How Ancient Trees and Botanical Indicators Evidence Both Change and Continuity

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How Ancient Trees and Botanical Indicators Evidence Both Change and Continuity

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Abstract: Knowledge of ancient trees and tree-forms helps inform understanding of landscape continuity and change. Information analysis of tree-form and growth rates may be combined with precise aging through dendro-chronology and carbon dating. Until recently, much of the information has been neglected, and indeed, there was an absence of accepted methodologies. Assessments of both coppice trees and pollards, for example, now suggest that trees achieve great age (for example, 500 years+ to 1500 years or more). These trees reflect both natural processes and human management. Examined within a robust conceptual and analytical framework, these trees generate insight into landscape evolution over centuries. Tree analysis combined with archival sources and site archaeological information, including mapping of 'botanical indicator species', soils, and other sediments, generate reliable timelines of human–environment interactions. Drawing together diverse approaches and insights into landscape evolution helps the formulation of new concepts of historical ecology and environmental history. Importantly, such emerging paradigms trigger new ways to demonstrate how understanding past landscape evolution both informs knowledge of contemporary ecologies and may guide future site planning. However, there is a rider to these observations since case studies in Great Britain highlight the vulnerability of such historic landscapes and show how they are being rapidly erased from the countryside.

Keywords: ancient trees; ancient woods; botanical indicator species; landscape evolution; landscape change; continuity; land-use planning

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1. Introduction

Research on coppice trees and pollards indicates their potential to achieve considerable age, in some cases from 500 years+ to in excess of 1500 years [1–6]. Such aged specimens result from a mix of natural processes and human, often traditional, management. If these trees are considered through a suitably robust conceptual and analytical framework, they may provide information on landscape evolution over many centuries. Case studies drawn from locations in Great Britain and subject to long-term action research and assessment have been presented in order to demonstrate the vulnerability of these historic landscapes. The studies indicate that these unique resources are being erased from the countryside, and the rate of attrition has increased dramatically in recent years [7–12].

Ancient woodlands can be evidenced through research on trees and on treescapes (such as ancient woods, wood-pastures, and wooded commons) and on botanical indicator species associated with them. Such indicator species distributions can be mapped and analysed in terms of their rates of recolonisation into new or disturbed sites together with their ability to persist or not, in the event of significant change. Indicators help inform

understanding of both continuity and antiquity, especially when combined with other site-related evidence [13].

Particularly in Great Britain, but also in North America, there has been considerable interest in the concepts of 'ancient' woods and 'old-growth' forest, e.g., [14–23]. Attempts are then made to relate these to contemporary management, to conservation, and to local and national planning issues though the Ancient Woodland Inventory [23]. The baseline for such approaches emerged from concepts of treed landscapes that emerged in Britain in the 1970s led by discussions between Cambridge University scholar Oliver Rackham and British government agency woodland advisor George Peterken (Peterken pers. comm. and [24]). This early dialogue was a first attempt to rationalise 'woodlands' and 'woods' in the historic landscape context. Additionally, site-based studies evidenced these landscapes with discernible long timelines were 'ancient' (defined as either by Rackham as pre-1600 AD or by Peterken as pre-1700 AD) but not 'primeval' wildwood, e.g., [25,26]. These were eco-cultural sites of anciently treed countryside but with long histories of human utilisation and impacts. Such observations challenged the wider, popular misconceptions of ancient woods being *de facto* 'wildwood' [27,28].

However, even as wider awareness of the importance of ancient woodlands was recognised, the misunderstanding of their origins has remained. Many approaches to woodland management are fundamentally flawed by a lack of understanding of their historic context [29–31].

With these issues in mind, research in Britain and also across Europe addressed the issues in order to develop a robust interrogation of forest and woodland histories and dynamics to provide information for managers and policy-makers [32]. This paper presents an overview of the assertions and a model for historical and ecological insight into more effectively framed woodland antiquity and ecological continuity for future management. The policy context of the discussion is the importance placed on the designation of 'ancient woodland' in, for example, British land-use planning, e.g., [33,34]. This takes the discussion of woodland histories and origins beyond an academic exercise to a matter of statutory recognition, protocols, and protection. Finally, though, it is asserted that woodland heritage and archaeology are widely neglected and contemporary management, even by conservation organisations, is rapidly eroding the resource.

1.1. What Is Ancient Woodland?

A fundamental concept relating to nature conservation and land-use planning, especially in Great Britain, but elsewhere in Europe too, is that of 'ancient woodland'. However, this designation presents many challenges when applied in practice, and definitions vary between countries and are affected also, by biogeographical influences. Furthermore, an understanding of the landscape history context is essential in evaluating ancient status.

'Ancient Woodland' in England is defined as an area that has been wooded continuously since at least 1600 AD. Some definitions give 1700 AD as the preferred date, a choice explained by Peterken [35], and more recently [24], and by Goldberg et al. [36]. The definitions are essential but also problematic. Across Great Britain, for example, there are different cut-offs in dates between England and Wales (1600 AD), Scotland (1750 AD), and Northern Ireland (1830 AD) [37]. This raises issues of both science and history since a woodland might be deemed ancient in Gretna Green (Southwest Scotland) but not so in nearby Carlisle (Northwest England) under a system based on the production of the first reliable maps, the subjective understanding of countryside history, and an assumption for England and Wales that there was little if any tree planning for woodland creation before the date of 1600 AD.

