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Ten years of change: Woodland research at Monks Wood NNR, 1993-2003

Proceedings of the 50th Anniversary Symposium, December 2003

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C. Gardiner & T. Sparks

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Contents

Introduction: Monks Wood National Nature Reserve – the first 50 years

Chris Gardiner and Tim Sparks

The year 2003 marked several Monks Wood related anniversaries: 50 years since the NNR came into existence (July 1953); 40 years since the opening of the research station (October 1963); 30 years since the publication of *Monks Wood – A Nature Reserve Record* (Steele & Welch 1973); 30 years since the split of the research and conservation arms of the Nature Conservancy (whose Monks Wood successors are now *Centre for Ecology and Hydrology* and *English Nature* respectively); 30 years of butterfly and moth monitoring in Monks Wood, and 10 years since the previous symposium summarising woodland research at Monks Wood (Massey & Welch 1994).

In June 2003 a public open day was held to celebrate 50 years of the National Nature Reserve, which attracted 800 people from the surrounding area. This was followed in December 2003 by a symposium held at Monks Wood which focused on research and changes to the wood in the preceding decade. This volume represents the contents of the talks presented and also updates previously published information.

Monks Wood no longer supports the intensity of research present in the first 20 years of its existence as an NNR but a surprisingly large amount of work has been undertaken in the last decade and is reported here. This volume should be read in association with Steele & Welch (1973) and Massey & Welch (1994). The opportunity has been taken to update species lists for groups where new information is available and it is hoped this will spur others to add to or correct these lists.

The chapters of this volume variously describe the establishment of a research station at Monks Wood and the status of plants, beetles, moths and butterflies. The influence of muntjac on the wood, the development of the 'Wilderness', a comparison with flora in nearby woods and the weather records of the last 40 years are included. The updated species lists add considerably to the published literature; many new species are included and information on their status included where appropriate.

It is clear that deer grazing has seriously affected the wood. Steps have now been taken to reduce their impact, and the early signs of recovery in the vegetation are reported here. The summary of weather records from Monks Wood show evidence of a change in climate. The next few years will tell whether impacts from changes in the external environment will be as great as, or greater than, those experienced from grazing damage.

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Monks Wood - The beginnings

John Sheail
NERC Centre for Ecology and Hydrology, Monks Wood, Abbots Ripton, Huntingdon,Cambridgeshire PE28 2LS

The Monks Wood Experimental Station was officially opened by Lord Hailsham on 28 October 1963. Local newspapers described how the Lord President of the Council and Minister for Science, who had so recently been a contender for the office of Prime Minister, had defied doctor's orders to rest his injured foot, and had made a special car journey to Monks Wood to open the new Experimental Station. In acknowledging the range of conservation research and educational roles of that Station, Lord Hailsham's speech focused for the most part on the impact of toxic chemicals on the environment.

The National Nature Reserve

The words 'Monks Wood' first acquired prominence as the name of a potential National Nature Reserve identified during the Second World War. The Nature Reserves Investigation Committee (NRIC), comprising a body of ecologists and naturalists, placed it, together with the adjacent Bevill's Wood, in its category A, namely a reserve of outstanding merit which, in the Committee's opinion, must be safeguarded. That was despite the damage wrought earlier to its wildlife interests. The wood's owner had, in 1921, begun to fell trees as a speculative venture, and immediately incurred the wrath of entomologists. He accordingly offered to sell Monks Wood to the National Trust, which sought appraisal from the Society for the Promotion of Nature Reserves. The distinguished banker, entomologist and founder of the Society, Charles Rothschild replied that 'I know Monks Wood well and it is certainly rich in insects. I do not, however, think that its acquisition by the National Trust is really desirable at the present time, bearing in mind the very large number of still more interesting areas, which are worthy of protection even more than this one'. Consequently, the National Trust refused to take up the offer. But the quality of those other woods had declined so dramatically that, by the 1940s, Monks Wood had become one of the very finest examples of its type in the East Midlands (Royal Society for Nature Conservation SPNR archives, Box 34, 3/306; Sheail 1976, 146).

The wartime lists of the NRIC were closely drawn upon by the post-war official Wild Life Conservation Special Committee, which similarly recommended Monks Wood and Bevill's Wood, an area of 600 acres, as a potential national nature reserve. It was

> the best of the few remaining examples of ancient ash-oak woodland on the heavy Huntingdonshire clays; it is partly covered with a dense growth of the grass *Calamagrostis epigeios*, and a classic locality for the characteristic fauna of such woodland; there are many rare plants as well as insects (Ministry of Town and Country Planning 1947, 101).

The wider recommendations of the Special Committee, and the Cabinet's Scientific Advisory Committee, led to the establishment of the Nature Conservancy in 1949, a hybrid research council that also had executive responsibilities of acquiring and managing national nature

reserves and giving conservation advice more generally. It purchased and designated an area of 387 acres of Monks Wood as a National Nature Reserve in 1953-54.

The reserve was accordingly one of the earliest test-beds for Conservancy thinking as to how such properties should be managed. The founder of British ecology, A.G. Tansley, was the Conservancy's founder-Chairman. In a paper to the Conservancy's Scientific Policy Committee in January 1952, he emphasised how most reserves would have to be actively managed, if they were not to degenerate and lose most, if not the whole, of their value (Centre for Ecology and Hydrology, Monks Wood (CEH) MSS, Box 8, S12/28, SP/M/52/2). But as the Director-General, Max Nicholson, observed, in a further paper, there was simply no useful precedent or body of accumulated experience as to how that object might be achieved. Any policy had necessarily to be highly tentative, directed above all to preventing 'deterioration or disaster arising from neglect or major mistakes in silvicultural treatment'. As well as removing, say, undesirable exotic trees, the aim had to be to conserve and recreate good examples of those types of natural vegetation as had become, or were becoming, scarce. And more generally, the intention should be to provide 'the best possible sites for long-term research' and, thereby

> contribute towards scientific understanding of, and advanced education in, the fundamental long-term requirements and conditions of British natural woodlands with a view to making unbiased and valuable information generally available for the benefit of foresters and of the public (CEH, S12/28, NC/M/53/6).

In practical terms, there should be a provisional statement of objectives for each reserve, a reconnaissance survey made of its topography, geology, climate, vegetation, fauna, scientific potentialities and management problems, as preparation for a silvicultural plan and allocation of supervisory responsibilities.

A conference of Conservancy scientific staff, held in October 1953, distinguished two forms of woodland reserve, 'living museum' reserves, which must be managed on 'a long-term trustee basis with the absolute minimum of interference beyond what may be reasonably calculated to maintain the woodlands in an ecologically healthy state', and, at the other extreme, those that contained 'nothing of outstanding rarity or scientific interest, which could be freely used for experimental purposes'. The need to encourage and protect the invertebrate life of such woodlands implied 'a working plan aiming at a rotational mosaic'. Certain parts of the wood should be deliberately left untouched and others assigned to various specified types of scientific experiment. Both up-to-date photographs and historical references should be tracked down. The BSBI and BTO might be encouraged to undertake contract surveys, with priority given to Monks Wood and the Blean Woods of Kent. Among the priorities for research were studies of energy cycles and productivity; identification, measurement and regulation of factors affecting regeneration, and 'the problem of tracing which are the most reliable and easily studied indicator species, and what it is they indicate' (CEH, S12/28, SP/M/53/28).

Such aspirations have stood the test of time, but the Conservancy's first regional officers, Eric Duffey and Norman Moore, also pointed to a paradox. Although many further reserves were being acquired, the two officers warned of how 'we are already losing habitats and species in our declared reserves, simply because we do not know enough about the requirements of the species which it is our duty to conserve'. There was a serious paucity of knowledge and understanding. Whilst the implication was that the research stations at

Merlewood and Furzebrook should devote a greater part of their effort to such questions as the impacts of seral succession on the reserves, one distinguished scientist dismissed this as 'a dangerous heresy'. It had to be stressed that conservation needs could only be met in a scientific sense by fundamental research, free of the subjectivity associated with *ad hoc* investigations of a more applied kind. Amid the furore which Duffey and Moore's further joint paper of October 1958 excited, the Conservation Officer, Scotland, Joe Eggeling, suggested the establishment of a pool of scientists that could be drawn upon to undertake *ad hoc* problems. Nicholson agreed but warned, from what he had seen on a recent visit to the United States, of how a very good research centre might easily be 'debased' through being 'overloaded' with such *ad hoc* problems. The answer might be to establish a separate station specifically to deal with such management experiments and public relations. In his words, 'we might have to start something which would be a connecting link between long-term fundamental research and the work of the regional officer' (Sheail 1998, 88-94).

An experimental station

Once convinced of the impending crisis on the reserves, there was no holding Nicholson back in pressing for what he called 'a centre of applied research and demonstration'. One of the most positive achievements of the Nature Conservancy, it was perhaps Nicholson's most personal achievement of a tangible kind. In a wide-ranging memorandum addressed to the Scientific Policy Committee in January 1959, he identified several 'applied' fields where the absence of 'any facilities for testing, experimenting, exchanging specialist experience and giving advice' was a source of intense embarrassment. There was need for 'a new and adequately staffed centre for the effective experimental study, testing, demonstration and dissemination of applied knowledge in animal and plant ecology, and the factors underlying successful management of the fauna and flora' (Sheail 1985, 37-57).

A Huntingdon Working Party was appointed by the Scientific Policy Committee. It included Duffey and Moore. Its report of March 1960 recommended four component parts to the new station. There should be a conservation research unit; a toxic chemicals and wild life unit; a woodlands research unit, and a vertebrate ecology unit. Crucially, it would also serve as the field station for the one-year Diploma Course in Nature Conservation, being established at University College London. The most contentious issue was the station's location, or rather Nicholson's insistence that it must be in the vicinity of Huntingdon, as opposed to Cambridge or Oxford. As Nicholson argued, a location in the East Midlands would be both within easy reach of University College London, and close to the largest and probably most neglected group of National Nature Reserves in England, namely Monks Wood, Woodwalton Fen, Holme Fen, and Castor Hanglands. Between them, they covered fenland peat, Oxford Clay and boulder clay deposits, and oolitic limestone. A paper by Eric Duffey in October 1959 outlined the potential of such extensive and varied conditions as both outdoor laboratories and demonstration areas in developing the techniques so desperately needed for conservation ecology.

Encouragement for the new station had come from an unexpected quarter. Following the General Election of September 1959, Lord Hailsham had been appointed to the new post of Minister for Science coupled with senior office as Lord Privy Seal. He had became considerably more receptive to scientific initiatives that demonstrably met a pressing public-need. After a long discussion in May 1960, he agreed to the Treasury's consent being sought for the new station, particularly as to research on toxic chemicals and the provision of facilities for the post-graduate conservation course. He accepted the Conservancy's

arguments that, if the Treasury approved those purposes, the station would also be the best place for pursuing reserve-management and vertebrate research. The Treasury agreed to the purchase of 66 acres of farmland to the south of the Monks Wood NNR for the sum of £3,500. Its imposition of a ceiling of only £100,000 meant however that only the first phase of development could proceed. In Nicholson's words, the 'only postponable part of the project' was the Vertebrate Ecology Section. It was a decision taken with considerable reluctance. There were still hopes of personnel of the Infestation Control Laboratory of the Ministry of Agriculture being attracted to the Station. All that remained was to find a name for the station. After some considerable debate, the name 'Monks Wood Experimental Station' was chosen. By adopting the same name as the National Nature Reserve, there would be no need to insert two names into one small part of the map! (Sheail 1998, 94-9).

Although the Treasury had approved acceptance of the lowest tender for erecting the buildings in March 1962, work was severely delayed, staff having to be accommodated in St Ives and an ex-army hut on the site. Since only £35,000 were allocated for the financial year 1962-63, representing only about six months' building time, construction could not start until half way through the financial year. The severe weather in January and February 1963 meant the date for handing over of the site, intended as July, had to be delayed until September. An insight into Monks Wood, written by Bruce Campbell, was published by *The Countryman* in the autumn of 1965. It was 'the Conservancy's first purpose-built station. The main buildings are single-storied; the water tower rises fifty feet above them .. comfortable bed-sitters for students and other visitors are ingeniously fitted in below the water tank'. The dispersed living habits of the staff prevented claustrophobia. Several drove fifty miles a day to and from Cambridge, where they found both the social life and big libraries. A minibus took some of the junior staff to St Ives (Campbell 1965).

The journal, *Nature*, described the founder-Director, Kenneth Mellanby, as 'one of the few senior entomologists with experience in both medical and agricultural entomology'. The first Principal of Ibadan University, he had been for six years head of the entomology section at Rothamsted (Anonymous 1961). That Rothamsted influence was in fact the model for achieving Nicholson's intentions for Monks Wood. As Mellanby made immediately clear, there would be no rigid demarcation. Fundamental aspects would be tackled as necessary. As Bruce Campbell wrote, the Monks Wood Experimental Station did 'not woo visitors with the cosmetic attractions of carpet gardening and glossy lawns. The green grass grows all round, and a few young oaks are discernible through it'. The four fields, on which the station stood, had been so neglected in recent years that deep ploughing and cultivation were needed. Although most was to be kept under a bare fallow, the Rothamsted influence was again effected by designating one part as the 'wilderness' to be set aside for long-term monitoring of 'natural' succession. The Conservancy's *Annual Report* for 1963 reported how the dominant cover of charlock in the previous year had been replaced by various plants, included Curled Dock, Teasel, Hemlock, *Atriplex* spp and Sow Thistle (Nature Conservancy 1962; 1963).

Monks Wood, with the remainder of the Nature Conservancy, became part of the new Natural Environment Research Council in June 1965 and, together with the other research sites, remained within that Council, when the Nature Conservancy was abolished in 1973. The conservation part of the Conservancy's functions became the new Nature Conservancy Council, a granted-aided body of the Department of the Environment, whilst the research function and stations (including after much debate the whole of the Monks Wood

Experimental Station) remained in NERC as the greater part of the new Institute of Terrestrial Ecology.

We celebrate the fiftieth anniversary of the initial establishment of Monks Wood as a National Nature Reserve, the fortieth anniversary of Monks Wood as a centre for ecological research, and the thirtieth anniversary of the 'Split' and, more generally, the introduction of the 'customer-contractor relationship' in government research. Such focus upon an individual nature reserve and research site offers opportunity to appraise further the advances made in both the ecological sciences and their application and extension through practical conservation management.

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The drunken tractor driver: changes in management and public access at Monks Wood NNR 1993-2003

Chris Gardiner

English Nature, Bedfordshire and Cambridgeshire Team, Ham Lane House, Ham Lane, Peterborough PE2 5UR

Significant changes have occurred in the way in which Monks Wood is managed, over the 50 years since it was declared as a Nature Reserve, and more particularly over the past 10 years, since the publication of the 40th Anniversary Symposium proceedings (Massey & Welch 1994). It may be surprising to some that such change should occur in the management of a protected ancient semi-natural woodland, where the ecosystem is relatively stable, and the pace of natural change relatively slow; but significant changes have been made, both through choice and necessity. The principal causes of these changes come from several different quarters:

- Changes in conservation priorities.

There is no doubt that the theory and practise of nature conservation has evolved over the years and has in many instances been subject to trends, fashions, and conflicting theories, some of which are described in the paper by Sheail (this volume). Some debates have been concerned principally with operational matters: the preferred timing, methodology or coupe size of coppice, for example. Others are policy related, and exert a more subtle influence over management of individual sites. In the 1970s, the Nature Conservation Review (Ratcliffe 1973) defined and described sites and features of nature conservation importance on a National scale. In the 1990s this was supplanted by the area-based biogeographic approach of English Nature's Natural Areas programme, and the more target-led Biodiversity Action Plans. Even more recently, the Government's Public Service Agreement (PSA) target to achieve a clearly defined 'favourable condition' for all SSSI's has been the driving force. These overarching objectives create a climate which does impact on individual sites: for example, the fields can be seen as glades within the wood, or they can be conserved as significant examples of neutral grassland in their own right.

- Changes in resources.

Inevitably, the resources available to carry out planned work have always been limited to some extent. This is epitomised by the chapter on 'Managerial Constraints' in the 1984 management plan, which states that: "the only managerial constraint ….is the …continuing shortage of manpower to undertake all the proposed projects for the reserve". In other words, an extensive programme of work has been devised, for which the requisite manpower is not available.

Until 1995, Monks Wood had its own site based warden, who could call upon the Woodwalton Fen NNR estate team of four staff to carry out practical management and estate work. After this date, the site became the responsibility of the author, who as Warden for Castor Hanglands thereafter managed a total of four NNRs which, including Monks Wood, cover over 400 ha. At the same time, Estate Worker support was transferred to two full-time staff covering the same suite of sites. Inevitably this led to a reduction in the time and labour available to carry out desired, and even essential work. Latterly the situation has improved with the employment of an additional part-time post to help with winter woodland

management. At the same time, the financial and particularly the material resources available to manage the reserves have increased. This, together with a more liberal attitude to the use of mechanised, rather than manual working methods, means that more has been achieved with the more limited staff resources.

- Responses to changes in the wood.

It should not be forgotten that when Monks Wood first became a nature reserve, it was scarcely more than 30 years since the whole site had been virtually clear-felled. The early management plans dealt with vastly different conditions and structures to those now encountered, and eighty years after felling the wood is still developing and responding to that drastic felling. The maintenance of the traditionally wide 'Monks Wood ride', for example, can only keep pace with the increasing canopy height of the surrounding trees by removing increasing numbers of these trees, and increasing the width of ride edge shrub zones. Recent decades have also seen the arrival of deer, dutch elm disease, and significant changes in the ground flora; management (and management plans) should be responsive to these changes as they occur, but there has sometimes been a delayed response to such events. The changes have often been chronicled but not dealt with directly, perhaps because of an innate conservatism amongst conservation managers.

These influences have together led to at least some change in every significant facet of management within the wood. The most recent revision of the management plan (Gardiner 2001) has incorporated these changes and each of the main aspects of management listed below has been subject to some degree of revision. These are:

- Coppice with standards
- High forest
- Non intervention
- Ride management
- The fields & glades
- Ponds and ditches
- Deer
- Survey and monitoring
- People

Coppice with standards

The 1958 management plan noted the "importance of coppice to entomologists" (note, not insects!) and coppice areas were said to be "most interesting floristically and entomologically in their earlier stages" (Management Plan 1986). These assertions may have been theoretically sound but the reality was that all of the specialised butterflies associated with coppice had, even at that time, disappeared from the wood (Pollard & Yates 1994), and dramatic changes were taking place in the composition of the ground flora, with coarse grasses and pendulous sedge *Carex pendula* replacing dog's mercury *Mercurialis perennis* and other herbs on a large scale. These changes are well documented in the 40th Anniversary Symposium Report (Massey & Welch 1994).

In spite of these considerations, Monks Wood does have a long history of coppicing and was at the time of its declaration 30-year old coppice. In recent years, no more than 12 ha (8%) of the wood has been coppiced, allowing the vast majority of the wood to remain as high forest. Thus, while coppicing was suspended in 1997, this did not signal an end to a centuries-old management regime but was regarded as a temporary necessity while the questions of deer control and protection of coppice were addressed. The suspension also allowed a longer rotation to be established, as the 10-year regime was felt to be unsustainable in practical terms and not necessarily beneficial to invertebrates or indeed to the ground flora: the closed canopy phase, where some of the less desirable dominant species could be suppressed by shade, was not being reached. Coppicing has been continued in the meantime, but with the emphasis concentrated along the ride edges. This still produces the benefits of open space and structural diversity that coppice can provide, whilst allowing the concept of a ride network with broad shrubby margins to be maintained. It also increases the continuity of coppiced vegetation in physical terms, so theoretically at least increasing the benefits for the less mobile species associated with coppice (Fuller & Warren 1990).

The final piece in the coppice jig-saw is the restoration of areas which, although designated as coppice in the management plan, now bear little relation to coppice with standards in the generally understood sense. Compartment 23, an area of 6 ha which comprises the main coppice plot within the reserve, has in particular changed significantly in recent decades, with many of the original coppice stools having died, and a coppice component, where it occurs, consisting mainly of species less palatable to deer including aspen *Populus tremula*, birch *Betula pendula* and blackthorn *Prunus spinosa*. This main coppice block together with Compartments 27 and 30 were deer fenced in 1999, to free both coppice and non-coppice vegetation from deer grazing and browsing, the benefits of which are starting to become apparent (Cooke this volume). Deer have been effectively excluded from compartment 23 but a dense cover of pendulous sedge *Carex pendula* inhibits the recovery of woody vegetation. In the autumn of 2003 a small group of Tamworth pigs were introduced to part of this area in order to break up the sedge and create open ground where woody regeneration might occur. In the space of a few weeks they succeeded in the first of these objectives and there are early signs of plentiful ash seeding but it is too early to tell whether these will succeed as saplings in the face of competition from the recovering sedge. In any event the project serves to fulfil another *raison d'être* of NNRs, that of providing a testing ground for innovative conservation management.

High Forest

High Forest has been an objective for the woodland at least since the 1958 management plan. In later plans this was translated into a more general 'woodland' objective which included a variety of woodland states. From the early days of the reserve, many detailed proposals were advanced to actively manage the high forest by thinning, singling, planting and so on, but in reality virtually none of this work was ever carried out, a fact which had already been recognised by 1993 (Massey & Welch 1994). The most recent revision of the management plan (Gardiner 2001) has legitimised this reality by designating more of the reserve as minimum intervention (Table 1). This is not merely an expedient imposed by a lack of resources, however. It reflects a growing recognition of the importance of minimum intervention as a meaningful objective for woodlands (Peterken 2000) and the very significant importance of the dead wood and ancient woodland component of the Monks Wood fauna, particularly amongst the invertebrates (Table 2).

Table 1. Management categories in the *Monks Wood Management Plan* 1995 and 2001

Management Categories (1995 plan)	**Area (ha)**	**Equivalent categories (2001 plan)**	**Area (ha)**
Woodland	58	High Forest	41
Mixed Woodland	42	Managed Woodland	31
Non Intervention	34	Minimum Intervention	62
Coppice with Standards	14	Coppice with Standards	14

Table 1 illustrates the shift in the allocation of various parts of the reserve to different management categories. For most practical purposes the High Forest category is also effectively also minimum intervention. The distinction being that in the event of major unforeseen events such as storm damage or tree disease, the High Forest category would be restored to woodland by planting or other means, while the minimum intervention would be allowed to recover naturally, whether as woodland or not according to natural processes. The 'managed woodland' comprises a mixture of areas such as elm woodland, blackthorn thickets, and glade edges which may all require periodic management to maintain their individual character.

The revised management plan of 2001 examined the habitat associations of important (ie Red Data Book and Nationally Notable) invertebrates that have been recorded in Monks Wood and these are shown in Table 2.

Table 2. Habitat associations of nationally important invertebrates found in Monks Wood

Habitat category	**Number of species**	**Combined categories**	**Totals (%)**
Dead wood, rot holes etc.	59		
Fungi	36	Saproxylics	38%
Trees and shrubs	35		
Low plants and herbs	18		
Soil, litter and moss	14	Woodland trees/plants/soil	27%
Ponds and streams	19		
Wet woodland and marshland	17	Wet woodland habitats	15%
Open woodland & grassland	14		
Bare and disturbed ground	4	Open and marginal habitats	8%
Predators and parasites	10		
Carrion, dung, nests etc.	6	Predators, commensals	7%
Miscellaneous, unknown	14	Others	6%

It is apparent that a large proportion of invertebrates of importance present on the site are dependent upon the ancient woodland, dead wood and associated habitats. This balance should be reflected in the management and therefore a more pro-active approach to dead wood management has been developed to supplement the designation of minimum intervention woodland. The principles of the policy can be summed up in a simple rule of thumb for the provision of dead wood for invertebrates, as expressed by English Nature's

Senior Invertebrate Ecologist: “the bigger the better, and the more the merrier” (R.Key, pers comm.). In practise this translates to:

- No timber has been sold or removed from site in recent years.
- Wood is stacked in preference to being burned.
- Timber is winched whole, or in large units, from cleared areas in to the woodland edge.
- Pollards are being created to establish new habitat for saproxylic species.

The creation of new pollards, whilst quite labour intensive, is designed to encourage new features of interest for saproxylic invertebrates, whilst retaining the boles of semi mature trees. This has particular benefits where rides are being widened, as a proportion of more mature trees can be retained without the problem of overshading the ride. The fact that Monks Wood currently has only one remaining venerable old pollard has not been regarded as a handicap; these will become the venerable trees of the future, and there are significant veteran pollards present on nearby estate land where a reservoir of their associated fauna may also survive.

Fields and glades

It is well documented that the fields in Monks Wood are only of recent origin, having been cultivated within the past 60 years (Steele & Welch 1974). Nevertheless they are one of the criteria features of the SSSI, which was notified both for its ancient woodland and neutral grassland interest. This makes it imperative that they are managed to maintain this interest.

For many years the fields were in effect managed as hay meadows, although as a rule they were not cut until the autumn, and perhaps every third or fourth year the cut would be missed due to waterlogged ground conditions. Problems were also encountered in disposing of the vast bulk of litter and vegetation which had accumulated by the end of each growing season, which (weather permitting) was usually burned. This was also somewhat labour intensive. Cutting is also more damaging to invertebrates (Kirby 1992), and in 1998 grazing was introduced in preference to cutting. Initially this was tried with sheep but subsequently cattle have been used, most recently with stock from the Galloway herd kept at Woodwalton Fen NNR. Grazing has allowed a less uniform, more diverse sward structure to develop but in parts of East Field, has allowed aspen and sallow scrub to increase. Although mowing had controlled this growth, it had tended to promote coppice and sucker growth amongst the incipient scrub, greatly increasing the density of woody vegetation low down within the sward. This has been treated by weed wiping during the summer with a treatment of gyphosate, which has proved to be extremely effective.

These treatments alone have not produced the more varied and open sward which quite clearly existed until relatively recent times. A more radical approach has been pioneered, taking as its cue the early photographs showing large areas of bare ground and sparse, patchy vegetation cover (Steel & Welch 1974). A return to these conditions would reduce the dominance of scrub and coarse tussocks of *Calamogrostis* and other species which have become established over large areas. In 1998 heavy machinery was brought in, to remove rank vegetation and open up the sward over a small experimental area. The machine used was a ‘Blecavator’, a combined stone-burier and roller more usually employed on golf courses, which takes the top 10 –20 cm of the ground surface, and inverts it, bringing the sub-soil to

the top. The results of this, both in the initial trial and several subsequent uses, have exceeded expectations. Sward density, grass and scrub cover have all reduced, whilst the proportion of herbs, available nectar sources and bare ground have all increased. (Figures 1 & 2).

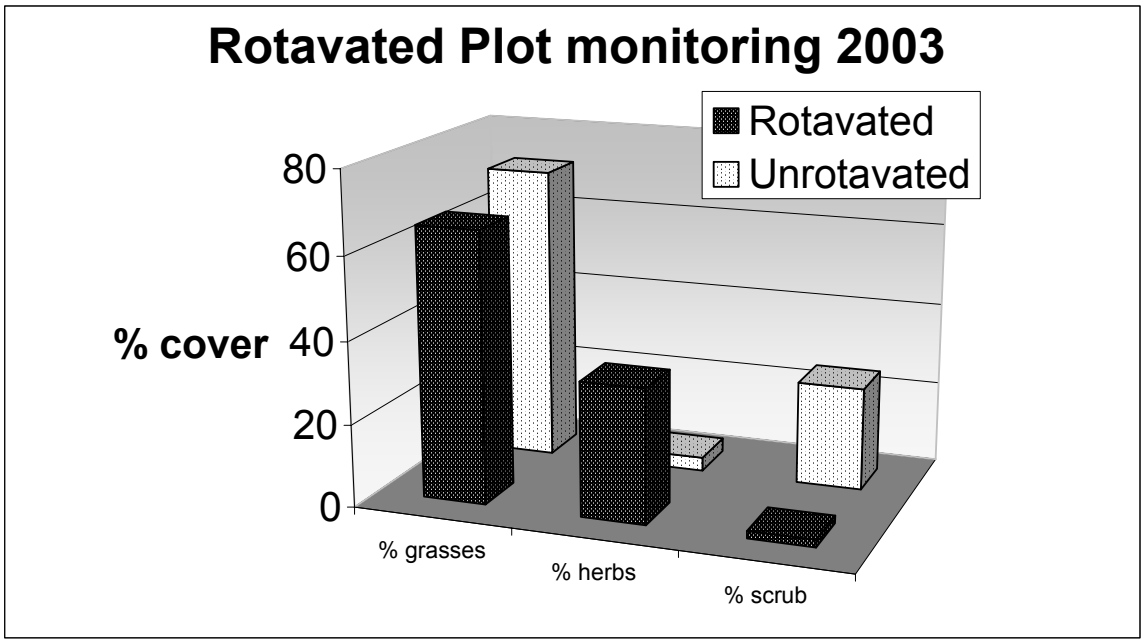


Figure 1.

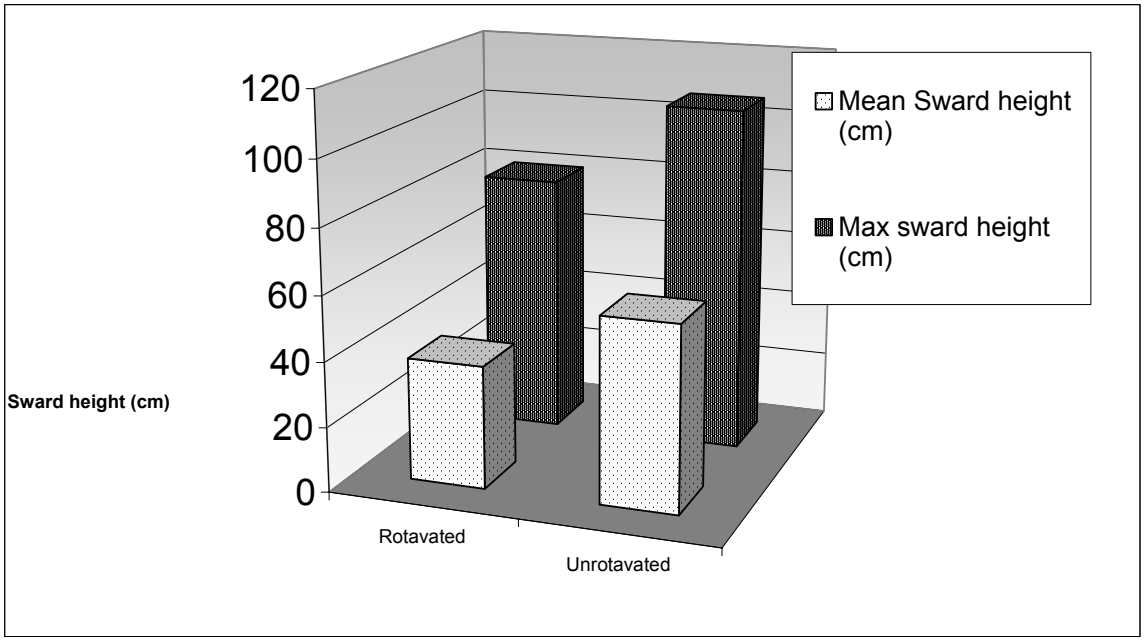


Figure 2

The Monks Wood rides

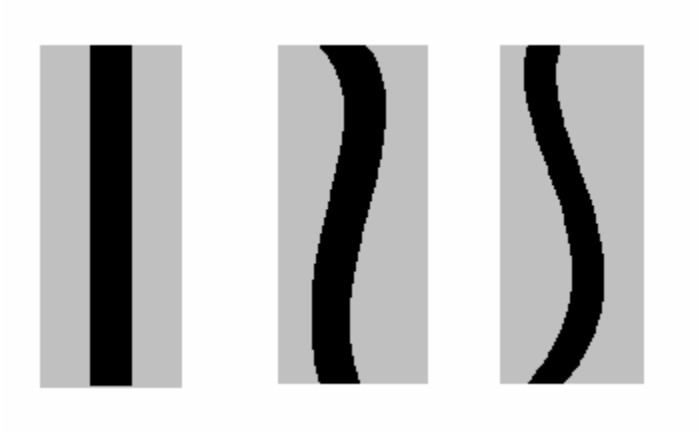
The rides have changed significantly over 50 years, although the objectives for the 'Monks Wood Ride' – a broad, open track, with distinct zones of short and tall herb vegetation flanked by dense shrub margins grading in to the mature woodland – remain unchanged. One of the difficulties in achieving this ideal has been the ever increasing height of the canopy already alluded to, necessitating a wider and wider swathe of ride being managed to achieve the originally envisaged benefits of light penetration to the ride floor. There has perhaps been some reluctance over the years to thin out or remove enough of the many oak trees bordering the rides to allow the ideal objectives to be reached. This has now been dealt with by the pollarding already described, coupled with a more robust approach to felling, which recognises that if the rides are to fulfil their purpose of providing open space within the woodland, this is unavoidably at the expense of tree cover. In any event the number of rides which are selected for this treatment is still limited to a small proportion of the overall total. With parts of main, hotel, barrow and stocking close rides being managed in this way, less than 3.5 km of the 18.5 km ride network will be actively managed for any purpose other than access.

The management of the herb vegetation has also been challenging, especially so since the vegetation of the rides has altered considerably over the years as shown in Table 3. This has often been a case of moving goalposts, as the management carried out on the rides has evidently not maintained the flora which it was presumably established to preserve.

The main rides, managed for their botanical interest, are now cut 2 or 3 times a year with a final cut-and-gather in the autumn. Earlier management prescriptions involving 2, 3, or 4 year cutting rotations have all been discontinued, as in addition to being rather complicated, they also allowed rank grasses and even woody species to build up on the rides particularly if there was any slippage in the programme. This made subsequent cuts very difficult. The ride centres, on the other hand, having been cut regularly over a period of years, became in effect 'lawns', with little botanical interest. The current management aims to maintain or improve botanical diversity rather than simultaneously trying to satisfy the needs of both plants and "invertebrates" (which ones were rarely specified), as had previously been the case. The most successful of the new cutting regimes has been the 'drunken tractor driver' system. This involves replacing the periodic summer cuts down the ride centre (Figure 3a) with a more sinuous route, taking in parts of the ride margin and taller herb vegetation. (Figure 3b). This cut is repeated several times as necessary during the season in the normal way. In the following year, a similarly random but different route is followed (Figure 3c). Each autumn, more or less the whole width of the ride is also cut and gathered off. The effect of this approach is to ensure that more of the ride is managed more intensively, and it also produces a greater variety of structural variation within the sward. Taller, unmanaged herb vegetation is retained at the ride margins, ditches and in the more open parts of the ride edge coppice.

Table 3. Comparative assessment of the abundance of ground flora on the rides. Symbol size is indicative of the relative abundance reported by each author. (Based on Brierley (1999))

Westhouse Ride	**Dony**	**Ward**		**Main Ride**	**Dony**	**Ward**	**Hughes**
	1953	**1977**			**1953**	**1977**	**1999**
Agrimonia eupatoria	●			*Circaea lutetiana*	●	•	
Cirsium palustre	●			*Potentilla reptans*	●	●	•
Circaea lutetiana	•	●		*Anagallis arvensis*	•	•	
Epilobium sp.	•	•		*Centaurium sp.*	•	•	
Galium palustre	•			*Epilobium montanum*	•	•	.
Hypericum tetrapterum	•			*Prunella vulgaris*	•	•	●
Rubus sp.	•			*Sagina procumbens*	•	•	
Ajuga reptans	•			*Veronica serpyllifolia*	•	•	
Dipsacus fullonum	•			*Cerastium glomeratum*	•	•	
Prunella vulgaris	•	●		*Myosotis arvensis*	•		
Grasses		●		*Grasses*		●	●
Glechoma hederacea		●		*Capsella bursa-pastoris*		●	
Filipendula ulmaria		●		*Glechoma hederacea*		●	•
Capsella bursa-pastoris		●		*Agrimonia eupatoria*		●	
Geum urbanum		●		*Hypericum hirsutum*		•	•
Ranunculus repens		●		*Plantago major*		•	
Rumex acetosa		●		*Veronica chamaedrys*		•	
Veronica chamaedrys		●		*Viola hirta*		•	
Hypericum hirsutum		•		*Bellis perennis*		•	•
Mercurialis perennis		•		*Cirsium arvense*		•	
Plantago major		•		*Euphrasia nemorosa*		•	
Mentha arvensis		•		*Hypericum perforatum*		•	
Sonchus asper		•		*Kickxia spuria*		•	
Viola riviniana		•		*Potentilla anserine*		•	
				Sonchus asper		•	
				Taraxacum agg.		•	
				Viola riviniana		•	.
				Ajuga reptans		•	•
				Chaemanerion angustifolium		•	
				Dipsacus fullonum		•	
				Epilobium sp.		•	
				Lysimachia nummularia		•	•
				Malva moschata		•	
				Plantago lanceolata		•	
				Rumex sp.		•	•
				Trifolium repens		•	●
				Veronica officinalis		•	
				Ranunculus repens			●
				Filipendula ulmaria			●
				Lathyrus pratensis			●
				Rubus fruticosus agg.			●
				Carex sylvatica			•
				Crataegus monogyna			•
				Ligustrum vulgare			•
				Solanum dulcamara			•
				Potentilla sterilis			•



3a 3b 3c

Figure 3. Ride cutting patterns

Glade management

Many of the remarks made about ride management also apply to the smaller glades within the wood, and for all practical purposes these glades are now treated as a part of the ride system, where the presence of the glade provides additional permanent open space within the wood. In recent years, work has focused on removing trees which have been overshading the glades, especially those belts of trees which previously separated the glades from the rides. Shrub margins have also been managed more actively. The glades have also benefited from the pollarding, mowing and rotavating methods as described, and significant recoveries, albeit based on subjective assessments, have been seen in species such as bugle *Ajuga reptans* after rotavation.

Ponds and ditches

One of the most noticeable aspects of earlier management plans is the high priority which was accorded to the maintenance of ditches, and it is apparent from surviving work programmes that large amounts of time were spent on this activity. This contrasts sharply with current practise, where no management at all is carried out on the ditches apart from the maintenance of culverts for safety reasons, and clearance of boundary ditches in order to meet obligations to our neighbours. This is not so much due to a lack of resources as the lack of a perceived need to carry out this work. Regarding the ponds, the situation is somewhat different as they clearly bring a number of conservation benefits to the site and support a significant minority of the important invertebrates recorded in Monks Wood (Table 2). The biggest problem affecting the ponds seems to be a general lowering of the water table, and six of the sixteen ponds recorded in Steele & Welch (1973) no longer function as ponds in any meaningful way. Small-scale clearance has been carried out on two of the ponds, and indeed two new ponds have been dug, albeit to provide water for grazing stock in the fields and not principally for habitat creation.

Survey and monitoring

One of the difficulties in determining the success (or otherwise) of management over the years has often been the lack of detailed monitoring data to support decisions. Complex and ambitious monitoring programmes have variously been proposed or even set up in the past, but rarely maintained or completed, and the reality is that there are never likely to be sufficient resources available to monitor each aspect of management in detail, and over long periods of time. There is now an emphasis on simple assessment monitoring to see if objectives have been achieved (Table 4). This draws upon current research or survey data where available, combined with basic visual or photographic records to see if objectives are being met.

Table 4. Example of Annual Monitoring Summary from Monks Wood management plan

Compartment	Notes, Impacts, Changes	Supporting Data	Objectives met (Y/N)
0 (whole site)	**Deer management**: 65 deer shot in/around wood; deer score remains low, grazing/browsing damage still apparent; Maintain/increase cull, maintain monitoring.	Cooke (2002) Deer monitoring report; cull returns	Y
	Ride edge coppice: increased light to ride and glades, mixed re-growth, continue monitoring	Visual observation (Sept 2002)	Y
	Scrub control: glyphosate. 60-90% kill rate across field; some re-treatment may be needed; good botanical response in treated area.	Visual observation, photographs	Y
	Cut/gather for Melampyrum; open sward structure achieved, successful flowering	Visual observation, monitoring figures (Hughes)	Y

These simple and ad-hoc methods provide a limited amount of information, largely confined to monitoring the effects of management. As the time and opportunity available for English Nature staff to engage in 'scientific' recording has declined, so the contribution made by staff at CEH becomes more important. The register of current research would look very thin indeed without their contribution. Reference to the table in the bibliography demonstrates that Monks Wood continues to be a significant source of published material, much of which can be used to inform the management of the site. A high value is also attached to the continuing supply of both casual observations and systematic records of the flora and fauna, which members of staff and other visitors to Monks Wood still provide.

Public access

Until 1990/91, access to Monks Wood was by permit only and around 500 permits were issued in that year. Since permits were rarely if ever checked, there is no indication as to whether this was the actual number of people using the reserve, and in reality the number of visitors was probably somewhat larger. Like all NNRs which are not covered by Leasehold restrictions, the Reserve is now classed as open access, which means that it is effectively open to the public all the year round and at any time, other than when it is temporarily closed for shooting. Nevertheless visitor numbers remain low, and it is possible to visit the site on many days without encountering anyone except members of CEH staff, who probably make up the largest user group for the reserve. Estimates in the NNR Annual Reports in recent years put the figure at a more realistic 5000 per year which would equate to about 15 visits per day. The main factors limiting increased visitor numbers are:

- Lack of adequate parking, and concerns over the security of parked cars.
- Lack of promotion – the reserve is not advertised widely, and information about its existence is not widely available locally.
- Location – there are no large settlements nearby.

The holding of two highly successful open days in 2000 and 2003, which attracted 2300 and 800 visitors respectively, showed that there is a demand for visits to Monks Wood and a large potential audience. The resources needed to run these events mean that they are likely to remain the exception, and Monks Wood will continued to be used in a relatively low-key way. However English Nature's policy of opening up reserves to increase public access is likely to result in greater public use in the future.

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Monks Wood NNR - vegetation studies 1993 – 2003

Keith Kirby
English Nature, Northminster House, Peterborough PE1 1UA

Summary

The last 10 years have confirmed the broad changes to the vegetation that were identified in the 1993 symposium (a) through further study of the current state of the wood, but also (b) through analysis of past records, notably a plot-based survey from the 1960s and the vegetation map in the 1973 reserve account. The key role of deer in causing these changes has been established, although other factors cannot be wholly eliminated. The management put in place to address the deer impact should mean that in the next decade there will be a recovery in at least some aspects of the vegetation and structure. Further work is desirable in the next three years to improve the baseline for assessing that recovery, but also to check whether the impact of other factors such as climate change or nutrient enrichment start to emerge as significant for the vegetation.

The 1993 review

The major changes in the vegetation up until 1993 noted by Wells (1994) were:

- dramatic decrease in flowering of vernal and pre-vernal species;
- increase in grasses and decrease in herbs along the rides;
- greater amounts and increased persistence of bramble in coppice plots;
- increases of coarse grasses (*Calamagrostis epigejos, Deschampsia cespitosa*) in the fields.

Grazing by muntjac *Muntiacus reevesi* (Cooke 1994) was proposed as the most important change in the wood over the previous 15 years, but the possibility that climatic variations and deposition of nitrogen might also be affecting the woodland vegetation was put forward. Management changes were thought to be a significant factor with respect to the increased grassiness of the rides.

Changes had occurred in the tree and shrub layer (Peterken 1994; Welch 1994) over the previous 15 years:

- through death of mature birch trees (a legacy of the 1976 drought);
- some small-scale windblow (1987, 1990 storms);
- loss in some places of short-lived trees such as aspen;
- loss of elm from elm disease.

However most of the wood was not affected by these disturbances and the main changes were brought about through the ongoing maturation of the stand from its derelict coppice state in 1953. Trees in the overstorey were thinning themselves out slowly, although basal area had

probably increased; underwood species were declining. In addition the destruction of privet undergrowth and groups of ash regeneration by deer was noted.

Work on the vegetation 1993-2003

Others (Gardiner this volume; Hughes this volume) consider the fate of the rarer plant species and the management of the rides, so this paper covers primarily the broad composition of the tree, shrub and ground flora layers in the woodland stands. As Wells (1994) noted "…it is a sad fact that there has been little long-term monitoring of vegetation in the wood, although there have been numerous starts made in the past…". However over the last 10 years some of the earlier records have been resurrected as a basis for quantifying the changes that were identified in 1993.

The key sources for assessing long-term change have been various surveys organised by R C Steele and colleagues in the 1960s, which included:

- 36 temporary survey plots (including both ground vegetation and tree and shrub records) recorded in 1966 across the wood (Crampton and others 1998);
- a permanent plot 70 x 35 m established in the north-west corner of the wood within which tree and shrub densities and sizes were measured (Welch 1994; Crampton and others 1998);
- the vegetation maps from the early 1970s that appeared in the back of the Monks Wood book (Steele & Welch 1973; Cooke and others 1995).

Further information on the tree and shrub layers has come from the four transects established by Christa Backmeroff in 1985, which were fully re-recorded in 1996 (Peterken 1994; Mountford and Peterken 1998). Detailed records on the impact of muntjac on the vegetation are summarised by Cooke (this volume) in a separate contribution. Some casual records made by the author at different times have also helped in interpreting the changes observed.

Changes in the ground flora

The frequency of selected species recorded in the 1966 survey, represented on the 1973 maps, noted in a field visit to part of the wood in 1979, and in 36 plots recorded in 1996 are given in Table 1. The vegetation appears to have been relatively stable up until 1979 at least, and to have undergone significant change sometime after that probably in the late rather than early 1980s, with a spread of grasses and sedges, the loss of cover of *Rubus fruticosus* and of *Mercurialis perennis* in particular. The increased dominance of bramble in the coppice areas noted by Wells (1994) may have been a temporary phase during which the impact of the deer in slowing the coppice regrowth (hence favouring bramble growth) outweighed the direct impact of the deer on the bramble itself. The changes at Monks Wood are similar to those seen elsewhere in lowland woods where deer pressures have increased, for example at Wytham Woods, Oxfordshire (Kirby and Thomas 2000; Kirby 2001) (Table 2).

Table 1. Frequency of selected ground flora species 1966-1996.

Date	1966	1973	1979	1996
Brachypodium sylvaticum	0	46	Occasional	32
Carex pendula	0	28	Occasional	18
Glechoma hederacea	18	379	Frequent	29
Hyacinthoides non-scripta	9	140	Locally abundant	11
Mercurialis perennis	21	32%	Abundant	7
Poa trivialis	0	8	Rare	35
Rubus fruticosus	15	431	Frequent	21
Urtica dioica	1	49	Occasional	9

1966 data - frequency of occurrence in 36 plots
1973 data - no of symbols shown on map for species (total all species 1513) except for *Mercurialis* where the cover figure is based on the area shaded on the map.
1979 data - subjective cover assessments from survey of central third of wood
1996 data - frequency of occurrence in 36 plots
(The 1966 figures differ slightly from those in Crampton and others (1998) because of a transcription error in that paper).

Table 2 Comparison of the changes in frequency/cover for selected ground flora species in Monks Wood and Wytham Woods

Species	Monks Wood (1964-1996)	Wytham Woods (1974-1991)
Brachypodium sylvaticum	Increased	Increased
Carex pendula	Increased	No change
Glechoma hederacea	Increased	Increased
Hyacinthoides non-scripta	No change	No change
Mercurialis perennis	Decreased	Decreased (cover)
Poa trivialis	Increased	Increased
Rubus fruticosus	Decreased (cover)	Decreased (cover)
Urtica dioica	Increased	No change

Changes in the tree and shrub layers

Table 3 Tree and shrub layer data from surveys based on temporary sample plots across the wood and from permanent transects.

Source	**Crampton and others 1998**		**Mountford and Peterken 1998**	
Method	36 temporary sample plots across whole wood		4 permanent transects	
Survey year	1966	1996	1985	1996
Basal area (trees) m^2ha^{-1}	22.3	27.9	23.8	26.2
Stem density (trees) per ha	1469	611	832	667
Shrub density	235 stools/ha	177 stools/ha	2993 stems/ha	2383 stems/ha
Composition	% of tree stems		% of tree stems	
Ash	57	54	65	63
Field maple	17	24	29	31
Oak	4	5	3	3
Birch	11	1	1	1
Aspen	6	4	<1	-
	% of shrub stools recorded		% of shrub stems recorded	
Hawthorn	45	49	52	62
Hazel	27	22	36	32
Blackthorn	19	19	3	3
Dogwood	6	5	5	1
Privet	Frequent in ground flora record		5	1

The two surveys of the tree and shrub layers (Table 3) show similar results, that are also in line with the preliminary conclusions of Peterken (1994) and Welch (1994). There has been little change in the woody layers in terms of species richness or composition apart from a decline in birch across the wood; there have been declines in the density of tree stems per hectare; the shrub layer has thinned out; and the basal area increased. The differences between the surveys are due to the differing methodologies, survey periods and amount of the woodland covered.

