich woodlands (van der Heijden *et al*., 1998) [18]. The evolution of *Anthriscus sylvestris* within woodland margins and semi-open environments demonstrates a suite of traits selected for rapid early growth, shade tolerance during early rosette stages, and opportunistic colonisation of disturbed gaps (Stace, 2019) [17]. Its phenological strategy—growing early before canopy closure— relies on gibberellin-mediated activation of stem elongation pathways and chlorophyll biosynthesis reactions, such as the NADPH-dependent reduction of protochlorophyllide to chlorophyll a. This biochemical tuning allows efficient utilisation of spring light before canopy leaf-out. Genetic variation within A. sylvestris populations across Britain indicates local adaptation to specific light and soil conditions, supporting its success in varied woodland microhabitats (Kleijn & Steinger, 2002) [9]. Its persistence in post-glacial refugia and ancient woodland edges suggests it may have played a long-standing role in the successional mosaic of British forests.

Challenges Posed by Cow Parsley (*Anthriscus sylvestris*) in Woodland Ecosystems: Competitive Dominance, Phytotoxic Effects, and Ecological Shifts While Cow Parsley plays a functional role in early successional stages, its dense and vigorous growth can outcompete less aggressive native woodland herbs and ground flora. In disturbed or fragmented habitats, it often forms monocultural stands that displace species such as Primula vulgaris (primrose), Hyacinthoides non-scripta (bluebell), and Viola reichenbachiana (early dog-violet), reducing overall plant diversity (Kirby *et al*., 2005) [8]. This competitive dominance is amplified by its ability to rapidly mobilise carbohydrates—amylase-driven starch hydrolysis followed by sucrose synthesis—allowing fast vertical growth before neighbouring plants can establish (Kirby *et al*., 2005) [8]. Its early phenology and rapid height gain create a shading effect that suppresses seedlings of shade-intolerant species, altering the typical stratification and successional dynamics of ancient and semi-natural woodlands. Prolonged shading affects the photosynthetic light-harvesting complexes of suppressed species, reducing chlorophyll a/b ratios and limiting the Calvin cycle. This dominance may shift community structure toward ruderal or generalist species and reduce microhabitat availability for woodland specialists (Grime *et al*., 2007) [4].

Cow Parsley produces allelochemicals such as umbelliferone, scopoletin, and falcarindiol, which may inhibit the germination and growth of neighbouring plants. These compounds act through several biochemical mechanisms:

- Inhibition of auxin efflux carriers (PIN proteins), impairing polar auxin transport required for root elongation.
- Reduction of root peroxidase activity, limiting cell wall loosening and expansion.
- Induction of reactive oxygen species (ROS) in root meristems, causing oxidative stress and reduced mitotic activity.

These secondary metabolites can also alter the chemical ecology of woodland soils by modifying microbial activ ity and disrupting mycorrhizal associations (Inderjit & Duke, 2003) [6]. Coumarins are known to interfere with fungal metabolism by inhibiting ergosterol biosynthesis, while polyacetylenes can impair fungal NADH dehydrogenase activity, reducing hyphal growth. Such disruptions weaken arbuscular mycorrhizal fungi that depend on stable oxidative

metabolic pathways, thereby compromising nutrient exchange with woodland herbs and geophytes.

While these compounds protect Cow Parsley from herbivory and pathogens, they may destabilise beneficial soil symbioses vital to slower-growing woodland flora. Such allelopathic interactions favour A. sylvestris at the expense of co-evolved, mycorrhiza-dependent species, possibly leading to long-term soil legacy effects and community homogenisation (Reigosa *et al*., 2006) [13]. Soil legacy effects may persist because allelochemicals can bind to humic substances and be slowly released through microbial hydrolysis, prolonging their influence on germination and root function.

Cow Parsley's promotion of early-season pollinators may come at the cost of phenological mismatches with other plant-pollinator systems. Its abundant sucrose-rich nectar can draw pollinators away from rarer plants whose floral nectar contains different sugar ratios or amino acids important for specialised species. This disruption interacts with pollinator physiology: invertase-mediated sucrose hydrolysis in bee midguts favours high-sucrose nectar, potentially biasing foraging away from species with lower sucrose content. Over time, such competitive pollinator attraction may reduce seed set in specialist woodland flora. Moreover, Cow Parsley's dominance provides fewer food resources for late-season herbivores and seed-feeders, potentially altering trophic timing, metabolic cycles, and prey availability for birds and invertebrate predators.

Furthermore, Cow Parsley supports generalist herbivores such as aphids, which may experience outbreaks in monoculture stands. Aphids benefit from the phloem's high sucrose concentration, which they process using sucrase–transglucosidase reactions that convert excess sugars into honeydew. These outbreaks can destabilise predator–prey dynamics and facilitate pest spillover into adjacent habitats (Hicks *et al*., 2016) [5]. Elevated honeydew levels may also stimulate the growth of sooty mould fungi, further affecting photosynthetic performance of nearby plants.

The ecological plasticity and evolutionary adaptability of Cow Parsley allow it to thrive in woodland margins, disturbed ground, and light gaps within canopy cover. Its rapid life cycle, seed dispersal ability, and tolerance of varied soil types have enabled it to expand beyond its traditional niche in Britain's wood-pasture and hedgerow systems (Stace, 2019) [17]. Seed germination is enhanced by gibberellin-mediated activation of α-amylase, ensuring strong establishment after disturbance events. Climate change and increased habitat disturbance have further en abled its incursion into ancient woodland interiors, where its presence was historically limited. Warmer springs accelerate gibberellin and cytokinin biosynthesis, favouring early bolting and flowering. Such expansion, often exacerbated by edge effects and nutrient enrichment from surrounding farmland or urban runoff, raises concern for its role as a "subtle invader"—not exotic, but increasingly disruptive (Kleijn & Steinger, 2002) [9].

Conclusion

Over the past three years of studying *Anthriscus sylvestris* in British woodlands, it was witnessed that the species got a remarkable ability to dominate early spring ground flora, often at the expense of native species diversity. Cow Parsley's rapid growth, prolific seed production, and phenological advantage enable it to colonize disturbed and semi-natural woodland habitats aggressively. While it undeniably provides important ecological services— such as supporting early-season pollinators, contributing to soil stabilization, and enhancing structural complexity—its unchecked proliferation poses significant challenges for woodland biodiversity. The observations made during this study underscore a growing concern: many native woodland herbs and specialist plants are increasingly marginalized or lost in areas where Cow Parsley forms dense, monospecific stands. This displacement threatens the integrity of woodland ecosystems, particularly in ancient woodlands where conservation of floral diversity is critical. The allelopathic potential of Cow Parsley and its ability to alter microhabitats and soil chemistry further exacerbate its suppressive effects on slower-growing, shade-intolerant species. The ecological duality of Cow Parsley as both a beneficial native species and a subtle invader highlights the complex consequences of anthropogenic changes—such as altered management practices, nutrient enrichment, and climate change—on woodland dynamics. It is imperative that woodland managers and conservationists recognize the nuanced role of A. sylvestris and develop strategies that mitigate its dominance without disregarding its ecological functions. Restoration efforts should aim to balance disturbance regimes, maintain heterogeneous canopy structures, and control nutrient inputs to support diverse and resilient woodland plant communities. Ultimately, the story of Cow Parsley serves as a powerful reminder of the fragile balance within temperate woodland ecosystems and the importance of vigilant, informed stewardship to safeguard native biodiversity in an era of rapid environmental change.

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