The 2023 report on the Ancient Woodland Inventory in Scotland expresses very clearly what it is, and how it should be applied with caution. The below is modified from the entry in the report by Hall [38]. The Ancient Woodland Inventory (AWI) is a provisional guide to the location of ancient woodland. It contains three main categories of woodland, all of which are likely to be of value for their biodiversity and cultural value by virtue of their antiquity:

i. Ancient woodland (1a and 2a)

Interpreted as semi-natural woodland from maps of 1750 (1a) or 1860 (2a) and continuously wooded to the present day. If planted with non-native species during the twentieth century they are referred to as plantations on ancient woodland sites (PAWS).

ii. Long-established woodlands of plantation origin (LEPO) (1b and 2b)

Interpreted as plantations from maps of 1750 (1b) or 1860 (2b) and continuously wooded since. Many of these sites have developed semi-natural characteristics, especially the oldest ones, which may be as rich as ancient woodland.

iii. Other woodlands on 'Roy' woodland sites (3)

Shown as unwooded on the first-edition maps but as woodland on the Roy maps. Such sites have, at most, had only a short break in continuity of woodland cover and may still retain features of ancient woodland.

iv. A note of caution

The AWI was derived from the Roy maps (*c*.1750) and the Ordnance Survey first edition (c. 1860). It is not definitive and should be used with care. When evaluating woods, it is important to conduct the following:

(a) Examine the site on the ground, looking for archaeological, biological, and other indicators of antiquity and of its current biodiversity value. (b) Examine old maps. The Ordnance Survey first edition and Roy maps are available online. Woods not shown in the AWI, but present on the historic maps, are likely to be ancient and should be treated as such unless evidence is available to the contrary. (c) Seek specialist advice if in doubt.

The idea of 'continuously wooded' should not imply continuous physical cover of trees and shrubs as open land (both temporary and permanent) is an important component of a woodland landscape and a core element of a wood-pasture or wood-meadow. Furthermore, in most and maybe all ancient woodlands, trees and shrubs have periodically been cut down as part of anthropogenic management. In England (Natural England, 2008), guidance states that an area is still considered ancient if it has been maintained by replanting or regrowth from, for instance, coppicing. In the latter case, if a working wood has been cut-over many times in its history, it will have very old (and frequently unrecognised) coppice stools but often few old standard trees [16–18]. Agency guidance in Britain advocates that woodland experiencing long periods over the last four centuries when the land was in effective open (grassland, heath, moor, or arable) is defined as 'recent' woodland. Natural England asserts that such a wooded site may retain high value for nature conservation, but it is not ancient. Reinterpretation from an ecological historical perspective of site-based studies and core criteria provides more nuanced interpretations of the landscape history [39]. Evidence of former human utilisation is also significant (Figures 1 and 2).

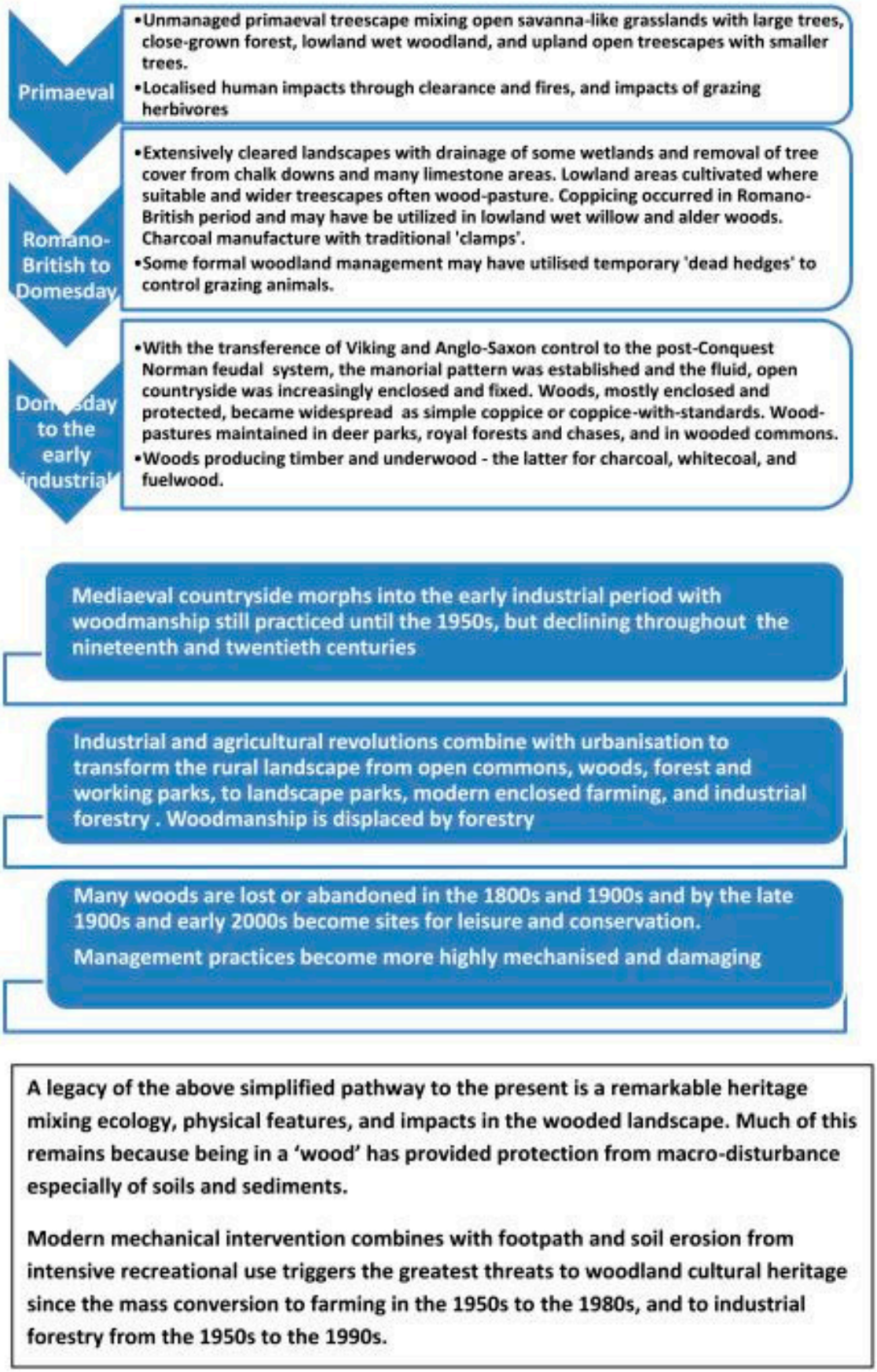

Figure 1. Overview timeline of typical English woodland history.