Both surveys noted the lack of stems less than 1.3 m high, even though in 1985 these had been abundant in parts of the permanent transects. Mountford and Peterken (1998) also report other signs of muntjac damage to the trees such as loss of bark.

The next decade - potential for vegetation recovery?

Within exclosures there are locally signs that *Rubus fruticosus* and *Mercurialis perennis* can recover. Cooke (this volume) notes the increased flowering of *Hyacinthoides non-scripta* following the reduction of deer populations by stalking in the wood. However the future development of the vegetation will take time and may not lead to exactly the same composition as existed in the 1960s. Even if the only driver of vegetation change has been the deer pressure this may have operated through a variety of different mechanisms and pathways (Figure 1), not all of which may be reversible.

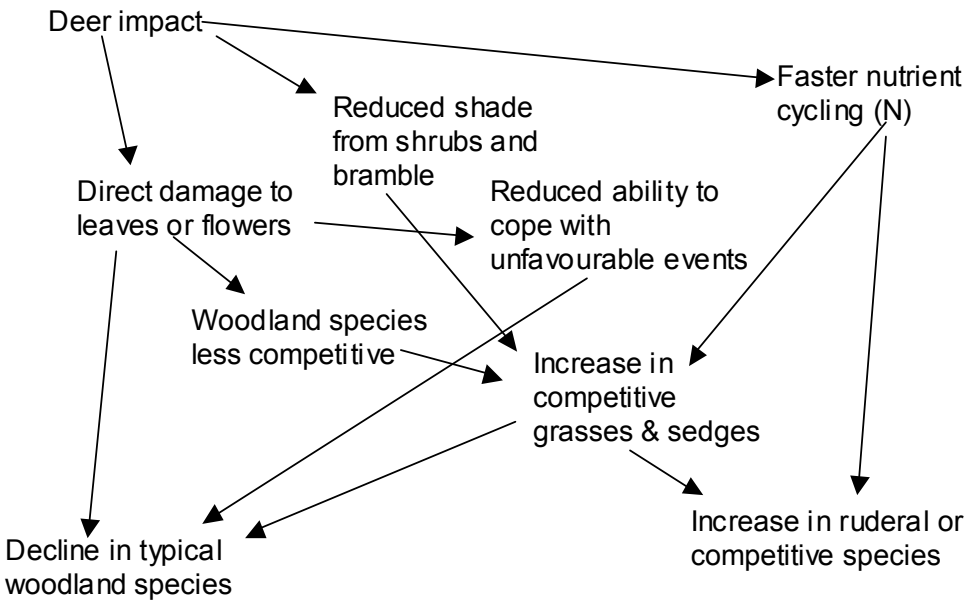

Figure 1 Possible pathways by which deer may have influenced the vegetation changes in Monks Wood.

A key factor is likely to be whether the species that have declined still occur in the stands, either as suppressed plants or as buried seed, and hence can take advantage of reduced grazing. However even if they are still present the now-established dense stands of coarse grasses and sedges (*Brachypodium sylvaticum*, *Calamagrostis epigejos, Deschampsia cespitosa, Carex pendula*) may now inhibit both regeneration of trees and shrubs and re-invigoration of the vernal herb species. Reduction in abundance of these competitive species (creating regeneration opportunities) may require a phase of dense shading. This might be brought about by development of dense bramble thickets that will substitute for the much reduced shrub layer in the wood. The shrub layer might also be artificially enhanced by planting.

Alternatively dense vegetation mats might come to be broken up by ground disturbance, for example the incidence of windthrow is likely to increase in future years as the canopy matures. The potential for pigs to increase opportunities for regeneration by breaking up vegetation mats is also being explored. Trials have been carried out at another National Nature Reserve, Langley Wood (Wiltshire), into their effectiveness in increasing regeneration in bracken-dominated stands. However these grass and sedge species do have considerable potential to spread back into disturbed areas and a single period of disturbance may not be sufficient, so it will be essential to monitor success or otherwise with this trial.

Conclusions

The high level of deer grazing in lowland coppices is a recent phenomenon (Rackham 2003) which has serious consequences for the conservation of their characteristic species and structures. At Monks Wood the introduction of deer control within the reserve and the creation of exclosures should allow opportunities for the ground vegetation to move more towards what it was like in the 1960s.

To what extent the changes brought about by the deer are reversible, and what treatments may be needed to assist this process, remains to be seen (cf Figure 1). As the deer impact is

reduced so other impacts (eg from climate change) may emerge, or they may not. We may have the opportunity in Monks Wood to explore different approaches on an experimental basis, provided this is not at the expense of other features of interest in the wood.

The symbol frequency for thirteen species shown on the 1973 ground flora map (the eight species in Table 1 plus five others not recorded in 1996) is closely correlated with the frequency of those species in the 1966 survey (Figure 2) (Pearson rank correlation coefficient 0.78). Therefore the map could be used as a quantitative baseline for exploring and comparing variations in current vegetation across the wood, that would provide a better spatial basis for assessing future changes. Ground flora records should also be made in association with the four permanent tree and shrub transects because changes in the tree and shrub layers do not necessarily correlate well with those in the ground flora.

The state of the woodland vegetation has not changed dramatically over the last decade, compared to the changes between 1973 and 1993; however the survey work that has been undertaken provides a much sounder basis for assessing future vegetation development.

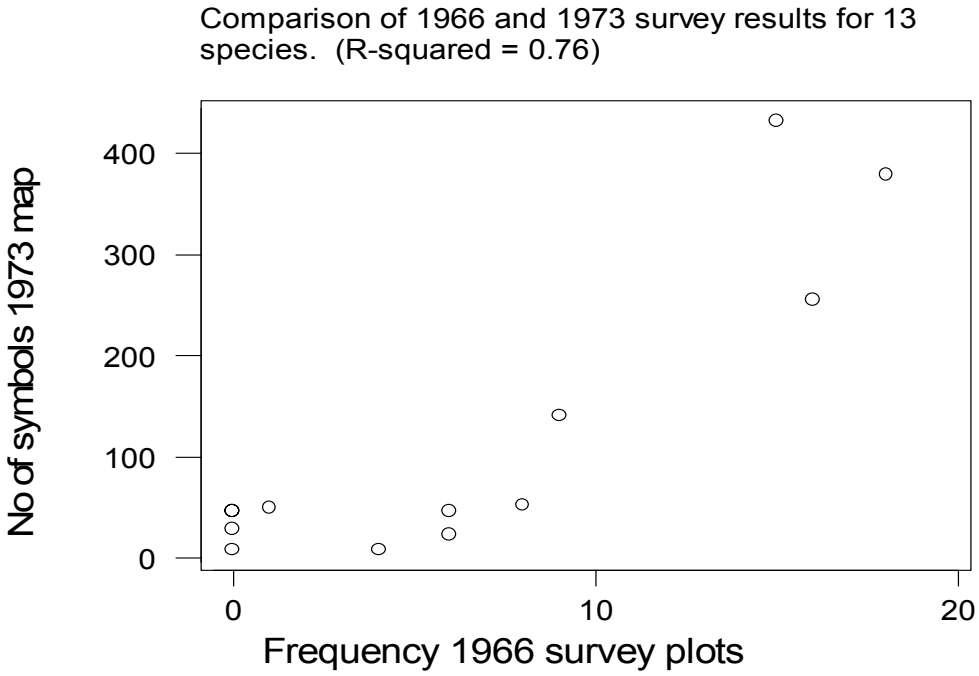

Figure 2 Comparison of results from 1966 plot survey with symbol frequency on 1973 map for thirteen species shown on map (two points are superimposed).

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Mapping the species composition and structure of Monks Wood using airborne spectral reflectance and LiDAR data

Ross A. Hill & Andrew Thomson

NERC Centre for Ecology and Hydrology, Monks Wood, Abbots Ripton, Huntingdon,Cambridgeshire PE28 2LS

Introduction

Monks Wood National Nature Reserve (NNR) is a broadleaf woodland, covering an area of 157 hectares. The canopy tree species are ash *Fraxinus excelsior*, pedunculate oak *Quercus robur*, field maple *Acer campestre*, silver birch *Betula pendula*, aspen *Populus tremula* and there are a few remaining small-leaved elm *Ulmus carpinifolia*. Ash is the most common and widespread species, oak occurs less frequently because of intense felling during the First World War. In fact, few trees in the canopy are more than 80 years old as a result of this. Field maple and silver birch are found scattered throughout, whilst aspen and elm form occasional clusters on the wetter soils. Elm declined significantly in the 1970s due to an outbreak of Dutch elm disease. Elm stands were left to regenerate naturally, and today tend to be rather scrubby in nature. The dominant shrub species making up the understorey and woodland fringes of Monks Wood are hawthorn *Crataegus monogyna*, common hazel *Corylus avellana*, blackthorn *Prunus spinosa*, dogwood *Cornus sanguinea* and wild privet *Ligustrum vulgare* (Steele & Welch 1973; Patenaude and others 2003). Monks Wood is extremely heterogeneous in terms of the woody species making up the canopy and understorey, their relative proportions in any area, canopy closure and density, tree height and trunk density. Bevill's Wood, by contrast, has stands of beech *Fagus sylvatica*, Scots pine *Pinus sylvestris* and Norway spruce *Picea abies* that were planted in the 1960s. These patches of woodland are dominated by single species, have a relatively homogeneous structure and tend to lack an understorey.

Mapping the heterogeneity of Monks Wood is no easy task. This paper explores the potential of airborne digital remote sensing data to map the species composition and structure of Monks Wood and the neighbouring Bevill's Wood. First, we give an overview of two different types of airborne remote sensing: multi-spectral scanning and laser scanning. Then, we give a brief outline of the benefits of integrating these two techniques and the resulting data products, and finally, show the results of mapping Monks and Bevill's Woods. This represents just one way of characterising the species composition and structure of these woods.

Airborne multi-spectral scanners

Reflected solar radiance in the visible and infrared parts of the electromagnetic spectrum can be recorded by airborne sensors, supplying complete spatial coverage of a landscape. Land-cover types vary in their reflectance characteristics at different points in the spectrum. Airborne sensors are designed to record reflected radiance in those parts of the spectrum where differences between land-cover types are likely to be greatest and where 'noise' from atmospheric attenuation is likely to be minimised. For example, the Airborne Thematic Mapper (ATM) is a multi-spectral scanner that records reflected radiation in 11 separate 'slices' of the electromagnetic spectrum, known as wavebands. These wavebands fall in the

visible, near infrared, short wave infrared and thermal infrared parts of the spectrum. The band widths vary from 30-50 nm for the visible and near infrared bands, to 170 nm for the short wave infrared bands and 5000 nm for the thermal infrared band. By contrast, Hymap is a hyper-spectral scanner that records reflected radiance in 126 wavebands, which each have a much finer division of the spectrum (band widths of 7-20 nm). The spatial resolution (ie pixel size) of airborne multi- or hyper-spectral data will depend on lens optics and aircraft altitude during data acquisition. A typical spatial resolution for airborne spectral scanners would be in the range of 1-5 m, whilst the swath width recorded on the ground beneath the aircraft is typically in the range of 500-1500 m.

Multi-spectral reflectance data can be used to map land-cover in a range of different environments (Zarco-Tejada & Miller 1999; Lewis 2000; Thomson and others 2003). This enables landscape characteristics to be assessed (Roughgarden and others 1991). This might include the proportional composition and spatial pattern of land-cover, or the size, shape and connectivity of individual features. However, confusion can occur between land-cover types with similar reflectance characteristics. For example, in multi-spectral data recorded in the summer, it can be difficult to separate different woodland types (even deciduous from coniferous woodland). Hyper-spectral data, with a greater number of narrow wavebands, can enable information such as plant species composition, green biomass and plant vigour to be ascertained.

Airborne laser scanners

Airborne laser scanning is a relatively recent technology that can record directly the three-dimensional structure of a landscape at a high spatial resolution. This technology operates on a principle of Light Detection And Ranging (LiDAR), using a laser range finder and a scanning mechanism to measure the elevation at points within a swath beneath the flight-path of an aircraft. A short-duration pulse of near infrared laser light is transmitted towards the ground by the aircraft-borne laser scanner. The timing of the return signal is recorded following reflection from a feature on the Earth's surface. The time-of-flight information is used to derive a ranging measurement. Control and recording units on board the aircraft regulate the process of on-line data acquisition. To identify the three-dimensional position of each ranged point, the aircraft must have an integrated position and orientation system consisting of a differential global positioning system (dGPS) and an inertial measurement unit (IMU). The IMU records the roll, pitch and heading of the aircraft to determine its orientation, whilst the dGPS records its precise location. During post-flight data processing, the position and orientation data are used to geo-reference the ranging measurements. Each incident laser pulse thus supplies accurate (in x-, y- and z-) point-sample elevation data for the ground surface and/or objects on it.

The return signal from an incident laser pulse over a forested area will take a waveform, containing information of scattering events from surfaces at varying distances within the canopy. The width of the returned waveform from a laser pulse will depend on the penetration depth of the incident pulse, which is a function of incidence angle and canopy density. Over a forested area, typically the first significant 'echo' in the return signal records information from the canopy surface, whilst the last significant 'echo' records information from within the canopy or possibly penetrates to the ground.

Laser scanners such as the Airborne Laser Terrain Mapper (ALTM) have a footprint size of each laser pulse on the Earth's surface of approximately 0.2-0.3 m diameter. For each laser

pulse, both the first and last part of the reflected signal are recorded, thereby giving two elevation measurements. High pulse-repetition laser scanners can record thousands of ranging points per second resulting in a high density of sampling points on the ground. The actual sample density and distribution will vary according to the altitude and speed of the aircraft, and the configuration of the scanner (in particular the laser repetition rate and scan angle). Sampling densities as high as 10 laser hits per m^2 can be achieved, although 1 hit per m^2 or fewer is more typical. By scanning in sweeps perpendicular to the flight-line, the forward motion of the aircraft generates a zig-zag pattern of point samples. This sampling density is adequate to render a distinguishable three-dimensional model of individual tree crowns. Fitting an interpolated surface through the cloud of point sample elevation measurements produces a Digital Surface Model (DSM). In a forested area a DSM produced from either first or last return elevation measurements will contain both geomorphologic height (describing the terrain) and morphologic height (relating to the overlying vegetation canopy). Separating these height features generates a Digital Terrain Model (DTM) of the forest floor and a Digital Canopy Height Model (DCHM) of the forest.

Prominent surface features such as trees and woodlands can be distinguished in processed LiDAR data, enabling information on pattern and size to be derived. However, the identification of land-cover types is limited in surface elevation data. This can prevent an assessment of surrounding context or species composition for woodlands, which can be useful information for assessing their condition or habitat quality.

Integrating airborne spectral reflectance and LiDAR data

Spectral reflectance data recorded by an airborne scanner can be used to identify land-cover, and potentially, plant species. Integrating spectral data with airborne LiDAR data can enable land-cover to be placed in a terrain context enabling two-dimensional landscape patterns to be understood in relation to elevation or topographic relief. In addition, the three-dimensional characteristics of surface vegetation can also be identified. Not only does this supply extra detail on the nature of the vegetation, but may also allow a greater variety of vegetation types to be distinguished than is possible using spectral reflectance data alone. Mapping woodland using integrated airborne spectral reflectance and LiDAR data is a novel approach, and one that offers an alternative way of characterising such landscape features.

Mapping the species composition and structure of Monks Wood & Bevill's Wood

Remote sensing data used

Hyper-spectral data of Monks and Bevill's Woods were acquired in June 2000 by the Hymap sensor. This recorded reflected radiation in 126 wavebands, for pixels with a 4 m spatial resolution. The 126 wavebands covered the spectral range from visible to shortwave infrared: bands 1-5 visible blue, bands 6-11 visible green, bands 12-17 visible red, bands 18-22 red-edge, bands 23-62 near infrared, bands 63-94 shortwave infrared (sensor 1), bands 95-126 shortwave infrared (sensor 2). On the basis of spectral profiles for woodland and other vegetated surfaces, a representative selection of 12 wavebands was chosen from the 126 that encompassed all significant spectral variation of Monks and Bevill's Woods (Table 1, Figure 1).

Table 1. The 12 wavebands selected from the Hymap spectral reflectance data of Monks & Bevill's Woods.

Waveband # in 12 band image	Waveband # in 126 band image	Comments
1	6	Blue-green, chlorophyll absorption
2	9	Green (minor peak in reflectance)
3	17	Red, chlorophyll absorption
4	19	Red edge
5	21	Near-infrared, top of red-edge
6	42	Near-infrared, *c.* mid-range high point
7	62	Near-infrared, extreme waveband for this sensor (low)
8	66	Shortwave infrared, sensor 1, low point
9	85	Shortwave infrared, sensor 1, *c.* mid-range high point
10	96	Shortwave infrared, sensor 2, low point
11	109	Shortwave infrared, sensor 2, *c.* mid-range high point
12	123	Shortwave infrared, sensor 2, low point

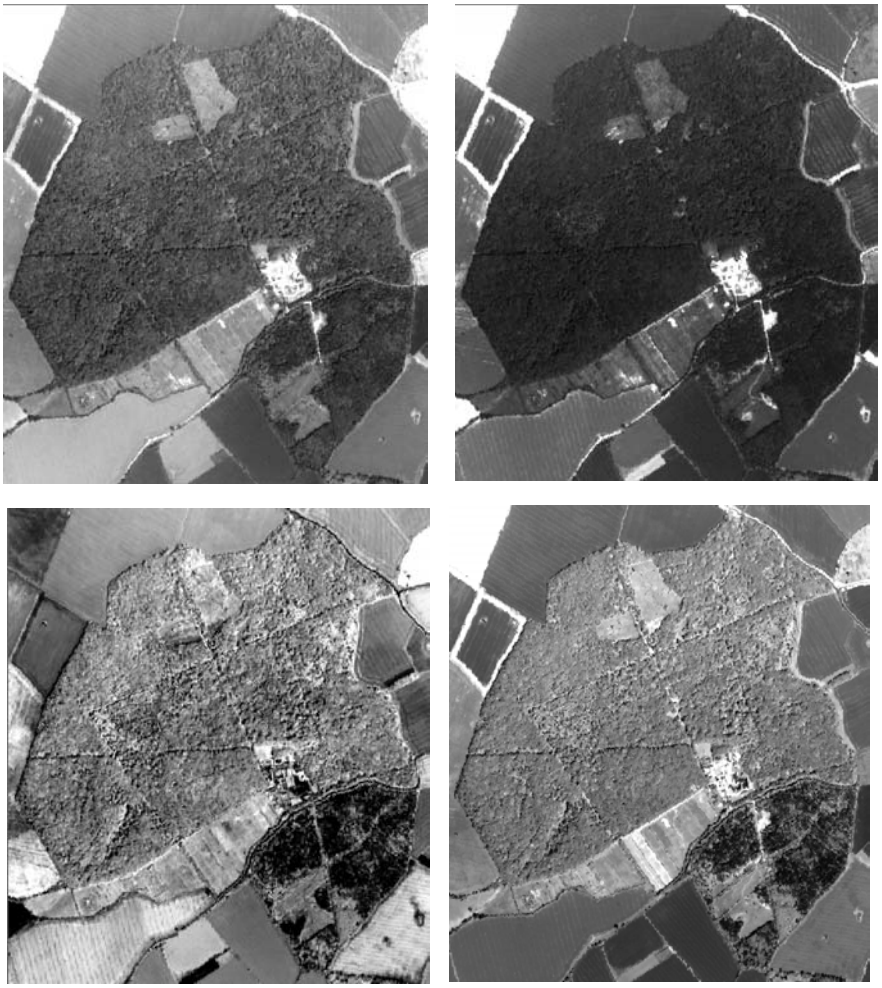

Figure 1. Grey-scale images showing reflected radiance recorded by the Hymap scanner: top left to bottom right; visible green (band 9), visible red (band 17), near infrared (band 21) and short wave infrared (band 85). Note how land-cover types have different reflectance characteristics across the spectrum.

An Airborne Laser Terrain Mapper (Optech ALTM 1210) was flown over Monks and Bevill's Woods also in June 2000. Laser pulses were emitted by the ALTM with a wavelength of 1047 nm (near infrared). The parallel flight lines had overlapping swaths of LiDAR data acquisition, resulting in an irregular distribution of points. On average, 1 point was recorded every 4.83 m^2 across the study site. Both first and last return elevation data were recorded for each laser pulse, which generated a circular footprint on the Earth's surface with a diameter of approximately 0.25 m. The x- and y- position of each scanned point were supplied in British National Grid (BNG) co-ordinates, whilst the z- position was supplied as elevation in metres above an Ordnance Survey datum (OSGB36). The x-, y- and z- data all had a gradation in millimetres, although the stated instrument precision at the flying altitude was approximately 0.60 m in x- and y-, and 0.15 m in z-.

Remote sensing data processing

The Hymap spectral reflectance data were supplied as 4 m spatial resolution, 126 waveband raster images which had been geo-registered to British National Grid co-ordinates using the aircraft telemetry from the time of data acquisition. The LiDAR data acquired by the ALTM were supplied as an *ascii* file of x-, y- and z- co-ordinates for the first and last significant return of each laser pulse echo. These point-sample elevation data were interpolated into a 1 m spatial resolution raster Digital Surface Model (DSM). A separate DSM was created for the first- and last-return elevation measurements. Surface terrain was modelled from the last-return DSM (which had a higher proportion of ground hits) by a process of adaptive morphological filtering to extract ground hits within the data. A complete terrain surface (ie Digital Terrain Model) was rendered by applying a thin-plate spline interpolation to the extracted ground hits. The DTM had a 1 m pixel size and supplied terrain elevation with a root mean square error of ±0.5 m. By subtracting the DTM terrain elevation values from the first-return DSM surface elevation values it was possible to derive canopy height in metres above the ground for Monks Wood and Bevill's Wood (Figure 2).

Figure 2. Canopy height derived from LiDAR data. (Shown as a grey-scale image with whiter tones representing taller canopy).

The spectral information from Hymap and the canopy height information from LiDAR were then brought together to enable the mapping of woodland species and structure. Because of the local heterogeneity of Monks Wood, the spatial variability of canopy height in the LiDAR data, and the fact that the Hymap and LiDAR raster data had different pixel sizes (4 m and 1 m respectively), it was decided to attempt parcel-based mapping. Thus, instead of assigning a woodland characteristic name for each pixel, this was to be done for spatial clusters of pixels. In particular, this reduced the difficulties associated with the spectral and LiDAR data having different pixel sizes and with pixel mis-alignment where the geometric correction was not absolute.

A segmentation algorithm was used to identify spatial groups of pixels with similar characteristics (Fuller and others 2002). As this algorithm could only operate on three bands of data, a Principal Components Analysis (PCA) was run on the 12 selected Hymap wavebands. PCA is designed to capture the variance in a dataset by identifying a set of variables that encapsulate the maximum amount of variation in the dataset and are orthogonal (and therefore uncorrelated) to each other. This reduces the dimensionality of the data, summarising the most important (ie defining) parts whilst simultaneously filtering out noise. Six Principal Components were derived from the 12 Hymap wavebands, of which PCs 1 and 2 contained 56% and 36% of the variation in the 12 wavebands (ie 92% of the total). Therefore, PCs 1 and 2 were used along with the LiDAR canopy height model as input to the segmentation procedure. This process involved: edge-detection using a Sobel filter to identify spatial disjunctions in the spectral and LiDAR data; region-growing from seed points selected to avoid the identified edges; and region-merging. The region-growing and -merging algorithms were guided by setting segmentation thresholds for the three bands of data and by establishing the number of standard deviations expected to contain the majority of the population of a segment. The resulting parcels did not relate to individual compartments of Monks or Bevill's Woods, but to areas of similar species composition and structure, as indicated by the spectral data and LiDAR canopy height model.

The benefits of deriving a parcel structure by image segmentation were two-fold. First, the procedure reduced pixel-scale (ie very local) variation in the spectral and canopy height data, enabling the more general patterns of vegetation within the woods to be discerned. Second, the parcel structure provided a spatial framework within which variables such as average spectral reflectance per waveband or average canopy height could be calculated, along with two-dimensional metrics such as canopy closure or canopy surface roughness.

Mapping the species composition and structure of Monks and Bevill's Woods was achieved by performing an unsupervised classification of the Hymap spectral data and LiDAR canopy height model. The same three bands of data were used for the unsupervised classification as for the image segmentation. The unsupervised classification method (ISODATA) identified a pre-selected number of clusters in the three-dimensional feature space of the input data. This was an iterative procedure calculated to ensure maximum statistical separability of the data clusters on the basis of the spectral and canopy height data. Because the three input bands of data were uncorrelated, the ISODATA 'cluster analysis' algorithm was able to identify over 50 separate clusters. Although statistically highly separable, these classes had to be named based on their species composition and structure. This was a far from simple task, and many of the identified classes were hard to separate in a meaningful way when visited in the woods. In the end, the 50+ data clusters identified in the spectral and LiDAR data were reduced down to 10 classes of reasonably distinct structure and species composition.

Results of remote sensing data integration

The outcome of remote sensing data integration and analysis is shown in Figure 3, and the 10 classes are explained in Table 2. There is overlap between some of the classes in terms of 'top canopy' species composition and canopy height ranges, but the 10 classes are all unique when the average canopy height and top canopy species composition are considered. The shrub layer characteristics were not mapped directly (except where the shrub layer is the top canopy) but were identified in the field as being associated with the mapped top canopy classes. Three of the classes occur only in Bevill's Wood, the remaining seven classes occur across Monks Wood. It is noticeable that the class definitions are much more specific for the three classes in Bevill's Wood than for the Monks Wood classes. This reflects the heterogeneity of Monks Wood. The jumble of species composition, tree ages, and canopy structure in Monks Wood makes any kind of characterisation extremely difficult. In Bevill's Wood, by contrast, it is a relatively simple task to identify and characterise homogeneous patches of vegetation.

This characterisation of the structure and species composition of Monks and Bevill's Woods represents just one way of mapping these ecological resources. The derived map is not definitive or completely correct, and is not intended to replace existing field-based maps or to be used in isolation. However, this map does represent a step forward in terms of woodland maps created from remote sensing data, as the integration of spectral and LiDAR data has enabled more to be identified than if only one data type had been used. In a woodland environment as heterogeneous as Monks Wood, this map picks out more detail than has been achieved by remote sensing techniques in the past. This map is thus an additional resource for those people interested in Monks and Bevill's Woods. Like all maps, it can be used along with other data to add an extra level of detail to a study, and will be of use for certain applications and unsuitable for others. Finally, this map indicates the characteristics of Monks Wood at approximately the time of its 50th anniversary as a National Nature Reserve. This provides an historical benchmark against which changes in Monks Wood NNR can be compared after the next 50 years of protection and management.

Acknowledgements

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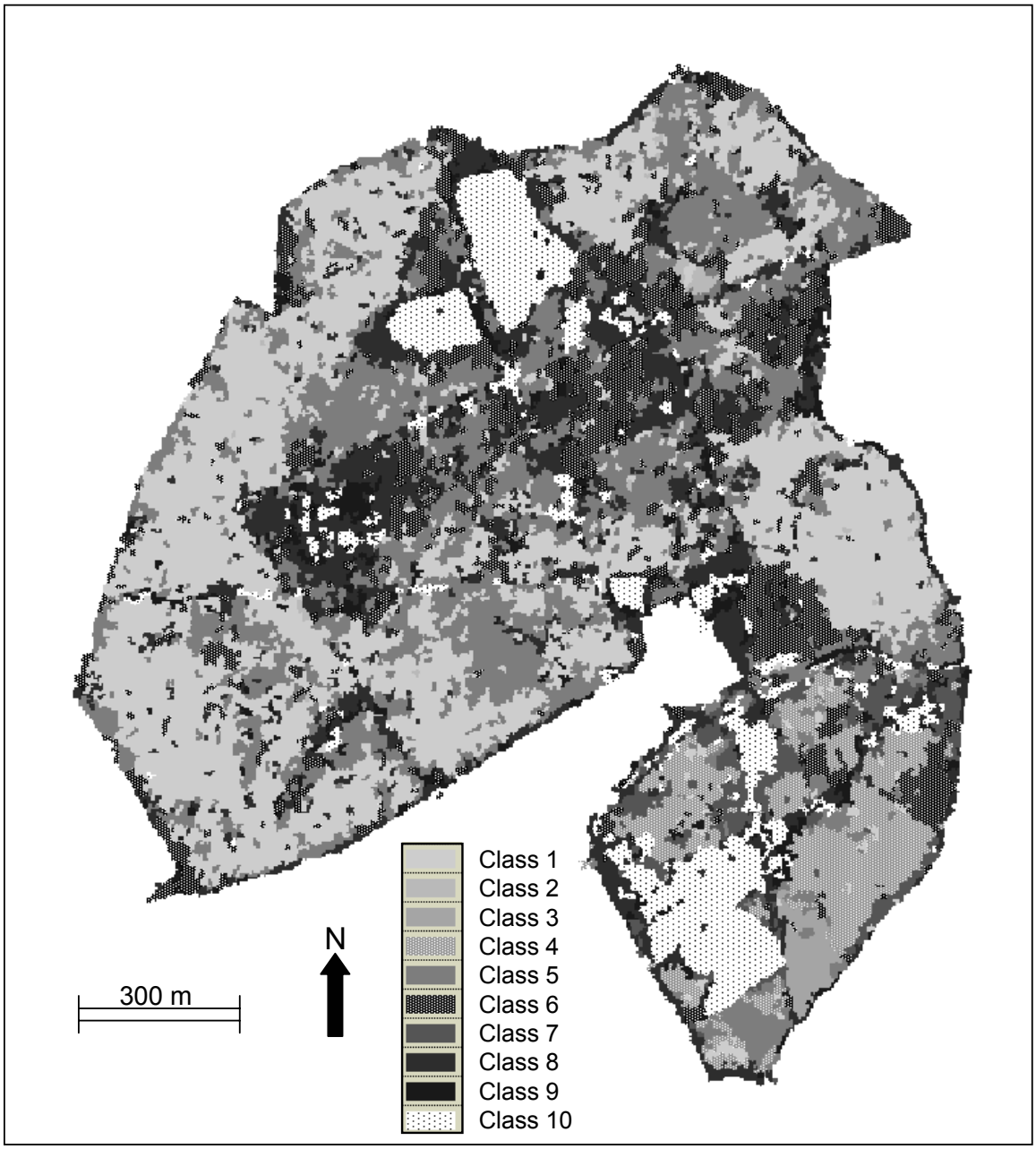

Figure 3. Classified vegetation map of Monks Wood and Bevill's Wood derived from the analysis of integrated airborne remote sensing data. (For description of classes see Table 2).

Table 2. The 10 vegetation classes mapped across Monks and Bevill's Woods using integrated airborne spectral reflectance and LiDAR data.

Class no.	Structure and species composition of 'top canopy'	Shrub layer characteristics
1	Mature closed canopy (mean 14-16 m tall, up to 20-23 m). Dominant species: ash &/or oak, with field maple and in some areas scattered birch.	Sporadic under-storey: predominant species is hawthorn. (Also possible: blackthorn, hazel, young oak/ash/maple, willow, crab apple, privet, elder).
2	Mature closed canopy (mean ca. 15-18 m tall, up to 23 m). Dominant species: elm with oak.	Sporadic under-storey: predominant species is hawthorn.
3	Closed canopy (mean ca. 12 m, up to 17 m). Dominant species: beech.	Sporadic: some hawthorn
4	Closed canopy (ca. 10-13 m, up to 16 m). Dominant species: Norway spruce or Scots pine.	None
5	Closed canopy (mean ca. 10-14 m tall, up to 17-21m). Dominant species: ash &/or oak, with birch &/or field maple. Compared with classes 1-3, there is often a higher density of younger trees with thinner trunks (especially ash), and a shorter canopy which is less dense resulting in a notable shrub layer.	Obvious under-storey of variable species composition, including any of: hawthorn, blackthorn, hazel, young birch or ash, aspen, maple, wild service, willow, elder, dogwood.
6	Closed canopy of irregular nature resulting from selective thinning. A mixture of mature oak, ash and field maple trees (mean 10-15 m, up to 19 m tall) and a shorter canopy (5-10 m tall) composed of either (i) birch &/or aspen trees, (ii) a high density of thin 'pole' trunks (predominantly ash), or (iii) shrubs (see shrub layer).	Obvious under-storey of variable species composition, including any of: hawthorn, blackthorn, hazel, aspen, wild service, willow, elder, dogwood.
7	Open conifer canopy composed of Norway spruce or Scots pine trees (up to 15 m tall) with gaps.	None
8	Scrub canopy (3-10 m tall: see shrub layer), with occasional 10-15 m tall trees (typically oak, ash or birch), and possibly with occasional gaps. NB frequently found in areas which were previously elm dominated.	A combination of birch, aspen, or hazel coppice OR a mixture of blackthorn, hawthorn, hazel, elder, willow, young oak/ash/maple, bramble.
9	Open scrub or coppice (2-5 m tall) with gaps.	Hazel, birch, willow, bramble
10	Herbaceous vegetation (grasses, sedges, soft rushes)	-

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Forty years of Monks Wood weather recording: are things hotting up?

Liz Heywood

NERC Centre for Ecology and Hydrology, Monks Wood, Abbots Ripton, Huntingdon, Cambridgeshire PE28 2LS

The weather station at Monks Wood is located at 52.4ºN 0.2ºE (Grid reference TL 201796) and at an elevation 41 metres above sea level. Its remoteness from the sea promotes a greater variation of daily and yearly temperature, humidity and other meteorological elements than in coastal areas of the British Isles. The climate of Monks Wood can thus be considered to be more continental, with a greater proportion of the annual rainfall occurring in the summer half of the year. The difference between day and night temperatures in summer can be up to 20^{o}C.

Climatological observations have been made at Monks Wood since 1964. Initially manual weather measurements were taken but in the spring of 2000 a new Met Office approved automatic weather recording and logging system was commissioned. The data from this system are downloaded directly into the national meteorological archive, held by the Met Office, as well as being held at CEH Monks Wood. The weather station records a range of climatic variables including maximum and minimum temperatures, wet and dry bulb temperatures, grass and concrete temperature, soil and earth temperatures, rainfall, sunshine, solar energy, wind speed and direction.

Observations for the more familiar climatic variables for the 40-year period 1964-2003 are summarized in Table 1. During this period the lowest annual average temperature was in 1965 (8.71ºC), and the warmest in 1990 (10.95ºC). The coldest month of the year was January with a mean temperature of 3.8ºC and the warmest months were July and August each with a mean temperature of 16.5ºC. The annual average temperature for the 40 year period was 9.7ºC. The highest maximum daily temperature was 35.5ºC (3 August 1990) and the lowest minimum daily temperature was -16.6ºC (14 January 1982).

Average annual rainfall over Great Britain (Barrow and others 1993) for the period 1961-1990 shows that Monks Wood lies in an area with one of the lowest rainfalls in the country. The average annual rainfall for Monks Wood in 1964-2003 was 570.2 mm. The least precipitation was in 1990 (365.1 mm) and the greatest was in 1992 (740.7 mm). February was on average the driest month and June the wettest. The wettest day of the whole period was 10 July 1968, when 92.7 mm fell, which is over 30 mm more rain than the next wettest day.

The sunshine of the sunniest month of the year varied from an average daily duration of 5.5 hours in June 1972 to 9.4 hours in May 1989, although June was the sunniest month on average. The sunniest day of the whole period was 3 July 1968 with 15.6 hours of sunshine, 93% of possible daylight hours. Wind direction is generally SW and wind speed varies from 0 to 40 m/sec.

Record-breaking 2003

Despite record-breaking temperatures and a prolonged dry spell, 2003 was only the fourth warmest year at Monks Wood since records began, with the mean temperature estimated to be 0.96ºC above the 1964-2003 average. All of the 11 warmest years have occurred since 1989, including each year since 1997. Total annual precipitation was 483.2 mm (87 mm less than the long term average). 2003 was the sunniest year on record at Monks Wood. A total of 1856.5 hours of sunshine were recorded, beating the previous sunniest in 1986 when 1826.8 hours were recorded.

March was the sunniest month at Monks Wood since 1995, with an average of 5.78 hours per day.

The second highest temperature at Monks Wood for the forty year period was registered on 10 August 2003. According to data from the temperature probe, the maximum temperature reached 35.2ºC. On the same day in Kent, the UK record was broken with 38.5ºC.

The records continued to be broken in September, the first month of autumn in meteorological terms. Monks Wood enjoyed an average 6.5 hours of sunshine a day, making it the sunniest September since records began forty years ago. October 2003 was the driest month since 1978, with only 8 mm of rain, which is 84% less than the average. November 2003 was wet, with more than 20 mm in two days over Monks Wood between 21st and 23rd. The total November monthly rainfall for England and Wales was above average at 74.2 mm. The third highest ever November temperatures at Monks Wood were recorded in 2003.

Local climate change

A change in temperature can be distinctly observed at Monks Wood. According to the meteorological records, the coldest period at Monks Wood was observed from 1964-1987, and afterward there has been a steady increase of temperature. During the 1964-2003 observation period yearly mean temperature at Monks Wood increased by a total of 1.4ºC (Figure 1). Changes in the local environment during this period eg more roads and buildings may have contributed to this increase. Another possibility is climate change, caused by increasing CO_2 concentration in the atmosphere (Houghton and others 2001). Other indicators of global warming, as well as increasing temperatures, are changes in the frequencies of extreme events – more hot summer days and less cold winter days. According to the Monks Wood weather record there has been an increase in recent years in the number of hot days (mean temperature above 20ºC, Figure 2). The summer of 1995 recorded 21 such days. The number of cold days (mean temperature below 0ºC, Figure 3) shows a negative trend, suggesting that there are now fewer cold days.

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Table 1. Summary of climatological observations at Monks Wood

	Period	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year
Temperature						*Average daily temperature (°C)*								average
Average daily maximum	1964-2003	6.8	7.3	10.1	12.7	16.5	19.3	21.7	21.8	18.7	14.7	9.9	7.4	15.4
Average daily minimum	1964-2003	0.9	0.7	2.1	3.5	6.3	9.2	11.2	11.2	9.4	6.7	3.5	1.7	5.5
Average daily mean (max. + min.) / 2	1964-2003	3.8	4.0	6.1	8.1	11.4	14.2	16.5	16.5	14.1	10.7	6.7	4.5	9.7
Rainfall						*Average monthly total Rainfall (mm)*								total
Average monthly total	1964-2003	45.1	34.2	40.0	46.7	48.2	55.1	48.1	48.7	50.3	51.3	51.4	51.0	570.2
Sunshine						*Average daily duration Sunshine (hr)*								average
Average daily duration	1966-2003	1.8	2.6	3.5	4.8	6.0	6.1	6.1	5.8	4.6	3.6	2.3	1.6	4.1
Wind						*Average Wind (km/day)*								average
Average Wind	1978-2003	196.4	194.6	192.1	163.0	144.2	129.2	119.6	123.0	133.0	147.2	158.9	180.7	157.1

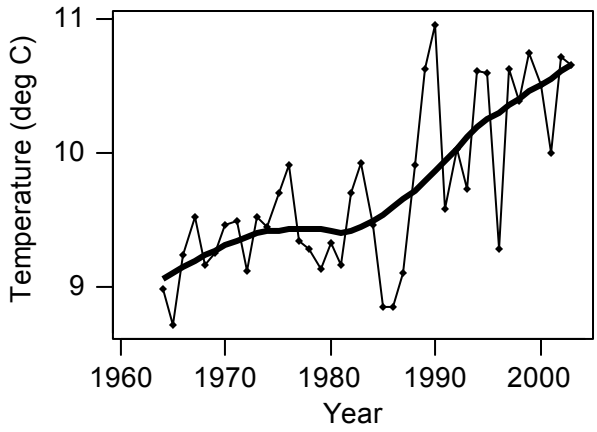

Figure 1 Annual mean Monks Wood temperature. The bold line highlights the underlying trend.

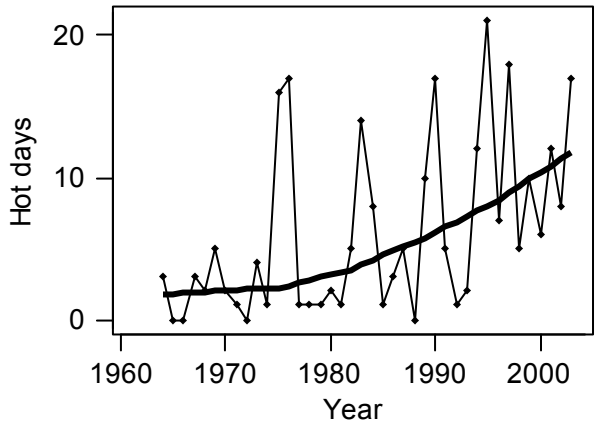

Figure 2 Annual number of 'hot' days (mean temperature greater than or equal to 20ºC) in the Monks Wood record. The bold line highlights the underlying trend.

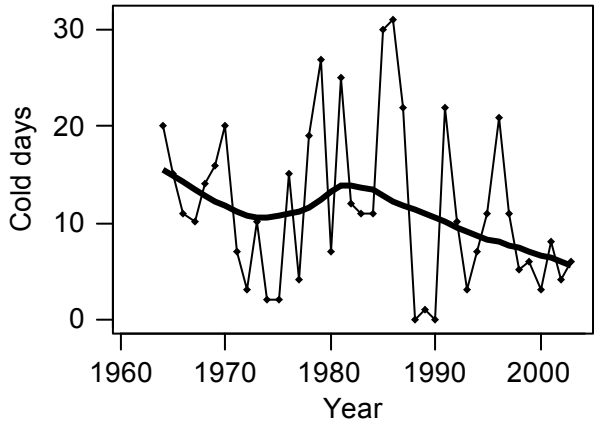

Figure 3. Annual number of 'cold' days (mean temperature less than 0ºC) in the Monks Wood record. The bold line highlights the underlying trend.

An extra 10 acres? Botanical research in the Monks Wood Wilderness

Kevin J. Walker

NERC Centre for Ecology and Hydrology, Monks Wood, Abbots Ripton, Huntingdon,Cambridgeshire PE28 2LS

Introduction

Interest in the natural regeneration of woodland has increased markedly in recent years as a result of the introduction of agri-environment schemes which promote the creation of woodland on abandoned agricultural land (Harmer 1999). Natural regeneration is considered to be superior to planting, especially in sites close to existing woodland, because it promotes the invasion of appropriate species and genotypes, is more 'natural' in terms of structure and composition and crucially, has low establishment and maintenance costs. However, the processes of colonisation and succession to secondary woodland on such sites are poorly understood. Furthermore, it has been suggested that 'natural regeneration' of recognisable semi-natural woodland is unlikely to occur in the short-term given the poor dispersal abilities of many woodland species and the isolation of the majority of 'new' woodland sites from available propagule sources (Kerr & Harmer 1996; Kirby 1992). Although there have been many studies of 'old-field succession' from arable to woodland in North America very little research has been carried out in the UK. The most famous examples are the Geescroft and Broadbalk Wildernesses at Rothamsted in Hertfordshire (Kerr & Harmer 1996; Harmer and others 2001) and the Monks Wood Wilderness in Cambridgeshire, an oak-ash woodland which developed on a former arable field last cropped for barley in 1960 (Walker & Sparks 1999; Walker, Sparks & Swetnam 2000). The latter site differs from the Hertfordshire wildernesses in two important respects: firstly, it is much larger (4 ha), and secondly, it is surrounded on three sides by ancient woodland. As a result it provides an ideal opportunity to study natural regeneration under near optimal conditions and is sufficiently large to study the effects of dispersal on colonisation and succession. This paper provides a brief review of botanical surveys carried out over the past five years in the Wilderness and research into the dispersal of woodland species onto the site.

History

The Monks Wood Wilderness is a 4 ha former arable field on the southern edge of Monks Wood National Nature Reserve. The site was probably cleared in Roman times (c. 300 AD) and it known to have been continuously cultivated between 1850 and 1960 (Steele & Welch 1973). It was then abandoned following ploughing in the autumn of 1961, after the site was acquired as part of the experimental station. With the exception of annual ride clearance this area has remained as Kenneth Mellanby, the station's first director, originally intended it, as a "…wilderness area, in which…to study the secondary successional changes which occur when such an area is left without human interference" (Mellanby 1968). Aerial photographs (Figure 1) show that the site remained relatively open until the 1980s. However, since then the majority of the area has reverted to an oak-ash woodland (c. 10 m in height) with two large glades dominated by wood small-reed *Calamagrostis epigejos* and thickets of blackthorn *Prunus spinosa* and dogwood *Cornus sanguinea* (Walker and others 2000).

Botanical surveys

Although Mellanby (1968) recorded the initial colonisation of woodland species on a small portion of the site in 1967 the first comprehensive survey of the flora was carried out by Phillip Schellens and Lonneke Schilte in 1998. In this study the whole of the Wilderness area was divided into a grid of 20 × 20 m plots and the corners of each 'cell' were permanently marked with wooden stakes. Each plot was then further sub-divided into four 10 × 10 m plots and the ground flora recorded in each (n = 408). During the following summer the positions of all the trees and shrubs were recorded within the permanently marked plots and pedunculate oak *Quercus robur*, ash *Fraxinus excelsior* and field maple *Acer campestre* trees were 'tagged' with numbered metal markers (Manning 1998). In 2002, 36 of the Wilderness plots were re-surveyed and compared with 50 equivalent plots recorded in the adjacent wood (Eigenbrod 2002). In addition, the bryophyte flora of the Wilderness was recorded by the Cambridgeshire Bryological Group in 2000 (see Preston and Walker this volume).

Natural regeneration

Although the understorey of the Wilderness remains relatively sparse, 83 species of higher plant have been recorded on the site since 1998. These included two ferns, 19 grasses, sedges and rushes and 62 herbs. The most abundant species (recorded from over half the plots) included five cosmopolitan species associated with fertile soils (cleavers *Galium aparine*, rough meadow-grass *Poa trivialis*, self-heal *Prunella vulgaris*, field forget-me-not *Myosotis arvensis*, common nettle *Urtica dioica*) and six shade-tolerant species (Lords-and-Ladies *Arum maculatum*, false brome *Brachypodium sylvaticum*, wood small-reed *Calamagrostis epigejos*, wood sedge *Carex sylvatica*, ground ivy *Glechoma hederacea* and wood dock *Rumex sanguineus*) which are all common in the surrounding hedgerows and woodland (Figure 2). However, a number of more localised woodland species were also recorded including two woodland herbs which are known to have poor dispersal abilities (bugle *Ajuga reptans*, dog's mercury *Mercurialis perennis*) as well as species with very small seeds or spores which are likely to have colonised from distant sites (eg common spotted-orchid *Dactylorhiza fuchsii*, male fern *Dryopteris filix-mas*, adder's-tongue fern *Ophioglossum vulgatum*).

In the 1998 survey four tree species were recorded in the Wilderness. *Quercus robur* was by far the most abundant canopy species with lesser amounts of *Fraxinus excelsior* largely confined to the margin of the site. In contrast, *Acer campestre* and downy birch *Betula pubescens* were relatively rare and wild service tree *Sorbus torminalis*, which was recorded by Mellanby (1968) in 1967, was no longer present. Both wych elm *Ulmus glabra* and aspen *Populus tremula*, which occur in isolated stands in the surrounding wood, were not recorded in the Wilderness.

The shrub layer was largely dominated by *Cornus sanguinea* and *Prunus spinosa*, which form extensive thickets toward the northern end of the site, as well as occurring as understorey species beneath both oak and ash. In contrast, hawthorn *Crataegus monogyna* and dog rose *Rosa canina* were more evenly distributed across the whole site occurring as scattered individuals in both open and shaded locations. Conversely midland hawthorn *Crataegus laevigata* was confined to the woodland understorey, whereas hazel *Corylus avellana*, spindle *Euonymous europaeus*, privet *Ligustrum vulgare*, buckthorn *Rhamnus catharticus*, grey willow *Salix cinerea* and elder *Sambucus nigra* all occurred as scattered individuals.

The moss flora was found to be relatively rich for such a small wood and to date 31 mosses and 5 liverworts have been recorded. The majority of species were recorded as epiphytes (n = 17) on trees and included very common species such as *Hypnum cupressiforme* as well as more localised species such as *Frullania dilitata* and the nationally scarce *Platygyrium repens*. In addition, many of the typical woodland floor species, such as *Plagiomnium undulatum* and *Mnium hornum*, were found to be abundant as well as the much more localised species such as *Ciriphyllum piliferum*.

An ancient wood?

Although the Wilderness shares many species with the surrounding woodland how similar is it to the adjacent ancient wood? In order to investigate this Eigenbrod (2002) compared 36 of the Wilderness plots with 50 equivalent plots recorded in adjacent areas of Monks Wood, positioned at set distances along transects radiating away from the edge of the Wilderness. Using ordination, Eigenbrod showed that although the plots were still distinct from those in Monks Wood there had been increasing convergence in the flora since they were first recorded in 1998 (Figure 3). This suggests that although successional changes are still taking place and the Wilderness is becoming increasingly similar to Monks Wood.

To assess the similarity in the 'woody' species Eigenbrod (2002) also measured the number of stems of tree and shrub species in these plots. This showed that the Wilderness is still much 'shrubbier' than the adjacent woodland with much higher proportions of *Cornus sanguinea*, *Prunus spinosa* and *Rosa canina*, but with only marginally more *Quercus robur* and *Fraxinus excelsior* (Figure 4). In contrast Monks Wood had much higher densities of *Acer campestre*, *Crataegus laevigata* and *Corylus avellana*.

The number of ancient woodland indicators (AWIs *sensu* Rose 1999) also provides a measure of 'antiquity' as these species are assumed to take many years to colonise new woodland sites (Peterken & Game 1984; Rose 1999). Forty-nine AWIs occur in Monks Wood as a whole: 12 of these are common (eg *Acer campestre,* pendulous sedge *Carex pendula*); 15 are local (eg wood anemone *Anemone nemorosa*, *Sorbus torminalis*); and 22 are rare (eg violet helleborine *Epipactis purpurata*, crested cow's-wheat *Melampyrum cristatum*). Of these, 10 (83%) of the common AWIs occur in the Wilderness, compared to 5 (33%) of the local and none of the rare.

Dispersal

The spatial distributions of the two dominant canopy species in the Wilderness are markedly different (Figure 5): *Quercus robur* is evenly distributed across the site whereas *Fraxinus excelsior* is largely concentrated in dense clusters around the edges. As a consequence the average distance to the edge of the wood for *Quercus robur* is 33 ± 0.7 m and *Fraxinus excelsior* 15 ± 0.5 m. A similar pattern emerges for the age structure of the trees themselves with the largest oaks occurring towards the centre of the plot whereas for ash they tend to occur close to the edge. These differences are largely due to dispersal mode. *Quercus robur* has large seeds which are dispersed over large distances in mast years by birds (especially jays and wood pigeons) and mammals (especially grey squirrel), whereas *Fraxinus excelsior* have much lighter seeds which are almost entirely wind-dispersed. As a result, seeds of *Fraxinus excelsior* are unlikely to disperse very far from the parental trees.

Some of the distributions of the most abundant ground flora species display similar patterns. For example, species which spread vegetatively under shade, such as *Glechoma hederacea* and *Arum maculatum*, have very obvious colonisation 'fronts' beyond which there is very little establishment (Figure 6). In most cases these species have colonised very slowly from the edges of the adjacent woodland and from refugia within the site, such as the pond which is clearly visible in Figure 1. In contrast, species which predominantly dispersed by seed, such as three-nerved sandwort *Moehringia trinervia* and *Brachypodium sylvaticum*, have much more random distributions with core areas adjacent to Monks Wood.

Conclusions

The survey work on the Wilderness has shown that natural regeneration of native woods can be relatively rapid (< 50 years) on abandoned arable sites which are adjacent to native seed sources. Virtually all the common woodland species which occur in Monks Wood have colonised the site and as a result the Wilderness has become increasingly similar in composition to the adjacent woodland in recent years. However, there are still important differences between the two woodland areas: the Wilderness is much 'shrubbier' than the adjacent woodland, although this is likely to decline as the stands of dogwood and blackthorn die back as a result of increased shading. Similarly, the Wilderness has a greater proportion of herbs and grasses of semi-shade and open habitats and a lack of woodland species which occur locally in the surrounding wood (eg *Sorbus torminalis*).

The main factors which are likely to account for these differences are seed availability and dispersal mode. The most abundant species in the Wilderness are also ubiquitous within the surrounding woodland and have colonised regardless of dispersal mode. In contrast, only the more localised species with effective dispersal mechanisms have reached the site. These include bird-dispersed species, such as berry-producing shrubs, as well as ferns and herbs with wind-dispersed seeds and spores. The greater proportion of herbs and shrubs of more open conditions also suggests that the Wilderness has yet to fully 'mature' as a woodland. Indeed, the die-back of both *Cornus sanguinea* and *Prunus spinosa* in recent years suggest that successional changes are still taking place. In addition, initial site conditions are likely to have favoured the regeneration of some species over others. For example the creation of a bare seed-bed in 1961 probably favoured the establishment of *Quercus robur*. This species is known to be more drought-tolerant than ash which regenerates more effectively under the cooler microclimate of an established sward. Furthermore, it is known that birds, particularly pigeons and jays, prefer to cache seeds of *Quercus robur* on bare soils such as arable fields.

Acknowledgements

I would like to thank the students who helped to set up and monitor the Wilderness plots over the last five years, in particular, Phillip Schellens, Lonneke Schilte, Peter Manning and Felix Eigenbrod on whose work this paper is based. I would also like to thank Chris Preston and the Cambridge Bryological Group for supplying bryological records and Tim Sparks for enthusiasm, ideas and advice.

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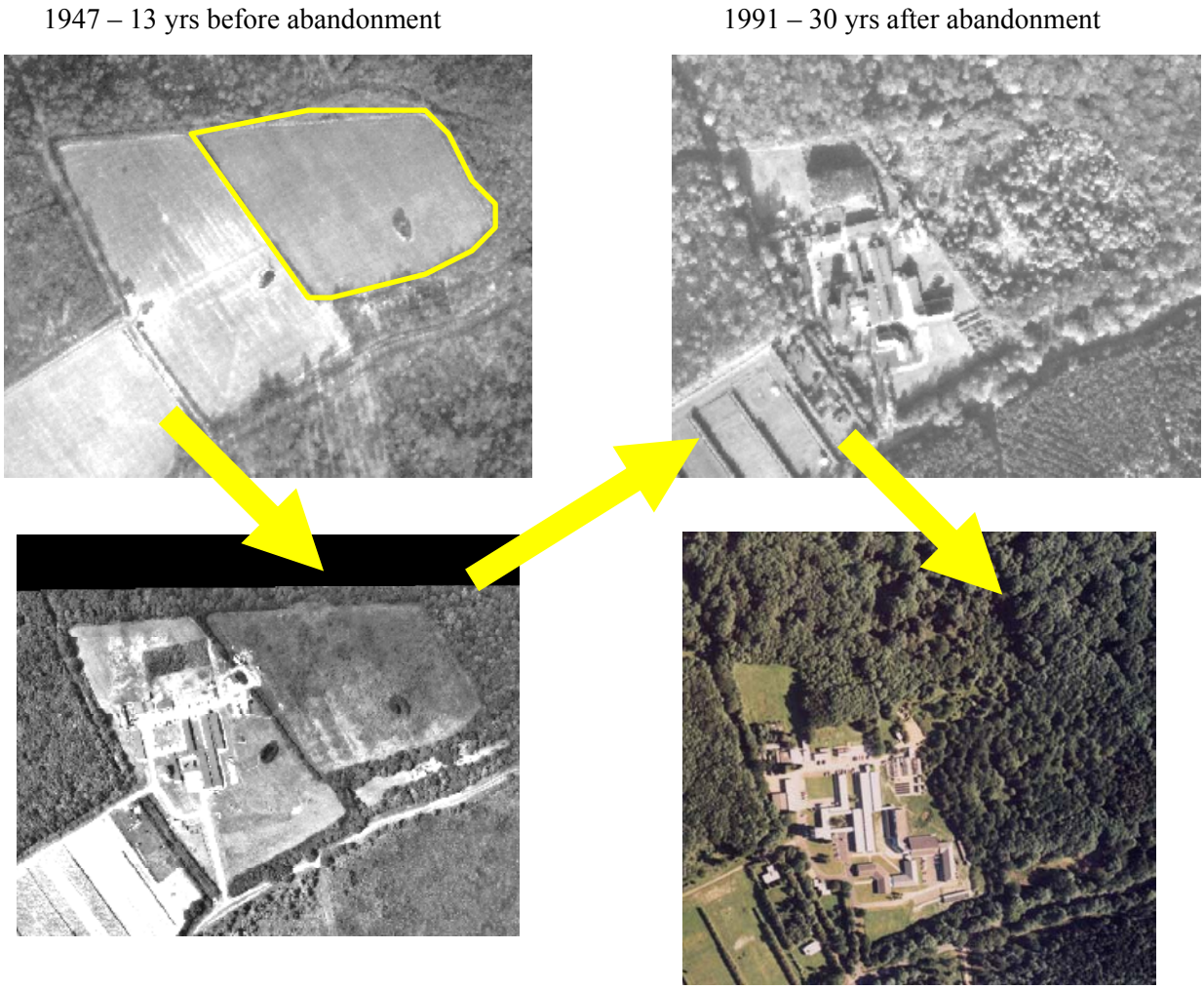

Figure 1. The Monks Wood Wilderness area in 1947, and following abandonment in 1971, 1991 and 2003.

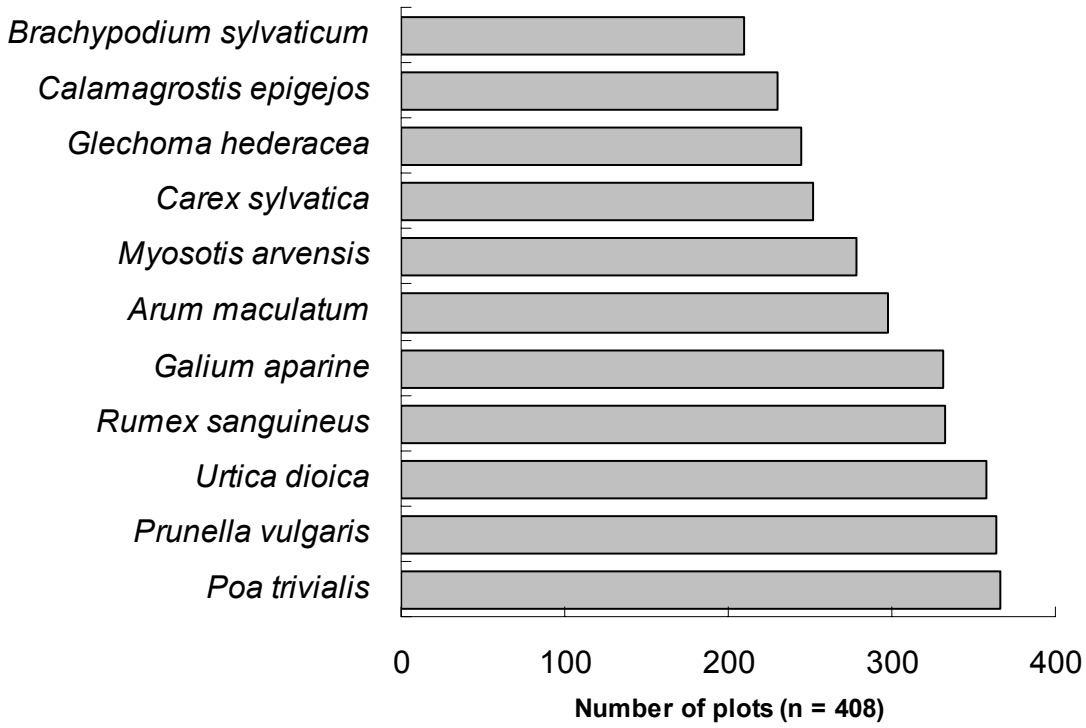

Figure 2. The most abundant ground flora species recorded in the Wilderness in 1997 (species present in over half of the 10 × 10 m grid cells).

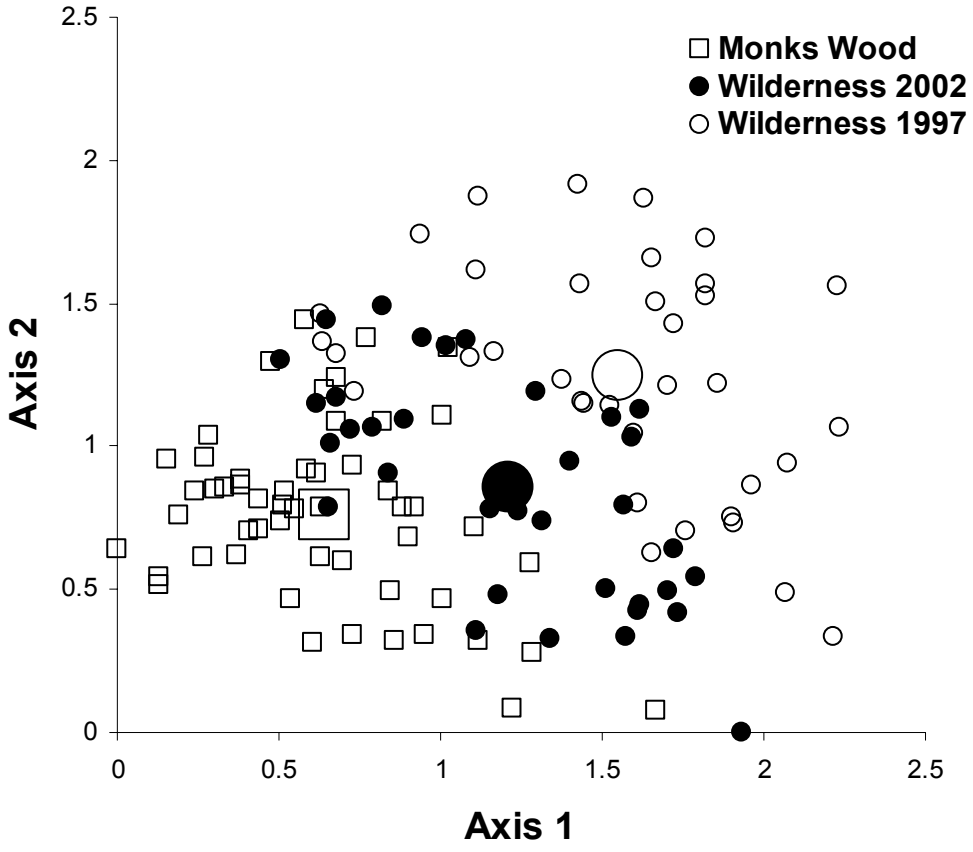

Figure 3. Sample ordination scores for the Wilderness (n = 36) and Monks Wood (n = 50) plots recorded in 2002. Small symbols represent the samples recorded and large symbols represent the centroids for each group.

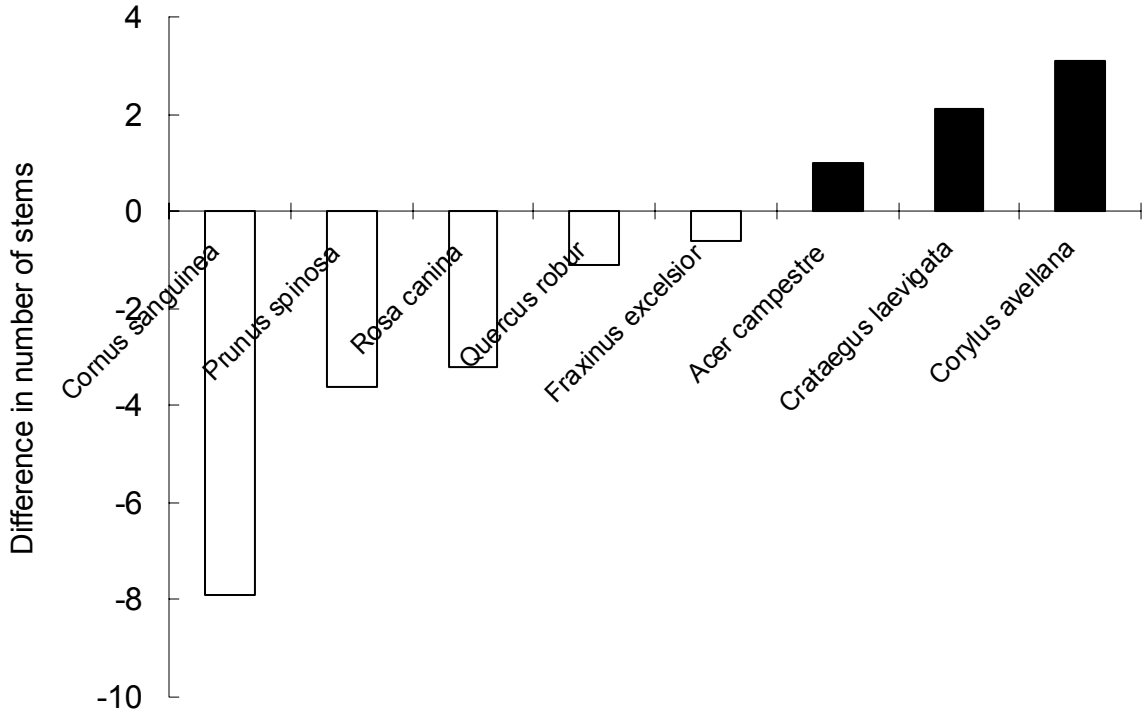

Figure 4. The difference in the abundance of tree and shrub species (mean number of stems per metre square) in the Wilderness (n = 36) and Monks Wood (n = 50) plots recorded in 2002 (Eigenbrod 2002). Species with positive values were more abundant in Monks Wood and those with negative values, more abundant in the Wilderness.

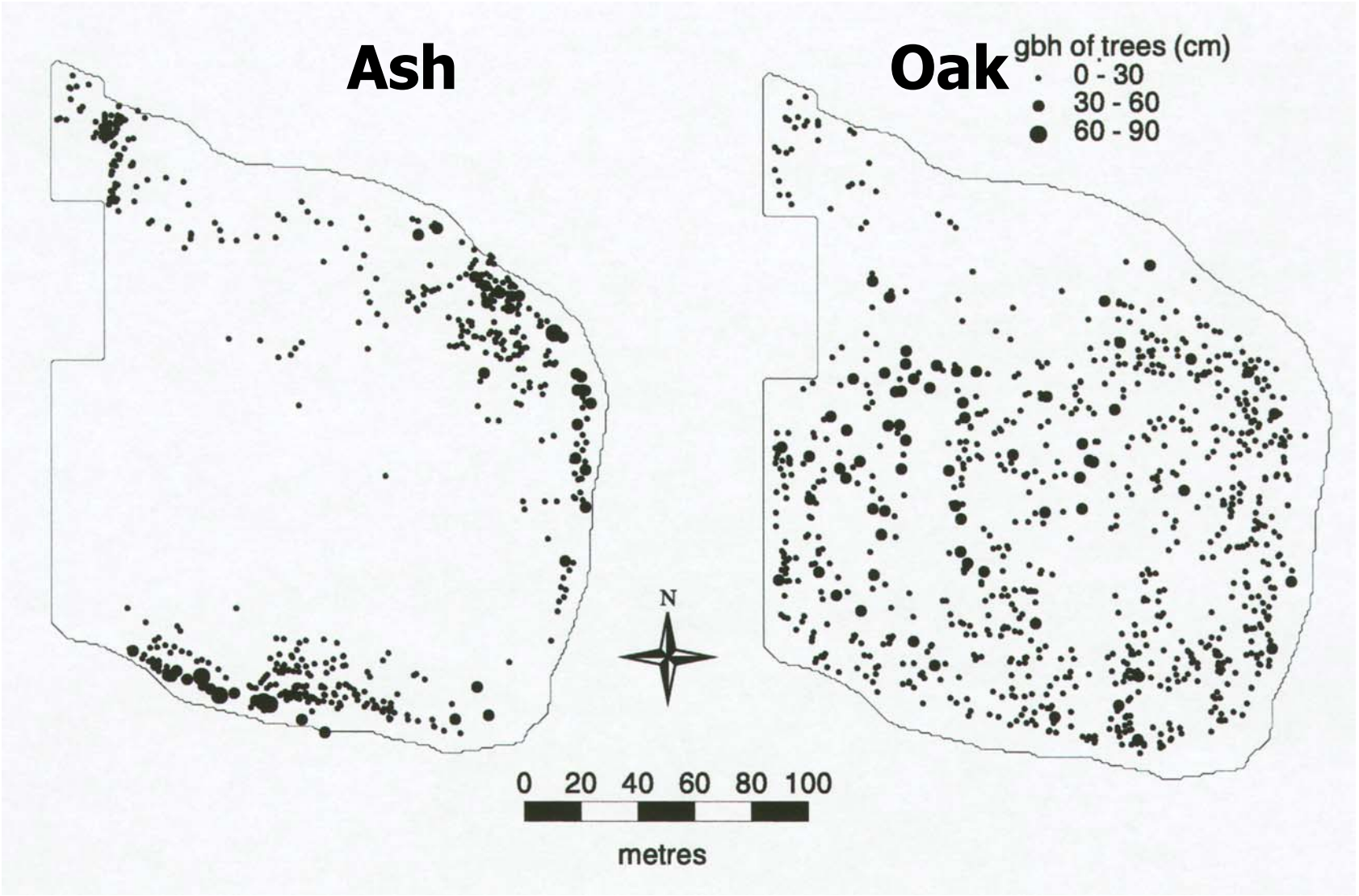

Figure 5. The spatial distributions of oak *Quercus robur* and ash *Fraxinus excelsior* trees (grouped by GBH class) in the Wilderness in 1998.

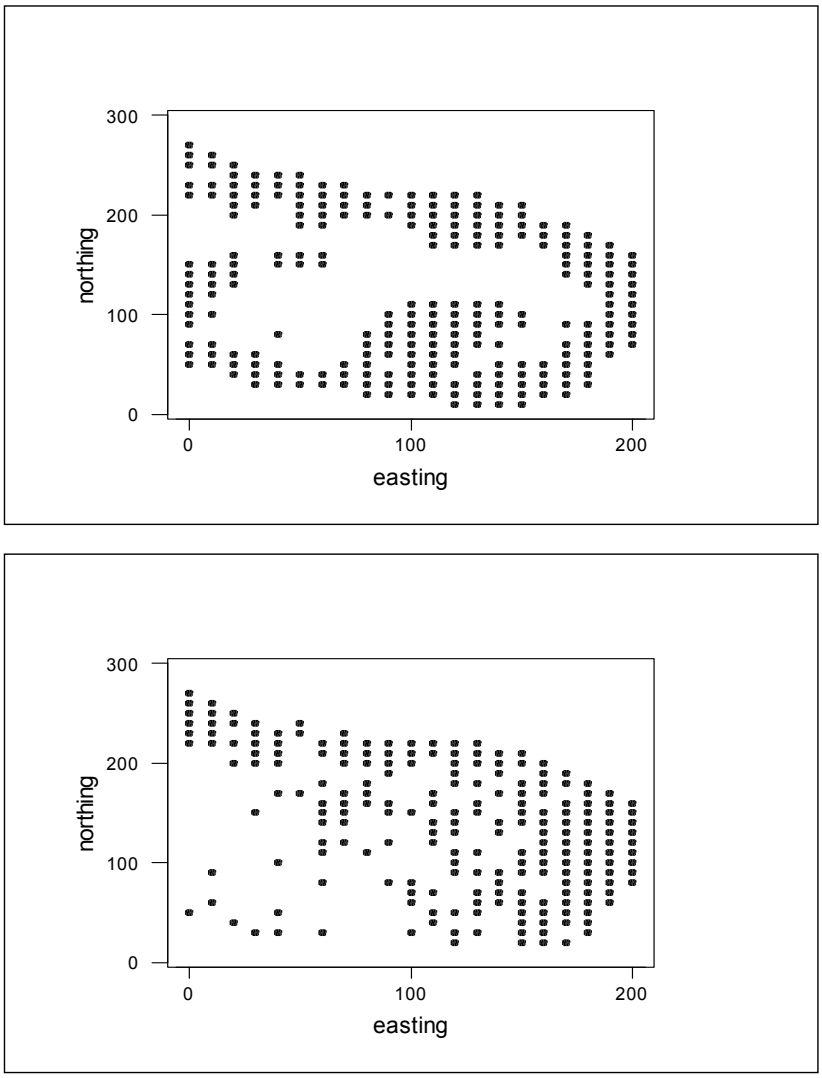

Figure 6. The spatial distributions of A) ground ivy *Glechoma hederacea* and B) false brome *Brachypodium sylvaticum* in the Wilderness in 1997. Each dot represents presence within a 10 × 10 m grid cell.

Monks Wood NNR and its neighbours: a comparison with local woods

Tim Sparks, Floor van Gaasbeek, Dennis Waasdorp and Johanna Willi

NERC Centre for Ecology and Hydrology, Monks Wood, Abbots Ripton, Huntingdon, Cambridgeshire PE28 2LS.

In Cambridgeshire, ancient woodland doesn't occur evenly in the landscape. For instance, the lack of woodland in the Fens reflects past and current land use. In the Cambridgeshire "uplands", as the balance of profitably shifted from woodland (as a supplier of fuel and timber) to farming (as a supplier of food), much woodland was converted to agriculture or replanted with conifers in a bid to restore its profitability. Much of this change has occurred within documented history, and some even within human memory. For example, the WWII clearance of the east and west fields within Monks Wood and the coniferisation of Bevill's Wood in the 1950s.

Cambridgeshire has several clusters of ancient woodland; the 20 km x 20km grid square centred on Monks Wood for example contains 33 designated Ancient Woodlands. Ownership of these woods is diverse and includes English Nature, the Woodland Trust, the local Wildlife Trust and local farmers and estates. Monks Wood is the only National Nature Reserve within this cluster and natural curiosity has encouraged us to seek to understand how 50 years of protection has served nature conservation.

Any comparison with Monks Wood is difficult. It is the county's largest wood and as such may not behave in the same way as smaller woods. It should also be remembered that it was selected for designation as a National Nature Reserve, so must have had some unique properties relative to other woods in 1953. One of these was that the wood was recovering from the clearfelling after WWI and may have been mimicking a 30 year old coppice wood at the time of its designation. With these caveats in mind this paper reports work from two surveys undertaken to compare Monks Wood with its close neighbours.

Materials and Methods

Survey 1 – Indicator species

Undertaken in April/May 1999 by FvG and DW. The flora in Monks Wood was compared with the eight local ancient woods listed in Table 1, one of which (Bevill's Wood) is a planted ancient woodland (PAW) having been replanted with conifers in the 1950s. However, as we shall see, it still retains elements of interest . This survey had two parts. Firstly, the rides and perimeter of each wood were walked and all records of *Primula* species (cowslip *P.veris*, primrose *P.vulgaris,* and false oxlip*, P.veris* × *vulgaris*) were recorded. The opportunity was also taken to note any incidences of spurge laurel *Daphne laureola* and early purple orchid *Orchis mascula*. This work has already been reported in the *Annual Report of the Huntingdonshire Fauna and Flora Society* (van Gaasbeek and others 2000). Secondly, six of the southernmost compartments in Monks Wood were compared with the same eight local woods. These compartments were selected to be similar in altitude and soil type as the local woods (except Odd Quarter which is lower). 1m^2 quadrats were placed c.10m in from rides in

numbers approximately proportional to wood area (see Table 2 for numbers of quadrats). In these quadrats the ground cover, height and number of dog's mercury *Mercurialis perennis* stems and numbers, height and flowers/spike for bluebell *Hyacinthoides non-scripta* were recorded.

Survey 2 – Ground flora

Undertaken in May/June 2002 by JW. 1m^2 quadrats (numbers approximately proportional to area) were placed along transects perpendicular to perimeters and rides of the 20 woods listed in Table 4, including six in the Grafham area. Each plant species was identified and its ground cover estimated. Some results have already been reported in the *Annual Report of the Huntingdonshire Fauna and Flora Society* (Willi & Sparks 2003) and further results will appear in *Biodiversity and Conservation*.

Results

Survey 1

Numbers of *P.vulgaris* were, surprisingly, at highest density in Bevill's Wood and density in Monks Wood was within the range of the local woods (Table 1). Although not statistially significant, it is interesting to note that the wood with the highest *P.vulgaris* density (Bevill's Wood) had the lowest *P.veris* density and vice versa (Odd Quarter). In Monks Wood, numbers of *D.laureola* may be considered high and numbers of *O. mascula* and *P.veris*×*vulgaris* low. The latter, in particular, appear to have declined (van Gaasbeek and others 2000). Regarding *M. perennis* (Table 2), Monks Wood compartments compare very poorly with local woods in terms of ground cover ($p<0.01$), height ($p<0.05$) and stem density ($p<0.01$). *M. perennis* has reduced substantially since Steel & Welch (1973) but has shown recent signs of recovery in Monks Wood (Cooke 2002). Whilst *Hyacinthoides non-scripta* density was similar in Monks Wood compartments and local woods ($p>0.05$), both height ($p<0.001$) and number of flowers/spike ($p<0.001$) were much reduced (Table 3).

Survey 2

In an ordination of ground flora (see Willi & Sparks 2003, Willi and others in press) Monks Wood appeared very different to other Huntingdonshire woods, even the Odd Quarter from which it was 'divorced' relatively recently (Steele & Welch 1973). The difference in the Monks Wood flora is perhaps most marked in high levels of *Brachypodium sylvaticum* and *Carex pendula* and low levels of *M.perennis* (Table 4). A great deal of variation was shown in the 20 woods; some were heavily eutrophic with up to 30% of *Urtica dioica* and up to 17% of *Galium aparine*, whilst others had heavy *Rubus fruticosus* infestation. The relatively high levels of *H.non-scripta* in Monks Wood suggest it still has the potential to return to a woodland with high visual impact in spring.

Discussion

Monks Wood is floristically different from other local woods and perhaps this is inevitable given its size and attraction for grazing animals. However it is also very clear that it has changed fundamentaly in comparison with the description in Steel & Welch (1973). Deer grazing is an obvious culprit as evidenced in Arnie Cooke's tireless work. However, its large size should ensure that it is less affected by eutrophication than smaller woods with high perimeter:area ratios. Through culling, efforts are already being made to improve the ground

flora of the wood, and the recovery of key species such as *M.perennis*, *H.non-scipta*, *P.vulgaris* and *Anemone nemorosa* are probably achievable given time. Recent work, yet to be reported, suggests that transplantation may assist in this recovery, particularly where deer pressure is reduced. Already the results reported here, particularly from survey 1, are probably out of date. Most people familiar with Monks Wood would now agree that there has been a visual improvement to the Monks Wood flora in recent years, and this is supported by measurements (eg Cooke 2002). We all hope that Monks Wood will return to be a showpiece wood in the future.

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Table 1. A comparison of the perimeter/rideside flora of Monks Wood and eight local woods

	Approx size (ha)	**Approx length of perimeter and rides (km)**	***Primula vulgaris* no/km**	***Primula veris* no/km**	***Primula veris* × *vulgaris* number**	***Daphne laureola* number**	***Orchis mascula* number**
Monks Wood	157	21.0	49	6	2	28	2
Bevill's Wood	37	6.1	207	0	3	0	0
Hill Wood	16	6.1	11	74	1	0	1
Long Coppice	7	2.7	22	23	0	0	0
Little Less Wood	18	6.5	99	9	6	2	136
Boulton's Hunch Wood	11	4.1	45	5	0	0	0
Round Wood	2	1.7	1	4	0	0	1
Hermitage Wood	13	3.5	83	49	0	0	3
Odd Quarter	15	1.9	0	171	0	0	0

Table 2. A comparison of dog's mercury in six Monks Wood compartments with eight local woods (* cannot be measured, not included in mean)

Wood (compartment - - area)	**Number of quadrats**	**Ground cover %**	**Plant height (cm)**	**Mean number of stems/quadrat**
Monks Wood (29 - - 5.9)	13	<0.1	4.8	0.4
Monks Wood (28 - - 4.5)	10	0.0	*	0.0
Monks Wood (27 - - 7.4)	13	<0.1	5.6	0.4
Monks Wood (21 - - 3.6)	10	0.0	*	0.0
Monks Wood (18 - - 4.3)	10	0.0	*	0.0
Monks Wood (15 - - 3.0)	10	0.0	*	0.0
Monks Wood average		**0.003**	**5.2**	**0.1**
Bevill's Wood	20	2.5	27.2	3.3
Hill Wood	17	38.8	27.6	62.5
Long Coppice	13	29.6	26.3	46.2
Little Less Wood	16	67.2	31.9	83.9
Boulton's Hunch Wood	16	59.1	29.9	67.3
Round Wood	10	69.0	30.6	83.8
Hermitage Wood	16	66.6	31.3	84.8
Odd Quarter	16	7.2	21.8	8.6
Other wood average		**42.5**	**28.3**	**55.1**

Table 3. A comparison of bluebell in six Monks Wood compartments with eight local woods (* cannot be measured because of absence or grazing, not included in mean)

Wood (compartment)	**Number of plants**	**Height cm**	**Number of flowers/spike**
Monks Wood (29)	22.5	30.7	4.4
Monks Wood (28)	14.9	29.4	3.6
Monks Wood (27)	16.5	25.6	4.5
Monks Wood (21)	0.0	*	*
Monks Wood (18)	0.0	*	*
Monks Wood (15)	19.1	*	*
Monks Wood average	**12.2**	**28.6**	**4.2**
Bevill's Wood	7.9	*	*
Hill Wood	25.2	38.7	7.9
Long Coppice	10.3	38.2	9.1
Little Less Wood	9.3	42.1	8.2
Boulton's Hunch Wood	2.5	41.1	5.9
Round Wood	8.2	40.8	9.2
Hermitage Wood	0.8	42.0	8.8
Odd Quarter	10.5	43.3	8.2
Other wood average	**9.3**	**40.9**	**8.2**

Table 4. The mean percentage cover of the more numerous plant species recorded in 20 Huntingdonshire ancient woods. Cumulative cover of AWI species and species richness given at the bottom of the table. + indicates <0.1%.

		Agdengreen	*Archers*	*Aversley*	*Brampton*	*Calpher*	*Hermitage*	*Holland*	*Lady*	*Little Less*	*Littless*	*Long Coppice*	*Monks*	*Odd Quarter*	*Perry West*	*Pingle*	*Rolts*	*Rose*	*Round Savage's*	*Spinney*	*Wistow*
Area/hectares		27	19	60	123	5	13	25	8	18	20	28	165	15	39	7	21	3	2	10	10
Latin name	*Common name*																				
Ajuga reptans	Bugle		+		2.0	+		0.7				1.9		+			0.5				
Anthriscus sylvestris	Cow Parsley		0.9	+			0.9	0.1			+	+				+	+	13.1		+	
Brachypodium sylvaticum	False Brome		3.2	5.4	9.3		+				1.9	0.3	23.2	6.4	0.6	1.3	3.0	0.7		1.8	1.2
Calamagrostis epigejos	Wood Small-reed				0.8								0.9	0.1							
Carex pendula	Pendulous Sedge		0.7	4.1	0.1	4.6					5.3	1.5	9.1	0.5	1.9					1.8	
Carex sylvatica	Wood-sedge	0.1	2.3	0.9	2.0	+		1.7			1.0	0.3	1.8	1.2	0.3		4.2			4.9	0.5
Circaea lutetiana	Enchanter's-nightshade	0.2	+		0.5	+		0.1		0.7	+	0.2		+	0.6	4.2	+		0.8		
Deschampsia cespitosa	Tufted Hair-grass		+		5.2						10.7		2.4	5.1			4.1			1.8	
Galium aparine	Cleavers	6.1	4.1	6.9	1.3	2.8	9.0	4.9	16.7	2.5	2.4	4.5	1.9	2.1	2.5	6.3	1.0	12.6	3.7	2.1	13.6
Geranium robertianum	Herb-Robert	0.1		0.8	0.1				4.1	0.8		1.3			+	+	0.2	0.2		+	1.3
Geum urbanum	Wood Avens	0.2	0.1	0.7	+	+	0.6	0.3		0.5		4.5	+	1.0	+	0.7	0.2		3.2	0.2	0.3
Glechoma hederacea	Ground-ivy	10.0	9.6	11.7	17.9	5.5	4.5	6.6	21.0	7.0	7.5	11.5	5.9	1.5	3.7	5.4	5.1	10.0	6.9	0.4	10.4
Heracleum sphondylium	Hogweed					0.7	11.2			1.7		+					+			+	0.2
Hyacinthoides non-scripta	Bluebell	1.6	4.6	6.7	1.9	1.2	0.4	2.4	8.2	5.4	1.7	2.7	5.1		1.8	2.5	1.1	0.5	0.6		3.8
Mercurialis perennis	Dog's Mercury	17.9	10.5	9.2	4.5	24.4	58.7	38.9	2.5	47.4	0.2	32.5		15.7	10.1	46.0	20.1	7.0	41.7	2.9	59.0
Poa trivialis	Rough Meadow-grass	8.9	12.1	27.3	3.4	31.6	49.1	24.8	23.5	4.0	34.0	7.3	5.9	2.8	7.9	10.4	35.7	15.5	9.7	8.1	2.4
Primula veris	Cowslip		0.7		2.3							0.9							0.1		
Primula vulgaris	Primrose				0.5								+	0.5			1.4				
Rubus fruticosus	Bramble	4.0	0.5	0.2	1.3	2.1	7.2	2.5	4.3	6.6	1.3	0.5	0.7	2.5	23.2	3.0	2.9	0.1	0.4	18.8	3.0
Rumex sanguineus	Wood Dock	0.2	0.7	2.7	1.5	0.5	0.6	0.5	0.2	+	1.6	1.1	0.4	0.8	0.6	0.8	1.1	0.8	3.5	0.6	1.0
Stellaria holostea	Greater Stitchwort								5.9				1.2					+			1.9
Urtica dioica	Common Nettle	0.7	0.1	5.2	0.5	9.9	8.8	5.1	0.2	8.2	4.6	7.8	0.3	1.1		1.6	1.1	30.7	8.9	2.4	
Viola reichenbachiana	Early Dog-violet	+	0.4	1.0	0.2				0.1	+		0.4	0.3	1.4	+		0.4		0.2	+	
Species richness per m^2		7.1	6.6	6.6	5.8	5.9	6.2	5.1	5.7	5.1	7.2	7.3	7.2	4.7	5.2	7.6	6.3	6.8	6.3	5.7	5.9
Mean %cover ancient woodland indicators		2.3	9.3	13.1	6.3	6.1	0.6	5.1	8.6	5.8	8.1	5.4	19.5	5.0	5.9	3.3	8.8	0.8	1.9	9.8	5.4

Muntjac deer *Muntiacus reevesi* in Monks Wood NNR: their management and changing impact

Arnold S. Cooke
13 Biggin Lane, Ramsey, Huntingdon, Cambridgeshire PE26 1NB

Introduction

At the 40th Anniversary Symposium of Monks Wood National Nature Reserve in 1993, I gave a preliminary account of the damage caused by muntjac *Muntiacus reevesi* (Cooke 1994). Since that time, the subject of deer damage in conservation woodland has assumed greater importance in Britain and elsewhere (Putman 1996; McShea, Underwood & Rappole 1997; Fuller & Gill 2001). In this paper, I update my previous account by considering three issues:

(1) How has the muntjac population in Monks Wood changed in relation to recent management?
(2) What effects have they had on conservation features in the reserve?
(3) How has their impact changed in response to management?

Changes in the deer population in relation to management

The two most significant attempts to manage muntjac in recent years involved the sanctioning of winter stalking within the reserve in 1998 and the fencing of two large areas in the autumn of 1999. During the winter of 1998/9, the Abbots Ripton Deer Management Group shot 106 muntjac inside and just outside the wood, and killed a total of 306 over the following four winters. Fencing was erected in 1999 around compartments 27 and 30 in the south west corner of the wood, an area of 10.6 ha, and around compartment 23 in the centre of the wood (6.1 ha). Thus about 11% of the wood was fenced, the aim being to exclude deer from areas with most of the traditional coppice plots (Massey 1994) and some of the more interesting features of the ground flora, eg the best remaining stands of bluebell and dog's mercury.

Muntjac were first recorded in Monks Wood in about 1970 and increased until 1985 (Cooke 1994). Changes since then have been monitored by calculating the mean number seen per hour on 6-16 surveillance walks undertaken at dusk during January-May each year (Figure 1). Up until 1998, mean numbers seen per hour fluctuated between 14 and 23, but the mean decreased significantly to 6 per hour in 1999 after stalking began in the wood (Cooke & Farrell 2001). Between 1999 and 2003, the downwards trend continued although it was not significant ($r_s = -0.50$).

A recruitment index was derived from numbers of deer with or without antlers recorded on surveillance walks (Figure 1). This index was an expression of the proportion of sub-adult muntjac in the population, assuming an even sex ratio and equal ease of sighting the sexes and age classes. While these conditions are unlikely to apply, sex ratio and ease of sighting may remain reasonably constant over time, and the index is used to reflect changes in recruitment. Initially, recruitment index was relatively low (Figure 1), but then increased following mortality incidents in the early 1990s (Cooke, Green & Chapman 1996). Since

1999, during the period when the population has been controlled by stalking, the index has remained high and fluctuated in parallel with sightings frequency ($r_s = 1.00$, Figure 1).

The wood appears to have switched from being a "source" of muntjac in 1998 to being a "sink" in 1999. Thus mean numbers counted during surveillance walks on the grass fields to the south of the wood fell from 4.9 in 1998 to 0.6 in 1999, indicating a reduced need to utilise habitat outside the reserve. Also shooting 92 deer in the winter of 1999/2000 failed to reduce the mean number seen per hour in 2000, suggesting significant immigration (Figure 1).

The decrease in sightings between 1998 and 1999 (66%) probably over-emphasised the real decline in population size because: (1) the tamest deer may have been shot first; (2) shooting in the wood changes deer behaviour and fewer are seen per hour (as confirmed before and during foot-and-mouth restrictions in 2001); and (3) individual deer may be more conspicuous at high densities (as in 1985; Cooke 1994).

Density determinations are summarised in Table 1. Although these estimates are regarded as tentative because of the methods used and assumptions made, they agree well with one another. A pre-stalking density of 1.1-1.2 deer per ha is indicated for the southern part of the wood, falling to 0.3-0.6 per ha in 1998 and 0.4 per ha in spring 2003. The decrease between 1998 and 1999 was therefore probably at least 50%, but less than 66% (the decrease in sightings on surveillance walks). Deer occur throughout Monks Wood. If these densities in the south can be extrapolated to the wood as a whole (see ivy feeding trial data below), 1.2 deer per ha equates to a total population of about 190 and 0.3-0.6 deer per ha to 50-100.

A simple scoring technique has been formulated to compare muntjac densities over time or space, based on the relative frequencies of four types of deer sign recorded during a visit of 1-2 hours. The signs are: encountering deer and seeing their slots, paths or droppings; each is scored 0-3, giving an overall score of 0-12. Scoring has been used to monitor density changes resulting from the start of shooting in 1998 and the erection of the large fences in 1999 (Table 2). Scores decreased after 1998, but scoring inside the fence in the south west corner has differed little from the rest of the wood, despite much stalking effort. It has proved impossible to prevent muntjac entering or leaving the fenced area, mainly through gaps underneath the wire. In contrast, deer density in compartment 23 has been lower than elsewhere in the wood - the fence around this compartment has extra wire mesh in contact with the ground, preventing access underneath.

Deer feeding activity in spring has been monitored by recording levels of browsing on stems of ivy *Hedera helix* inserted in the ground at five locations in the south of the wood (Cooke 2001). Occasional trials in other parts of the wood indicated monitoring in the south to be reasonably representative of the wood as a whole. The mean proportion of stems browsed after one day during three pre-stalking years was 0.83 and the mean during the five stalking years was 0.43, the difference being significant (Mann-Whitney $U_{3,5} = 0$, $P < 0.05$).

Effects of grazing and browsing

High levels of browsing on coppice regrowth were first noticed in 1985 (Massey 1994). During a study of the orange-tip butterfly *Anthocharis cardamines*, incidence of grazing by deer on the lady's smock *Cardamine pratensis*, the larval food plant, was observed to increase after 1985 (Dempster 1997). Up until the 40th Anniversary Symposium in 1993, deer were suspected of affecting other vegetation in the wood, but direct evidence was

lacking (Peterken 1994, Wells 1994). Between 1994 and 2003, however, many papers were published on the subject (Table 3). Other fieldwork by the author included in contract reports to English Nature is currently unpublished. Effects can be summarised as follows.

(1) Coppice regrowth was browsed to such an extent, despite attempts at protection, that stools died and the coppice canopy failed to develop. This resulted in indirect effects on other features of the coppice plots. Formal coppice operations were suspended in the wood in 1995.

(2) Tree regeneration was affected because seedlings and saplings of species such as ash *Fraxinus excelsior* were browsed, broken and frayed.

(3) Similarly, the height and density of the shrub layer was reduced and its species composition modified.

(4) The ground layer was altered with a general reduction in flowering plants and an increase in grasses and sedges.

(5) Changes in the species composition and structure of the vegetation indirectly resulted in effects on the fauna - most of these will have been negative.

Changes in impacts in relation to deer management

Changes in a selected example of each of the above impacts are discussed below to determine whether recoveries have occurred because of recent deer management. Stalking, which started in 1998/9, is the management most likely to have brought benefit to the wood as a whole. The effect on the deer was to reduce a very high density to a moderate one. From a study of 60 sites in eastern England, it is known that different impacts tend to occur at different deer densities (Cooke 2004). Those impacts that rarely occur at moderate densities elsewhere are likely to have started to recover in Monks Wood.

(1) Hazel coppice. Effects on coppice regrowth in conservation woodlands often occur at low deer densities (Cooke 1996, 2004). Cooke & Lakhani (1996) predicted that, to eliminate unacceptable browsing on unfenced coppice in Monks Wood, the deer population might need to be reduced by 90% - a level of reduction not yet achieved. Formal coppicing of the traditional plots stopped in the mid 1990s, but coppicing of rideside plots still takes place. In 2002 and 2003, 93 hazel stools that had been coppiced in the previous three years were examined in plots beside Main Ride. Of these, 83 (89%) had every regrowth stem browsed. In order to prevent unacceptable levels of browsing, such plots still need fencing. Because of the lower deer density in the fenced area of compartment 23 (Table 2), future coppice operations there may be successful.

(2) Ash seedlings. The relationship between deer density and effects on tree regeneration has not been studied. In 2003, ash seedlings were examined inside and outside 22 wire cages erected in 2000 in compartment 22 to protect violet helleborines *Epipactis purpurata*. Outside the cages, 38% of the ash seedlings were browsed, whereas none was browsed inside. Seedling density was greater inside (15.0 per m^2) than outside (4.5 per m^2, chi squared test, $P < 0.001$); and seedlings were taller inside the cages (t test, $P < 0.01$).

(3) Bramble. Serious effects on bramble *Rubus fruticosus* usually only occur at high deer densities (Cooke 2004). In 2000, mean bramble height attained in four 16 m^2 plots in eight prior-selected locations in Monks Wood was 63 cm. Mean height increased to 80 cm in

2001, to 89 cm in 2002 and 95 cm in 2003 (difference significant in 2002 and 2003, paired t test, $P < 0.05$). Thus bramble is beginning to recover from inhibition of seedling growth and loss of thickets through browsing.

(4) Bluebell. Two types of effect on bluebells *Hyacinthoides non-scripta* occur at high deer densities (Cooke 1997, 2004; Cooke & Farrell 2001). First, grazing of leaves leads to smaller plants that are less likely to flower. Secondly, inflorescences may be grazed off by deer. Since stalking began in the wood in 1998/9, frequency of grazing on leaves and inflorescences has decreased (Figure 2). Reduction of grazing on leaves resulted in more bluebells forming an inflorescence (Figure 3). When combined with reduced grazing of inflorescences, the increase in the density of flowering bluebells was more than six fold from 1998 to 2003 (Figure 3). Although the example given is for quadrats inside the south west fence, a similar recovery has been noted elsewhere in the wood where stands of bluebells occur. However, the recovery in plant size is minimal and it is possible that some effects of deer grazing may not be reversible.

(5) Chinese water deer. The Chinese water deer *Hydropotes inermis* is another introduced species, but is of greater conservation interest because it is now very rare in China (Cooke & Farrell 1998). Sightings decreased on surveillance walks from the late 1980s, perhaps because water deer were out-competed by muntjac for the dwindling winter food resource of bramble and other species (Cooke & Farrell 2001). No water deer has been seen on surveillance walks since 2000, although small numbers remain in the vicinity. Presumably a recovery cannot occur for this species until habitat in the wood has itself recovered sufficiently.

Discussion

That muntjac deer have had a range of effects on the conservation features of Monks Wood is supported by many types of evidence:

- direct observation of deer behaviour in the wood and in captivity;
- occurrence of characteristic damage on vegetation;
- changes noted in the vegetation inside enclosures with captive deer or in plots from which deer were excluded;
- positive relationships between effects and deer density when Monks Wood was compared with a number of other locations in eastern England;
- recovery in some forms of vegetation as deer density was reduced in Monks Wood.