Figure 2. Wood-collier's monument in Ecclesall Woods, Sheffield.

1.2. The Value of Ancient Woodlands

In nature conservation terms, ancient woodlands are of very high ecological and landscape importance, though their remarkable heritage values are frequently overlooked [40–42]. The Natural England 2008 standing advice noted how relatively undisturbed woodland sites often have heritage features of historical, archaeological, and landscape importance [43]. In terms of biodiversity, ancient woods have many associated species which are uncommon and often threatened. The 2008 guidance stresses the following as a basis for site conservation:

(1) Woodlands are exceptionally rich in biodiversity including rare species and habitats.
(2) They provide renewable resources such as hardwood timber and other woodland products [but note later concerns].
(3) Woods may include survivals from original natural 'forests', but this requires caution in its interpretation. Countryside considered either 'forest' (in Britain is a medieval hunting area and not necessarily treed or indeed, 'natural' [44]).
(4) Remaining or relict sites provide reservoirs of biodiversity so wildlife species may recolonise into new woodlands.
(5) Woodlands form integral parts of the historic landscapes.
(6) In the often-protected boundaries of ancient woodlands, the countryside may hold historic features little altered by modern cultivation, or other macro-disturbances such as urbanisation.
(7) Woods help provide a sense of place and imagination for a specific location.
(8) They have importance as features in the landscape.

It is widely accepted that woodlands of various types, together with their trees, provide some of the most important wildlife habitats in Britain and Europe. For nature conservation, the site condition has great influence, so that mature, mixed woodland having ancient and veteran trees, dead branches and timber both standing and fallen, together with open rides, clearings, and glades scattered throughout, is especially valuable. Topographic variation also influences diverse ground vegetation with distinctive field layers of shrubs and no individual component dominant. Such habitat combinations within a woodland macro-habitat generates the widest variety of conditions for woodland wildlife.

1.3. Ancient Woodland Indicators

The ability to reliably identify ancient woodland sites is increasingly important. Land is under pressure from urban development and from agricultural intensification. In Britain, these pressures and the financial imperatives for developers and farmers to encroach onto woodland sites lead to divergent attitudes to definition and the underpinning evidence-base. Government agencies, local authorities, community action groups, and other conservation bodies try to identify and protect woodlands. This action is in part by their designation as ancient sites which in Britain involves being added to the government's 'Ancient Woodland Inventory', which affords a degree of protection through specific planning guidance. The counter approach is by developers who pay ecological consultants in order to undermine such designation and thereby open up land for financially lucrative usage such as for housing. This conflict of interests presents problems since amongst other issues, neither the Ancient Woodland Inventory nor the concept of 'ancient woodland' were designed to be tested in the quasi-legal arena of, say, a public inquiry. Their origins were as an intellectual inquiry into the nature of woodlands. Recent guidance and a national review of ancient woodlands has begun to address some of the issues, e.g., [23,24,45]. However, the human footprint in ancient woodland is still generally overlooked (Figures 3 and 4). A major problem with the original designations was that they ignored all sites of less than an area of two hectares and thus excluded many smaller sites and those along topographic or historic linear features like streams, rivers, and, for example, medieval parish boundaries. Updates to the inventory seek to include these within the designations, but the need for multi-disciplinary research remains challenging.

Figure 3. Historic usage—wood-collier's wigwam hut, Parkwood Springs, Sheffield, late 1800s.

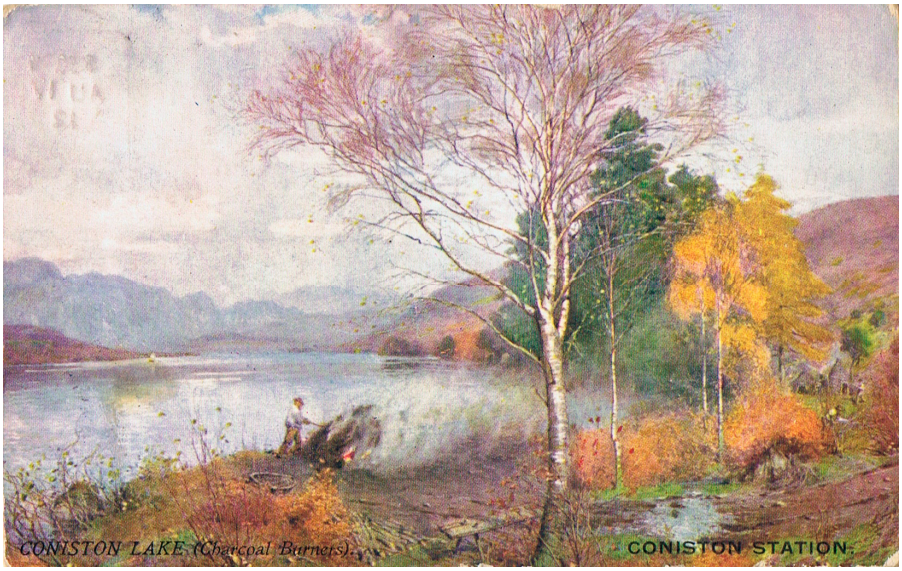

Figure 4. Historic usage—English Lake District charcoal burners in the early 1900s.

Identification of ancient woodland in Britain involves map-based reviews along with field evidence such as botanical indicator species. The latter are usually vascular plants more commonly found in ancient woods than in recent sites. The supporting evidence for the interpretation of indicators is from regional site species lists as discussed by [46]. Triggered by the pioneering work of Peterken [24] and Rackham [14], to identify ancient woods from map-based and field evidence the Nature Conservancy Council (a predecessor of the UK government English agency, Natural England) began the process of producing provisional county lists of ancient woodland sites [47]. Following the gathering of data and interrogation of species lists, the presence of suites of indicator species is taken as evidence for ancient status. Interrogation with local and regional context is essential and indicators vary in status biogeographically. Indeed, no single plant species is perfect as an ancient woodland indicator; the degree of species association with ancient woodland varies across landscapes with geology, topography, climate, and land-use historical factors. These considerations led to researchers assessing more critically such use of indicator lists, e.g., [36] and conducting this in relation to county-based site lists of the Ancient Woodland Inventories with assumed continuous tree cover since 1600 AD or earlier. These inventories included ancient, semi-natural woods along with plantations on ancient woodland sites (PAWS) [36]. The county-level reports are available online with digital maps showing ancient woodland boundaries.