Nevertheless, it should be remembered that other grazers and browsers occur in the wood, and changes in vegetation may also have been driven by factors such as natural succession, modifications in management practice or aerial enrichment (eg Cooke & Farrell 2001 and other papers in this volume). Furthermore, the diversity of the wood will benefit from a certain amount of grazing and browsing, especially if irregular in time and space (Kirby 2001a).

Whether such effects are unacceptable depends on the perspectives of the woodland managers. Putman (1996) reviewed deer management on English Nature's National Nature Reserves and concluded: "Deer are not universally a 'pest' within conservation sites…..only

in some woodland sites is the impact of deer browsing considered a problem in relation to other management objectives." As regards effects on woodland flora, Kirby (2001a) argued that decline of rarer or more characteristic species was likely to be unacceptable, as was loss of diversity at the scale of the stand or the wood. Such effects have occurred in Monks Wood, but management also depends on policies and resources relating to management. Thus there was a delay of a few years between demonstrating effects and attempting to rectify them by stalking and erecting large fences. Had stalking not been sanctioned in the wood in 1998, significant mortality incidents would have continued periodically amongst the deer population. These would not, however, have maintained the deer density at a level such that recoveries occurred for affected species of vegetation. Monks Wood would also have continued to be a source site for muntjac to spread out into the area.

To sustain the recovery in the wood's condition, it is necessary for stalking to continue. Stalking is best approached in a strategic manner across the local landscape so that no wood is a significant source of colonising animals. Thus the overall deer population will be gradually reduced, as will the stalking effort. It would then be easier to reduce deer densities further at specific sites should that be deemed appropriate.

Summary

Prior to stalking starting in the wood in 1998, deer density was >1 per ha, and the total population of the NNR probably approached 200. The subsequent decrease in numbers appears to have been exceeded 50%. In the 1990s, many of the conservation features of the wood were directly or indirectly affected by deer. The reduction in deer density has led to recovery by some species. Other species of plant or animal will only recover if deer density decreases still further, but some changes may be irreversible.

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Table 1. Deer density estimates in Monks Wood

Year	Location	Details	Density (number per ha)
1993	Transects off Leeds Ride	Dung counting using 7.5 pellet groups per day and decay rate of 100 days*	1.2
1993	50-100 m in from South Edge Ride	Deer counts in five 50 m x 200 m plots along a 1 km transect	1.2
1998	Southern study area of 61 ha	Mark-resighting method*	1.1
1999	Southern study area of 61 ha	Mark-resighting method*	0.3-0.6
2003	Transects off Leeds Ride	Dung counting using 7.5 pellet groups per day and decay rate of 100 days*	0.4

* Method/supporting data from Mayle, Peace & Gill (1999)

Table 2. Muntjac deer density scores in Monks Wood, 1995-2003. See text for derivation of score

Year	Whole wood	Fenced area of compts 27 and 30	Fenced area of compt 23
1995	9	-	-
1996	10	-	-
1997	-	-	-
1998	10	8*	-
1999	-	6*	-
2000	5	6	3
2001	7	6	-
2002	6	5	3
2003	4	4	-

* prior to erection of fence

Table 3. Information published on the effects of browsing and grazing by muntjac deer in Monks Wood, 1994-2003

Feature	Effects	References
Coppice	Mechanisms of browsing, death of stools	Cooke (1994, 1998); Cooke & Farrell (1995)
	Factors affecting success, protection, acceptability	Cooke (1994); Cooke & Lakhani (1996); Cooke & Farrell (2001)
Trees	Browsing and loss of ash seedlings and saplings – deer suspected	Peterken (1994); Crampton and others (1998); Mountford & Peterken (1998)
	Better survival of seedlings and saplings in exclosures	Cooke & Farrell (2001)
Shrub zone	Loss of individual specimens blamed on deer	Mountford & Peterken (1998)
	Better performance in exclosures	Cooke & Farrell (2001)
	Mechanisms of browsing	Cooke (1994); Cooke & Farrell (1995)

Feature	Effects	References
Bramble	Heavier browsing in summer and autumn	Cooke (1996)
	Reduction and loss of thickets	Crampton and others (1998); Mounford & Peterken (1998); Cooke & Farrell (2001); Kirby (2001b)
	Better growth in exclosures	Cooke and others (1995); Cooke & Farrell (2001)
Ground flora	General discussion of species declines – deer suspected	Massey (1994); Wells (1994); Crampton and others (1998); van Gaasbeek, Waasdorp & Sparks (2000)
Bluebell	Grazing effects	Cooke (1994, 1997); Cooke & Farrell (1995)
	Recovery	Cooke & Farrell (2001); Cooke (2002)
Dog's mercury *Mercurialis perennis*	Grazing effects	Cooke and others (1995); Crampton and others (1998)
	Recovery	Cooke & Farrell (2001); Cooke (2002)
Primula species	Level of grazing and effects	Cooke (1994); van Gaasbeek, Waasdorp & Sparks (2000)
Common spotted orchid *Dactylorhiza fuchsii*	Grazing effects	Cooke (1994)
Lords and ladies *Arum maculatum*	Grazing effects	Diaz & Burton (1996)
Lady's smock	Level of grazing	Dempster (1997)
Ground ivy *Glechoma hederacea*	Avoidance	Cooke & Farrell (2001)
	Increase in abundance	Crampton and others (1998)
Spurge laurel *Daphne laureola*	Lack of grazing and increase in abundance	van Gaasbeek, Waasdorp & Sparks (2000)
Grasses and sedges	Increased abundance and possible indirect effects of deer	Wells (1994); Cooke and others (1995); Crampton and others (1998); Pollard and others (1998); Cooke & Farrell (2001); Kirby (2001b)
	Rarer in exclosures	Cooke and others (1995); Cooke & Farrell (2001)
Chinese water deer	Apparent indirect effect on abundance	Cooke (1994); Cooke & Farrell (2001)
Nightingale *Luscinia megarhynchos*	Decline – possible indirect effect	Cooke & Farrell (2001)
Butterflies and moths	Effect on egg laying behaviour of white admiral *Ladoga camilla*	Pollard & Cooke (1994)
	Positive effects on species with grass-feeding larvae	Pollard and others (1998)

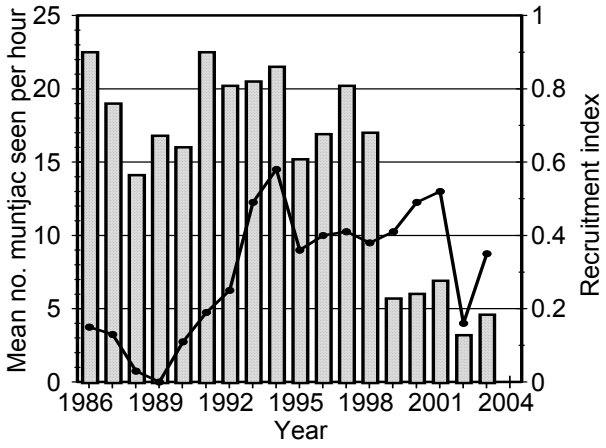

Figure 1. Muntjac surveillance, 1986-2003: the histogram shows the mean number of muntjac seen per hour on 6-16 dusk walks undertaken each spring with the help of Lynne Farrell; the dots and the line represent the recruitment index each spring. Recruitment index = (number of deer seen without antlers – number with antlers)/(number without + number with).

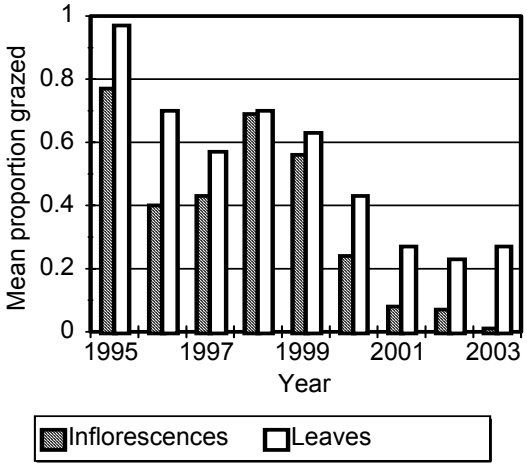

Figure 2. Mean frequency of grazing on bluebell inflorescences and leaves in thirty 0.5 m quadrats in compartment 27, 1995-2003. Shooting started in the wood in 1998.

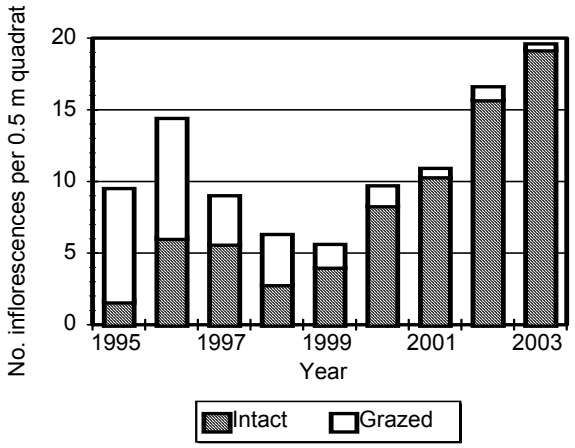

Figure 3. Mean number of bluebells per quadrat in thirty 0.5 m quadrats in compartment 27, 1995-2003. Shooting started in the wood in 1998.

The Monks Wood avifauna

Shelley A. Hinsley, Paul E. Bellamy and Ian Wyllie
NERC Centre for Ecology and Hydrology, Monks Wood, Abbots Ripton, Huntingdon, Cambridgeshire PE28 2LS

Introduction

David Elias, in Steele & Welch (1973), summarised the Monks Wood avifauna as follows: "One hundred and fifteen species of birds have been recorded on or over Monks Wood. Of these 57 are known to have bred at least once and a further six have probably bred; four occur only as winter visitors; 11 are recorded regularly as non-breeding birds; and the remaining 37 are vagrants to the wood". At the time of publication in 1973, 48 species were recorded as breeding regularly, but the information in the annotated list suggested that this number should be 49 (Table 1).

The number of bird species breeding in the wood itself in 2003 was estimated as 39 with a further three as possible breeders. Two of these "possibles" do breed in closely adjacent habitat, as do an additional 13 species, with a further three species as possible breeders in adjacent habitat. One additional species has also bred in adjacent habitat, but has not been recorded since the early 1990s. Therefore, the current breeding total for the wood and its immediate surroundings is 54 species, with a further four as possible breeders (Table 1). Data collected in the mid 1970s for the British Trust for Ornithology's Register of Ornithological Sites recorded that the mean number of breeding bird species in a sample of woods (mean area 120 ha, n = 71) in southern England was 41, and for a sample of woods (mean area 70 ha, n = 75) in the Midlands and East Anglia was 40 (Fuller 1982). Species richness for breeding birds in Monks Wood itself is therefore as expected, but diversity is enhanced by the close proximity of different habitat types. These adjacent habitats include coniferous woodland (Bevill's Wood, *c.* 37 ha adjoining part of the southern boundary across the road), hedgerows, a small area of scrub, grass fields, arable fields, free-standing trees and the buildings and vegetation of the CEH site.

Losses and reductions

The reduction in breeding species numbers in the wood itself from 49 to 39 - 41 is probably due in part to changes in habitat structure as the wood has matured. Species associated with immature woodland, clearings and scrub (common snipe, Eurasian turtle dove, little owl, tree pipit, common grasshopper warbler, Eurasian jackdaw, European greenfinch, European goldfinch, common linnet, yellowhammer, reed bunting) have disappeared from the wood itself, but are still found in low numbers in adjacent habitats which now supply their requirements. Other species (hedge accentor, lesser whitethroat, common whitethroat, garden warbler, common nightingale, willow warbler, common bullfinch) requiring certain characteristics associated with young woodland/scrub (eg dense cover) still breed in the wood, but have declined in numbers (Table 2). In addition to woodland maturation, habitat structure has also been severely modified by deer (mostly muntjac, *Muntiacus reevesi*). Damage to coppice re-growth, loss of low cover, particularly of bramble, and other changes to the ground flora and shrub layer were apparent by the mid 1980s (Cooke & Farrell 2001). Culling was introduced in the late 1990s to reduce deer numbers, and there is evidence of

recovery, in at least some elements of the ground flora, as grazing pressure has declined (Cooke, this report). Removal of ground cover, especially of bramble, by deer is cited as a major cause of the loss and decline of bird species such as hedge accentor, blackcap, garden warbler and common bullfinch at Wytham Woods in Oxfordshire (Perrins & Overall 2001) and the effects of deer on woodland bird populations in general is of increasing concern (Fuller & Gill 2001).

Table 1. The breeding birds of Monks Wood. Data listed under 1973 are from Steele & Welch (1973); data listed under 2003 have been compiled from various sources (see acknowledgements). Location: W = in Monks Wood itself, S = in immediately surrounding habitat. Abundance: W and S = rare or in low numbers, WW = moderate numbers or abundant. Brackets indicate species present, but breeding currently unconfirmed, see text.

Species		**1973**	**2003**
Mallard	*Anas platyrhynchos*	W	W
Common buzzard	*Buteo buteo*	-	(W) S
Eurasian sparrowhawk	*Accipiter nisus*	-	W
Common kestrel	*Falco tinnunculus*	-	W
Red-legged partridge	*Alectoris rufa*	W	W
Common pheasant	*Phasianus colchicus*	WW	WW
Common moorhen	*Gallinula chloropus*	W	W
Common snipe	*Gallinago gallinago*	W	-
Eurasian woodcock	*Scolopax rusticola*	W	W
Stock pigeon	*Columba oenas*	-	(W) S
Common wood pigeon	*Columba palumbus*	WW	WW
Eurasian collared dove	*Streptopelia decaocto*	-	S
Eurasian turtle dove	*Streptopelia turtur*	WW	S
Common cuckoo	*Cuculus canorus*	WW	W
Little owl	*Athene noctua*	W	S
Tawny owl	*Strix aluco*	WW	WW
Long-eared owl	*Asio otus*	-	(S)
Green woodpecker	*Picus viridis*	W	W
Great spotted woodpecker	*Dendrocopos major*	WW	WW
Lesser spotted woodpecker	*Dendrocopos minor*	-	(W)
Skylark	*Alauda arvensis*	W	S
Barn swallow	*Hirundo rustica*	-	S
Tree pipit	*Anthus trivialis*	W	-
Pied wagtail	*Motacilla alba*	-	S
Winter wren	*Troglodytes troglodytes*	WW	WW
Hedge accentor	*Prunella modularis*	WW	W
European robin	*Erithacus rubecula*	WW	WW
Common nightingale	*Luscinia megarhynchos*	WW	W
Common blackbird	*Turdus merula*	WW	WW
Song thrush	*Turdus philomelus*	WW	W
Mistle thrush	*Turdus viscivorus*	W	WW
Common grasshopper warbler	*Locustella naevia*	W	(S)
Lesser whitethroat	*Sylvia curruca*	WW	W
Common whitethroat	*Sylvia communis*	WW	W
Garden warbler	*Sylvia borin*	WW	W
Blackcap	*Sylvia atricapilla*	WW	WW
Common chiffchaff	*Phylloscopus collybita*	WW	WW
Willow warbler	*Phylloscopus trochilus*	WW	W

Species		1973	2003
Goldcrest	*Regulus regulus*	W	W
Spotted flycatcher	*Muscicapa striata*	WW	W
Long-tailed tit	*Aegithalos caudatus*	WW	WW
Marsh tit	*Parus palustris*	WW	WW
Willow tit	*Parus montanus*	WW	(S)
Coal tit	*Parus ater*	-	W
Blue tit	*Parus caeruleus*	WW	WW
Great tit	*Parus major*	WW	WW
Wood nuthatch	*Sitta europaea*	-	W
Eurasian treecreeper	*Certhia familiaris*	W	WW
Eurasian jay	*Garrulus glandarius*	WW	WW
Black-billed magpie	*Pica pica*	-	W
Eurasian jackdaw	*Corvus monedula*	W	S
Carrion crow	*Corvus corone*	-	W
Common starling	*Sturnus vulgaris*	W	S
House sparrow	*Passer domesticus*	S[1.]	-
Eurasian tree sparrow	*Passer montanus*	W	-
Chaffinch	*Fringilla coelebs*	WW	WW
European greenfinch	*Carduelis chloris*	WW	S
European goldfinch	*Carduelis carduelis*	W	S
Common linnet	*Carduelis cannabina*	W	S
Lesser redpoll	*Carduelis cabaret*	W	-
Common bullfinch	*Pyrrhula pyrrhula*	WW	W
Hawfinch	*Coccothraustes coccothraustes*	-	(S[2.])
Yellowhammer	*Emberiza citrinella*	WW	S
Reed bunting	*Emberiza schoeniclus*	W	S

[1.] House sparrows were not recorded as breeding in the wood in Steele & Welch (1973), but did breed in boxes on the CEH buildings, see text.
[2.] One pair recorded breeding in the early 1990s, and a single bird present at the time of writing (March 2004).

The impact of deer on vegetation in Monks Wood may have influenced the decline of common nightingale (Fuller 2001), but woodland maturation has probably been the main cause. There were 20-25 pairs in 1973, and the species was still relatively common in the early 1990s (*c.* 10-15 pairs), but had declined to one or two singing males in 2003. Singing was recorded to the south west and north east of the junction of Stocking Close Ride and Main Ride and thus might have been due to the same bird. Common snipe, although still recorded in the wood (eg in the East Field and on the CEH field plots), no longer breeds; structural habitat changes will have played a part in this loss, but drier conditions arising from improvements in drainage in the area in general may also have been involved. In addition to habitat changes, losses and reductions in some of these species (notably Eurasian turtle dove, common linnet, yellowhammer, reed bunting, hedge accentor, willow warbler, common bullfinch) may also have been influenced by changes in national populations.

The loss and decline of other species (common cuckoo, song thrush, spotted flycatcher, willow tit, common starling, Eurasian tree sparrow, lesser redpoll) appears to be largely due to national population declines, but habitat changes might also be involved. Willow tit was last recorded in 2000 when a pair was caught and ringed coming to a peanut feeder in the garden of one of the CEH bungalows, and singing was heard later in April along Southedge Ride. The feeder was within 50 m of the road and these birds were thought to have come

from Bevill's Wood, as might have been the case with the Southedge bird. Whether or not the species is still present in Bevill's Wood is unknown. Willow tits have declined by more than 50% in the last 25 years and have recently been added to the Red List of Birds of Conservation Concern (Gregory and others 2000, 2002). Willow tits excavate their own nest holes in rotting wood and it has been suggested that they are losing out in competition for possession of completed sites to blue and great tits (whose populations are increasing). Tree sparrows and starlings both disappeared from the wood between 1983 and 1993 (Table 2.). Both species used to breed in boxes on the CEH buildings, but tree sparrows (and house sparrows) had disappeared by 1982 and starlings were down to one pair in 2003 although some of the recent decline in starlings may be due to many of the boxes falling into disrepair during the late 1990s.

Table 2. Mean numbers of songbirds in three April censuses at dawn. The census route was a closed loop comprising Top Ride (from the CEH site gate), Stocking Close Ride, Eastfield Ride, Hotel Ride, Main Ride, Southedge Ride, Hotel Ride, Top Ride (back to the gate) and took about an hour to walk. Data collected by Ian Wyllie.

Species	1982	1983	1993	1995	1996	1997	1998
Great spotted woodpecker	3.0	3.3	0.7	1.3	0.7	0.0	0.0
Winter wren	9.3	23.0	20.0	22.0	11.7	9.7	18.0
Hedge accentor	7.0	8.0	3.0	1.0	1.0	1.3	0.7
European robin	7.0	10.3	15.3	23.3	23.3	17.0	11.7
Common blackbird	17.7	14.7	6.3	11.7	13.0	9.7	6.3
Song thrush	31.3	35.0	6.7	6.7	5.7	5.3	6.7
Common chiffchaff	1.7	1.0	7.0	4.3	2.7	6.7	7.3
Willow warbler	30.7	18.0	11.3	17.3	11.0	13.0	11.7
Long-tailed tit	3.3	3.7	4.0	8.7	0.3	2.0	4.0
Marsh tit	6.3	6.7	5.0	2.7	8.7	3.3	2.3
Coal tit	0.0	0.6	3.7	0.7	2.0	1.3	1.0
Blue tit	22.7	20.3	27.0	25.3	26.3	27.3	27.3
Great tit	9.0	15.7	12.0	11.7	10.3	15.3	10.0
Treecreeper	2.3	0.6	4.3	3.0	4.0	2.7	1.0
Starling	11.0	22.7	0.0	1.0	0.0	0.0	0.0
Eurasian tree sparrow	1.7	3.7	0.0	0.0	0.0	0.0	0.0
Chaffinch	11.3	7.3	9.3	11.0	10.0	11.0	9.7
European greenfinch	0.3	0.3	0.3	2.0	1.3	0.3	0.3
Common bullfinch	4.0	3.7	1.7	3.3	2.0	3.3	3.7

Nationally, tree sparrows have declined by 95% (data for 1970 to 1998, Gregory and others 2000, 2002), and the decline was well established by the time they disappeared from Monks Wood. Starlings began to show a decline around 1980 and their numbers have more than halved since then (Marchant and others 1990; Mead 2000).

Song thrushes have declined nationally by 59% and spotted flycatchers by 78% (data for 1970 to 1998, Gregory and others 2000, 2002). In Monks Wood, a large drop in numbers (*c.* 80%) of song thrushes occurred between 1983 and 1993 (Table 2). There has been a small increase in numbers in the wood in the last few years (see below), but this is relatively insignificant compared to the earlier losses. In 2003, spotted flycatcher activity was recorded at four locations in the wood, but only one pair by Bevill's Gate was confirmed. Alcoves in the back of buildings adjacent to the wood near Bevill's Gate have been used as nest sites on occasion by the pair of spotted flycatchers in this location. Lesser redpoll no longer breeds in

the wood, but is seen fairly regularly as single birds or small flocks of 10 to 20 birds in winter. A larger flock of about 50 birds was seen near the junction of Top Ride and Stocking Close Ride in 2000, and birds are seen occasionally in birches around the CEH site. In spring, small numbers are frequently seen feeding on aspen catkins. Nationally, lesser redpoll appears to have declined dramatically (by 93% from 1970 to 1998, Gregory and others 2000, 2002), but there is some confusion over the population estimates for this species in that much suitable habitat may not be well covered and the extent of decline may have been exaggerated by shifts in the species distribution (Gibbons and others 1993).

Gains and increases

Despite losses and reductions in some species, others have returned to the wood, some after absences of up to 160 years (Steele & Welch 1973). Sparrowhawks disappeared as a breeding species in the late 1950s to early 1960s as part of a national population crash due to organochlorine pesticide poisoning (Newton 1979, 1986). They re-established in the 1990s and are now regular breeders with 2 or 3 pairs present each year. Buzzards have returned to Cambridgeshire in the last few years as part of the nationwide expansion of the species range (Clements 2000). They have been seen around the wood with increasing frequency since about 1994 and have probably been breeding in the area since about 2000. They may have bred in Monks Wood itself in 2002, there was a lot of activity, especially around the western edge, or possibly the actual nest site was over the road in Bevill's Wood. A juvenile was caught and ringed by SAH in the CEH field plots on the south side of the wood in November 2001. A third raptor, the red kite, which disappeared in the 1840s has yet to breed again in the wood, but has been seen sporadically since the mid to late 1990s, probably as a consequence of the release programme in Rockingham Forest and elsewhere in England. In 2002, two red kites and a buzzard were seen together over the south of the wood. Red kite activity around the wood in 2003 was notably less than in 2000-2002. Sightings of goshawks, usually in April and sometimes of birds displaying, have occurred regularly since about 2000, but as yet there has been no evidence of breeding.

Records of nuthatch were sparse in the past and it is only recently that breeding has been confirmed in Monks Wood. A pair was present (and assumed to have bred) in 1992, but despite records of single birds in a few years thereafter, breeding was not confirmed again until 1998. One pair (and possibly one or two additional individuals) have been present in the wood since 1998, and although breeding has not been confirmed in every year, it is likely that at least an attempt has been made each year. Fledged juveniles were present in 2001 (two individuals caught and ringed in August near Sallow Ride) and 2003. In an analysis of the distribution of nuthatches in eastern England (Bellamy and others 1998), it was concluded that isolation of woodland was likely to be a prime cause of the absence of this species from Monks Wood as a regular breeder. Its establishment in recent years may be due to a national increase in both abundance and range (Gibbons and others 1993; Raven & Noble 2003). Small populations are vulnerable to local extinction for reasons of chance alone and thus an increase in the numbers of potential colonists dispersing into the area from surrounding populations may be contributing to this recent increase in population persistence. The quality of the wood as nuthatch habitat may have improved as the trees have aged, further increasing the likelihood of population persistence. Increasing maturity and quality (coupled with relatively mild winters) may also have favoured treecreeper, another specialist bark-feeding species. In 1973, treecreepers were reported as "A regular but scarce breeding species." but are now quite common.

Three other species which were previously noted in or around the wood, but not as breeders, now do breed in low numbers. Coal tit, kestrel and carrion crow all bred in 2003, and have done so since at least the early 1990s, although not necessarily in every year. Two broods of coal tits have been ringed in nestboxes since 1993. Nationally, coal tits show no particular long-term trend, although the latest results from the Breeding Bird Survey indicate a population increase for the period 1994 to 2002 (BTO web site) and they are probably the most regular breeders of the three species. Their presence now may be largely due to habitat changes as the wood has matured, for example the availability of nest sites may have increased. Kestrels have declined nationally so habitat changes may again be responsible for their presence, and again, an increase in potential nest sites as trees have matured could be important. A pair was present around the East and West Fields and the Walton Gate in 2003 and may have used an old squirrel dray near the fields as a nest site. Carrion crow populations have increased probably as a consequence of this species ability to utilise resources arising from human activity (eg road kill, waste food) and from a decrease in persecution. Magpies were recorded as "very common on the margins of the wood" until the 1950s when they disappeared, from both the wood and the area in general, due to pesticide poisoning (and possibly persecution). They have now recovered and have been abundant and widespread in the locality from at least 1990 and currently breed in the wood in small numbers.

Mistle thrushes and green woodpeckers have both increased in the wood over the last five or six years, possibly as a result of increased rainfall (green woodpeckers have also increased nationally, but mistle thrushes have declined, Gregory and others 2000, 2002). Figure 1 shows rainfall recorded by the Monks Wood meteorological station plotted as the deviation from the 40 year mean (1964-2003); rainfall has been above average in five of the six years since 1998. The distribution of rainfall throughout the year may also be important. Both these species feed chiefly on the ground in the summer and hence drying out of the ground will curtail breeding activity. Damp conditions may favour breeding success by improving foraging conditions and increasing the length of the breeding season and hence the number of broods that can be reared. In 1990, mistle thrushes were rarely heard, but they are now a regular feature of the dawn chorus in Monks Wood, and in 2003 the breeding population was probably about 6 pairs. Two broods have been ringed in nests on the CEH site. Excessive drying of the ground has been implicated in the decline of the song thrush in farmland habitats and thus it is no surprise that both song thrushes and blackbirds have also increased in numbers in Monks Wood in recent years.

Despite this recent change in some species, there has been no evidence of a return of snipe as a breeding species, but woodcock still breed, and probably in reasonable numbers. A nest was found near Leeds Ride in 1993, a male was caught and ringed near Brown's Gate in June 1996, a female with two *c.* week old chicks was nearly trodden on near the East Field in the mid 1990s and another was seen with small young in 2000. At other times of year, birds are infrequently, but regularly, encountered. During the National Woodcock Survey in 2003, the maximum number of roding events recorded in *c.* one hour of observation at the junction of Barrow and Main Rides was 18 (A. Cooke, pers. com.).

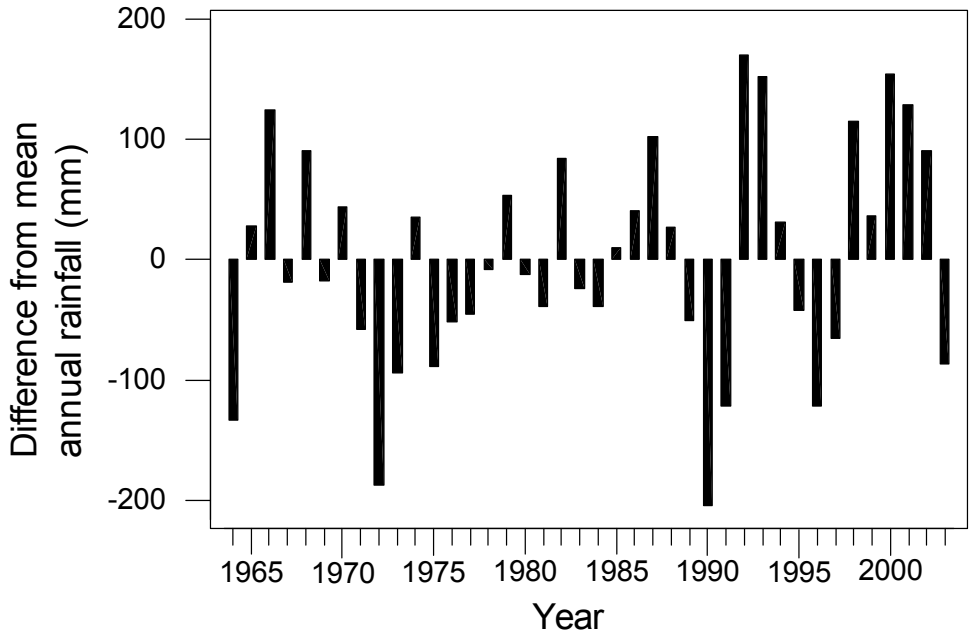

Figure 1. Annual rainfall recorded by the Monks Wood Met. Station for 1964 to 2003. Values are plotted as deviations from the 40 year mean (570 mm).

The status of lesser spotted woodpecker was a bit of a mystery in 1973, the species being "rarely recorded" with the exception of a bird calling and drumming near the centre of the wood in April and May in 1973. This species is still a bit of a mystery, with sporadic records, mostly in autumn and winter, but breeding may have occurred, or been attempted, in 2000 and 2001. Drumming, displaying and calling were recorded on several occasions in spring, usually in the area of Barrow and Main Rides, and two birds were seen together, but breeding was not confirmed. In contrast, great spotted woodpeckers are regular breeders in good numbers, and are probably more numerous now than the 4-5 pairs estimated in 1973.

Marsh tits, like willow tits, are showing a large national decline (62%, 1970 to 1998, Gregory and others 2000, 2002) and have also been added recently to the Red List of Birds of Conservation Concern. Unlike willow tits, they have maintained, and perhaps even increased, their numbers in Monks Wood, the breeding population currently being estimated at about 20 pairs (R. Broughton, pers. com.) The birds' distribution in the wood seems to favour those areas with the tallest trees and hence their continued presence, or even increase, may be due to an increase in habitat suitability as the wood has matured. In relation to the national decline, the species is the subject of several on-going projects based in the wood. Tawny owls in Monks Wood were also the subject of study in the early 1990s when the population was estimated at ten pairs (Redpath 1995). Previous estimates were considerably lower at three pairs in 1968 and two in 1972 (Steele & Welch 1973) which may once again indicate increasing habitat suitability with time. However, numbers may well have been increased by the provision of nestboxes.

Adjacent habitat

Bevill's Wood, in addition to current records of buzzard and past ones of willow tit, was also thought to support two pairs of long-eared owls in the early to mid 1990s. One long-eared owl seen hunting in Monks Wood in March 1994 may have been one of these birds, but their current status in Bevill's Wood is unknown. Although not recorded in Monks Wood in recent years, a roost of up to 13 birds was noted in scrub in Com's Field (adjacent to the southern edge of the wood) in the winter of 2002, and such a winter roost has been present here for several years. This area of scrub and associated hedges and trees, including Saul's Lane and Judith's Hedge, supports small numbers of breeding pairs of many of the species which disappeared from or declined in the wood itself as it matured, in particular Eurasian turtle dove, hedge accentor, common whitethroat, garden warbler, willow warbler, European greenfinch, European goldfinch, common linnet, common bullfinch, yellowhammer and reed bunting. Common grasshopper warbler has been recorded singing here in spring in several recent years, and in the mid to late 1990s also sang in dense blackthorn and dogwood scrub near the CEH sewage treatment works, but breeding has never been confirmed for either location.

One or two skylarks are usually recorded singing over adjacent fields, and when apparently nesting in crops between the road and Judith's Hedge, also sing over the CEH field plots. Three other species, stock pigeon, little owl and jackdaw have not been confirmed as breeding in the wood itself, but are known to use nearby individual trees with suitable holes. Little owls have bred regularly in trees near the road at the Walton Gate for a number of years. Stock pigeons are also likely to be breeding in the edges of the wood and in the past have used boxes put up for tawny owls in the early 1990s (although many of these have now fallen into disrepair).

The buildings, boxes and associated vegetation of the CEH site provide breeding and roosting opportunities for a number of species (eg see mistle thrush, spotted flycatcher, starling, tree and house sparrow above). Some of these species no longer breed (eg the sparrows) and another, hawfinch, was present as a single pair in the early 1990s in hedges around one of the bungalows. However, at the time of writing (March 2004), a single hawfinch has been present in the same location for about three weeks. Greenfinches and collared doves (amongst other more abundant species such as chaffinch) breed in the taller conifers (Leyland cypress) and long-tailed tits are regular nesters in the smaller junipers. For collared doves, two records (one in 1968 and one in 1972) of single birds are mentioned in Steele and Welch (1973) which tallies with this species relatively recent colonisation of the UK (Gibbons and others 1993). Similarly, its absence from the wood itself and its presence on the CEH site is as expected from its association with human activity around rural and suburban sites. Two other species breed on the CEH site, which have not been recorded in the wood, these being swallow and pied wagtail. Swallows have declined markedly in the last four or five years, but one or a few pairs still find nest sites around the buildings. Two, or occasionally three, pairs of pied wagtails nest in various locations on the buildings, the most unlikely site being a nest on the head of a mop in a rack under a roofed walk way outside the canteen. A number of holes (and less suitable sites such as extractor fan cowls and cable ducts) are routinely used by tits, mostly blue tits, and in 2003, two cigarette disposal bins on outside walls were used, despite the lack of space and high levels of disturbance. The blue tit eggs failed to hatch and the outcome of the great tit attempt was unknown. As with the ponds in the wood, moorhens regularly nest on the ponds around the CEH site, including in one year, the pond outside the main entrance.

Records of non-breeders

Regular winter visitors in the wood include fieldfare and redwing, and often brambling. Grey wagtail is usually seen around the CEH site in early winter. Other species recorded on passage (or otherwise sporadically), as in 1973, include grey heron, common kingfisher, Eurasian wryneck, meadow pipit, yellow wagtail, black redstart, common redstart, sedge warbler, Eurasian reed warbler, Eurasian golden oriole and Eurasian siskin. Herons are seen occasionally at the ponds in the wood and also around those on the CEH site. A brambling was caught and ringed in February 1991, and a wryneck was seen from the BAS building when it perched briefly on a disused oil tank in August 1995. Black redstarts used to be regular passage birds around the CEH site, but have become less frequent in recent years. Common redstarts are seen occasionally on passage and a male was caught and ringed near Brown's Gate in June 1994. Sedge and reed warblers are sometimes recorded singing in spring in the scrub in Comm's field and reed warblers have also been seen and heard around the CEH sewage treatment works and elsewhere in the wood, including around the main ponds. A golden oriole was heard in the wood in early summer in the mid to late 1970s, and siskins are recorded in some winters. Records of sporadic species not noted in Steele and Welch (1973) include peregrine falcon, Bohemian waxwing, firecrest and common crossbill. Records of peregrines are of birds flying over. A small flock of waxwings was seen in a rowan on the CEH site in December 2003, but was chased off by a mistle thrush. Firecrests (single birds) have been seen in autumn in 1999 and 2000 and a singing bird was seen in April 2002. Crossbills are rather sporadic, sometimes being seen quite frequently for a period, usually in winter, and then disappearing - they have been seen feeding in birches on the CEH site and drinking at the pond outside the main entrance. A pair of mealy redpolls were reported in early 2002 and two more were tentatively identified in winter 2003, also in birches on the CEH site.

Other bird studies

Other studies of birds (both completed and on-going) in Monks Wood have included estimates of turnover rates of individual breeding species (Hinsley, Bellamy & Newton 1994), collection of moult data (Hinsley and others 2003), measurements of individual bird quality (Ferns & Hinsley 2004), monitoring of breeding success (Hinsley, Rothery & Bellamy 1999), measurements of energy expenditure of breeding birds (on-going) and the application of airborne remote sensing to quantifying habitat quality for birds (Hinsley and others 2002). A large body of work (including studies of birds) is also focussed on the CEH Wilderness, 4 ha of woodland regenerating naturally from a previous life as a barley field in the early 1960s adjacent to the east side of the CEH site. A second "New" Wilderness of 2.5 ha was established in 1996 to the west of Saul's Lane.

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Updates on the Monks Wood fauna

Henry Arnold
NERC Centre for Ecology and Hydrology, Monks Wood, Abbots Ripton, Huntingdon, Cambridgeshire PE28 2LS

Steele & Welch (1973) included exhaustive lists of the flora and fauna of Monks Wood, of which the information on butterflies and vascular plants was updated in Massey & Welch (1993). The Flora, Lepidoptera, Coleoptera and avifauna of Monks Wood are covered elsewhere in this report. This leaves other groups, particularly the vertebrates, for which the published list is now 30 years out of date. A revised annotated list is included here. Observations on a few new or interesting invertebrates are appended.

Monks Wood mammals – current knowledge

Insectivora

Hedgehog *Erinaceus europaeus.* Present – occasional dead ones found, and droppings seen.
Water shrew *Neomys fodiens.* Status unknown.
Common shrew *Sorex araneus.* Occasionally found dead on rides (DH).
Pygmy shrew *Sorex minutes.* Status uncertain, one in a nestbox, 2000 (HH).
Mole *Talpa europaea.* Present – many workings seen and dead ones found regularly especially in late summer.

Chiroptera

Barbastelle *Barbastella barbastellus.* One found dead in 2002.
Serotine *Eptesicus serotinus.* Status unknown – records from 1970s in buildings adjacent to wood.
Whiskered/Brandt's bat *Myotis brandtii/mystacinus.* Status unknown.
Daubenton's bat *Myotis daubentonii.* Status unknown.
Natterer's Bat *Myotis nattereri.* Status unknown.
Leisler's bat *Nyctalus leisleri.* Status unknown – records from 1970s in buildings adjacent to wood.
Noctule *Nyctalus noctula.* Status unknown, but found in Woodwalton village, less than 1km away.
Nathusius' pipistrelle *Pipistrellus nathusii.* Not known to be present, but records from surrounding areas have been reported.
Pipistrelle *Pipistrellus pipistrellus*. Known to be present in buildings on edge of wood. One in a nestbox (HH, 2000).
Brown long-eared bat *Plecotus auritus.* Known to be present in buildings on edge of wood.

Lagomorpha

Brown hare *Lepus capensis.* Seen regularly within wood, even in the most wooded areas.
Rabbit *Oryctolagus cuniculus.* Frequent.

Rodentia

Wood mouse *Apodemus sylvaticus.* Presumed frequent. One found in nestbox (HH, 2000).
Water vole *Arvicola terrestris.* Status uncertain. Last seen by me in 1970s.
Bank vole *Clethrionomys glareolus.* Presumed frequent (RNB 1987).
Harvest mouse *Micromys minutes.* Few records, but known to be present in Bevill's Wood.
Field vole *Microtus agrestis.* Presumed frequent, occasionally seen dead on rides.
House mouse *Mus domesticus.* Not known if still present in centre of wood (RNB 1987), but still found in buildings on edge of wood.
Common dormouse *Muscardinus avellanarius.* Presumed absent. Nestbox survey in 1999/2000 produced negative results.
Brown rat *Rattus norvegicus.* Presumed frequent (RNB 1987).
Grey squirrel *Sciurus carolinensis.* Frequent – black squirrels have been seen recently in the wood.
Red squirrel *Sciurus vulgaris.* Certainly no longer present.

Carnivora

Badger *Meles meles.* Recent observations of extensive diggings in northern half of wood.
Stoat *Mustela erminea.* Seen regularly.
Feral ferret *Mustela furo.* May be present as occasional escape/release.
Weasel *Mustela nivalis.* Seen regularly.
Polecat *Mustela putorius.* Records from not far away, eg Yarwell.
American mink *Mustela vison.* No records, but has been seen close to wood.
Red fox *Vulpes vulpes.* Regular sightings, droppings and scent. (DH).
Feral cat *Felis catus.* Occasionally seen in wood, and present around buildings adjacent to wood.

Artiodactyla

Roe deer *Capreolus capreolus.* A small population now resident in wood.
Red deer *Cervus elaphus.* Occasional visitors.
Fallow deer *Dama dama.* Occasional visitors.
Chinese water deer *Hydropotes inermis.* Several resident.
Muntjac *Muntiacus reevesi.* Numerous but now being controlled.

Monks Wood Amphibians – current knowledge

(Based mainly on notes by A.S. Cooke)

Common frog *Rana temporaria*

Occasional sightings in and around the wood, but no spawn seen in any of the ponds.

Common toad *Bufo bufo*

Occasional sightings near the wood (eg near the entrance gate, and squashed on the road between Monks Wood and Bevill's Wood), and newly hatched tadpoles seen in Pond 71 on 03/05/03 .

Great crested newt *Triturus cristatus*

Not seen in Pond 71 since 1970s. Pond 72 (1980 - RNB). Present in Pond 75 from 1973 to at least 1997 (up to 13 adults seen). Present in Pond 77 in 1989 when 40 adults counted. Present in pond just outside boundary of NNR (TL206802) 1986 – 1997 (up to 12 adults seen).

Smooth newt *Triturus vulgaris*

Also present in Pond 75, Pond 77 and pond at TL206802. Not seen recently in Ponds 71 & 72 (RNB 1987), but juveniles found twice in Compartment 27 in the 1990s (HRA and ASC) so a few may still be breeding.

Monks Wood reptiles – current knowledge

Slow worm *Anguis fragilis*. Andy Thomson saw a single slow worm in the wood in about 2001.

Grass snake *Natrix natrix*. Still regularly seen (with a maximum count of eight together having just emerged from hibernation).
Common lizard *Lacerta vivipara*. Now more often seen on the edge of the wood, but there are occasional sightings in East Field and elsewhere.

Monks Wood Invertebrates –some updates

Odonata

Pyrrhosoma nymphula, *Libellula fulva* and *Libellula quadrimaculata* are all recorded in the wood. *Lestes sponsa, Brachytron pratense, & Anax imperator* – all recorded in 2001 (MEM). *Orthetrum cancellatum* recorded in 2002 & 2003 (DH).

Orthoptera

Conocephalus dorsalis is now considerably more widespread. It occurs over much of East Field and West Field, along Main Ride towards the east edge of the wood and along Hotel Ride as far as Dogwood Path.

Roesel's bush cricket *Metrioptera roeselii* was first recorded in the reserve in 2000, and though not common inside the reserve is abundant in the Monks Wood Field Plots.
Tetrix subulata is quite common in South Edge Ride, Hotel Ride and Main Ride.

Homoptera

Cercopis vulnerata is common in the wood now. I sweep *Ledra aurita* about every other year.

Neuroptera

Drepanepteryx phalaenoides and Psectra diptera (Hemerobiidae) are new to the reserve.

Mecoptera

Panorpa germanica added to list.

Plecoptera

Amphinemura standfussi (Nemouridae) new to the reserve (JHB 1994).

Diptera

Add *Beris chalybata* (Stratiomyidae) and *Rhagio scolopacea* (Rhagionidae) to the list.

Hymenoptera

Xiphydria longicollis (Symphyta) was found in Monks Wood, new to the county, on 02/08/93

Chilopoda

Brachygeophilus truncorum (Geophilidae) and *Lithobius microps* (Lithobiidae) added to list.

Amphipoda

Crangonyx pseudogracilis (Crangonyctidae). A freshwater shrimp introduced from America, now naturalised. (JHB 1992).

HRA – Henry Arnold. RNB – Roger Boston. JHB – John Bratton. ASC – Arnold Cooke.
HH – Howard Hillier. DH – Dave Hughes.

Changes in the Lepidoptera of Monks Wood NNR (1974-2003)

Nick Greatorex-Davies*, Tim Sparks* and Ian Woiwod†

* NERC Centre for Ecology and Hydrology, Monks Wood, Abbots Ripton, Huntingdon, Cambridgeshire PE28 2LS
†Rothamsted Research, Harpenden, Hertfordshire AL5 2JQ

Introduction

Scientific names for the mentioned butterflies and moths are given in the tables to this paper.

Monks Wood has been noted for the richness of its Lepidoptera, particularly butterflies, since at least the middle of the 19th century. In 1828 the black hairstreak was discovered for the first time in Britain in Monks Wood. A total of 48 butterfly species have been recorded in the Monks Wood area but today only 30 species (including two non-resident migrants) can be found there. Most of the losses had occurred by the time the Monks Wood book (Steele & Welch 1973) was published (Table 1).

Less is known historically about the moth fauna. Steele & Welch (1973) listed some 129 microlepidoptera and 332 macrolepidoptera (hereafter referred to as macro-moths). These records came from variety of sources collated from the many collectors who had visited Monks Wood for well over a century. The list includes some species that have not been recorded in recent decades, some of which are almost certainly extinct in the wood (Table 2). The number of microlepidoptera recorded in the wood has greatly increased but no current list has been compiled. The current list of macro-moths stands at 460 species.

Monks Wood has contributed to national recording schemes for both butterflies (Butterfly Monitoring Scheme – BMS) and moths (Rothamsted Insect Survey) for three decades and it is these standardised observations that allow an examination of change within Monks Wood and a comparison with national statistics. An earlier study by Pollard and others (1998), using these data, concluded that an increase in coarse grasses had benefited Lepidoptera feeding on them at the expense of those feeding on finer grasses. Several possible causes included ride management practices, the colonisation of the wood by muntjac, and an increase in atmospheric nitrogen deposition.

In the current study we examine both the butterfly transect data and the Rothamsted Insect Survey (light trap) moth data for changes over the last 30 years.

Methods

Butterflies

Weekly counts have been made on the Monks Wood BMS transect from April to September (26 weeks) since 1974. For each species an annual index is calculated as the sum of the weekly counts including estimates for any missed weeks. For some double-brooded species, or species with a separate pre- and post-hibernation flight (brimstone and peacock), separate

indices are produced. Significant trends in annual indices were identified using linear regression. A comparison with national trends was made.

Moths

The Monks Wood Rothamsted trap has operated continuously since 1974 except for occasions when there has been power or bulb failure. Most identification was done by staff at Rothamsted Experimental Station. Analysis of annual trap counts over the monitoring period 1974-2002 (2003 data were not available at the time when analysis for this paper was carried out) was carried out as for the butterflies. 315 species were recorded for five or more years. These were assigned to foodplant categories listed in Table 6 using Waring and others (2003). A comparison with national trends (Kelvin Conrad, pers comm.) was made.

Results

Butterflies

All the butterfly species known to occur currently in the Monks Wood area have been recorded on the butterfly transect. A total of 106,911 butterflies have been recorded on the transect. The most frequently recorded species is the ringlet (25% of records) followed by the meadow brown (20%). Apart from the rare migrant clouded yellow (recorded once), the re-introduced wood white, vagrants or recent colonists, the most infrequently recorded species is the white-letter hairstreak (17 individuals on 8 occasions).

The number of butterflies recorded annually on the transect increased dramatically during the first few years of recording from 500-1000 and has remained at 2000-3000 since 1979. Despite this, more species have declined over the recording period than have increased. Table 3 shows trends in the abundance of those species where these trends are statistically significant. Several species, most notably three species of butterfly that feed on coarse grasses, have increased dramatically. These are large skipper, speckled wood and ringlet. The combined count of the grass-feeding small and Essex skippers (difficult to separate on transect counts) has also increased dramatically. These increases were noted by Pollard and others (1998).

Moths

Of the 332 species of macro-moth listed for Monks Wood in Steele & Welch (1973), 40 have not been recorded in the Rothamsted trap or observed in the wood (Table 2). Conversely 127 species of moth have been recorded in the trap that were not listed by Steele & Welch (1973) (Table 4).

A total of 406,870 macro-moths were recorded in the light trap. Annual numbers of moths caught have varied from between about 7000 (in 2002) to about 27,000 (in 1979). There has been an overall decline over the recording period. Numbers of species recorded have not shown a similar pattern of decline though numbers have been noticeably lower in the last 5 years. The number of macro-moth species trapped in a year has varied from 271 (1976) to 211 (2001).