This review-based paper considers the identification and designation of ancient woodland and asks whether current approaches are fit for purpose in the broadest sense.

2. Materials and Methods

The paper considers the following:

(a) Methodological issues including approaches to survey, information gathering, and analysis [the studies have involved field survey, archival research, citizen science, GIS manipulation, and LiDAR analysis].
(b) Review of the selected literature [on indicators, colonisation rates, issues of tree forms and aging].
(c) Emerging concepts [shadow woods (suggested to be remnant, unenclosed, medieval wooded commons [39]) and indicators.
(d) Synthesis of ongoing research.

The long-term research involved stakeholder workshops, interviews, and questionnaires, site-based field research, in-depth case studies, and extensive literature review [38,44,48,49].

The approaches to site identification and designation discussed above are then examined in relation to the case study and action research examples.

3. Results

3.1. Evidence for Ancient Woodlands Using Botanical Indicators

The variety of plants and trees in woodland is strongly influenced by soil type and underlying geology, wetness, and land-use history [13,16]. However, the patterns of sunlight reaching the woodland floor are also important along with influencing factors such as aspect, dominant tree species in the canopy, natural treefall, and woodland management [15]. So, for example, heavily shaded sites such as conifer monocultures and beech-dominated woodland are not conducive to diverse ground floras. In turn, without diverse flowering plants, invertebrate variety is much reduced and consequently, populations of small mammals and of birds will be restricted too. Trees such as beech especially, but also sycamore, come into leaf early in spring and cast a very dense shade [50,51]. Consequently, the ground layer under such a canopy may be totally eradicated and the soil exposed to massive erosion [52–56].

Mixed composition and the age of woodland trees and shrubs are generally accepted as necessary for high nature conservation value in most sites along with structural diversity with clearings and glades formed by treefall or loss of major limbs from large, mature trees, e.g., [17]. Such openings in the woodland canopy with dynamic successional processes are very significant in maintaining diversity. Traditional woodland management (coppicing and timber extraction), implemented systematically over long periods, result in variety and cycles of light conditions [54,55]. Compartments which have been recently coppiced are open to the penetration of sunlight to the woodland floor, whereas later in the cycle with regrown springwood, conditions are much darker. Management history therefore impacts the presence and apparency of indicator plants in woodland and affects invertebrates and other biodiversity both indirectly through vegetation and directly via the microclimate (Figures 5 and 6). Along with seasonality, these factors must be considered if assessing woodland survey data.

Figure 5. Example of a typical ancient woodland botanical indicator—bluebell (*Hyacinthoides non-scripta* (L.) Chouard ex Rothm.)—in the Moss Valley Woodlands, Sheffield.

Figure 6. Bluebell and stitchwort (*Stellaria holostea* L.) in ancient woodland ground vegetation the Moss Valley Woodlands, Sheffield.

3.2. Traditional Management Impacts

Traditional coppice management involves cutting and removing 'wood' from the woodland. The intensity of such historic activity should not be underestimated since it included 'tidying up' coppice stools and having a 'clean' housekeeping approach in the working wood. Dead wood such as fallen limbs from trees and 'ramel' left after extraction of timber or underwood were cleared away and used. This clearance of dead wood adversely affected associated saproxylic invertebrates and fungi through the removal of habitats. However, in the medieval wood for instance, the habitat was extensive and there was still abundant dead wood in the tree and shrub canopy, though this may have been reduced in the early industrial coppice woods such as in the study areas around Sheffield, in England. Furthermore, the stage of dead wood decay also influences invertebrate associations, with some species in recent dead wood and others in well-rotted material. Whether wood is standing or fallen to the forest floor is also significant. Other factors include ground flora flowering plants, along with flowering trees and shrubs, being important nectar and pollen sources for the flighted adult stages of deadwood insects. This means that mature hawthorn and wild fruit trees like crab apple and wild pear, for example, in the woodland edge, along glades, or rides, are important food sources for adult deadwood beetles, craneflies, and hoverflies whose larvae feed on the ancient trees.

Specific activities had varying types and scales of impact on soils and woodland plants. So, for example, the production of traditional and industrial products like charcoal and 'white-coal' (kiln-dried wood used in metal smelting) are activities that involved stripping vegetation and soil from the woodland floor. These were used to cover charcoal clamps and white-coal kilns and controlled oxygen penetration to the burn. Such usage occurred in some cases over many centuries with densities of charcoal hearths recorded in the Sheffield region up to 350 in around a hundred hectares of managed woodland which also held around 150 white-coal kilns. These intensities of usage resulted in managed woods from the early industrial period today having very limited flowering plant diversity and

soils depauperate in upper horizons. Many of these woodland soils were replaced almost entirely by shallow layers of pure charcoal dust seated on a clay C-horizon [12,27].

3.3. Woodland Types

The various influences on plant species in ancient woodlands interact rather intimately. With this in mind, in understanding indicator plants and their interpretation, it is essential to recognise the diverse woodland types and their origins. These are broadly, as follows:

(a) Medieval and industrial coppice.
(b) Park and wood-pastures including ancient forest, wooded common, and 'shadow woods' [39] (Figure 7).
(c) Linear remnants and fragments [23,57].

Figure 7. Wood-pasture veteran oak (*Quercus robur* L.) at Chatsworth Park, Derbyshire, England.

Generally speaking, ancient coppice woods were, from the medieval period, enclosed and protected from intensive stock grazing and tended to be botanically species-rich but often lacking in deadwood habitat and associated biodiversity.

Wood-pastures have often had histories of open grazing with the consequent reduction in ground flora diversity, but more abundant deadwood habitat associated with ancient pollard and maiden trees (features generally lacking in ancient coppice woods) [56,57]. Wood-pasture sites tend to be biodiversity hotspots for rare lichens, fungi, and invertebrates [58,59].