412 macro-moth species have been recorded in the trap of which 315 were recorded in five or more years. Twice as many species declined significantly than increased significantly (Table

5). Table 6 shows species declines and increases by foodplant groups. Six of the eight species feeding in the lichens and algae foodplant group showed a significant increase in numbers. Species in several other foodplant groups also showed more increases than decreases though many of these changes were not significant. These included species in the foodplant groups: conifers, grasses and herbs, bedstraws and oak. Grass feeding species showed a mixed response with 15 of the 31 species in this category increasing (nine significantly), and 16 decreasing (eight significantly). Of the 9 species showing a significant increase, eight feed on coarse grasses. Wood false-brome *Brachypodium sylvaticum* is considered a coarse grass and it has become extremely abundant in Monks Wood. It is mentioned specifically as a foodplant for three of the species by Waring and others (2003).

Species groups which have shown more declines than increases include those feeding on herbs (specialists and generalists), those on both herbs and woody species, those on poplars (in Monks Wood this is mainly aspen *Populus tremula*, though some of these species also feed on sallows), woody plant generalists, those on various Rosaceae, shrub specialists, ash *Fraxinus excelsior* and/or privet *Ligustrum vulgare* feeders and those on birches *Betula* spp. The highest declines proportionally were among those feeding on birch and ash. All eight birch feeders have declined, six significantly so. Of particular note among the woody plant feeders is the large number of species of the subfamily Ennominae of the Geometridae that have declined, particularly the 'thorns' and their close allies.

Discussion

The butterfly transect covers sufficient of the wood that we can be certain that all species of butterfly that occur in the wood are recorded. In contrast, the moth trap samples just a small area of the wood and species that breed elsewhere in the wood may escape detection. Changes in the moth fauna shown by the trap may be primarily a reflection of changes in the habitat in the immediate vicinity of the trap rather than over the wood as a whole. With respect to the Rothamsted light traps it has been shown that the diversity and abundance of moths is most closely associated with land use within a 50 radius of the trap (Woiwod & Thomas 1993). However, moths are mobile enough to disperse away from their breeding habitat and wander into the area sampled by the trap. Proof of this is that species that breed elsewhere in the wood (eg on aspen and elm *Ulmus* sp.) have been recorded in the trap over the years, some regularly. Looking at the composition of the catches it is clear that at least some of the changes reflect wider changes in the wood.

Some open ground species also occur regularly in the trap, for example the cinnabar. There has been a dramatic increase in numbers of this species taken in the trap. The first was recorded in 1984. Since 1986 it has been recorded every year and in double figures in eight years. Data from Rothamsted's national network indicate that this species has declined nationally. So not only is the cinnabar flying into the wood from its breeding area, which include the field plots along the south edge (the nearest point to the trap being about 50m distance), but numbers have been increasing against the national trend.

Broad habitat description

Monks Wood can be described as largely derelict coppice dominated by ash and pedunculate oak *Quercus robur* dissected by fairly wide, but often shady, rides and with some small and larger glades. There are significant stands of aspen and elm within the wood. Field maple *Acer campestre* and silver birch *Betula pendula* also occur scattered throughout many parts of

the wood, and in smaller numbers wild service tree *Sorbus torminalis*. The wood has a rich shrub under storey amongst which hawthorn *Crataegus monogyna*, midland hawthorn *Crataegus laevigata* and stands of blackthorn *Prunus spinosa* are abundant. Many other shrub species occur throughout the wood particularly on the ride edges. The ground flora was once a rich mix of spring flowering plants fairly typical of coppiced woodland on clay soils. Dog's mercury *Mercurialis perennis* and bluebells *Hyancinthoides non-scripta* were particularly abundant in some parts of the wood. Following the introduction and subsequent increase in muntjac deer in the wood the ground flora has experienced a dramatic change and of particular note today is the scarcity of many of the formerly common species of woodland ground flora throughout much of the wood and in its place the dominance of coarse grasses, particularly wood false-brome and pendulous sedge *Carex pendula*.

Grass feeders – dramatic increase in coarse grass feeders

The massive increase in coarse grasses in Monks Wood has clearly benefited those butterflies and moths that feed on them. This is evidenced by the dramatic increase in these species on transect counts and in light trap catches. Among the coarse grasses that have increased, wood false-brome has shown the most dramatic increase for it not only grows in the rides and glades of the wood but also under the tree canopy. However other coarse grasses have increased in the open areas, notably cock's-foot *Dactylis glomerata*, tufted hair-grass *Deschampsia cespitosa* and wood small-reed *Calamagrostis epigejos* (Pollard and others 1998).

The three butterflies showing the greatest increases, ie ringlet, speckled wood and large skipper, all feed on wood false-brome as well as other grasses such as cock's-foot. Of the nine grass-feeding moths that showed significant increases, eight are known to feed on coarse grasses. Three of these have wood false-brome listed as a food plant by Waring and others (2003). In addition the drinker moth is also known to feed on wood false-brome. Two more, the small dotted buff and the mere wainscot are monophages and feed on tufted hair-grass and wood small-reed respectively. Interestingly neither tufted hair-grass nor wood small-reed are prevalent in the vicinity of the light trap indicating that these moths roam widely in the wood.

Almost as many grass feeding butterflies and moths showed significant declines as increases. In the case of butterflies, the small heath feeds on finer grasses in a short sward in open situations. The wall brown is an open ground species particularly favouring areas where there is plenty of bare ground or sharply defined edges such as path edges and fence lines (Thomas & Lewington 1991). It feeds on a range of grasses amongst which wood false-brome is one of its favourites. In both cases the required habitat is greatly reduced in Monks Wood even though in the case of the wall brown the foodplants are abundant. Instead the grassland in open areas is mostly tall and rank by mid-summer. Generally rather less is known about the precise ecological requirements of moths than butterflies. However it is likely that, as for the small heath and wall brown, current conditions for some grass-feeding moths have become much less suitable.

Lichen and algae feeders – big increases

There have been significant and dramatic increases in six of the eight lichen and algae feeders recorded in the trap in five years or more. This is most likely explained by the improvement in air quality due to government regulations controlling the emissions of certain gases from

industrial processes, most notably a reduction in sulphur dioxide (SO_2). This in turn has benefited the growth of lichens and algae on the bark of trees and shrubs and other surfaces in the wood. From anecdotal observations this certainly appears to be the case. No studies have been carried out on lichens from which changes over time can be examined. However Preston & Walker (this volume) noted a clear increase in epiphytic mosses from 1973 to 2003. Epiphytic mosses are also affected by SO_2 pollution and they concluded that the increase in these mosses was due to lower concentrations of SO_2 in the air.

Herb and woody plant feeders

Species that feed on herbs, and particularly those that feed on both herbs and shrubs as larvae, have also shown rather more declines than increases. Some of these declines have been dramatic especially among the Noctuidae. They include the double dart and the garden dart both of which have declined nationally. The loss of abundance of many herb species probably explains this.

Woody plant feeders

Many woody plant feeders have significantly declined. Crampton and others (1998) compared species frequency and density of trees and shrubs in Monks Wood between surveys of Monks Wood in 1964-66 and 1996. The density of shrub species in the understorey declined by more than half in that period. At least some of these understorey species may be important for some of the woody plant feeders that have declined. However this is certainly not true in all cases. The greatest decline of all species was shown by the dusky thorn, a species that feeds primarily on ash but possibly also privet. Ash is still the dominant tree within the wood and privet is abundant at least in parts of the wood. However results from the Rothamsted Insect Survey suggest that this moth is among those that have declined the most nationally.

The canopy of larger trees has grown higher and the trees themselves grown larger and fewer. It is possible, though it seems unlikely, that as a result tree and shrub feeding moths are flying higher than in the early years of trapping and are therefore not so readily attracted by the trap. The design of the trap prevents light from shining upwards. It shines out only horizontally and downwards. Only those moths flying relatively low down amongst the trees will come directly into the light emitted from the trap.

Birch feeders

Seven of eight birch feeders recorded (in five or more years) have declined, six significantly. A lot of birch in the wood died after the1976 drought (Wells 1994, Crampton and others 1998). Less severe droughts of 1989/90 and 1995/96 exacerbated the situation and caused further deaths. The big decline in the amount of birch, especially mature birch, in the wood is the most likely explanation for the decline in birch feeders.

Bedstraw feeders

Among those species that feed on bedstraws there have been more increases than declines, however as many have significantly declined as have significantly increased. In Steele & Welch (1973) common marsh-bedstraw *Galium palustre* is described as widespread in the wood, hedge bedstraw *Galium mollugo* as scattered along rides and around the edge of the wood and ladies bedstraw *Galium verum* as local in rides. All these species, especially the

former, appear to be appreciably less common in the wood than they were. However cleavers *Galium aparine* is abundant in places including, generally as rather small plants, under the canopy of the woodland. Cleavers has also increased nationally (Preston and others 2003), apparently in response to eutrophication of soils through fertiliser application and atmospheric nitrogen deposition. It seems likely that those bedstraw feeders that have increased are able to exploit the increased cleavers whereas those that have declined are not.

Conclusions

It is possible that the picture of declines is not as bad as it first appears. Local weather during the years 1998-2002 may have been unfavourable for moth trapping (Barry Dickerson *pers. comm.*). 2003 light trap data received since the analysis for this paper was carried out showed that numbers were the highest since 1996. Reanalysis including the 2003 data will affect the overall number of declines versus increases and a few of the declines may simply be reflecting poor weather rather than deleterious changes in habitat. However in many cases it is clear that this is not the case. Results from the Monks Wood butterfly transect confirm the moth data, with numbers in 2003 being the highest since 1996. This was almost certainly due, at least in part, to the beneficial effects of the hot, dry summer. Nationally too the period 1998-2002 was generally poor for butterflies (Greatorex-Davies & Roy 2004).

Data from the nationwide network of light traps has been analysed by staff at Rothamsted and some results made available through public presentations. These results were due to be published late in 2004. Among a list of 10 species which have shown the biggest declines nationally, eight have also declined significantly in the Monks Wood catches. One of the remaining two species, the lead belle (*Scotopteryx luridata*), has never been recorded in Monks Wood and the other, the v-moth (*Macaria wauaria*), was recorded only in 1976. Three of the above eight are also near the top of the decline group in Monks Wood (Table 5). These are dusky thorn, double dart and figure of eight. The ash-feeding dusky thorn is second in the national list and first in the Monks Wood list.

Among those species that have shown the greatest increases nationally only three, the treble brown-spot, the scarce footman and the grey shoulder-knot have shown significant increases in Monks Wood catches. The remaining seven species among Rothamsted's top 10 national increases have occurred in less than five years (the Devon carpet *Lampropteryx otregiata*) does not occur in Monks Wood at all) but in three cases data point to an increase in Monks Wood.

The fact that so many of the Monks Wood changes reflect the national pattern suggest that our changes can be regarded in a wider context, and at least to some extent reflect changes in the wood as a whole not just the compartment where the trap is situated. Much of this will depend upon the mobility of the individual species of moth and where they are actually breeding. Unfortunately in both these cases there is very little information available.

Finally, it has been suggested that one of the reasons for the declines may be that moths have become 'trap-shy' over the years because those that are trapped are killed resulting in greater survival of those that are not attracted to the light. This seems a very unlikely explanation because of the small sample size taken by the Rothamsted trap (Taylor & French 1974) and its relatively small radius of influence. Only a proportion of those initially attracted will end up inside the trap and consequently die, as is evidenced by the number resting on the outside or on adjacent tree trunks. It therefore seems that the tiny selective pressure exerted by taking

such a small sample from mixing populations within the wood is unlikely to affect numbers of moths coming to the light.

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Table 1. Butterflies past and present of Monks Wood. For extinct species, the last year (where known) of record is given in brackets.

19th century records only

Black-veined white (*Aporia crataegi*)
Large blue (*Maculinea arion*)
Small blue (*Cupido minimus*)
Marsh fritillary (*Eurodryas aurinia*)

Pre NNR 20th century extinctions

Duke of Burgundy (*Hamearis lucina*) (1940s)
Small pearl-bordered fritillary (*Boloria selene*) (1939)
Purple emperor (*Apatura iris*) (1941)

Post NNR extinctions

Chequered skipper (*Carterocephalus palaemon*) (1975)
Wood white* (*Leptidea sinapis*) (1923) (1984-88)
Green hairstreak (*Callophrys rubi*) (~1987)
Brown hairstreak (*Thecla betulae*) (mid 1970s)
Silver-washed fritillary** (*Argynnis paphia*) (1970)
Dingy skipper (*Erynnis tages*) (early 1970s)
Large tortoiseshell (*Nymphalis polychloros*) (1962)
Pearl-bordered fritillary (*Boloria euphrosyne*) (1966)
High brown fritillary (*Argynnis adippe*) (1962)
Dark green fritillary (*Argynnis aglaja*) (1955)

Extant

Small skipper (*Thymelicus sylvestris*)
Essex skipper (*Thymelicus lineola*)
Large skipper (*Ochlodes venatus*)
Grizzled skipper (*Pyrgus malvae*)
Clouded yellow (*Coleus croceus*)
Brimstone (*Gonepteryx rhamni*)
Large white (*Pieris brassicae*)
Small white (*Peiris rapae*)
Green-veined white (*Pieris napi*)
Orange tip (*Anthocharis cardamines*)
Purple hairstreak (*Zeonephrus quercus*)
White-letter hairstreak (*Satyrium w-album*)
Black hairstreak (*Satyrium pruni*)
Small copper (*Lycaena phlaeas*)
Brown argus (*Aricia agestis*) (<1960; 1995-)
Common blue (*Polyommatus icarus*)
Holly blue (*Celastrina argiolus*)
White admiral (*Ladoga camilla*) (1st in 1953)
Red admiral (*Vanessa atalanta*)
Painted lady (*Vanessa cardui*)
Small tortoiseshell (*Aglais urticae*)
Peacock (*Inachis io*)
Comma (*Polygonia c-album*)
Speckled wood (*Parage aegaria*)
Wall brown (*Lasiommata megera*)
Marbled white (*Melanargia galathea*) (<1976, 1992-)
Gatekeeper (*Pyronia tithonus*)
Meadow brown (*Maniola jurtina*)
Small heath (*Coenonympha pamphilus*)
Ringlet (*Aphantopus hyperantus*)

*The wood white was reintroduced in 1984 and survived until 1988.

**The silver-washed fritillary has been recorded occasionally since 1970 including on the butterfly transect in 1994, however these are almost certainly released individuals and not part of a local breeding population.

A single example of the monarch (*Danaus plexippus*) was seen in 1958.

Table 2. Macro-moth species listed in Steele & Welch (1973) which have not since been recorded in the RIS light trap or observed in the wood. Species have been divided into probable, possible and unlikely extinctions. National status follows that given in Waring and others (2003). Information on status in Huntingdonshire, VC 31, (Hunts) from Dickerson (2001, 2004).

Comments on distribution refer to Britain or at least southern Britain unless otherwise stated. Status abbreviations: Na: Nationally Scarce A; Nb: Nationally Scarce B; BAP: UK Biodiversity Action Plan species; Occ: Occasional; MW: Monks Wood.

English name	Latin name	National status (where local or more scarce), foodplant(s) (in most cases), status in Monks Wood / Hunts.
Probable extinctions		
Orange-tailed clearwing	*Synanthedon andrenaeformis*	**Nb.** On wayfaring tree & guelder rose. Not recorded in Hunts since 1947.
False mocha	*Cyclophora porata*	**Nb.** On oaks. "First record 1971". Woodwalton Fen 1958.
Smoky wave	*Scopula ternata*	**Local**. One other record: Woodwalton Fen 1968.
Ruddy carpet	*Catorhoe rubidata*	**Nb.** On lady's bedstraw & hedge bedstraw. One recent record in Hunts (1995).
Dark bordered beauty	*Epione vespertaria*	**RDB. UK-BAP.** On low aspen or willow. "First recorded 1970". No other records for Hunts.
Orange moth	*Angerona prunaria*	**Local.** Probably extinct in Hunts.
Sloe carpet	*Aleucis distinctata*	**Nb.** On blackthorn. No other Hunts Records.
Broad-bordered bee hawk-moth	*Hemaris fuciformis*	**Nb.** On honeysuckle. "Last recorded 1949". No other Hunts records.
Wood tiger	*Parasemia plantaginis*	**Local** and declining. No other Hunts records.
Small black arches	*Meganola strigula*	**Na**, declining. On oak. No other Hunts records.
True lover's knot	*Lycophotia porphyrea*	Feeds on heathers. Last Hunts record Woodwalton Fen 1978.
Silvery arches	*Polia hepatica*	**Nb.** Wooded heaths & moors. No other records in Hunts.
Beautiful brocade	*Lacanobia contigua*	**Local.** Rare in Hunts - last county record 1990.
Blossom underwing	*Orthosia miniosa*	**Local.** Extinct as resident in Hunts. Rare immigrant.
Marsh dagger	*Acronicta strigosa*	Former resident. Mainly on hawthorns. Extinct in UK.
Heart moth	*Dicycla oo*	**RDB.** Requires large oaks. Extinct in Hunts.
Bordered sallow	*Pyrrhia umbra*	**Local.** Esp. on restharrows. Rare migrant.
The confused	*Apamea furva*	**Local.** Grasses. Possibly extinct in Hunts (last record 1975).
Possible extinctions		
Flounced chestnut	*Agrochola helvola*	Rare in Hunts eg Woodwalton Fen.
Yellow-legged clearwing	*Synanthedon vespiformis*	**Nb.** In coppiced oak stumps. Possibly still present.
Small eggar	*Eriogaster lanestris*	**Nb**, declined. Scarce but occurs widely in Hunts in hedgerows.
Lappet moth	*Gastropacha quercifolia*	Declined in Hunts & nationally. Last Hunts record 1994..
Poplar kitten	*Furcula bifida*	**Local.** Mainly on poplars. Scarce in Hunts.
Marbled brown	*Drymonia dodonaea*	**Local.** On oak. Occurs mainly in south Hunts.
Early tooth-striped	*Trichopteryx carpinata*	Very rare in Hunts - two recent records 1992 & 1997.

English name	Latin name	National status (where local or more scarce), foodplant(s) (in most cases), status in Monks Wood / Hunts.
Common heath	*Ematurga atomaria*	Day flying but no recent records. Declined in Hunts. Last record Woodwalton Marsh in 1998.
Heart and club	*Agrotis clavis*	Occasional in Hunts.
Light brocade	*Lacanobia w-latinum*	**Local.** Rare in Hunts.
Striped wainscot	*Mythimna pudorina*	**Local.** Coarse grasses. Occurs in Hunts including Woodwalton Fen.
Crescent	*Celaena leucostigma*	Wetland – on yellow iris & great fen sedge. Increasing in Hunts.
Gold spot	*Plusia festucae*	Rare in Hunts. Recorded in 1997 at Woodwalton Fen.
Unlikely extinctions		
Puss moth	*Cerura vinula*	On poplars & willows. Sporadically recorded in Hunts.
Small engrailed	*Ectropis crepuscularia*	Arguably the same species as engrailed which is very common in MW.
Privet hawk-moth	*Sphinx ligustri*	On eg ash and privet Common in Hunts.
Lime hawk-moth	*Mimas tiliae*	On eg elm & birch. Common in Hunts.
Eyed hawk-moth	*Smerinthus ocellatus*	On willows, poplars & apple. Common in Hunts.
Hummingbird hawk-moth	*Macroglossum stellatarum*	**Immigrant.** Mainly on bedstraws. Many records in Hunts in 2003 but not MW.
Small elephant hawk-moth	*Deilephila porcellus*	**Local.** Mainly on bedstraws. Occurs in Hunts commoner in recent years.
Shark	*Cucullia umbratica*	Occurs in Hunts.
Old lady	*Mormo maura*	**Local.** Occurs in Hunts.

Table 3. Butterfly species recorded on the Monks Wood butterfly transect between 1973 and 2003 showing significant trends in abundance. 37 species/broods were tested. Significant changes ordered with the greatest first.

Species	Brood	Suggested causes
Increases		
Speckled wood	All	Increase in shade and coarse grasses especially wood false-brome.
Ringlet	1	Increase in coarse grasses especially wood false-brome.
Large skipper	1	Increases in coarse grasses especially wood false-brome.
Small / Essex skipper	1	Unknown (Essex skipper increases could be attributed to increase in coarse grasses).
Brown argus	2	Recolonisation in line with range expansion due to improved climatic conditions and increased habitat availability.
Peacock	1	Increased overwintering survival due to mild winters.
Purple hairstreak	1	Maturing oaks supporting larger populations.
Comma	All	Ameliorating climatic conditions.
Declines		
Small heath	All	Increased shading of open rides, ranker vegetation, and increase in coarse grasses at the expense of finer grasses in East and West fields.
Brimstone	2	Unknown.
Wall brown	2	Ranker vegetation and loss of bare patches in open areas. Increased shading of rides.
Large white	1	Unknown.
Grizzled skipper	1	Increased shading of rides, ranker vegetation and loss of bare patches in open areas especially in East and West Field.
Orange tip	1	Unknown.
Wall brown	1	Increased shading of rides, ranker vegetation and loss of bare patches in open areas.
Brimstone	1	Unknown.
Peacock	2	Unknown.
Green-veined white	1	Unknown.
Small white	1	Unknown.
White-letter hairstreak	1	Further death of elms in vicinity of the transect route.

Table 4. Macromoth species recorded in the Rothamsted trap not included in Steele & Welch (1973).

Comments on distribution refer to Britain or at least southern Britain unless otherwise stated. Status abbreviations: Na: Nationally Scarce A; Nb: Nationally Scarce B; BAP: UK Biodiversity Action Plan species; Occ: Occasional; MW: Monks Wood.

If no indication of numbers is given, it can be assumed that the moth has been trapped in more than eight years. Many species of Pugs (*Eupithecia* spp. and related genera) are very similar and can be difficult to identify. However Adrian Riley, who identified most of the catches from 1979-2000, is a national expert in this group. Many of the species in this group are common and widespread and have presumably been overlooked in the past.

English name	Latin name	Notes, eg National status, foodplant, habitat, status in Hunts., RIS 277 records (some or all of these, generally in this order).
Orange swift	*Hepialus sylvina*	Common & widespread in grassy places.
Map-winged swift	*Hepialus fusconebulosa*	Often common where bracken occurs. Rare vagrant in Hunts. One in 1978.
Oak eggar	*Lasiocampa quercus*	Widespread. Mainly on shrubs. Rare in Hunts. One female in 1992.
Yellow horned	*Achlya flavicornis*	Frequent in birch woodland.
Grass emerald	*Pseudoterpna pruinata*	Frequent on gorse, broom etc. Very rare in Hunts. One in 2002.
Small emerald	*Hemistola chrysoprasaria*	**Local.** On traveller's-joy, (present in MW), & other *Clematis*. Frequent in Hunts.
Little emerald	*Jodis lactearia*	Woodland. Polyphagus on trees. Scarce in Hunts. Occasional.
Birch mocha	*Cyclophora albipunctata*	**Local.** On birch. Very rare in Hunts. Singletons in 1993 & 1995.
Maiden's blush	*Cyclophora punctaria*	Locally common in oak woodland.
Clay triple-lines	*Cyclophora linearia*	**Local.** Very rare in Hunts. but perhaps established in beech plantation in Bevill's Wood. One in 1983.
Small blood-vein	*Scopula imitaria*	Common where privet grows in open situations.
Lesser cream wave	*Scopula immutata*	**Local** on meadowsweet and common valerian.
Least carpet	*Idaea rusticata*	**Local** & suspected immigrant. Polyphagous. **Big increase nationally.** Two in 1996, one in 2003.
Dwarf cream wave	*Idaea fuscovenosa*	Widely distributed species of bushy places. Increasing.
Small dusty wave	*Idaea seriata*	Widely distributed species of bushy places.
Satin wave	*Idaea subsericeata*	Widespread, but very rare in Hunts. Two in 1985.
Plain wave	*Idaea straminata*	**Local** & uncommon. Very rare in Hunts. One in 1977.
Vestal	*Rhodometra sacraria*	Regular immigrant to the UK esp. the south. Rare in Hunts. Singletons in 1989, 1994 & 1998.
Mallow	*Larentia clavaria*	Common where common mallow grows.
Dark spinach	*Pelurga comitata*	Widespread & locally common on waste ground & weedy places. On orache and goosefoots. Occasional.
Phoenix	*Eulithis prunata*	Most often in gardens & allotments where currants & gooseberry are grown but rarely common. Occasional.
Spinach	*Eulithis mellinata*	Found where currants grow. Occasional.
Red-green carpet	*Chloroclysta siterata*	**Increasing nationally**. Most often in woodland on various deciduous trees. Four years since 1995.

English name	Latin name	Notes, eg National status, foodplant, habitat, status in Hunts., RIS 277 records (some or all of these, generally in this order).
Pine carpet	*Thera firmata*	Where pine grows - as in Bevill's Wood. Very rare in Hunts. One in 1976.
Grey pine carpet	*Thera obeliscata*	Common where conifers grow.
Spruce carpet	*Thera britannica*	Common in spruce plantations as in Bevill's Wood. Recorded five years since 1996.
Juniper carpet	*Thera juniperata*	Juniper including cultivated species. Mostly on calcareous soils. Rare but increasing in Hunts. One in 1989.
May highflyer	*Hydriomena impluviata*	Where alder grows. Occasional.
Small waved umber	*Horisme vitalbata*	Widespread & often common where traveller's-joy grows.
Fern	*Horisme tersata*	Widespread & often common where traveller's-joy grows.
Scarce tissue	*Rheumaptera cervinalis*	**Increasing nationally** especially in urban areas where cultivated *Berberis* are grown. One in 1979.
Tissue	*Triphosa dubitata*	On buckthorn & alder buckthorn. Rare in Hunts. Singletons in 1975, 1980 & 1985.
Brown scallop	*Philereme vetulata*	On buckthorn.
Dark umber	*Philereme transversata*	On buckthorn.
Sharp-angled carpet	*Euphyia unangulata*	Local. On Stitchworts. Very rare in Hunts. One in 1976.
Pale November moth	*Epirrita christyi*	Common in MW. Easily confused with others of the genus.
Autumnal moth	*Epirrita autumnata*	Much less common locally than the previous species.
Barred rivulet	*Perizoma bifaciata*	**Local.** Widespread in Hunts. On red bartsia & eyebright.
Grass rivulet	*Perizoma albulata*	Confined to where yellow rattle grows. Not since 1993.
Twin-spot carpet	*Perizoma didymata*	Common & widespread. Generally less common in the lowlands. Most years to 1996, not since.
Marsh carpet	*Perizoma sagittata*	**Na.** Fenland. On meadow rue. Breeds locally at Woodwalton Fen. One in 1986.
Slender pug	*Eupithecia tenuiata*	Common & widespread on sallow.
Maple pug	*Eupithecia inturbata*	Locally common on field maple.
Haworth's pug	*Eupithecia haworthiata*	Widespread on traveller's-joy & other *Clematis*.
Toadflax pug	*Eupithecia linariata*	Common & widespread. Open disturbed sites. On common toadflax (which does not occur in MW). Occasional.
Foxglove pug	*Eupithecia pulchellata*	Common. Larvae feed on foxgloves - not present in MW. A species of gardens in Hunts. Singletons in 1989 & 1996.
Mottled pug	*Eupithecia exiguata*	Common & widespread species.
Pinion-spotted pug	*Eupithecia insigniata*	**Nb.** Old hedgerows & woodland edges. Rare in Hunts. Occasional.
Freyer's pug	*Eupithecia intricata*	On juniper & other conifers. Much increased esp. in urban areas.
Satyr pug	*Eupithecia satyrata*	Local but widespread. Moors, heaths, fens and downland.
Wormwood pug	*Eupithecia absinthiata*	Common and widespread.
Ling pug	*Eupithecia goossensiata*	Heaths & moors. Now considered to be a form of the wormwood pug. Three in 1980.

English name	Latin name	Notes, eg National status, foodplant, habitat, status in Hunts., RIS 277 records (some or all of these, generally in this order).
Currant pug	*Eupithecia assimilata*	Occurs where currants & wild hop grow - the latter does not occur in MW.
Common pug	*Eupithecia vulgata*	Common & widespread. Occasional.
White-spotted pug	*Eupithecia tripunctaria*	**Local** but widespread. On elder & umbellifers.
Grey pug	*Eupithecia subfuscata*	Common & widespread.
Tawny-speckled pug	*Eupithecia icterata*	Common & widespread. On yarrow & sneezewort.
Shaded pug	*Eupithecia subumbrata*	SE England, local. Scarce in hunts. Occasional.
Plain pug	*Eupithecia simpliciata*	**Local.** Disturbed ground. Scarce in Hunts. Occasional.
Ochreous pug	*Eupithecia indigata*	Common & widespread where pine occurs. Nine in 1980.
Pimpinel pug	*Eupithecia pimpinellata*	Mostly on calcareous soils where burnet-saxifrage occurs. Very few records for Hunts. Two 1983, two in 1992.
Narrow-winged pug	*Eupithecia nanata angusta*	Common on heaths & moors. On heather. Presumed vagrant in MW, most likely from nearby Woodwalton Fen. Occasional.
Ash pug	*Eupithecia fraxinata*	Probably an ash-feeding sub-species of the angle-barred pug (*E. innotata*). Frequent in ash woodland. Occasional.
Golden-rod pug	*Eupithecia virgaureata*	On golden-rod & ragworts. Rare in Hunts. Occasional.
Oak-tree pug	*Eupithecia dodoneata*	Common in woodland with hawthorn.
Juniper pug	*Eupithecia pusillata*	On junipers & some cultivated conifers (eg in gardens). Very few records for Hunts. Singletons in 1979 & 2000, 3 in 1983.
Larch pug	*Eupithecia lariciata*	On larch (none locally). Rarely recorded in Hunts. Occ. (vagrants?).
Dwarf pug	*Eupithecia tantillaria*	On conifers. Common in Bevill's Wood.
Streak	*Chesias legatella*	On broom. Occ. records in Hunts. - but many in 2001 where data suggested possible internal UK migration. Four in 1989, 5 in 1999 & 2001.
Broom-tip	*Chesias rufata*	**Nb.** On broom. Very rare in Hunts. One in 2001.
Lesser treble-bar	*Aplocera efformata*	Common. On St. John's-worts. Very few records for Hunts. - the very similar treble bar (*A. plagiata*) is much more common. Occasional.
Blomer's rivulet	*Discoloxia blomeri*	**Nb.** On Wych Elm. One in 2003 **- new VC record**
Waved carpet	*Hydrelia sylvata*	**Nb. BAP species**. One in 2003 - **1st for Hunts. since VCH.**
Barred tooth-striped	*Trichopteryx polycommata*	**Na. BAP species.** Recorded in 13 years; not since 1997. On scrubby Privet in full sun.
Clouded magpie	*Abraxas sylvata*	On elm. Uncommon in Hunts. Occasional.
Peacock moth	*Macaria notata*	**Local**, **Big increase nationally.** Mainly on birch. Occasional.
Sharp-angled peacock	*Macaria alternata*	**Local.** Very few records for Hunts. Several in each of 3 years.
V-moth	*Macaria wauaria*	**Major decline nationally.** On currants & gooseberry. Two in 1976.
Large thorn	*Ennomos autumnaria*	**Nb.** Some range expansion from SE England. Suspected immigrant. Occ.
August thorn	*Ennomos quercinaria*	**Local** but widesp. On ash. Become much scarcer in trap.

English name	Latin name	Notes, eg National status, foodplant, habitat, status in Hunts., RIS 277 records (some or all of these, generally in this order).
Satin beauty	*Deileptenia ribeata*	**Big increase nationally.** Mainly on conifers. Occasional.
Brussels lace	*Cleorodes lichenaria*	On lichens on branches. Very few records for Hunts. Six in 1980.
Barred red	*Hylaea fasciaria*	Common & widespread. On conifers.
Pine hawk-moth	*Hyloicus pinastri*	Increasing & expanding range. Occurs where pines grow. One in 2002.
Vapourer	*Orgyia antiqua*	Common & widespread. Males often seen flying in the daytime.
Round-winged muslin	*Thumatha senex*	**Local** on mosses & lichens at ground level. Frequently recorded in Hunts. Occasional (including eight in 1983).
Scarce footman	*Eilema complana*	**Increasing nationally.** Local on lichens & algae. Frequent in Hunts. Increasing.
Least black arches	*Nola confusalis*	**Increasing nationally.** On broadleaved trees. Big increase.
White-line dart	*Euxoa tritici*	Mainly coasts & heaths. Singleton in 1984 (presumed vagrant).
Dotted rustic	*Rhyacia simulans*	Once considered rare. Experienced temporary population explosion in the early 1980s. Singletons on four occasions but not since 1990.
Least yellow underwing	*Noctua interjecta*	Common & widespread. Occasional.
Pearly underwing	*Peridroma saucia*	A not uncommon immigrant. Occasional.
Square-spotted clay	*Xestia rhomboidea*	**Nb. BAP species.** One in 1977. Occurs in south Hunts.
Six-striped rustic	*Xestia sexstrigata*	Common & widespread.
Great brocade	*Eurois occulta*	**Nb.** Esp. on bog myrtle. Resident in Scotland, immigrant elsewhere. Occasional.
Green arches	*Anaplectoides prasina*	Common & widespread woodland species.
White-marked	*Cerastis leucographa*	**Local** but widespread. One in 1979.
White colon	*Sideridis albicolon*	**Nb.** Coasts & heaths. Singleton in 1978 (presumed vagrant).
Glaucous shears	*Papestra biren*	Moorland & suspected immigrant. One in 1978.
Broad-barred white	*Hecatera bicolorata*	Disturbed ground including some gardens. One in 1983.
Campion	*Hadena rivularis*	Common & widespread on campions. One in 1980.
Tawny shears	*Hadena perplexa*	Common & widespread on campions. Rare in Hunts. Singletons in 1976 and 1983.
Antler	*Cerapteryx graminis*	Common & widespread in open grassland. Very rarely recorded in Hunts. One in 1978.
Pine beauty	*Panolis flammea*	Common & widespread where pines grow. One in 1980, one on outside of trap 2003.
Flame wainscot	*Mythimna flammea*	**Na.** Fens and marshes on common reed. One in 1975.
Deep-brown dart	*Aporophyla lutulenta*	Common & widespread in southern Britain.
Black rustic	*Aporophyla nigra*	**Local** but increasing in the east. Frequent in Hunts. One in 1977.
Pale pinion	*Lithophane hepatica*	**Local.** Woodland species. Rare in Hunts. Five in 2003.
Grey shoulder-knot	*Lithophane ornitopus*	**Big increase nationally.** On oak. Most years since mid 1980s.

English name	Latin name	Notes, eg National status, foodplant, habitat, status in Hunts., RIS 277 records (some or all of these, generally in this order).
Blair's shoulder-knot	*Lithophane leautieri*	First UK record 1951 now common & widespread mainly on cypress. Singletons in 1990 and 1995.
Yellow-line quaker	*Agrochola macilenta*	Common & widespread. On woody & herbaceous plants.
Pink-barred sallow	*Xanthia togata*	Common & widespread. On sallows, poplars & herbs.
Alder moth	*Acronicta alni*	**Local** woodland species. Singletons in 1975 and 1992.
Bird's wing	*Dypterygia scabriuscula*	**Local** but frequently recorded in Hunts. Mainly woodland. One in 1995 only.
Double kidney	*Ipimorpha retusa*	**Local** in damp woodland fens etc. on sallows & poplars. Very rarely recorded in Hunts. Two in 1995.
Clouded brindle	*Apamea epomidion*	Common & widespread. On grasses.
Slender brindle	*Apamea scolopacina*	Common & widespread on grasses mainly in woodland.
Double lobed	*Apamea ophiogramma*	Common & fairly widespread. Some coarse grasses. Damp habitats. Three in 1996.
Rufous minor	*Oligia versicolor*	**Local.** Frequent in Hunts. & in MW trap.
Rosy minor	*Mesoligia literosa*	Common on coast, widespread elsewhere. Open calcareous habitats. Singletons 1976 & 1984.
Flounced rustic	*Luperina testacea*	Common & widespread. On grasses.
Bulrush wainscot	*Nonagria typhae*	Common & widespread. On reedmaces. Occasional.
Brown-veined wainscot	*Archanara dissoluta*	**Local.** Reedbeds. Frequent in Hunts. One in 1975.
Fen wainscot	*Arenostola phragmitidis*	**Local.** Reedbeds. Frequent in Hunts. Singletons in 5 scattered years.
Small rufous	*Coenobia rufa*	**Local.** Various *Juncus* spp. Very rarely recorded in Hunts. Singletons in 1984 & 2003.
Vine's rustic	*Hoplodrina ambigua*	Common & widespread in southern Britain. Occasional.
Pale mottled willow	*Paradrina clavipalpis*	Common & widespread.
Scarce bordered straw	*Helicoverpa armigera*	Immigrant. One in 1998.
Blackneck	*Lygephila pastinum*	**Local.** Grassland. Mainly on tufted vetch. Becoming less frequent.
Pinion-streaked snout	*Schrankia costaestrigalis*	**Local.** Damp habitats. Occasional.
Dotted fan-foot	*Macrochilo cribrumalis*	**Nb.** Wet habitats mainly in East Anglia & Essex. One in 2003 - occurs at Woodwalton Fen.

Table 5. Macro-moths showing significant increases and declines from the Monks Wood light trap (1974-2002).

Species - English	**Species - Latin**
Increases (greatest first)	
Small wainscot	*Chortodes pygmina*
Water carpet	*Lampropteryx suffumata*
Marbled white-spot	*Protodeltote pygarga*
Four-dotted footman	*Cybosia mesomella*
Straw dot	*Rivula sericealis*
Cinnabar	*Tyria jacobaeae*
Dingy footman	*Eilema griseola*
Small dotted buff	*Photedes minima*
Least black arches	*Nola confusalis*
Pale oak beauty	*Hypomecis punctinalis*
Buff footman	*Eilema depressa*
Brindled white-spot	*Parectropis similaria*
Green carpet	*Colostygia pectinataria*
Drinker	*Euthrix potatoria*
Dwarf cream wave	*Idaea fuscovenosa*
Common wainscot	*Mythimna pallens*
Slender brindle	*Apamea scolopacina*
Common pug	*Eupithecia vulgata*
Blue-bordered carpet	*Plemyria rubiginata*
Scarce footman	*Eilema complana*
Maiden's blush	*Cyclophora punctaria*
Mere wainscot	*Chortodes fluxa*
Grey shoulder-knot	*Lithophane ornitopus*
Yellow-tail	*Euproctis similis*
Broad-bordered yellow underwing	*Noctua fimbriata*
Wormwood pug	*Eupithecia absinthiata*
Rufous minor	*Oligia versicolor*
Spectacle	*Abrostola triplasia*
Lesser cream wave	*Scopula immutata*
Lesser yellow underwing	*Noctua comes*
Large yellow underwing	*Noctua pronuba*
Chestnut	*Conistra vaccinii*
Square-spot rustic	*Xestia xanthographa*
Oak-tree pug	*Eupithecia dodoneata*
Satyr pug	*Eupithecia satyrata*
Green silver-lines	*Pseudoips prasinana*
Slender pug	*Eupithecia tenuiata*
Barred yellow	*Cidaria fulvata*
Broken-barred carpet	*Electrophaes corylata*
Common footman	*Eilema lurideola*

Species - English	**Species - Latin**
Spruce carpet	*Thera britannica*
Barred straw	*Eulithis pyraliata*
Dusky sallow	*Eremobia ochroleuca*
Maple prominent	*Ptilodontella cucullina*
Treble brown-spot	*Idaea trigeminata*
Riband wave	*Idaea aversata*
Freyer's pug	*Eupithecia intricata*
Marbled beauty	*Cryphia domestica*
Declines (greatest first)	
Dusky thorn	*Ennomos fuscantaria*
Common marbled carpet	*Chloroclysta truncata*
Small phoenix	*Ecliptopera silaceata*
Dark marbled carpet	*Chloroclysta citrata*
Ingrailed clay	*Diarsia mendica*
September thorn	*Ennomos erosaria*
Double dart	*Graphiphora augur*
Canary-shouldered thorn	*Ennomos alniaria*
Buff ermine	*Spilosoma luteum*
Scalloped oak	*Crocallis elinguaria*
Oak hook-tip	*Watsonalla binaria*
Green-brindled crescent	*Allophyes oxyacanthae*
Magpie moth	*Abraxas grossulariata*
Beaded chestnut	*Agrochola lychnidis*
Purple clay	*Diarsia brunnea*
Rosy rustic	*Hydraecia micacea*
Peach blossom	*Thyatira batis*
Barred umber	*Plagodis pulveraria*
Figure of eight	*Diloba caeruleocephala*
Scalloped hazel	*Odontopera bidentata*
Smal square-spot	*Diarsia rubi*
Coxcomb prominent	*Ptilodon capucina*
Early thorn	*Selenia dentaria*
Lackey	*Malacosoma neustria*
Lilac beauty	*Apeira syringaria*
Shaded broad-bar	*Scotopteryx chenopodiata*
Willow beauty	*Peribatodes rhomboidaria*
Brimstone moth	*Opisthograptis luteolata*
Garden dart	*Euxoa nigricans*
V pug	*Chloroclystis v-ata*
Chevron	*Eulithis testata*
Swallow prominent	*Pheosia gnoma*
Fan-foot	*Zanclognatha tarsipennalis*
Brown-line bright-eye	*Mythimna conigera*
Brown-spot pinion	*Agrochola litura*

Species - English	**Species - Latin**
White-pinion spotted	*Lomographa bimaculata*
Shoulder-stripe	*Anticlea badiata*
Latticed heath	*Chiasmia clathrata*
Bordered beauty	*Epione repandaria*
Scarce umber	*Agriopis aurantiaria*
Feathered thorn	*Colotois pennaria*
Small emerald	*Hemistola chrysoprasaria*
Scalloped shell	*Rheumaptera undulata*
Sprawler	*Asteroscopus sphinx*
Flounced rustic	*Luperina testacea*
Buff arches	*Habrosyne pyritoides*
Early grey	*Xylocampa areola*
Pretty chalk carpet	*Melanthia procellata*
Streamer	*Anticlea derivata*
Lunar thorn	*Selenia lunularia*
White ermine	*Spilosoma lubricipeda*
Dark-barred twin-spot carpet	*Xanthorhoe ferrugata*
Early moth	*Theria primaria*
Mottled rustic	*Caradrina morpheus*
Purple thorn	*Selenia tetralunaria*
Northern winter moth	*Operophtera fagata*
Frosted green	*Polyploca ridens*
Grey birch	*Aethalura punctulata*
Beautiful hook-tip	*Laspeyria flexula*
Rustic	*Hoplodrina blanda*
Powdered quaker	*Orthosia gracilis*
Poplar hawk	*Laothoe populi*
Dotted border	*Agriopis marginaria*
Swallowtail moth	*Ourapteryx sambucaria*
Sallow	*Xanthia icteritia*
Twin-spot carpet	*Perizoma didymata*
Garden carpet	*Xanthorhoe fluctuata*
Silver Y	*Autographa gamma*
July highflyer	*Hydriomena furcata*
Pale brindled beauty	*Apocheima pilosaria*
Blood-vein	*Timandra comae*
Turnip moth	*Agrotis segetum*
Dark chestnut	*Conistra ligula*
Dark umber	*Philereme transversata*
Tawny marbled minor	*Oligia latruncula*
August thorn	*Ennomos quercinaria*
Fern	*Horisme tersata*
Scorched wing	*Plagodis dolabraria*
Clouded drab	*Orthosia incerta*

Species - English	**Species - Latin**
Heart and dart	*Agrotis exclamationis*
Clay	*Mythimna ferrago*
Small scallop	*Idaea emarginata*
Straw underwing	*Thalpophila matura*
Scalloped hook-tip	*Falcaria lacertinaria*
Purple bar	*Cosmorhoe ocellata*
Centre-barred sallow	*Atethmia centrago*
Blackneck	*Lygephila pastinum*
Red-line quaker	*Agrochola lota*
Hebrew character	*Orthosia gothica*
Mallow	*Larentia clavaria*
Pebble hook-tip	*Drepana falcataria*
Pale prominent	*Pterostoma palpina*
Red chestnut	*Cerastis rubricosa*
Beautiful carpet	*Mesoleuca albicillata*
Minor shoulder-knot	*Brachylomia viminalis*
March moth	*Alsophila aescularia*
Wood carpet	*Epirrhoe rivata*
Rustic shoulder-knot	*Apamea sordens*
Yellow horned	*Achlya flavicornis*
Grey arches	*Polia nebulosa*
Small fan-foot	*Herminia grisealis*
Sandy carpet	*Perizoma flavofasciata*
Grass rivulet	*Perizoma albulata*
Common swift	*Hepialus humuli*
Red twin-spot carpet	*Xanthorhoe montanata*
Small angleshades	*Euplexia lucipara*
December moth	*Poecilocampa populi*
Hedge rustic	*Tholera decimalis*
Scarce silver-lines	*Bena bicolorana*
Feathered gothic	*Tholera cespitis*
Small fan-footed wave	*Idaea biselata*
Dark spinach	*Pelurga comitata*
Gothic	*Naenia typica*

Table 6. Macro-moth species which were recorded in at least five years of the recording period 1974-2002 (315 species) divided by foodplant group showing numbers in each group which have declined or increased when comparing the first and last 10 year periods. Significant declines or increases are determined by linear regression on the log transformed values.

Foodplant group	No spp.	Decline	Signif. Decline	Increase	Signif. Increase	Approx. ratio
Conifers	**7**	1	**-**	6	**2**	**1:6**
Grasses & herbs	**6**	1	**1**	5	**2**	**1:5**
Lichens & mosses	**8**	2	**1**	6	**6**	**1:3**
Elm	**3**	1	-	2	-	**1:2**
Bedstraws	**9**	3	**3**	6	**3**	**1:2**
Oak	**16**	6	**3**	10	**2**	**3:5**
Wetland monocotyledons	**2**	-	-	2	**1**	
Field maple	**4**	2	**-**	2	**1**	**1:1**
Grasses	**31**	16	**8**	15	**9**	**1:1**
Traveller's joy	**5**	3	**3**	2	-	**3:2**
Aspen & poplar	**19**	13	**7**	6	-	**2:1**
Herbs - specialists	**27**	19	**10**	8	**4**	**2:1**
Herbs - generalists	**33**	19	**10**	14	**3**	**4:3**
Herbs & woody	**36**	25	**17**	9	**4**	**3:1**
Rosaceous woody	**14**	10	**-**	3	**2**	**3:1**
Woody - generalists	**68**	53	**27**	15	**8**	**4:1**
Shrubs - specialists	**11**	9	**4**	2	**1**	**5:1**
Ash and/or privet	**8**	7	**3**	1	-	**7:1**
Birch	**8**	7	**6**	1	-	**7:1**
Totals	**315**	197	103	115	48	**2:1**

Monks Wood Coleoptera – an update: 1973-2003

R. Colin Welch
The Mathom House, Hemington, Oundle, Northamptonshire PE8 5QJ

With the splitting up of the Nature Conservancy in 1973 the newly formed Nature Conservancy Council retained ownership of Monks Wood National Nature Reserve whereas the Field Plots, along the southern edge of the wood, and the grounds of the Monks Wood Experimental Station came under the ownership of the new Institute of Terrestrial Ecology. This had serious repercussions on the validity of the records for many species previously included in the formal list for Monks Wood, but which had not been collected within the prescribed reserve boundaries. A re-assessment of the coleopterous fauna was called for. This showed that many of the species I had recorded, since taking up my post as woodland entomologist in January 1965, had been collected either in these Field Plots or around the Station buildings. Some of these had been collected very close to the wood edge while others had doubtless flown out of the reserve. By 1979, 62 such species had been recognized (Welch 1980a). Of these, 10 have since been found within the reserve, but during the ensuing years a further 23 species were recorded from such sites (Welch 1993a). A full list of the 75 species remaining in this category is given in Table 1. Doubt has been cast on several of the older records, particularly those from the 19th and early 20th Century, especially where the foodplant of a particular species no longer occur in the wood. However, given the recent dramatic changes in the wood's herbaceous flora, who can guess what plants may have been present over 100 years ago? Changes in nomenclature, advances in taxonomy, and lack of reference material, makes the interpretation of many early records difficult to interpret and a few have proved impossible to decipher.