Woodland historical status may be assessed by means of botanical indicators [60–62], whereas woodland vegetation is often subject to more rigorous but less historically informed approaches [63]. The use of botanical indicators relates particularly to coppice woods because of their botanical richness [30,33,34,64–72] whereas wood-pastures are better evaluated with invertebrates, lichens, and fungi. Ongoing research over a forty-year period with long-term action research involving expert stakeholders, together with detailed regional audits has allowed a review of evidence [29,46,49]. The two-year project on the *Woodland Heritage Manual* [40] evolved into a series of expert stakeholder workshops examining and reviewing woodland indicators, woodland inventories, and associated landscape issues. The research produced major reviews of the literature, of evidence-bases, practitioner approaches [46,48,49], and a toolkit [29]. The study generated a review of the use and interpretation of botanical indicator species and lists, and the promotion of holistic evidence-based evaluations.

3.4. Ancient Woodland Inventories

In England, Ancient Woodland Inventories (lists of known ancient woods as determined by the criteria described earlier) are held by Natural England, each covering a specific county. This provides a first step in identifying whether woodland is already recognised and listed as ancient. The inventories were originally based on work conducted in the 1980s and 1990s by the Nature Conservancy Council (now in England called Natural England) producing inventories for England, Scotland, and Wales. The documents are now held and administered by the relevant statutory conservation agency in each British devolved country, and also in their county or regional offices. Ancient Woodland Inventories are essentially provisional with the maps and sources interrogated varying regionally. In England and Wales, the main cartographic sources used were 1:25,000 maps from the 1920s and 1930s, the first edition one-inch Ordnance Survey maps (generally mid-1800s), and aerial photographs, along with any available survey reports. Recent reviews have been aided by use of LiDAR imagery and GIS computer mapping. The original surveys and reviews generally did not consider wood-pastures and parkland. Evaluation of individual woods may not always be clear from the regional inventory summaries [33,38,40].

Most inventories were based on research during the late 1970s and early 1980s, with ground-truthing where possible. The indicators used were generally intuitive lists produced by known local experts and target sites were identified from first edition Ordnance Survey maps (dating around 1830 to 1840). Earlier documentation, such as estate plans and surveys, was used if available. These might support the initial assessment and then likely sites had ecological field surveys during the subsequent period of ten to fifteen years. Depending on surveyors and their experience, the results varied in quality. The landmark 2008 *Woodland Heritage Manual* [40] was the first time sites had wider evaluations of factors like soils, woodland archaeology and heritage, and historic context. The development of the Ancient Woodland Inventories was a first step and proved useful over the following period of thirty to forty years. However, it was not intended as a statutory tool and proved to be not 'fit for purpose' in that context. As the methodology was neither comprehensive nor robust, it was challenged by developers and their consultants. To complicate things further, the initial schedules were generally 'conservative' and omitted sites such as smaller woods. Identification of the limitations of the original process was a key driver of the methodological reviews to develop evidence-based assessments [31].

Glaves et al. [46,48,49] concluded that historic sources and archaeological evidence providing broader context were often overlooked. Consultation with users noted that even approaches like evaluation of map-based, place names, for example, were not widely used. Other issues identified were the lack of awareness by surveyors of the likely age

of multi-stemmed coppices and clonal trees. These are often present in ancient coppice woods, but surveyors were frequently looking for large, old-looking, standard trees, as are found in wood-pastures but much less commonly in woods. Since inventories largely record former medieval coppice woods, which because of their management history often lack veteran standard trees, this is a serious omission. There is a further complication of there being a lack of accepted, robust approaches to the aging of old coppice stools. Additionally, many conservation organisations remain reluctant to recognise such trees as ancient or veteran, and yet for evidencing ancient woods for formal scheduling and protection from development, presence of verifiable, ancient, coppice stools is confirmation of woodland going back centuries. Moreover, such trees evidence both site antiquity and past management. Trees which are naturally self-coppicing or clonal (e.g., *Ilex aquifolium* L., *Alnus glutinosa* (L.) Gaertn., *Tilia cordata* Mill.) can provide additional timeline information, in some cases for well over a thousand years.

3.5. Robust Methodologies

Interest in the effective evaluation of woodland histories necessitated robust, evidence-based methods to assess and define ancient woodland, and an integrated approach was developed [29]. This involves logical steps through a decision-making tree for the evidence-based process. Evolved from *The Woodland Heritage Manual* [40], the approach has been tested successfully in planning inquiries and other conflict situations. Carefully considered steps and decisions address and evaluate information such as site documentation, maps, place names, ecology, pedology, archaeology, and history. Developed from established ancient woodland definitions, this uses a broader information base than formerly available to provide a logical framework for woodland assessment with evidence combined to confirm woodland continuity and status. Evidence varies in the level of certainty and robustness but combined it may support, confirm, or indicate woodland continuity or not [72–76]. Using mixed sources combined lends more confidence to any interpretation. Many texts on woodlands and forests are researched and written from either an ecological or an historical perspective and relatively few cross the divider to employ mixed sources. This has a further consequence in that quite frequently the insights and knowledge are then not picked up by researchers in other disciplines [77–82]. Joined-up approaches to forest and woodland management begin to join otherwise disparate research and perceptions into a more unified whole [83–86]. The emerging discipline of 'historical ecology' also helps to cross the divide [87–89]. Confidence in designating a site as ancient woodland depends on two factors:

(1) Evidence of woodland continuity or of gaps in woodland cover.
(2) Reliability evidence for continuity or gap.

Most woods will only have some evidence types available, and confirmation of ancient status may rest on subjective judgment based on objectively gathered information.

3.6. Intelligent Interrogation

The evaluation concludes with 'intelligent interrogation' of lists, sources such as maps and archives, indicators, field survey data, and any other relevant information. If required, a formulaic outcome is achieved by assigning subjective numerical weightings to particular factors in the analysis. It may be helpful to generate a numeric index or gradation based on scrutiny and assessment of evidence such as lists of botanical indicators or observations on ancient coppice stools. Evidence is assessed and evaluated in terms of site history, map information of land-use, archaeological and heritage information relating to human activity, with documentation, archives and other historical sources, and both vegetation communities and botanical indicators.

Overall, there is a wide diversity of information and sources to assess. Site evaluation may include soils and other sediments and the evidence they hold which may include paleo materials such as pollen, pollution profiles, and sediment downwash giving information on tree species and on other flowering plants and land-use history. Working and worked trees can be very informative, and site location, biogeography, and landscape context are significant influences. All these factors are taken into account in the final assessment. However, in many of the earlier site evaluations, the trees themselves were often not assessed in detail, and this was in part because of a lack of recognition but compounded by the absence of accepted methodologies.

3.7. The Importance of Ancient and Veteran Trees in Woodland

The presence of ancient and veteran trees in woodland adds a highly valuable habitat component for many uncommon and rare species, particularly invertebrates. However, and frequently overlooked, is that the ancient trees can, if effectively recognised and assessed, provide key confirmation of 'ancient' status by proving a woodland has existed on the site beyond the date accepted for ancient woodland. In this context, the definition becomes important and the terms 'ancient' and 'veteran' are accepted as below [40].

Ancient: This term relates to a tree that is very old, in the declining stages of life for that species, and usually with relatively large girth compared with other trees of the same species. This does depend on how it has grown and factors like altitude, aspects, soil, and geographic location which affects climate. Ancient trees are often visually distinctive, but recognition depends on the experience of the surveyor. One category of ancient or veteran trees is that of worked trees (i.e., those once managed to produce particular crops and products), which can be hugely informative but also sometimes difficult to recognise or age. These may include coppices, clones, stubs, shreds and most easily recognised, pollards. Ancient specimens of smaller tree species are also problematic and often missed in surveys.

Veteran: Varying from species to species, a veteran tree is one usually in a mature phase of its lifecycle. This stage will generally be associated with the development of important wildlife and habitat features such as hollowing, holes, wounds, and large dead branches and decay fungi. The specimens will generally be old trees, but perhaps due to environmental stress premature aging characteristics may develop in younger, middle-aged trees. This varies from species to species and with levels of environmental stress experienced. Stress might be factors such as drought, waterlogging, low levels of available nutrients, extremes of soil pH, and intensive grazing, etc.

Ancient and veteran trees are important in terms of their presence or absence, but also, if they are present, in their growth form. This may be a vital piece of information in understanding past woodland management. Furthermore, what is defined as woodland and then as ancient is also very significant. This is often more complex than is generally assumed. As noted earlier, most sites recognised by means of botanical indicators and historical sources are medieval coppice woods, and whilst current reviews across England are more inclusive, many sites atypical, historical, timelines are omitted from ancient woodland designations. The consequences for conservation and also for site management are serious.

Two main important considerations emerge from the current research. Firstly, there is a need for widely accepted, robust indicators which need to be considered within their geographical, historical, and environmental contexts. Secondly, such indicators must be integrated into a broader framework for integration and interrogation [29].

4. Discussion

Emerging Concepts About Ancient Woodlands

With the exceptions of obviously pollarded trees, 'worked' trees, 'modified' trees, and naturally contorted trees (such as by animal grazing and/or extreme weather) have often been overlooked in woodland assessments. Except for the pioneering work of Donald Pigott [1], historically coppiced and self-coppicing trees such as ancient limes, alders, and willows (*Salix* spp.) have generally been neglected. There are ongoing studies on some species like sweet chestnut (*Castanea sativa* Mill.) and coppiced oak, e.g., [87]. There is also a tendency to overlook smaller species and to neglect peripheral habits such as '*Shadow Woods*' [39]. This is especially the case in upland areas, but ancient coppiced trees are widely ignored in the lowlands too. Whilst understanding and aging these specimens may be challenging, they provide intimate connections to human exploitation of the countryside and sometimes to extreme weather events. In these respects, such trees have important stories to tell. Many are older than 'standard' trees, more generally recognised as significant, and therefore provide important evidence of woodland being ancient and moreover of its management history.

As noted earlier, there are distinct categories of woodland with coppice woods being treed sites enclosed from the wider countryside, named and managed over subsequent centuries. Trees were protected from large grazing herbivores at least during the early years of the coppice cycle or after major tree-felling to allow regeneration of the wood. The other broad woodland type is wood-pasture of varying sorts and treed landscapes mixing tree cover with open ground grazed by large herbivores, both wild and domesticated. The most widely recognised forms of wood-pastures derive largely from medieval land-use and are parks, chases, forests, and wooded commons. However, there are complications with changing land-use and human impacts over long periods. These have led to the emerging concept in recent times of 'shadow woods' [39] (Figure 8).

Figure 8. Bluebell as an indicator in ancient shadow wood, Peak District, England.

The concept of 'shadow woods' as 'lost Domesday landscapes' [39] is one of the most exciting outcomes from ongoing research. It is argued that these are remnants of once extensive, Domesday wood-pastures which survived unenclosed into the medieval period as wooded commons. Furthermore, it is suggested that the enclosed woods managed for centuries as coppice woods, originating from landscapes like these, and having survived episodes of medieval, Tudor, and parliamentary enclosures, some areas of former wood-pasture common remain. Research into this phenomenon has included observations nationwide and detailed site studies in the England Peak District and Pennines. Interestingly, some Peak District moors, for example, are shown on nineteenth-century maps as 'wood-pastures', and paleo evidence indicates greater tree cover at that time [88]. Relict sites were identified through detailed field surveys of botanical indicators, smaller veteran trees, soils, and other evidence. Not being managed 'woods', however, these sites often have limited, associated documentary evidence.

Other complicating factors in woodland assessment include changes between wood-pasture and enclosed coppice, and sometimes back again over time. Other sites are effectively lost as woods because of land-use changes. Enclosed woods often suffered damage, loss or destruction over the centuries following their establishment, and so, 'lost woods' are sites that were enclosed and named as woods, but where the tree cover was subsequently removed. This might be by conversion to farmland, to urban development, or by infrastructure such as roads. In some cases, the sites were simply opened up and reverted to a grazed landscape. Some ancient woods, still exist but for various reasons have been 'lost' as woods from memory and even from maps. An example is a Peak District wood now shrouded by secondary birch growth, but with over 1000 veteran coppice trees overlooked by contemporary ecological surveyors mapping ancient trees and woods [39,89].