In attempting to assess how our knowledge of the beetle fauna of Monks Wood has increased over the last 30 years one would be forgiven for thinking that one simply compares the list in Steele & Welch (1973) with my current faunal list. At the time the Monks Wood book was prepared the total number of Coleoptera known from the reserve was given as 1017 species. Since then I have published Supplements 4-7 to the Coleoptera of Monks Wood (Welch 1975, 1980b, 1993b, 2004b). The current total, at the end of 2003, stands at 1197 species, indicating that 180 species have been added during the last 30 years. However, as I have already explained, a substantial number of species have had to be removed from this list. As new sources of older records continue to be discovered their publication in recent Supplements tends to confuse our interpretation as to when species were recorded from Monks Wood. In an attempt to clarify this I settled on what I considered to be five significant periods in the history of Coleoptera recording in Monks Wood:-

1. 1926 – all records up to and including the Victoria County History (Omer-Cooper 1926);
2. 1959 – to include Buck's (1959) survey of Monks Wood;
3. 1965 – to include my own first year's survey of the reserve (Welch 1968);
4. 1973 – based on my list in the Monks Wood book (Steele & Welch 1973) and my 4th Supplement (Welch 1975);
5. 2003 – based on my latest manuscript list including species recorded in my 5th, 6th and 7th Supplements (Welch 1980b, 1993b & 2004b).

All Coleoptera records for Monks Wood NNR, no matter when they were published, have been allocated to one of these periods and are summarized in Table 2. Running totals for the number of species known for each of the beetle families known from the reserve are listed. From this table it can be seen that by 1973 a total of 1043 species were known from Monks Wood, 26 more than the figure given in Steele & Welch (1973), and 154 species have been recorded for the first time in the last 30 years. It can also be appreciated that the number of Coleoptera species known from Monks Wood has more than quadrupled since its declaration as a National Nature Reserve and has considerably more than doubled in the 40 years since the Nature Conservancy staffed its newly built Experimental Station at Monks Wood with a number of professional entomologists.

Whilst carrying out an inventory of the Coleoptera (and other invertebrates) was considered a priority during my first years at Monks Wood, it soon became apparent that this knowledge needed to be incorporated into plans for the future management of the reserve. Our knowledge of the biology and habitat requirements of our fauna and flora is increasing all the time and management practices change to keep pace with new information. Some aspects of these changes, both natural and man-made, have been discussed in our earlier Symposium (Massey & Welch 1994) and by other contributors to this current one. Publication of Britain's first *Insect Red Data Book* (Shirt 1987) was followed by a *Review of the scarce and threatened Coleoptera of Great Britain* (Hyman 1992,1994) which classified our rarer beetles into Red Data Book and Nationally Notable categories and, perhaps more importantly, summarized current knowledge of the distribution, habitats and status of each. Now it became possible to identify, and categorize, the rarer components of the Monks Wood beetle fauna and 34 species were found to be in one of the RDB categories and are listed in Table 3. A further 9 species of Nationally Notable A and 68 Nationally Notable B are too numerous to list here. By checking the last known date on which each species was recorded it can be seen that two of the Endangered species must be considered extinct in Monks Wood. Their loss is perhaps balanced by the fact that the third RDB 1 species, *Axinotarsus pulicarius* (F.) (Melyridae), was recorded for the first time in 1993 (Welch 2004b), and that *Diaperis boleti* (L.), a large brightly coloured Tenebrionid has colonized all three Fenland National Nature Reserves during a recent unexplained expansion of its range in southern England (Welch 1998,1999). It is reassuring that only four other species are included on the strength of 19th Century records. Of the remaining species only *Hypulus quercinus* (Quens.) (Melandryidae) has not been recorded in the last 50 years.

In recent years a system of attributing 'Rarity Scores' to the RDB and Nationally Notable Coleoptera has been adopted in order to compare faunas of different sites. This has been most successful in assessing the saproxylic fauna of woods and parkland sites (Fowles and others 1999). By using the total number of saproxylic species and their accumulated rarity scores one can calculate a Species Quality Score, and from these a Species Quality Index (SQI; see Table 4). For Monks Wood I have calculated one SQI of 533.9 for all records from the reserve and another, only slightly lower, of 518.1 for records from the last 50 years since this is a period being used in other comparable studies. Fowles and others (1999) provide an appendix listing their calculations for 56 selected British sites in which Monks Wood is placed 19th, based on old data comprising 157 species giving an SQI of 462.0. My new figures place Monks Wood 10th or 12th in their list behind some of Britain's best known wood and parkland sites. Clearly such a list is dynamic and previously poorly studied parkland sites in particular may change position, or be added to the list, as and when more records become available (Denton 2003).

An alternative method of assessing a woodland's beetle fauna was devised by Harding & Rose (1986) in which they categorized species according to their association with ancient woodland. Their Grade 1 species (AWI 1) were those regarded as occurring only in ancient woodland/pasture woodland; Grade 2 (AWI 2) included species which occur mainly, but not exclusively in such sites and Grade 3 (AWI 3) species occurred more widely in wooded land collectively characteristic of ancient woodland. In Table 5 I have listed only those species in the top two categories and summarized the families in which AWI 3 species have been recorded in Monks Wood. In 1987 Alexander (1988) proposed a method of adapting this classification to calculate an Index of Ecological Continuity (IEC) which he later refined (Harding & Alexander 1994). In this latter publication they calculated an IEC for Monks Wood of 53, placing it 13th in a list of "the most important national sites for saproxylic Coleoptera of ancient woodlands". Their calculation was based on 38 species, 5 AWI 1, 5 AWI 2 and 28 AWI 3 species. In Table 6 I have calculated an IEC of 84 for all records, and 72 for those from the last 50 years. Such figures would place Monks Wood 6th or 13th respectively in their site list.

The changes which have occurred in Monks Wood over the years, and more especially the recent dramatic reduction in numbers of herbaceous plants, must have had an effect upon the coleopterous fauna. Some phytophagous species will have become extinct if their host plants are no longer present and the loss of Umbelliferae and other flowers will affect pollen and nectar feeding beetles, including many saproxylic species. During June 2003 I surveyed trees felled during the winter of 2002/03 and recorded four species of saproxylic Coleoptera for the first time in Monks Wood, including *Diplocoelus fagi* Guerin-Meneville, a Nationally Notable B species of the Biphyllidae (Welch 2004a). It would appear that as long as a sufficient supply of dead wood is available in Monks Wood the saproxylic beetle fauna will thrive. For many other species with differing habitat requirements their continued presence within the reserve is more doubtful and the surrounding agricultural land offers few opportunities for recolonization once a species is lost.

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Table 1. Coleoptera recorded from the immediate environs of Monks Wood but not yet recorded from within the nature reserve.

The following list of 75 species have been recorded from the grounds, and within the buildings, of what is now CEH Monks Wood, and from the experimental fields and hedgerows between the southern edge of the wood and the road, but as of December 2003 have not been recorded from within Monks Wood NNR.

Carabidae	**(Staphylinidae contd.)**
Calathus (*s.str.*) *fuscipes* (Goez.)	*Stenus (Parastenus) ossium* Steph.
Amara (*s.str.*) *lucida* (Duft.)	*Philonthus discoideus* (Gr.)
Amara (*s.str.*) *ovata* (F.)	*Philonthus longicornis* Steph.
Microlestes maurus (Stm.)	*Philonthus rectangulus* Shp.
Dytiscidae	*Philonthus sanguinolentus* (Gr.)
Agabus nebulosus (Forst.)	*Bisnius sordidus* (Gr.)
Hydrophilidae	*Quedius (Raphirus) semiaeneus* (Steph.)
Sphaeridium scarabaeoides (L.)	*Quedius (Raphirus) semiobscurus* (Marsh.)
Cercyon quisquilius (L.)	*Leptacinus batychrus* (Gyll.)
Laccobius atrocephalus Reitt.	*Leptacinus intermedius* Donis.
Histeridae	**Geotrupidae**
Carcinops pumilio (Er.)	*Geotrupes stercorarius* (L.)
Hister impressus F.	**Scarabaeidae**
Atholus duodecimstriatus (Schr.)	*Aphodius (Agrilinus) ater* (Deg.)
Ptiliidae	*Aphodius (Calomostema) granaries* (L.)
Acrotrichis sericans (Heer)	**Clambidae**
Leiodidae	*Clambus gibbulus* (LeConte)
Choleva oblonga Lat.	**Cantharidae**
Silphidae	*Rhagonycha lutea* (Müll.)
Nicrophorus investigator Zett.	**Dermestidae**
Scydmaenidae	*Dermestes haemorrhoidalis* Kuest.
Neuraphes elongatulus (M✧ll. & Kunze)	*Dermestes lardarius* L.
Euconnus duboisi Meq.	**Anobiidae**
Staphylinidae	*Stegobium paniceum* (L.)
Lesteva pubescens Man.	**Ptinidae**
Euplectus sanguineus Denny	*Ptinus tectus* Boield.
Oxypoda longipes Muls. & Rey	**Nitidulidae**
Crataraea suturalis (Man.)	*Carpophilus marginellus* Mots.
Pycnota paradoxa (Muls. & Rey)	**Rhizophagidae**
Dochmonota clancula (Er.)	*Monotoma longicollis* Gyll.
Philhygra luridipennis (Man.)	**Silvanidae**
Atheta brunneipennis (Th.)	*Ahasverus advena* (Waltl)
Atheta coriaria (Kr.)	**Coccinellidae**
Atheta harwoodi (Will.)	*Scymnus (Pullus) haemorrhoidalis* Hbst.
Aleochara (Xenochara) lygaea Kr.	**Lathridiidae**
Anotylus insecatus (Gr.)	Cortinicara similata (Gyll.)
Anotylus inustus (Gr.)	Adistemia watsoni Woll.
Ciidae	**Chrysomelidae**
Rhopalodontus perforatus (Gyll.)	*Sermylassa halensis* (L.)
Sulasis bicornis (Mell.)	*Longitarsus jaccobaeae* (Wat.)
Tenebrionidae	*Altica lythri Aube*
Tenebrio molitor L.	*Crepidodera transversa* (Marsh.)

Tenebrio obscurus F.	*Psylloides dulcamare* (Koch.)
Isomira murina (L.)	**Apionidae**
Anthicidae	*Catapion pubescens* (Kirby)
Anthicus formicarius (Goez.)	**Curculionidae**
Cerambycidae	*Gymnetron labile* (Hbst.)
Arhopalus rusticus (L.)	*Mogulones asperifoliarum* (Gyll.)
Anoplodera rubra (L.	*Zacladus exiguus* (Ol.)
Molorochus minor (L.)	*Hypera* (s.str.) *postica* (Gyll.)
	Hypera (Antidonus) zoilus (Scop.)
	Hylastes angustulata (Hbst.)

Table 2. Monks Wood Coleoptera – species per family recorded by date class

Family	Cumulative species totals up to date indicated				
	<1926	**<1959**	**<1965**	**<1973**	**<2003**
Carabidae	19	46	95	97	104
Haliplidae	-	-	3	5	5
Hygrobiidae	-	-	-	1	1
Dytiscidae	1	3	11	23	24
Gyrinidae	-	-	1	1	1
Hydraenidae	-	1	2	8	8
Hydrophilidae	1	7	18	24	24
Helephoridae	1	1	4	7	7
Histeridae	-	2	4	7	7
Ptiliidae	3	3	7	15	20
Leiodidae	6	9	25	39	41
Silphidae	2	4	5	6	8
Scydmaenidae	-	1	2	5	4
Scaphidiidae[1]	-	2	2	2	2
Micropeplidae[1]	-	2	3	4	5
Staphylinidae[1]	46	101	198	288	319
Pselaphidae[1]	-	3	5	11	14
Lucanidae	1	1	1	2	2
Trogidae	-	-	-	-	1
Scarabaeidae	5	6	9	11	15
Clambidae	-	-	1	3	3
Scirtidae	3	3	5	8	9
Byrrhidae	1	1	1	2	2
Heteroceridae	-	-	1	2	2
Buprestidae	3	3	3	4	5
Elateridae	6	14	16	17	18
Throscidae	-	-	-	1	3
Eucnemidae	-	1	1	1	1
Cantharidae	7	15	18	19	24
Lampyridae	1	1	1	1	1
Lycidae	-	-	-	-	1
Dermestidae	3	4	5	6	8
Anobiidae	1	3	4	6	6
Lyctidae	-	-	1	1	1
Cleridae	2	5	5	5	6
Melyridae	3	5	6	6	10
Kateretidae[2]	-	1	2	5	5
Nitidulidae[2]	4	17	24	25	23
Rhizophagidae	3	3	5	5	6
Sphindidae	-	-	-	1	1
Cucujidae	1	1	2	3	4
Silvanidae	-	-	-	1	1
Cryptophagidae	3	8	21	25	29
Biphyllidae	-	-	1	1	2
Byturidae	1	2	2	2	2
Erotylidae	-	-	1	2	4
Phalacridae	-	2	3	3	3
Cerylonidae	-	-	2	2	2

Family	Cumulative species totals up to date indicated				
	<1926	**<1959**	**<1965**	**<1973**	**<2003**
Corylophidae	-	1	2	2	2
Coccinellidae	9	16	17	20	22
Endomychidae	-	-	1	2	4
Lathridiidae	2	7	14	14	19
Ciidae	-	2	7	8	12
Mycetophagidae	1	2	4	7	8
Colydiidae	-	1	1	1	3
Tenebrionidae	1	4	4	5	6
Tetratomidae	-	-	1	1	1
Salpingidae	1	5	5	5	5
Pyrochroidae	1	1	1	1	1
Melandryidae	2	8	8	8	9
Scraptiidae	2	6	7	8	10
Mordellidae	5	6	6	6	8
Rhipiphoridae	-	-	-	1	1
Oedemeridae	3	3	4	4	4
Anthicidae	2	2	3	3	2
Aderidae	-	-	1	1	1
Cerambycidae	17	25	25	25	29
Bruchidae	2	3	4	4	3
Chrysomelidae	24	48	53	58	85
Anthribidae	4	6	6	5	5
Rhynchitidae[3]	7	9	9	11	11
Attelabidae[3]	-	2	2	2	2
Apionidae	13	17	20	27	31
Nanophyidae*	-	-	-	1	1
Erirhinidae*	-	-	-	-	1
Curculionidae*	24	44	48	88	103
Scolytidae	3	4	9	12	15
Total species	**249**	**503**	**789**	**1043**	**1197**

Families marked[1] now all included in Staphylinidae
Families marked[2] now both included in Nitidulidae
Families marked[3] previously both included in Attelabidae
Families marked* previously all included in Curculionidae
Scolytidae now included in Curculionidae

Table 3. Monks Wood NNR – Red Data Book Coleoptera

	Last recorded date
RDB 1	
Onthophagus nutans (F.)	1828
Axinotarsus pulicarius (F.)	1993
Chrysomela tremula F.	1896
RDB 2	
Diaperis boleti (L.)	2003
Hypulus quercinus (Quens.)	1939
Tropideres sepicola (F.)	1962
RDB 3	
Ochthebius pusillus Steph.	1972
Hydrochus carinatus Germ.	1972
Acritus homoepathicus Woll.	1966
Amauronyx maerkeli (Aub—??)	1977
Oxylaemus variolosus (Duf.)	1977
Osphya bipunctata (F.)	2003
Scraptia testacea Allen	1974
Anoplodera sexguttata (F.)	1828
Mesosa nebulosa (F.)	<1890
Neocoenorrhinus pauxillus Germ.	1962
RDB I	
Euplectus nanus (Reich.)	2003
Elodes elongata Tourn.	1993
Cassida nebulosa L.	<1890
RDB K	
Smicrus filicornis (Fairm.)	1966
Acrotrichis pumila (Er.)	1980
Colon appendiculatum (Sahlb.)	1965
Colon viennense Hbst.	1966
Calodera rufescens Kr.	1966
Ilyobates nigricollis (Pk.)	1965
Aloconota subgrandis Brund	1995
Gyrophaena munsteri Strand	2003
Neobisnius procerulus (Gr.)	1956
Heterothops dissimilis (Gr.)	1972
Atomaria morio Kol.	1965
Hippodamia tredecimpunctata (L.)	1831
Mordellistena humeralis (L.)	1998
Mordellistena neuwaldeggiana (Pz.)	2003
Tetrops starkii Chevr.	1993

Table 4. Monks Wood NNR – *saproxylic Coleoptera:* species quality score

(Fowles, Alexander & Key 1999)

category	Number of species	SQS	total SQS
RDB 2	1	32	32
RDB3	6	24	144
RDB I	1	24	24
RDB K	4	16	64
Na	13(10)	16	208(160)
Nb	49(47)	8	392(376)
v. local	29	4	116
local	82(81)	2	164(162)
common	36	1	36
	221 species (215)		1180 Species Quality Score (1114)

Main columns refer to the total number of all species recorded since first record in 1828
Numbers in brackets refer only to those species recorded during last 50 years.

Species Quality Index = $\frac{\text{Species Quality Score}}{\text{Number of species}} \times 100$

SQI for all records = $\frac{1180}{221} \times 100 = 533.9$

SQI for last 50 years = $\frac{1114}{215} \times 100 = 518.1$

Table 5. Monks Wood NNR – Coleoptera - Ancient Woodland Indicators

(Harding & Rose 1986)

AWI 1 (7 species)

Pselaphidae	*Euplectus nanus* (Reich.)	2003
Elateridae	*Ampedus quercicola* (Du Buy.)	2002
Lathridiidae	*Lathridius consilimis* Man.	1965
Melandryidae	*Abdera quadrifasciata* (Curt.)	1937*
Scraptiidae	*Scraptia testacea* Allen	<1974
Mordellidae	*Tomoxia bucephala* Costa	1999
Anthribidae	*Tropideres sepicola* (F.)	1962

AWI 2 (11 species)

Histeridae	*Plegaderus dissectus* Er.	1993
Ptiliidae	*Ptenidium gressneri* Er.	1995
Scirtidae	*Prionocyphon serricornis* M∫??ll.	1972
Buprestidae	*Agrilus pannonicus* (Pill. & Mitt.)	2002
Cucujidae	*Pediacus depressus* (Hbst.)	1965
Biphyllidae	*Diplocoelus fagi* Gu—??r.-M—??n.	2003
Lathridiidae	*Dienerella separanda* (Reit.)	1998
Colydiidae	*Oxylaemus variolosus* (Duf.)	1977
Tenebrionidae	*Pseudocistela ceramboides* (L.)	1956
Melandryidae	*Hypulus quercinus* (Quens.)	1947*
Cerambycidae	*Mesosa nebulosa* (F.)	<1926*

AWI 3 (41 species)

2 Staphylinidae	1 Rhizophagidae	1 Tetratomidae
1 Lucanidae	1 Cucujidae	4 Melandryidae*
1 Elateridae	1 Silvanidae	2 Mordellidae**
1 Eucnemidae	1 Biphyllidae	2 Cerambycidae
1 Lycidae	2 Erotylidae	2 Anthribidae
1 Dermestidae	1 Endomychidae	1 Curculionidae
1 Lyctidae	4 Mycetophagidae*	3 Scolytidae
4 Cleridae	1 Colydiidae	
1 Melyridae*	1 Tenebrionidae	

* indicates where a species has not been recorded for >50 years.

Table 6. Monks Wood Coleoptera – Index of ecological continuity

(Harding & Alexander 1994)

Grade	Number of species	Score	IEC
1	7(6)	x3	21(18)
2	11(9)	x2	22(18)
3	41(36)	x1	41(36)
	59 (51)		**84** (72)

Index of **E**co logical **C**ontinuity

Main columns refer to the total number of species recorded since first record in 1828
Numbers in brackets refer only to those species recorded during last 50 years.

Table 7. Monks Wood NNR – Red Data Book & Nationally Notable Coleoptera

		Last recorded date
RDB 1		
Scarabaeidae	*Onthophagus nutans* (F.)	1828
Melyridae	*Axinotarsus pulicarius* (F.)	1993
Chrysomelidae	*Chrysomela tremula* F.	1896
RDB 2		
Tenebrionidae	*Diaperis boleti* (L.)	2003
Melandryidae	*Hypulus quercinus* (Quens.)	1975
Anthribidae	*Tropideres sepicola* (F.)	1962
RDB 3		
Hydraenidae	*Ochthebius pusillus* Steph.	1972
Hydrophilidae	*Hydrochus carinatus* Germ.	1972
Histeridae	*Acritus homoepathicus* Woll.	1966
Staphylinidae (Pselaphidae)	*Amauronyx maerkeli* (Aubé)	1977
Colydiidae	*Oxylaemus variolosus* (Duf.)	1977
Melandryidae	*Osphya bipunctata* (F.)	2003
Scraptiidae	*Scraptia testacea* Allen	1974
Cerambycidae	*Anoplodera sexguttata* (F.)	1828*
Mesosa nebulosa (F.)		<1890*
Rhynchitidae	*Neocoenorrhinus pauxillus* Germ.	1962
RDB I		
Staphylinidae (Pselaphidae)	*Euplectus nanus* (Reich.)	2003
Scirtidae	*Elodes elongata* Tourn.	1993
Chrysomelidae	*Cassida nebulosa* L.	<1890*
RDB K		
Ptiliidae	*Smicrus filicornis* (Fairm.)	1966
	Acrotrichis pumila (Er.)	1980
Leiodidae	*Colon appendiculatum* (Sahlb.)	1965
	Colon viennense Hbst.	1966
Staphylinidae	*Calodera rufescens* Kr.	1966
	Ilyobates nigricollis (Pk.)	1966
	Aloconota subgrandis Brund.	1995
	Gyrophaena munsteri Strand	2003
	Neobisnius procerulus (Gr.)	1956
	Heterothops dissimilis (Gr.)	1972
Cryptophagidae	*Atomaria morio* Kol.	1973
Coccinellidae	*Hippodamia tredecimpunctata* (L.)	1831*
Mordellidae	*Mordellistena humeralis* (L.)	1998
	Mordellistena neuwaldeggiana (Pz.)	2003
Cerambycidae	*Tetrops starkii* Chevr.	1993
RDB Appendix (extinct)		
Rhynchitidae	*Rhynchites bacchus* (L.)	1865
Na		
Carabidae	*Acupalpus flavicollis* (Sturm)	1965
Histeridae	*Abraeus globosus* (Hoff.)	1966
Scarabaeidae	*Onthophagus nuchicornis* (L.)	1831*
Buprestidae	*Agrilus pannonicus* (Pill.& Mitt.)	2002
	Trachys scobriculatus Kies.	1965
Melyridae	*Aplocnemus nigricornis* (F.)	1922 †
	Cerapheles terminatus (Mén.)	<1890*
Cucujidae	*Pediacus depressus* (Hbst.)	1965
Colydiidae	*Aulonium trisulcum* (Fourc.)	1978

		Last recorded date
Tenebrionidae	*Mycetochara humeralis* (F.)	1993
Melandryidae	*Anisoxya fuscula* (Ill.)	1937 †
	Abdera quadrifasciata (Curt.)	1937 †
Scraptiidae	*Anaspis thoracica* (L.)	2002
Mordellidae	*Tomoxia bucephala* Costa	1998
Cerambycidae	*Grammoptera abdominalis* (Steph.)	2003
	Molorchus umbellatarum (von Schr.)	1993
	Saperda carcharias (L.)	1939 †
Chrysomelidae	*Longitarsus curtus* (Allard)	1965
	Longitarsus parvulus (Pk.)	1994
	Altica brevicollis Foud.	2003
	Pilostoma fastuosa (Schal.)	1935 †
Anthribidae	*Anthribus fasciatus* (Forst.)	1865*
Curculionidae	*Hypera (Darpalinus) meles* (F.)	1831*
	Magdalis (Odontomagdalis) barbicornis (Latr.)	1999
Nb		
Carabidae	*Bembidion (Peryphus) lunatum* (Duft.)	1956
	Bembidion (Peryphus) saxatile Gyll.	1955
	Pterostichus (Pedius) longicollis (Duft.)	1965
	Pterostichus (Pseudomaseus) anthracinus Ill.	1956
	Agonum (Batenus) livens (Gyll.)	1980
	Badister (s.str.) unipustulatus Bon.	1999
	Chlaenius nigricornis (F.)	1956
	Lebia (Lamprias) chlorocephala (Hoff.)	1966
	Brachinus crepitans (L.)	1965
Haliplidae	*Haliplus heydeni* Wehncke	1965
Dytiscidae	*Agabus chalconatus* (Pz.)	1965
	Rhantus grapii (Gyll.)	1965
Hydraenidae	*Ochthebius bicolon* Germ.	1966
	Hydraena nigrita Germ.	1972
Hydrophilidae	*Cercyon convexiusculus* Steph.	1970
	Cercyon tristis (Ill.)	1970
	Cercyon ustulatus (Preys)	1970
	Enochrus melanocephalus (Ol.)	1965
	Enochrus quadripunctatus (Hbst.)	1831*
Helephoridae	*Helophorus dorsalis* (Marsh.)	1994
	Helophorus nanus Sturm.	?1968
Histeridae	*Plegaderus dissectus* Er.	2003
Ptiliidae	*Nossidium pilosellum* (Marsh.)	1995
	Ptenidium (Gressnerium) gressneri Er.	1995
	Ptinella denticollis (Fairm.)	1967
Leiodidae	*Agathidium (Neoceble) marginatum* Sturm.	<1928 †
Silphidae	*Dendroxena quadrimaculata* (Scop.)	1998
Scydmaenidae	*Scydmoraphes helvolus* Schaum	1966
Staphylinidae (Pselaphidae)	*Euplectus bonvouloiri* Reitt.	1995
Staphylinidae	*Sepedophilus bipunctatus* (Gr.)	1993
	Sepedophilus pedicularius (Gr.)	1966
	Sepedophilus testaceus (F.)	2003
	Myllaena elongata (Matth.)	1967
	Oxypoda spectabilis Maerk.	1965
	Calodera riparia Er.	1980
	Phloeopora corticalis (Gr.)	1968
	Gnypeta ripicola (Kies.)	1970

		Last recorded date
	Alaobia scapularis (Baudi)	1966
	Philhygra hygrobia (Th.)	1970
	Atheta basicornis (Muls.& Rey)	1969
	Alevonota rufotestacea (Kr.)	1976
	Aleochara (Xenochara) kamila Lik.	1972
	Aleochara (Xenochara) stichai Lik.	1976
	Aleochara (Ceronota) ruficornis Gr.	1993
	Gyrophaena angustata (Steph.)	2003
	Gyrophaena joyi Wend.	1966
	Gyrophaena joyioides Wust.	1975
	Gyrophaena strictula Er.	<1928 †
	Leptusa norvegica Strand	1978
Staphylinidae (Scaphidiidae)	*Scaphisoma boleti* (Pz.)	1990
Staphylinidae	*Platystethus (Craetopycrus) nodifrons* Man.	1980
	Stenus (Parastenus) fuscicornis Er.	1994
	Sunius melanocephalus (F.)	<1928 †
	Achenium humile (Nic.)	1897*
	Platydracus latebricola (Gr.)	1940 †
	Quedius (Microsaurus) brevicornis (Th.)	1973
	Quedius (Microsaurus) microps (Gr.)	1965
Scirtidae	*Prionocyphon serricornis* (Muell.)	1972
Buprestidae	*Agrilus angustulatus* (Ill.)	1993
	Agrilus laticornis (Ill.)	2002
Elateridae	*Calambus bipustulatus* (L.)	1865*
	Ampedus quercicola (Du Buys)	2002
Eucnemidae	*Melasis buprestoides* (L.)	1956
Cantharidae	*Silis ruficollis* (F.)	1940 †
	Malthinus balteatus Suff.	1956
	Malthinus frontalis (Marsh.)	1999
	Malthodes guttifer Kies.	1999
Lycidae	*Platycis minutus* (F.)	2002
Dermestidae	*Megatoma undata* (L.)	1956
	Ctesias serra (F.)	<1974
Anobiidae	*Ptinomorphus imperialis* (L.)	1956
Cleridae	*Tillus elongatus* (L.)	1999
	Opilio mollis (L.)	1956
	Korynetes caeruleus (Deg.)	1956
Melyridae	*Malachius marginellus* (Ol.)	<1958
Rhizophagidae	*Rhizophagus nitidulus* (F.)	1965
Cryptophagidae	*Cryptophagus ruficornis* Steph.	1993
	Atomaria (s.str.) strandi Johnson	1965
	Atomaria (s.str.) umbrina (Gyll.)	1970
Biphyllidae	*Dipocoelus fagi* Guér.-Mén.	2003
Coccinellidae	*Scymnus (S.str.) femoralis* (Gyll.)	1959
	Hippodamia tredecimpunctata (L.)	1831*
Endomychidae	*Symbiotes latus* Redt.	1998
Lathridiidae	*Lathridius consimilis* Man.	1965
Colydiidae	*Synchita humeralis* (F.)	2003
Tenebrionidae	*Pseudocistela ceramboides*	1956
Salpingidae	*Lissodema quadripustulata* (Marsh.)	2003
Melandryidae	*Orchesia micans* (Pz.)	2003
	Orchesia minor Walk.	1993
	Melandrya caraboides (L.)	1998

		Last recorded date
	Conopalpus testaceus (Ol.)	1999
Mordellidae	*Variimoda villosa* (Schr.)	?1829*
Aderidae	*Aderus populneus* (Creutz)	1965
Cerambycidae	*Aromia moschata* (L.)	1998
	Phymatodes alni (L.)	1998
	Phytoecia cylindrica (L.)	1941 †
Bruchidae	*Bruchus atomarius* (L.)	<1928 †
Chrysomelidae	*Cryptocephalus aureolus* Suff.	<1958
	Cryptocephalus bipunctatus (L.)	<1958
	Cryptocephalus moraei (L.)	1993
	Chrysolina violacea (Muell.)	1965
	Gonioctema decemnotata (Marsh.)	1956
	Longitarsus dorsalis (F.)	1999
	Batophila aerata Duft.	1965
	Chalcoides nitidula (L.)	1831*
	Podagrica fuscicornis (L.)	1950
	Mantura rustica (L.)	1939 †
	Cassida nobilis L.	1831*
	Cassida prassina Ill.	1935 †
Anthribidae	*Anthribus nebulosus* (Forst.)	1865*
	Platyrhinus resinosus (Scop.)	1973
	Platysomos albinus (L.)	1955
Rhynchitidae	*Lasiorhynchites (s.str.) cavifrons* (Gyll.)	1998
	Neocoenorrhinus interpunctatus Steph.	1994
	Byctiscus betulae (L.)	1994
Curculionidae	*Archarius villosus* F.	1998
	Curculio rubidus (Gyll.)	1966
	Anthonumus (s.str.) ulmi (Deg.)	1973
	Dorytomus salicinus (Gyll.)	1970
	Gymnetron veronicae (Germ.)	1831*
	Pseudorchestes pratensis (Germ.)	<1958
	Orthochaetes setiger (Beck.)	1966
	Coeliodes ruber (Marsh.)	2002
	Coeliodes transversalbofasciatus (Goez.)	1962
	Acalles ptinoides (Marsh.)	1965
	Acalles roboris Curt.	2002
	Polydrusus (Eustolus) flavipes (Deg.)	1998
	Tanymecus palliatus (F.)	<1928 †
	Magdalis (Neopanus) cerasi (L.)	1998
Curculionidae (Scolytidae)	*Kissophagus hederae* (Schmidt)	1999
	Xyleborus dispar (F.)	1998

Note: † Denotes records from the period 1900-1950
* Denotes records prior to 1900

Rare plants in Monks Wood NNR 1993-2003

Dave Hughes
English Nature, Bedfordshire and Cambridgeshire Team, Ham Lane House, Ham Lane, Peterborough PE2 5UR

Introduction

My experience of the flora of Monks Wood began in 1997 when I took up the position of assistant site manager responsible for the day to day running of the reserve.

This article covers the status of some of the rarer species occurring within the wood and the factors which may influence them. Whilst every effort has been made to ensure the following data is as comprehensive as possible, the present status of a number of the rarest species is not known and for this reason these species have been omitted.

Factors that may influence the flora

There has been concern over the years about the decline of flowering plants in the reserve and various reasons for this decline have been suggested, including deer, management, and diffuse pollution (Massey & Welch 1994). For some species the situation has improved somewhat in recent years. This may be partly due to changes in management, and also increased rainfall; species such as crested cow-wheat and violet helleborine *Epipactis helleborine* seem to have been noticeably scarcer during the drier years of the mid-1990's. Average rainfall for the five year period 1993 to 1997 was 554 mm (Figure 1) - a period when rare plant populations, in particular orchid species, declined. Average rainfall in the following five year period 1998 to 2002 increased to 676 mm, and rare plant species also increased during this period. Wells (1994) also noted a correlation between rainfall and plant populations, suggesting that "orchids seem particularly vulnerable to drought".

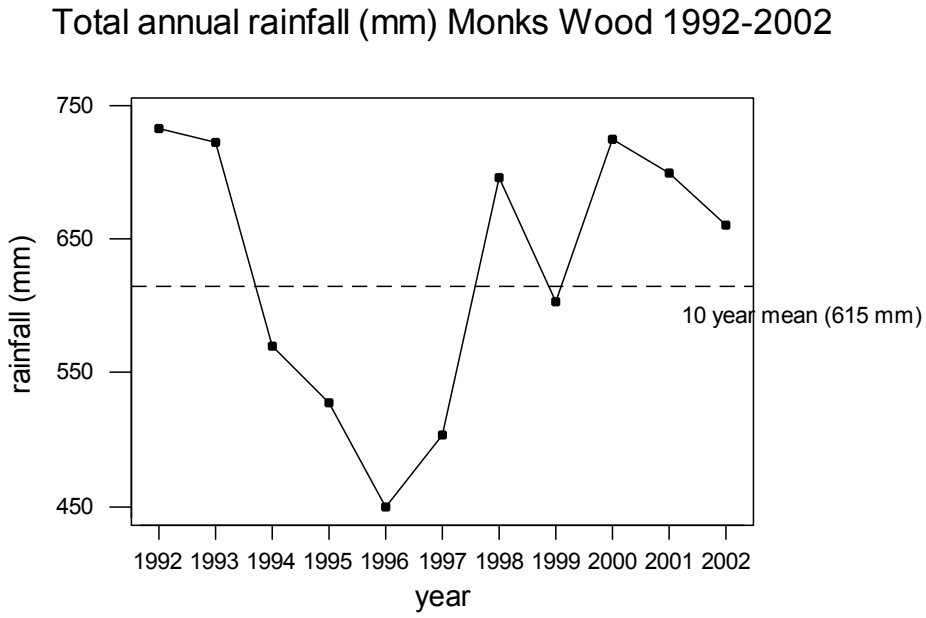

Figure 1.

Since the control of Muntjac deer *Muntiacus reevesi* began in Monks Wood in 1999, species such as Bluebell *Hyacinthoides non-scripta*, Primrose *Primula vulgaris* and, in some areas, Wood Anemone *Anemone nemorosa* have become noticeably more abundant. The effect that this reduction in deer numbers may have on the rarer species is as yet unknown.

Along the main rides where they have been widened, and the 'cut and remove' management regime has been brought back to a annual rotation, the grass sward is becoming noticeably less dominant and more flowering herbs are beginning to appear. It may be that we begin to see some of the rarer species that used to occur along these rides reappearing.

Monitoring

Each year scarce or interesting plant species are counted; a summary of these species counts is given below.

Crested cow-wheat *Melampyrum cristatum*

This is the only species for which specific management is carried out. It grows in one small area on the southern edge of the reserve, the vegetation in this area is cut and removed once a year. Available information on this species suggests the seed needs to be subjected to cold and light to stimulate germination. Because of demands on staff time, management had not been carried out until February or March, this would result in the seed being covered in a mat of dead vegetation for most of the winter depriving it of light and insulating it from cold, this may have been a contributing factor in the decline in numbers up to 1997. Since then management has been carried out in October/November and numbers have steadily increased, although I have no proof that management is directly responsible for this increase.

Annual counts	Number of plants
1993	11
1994	19
1995	17
1996	14
1997	4
1998	22
1999	24
2000	61
2001	82
2002	182
2003	300 plus (plants too numerous and tangled to count)

Water purslane *Lythrum portula*

This species had not been recorded between 1993 and 2000 when it was found in water filled wheel ruts in the large glade off main ride, a previously known site. It was also found in two water filled, shallow scrapes that had been created in the west field, a new location where it thrived until the scrapes dried out in late summer. This species has since been recorded annually from both areas.

Violet helleborine *Epipactis purpurata*

Although not proven, this species appears to respond to fluctuations in rainfall. Wire cages are still used to protect plants from being grazed by deer and rabbits. The counts given below represent whole plants and not the number of flowering stems.

Year	Number of plants
1993	3
1994	1
1995	0
1996	0
1997	0
1998	0
1999	0
2000	0
2001	20
2002	31
2003	11

Southern marsh-orchid (Dactylorhiza praetermissa)

This species was recorded along main ride from 1964 to 1970, but not since. Its' only known location at present is the east field. Research suggests that populations of this species fluctuate greatly and, again, rainfall would appear to be a major factor.

Year	Number of flower spikes
1993	2
1994	0
1995	0
1996	0
1997	0
1998	0
1999	0
2000	0
2001	0
2002	9
2003	species present but not counted

Southern marsh-orchid x Common spotted orchid *Dactylorhiza* x *grandis* (*D. praetermissa* x *D. fuchsii*)

In 2002 Maurice Massey recorded 55 flowering spikes of this species amongst *D. praetermissa* plants in the east field. He confirmed it to be a new species for the reserve and only the second site in the county for this species. Flowering spikes were found in 2003 but not counted.

Early marsh-orchid *Dactylorhiza incarnata*

Recorded in the small glade off main ride in 1985. There had been no other sightings until 2003 where I found one flowering spike in the same location and Maurice Massey later found two flowering spikes.

Bird's-nest orchid *Neottia nidus-avis*

Last recorded in 1984 and known from several locations on the reserve. This species may still occur as it is easily overlooked and time has not allowed for intensive searching. There also remains the possibility that plants are being eaten by deer.

Greater butterfly-orchid *Plantanthera chlorantha*

One or two flowering spikes have been found every year since 1997 but only on main ride and hotel ride.

Pyramidal orchid *Anacamptis pyramidalis*

Has been recorded in the east field but not seen since the 1970s.

Small teasel *Dipsacus pilosus*

Despite disturbance taking place this species has not been recorded since 1992. It may be worth disturbing the soil making up the main dam wall of the ponds, where it was last recorded, to see if this triggers a response.

Sedges

Two sedges of interest, pale sedge (*Carex pallescens*) and oval sedge (*Carex ovalis*) are still abundant and widespread in the east field and to a lesser extent along hotel ride.

Ferns and mosses

Very little is known about the current status of species within these groups, the following information was kindly submitted by Kevin Walker. The following species have been recorded over the last few years:

Athyrium felix-femina	=	Southedge Ride
Dryopteris flix-mas	=	scattered locations
Phyllitis scolopendrum	=	Owl Ride ditch
Ophioglossum vulgatum	=	Southedge and Main Rides and East Field
Polypodium interjectum	=	near the Ewingswode stream – year not known

There are no known recent records for the following:

Dryopteris carthusiana
D. dilatata
D. affinis ssp. *borerri*

Platygyrium repens

Kevin Walker and Chris Preston have recently been carrying out random sampling of mosses within the wood, they have reported that this species is becoming much more abundant and widespread, brought about by a drop in sulphur dioxide in the atmosphere.

New species

As far as known, four new species have been found in the wood since 1993. These are:

Potamogeton pusillus (lesser pondweed). M. Massey – East Field Pond 2001
Phragmites australis (common reed). Pond in cpt. 57 – M. Massey 2000.
Carex elata (tufted sedge). M. Massey – Pond in cpt 57 2001
Dactylorhiza x *grandis* (southern marsh-orchid x common spotted orchid, (*D. praetermissa* x *D. fuchsii*) M. Massey – East Field 2001

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Ferns and flowering plants

Kevin J. Walker

NERC Centre for Ecology and Hydrology, Monks Wood, Abbots Ripton, Huntingdon, Cambridgeshire PE28 2LS

This list is a revision of Steele's (1973) annotated checklist of the ferns and flowering plants of Monks Wood NNR and has been compiled from Nature Conservancy (NC) record cards, Wells (1993, 2003), botanical reports of the Huntingdonshire Fauna and Flora Society (HFFS) and papers therein, herbarium material as well as casual observations from staff of the Centre for Ecology and Hydrology (CEH; formerly Institute of Terrestrial Ecology).

Revisions to the 1973 list

Steele's (1973) list covers the wood itself as well as the experimental grounds, fields, roadsides, hedgerows and lanes, which occur immediately outside the perimeter of the NNR. As a result the '1973 list' includes a number of species which have only been recorded outside the wood, or are very likely (on ecological grounds) to have been found there. These excluded taxa are included after the main list below.

Surveys of the flowering plants and ferns since 1973

Although there have been no detailed surveys of the flowering plants and ferns of Monks Wood since 1973, numerous records have been made by NC/NCC (latterly English Nature) and CEH staff. From 1960 to 1990 wardening staff (D.O. Elias, M.E. Maurice Massey, J.A. Woodward) collated information on the distribution of scarcer species on Reserve Record Cards. Observations by research staff from the experimental station have also provided many interesting records some of which were reported in botanical reports (Wells 1979-2003) or papers in HFFS annual reports (eg Croft 1994, 1995, 1996). In 1991 and 1992 Chris Preston and Jane Croft carried out a survey of the roses of the wood, following a brief visit by Tony Primavesi (Preston & Croft 1992), and more latterly student projects have contributed records for a number of scarce species such as false oxlip *Primula veris* × *vulgaris*, early-purple orchid *Orchis mascula* and spurge laurel *Daphne laureola* (Gaasbeek and others 1999). Since 1998 the flora of the Monks Wood Wilderness, a former arable field adjacent to the research station, has been surveyed as part of a larger study of woodland succession on the site (see Walker this volume).

Scope of the new list

All species known from Monks Wood NNR and from the adjacent Wilderness are included in the list below. For species not listed by Steele (1973), and therefore first recorded after 1973, brief details of the habitat and the recorder and date of first record are provided. Species which have not been recorded since 1973 are noted, and the date of the last record given (as 'MWRR 1973' if no further details are available). First records noted by Wells (1993) but with no further details are recorded as 'MWS, 1993'. It will be seen from the list that many species have not been reliably recorded since 1973 and it is hoped that this list will provide a stimulus for further recording in the wood and the production of a more definitive checklist in the near future.

Recorders names and sources are abbreviated as follows: **ABRN**, herbarium of the experimental station, Monks Wood; AF, A. Fryer; BD, B. Ducker; CDP, C.D. Preston; DOE, D.O. Elias; JAM, J.A. Marriott; JAT, J.A. Thompson; JAW, J.A. Woodward; JFA, J.F. Archibald; JGD, J.G. Dony; JLG, J.L. Gilbert; JLR, J.L. Radford; JMC, J.M. Croft; KJW, K.J. Walker; MEM, M.E. Massey; MW, M. Way; MWRR, Monks Wood Reserve Record; MWS, Monks Wood symposium (Wells 1993); NCR, Nature Conservancy record; PDS, P.D. Sell; PP, P. Pitkin; PMN, P.M. Nathan; RP, R. Parslow; SH, S. Hodkins; SMW, S.M. Walters; TCEW, T.C.E. Wells; TEP, T.E. Patson; VCH, Victoria County History (Druce 1926).

Species known to occur in the Wilderness, around the experimental buildings or in surrounding fields and hedgerows (including road verges) are denoted by 'W', 'E', 'F' and 'H' respectively. Species denoted with an asterisk '*' are assumed to have been introduced to the wood or only occur as casuals.

Nomenclature follows Stace (1997). If the name in Steele's list differs, the earlier name is given as a synonym.

Ferns

Athyrium felix-femina Edges of rides. First record: JAW, 1980.
Dryopteris affinis subsp. ***borreri*** (*Dryopteris borreri*) A single record: JLR, 1961 (**ABRN**).
Dryopteris carthusiana Last record: MWRR, 1973.
Dryopteris dilatata Last record: MWRR, 1973.
Dryopteris filix-mas (W)
Ophioglossum vulgatum (W)
Phyllitis scolopendrum Ditch adjacent to Owl Ride. First record: KJW, 2002.
Polypodium interjectum On field maple in compartment 27. First record: CDP, 1995 (Croft 1995).

Flowering plants

Acer campestre (W)
Acer pseudoplatanus* First record: MWS, 1993.
Achillea millefolium
Aegopodium podagraria A single record: JAM, 1960s.
Aesculus hippocastanum* Last record: JAW, 1978.
Agrimonia eupatoria
Agrimonia odorata
Agrostis canina
Agrostis capillaris (*Agrostis tenuis*)
Agrostis gigantea First record: MWS, 1993.
Agrostis stolonifera
Ajuga reptans
Alisma plantago-aquatica Last record: JAW, 1979.
Alnus glutinosa Last record: NCR, 1965-69.
Alopecurus geniculatus Last record: MWS, 1993.
Alopecurus myosuroides A single record: SMW, pre-1973.
Alopecurus pratensis

Anacamptis pyramidalis Last record: JAM, 1969.
Anagallis arvensis (E) Last record: MWRR, 1973 (**ABRN**).
Anemone nemorosa
Angelica sylvestris Last record: DOE, 1973.
Anisantha sterilis (W) Last record: MWRR, 1973.
Anthoxanthum odoratum (F)
Anthriscus sylvestris (W)
Arctium lappa Last record: MWRR, 1973.
Arctium minus (W)
Arctium nemorosum (*Arctium minus* subsp. *nemorosum*) Last record: MWRR, 1973.
Arrhenatherum elatius (W)
Artemisia vulgaris Last record: JAM, pre-1973.
Arum maculatum (W)
Asparagus officinalis* A single record: DOE, 1972.
Atriplex patula A single record: JGD, pre-1973.
Avena fatua A single record: JFA, 1954-56.
Barbarea vulgaris
Bellis perennis (W)
Betula pendula
Betula pubescens (W)
Blackstonia perfoliata Last record: JAM, 1969.
Brachypodium pinnatum (W)
Brachypodium sylvaticum (W)
Briza media Last record: MWRR, 1973.
Bromopsis erecta (*Zerna erecta*)
Bromopsis ramosa (*Zerna ramosa*)
Bryonia dioica
Calamagrostis canescens
Calamagrostis epigejos (W)
Callitriche obtusangula In pond 74, compartment 21. First record: JMC, 1990.
Callitriche stagnalis
Calystegia sepium Not recorded in Steele (1973) but there is a specimen in **ABRN** from 1965, PMN.
Campanula trachelium A single record: JAM, 1966.
Capsella bursa-pastoris
Cardamine pratensis
Carduus crispus (*Carduus acanthoides*) Last record: MWRR, 1973.
Carex caryophyllea North end of East Field. First record: MEM, 1980.
Carex divulsa First record: MWS, 1993.
Carex elata Pond 81/cpt 57. First record: MEM, 2002
Carex flacca (W)
Carex hirta
Carex otrubae (W)
Carex ovalis
Carex pallescens
Carex panicea A single record: NCR, 1965-69.
Carex pendula (W)
Carex pilulifera A single record: MWRR, 1973.
Carex pseudocyperus Last record: JAW, 1983.
Carex remota (W)

Carex riparia
Carex spicata A single record: PDS, 1967.
Carex sylvatica (W)
Carex viridula subsp. ***oedocarpa*** East side of glade in cpt 4e. First record: KJW, 2004.
Carpinus betulus* (H)
Catapodium rigidum (E) A single record: JLG, 1959.
Centaurea nigra (W)
Centaurium erythraea (W)
Centaurium pulchellum Last record: recorder unknown, 1987 (**ABRN**).
Cerastium fontanum (*Cerastium holosteoides*) (W)
Cerastium glomeratum (E)
Chamerion angustifolium (*Chamaenerion angustifolium*) Last record: MWRR, 1973.
Chenopodium album Last record: DOE, 1973.
Chenopodium polyspermum Last record: DOE, 1975.
Chenopodium rubrum Last record: MWRR, 1973.
Circaea lutetiana
Cirsium acaule (*Cirsium acaulon*) Last record: MWRR, 1973.
Cirsium arvense (W)
Cirsium palustre
Cirsium vulgare (W)
Clematis vitalba (W)
Conium maculatum Last record: MWRR, 1973.
Conopodium majus Last record: MWRR, 1973.
Convolvulus arvensis Last record: DOE, 1973.
Cornus sanguinea (W)
Coronopus squamatus* Last record: DOE, 1975.
Corylus avellana (W)
Crataegus laevigata (*Crataegus oxycanthoides*) (W)
Crataegus monogyna (W)
Crataegus* × *media* = *C. laevigata* × *C. monogyna (*C. monogyna* × *C. oxycanthoides*)
Crepis capillaris (W) Last record: MWRR, 1973.
Cynoglossum officinale A single record: JAM, 1967.
Cynosurus cristatus
Dactylis glomerata (W)
Dactylorhiza fuchsii (W)
Dactylorhiza incarnata
Dactylorhiza praetermissa
Dactylorhiza* ×*grandis* = *D. fuchsii* × *D. praetermissa 50 plants in East Field. First record: MEM, 2002.
Daphne laureola
Daucus carota (W) Last record: MWRR, 1973.
Deschampsia caespitosa (W)
Digitalis purpurea A single record: JGD, 1950.
Dipsacus fullonum (*Dipsacus fullonum* ssp. *fullonum*) (W)
Dipsacus pilosus
Echium vulgare Last record: NCR, 1960-64.
Eleocharis palustris Last record: NCR, 1965-69.
Elymus caninus (*Agropyron caninum*)
Elytrigia repens First record: MWS, 1993.
Epilobium ciliatum* (*Epilobium adenocaulon*) Last record: MWRR, 1973 (**ABRN**).