When woods are lost, destruction may be total with tree cover and vegetation completely removed. However, in many cases the 'ghost' of a lost wood can still be seen in the landscape where physical anthropogenic features like woodbanks, walls, charcoal hearths, lanes, etc., survive. However, in many cases, veteran trees and ancient woodland botanical indicators mark the existence former woodland now etched in the modern landscape. Even in intensively farmed or highly urbanised areas, indicators and other evidence survive alongside field names, lane names, and place names connected to one-time woodland.

For the range of woodland types in the landscape, a big challenge is being able to recognise and understand them. Firstly, we must see them in the landscape and searching for lost woodlands, hidden ecologies, and forgotten histories requires patience and persistence. Yet once the surveyor is able to see the evidence and read the signs, then new insights into the countryside's past and present emerge. They are there all along but often they remain unseen.

Key questions considered in this paper relate to the development of unenclosed wood-pastures, the origins of enclosed 'ancient coppice woods', and the nature of the countryside within which such enclosure occurred. Management of enclosed woods by formal coppice was known to the Romans and they undoubtedly applied this to British woodlands especially in the southeast of England where the Weald was a significant charcoal manufacturing area. Charcoal is essential for, amongst other things, metal smelting and working, and so a sustainable supply of cut poles for coaling was important [90]. Furthermore, examination of the archaeological evidence of fenland prehistoric trackways, for example, shows large amounts of 'brushwood' being used which suggests ample supplies of small-bore underwood. However, simply cutting back of willow and hazel might be the source rather than formally coppiced, enclosed woods.

It seems that most English coppice woods originated after Domesday (1086 AD) though some might have originated in the Saxon countryside [39,91]. This further chal-

lenges the persistent myth that today's ancient woods are direct descendants of the so-called 'wildwood', which they are not. Indeed, one of the reasons that ancient woods are so unique and valuable in conservation terms is that they hold evidence of human occupation and land-use sometimes going back millennia, and these bear evidence of non-woodland phases. Probably the closest to wildwood or primeval countryside lies in some of the most ancient of the medieval forests or deer parks, and perhaps in some of the shadow wood fragments of wooded commons. These were extensive tracts of wood-pasture with scattered trees and areas of scrubland, with probably large patches of closed-canopy forest, and of course, the whole landscape was much wetter than today. Due to the latter observation, there would be a far greater extent of wet woodlands dominated by willow and alder from the lowland fens to the upland moors, which were wood-pastures with scattered smaller trees and willow in wet fen areas. It was from this extensive landscape of large wood-pastures that coppice woods were enclosed and protected. A driver for this practice was the fixed manorial system imposed by the Norman feudal overlords and rising human populations. Since each manor or parish was largely self-reliant in terms of resources such as underwood and timber, as wood-pasture was cleared and cultivated for arable production to feed local people, the woodland was reduced to near critical levels. Protection from incursions by local peasantry and their grazing animals allowed a system of renewable timber and underwood supply called 'coppice-with-standards', and the 'woods' enclosed by a bank and ditch, a stone wall, a hedge or a dead hedge was then named in the landscape. The evidence today is in names like 'The Manor Wood', 'The Lady's Wood', or 'The Lord's Wood', for example [92,93].

Once enclosed, the 'woods' were managed over centuries as simple coppice or coppice-with-standards, and those surviving today are the 'ancient woodlands'. In this context, the botanical indicators of ancient woodlands are plants that provide robust evidence of antiquity and continuity back to these medieval landscapes. The Domesday survey (1086 AD) shows that these woods were enclosed from extensive wood-pasture in the pre-Domesday Saxon countryside. The areas which remained unenclosed were mostly a mix of royal forest and wooded commons [39,89,90].

From extensive literature review, stakeholder workshops, and from a questionnaire survey of experts and practitioners across England [46,48,49], the application of botanical indicators of ancient woodland was shown to be universal in the country. In particular, the indicators help identify potential locations of ancient woodland and confirm the ancient woodland status of former medieval and industrial coppices.

Issues remain in terms of interpretating what such status implies and how this relates to the ideas of the nature of the primeval landscapes proposed by Frans Vera [91]. Clearly, a value of anciently wooded landscapes relates to our emotional attachments to 'ancient' woods, as fragments of a perceived primeval 'wildwood'. Nevertheless, as already noted, such direct lineage is largely misconceived. However, it may be that the woodland-associated indicators (including plants and invertebrates) might provide connections to former landscapes and ecologies. Field research in landscapes that have not suffered major disruption such as deep ploughing, chemical fertilisation, or urbanisation suggest the presence of presently unrecognised and unrecorded 'ghosts' or 'shadow woods'. These are marked out by ground flora, veteran trees, and typical woodland soils. Often unnamed (unlike typical ancient woods), these are probably ancient, wooded commons and forestlands, and they remained unenclosed during major phases of land enclosure in early medieval or early industrial times [2,8,94,95].

A key process in transforming the pre-Domesday wood-pastures was the piecemeal enclosure of land in the early medieval period, something recognised in the 1235 Act of Commons or Statute of Merton. This legislation passed by King Henry III probably

reflected what was already happening rather than itself being a driver of change. It was this Act, however, that empowered the Lord of the Manor to enclose and protect the various constituents of the manorial lands. So, the still fluid and generally unimproved English countryside of the Saxon era was replaced by enclosed 'woods', common fields, heaths and commons, parks, fens, bogs, forest and other features. At this time, these were now fixed in place, named, and accounted for [39].