Epilobium hirsutum (W)
Epilobium montanum (E) Last record: MWRR, 1973 (**ABRN**).
Epilobium obscurum (E) Last record: PDS, 1967.
Epilobium palustre Last record: PDS, 1967.
Epilobium parviflorum (E) Last record: MWRR, 1973.
Epilobium roseum Edge of Westhouse Ride (TL194795). A single record: RP & SH, 1979.
Epilobium tetragonum (W)
Epipactis helleborine Last record: MWRR, 1993.
Epipactis purpurata
Erigeron acer A single record: JAT, 1961.
Euonymus europaeus (W)
Eupatorium cannabinum
Euphorbia amygdaloides A single record: MWRR, 1973.
Euphorbia lathyrus* (E) Last record: MWRR, 1967.
Euphrasia nemorosa (E) Last record: MWRR, 1973.
Fallopia convolvulus (*Polygonum convolvulus*) Last record: DOE, 1973 (**ABRN**).
Festuca arundinacea
Festuca gigantea (W)
Festuca pratensis
Festuca rubra
Filipendula ulmaria (W)
Fragaria vesca (W)
Fraxinus excelsior (W)
Fumaria officinalis (E) Last record: MWRR, 1973.
Galeopsis speciosa A single record: JAM, 1964.
Galeopsis tetrahit Last record: MWRR, 1973.
Galium aparine (W)
Galium mollugo subsp. ***mollugo*** Last record: MWRR, 1973 (**ABRN**).
Galium palustre
Galium verum
Geranium dissectum (E, W) Last record: DOE, 1975 (**ABRN**).
Geranium molle Last record: JAT, 1962.
Geranium pratense MWRR, 1973 (**ABRN**).
Geranium pusillum A single record: SMW, 1956.
Geranium pyrenaicum* Last record: MWRR, 1973.
Geranium robertianum
Geum urbanum (W)
Glechoma hederacea (W)
Glyceria fluitans Wet rides with *Lythrum portula* (Croft, 1995). First record: MWS, 1993.
Gnaphalium uliginosum Last record: TCEW, 1973.
Hedera helix Last record: MWRR, 1973.
Helictotrichon pubescens First record: MWS, 1993.
Heracleum mantegazzianum* First record: NCR, 1980-84.
Heracleum sphondylium (W)
Holcus lanatus (W)
Holcus mollis Last recorded: MWRR, 1973.
Hordeum murinum First record: MWS, 1993.
Hordeum secalinum A single record: MWRR, 1963 (ABRN).
Hottonia palustris* Last record: DOE, 1973.
Hyacinthoides non-scripta **(***Endymion non-scripta***)**

Hypericum hirsutum (W)
Hypericum humifusum
Hypericum maculatum Last record: JAW, 1980.
Hypericum perforatum First record: MWS, 1993.
Hypericum pulchrum
Hypericum tetrapterum
Hypochaeris radicata Last record: MWRR, 1973.
Ilex aquifolium
Iris foetidissima* Last record: MWRR, 1973.
Iris pseudacorus Last record: DOE, 1975.
Juncus acutiflorus Last record: MWRR, 1973.
Juncus articulatus Last record: MWRR, 1973.
Juncus bufonius
Juncus conglomeratus (W)
Juncus effusus (W)
Juncus inflexus (W)
Juncus × ***diffusus*** (***J. inflexus*** × ***effusus***) A single record: MW, 1972.
Kickxia elatine A single record: MWRR, 1973.
Kickxia spuria A single record: MWRR, 1973 (ABRN).
Lamiastrium galeobdolon (*Galeobdolon luteum*)
Lamium album (E) Last record: MWRR, 1973.
Lamium purpureum (E) First record: MWS, 1993.
Lapsana communis Last record: MWRR, 1973.
Lathyrus palustris A single record: JFA, 1954-56.
Lathyrus pratensis
Lemna minor Ponds. First record: MWS, 1993.
Lemna trisulca Ponds. First record: MWS, 1993.
Leontodon autumnalis Last record: MWRR, 1973.
Leontodon saxatilis (*Leontodon taraxacoides*) A single record: MWRR, 1973.
Leucanthemum vulgare (W) First record: MWRR, 1973.
Ligustrum vulgare (W)
Linum catharticum
Listera ovata
Lithospermum officinale
Lolium perenne
Lonicera periclymenum (W)
Lotus corniculatus
Lotus pedunculatus East Field. First record: KJW, 2004.
Luzula campestris
Luzula multiflora subsp. ***multiflora***
Luzula pilosa
Lychnis flos-cuculi
Lycopus europaeus
Lysimachia nummularia (W)
Lythrum portula (*Peplis portula*)
Lythrum salicaria Last record: DOE, 1972.
Malus sylvestris
Malva moschata
Malva sylvestris Last record: MWRR, 1973.
Matricaria matricarioides Last record: DOE, 1974.

Matricaria recutita Last record: MWRR, 1973.
Medicago lupulina
Melampyrum cristatum
Melica nutans A single record: NCR, 1960-73.
Melica uniflora
Mentha aquatica Last record: JAM, 1963.
Mentha arvensis Last record: MWRR, 1973.
Mercurialis perennis (W)
Milium effusum
Moehringia trinervia (W)
Myosotis arvensis (W)
Myosotis discolor (W)
Myosotis laxa (*Myosotis caespitosa*) Last record: MWRR, 1973.
Myosotis scorpioides A single record: JAT, 1950.
Narcissus sp.* A single record: DOE, 1973.
Neottia nidus-avis Last record: JAW, 1984.
Odontites verna (*Odontites verna* subsp. *serotina*)
Ononis spinosa A single record: JGD, 1948.
Onopordum acanthium* A single record: JFA, 1954-56.
Ophrys apifera Last record: JAW, 1982.
Orchis mascula
Orchis morio* One plant recorded in West Field probably having originated from imported hay. A single record: JAW, 1982.
Ornithogallum umbellatum Last record: DOE, 1975.
Papaver rhoeas Last record: MWRR, 1973.
Papaver somniferum* Last record: MWRR, 1973.
Paris quadrifolia Last record: TCEW, 1987.
Pastinaca sativa (E) Last record: MWRR, 1973.
Persicaria hydropiper (*Polygonum hydropiper*) A single record: JAT, 1960.
Persicaria lapathifolia (*Polygonum lapathifolium*) (E) A single record: DOE, 1973.
Persicaria maculosa (*Polygonum persicaria*) A single record: DOE, 1973.
Phalaris arundinacea First record: MWS, 1993.
Phleum bertolonii A single record: PDS, 1967.
Phleum pratense (F) Last record: MWRR, 1973.
Phragmites australis First record: MEM, 2000.
Picris echioides (W)
Picris hieracioides A single record: JAW, 1984.
Pimpinella major Last record: MWRR, 1973.
Plantago lanceolata (W)
Plantago major (W)
Plantago media First record: MWS, 1993.
Platanthera chlorantha
Poa annua (W)
Poa humilis Last record: NCR, 1960-73.
Poa nemoralis
Poa pratensis (*Poa pratense*)
Poa trivialis (W)
Polygala vulgaris Last record: DOE, 1974.
Polygonum aviculare (E) Last record: MWRR, 1973.
Populus tremula

Potamogeton crispus (**ABRN**)
Potamogeton natans A single record: DOE, 1973.
Potamogeton pusillus Newly created pond in East Field. First record: MEM, 2000, but not there in 2004.
Potentilla anglica A single record: PP, 1967.
Potentilla anserina
Potentilla erecta
Potentilla reptans (W)
Potentilla sterilis (W)
Primula veris
Primula vulgaris (W)
Primula* × *polyantha* = *P. veris* × *P. vulgaris
Prunella vulgaris (W)
Prunus domestica Last record: MWRR, 1973.
Prunus spinosa (W)
Pulicaria dysenterica (W)
Pyrus communis Last record: DOE, 1972.
Quercus robur (W)
Ranunculus acris (W)
Ranunculus auricomus
Ranunculus ficaria
Ranunculus flammula subsp. ***flammula***
Ranunculus repens (W)
Ranunculus sceleratus (H) Last record: MWRR, 1973.
Ranunculus trichophyllus Last record: DOE, 1972.
Raphanus raphanistrum (E) First record: MWS, 1993.
Reseda lutea First record: MWS, 1993.
Reseda luteola A single record in 1959, recorder unknown.
Rhamnus catharticus Last record: JAW, 1985.
Rhinanthus minor Last record: JAM, 1979.
Ribes nigrum First recorded in cpts 2 and 22 by JAW, 1980, last seen 1984.
Ribes rubrum Last recorded: JAW, 1984.
Ribes uva-crispa Last recorded: JAW, 1984.
Rorippa nasturtium-aquaticum
Rosa arvensis (W)
Rosa canina agg. (W)
Rosa canina Group ***Dumales*** First record: CDP & JMC, 1992.
Rosa canina Group ***Lutetianae*** First record: CDP & JMC, 1992.
Rosa canina Group ***Pubescentes*** First record: CDP & JMC, 1992.
Rosa canina Group ***Transitoriae*** First record: CDP & JMC, 1992.
Rosa obtusifolia Southedge Ride. First record: CDP & JMC, 1992.
Rosa stylosa Edges of rides. First record: CDP & JMC, 1992.
Rosa tomentosa
Rosa* × *dumalis* = *R. caesia* ssp. *caesia* × *R. canina Rides and edges of wood. First record: CDP & JMC, 1992.
Rosa* × *dumalis* = *R. caesia* ssp. *glauca* × *R. canina Rides and edges of wood. First record: CDP & JMC, 1992.
Rosa* × *dumetorum* = *R. canina* × *R. obtisifolia SE corner of West Wood. First record: CDP & JMC, 1992.

Rosa* × *rouyana* = *R. arvensis* × *R. obtusifolia Eastedge Ride. First record: CDP & JMC, 1992.
Rosa* × *sambriuscula* = *R. canina* × *R. tomentosa North edge of West Field. First record: CDP & JMC, 1992.
Rosa* × *verticillacantha* = *R. arvensis* × *R. canina Southedge Ride. First record: CDP & JMC, 1992.
Rubus apiculatus Last record: VCH, 1926.
Rubus caesius
Rubus conjungens Last record: VCH, 1926.
Rubus discerptus Last record: VCH, 1926.
Rubus fruticosus agg. (W)
Rubus rufescens A single record: PDS, 1967.
Rubus tuberculatus A single record: PDS, 1967.
Rubus ulmifolius A single record: PDS, 1967 (**ABRN**).
Rubus vestitus A single record: PDS, 1967.
Rubus watsoni A single record: PDS, 1967.
Rumex acetosa First record: MWS, 1993.
Rumex acetosella Last record: MWRR, 1973.
Rumex conglomeratus Last record: MWRR, 1973.
Rumex crispus (W)
Rumex hydrolapathum First record: MWS, 1993.
Rumex obtusifolia
Rumex palustris Last record: MWRR, 1973.
Rumex sanguineus (W)
Sagina apetala (E) A single record: SMW, 1956.
Sagina procumbens (E) Last record: DOE, 1973.
Salix alba Last record: DOE, 1973.
Salix caprea
Salix cinerea subsp. ***oleifolia*** **(***Salix cinerea* subsp. *atrocinerea*) (W)
Salix fragilis Last record: MWRR, 1973.
Sambucus nigra (W)
Samolus valerandi Last record: MWRR, 1973.
Sanguisorba minor Last record: JAT, 1964.
Sanguisorba officinalis First record: MWS, 1993.
Sanicula europaea Last record: MWRR, 1973.
Schoenoplectus lacustris
Scrophularia auriculata First record: MWS, 1993.
Scrophularia nodosa
Scutellaria galericulata
Sedum telephium Last record: JAW, 1983.
Senecio erucifolius (W)
Senecio jacobaea (W)
Senecio vulgaris (E) Last record: MWRR, 1973.
Sherardia arvensis Last record: MWRR, 1973.
Silaum silaus Last record: JGD, 1950s.
Silene dioica Last record: MWRR, 1973.
Silene latifolia **(***Silene alba*) Last record: DOE, 1974.
Silene noctiflora Last record: JGD, 1950s.
Silene vulgaris Last record: MWRR, 1973.
Sinapsis arvensis Last record: MWRR, 1973.

Sison amomum A single record: PDS, 1967.
Sisymbrium officinale A single record from cpt 2 in 1964.
Solanum dulcamara Last record: MWRR, 1973.
Solanum nigrum Last record: DOE, 1973.
Sonchus arvensis Last record: MWRR, 1973.
Sonchus asper (W) Last record: MWRR, 1973.
Sonchus oleraceus (W) Last record: JFA, 1954-56.
Sonchus palustris* A single record, presumably self-sown from the introduced population at Woodwalton Fen: MEM, 1988.
Sorbus torminalis
Sparganium erectum subsp. ***erectum*** Last record: DOE, 1973.
Spiraea salicifolia* A single record: MWRR, 1973.
Stachys palustris Last record: MWRR, 1973.
Stachys officinalis (*Betonica officinalis*) Last record: MWRR, 1973.
Stachys sylvatica Last record: MWRR, 1973.
Stellaria graminea
Stellaria holostea
Stellaria media (W)
Stellaria uliginosa (*Stellaria alsine*) Last record: MWRR, 1973.
Succisa pratensis
Symphoricarpos rivularis*
Symphytum officinale Last record: MWRR, 1973.
Tamus communis (W)
Taraxacum officinale (W)
Thalictrum flavum Last record: DOE, 1975.
Torilis japonica (W)
Tragopogon pratensis A single record: SMW, 1956.
Trifolium campestre Last record: MWRR, 1973.
Trifolium dubium Last record: MWRR, 1973.
Trifolium fragiferum A single record: PDS, 1967.
Trifolium micranthum A single record: JGD, 1950s.
Trifolium ochroleucon Last record: JAW, 1985.
Trifolium pratense
Trifolium repens (W)
Tripleurospermum inodorum (*Tripleurospermum maritimum*) Last record: DOE, 1974.
Trisetum flavescens Last record: MWRR, 1973.
Typha latifolia (E) First record: pond, East Field, KJW, 2004.
Tussilago farfara Last record: MWRR, 1973.
Ulmus minor subsp. ***minor*** (*Ulmus carpinifolia*)
Ulmus procera
Ulmus × ***vegeta*** Last record: NCR, 1970-74.
Urtica dioica (W)
Urtica urens S single record: JGD, 1953.
Valeriana officinalis Last record: DOE, 1975.
Verbascum thapsus A single record: JAT, pre-1973.
Veronica arvensis Last record: MWRR, 1973.
Veronica beccabunga
Veronica catenata Last record: DOE, 1973.
Veronica chamaedrys (W)
Veronica montana Last record: JAM, 1968.

Veronica officinalis (W)
Veronica persica A single record: SMW, pre-1973.
Veronica polita (E) First record: MWS, 1993.
Veronica scutellata First record: MWS, 1993.
Veronica serpyllifolia (W)
Viburnum lantana
Viburnum opulus
Vicia cracca (W)
Vicia hirsuta First record: MWS, 1993.
Vicia sativa Last record: MWRR, 1973.
Vicia sepium
Vicia tetrasperma (W) Last record: MWRR, 1973.
Viola arvensis Last record: DOE, 1973.
Viola canina subsp. ***canina*** East Field. First record: MEM & JAW, 1984.
Viola hirta Last record: MWRR, 1973 (**ABRN**).
Viola odorata Last record: DOE, 1975.
Viola reichenbachiana (W)
Viola riviniana (W)
Viola × ***bavarica*** = ***V. reichenbachiana*** × ***V. riviniana*** Last record: MWRR, 1973.
Viola tricolor (E) First record: MWS, 1993.
Vulpia bromoides A single record: JAT, 1960.

Excluded species

Species thought to be dubious on distributional grounds or most likely recorded from fields and field edges surrounding the wood:

Agrostis gigantea First record in MWS, 1993, but unlikely to occur in the wood itself as there is no suitable habitat.
Anthyllis vulneraria Formerly on lanes outside the wood. Last record: JAM, 1962.
Bromus commutatus Still present in fields to the south of the wood.
Bromus hordeaceus (*Bromus mollis*) Still present in fields to the south of the wood.
Bromus racemosus Still present in fields to the south of the wood.
Bromus × ***pseudothominei*** = ***B. hordeaceus*** × ***B. lepidus*** Last record: MWRR, 1973.
Centaurea scabiosa South side of cpt 1. Last record: MWRR, 1973.
Cerastium semidecandrum A single record: BD, 1956. Rare in v.c. 31 and not recorded from the wood by Wells (2003). Unlikely to occur given the lack of suitable habitat in the wood.
Chaerophyllum temulentum Saul's Lane. Last record: DOE, 1975.
Cichorium intybus Roadside. Last record: JAM, 1968.
Clinopodium vulgare Fields to the south of the wood and Saul's Lane. Last record: DOE, 1974.
Colchium autumnale Last record: VCH, 1908.
Delphinium ambiguum Road verge. Last record: JAM, 1974.
Euphorbia exigua Last record: MWRR, 1973.
Festuca ovina Last record: NCR, 1965-69. Requires confirmation as this species is rare in v.c. 31 (Wells 2003).
Galium odoratum Last record: NCR, 1960-64. Requires confirmation as this species has only been recorded as a garden escape in v.c.31 (Wells 2003).

Gastridium ventricosum Recorded from near Monks Wood by AF in 1882 (Wells 2003).
Hesperis matronalis Road verge. Last record: DOE, 1973.
Melilotus alba Saul's Lane. Last record: JAM, 1965.
Melilotus officinalis Saul's Lane. Last record: MWRR, 1973.
Ranunculus arvensis Ditch near North Gate. Last record: MWRR, 1973.
Tanacetum parthenium (*Chrysamthemum parthenium*)
Tephroseris integrifolia There is a reserve record for the period 1960-73 but considered to be an error as there is no suitable habitat. There are no records for v.c. 31 (Wells 2003).
Torilis arvensis Last record: MWRR, 1973.

In addition, the following species have been recorded around the experimental buildings in recent years; *Armoracia rusticana, Carduus tenuiflorus, Campanula glomerata, Cochlearia danica, Consolida ajacis, Elytrigia atherica, Lotus glaber, Mercurialis annua, Papaver dubium, Saxifraga granulata, Spiranthes spiralis, Teucrium scorodonia* and *Thlaspi arvense*. All are assumed to be casuals introduced on vehicles, clothing and imported soil.

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Bryophytes of Monks Wood

Chris Preston and Kevin J. Walker
NERC Centre for Ecology and Hydrology, Monks Wood, Abbots Ripton, Huntingdon,Cambridgeshire PE28 2LS

This paper aims to revise and update the bryophyte list for Monks Wood NNR presented by Horrill (1973) in *Monks Wood: a nature reserve record*, and to discuss changes in the flora of the wood in the last 30 years.

Surveys of the bryophyte flora since 1973

There has not been a detailed survey of the bryophytes of Monks Wood since 1973, but the wood has been visited by bryologists on numerous occasions. In 1985-7 N.G. Hodgetts was working at the Biological Records Centre and made many interesting records in the wood. A summary of the bryological importance of the site, with lists of its most interesting species, was prepared by Hodgetts (1985, 1986). The Cambridgeshire Bryophyte Group (formerly a group from the Botany School, University of Cambridge, co-ordinated by Dr H.L.K. Whitehouse; now a local group of the British Bryological Society) visited the Wood in 1995 and 2000. In 2000 the party recorded the bryophytes in the Wilderness for the first time. Other records result from casual observations by Monks Wood staff. In November 2003 we began a new survey of the Wood, compartment by compartment, but this is still incomplete.

Revisions to the 1973 list

Like other contributors to Steele & Welch, Horrill's (1973) bryophyte list covered both the wood itself and the grounds of the Experimental Station. In particular, the interesting bryophytes known in the 1960s from the stubble fields or grass leys south of the wood were included (this area is now permanent grassland and these species are absent, or only present in the soil diaspore bank). We have excluded from our list those species which are known to have been recorded outside the wood, or are very likely (on ecological grounds) to have been found outside it. There is a particular problem with plants recorded from 'Fields' in Horrill's account as this term includes both East and West Fields within the wood and the cultivated fields outside the boundary of the NNR. The excluded taxa are listed after the main list. A number of common species (eg *Bryum bicolor*) were only known to Horrill outside the wood but have since been found within the NNR; these are included in the main list without further comment.

We have also taken the opportunity of assessing the records of species which have not been recorded since Horrill's list was published. All the species listed by Horrill could conceivably have been present in the wood, but there are some which are very uncommon in the area and which may have been recorded erroneously. The species which we have excluded as doubtful are also listed.

A revised list of Monks Wood bryophytes

All species known from Monks Wood NNR and from the adjacent 'Wilderness' are included in the list below. For species which are not listed by Horrill, brief details of the habitat,

recorder and date of the first record are provided. We have noted species which have not been recorded since 1973, and given the date of the last record. Species both listed by Horrill (1973) and recorded subsequently.are presented without either a first or a last record.

Recorders names are abbreviated as follows: ADH, A.D. Horrill; AEN, A.E. Newton; CBG, Cambridgeshire Bryophyte Group; CDP, C.D. Preston; HLKW, H.L.K. Whitehouse; KJW, K.J. Walker; MDM-S, Mrs M.D. Milnes-Smith; MOH, M.O. Hill; NGH, N.G. Hodgetts; RS, R. Schumacker; MJMY, M.J.M. Yeo.

Species indicated by '(W)' have been recorded both in the NNR and in the adjacent Wilderness; those indicated '(WO)' have been recorded only in the Wilderness, not in the NNR.

Nomenclature follows Blockeel & Long (1998). If the name in Horrill's list differs, the earlier name is given as a synonym. A summary of the number of species recorded from the area, based on accepted records, is provided in Table 1.

Table 1. Summary of the number of bryophytes recorded from Monks Wood NNR and the Wilderness.

	Liverworts	**Mosses**	**Total**
Recorded by Horrill (1973) but not refound.	2	6	8
Recorded by Horrill (1973) and subsequently.	12	66	78
First recorded after 1973.	8	26	34
Total	22	98	120

Liverworts

Aneura pinguis (*Riccardia pinguis*)

Calypogeia fissa

Cephalozia lunulifolia (*C. media*) Only recorded in 1967.

Chiloscyphus pallescens

Conocephalum conicum

Fossombronia pusilla

Frullania dilatata (W) Epiphyte. First record: CBG, 1995.

Lejeunea cavifolia Base of field maple and ash trees by pools and streams. First record: NGH, 1986.

Lepidozia reptans Ash trunk by stream. First record: NGH, 1987.

Lophocolea bidentata (including *L. cuspidata*) (W)

Lophocolea heterophylla (W)

Marchantia polymorpha subsp. ***ruderalis*** (WO) Ground. First record: CBG, 2000.

Metzgeria fruticulosa (WO) Epiphytic on a single large dogwood. First record: CDP & KJW, 2003.

Metzgeria furcata (W)

Microlejeunea ulicina Epiphytic on ash. First record: CDP & KJW, 2004.

Pellia endiviifolia

Pellia neesiana Moist soil on rutted rides. First record: CDP & RS, 1983.

Plagiochila asplenioides (*P. aspleniodes* var. *major*) (W)

Porella platyphylla

Ptilidium pulcherrimum Epiphytic on hawthorn. First record: CDP, 1980.

Radula complanata (W)

Riccardia chamedryfolia (*R. sinuata*) Recorded from 'Fields' by Horrill (1973) but probably in East Field as well as the cultivated fields outside the wood (see discussion of *R. multifida* below). Not seen since 1967.

Mosses

Amblystegium serpens (W)

Amblystegium varium Only recorded in 1967.

Anomodon viticulosus

Aphanorhegma patens Dried-up ditch. First and only record: CDP, 1983.

Atrichum undulatum (W)

Aulacomnium androgynum (W)

Aulacomnium palustre On ground in West and East Fields, and in one glade. First record: NGH, 1986.

Barbula unguiculata (W)

Brachythecium rivulare

Brachythecium rutabulum (W)

Brachythecium velutinum

Bryum argenteum

Bryum bicolor

Bryum capillare (W)

Bryum klinggraeffii Dried-up ditch, with *Aphanorhegma patens*. First and only record: CDP, 1983.

Bryum rubens

Bryum ruderale

Bryum subelegans (W) Epiphyte; rarely on ground. First record: MDM-S, 1977.

Calliergonella cuspidata (*Acrocladium cuspidatum*) (W)

Campylium stellatum* var. *protensum (*Campylium protensum*) Not recorded since 1967.

Campylopus flexuosus Only recorded in 1967.

Campylopus introflexus Rotting wood. First record: NGH, 1987.

Ceratodon purpureus (W)

Cirriphyllum piliferum (W)

Climacium dendroides Not recorded since 1965.

Cratoneuron filicinum

Cryphaea heteromalla Epiphytic on elder. First record: NGH, 1987.

Ctenidium molluscum

Dicranella heteromalla

Dicranella schreberiana Disturbed ground. First and only record: NGH, 1987.

Dicranella varia

Dicranoweisia cirrata (W)

Dicranum fuscescens Epiphytic on ash. First and only record: NGH, 1987.

Dicranum montanum Epiphytic on ash. First and only record: NGH, 1987.

Dicranum scoparium

Dicranum tauricum Rotting wood, and epiphytic on ash. First record: NGH, 1987.

Didymodon fallax (*Barbula fallax*) (W)

Didymodon insulanus Concrete of dam. First record: CDP & KJW, 2003.

Didymodon sinuosus Base of ash by stream and concrete of dam. First record: AEN & CDP, 1985.

Didymodon tophaceus (W) On ground, especially in moist places. First record: CBG, 2000.

Drepanocladus aduncus

Eurhynchium crassinervium Habitat not recorded, probably on tree bases by streams or ditches. First record: ADH, 1965 (though not included in the 1973 list).

Eurhynchium hians (*E. swartzii*) (W)

Eurhynchium praelongum (W)

Eurhynchium pumilum (*Rhynchostegiella pumila*)

Eurhynchium striatum (W)

Fissidens bryoides

Fissidens exilis (W)

Fissidens incurvus (W)

Fissidens taxifolius (W)

Fissidens viridulus

Funaria hygrometrica

Grimmia pulvinata (W) Concrete of dam. First record: CDP & HLKW, 1980.

Herzogiella seligeri Rotting wood, with *Calypogeia fissa*. First record: CDP & KJW, 2004.

Homalia trichomanoides (*Omalia trichomanoides*)

Homalothecium sericeum (*Camptothecium sericeum*) (W)

Hylocomium splendens Not recorded since 1967.

Hypnum cupressiforme (W)

Hypnum jutlandicum Acidic ground in East Field and at base of birch trees in wood. First record: MOH, 1989.

Hypnum resupinatum (W) Epiphyte. First record: ADH, 1965 (though not included in the 1973 list, when it was regarded as a variety of *H. cupressiforme*).

Isothecium alopecuroides (*I. myurum*)

Isothecium myosuroides

Leptodictyum riparium (W)

Leskea polycarpa Wooden footbridge by main ride. First and only record: NGH, 1986.

Microbryum davallianum (*Pottia davalliana*)

Mnium hornum (W)

Neckera complanata (W)

Orthodontium lineare

Orthotrichum affine (W) Epiphyte. First record: AEN, 1986.

Orthotrichum diaphanum (W) Epiphyte; concrete of dam. First record: CBG, 1995.

Orthotrichum lyellii (W) Epiphyte. First record: CBG, 2000.

Plagiomnium rostratum (*Mnium longirostrum*)

Plagiomnium undulatum (*Mnium undulatum*) (W)

Plagiothecium curvifolium

Plagiothecium denticulatum

Plagiothecium nemorale (*P. sylvaticum*)

Plagiothecium ruthei Habitat not recorded, probably epiphytic. First and only record: CBG, 1967.

Platygyrium repens (W)

Pleuridium subulatum Disturbed clay soil, East Field. First record: CDP & KJW, 2003. The earlier (1967) record was from a stubble field by the Wood (Horrill, 1968).

Pohlia melanodon (*P. delicatula*)

Pohlia nutans

Polytrichum formosum

Pseudotaxiphyllum elegans (Isopterygium elegans) Acidic ground. Listed in Steele & Welch (1973, p. 53) but not included by Horrill's list; subsequently recorded by NGH, 1986.

Rhizomnium punctatum *(Mnium punctatum)*

Rhynchostegium confertum (*Eurhynchium confertum*) (W)

Rhynchostegium riparioides (*Eurhynchium riparioides*)

Rhytidiadelphus squarrosus (W)

Rhytidiadelphus triquetrus

Schistidium crassipilum Concrete of dam. First record: MJMY, 1987.

Scleropodium purum (*Pseudoscleropodium purum*)

Syntrichia papillosa Epiphytic on *Salix cinerea*. First record: CDP & KJW, 2003.

Tetraphis pellucida

Thamnobryum alopecurum (*Thamnium alopecurum*) (W)

Thuidium tamariscinum (W)

Tortula muralis (W)

Tortula truncata (*Pottia truncata*)

Ulota bruchii (W) Horrill lists '*U. crispa*' but this species and *U. bruchii* are very similar and *U. crispa* is not listed for v.c. 31 by Blockeel & Long (l998). Only plants with mature capsules can be identified and all recent material with such capsules is *U. bruchii*.

Zygodon viridissimus Epiphyte. First record: MDM-S, 1977.

Excluded species

The following species are either listed by Horrill (1973) or have otherwise been recorded from the Wood, but for the reasons given are excluded from the list above.

Records of the following liverworts may be based on misidentifications:

Cephalozia bicuspidata Recorded from 'soil' in Horrill's (1973) list but the species was not included in his "Preliminary Flora" (1974) and only much later accepted for v.c. 31.

Chiloscyphus polyanthus Often confused with *C. pallescens*.

Pleurozium schreberi Not recorded since 1965, when it was recorded in all four 10-km squares in the wood. The occurrence of this calcifuge is not impossible (it is known, for example, from Woodwalton Fen), though it is rare in the area. However, we regard it as doubtful as it was not recorded between 1966 and 1973, a period of rather intensive bryological activity.

Riccardia multifida There is no confirmed record from v.c. 31 and although this is listed from East Field by Horrill (1973) it is not included in Horrill's 'Preliminary Flora' (1974); the species is often confused with *R. chamaedryfolia*.

The following are known to have been recorded from the stubble fields or grass leys near the wood (see Horrill 1968, 1971,1973, p. 89, 1974):

Acaulon muticum

Dicranella staphylina

Entosthodon fascicularis (*Funaria fascicularis*)

Ephemerum serratum* var. *minutissimum

Physcomitrium pyriforme

Weissia controversa* var. *controversa

Weissia longifolia* var. *angustifolia (*W. crispa*) Rather confusingly, *W. crispa* and *W. crispa* var. *aciculata* are reported by Horrill (1968, 1973, 1974). It is not clear whether *W. crispa sens. str.* (now *Weissia longifolia* var. *angustifolia*) is intended by the former name, but as this plant is normally a calcicole of chalky soils, the recorder may simply have intended *W. crispa sens. lat.*

Weissia longifolia* var. *longifolia (*W. crispa* var. *aciculata*)

Weissia squarrosa

Weissia rostellata Horrill (1968, 1973) reported a record made by H.L.K. Whitehouse from a stubble field by the Wood, but the record was never published as new to v.c. 31 and was presumably an error for the similar *W. squarrosa*, also reported (by J.G. Duckett) at the same time. Indeed, Horrill (1974) lists only the record of *W. squarrosa* in his "Preliminary Flora" and includes Whitehouse as one of its recorders.

The following seem likely to have been recorded in these fields, though they may have been found in East or West Fields or on disturbed soil elsewhere in the wood:

Ditrichum cylindricum

***Tortula acaulon* (*Phascum cuspidatum*)**

The following species were probably found around the Experimental Station:

Barbula convoluta
Brachythecium albicans
Pseudocrossidium hornschuchianum

Changes in the bryophyte flora, 1973-2003

Bryophytes are small and often grow in shaded and therefore partially concealed places – searching for them is often, literally, carried out on hands and knees. Many species colonise ephemeral or short-lived habitats such as disturbed soil, tree branches or rotting stumps and logs. These plants have populations which are highly mobile, and spread to suitable habitat patches as they arise, or persist for long periods as dormant spores or vegetative propagules. This combination of inconspicuousness and mobility means that it is impossible to obtain a complete species list for an area as large and complex as Monks Wood. It is not therefore surprising that there have been additions to the flora since 1973; the discovery of new species (or failure to record species which have been seen before) does not *necessarily* indicate environmental change.

Despite this qualification, it is clear that the epiphyte flora of the wood has increased since 1973. The changes have not greatly affected the species growing on the base-rich lower bark and old coppice stools of trees such as ash and field maple. These epiphytes were relatively well-represented in 1973 (typical species include *Porella platyphylla*, *Homalia trichomanoides*, *Isothecium myosuroides* and *Neckera complanata*). The one significant addition to this list since 1973 has been *Lejeunea cavifolia*, which has only been found on three tree bases; it was probably present but not noticed until 1986.

The increase in the epiphyte flora is in species of tree boles, branches and twigs. In 1973 epiphytes were "restricted to the lower tree boles and bases and rarely grow above a height of 2 m." (Horrill 1973, p. 89). At this period SO_2 pollution was high nationally, and Monks Wood was almost certainly adversely affected by a more local source, the Yaxley-Peterborough-Whittlesey brick pits. The mean annual and winter average SO_2 concentrations in 1968-69 were 52 and 64 μgm^{-3} respectively, and Laundon (1973) concluded that "the effects of sulphur dioxide on the lichen flora is quite pronounced". He suggested that pollution had increased between 1954 and 1971. Of the epiphytic bryophytes mentioned by Horrill, *Bryum capillare*, *Dicranoweisia cirrata* ('frequent'), *Dicranum scoparium* ('rare') and *Lophocolea heterophylla* ('common') are pollution-tolerant species which remained frequent even during the period of maximum SO_2 concentrations. The only other species mentioned by Horrill are *Metzgeria furcata* ("locally abundant" in Compartment 30), a species of basic bark which did not appear to be particularly badly affected by pollution, *Radula complanata*, which was then confined to ash stools by Ewingeswode stream, *Platygyrium repens*, a rarity discussed in more detail below, and *Ulota crispa* [sens. lat.]. The latter is a surprising record, as it was almost absent from eastern England in this period. In Monks Wood, the only Huntingdonshire site known at this time, it was found on a "tree by Badger Ride Pond" in 1967 (Horrill 1974); in neighbouring Cambridgeshire (v.c. 29) it was not seen from 1881 until its rediscovery in 1984. Despite the presence of *U. crispa*, this is a very limited list of specialist epiphytes - even common species such as *Orthotrichum affine*, *O. diaphanum* and *Zygodon viridissimus* are absent from it. Indeed Horrill (1974) described

the two *Orthotrichum* species as rare in Hunts as a whole at this period and he knew no recent records of the *Zygodon*.

SO_2 concentrations have fallen dramatically in recent decades and the annual mean concentration at Monks Wood for the period 1999-2001 is estimated (by modelling rather than direct measurement) as 4.2 μgm^{-3} (www.apis.ac.uk)**.** Although bryophytes still tend to be restricted to the lower parts of trees in the drier parts of the wood, there is now no clear upper limit to the epiphyte flora in moister areas. Examination of recently fallen ash trees in the valley of the Ewingswode stream shows that epiphytes extend up the trunk into the canopy, reaching heights of 17 m or more. Since 1973 numerous epiphytic species have been discovered in the Wood. Historic records show that at least seven of these were formerly adversely affected by SO_2 pollution in the London area: *Frullania dilatata*, *Cryphaea heteromalla*, *Orthotrichum affine*, *O. diaphanum*, *O. lyellii*, *Syntrichia papillosa* and *Zygodon viridissimus* (Adams & Preston 1992). These have certainly increased in range in eastern England since the 1980s, presumably in response to cleaner air. *Metzgeria fruticulosa* probably falls into the same category. The suboceanic liverwort *Microlejeunea ulicina* is perhaps just starting to show a range expansion in eastern England, but not necessarily for the same reason.

Three other additional species, *Lepidozia reptans*, *Ptilidium pulcherrimum* and *Dicranum montanum* are rather different ecologically to the *Frullania dilatata* group as they generally prefer acidic bark, and they often extend onto decaying wood, a habitat in which three more species have been found since 1973, *Campylopus introflexus*, *Dicranum tauricum* and *Herzogiella seligeri*. *Campylopus introflexus* is an alien species, first found in Britain in 1941. The two *Dicranum* species and *H. seligeri* might also be gradually increasing nationally; it has been suggested that this increase is attributable to "acid rain" but the increase appears to have continued into the clean-air era. They may be responding gradually to a national increase in decaying wood resulting from less intensive woodland management, including a decreased tendency for people to collect firewood from their local woods. (The increase in dead wood following Dutch Elm Disease is not relevant to this story, as elm rots rapidly and is usually colonised only by very common species, notably *Brachythecium rutabulum*.)

The most notable epiphyte in the wood is *Platygyrium repens*, which was discovered by J.G. Duckett in 1968. At that time it was known in Britain only from Bagley and Wytham Woods near Oxford. It was still very uncommon at Monks Wood in 1980, but by 1986-7 it was "widespread and locally abundant" (Hodgetts 1987). It is still widespread and in some areas (eg in the valley in Compartment 27) it is one of the commonest epiphytes. It reproduces by bulbils which arise in abundance in the upper leaf axils. Plants often form circular colonies on ash trunks, with the short, erect bulbil-bearing stems in the centre and the prostrate, rather glossy pioneer stems around the edge, the overall appearance curiously suggestive of a fungus colony on an agar plate. Since 1968 it has gradually been discovered at other sites in S. England and Wales.

A small group of additions to Horrill's (1973) list are colonists of the concrete dam in Compartment 27, *Didymodon insulanus*, *D. sinuosus*, *Grimmia pulvinata* and *Schistidium crassipilum*. The Lower Pond was created by Mr Neaverson in 1935. When it was repaired in 1961 using puddled clay for the dam it was provided with a concrete overspill; in 1980 the sluice was repaired with clay and concrete blocks and in 1991 there was a further major reconstruction. The first moss records known to have been made from the concrete of the

dam date from 1980. Another species which may also be a recent colonist is *Aulacomnium palustre*, a conspicuous plant which is unlikely to have been missed by Horrill and his colleagues in East Field. There is little to say about the other additions to the Flora, many of which are inconspicuous plants, species of ephemeral habitats or perhaps casual colonists. Their discovery has been a result of further bryophyte recording in the Wood rather than a reflection of any general trends.

Most of the species reported by Horrill (1973) have been refound subsequently. Of the exceptions, *Amblystegium varium* and *Plagiothecium ruthei* are very similar to commoner species and may have been overlooked. *Cephalozia lunulifolia* and *Campylopus flexuosus* are colonists of rotting wood, and *Hylocomium splendens* is also calcifuge, albeit mildly so. *Riccardia chamaedryfolia* perhaps grew in open habitats that have now become more overgrown, and *Climacium dendroides* is an easily recognisable, perennial species which has a curiously erratic history in some of its local sites (eg Wicken Fen). *Campylium stellatum* var. *protensum*, a calcicole known to Horrill on rides, is the only other species which has not been refound.

In summary, the main change which has taken place in the Wood reflects a national and regional change, the expansion of pollution sensitive epiphytes in response to the reduction of SO_2 levels. There are relatively few signs of change in response to local site factors. It must be admitted that any analysis based on presence or absence of species must be crude, and will only detect major changes. A more detailed comparison of Horrill's abundance assessments with the current situation may be possible once our current compartment-by-compartment survey is completed, but in general there is little in Horrill's description of the bryophytes of the wood, epiphytes apart, which strikes us as inappropriate today.

Colonisation of the Wilderness

The Wilderness is a 4ha area of recent secondary woodland. A small segment (the 'Old Wilderness') probably arose on fields abandoned in the inter-war years. The main area was a field which was last cropped (for barley) in 1960, ploughed in autumn 1961 then allowed to revert naturally to woodland (Walker and others 2000). It is now a closed woodland dominated by ash and oak trees c. 12 m high; there are also two open stands of *Calamagrostis epigejos*. There is little topographical variation. The area is surrounded on two sides by the ancient woodland of the NNR.

The bryophytes which have colonised the Wilderness are indicated in the main list. The number of colonists is compared in Table 2 to the number of species recorded from the NNR since 1973 but not seen in the Wilderness.

We have allocated species to 10 categories on the basis of the habitats in which they usually occur:

Epiliths: plants of concrete, stonework, brickwork, single stones and discarded bricks.

Epiphytes: plants of tree boles, branches and twigs.

Generalists: species which grow in a range of habitats.

Grassland: grassland in East and West fields and on rides.

Living/rotting wood: plants which occur both on living wood (in 'epiphyte' or 'tree base' categories) and on rotting wood.

Moist ground: moist ground, often by water or in seasonally flooded sites, plus plants of wet wood by water and aquatics.

Open ground: open, disturbed ground.

Rotting wood: colonists of rotting wood.

Tree bases: bases of trees, including coppice stools and tree bases in humid places near water.

Woodland floor: undisturbed ground in woodland, including stable earth banks.

Table 2. The number of species recorded since 1973 in Monks Wood NNR and the Wilderness. The numbers are also expressed as a percentage of the total number of plants in that habitat category. For details of the habitat categories, see text.

Habitat	Both	Wilderness only	NNR only	Total
Generalists	6 (86%)	0	1 (14%)	7
Epiphytes	12 (60%)	1 (5%)	7 (35%)	20
Woodland floor	14 (54%)	0	12 (46%)	26
Epiliths	2 (50%)	0	2 (50%)	4
Grassland	1 (33%)	0	2 (67%)	3
Living/rotting wood	3 (27%)	0	8 (73%)	11
Open ground	3 (17%)	1 (5%)	14 (78%)	18
Tree bases	1 (11%)	0	8 (89%)	9
Moist ground	1 (9%)	0	10 (91%)	11
Rotting wood	0	0	3 (100%)	3
Total	43 (38%)	2 (2%)	67 (60%)	112

The generalists are, not surprisingly, the most effective colonists. The only absentee is *Hypnum jutlandicum*, an uncommon calcifuge which grows in both grassland and on acidic tree bases. The high proportion of epiphytes which have colonised the Wilderness is probably also to be expected, in view of the success of this group in colonising the ancient woodland since 1973. However, woodland floor species are perhaps more surprising colonists. Species now found in the main Wilderness (not only the Old Wilderness) include *Plagiochila asplenioides* and *Thuidium tamariscinum*, both of which show rather little tendency to spread into more isolated secondary woodland in the area. A smaller proportion of plants of both living and rotting wood (which are often calcifuges) is represented amongst the colonists, and the rotting wood specialists are completely absent. The low proportion of plants of open ground perhaps reflects not only the rather closed and undisturbed nature of the woodland floor but perhaps also the short period over which the Wilderness bryophytes have been recorded (open ground plants may tend to be casuals and records may therefore accumulate gradually over time). The low proportion of plants of moist ground and of large tree bases reflects the absence of these habitats. The one tree base species recorded is *Neckera complanata* (found on dogwood and field maple in the main wilderness) and the one moist ground species *Leptodictyum riparium*. The species of tree bases may be expected to increase as this habitat becomes available but the high, summer dry nature of the site limits its suitability for species of permanently moist ground.

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The fungi of Monks Wood NNR 1973-2003

Sheila Wells
94 High Street, Upwood, Cambridgeshire PE26 2QE

Unlike flowering plants, fungi are difficult to monitor. Fruiting is dependent on moisture, temperature and other factors. Since the fruitbodies are ephemeral, they are easily missed if observers are not present at the time of fruiting. It is therefore difficult to assess whether there has been an increase or a decrease in fungal richness in the years since the Monks Wood book (Steele & Welch 1973) was published. Many fungi are eaten by slugs and snails, mice, squirrels and deer. It is possible that the increase in deer population has affected the observable number of fruitbodies.

The early 1970's, especially 1973 and 1974 were remarkable for the abundant fruiting of the larger fungi. This may have been due to the widening of Top and Hotel rides together with very favourable weather conditions. As far as I know, such abundance has not been seen since. However, in spring 1999, mycologists visiting Monks Wood found an unusual abundance of several species of large Ascomycetes in Saul's Lane, some of which are notable for their rarity.

Steele & Welch (1973) gave details of 335 species, recorded between 1956 and 1972. Since then a further 274 new species have been added. Members of the British Mycological Society spent a day in the wood on 7 September 1974 and recorded a total of 252 species, of which 126 were new to the site list. Mr R. Rayner, a *Russula* expert was one of the mycologists present that day. Among the species he identified, two were second records for Britain and another was a third British record. The remaining 148 new species have been recorded by individual visitors particularly by myself, Terry Wells and the Huntingdon Fungus Group.

Important records include a species of *Cortinarius* new to science. *C. silvae-monachi* was collected by Ron Murton on 25th Sept. 1974, in mixed deciduous woodland between Main Ride and Leeds Ride. It was described and published by Dr Derek Reid at Kew. It fruited vigorously for over a month, but has not been seen since. Three species of *Russula* – *R.carminea, R.decipiens* and *R.rosea* recorded in 1974 are on the UK Red Data List, Annex 2; *Boletus impolitus* and *Rhodotus palmatus* are in Annex 3 – European Species of Conservation Concern. The first four of these are mycorrhizal species, so that although the locations of the finds are unknown, they could still be present. *Rhodotus palmatus* which is a saprophyte living on dead elm is likely to be present wherever there is dead wood of the right age and the species will persist so long as suitable substrate remains in the wood.

The number of species recorded for a site, depends largely on the expertise and frequency of visits by mycologists, but Monks Wood compares well with other woods in the area for the number of species recorded, (Table 1), although many more are likely to be found in coming years.

Table 1. Number of fungi recorded from selected local woodlands.

Site	Area in hectares	No. of species recorded
Brampton Wood	123	475
Waresley Wood	49	324
Gamlingay Wood	46	400
Bedford Purlieus	212	607
Monks Wood	165	609

The following list give details of the 274 new species recorded from January 1973 to November 2003.

Reference

STEELE, R. C., & WELCH, R. C. 1973. *Monks Wood: a nature reserve record*. Huntingdon: Nature Conservancy.

Fungi recorded from Monks Wood NNR 1973-2003

Taxonomic Index

Anamorphic Fungi

coelomycetous anamorph

Macrophoma fraxini
broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

hyphomycetous anamorph

Aphanocladium album
Craterium minutum, fruitbody, broad-leaved semi-natural woodland, Col.: Anon, Det.: B. Ing, 07/09/1974.

Arthrinium phaeospermum
Deschampsia cespitosa, stem, dead, broad-leaved semi-natural woodland, Col.: M. Parslow, Det.: M. Parslow, 07/07/2001.

Blistum tomentosum
Trichia persimilis, fruitbody, broad-leaved semi-natural woodland, Col.: Anon, Det.: B. Ing, 07/09/1974.

Cryptocoryneum condensatum
broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Sporidesmium leptosporum
broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Sporoschisma mirabile
Quercus robur, wood, dead, broad-leaved semi-natural woodland, Col.: M. Parslow, Det.: M. Parslow, 07/07/2001.

Taeniolina centaurii
as *Torula centaurii*, *Centaurium erythraea*, stem, broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Ascomycota

Diaporthales

Caudospora taleola
Quercus robur, branch, rotten, broad-leaved semi-natural woodland, Col.: M. Parslow, Det.: M. Parslow, 07/07/2001.

Valsaceae

Diaporthe pardalota
Rumex conglomerata, stem, dead, broad-leaved semi-natural woodland, Col.: M. Parslow, Det.: M. Parslow, 07/07/2001.