Therefore, in England at this time, woods were recorded, enclosed, named, and protected, but other treed landscapes remaining in the wider countryside were subject to the vagaries of agricultural and then urban encroachment. This situation gave rise to the two major resources of ancient, wooded landscapes which remain in Britain today and as described earlier. These are the relatively widespread coppices of various types descended from sites enclosed and named post-Domesday, and the medieval parks and forests. However, there is growing evidence of shadow woods which are unrecognised and unenclosed and still survive in commons, heaths, and other unimproved countryside, and as fragments elsewhere in places like roadsides.

A question often raised is that of what should be carried out to conserve veteran or ancient 'worked' trees, now 'retired'. These specimens include ancient pollards (resulting entirely form historic human management) and coppices of varying ages, in particular. Pollards are problematic because if left uncut, they eventually become top-heavy and tend to break up. Furthermore, if trees are abandoned from traditional management and then re-cut, there is a high failure rate and many trees die. Research through the auspices of the Ancient Tree Forum, the Tree Council, and partners has improved practice and increased success rates [94,96]. However, with abandoned coppices, the issues are somewhat different and the use of big machines on steeply sloping ancient woods, for example to 're-coppice' sites [95], is very damaging to site archaeology and heritage. Like pollards, if abandonment has been for some decades, it is likely that re-coppicing may result in death. Additionally, if the coppicing last took place say, two hundred years ago, the regrown trees are both vulnerable to shock in re-cut but have also become an important part of the historic landscape and the tangible heritage. Some trees such as alder and small-leaved lime will naturally self-coppice and regrow if a stem collapses, and the suggestion is to allow nature to take its course. More recently, abandoned coppice can be reworked, but this should be by hand and not by vehicle-mounted machines, and older trees should be left. Two global authorities, the late Professor Donald Pigott and the late Professor Oliver Rackham, both commented on this issue to me when they implored me to try to dissuade agencies and conservation bodies from intervening with what in their minds were historically significant trees.

5. Conclusions

In terms of their significance, the ancient woods of Britain are hugely important for nature conservation and heritage reasons. However, perhaps the special importance of an ancient wood is the feeling of walking in the footsteps of the ghosts of people that lived and worked our woods over thousands of years. These 'ghosts' have left their mark on the wooded landscape, on the soils, and even on the vegetation itself, and these landscapes are strongly eco-cultural rather than being some sort of wildwood. The human element in ancient woods may be evidenced back over thousands of years with field boundaries, settlement sites and enclosures, carved stones, and burial sites from prehistory. However, alongside extensive medieval and early industrial heritage (such as charcoal pits and platforms), in recent centuries modern impact has included felling and replanting with exotic trees (both broadleaves and confers) and contemporary management for amenity and recreational usage. The human cultural influence interacts with nature to produce what

we now define as 'ancient woods' and which result from unique and unrepeatable timelines. As stewards of the environment, we now have a responsibility to protect ancient, semi-natural woodlands for future generations. Furthermore, the discovery that shadows and ghosts of woodlands persist today beyond the 'wood' boundary is exciting and challenging.

In Great Britain, recognition and designation of ancient woodland status gives a modicum of protection under national planning guidance. However, as discussed, the process of designation still leaves some important questions unanswered. Either oversight or even misrepresentation at planning inquiries has been shown to lead to serious, long-term damage to woodlands because they were not recognised at 'ancient' by the landowner, the local authority, the government agency (Natural England), or by the consultants for the developer [6–8].

Such oversights and the other complicating issues are problematic. However, it is clear that the 'precautionary principle' should apply, and if there is evidence to support the status of a site even if not currently on the Ancient Woodland Inventory, then the onus is upon the developer to prove it is not ancient. Current practice often means that local community action groups and the Woodland Trust (Britain's leading woodland conservation charity) or the Wildlife Trust have to prove the site is ancient at every inquiry or planning application, even when a site is listed on the inventory. The present situation raises serious issues of whether a local planning authority charged with a responsibility under PPG 9 (Planning Policy Guidance 9) [23,97], and later guidance [98], is actually able to discharge its duty, and this is even more onerous when the local authority itself is a landowner with a significant financial interest in a consent being granted. Furthermore, in many cases, the local authority planning officer simply does not have the skill or experience to decide on these technical issues. Increasingly they also lack access to adequate in-house professional support.

Finally, the process of identification and designation largely overlooks historic landscape, heritage, and woodland archaeology issues. Yet, as argued elsewhere, it is this eco-cultural element of the ancient wood that strongly influences the ecological features associated with antiquity [16,27,38]. However, following from the last paragraph regarding local authority and agency competence in deciding these issues, in most cases observed there was little if any input to case inquiries or assessments by archaeological or heritage specialists [7,8]. This situation leaves the identification and protection of ancient woodlands in England, and probably elsewhere too, as at best a work in progress.

Detailed case studies and long-term action research evidence serious issues with a flawed planning system [7,8,92]. It is argued that the historic timelines of ancient woodlands govern the contemporary ecology, and that the archaeological features associated with human usage of these eco-cultural landscapes amount to unique and irreplaceable heritage. Furthermore, this remarkable resource remains largely unrecognised and extremely vulnerable to the impacts of contemporary management (Figures 9 and 10).

This account has focused largely on examples from Great Britain but of course, similar processes and phenomena are occurring around the world but particularly across Europe. Europe-wide examples are presented in the two volumes *Ancient Woodlands and Trees: A Guide for Landscape Planners and Forest Managers*, published in 2018 [32] and the follow-up book [99], which include national case studies, for Austria and Turkey for instance. Having worked with colleagues and attended conferences across Europe, it is clear that in many cases the necessary research and archiving and inventory of woodland and forest heritage (both tangible and intangible) are undertaken more effectively. For example, the work of Elisabeth Johann in Austria has been exemplary in impacting awareness, guidance, and practical conservation [100,101]. More widely across Europe, such approaches are actively promoted by IUFRO (The International Union or Forest Research Organisations) and ESEH (The European Society for Environmental History) [80 (Agnoletti)]. These integrated

approaches to treescapes, their history, and future management are generally lacking in Great Britain.

Figure 9. Forestry extraction through archaeological site at Whitwell Wood, Derbyshire.

Figure 10. Rough Standhills PAWS clear-felled with unrecorded archaeology erased, Sheffield.

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