Diatrypales

Diatrypaceae

Cryptosphaeria eunomia
broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Diatrypella quercina
broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.
Quercus robur, branch, fallen, broad-leaved semi-natural woodland, Col.: M. Parslow, Det.: M. Parslow, 07/07/2001.

Dothideales

Lidophia graminis
Anamorph, *Holcus lanatus*, leaf, live, broad-leaved semi-natural woodland, Col.: K. Newsome, Det.: S.E. Wells, 03/05/1995.

Melanommataceae

Melanomma fuscidulum
Quercus robur, branch, rotten, broad-leaved semi-natural woodland, Col.: M. Parslow, Det.: M. Parslow, 07/07/2001.

Mycosphaerellaceae

Mycosphaerella lineolata
Carex pendula, leaf, live, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 21/05/1998.

Phaeosphaeriaceae

Paraphaeosphaeria michotii
Deschampsia cespitosa, stem, dead, broad-leaved semi-natural woodland, Col.: M. Parslow, Det.: M. Parslow, 07/07/2001.

Phaeosphaeria herpotrichoides
as *Leptosphaeria herpotrichoides*, *Carex pendula*, stem, dead, broad-leaved semi-natural woodland, Col.: M. Parslow, Det.: M. Parslow, 07/07/2001.

Phaeosphaeria nigrans
as *Leptosphaeria nigrans*, *Carex pendula*, stem, dead, broad-leaved semi-natural woodland, Col.: M. Parslow, Det.: M. Parslow, 07/07/2001.
as *Leptosphaeria nigrans*, *Deschampsia cespitosa*, stem, dead, broad-leaved semi-natural woodland, Col.: M. Parslow, Det.: M. Parslow, 07/07/2001.

Erysiphales

Erysiphaceae

Erysiphe aquilegiae* var. *ranunculi
as *Erysiphe ranunculi*, *Ranunculus repens*, leaf, live, broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Erysiphe circaeae
Circaea lutetiana, leaf, live, broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Erysiphe depressa
broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Erysiphe galeopsidis
Stachys sylvatica, leaf, live, broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Erysiphe heraclei
Heracleum sphondylium, leaf, live, broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Microsphaera alphitoides
Quercus robur, leaf, live, broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Microsphaera euonymi
Euonymus europaeus, leaf, live, broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Microsphaera hypericacearum
as *Erysiphe hyperici*, *Hypericum hirsutum*, leaf, live, broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Microsphaera lonicerae
Lonicera periclymenum, leaf, live, broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Podosphaera clandestina
Crataegus monogyna, leaf, live, broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Podosphaera tridactyla
Prunus spinosa, leaf, live, broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Sawadaea bicornis
as *Uncinula bicornis*, *Acer campestre*, leaf, live, broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Sphaerotheca aphanis
as *Sphaerotheca alchemillae*, *Filipendula ulmaria*, leaf, live, broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Sphaerotheca dipsacacearum
Dipsacus fullonum, leaf, live, broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Sphaerotheca epilobii
Epilobium hirsutum, leaf, live, broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Sphaerotheca fusca
as *Sphaerotheca melampyri*, *Odontites verna*, leaf, live, broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

as *Sphaerotheca xanthii*, *Senecio jacobaea*, leaf, live, broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Sphaerotheca pannosa

Rosa sp., leaf, live, broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Hypocreales

Clavicipitaceae

Claviceps purpurea

Anamorph, sclerotium,Poaceae, inflorescence,broad-leaved semi-natural woodland, Col.: H. Arnold, Det: H. Arnold, Conf: S.E. Wells

Teleomorph, Poaceae, Col: S.E. Wells, Det.: S.E. Wells, 07/07/2000, On grass fruits, lying on wet soil on ride. Herb.: FUNGUS2000.

Poaceae, fruit, broad-leaved semi-natural woodland, Col.: T.C.E. Wells, Det.: T.C.E. Wells, 04/08/2001.

Cordyceps militaris

Lepidoptera, pupa, buried, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 14/08/2002.

Epichloë typhina

grass stem, kiving, broad-leaved semi-natural woodland, Col.: T.C.E. Wells, Det.: T.C.E. Wells, 07/07/2000.

Brachypodium sylvaticum, shoots, live, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 07/07/2001.

Hypocreaceae

Chromocrea aureoviridis

Ulmus sp., wood, de-corticate, broad-leaved semi-natural woodland, Col.: T.C.E. Wells, Det.: S.E. Wells, 12/11/2000.

Hypocrea pulvinata

broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Nectria candicans

as *Nectriopsis candicans*, broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Nectria rubefaciens

Parmelia sp., thallus, dead, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, Conf.: B. Spooner, 14/08/2002.

Leotiales

Dermateaceae

Belonopsis filispora

broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Brachypodium sylvaticum, stem, dead, broad-leaved semi-natural woodland, Col.: M. Parslow, Det.: M. Parslow, 07/07/2001.

Hyaloscyphaceae

Calycellina punctata

as *Calycellina punctiformis*, broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Calycellina spiraeae

as *Urceolella spiraeae*, broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Lachnum apalum

as *Dasyscyphus apalus*, *Juncus sp.*, stem, dead, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 06/03/1997.

Lachnum dumorum

as *Dasyscyphus dumorum*, broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Lachnum tenuissimum

as *Dasyscyphus tenuissimus*, *Poaceae*, stem, rotten, broad-leaved semi-natural woodland, Col.: T.C.E. Wells, Det.: S.E. Wells, 04/08/2001.

Lachnum virgineum

as *Dasyscyphus virgineus*, broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Polydesmia pruinosa

broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Leotiaceae

Bisporella sulfurina

as *Calycella sulfurina*, broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Calycina herbarum

as *Hymenoscyphus herbarum*, stem, dead, broad-leaved semi-natural woodland, Col.: T.C.E. Wells, Det.: T.C.E. Wells, 15/10/1995.

Chlorociboria aeruginascens

wood, rotten, broad-leaved semi-natural woodland, Col.: T.C.E. Wells, Det.: T.C.E. Wells, 12/11/2000.

Crocicreas amenti

as *Pezizella amenti*, *Salix cinerea*, catkin, female, fallen, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 06/03/1997.

Crocicreas cyathoideum

as *Phialea cyathoidea*, broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Hymenoscyphus albidus

broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Fraxinus excelsior, petiole, fallen, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 07/07/2000.

Hymenoscyphus caudatus

broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/2001.

Fraxinus excelsior, petiole, fallen, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 20/07/2001.

Hymenoscyphus fructigenus

broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Quercus robur, cupule, fallen, broad-leaved semi-natural woodland, Col.: T.C.E. Wells, Det.: T.C.E. Wells, 04/08/2001.

Hymenoscyphus imberbis

Doubtful record, wood, fallen, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 07/07/2001.

Orbiliaceae

Orbilia auricola

broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Orbilia xanthostigma

broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Sclerotiniaceae

Ciboria caucus

as *Ciboria amentacea*, *Corylus avellana*, catkin, fallen, male, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 06/03/1997.

Pezizales

Helvellaceae

Helvella acetabulum

Crataegus monogyna, soil, broad-leaved semi-natural woodland, Col.: M. Telfer, Det.: S.E. Wells, 15/04/1998.

Helvella ephippium

Crataegus monogyna, soil, broad-leaved semi-natural woodland, Col.: M. Telfer, Det.: S.E. Wells, Conf.: B. Spooner, 10/04/1998.

Helvella lacunosa

soil, broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Morchellaceae

Disciotis venosa

soil, clayey, broad-leaved semi-natural woodland, Col.: T.C.E. Wells, Det.: T.C.E. Wells, 26/05/1973.

Verpa conica

Crataegus monogyna, soil, boundary hedge, Col.: A. Robbins, Det.: A. Robbins, 20/04/2003.

Otideaceae

Aleuria aurantia

broad-leaved semi-natural woodland, Col.: T.C.E. Wells, Det.: T.C.E. Wells, 29/09/1974.

Aleuria luteonitens
broad-leaved semi-natural woodland, Col.: T.C.E. Wells, Det.: T.C.E. Wells, 29/09/1974.

Anthracobia macrocystis
broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Anthracobia melaloma
bonfire site, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 11/04/1974.

Geopora tenuis
Betula sp., soil, wet, broad-leaved semi-natural woodland, Col.: T.C.E. Wells, Det.: T.C.E. Wells, 15/10/1995.

Humaria hemisphaerica
soil, bare ground, Col.: S.E. Wells, Det.: S.E. Wells, 07/07/2000, Herb.: FUNGUS2000.

Ramsbottomia asperior
as *Scutellinia asperior*, soil, wet, mossy, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 22/07/1975.

Scutellinia crinita
as *Scutellinia scutellata* var. *cervorum*, muddy ditch side, Col.: S.E. Wells, Det.: S.E. Wells, 07/07/2000.

as *Scutellinia scutellata* var. *cervorum*, *Salix cinerea*, branch, fallen, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 04/08/2001.

Scutellinia subhirtella
mud, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: T.C.E. Wells, Conf.: S.E. Wells, 07/07/2000, Herb.: herb. S.E. Wells.

Pezizaceae

Peziza badia
broad-leaved semi-natural woodland, Col.: S. Carter, Det.: S. Carter, 28/09/1974.

Peziza depressa
Quercus robur, soil, broad-leaved semi-natural woodland, Col.: T.C.E. Wells, Det.: T.C.E. Wells, Conf.: S.E. Wells, 04/08/2001.

Peziza petersii
broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Peziza vesiculosa
broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Pyronemataceae

Pyronema omphalodes
bonfire site, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 11/07/1974.

Rhytismatales

Rhytismataceae

Lophodermium gramineum
Deschampsia cespitosa, stem, dead, broad-leaved semi-natural woodland, Col.: M. Parslow, Det.: M. Parslow, 07/07/2001.

Propolomyces farinosus
as *Propolis versicolor*, broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Sordariales

Lasiosphaeriaceae

Lasiosphaeria ovina
broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Lasiosphaeria spermoides
broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Xylariales

Xylariaceae

Hypoxylon confluens
broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Hypoxylon fragiforme
broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Nemania serpens
as *Hypoxylon serpens*, broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Basidiomycota

Basidiomycetes

Agaricales

Agaricaceae

Agaricus arvensis
soil, broad-leaved semi-natural woodland, Col.: T.C.E. Wells, Det.: T.C.E. Wells, 26/07/1973.

Agaricus augustus
soil, broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Agaricus excellens
soil, broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 28/09/1974.

Agaricus semotus
soil, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 15/10/1995.

Agaricus vaporarius
soil, broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 28/09/1974.

soil, broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 28/09/1974.

Lepiota cristata
soil, broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Lepiota friesii
soil, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 08/10/1974.

Macrolepiota konradii
soil, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 08/07/1997.

Macrolepiota rhacodes
soil, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 26/07/1973.

Amanitaceae

Amanita citrina
Quercus robur, soil, broad-leaved semi-natural woodland, Col.: T.C.E. Wells, Det.: T.C.E. Wells, 24/09/1999.

Amanita phalloides
soil, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 26/07/1973.

Amanita rubescens
soil, broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 28/09/1974.

Amanita rubescens* var. *annulosulphurea
soil, broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 28/09/1974.

Quercus robur, soil, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 04/08/2001.

Bolbitiaceae

Agrocybe praecox
soil, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, --/05/1973.

Bolbitius reticulatus
Acer campestre, stump, rotten, broad-leaved semi-natural woodland, Col.: T.C.E. Wells, Det.: S.E. Wells, 12/11/2000.

Conocybe appendiculata
soil, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 08/07/1997.

Conocybe mairei
soil, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 08/07/1997.

Conocybe sordida
soil, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 08/07/1997.

Conocybe tenera
soil, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 08/07/1997.

wood, rotting, broad-leaved semi-natural woodland, Col.: T.C.E. Wells, Det.: S.E. Wells, 07/07/2000.

Coprinaceae

Coprinus acuminatus
broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Coprinus angulatus
bonfire site, broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Coprinus auricomus
soil, broad-leaved semi-natural woodland, Col.: J. Emmony, Det.: S.E. Wells, 07/07/2001.
soil, broad-leaved semi-natural woodland, Col.: T.C.E. Wells, Det.: S.E. Wells, 07/07/2000.

Coprinus cortinatus
soil, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 07/07/2000, Herb.: FUNGUS2000.

Coprinus domesticus
wood, rotten, broad-leaved semi-natural woodland, Col.: Anon, Det.: S.E. Wells, 19/07/1992.

Coprinus friesii
Poaceae, stem, dead, broad-leaved semi-natural woodland, Col.: T.C.E. Wells, Det.: S.E. Wells, 14/08/2002.

Coprinus lagopus
soil, broad-leaved semi-natural woodland, Col.: T.C.E. Wells, Det.: S.E. Wells, 14/08/2002.
soil, broad-leaved semi-natural woodland, Col.: T.C.E. Wells, Det.: S.E. Wells, 07/07/2000.
Quercus robur, twig, rotten, broad-leaved semi-natural woodland, Col.: M. Parslow, Det.: M. Parslow, Conf.: S.E. Wells, 04/08/2001.

Coprinus picaceus
broad-leaved semi-natural woodland, Col.: T.C.E. Wells, Det.: T.C.E. Wells, 24/10/1973.

Coprinus rhombisporus
Poaceae, stem, dead, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 04/08/2001.

Coprinus stercoreus
as *Coprinus stercorarius*, dung, rabbit, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 15/10/1995.

Coprinus truncorum
broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 17/05/1974.

Psathyrella atrolaminata
as *Psathyrella caudata*, broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Psathyrella cernua
broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Psathyrella conopilea
soil, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 12/11/2000.

Entolomataceae

Entoloma clypeatum
broad-leaved semi-natural woodland, Col.: Anon, Det.: S.E. Wells, 29/10/1974.

Entoloma hebes
Quercus robur, soil, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 12/11/2000.

Entoloma porphyrophaeum
broad-leaved semi-natural woodland, Col.: T.C.E. Wells, Det.: T.C.E. Wells, 12/09/1974.

Pluteaceae

Pluteus nanus
soil, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 15/10/1995.

Pluteus phlebophorus
Ulmus sp., branch, fallen, broad-leaved semi-natural woodland, Col.: T.C.E. Wells, Det.: R. Watling, 26/05/1973.

Pluteus romellii
soil, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 07/07/2000.

Pluteus semibulbosus
soil, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 09/09/1977.

Pluteus thomsonii
soil, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 08/07/1997.
soil, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 12/11/2000.

Pluteus umbrosus
Ulmus sp., log, broad-leaved semi-natural woodland, Col.: T.C.E. Wells, Det.: T.C.E. Wells, 12/11/2000.

Volvariella parvula
Poaceae, soil, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 23/08/1974.

Strophariaceae

Panaeolus rickenii
soil, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 12/11/2000.

Panaeolus sphinctrinus
broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Pholiota aurivella
broad-leaved semi-natural woodland, Col.: T.C.E. Wells, Det.: D.A. Reid, --/09/1974.

Pholiota squarrosa
broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Psilocybe crobula
Epilobium hirsutum, stem, dead, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 15/10/1995.

Stropharia inuncta
Carex pendula, tuft, live, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 12/11/2000.

Tricholomataceae

Armillaria tabescens
broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 28/09/1974.

Clitocybe candicans
soil, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 12/11/2000.

Clitocybe dicolor
soil, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 12/11/2000.

Clitocybe infundibuliformis
Corylus avellana, soil, broad-leaved semi-natural woodland, Col.: T.C.E. Wells, Det.: S.E. Wells, 12/09/1973.

Delicatula integrella
Ulmus sp., log, rotten, broad-leaved semi-natural woodland, Col.: T.C.E. Wells, Det.: T.C.E. Wells, Conf.: S.E. Wells, 14/08/2002.

Gymnopus erythropus
as *Collybia erythropus*, *Quercus robur*, debris on the ground, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 28/09/1974.

Gymnopus fusipes
as *Collybia fusipes*, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 21/09/1973.

Gymnopus peronatus
as *Collybia peronata*, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 21/09/1973.
as *Collybia peronata*, *Quercus robur*, soil, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 24/09/1999.

Hemimycena tortuosa
Ulmus sp., branch, fallen, wet, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 03/03/1996.
as *Mycena tortuosa*, wood, rotten, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 12/11/2000.

Hohenbuehelia reniformis
Quercus robur, twig, fallen, broad-leaved semi-natural woodland, Col.: T.C.E. Wells, Det.: S.E. Wells, 14/08/2002.

Lepista flaccida
as *Clitocybe flaccida*, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 28/09/1974.

Lyophyllum decastes
soil, broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Marasmiellus vaillantii
twig, fallen, broad-leaved semi-natural woodland, Col.: T.C.E. Wells, Det.: T.C.E. Wells, Conf.: S.E. Wells, 07/07/2000, Herb.: FUNGUS2000.

Marasmius graminum
soil, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 07/07/2001.
broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.
Poaceae, stem, dead, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 14/08/2002.

Marasmius rotula
twig, fallen, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 07/07/2000.
soil, broad-leaved semi-natural woodland, Col.: J. Emmony, Det.: S.E. Wells, 07/07/2001.
broad-leaved semi-natural woodland, Col.: T.C.E. Wells, Det.: T.C.E. Wells, 26/07/1973.

Melanoleuca strictipes
Poaceae, soil, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 27/10/1991.

Mycena acicula
soil, mossy, broad-leaved semi-natural woodland, Col.: T.C.E. Wells, Det.: T.C.E. Wells, 14/08/2002.
broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.
soil, mossy, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 07/07/2000.

Mycena adscendens
Ulmus sp., bark, rotten, broad-leaved semi-natural woodland, Col.: T.C.E. Wells, Det.: T.C.E. Wells, 12/11/2000.

Mycena alba
Ulmus sp., log, mossy, broad-leaved semi-natural woodland, Col.: T.C.E. Wells, Det.: T.C.E. Wells, 12/11/2000.

Mycena capillaris
Quercus robur, leaf, fallen, broad-leaved semi-natural woodland, Col.: T.C.E. Wells, Det.: T.C.E. Wells, 12/11/2000.

Mycena hiemalis
broad-leaved semi-natural woodland, Col.: T.C.E. Wells, Det.: T.C.E. Wells, 07/09/1974.

Mycena leptocephala
broad-leaved semi-natural woodland, Col.: T.C.E. Wells, Det.: T.C.E. Wells, 26/05/1973.
Quercus robur, soil, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 12/11/2000.
Ulmus sp., wood, rotten, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 14/08/2002.

Mycena rorida
broad-leaved semi-natural woodland, Col.: T.C.E. Wells, Det.: T.C.E. Wells, 28/09/1973.

Mycena speirea
Ulmus sp., bark, rotten, broad-leaved semi-natural woodland, Col.: T.C.E. Wells, Det.: T.C.E. Wells, 12/11/2000.

Mycena vitilis
broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Resupinatus applicatus
Ulmus sp., twig, fallen, broad-leaved semi-natural woodland, Col.: T.C.E. Wells, Det.: S.E. Wells, 03/03/1996.

Rhodocollybia butyracea
as *Collybia butyracea*, *Quercus robur & Fraxinus excelsior*, soil, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 15/10/1995.

Rhodocollybia maculata
as *Collybia maculata*, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 28/09/1974.

Rhodotus palmatus
Ulmus sp., log, broad-leaved semi-natural woodland, Col.: Anon, Det.: S.E. Wells, 19/07/1992.

Rickenella fibula
as *Mycena fibula*, broad-leaved semi-natural woodland, Col.: T.C.E. Wells, Det.: T.C.E. Wells, 28/07/1973.
soil, mossy, broad-leaved semi-natural woodland, Col.: T.C.E. Wells, Det.: T.C.E. Wells, 14/08/2002.
sawdust, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 07/07/2000.

Rickenella swartzii
mossy, soil, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 15/10/1995.

Tephrocybe anthracophila
as *Collybia carbonaria*, bonfire site, broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Tephrocybe atrata
as *Collybia atrata*, bonfire site, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 28/09/1974.

Tricholoma fulvum
broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 28/10/1974.

Tricholoma sulphureum
broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Xerula longipes
as *Oudemansiella longipes*, broad-leaved semi-natural woodland, Col.: R. Merton, Det.: R. Merton, 03/08/1973.

Auriculariales

Auriculariaceae

Auricularia auricula-judae
Sambucus nigra, wood, dead, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 24/09/1999.
Sambucus nigra, branch, attached, broad-leaved semi-natural woodland, Col.: T.C.E. Wells, Det.: T.C.E. Wells, 12/11/2000.

Boletales

Boletaceae

Boletus impolitus
broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 11/07/1974.

Pulveroboletus cramesinus
as *Boletus cramesinus*, broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 28/09/1974.

Strobilomycetaceae

Chalciporus piperatus
as *Boletus piperatus*, broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 28/09/1974.
as *Boletus piperatus*, broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Cantharellales

Clavariaceae

Macrotyphula juncea
leaf, litter, broad-leaved semi-natural woodland, Col.: T.C.E. Wells, Det.: S.E. Wells, 04/12/1989.

Cortinariales

Cortinariaceae

Cortinarius crocolitus
broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Cortinarius silvae-monachi
as *Phlegmacium silvamonachorum*, *Mercurialis perennis*, soil, clayey, broad-leaved semi-natural woodland, Col.: R.K. Merton, Det.: D.A.Reid, 25/09/1974.

Galerina hypnorum
Doubtful record, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 26/05/1973.

Gymnopilus junonius
broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 14/09/1973.

Inocybe asterospora
soil, broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Inocybe corydalina
soil, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 28/09/1974.

Inocybe flavella
soil, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 08/07/1997.

Inocybe langei
Populus tremula, soil, broad-leaved semi-natural woodland, Col.: R. Shotbolt, Det.: S.E. Wells, 15/10/1995.

Inocybe lanuginosa
Corylus avellana, soil, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 26/10/1973.
Inocybe margaritispora
soil, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 19/07/1992.
Inocybe napipes
soil, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: T.C.E. Wells, Conf.: S.E. Wells, 07/07/2000.
Inocybe phaeocomis
as *Inocybe cincinnata*, soil, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 26/07/1973.
Inocybe pyriodora
soil, broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.
Phaeomarasmius erinaceus
broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.
Simocybe centunculus
wood, fallen, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 08/07/1997.

Crepidotaceae

Crepidotus inhonestus
twig, fallen, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 08/07/1997.
Crepidotus variabilis
broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 20/10/1973.
Lonicera periclymenum, twig, broad-leaved semi-natural woodland, Col.: M. Parslow, Det.: M. Parslow, 12/11/2000.
Tubaria autochthona
Crataegus sp., soil, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 08/07/1997.
Tubaria conspersa
Fraxinus excelsior, soil, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 14/08/2002.

Dacrymycetales

Dacrymycetaceae

Calocera cornea
Ulmus sp., wood, dead, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 24/09/1999.

Gomphales

Ramariaceae

Ramaria botrytis
broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Hymenochaetales

Hymenochaetaceae

Phellinus tuberculosus
Crataegus monogyna, branch, attached, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 12/11/2000.

Lycoperdales

Lycoperdaceae

Calvatia gigantea
as *Langermannia gigantea*, soil, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 26/07/1973.
Handkea excipuliformis
as *Calvatia excipuliformis*, soil, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 08/07/1997.
Lycoperdon lividum
soil, gravel, broad-leaved semi-natural woodland, Col.: T.C.E. Wells, Det.: S.E. Wells, 29/09/1994.

Poriales

Coriolaceae

Byssomerulius corium
as *Meruliopsis corium*, *Ulmus sp.*, branch, fallen, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 03/03/1996.
Oligoporus caesius
as *Tyromyces caesius*, broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.
Piptoporus betulinus
Betula sp., trunk, dead, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 15/10/1995.
Skeletocutis nivea
as *Incrustoporia semipileata*, broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.
Tyromyces fissilis
as *Aurantiporus fissilis*, *Populus tremula*, dead, standing, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 15/10/1995.

Lentinaceae

Faerberia carbonaria
as *Geopetalum carbonarium*, broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.
Pleurotus cornucopiae
Sorbus torminalis, tree, standing, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 21/10/1989.
Ulmus sp., log, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 12/11/2000.
Ulmus sp., log, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 14/08/2002.
Ulmus sp., trunk, fallen, broad-leaved semi-natural woodland, Col.: J. Emmony, Det.: S.E. Wells, 07/07/2001.

Polyporaceae

Dichomitus campestris
Corylus avellana, twig, fallen, broad-leaved semi-natural woodland, Col.: T.C.E. Wells, Det.: S.E. Wells, 04/08/2001.
Polyporus varius
broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Russulales

Russulaceae

Lactarius azonites
Quercus robur, soil, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 04/08/2001.
Lactarius controversus
soil, broad-leaved semi-natural woodland, Col.: Anon, Det.: R. Rayner, 07/09/1974.
Russula betularum
broad-leaved semi-natural woodland, Col.: Anon, Det.: R. Rayner, 07/09/1974.
Russula carminea
broad-leaved semi-natural woodland, Col.: Anon, Det.: R. Rayner, 07/09/1974.
Russula decipiens
broad-leaved semi-natural woodland, Col.: Anon, Det.: R. Rayner, 07/09/1974.
Russula delica
broad-leaved semi-natural woodland, Col.: Anon, Det.: S.E. Wells, 28/09/1974.
Russula densifolia
broad-leaved semi-natural woodland, Col.: Anon, Det.: R. Rayner, 07/09/1974.
Russula emeticella
broad-leaved semi-natural woodland, Col.: Anon, Det.: R. Rayner, 07/09/1974.
Russula farinipes
broad-leaved semi-natural woodland, Col.: Anon, Det.: R. Rayner, 07/09/1974.
Russula gigasperma
broad-leaved semi-natural woodland, Col.: Anon, Det.: R. Rayner, 07/09/1974.
Russula gracillima
broad-leaved semi-natural woodland, Col.: Anon, Det.: R. Rayner, 07/09/1974.
Betula, soil, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: T.C.E. Wells, Conf.: S.E. Wells, 07/07/2000.
Russula laurocerasi
broad-leaved semi-natural woodland, Col.: Anon, Det.: R. Rayner, 07/09/1974.
Russula melitodes
broad-leaved semi-natural woodland, Col.: Anon, Det.: R. Rayner, 07/09/1974.

Quercus robur, soil, broad-leaved semi-natural woodland, Col.: T.C.E. Wells, Det.: T.C.E. Wells, Conf.: S.E. Wells, 04/08/2001.

Russula odorata
broad-leaved semi-natural woodland, Col.: Anon, Det.: R. Rayner, 07/09/1974.

Russula parazurea
broad-leaved semi-natural woodland, Col.: Anon, Det.: R. Rayner, 07/09/1974.

Russula puellaris
broad-leaved semi-natural woodland, Col.: Anon, Det.: R. Rayner, 07/09/1974.

Russula pulchella
broad-leaved semi-natural woodland, Col.: Anon, Det.: R. Rayner, 07/09/1974.

Russula rosea
broad-leaved semi-natural woodland, Col.: Anon, Det.: R. Rayner, 07/09/1974.

Russula rutila
broad-leaved semi-natural woodland, Col.: Anon, Det.: R. Rayner, 07/09/1974.

Russula subfoetens* var. *grata
broad-leaved semi-natural woodland, Col.: Anon, Det.: R. Rayner, 07/09/1974.
broad-leaved semi-natural woodland, Col.: Anon, Det.: R. Rayner, 07/09/1974.

Russula versicolor
broad-leaved semi-natural woodland, Col.: Anon, Det.: R. Rayner, 07/09/1974.

Russula xerampelina* var. *olivascens
Quercus robur, soil, broad-leaved semi-natural woodland, Col.: R. Shotbolt, Det.: R. Shotbolt, 15/10/1995.

Sclerodermatales

Sclerodermataceae

Scleroderma verrucosum
broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 28/09/1974.

Stereales

Corticiaceae

Vuilleminia comedens
broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Hyphodermataceae

Basidioradulum radula
as *Hyphoderma radula*, *Quercus robur*, branch, fallen, broad-leaved semi-natural woodland, Col.: R. Shotbolt, Det.: R. Evans, 21/10/1989.

Meruliaceae

Auriculariopsis ampla
Salix sp., twig, dead, broad-leaved semi-natural woodland, Col.: T.C.E. Wells, Det.: S.E. Wells, 06/03/1997.

Sistotremataceae

Trechispora farinacea
as *Cristella farinacea*, broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Steccherinaceae

Steccherinum fimbriatum
log, rotten, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 04/08/2001.

Stereaceae

Stereum ochraceoflavum
Quercus robur, twig, fallen, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 12/11/2000.

Tremellales

Exidiaceae

Exidia thuretiana
Fraxinus excelsior, branch, fallen, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 12/11/2000.

Teliomycetes

Uredinales

Coleosporiaceae

Coleosporium tussilaginis
Odontites verna, leaf, live, broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Melampsoraceae

Melampsora caprearum
Salix cinerea, leaf, live, broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Melampsora populnea
Stage 1, *Mercurialis perennis*, leaf, live, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 21/04/1974.

Phragmidiaceae

Phragmidium bulbosum
Stage 111, *Rubus fruticosus agg.*, leaf, live, broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Phragmidium violaceum
Stage 1, *Rubus fruticosus agg.*, stem, live, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 07/05/1974.

Pucciniaceae

Puccinia calcitrapae
Centaurea nigra, leaf, live, broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.
Cirsium palustre, leaf, live, broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Puccinia caricina* var. *ribesii-pendulae
Stage 11, *Carex pendula*, leaf, live, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 07/07/2001.
Stage 111, *Carex pendula*, leaf, live, broad-leaved semi-natural woodland, Col.: M. Parslow, Det.: M. Parslow, 07/07/2001.

Puccinia circaeae
Circaea lutetiana, leaf, live, broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.
Circaea lutetiana, leaf, live, broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Puccinia coronata
Alopecurus pratensis, leaf, live, broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Puccinia glechomatis
Glechoma hederacea, leaf, live, broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Puccinia hieracii
Picris echioides, leaf, live, broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Puccinia punctiformis
Stage 11& 111, *Cirsium arvense*, leaf, live, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 06/07/1996.

Puccinia sessilis
Stage 1, *Arum maculatum*, leaf, live, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 20/04/2003.
Stage 111, *Phalaris arundinacea*, leaf, dead, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 06/03/1997.

Ustomycetes

Ustilaginales

Ustilaginaceae

Ustilago hypodytes
Trisetum flavescens, stem, internodes, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 06/07/1996.

Ustilago segetum* var. *avenae
as *Ustilago avenae*, *Arrhenatherum elatius*, inflorescence, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 06/07/1996.

Myxomycota

Ceratiomyxomycetes

Ceratiomyxales

Ceratiomyxaceae

Ceratiomyxa fruticulosa

wood, rotten, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 14/08/2002.

broad-leaved semi-natural woodland, Col.: Anon, Det.: B. Ing, 07/09/1974.

Myxomycetes

Echinosteliales

Echinosteliaceae

Echinostelium minutum

broad-leaved semi-natural woodland, Col.: Anon, Det.: B. Ing, 07/09/1974.

Liceales

Lycogalaceae

Enteridium olivaceum

as *Reticularia olivacea*, broad-leaved semi-natural woodland, Col.: Anon, Det.: B. Ing, 07/09/1974.

Lycogala terrestre

broad-leaved semi-natural woodland, Col.: Anon, Det.: B. Ing, 07/09/1974.

wood, rotten, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 14/08/2002.

Physarales

Didymiaceae

Didymium squamulosum

Urtica dioica, stem, dead, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 15/10/1995.

Mucilago crustacea

stem, herbaceous, broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 15/10/1995.

Physaraceae

Craterium minutum

broad-leaved semi-natural woodland, Col.: Anon, Det.: B. Ing, 07/09/1974.

Stemonitales

Stemonitidaceae

Stemonitis fusca

broad-leaved semi-natural woodland, Col.: Anon, Det.: B. Ing, 07/09/1974.

Stemonitopsis typhina

as *Comatricha typhoides*, broad-leaved semi-natural woodland, Col.: Anon, Det.: B. Ing, 07/09/1974.

Trichiales

Arcyriaceae

Arcyria obvelata

as *Arcyria nutans*, broad-leaved semi-natural woodland, Col.: Anon, Det.: B. Ing, 07/09/1974.

Arcyria pomiformis

broad-leaved semi-natural woodland, Col.: Anon, Det.: B. Ing, 07/09/1974.

Trichiaceae

Perichaena depressa

broad-leaved semi-natural woodland, Col.: Anon, Det.: B. Ing, 07/09/1974.

Trichia scabra

broad-leaved semi-natural woodland, Col.: S.E. Wells, Det.: S.E. Wells, 02/04/1974.

Trichia varia

broad-leaved semi-natural woodland, Col.: Anon, Det.: B. Ing, 07/09/1974.

Oomycota

Oomycetes

Peronosporales

Peronosporaceae

Peronospora dipsaci

Dipsacus fullonum, leaf, live, broad-leaved semi-natural woodland, Col.: Anon, Det.: Anon, 07/09/1974.

Monks Wood NNR: a bibliography, 1993-2003

Chris Gardiner
English Nature, Bedfordshire and Cambridgeshire Team, Ham Lane House, Ham Lane, Peterborough PE2 5UR

The Proceedings of the 40th Anniversary Symposium included a bibliography of articles and publications relating to the flora and fauna of Monks Wood, and published up to 1993 (Massey & Welch 1994). The bibliography excluded references which had been included in the original Monks Wood book (Steele & Welch 1973), but added any pre-1973 publications that had been subsequently uncovered, or omitted from the book for any reason. The current list follows the same format, listing firstly all known additions to the literature for the period 1993-2003. Further references identified from both the pre- and post 1973 periods and not included in either of the earlier works, have then been appended. This allows a full bibliography to be compiled from the three sources. As in Massey & Welch (1994), neither the annual *Report to Recorders* of the National Butterfly Monitoring Scheme, nor the Annual Reports of the Rothamsted Insect Survey have been included although they will frequently carry at least one reference to a species recorded in Monks Wood.

The number of publications contained in each list is as follows:

Date Period	Steele & Welch 1973	Massey & Welch 1994	Gardiner & Sparks 2005	Date Period Totals
Pre-1973	89	8	68	165
1973-1993	-	187	46	233
1993-2003	-	-	140	140
Publication Totals	89	195	254	538

The apparent 'increase' in the number of pre-1973 publications, with the discovery of a further 68 references (approaching the number that were in the original book), may be in part a product of the more advanced technology now available for retrieving published information through keyword searches at the touch of a computer button.
There is no evidence here that the 1960s or 70s were a 'golden age' of Monks Wood research, although of course much important information was published in that period. The years 1973-1993 produced 233 publications over the twenty years, giving an average of nearly one new title per month – a record which most other Nature Reserves would surely envy. The period since 1993 has actually seen an increase in the rate at which publications have appeared, and Monks Wood continues to provide a significant focus for recording and research.

1. Publications from the period 1993-2003

APPLEBY, B.M., & REDPATH, S.M. 1997. Variation in the male territorial hoot of the tawny owl *Strix aluco* in three English populations. *Ibis*, 139(1), 152-158.

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ARNOLD, H.R., & JEFFRIES, D.J. 2002. Mammal report for 2001. *Annual Report of the Huntingdonshire Fauna and Flora Society,* 54, 36-41.

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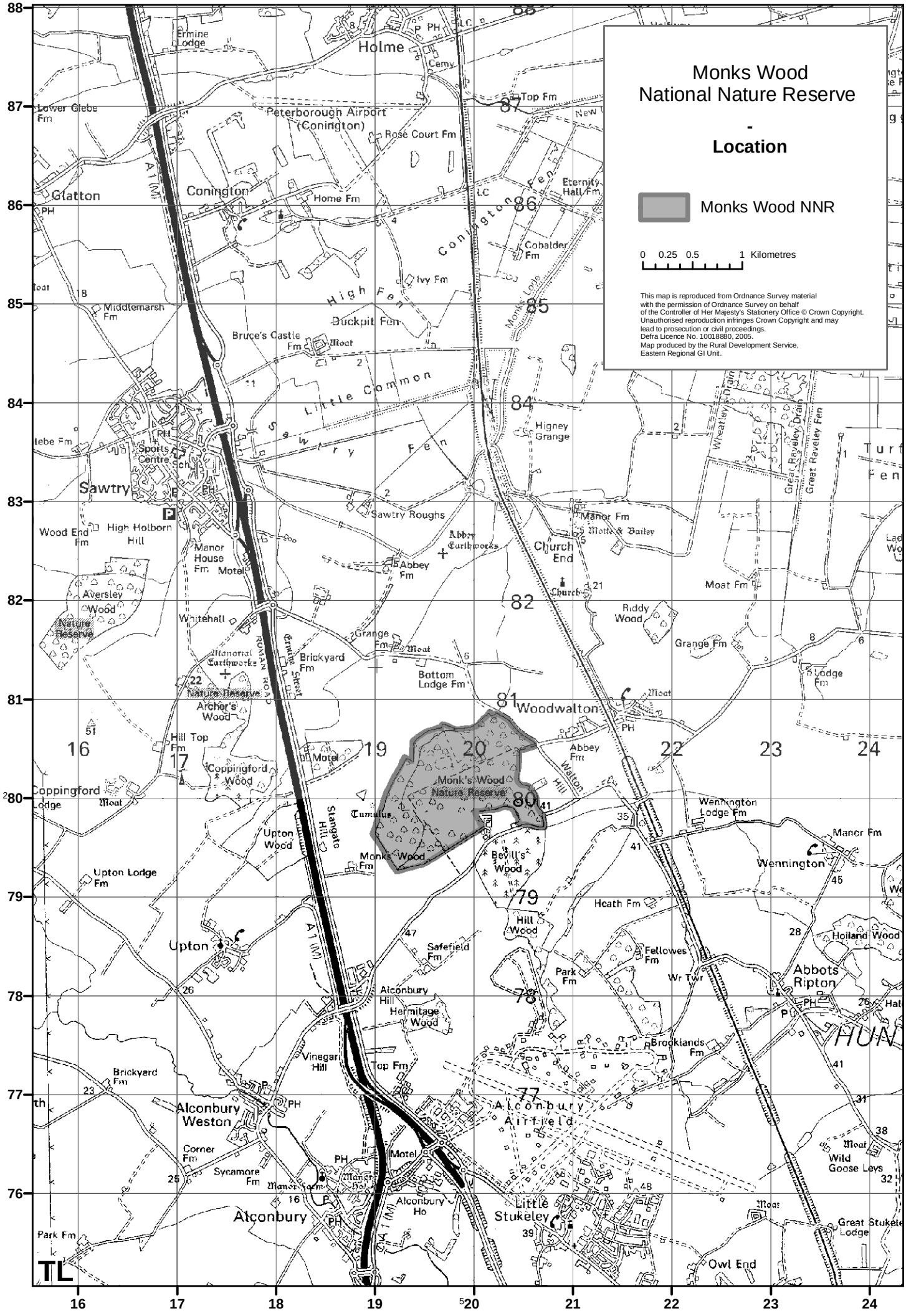
Appendix 1 Maps


Monks Wood
National Nature Reserve
-
Location
Monks Wood NNR
0 0.25 0.5 1 Kilometres
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Holme
Peterborough Airport (Conington)
Glatton
Conington
Sawtry
Woodwalton
Upton
Alconbury Weston
Alconbury
Alconbury Airfield
Little Stukeley
Abbots Ripton
Wennington
Coppingford
Upton Lodge Fm
Sawtry Roughs
Bevill's Wood
Hill Wood
Holland Wood
Wild Goose Leys
Great Stukeley
Owl End
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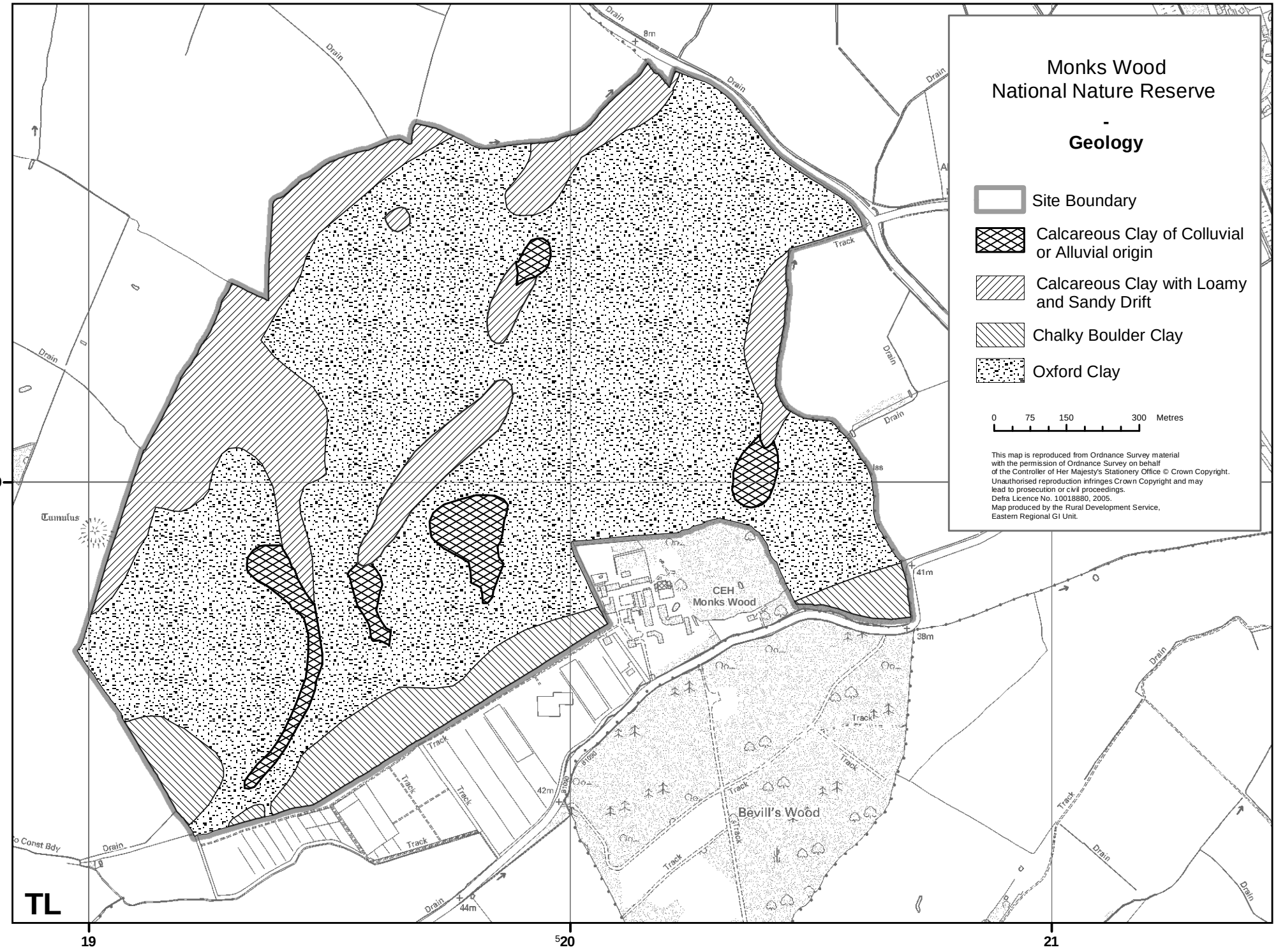
Monks Wood
National Nature Reserve
-
Geology
Site Boundary
Calcareous Clay of Colluvial or Alluvial origin
Calcareous Clay with Loamy and Sandy Drift
Chalky Boulder Clay
Oxford Clay
0 75 150 300 Metres
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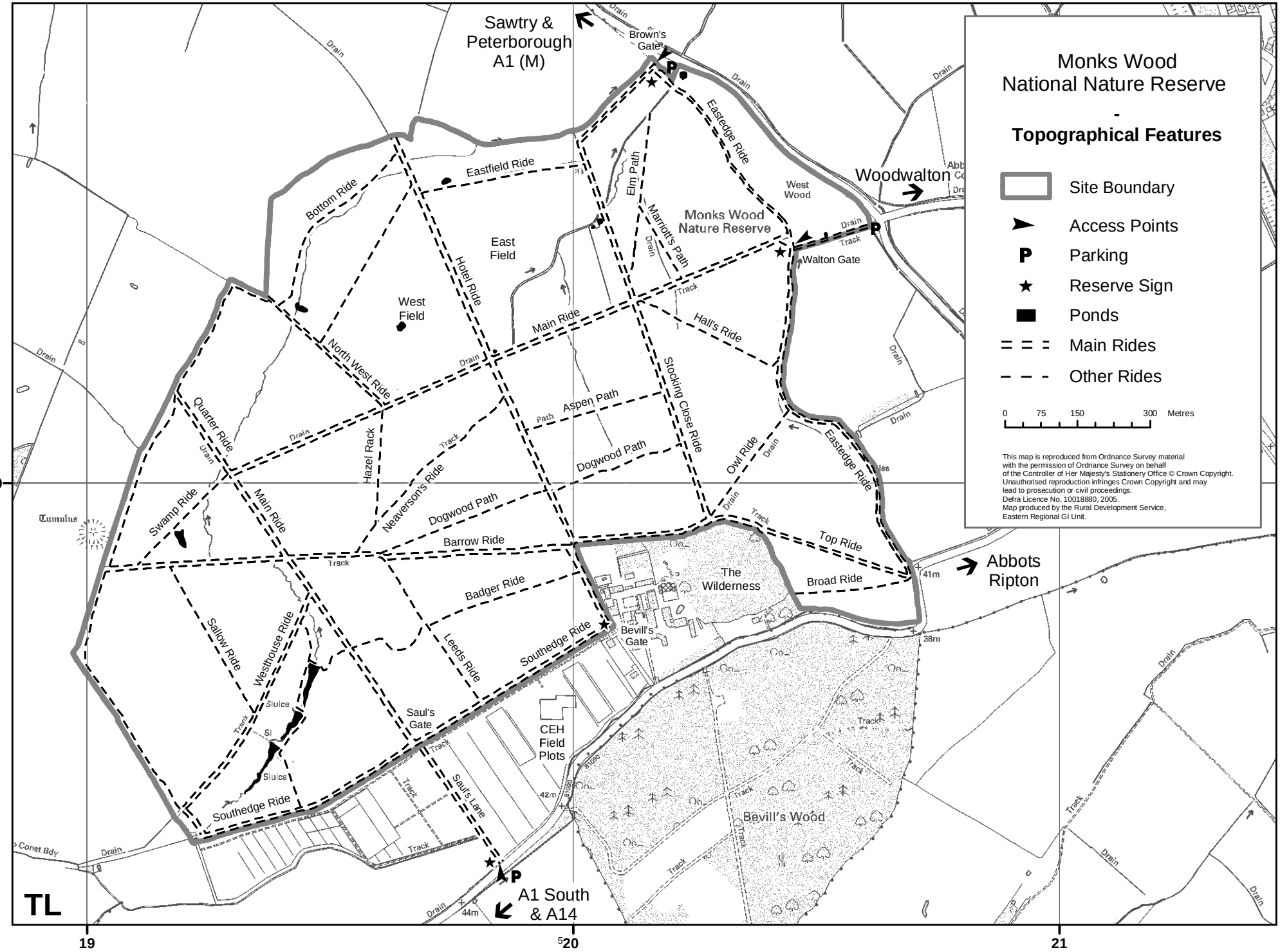
CEH Monks Wood
Bevill's Wood
Tumulus
Track
Drain
Bridge
8m
41m
38m
42m
44m
TL
280
19
520
21


Monks Wood
National Nature Reserve
-
Topographical Features
Site Boundary
Access Points
Parking
Reserve Sign
Ponds
Main Rides
Other Rides
0 75 150 300 Metres
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Sawtry & Peterborough A1 (M)
Brown's Gate
Woodwalton
Monks Wood Nature Reserve
Walton Gate
Eastfield Ride
Bottom Ride
Eastedge Ride
Elm Path
Marriott's Path
West Wood
East Field
West Field
Hotel Ride
Main Ride
Hall's Ride
North West Ride
Stocking Close Ride
Quarter Ride
Aspen Path
Hazel Rack
Neaverson's Ride
Dogwood Path
Owl Ride
Swamp Ride
Barrow Ride
Top Ride
Broad Ride
Badger Ride
The Wilderness
Abbots Ripton
Bevill's Gate
Sallow Ride
Westhouse Ride
Leeds Ride
Southedge Ride
Sluice
Saul's Gate
CEH Field Plots
Saul's Lane
Bevill's Wood
A1 South & A14
Tumulus
TL
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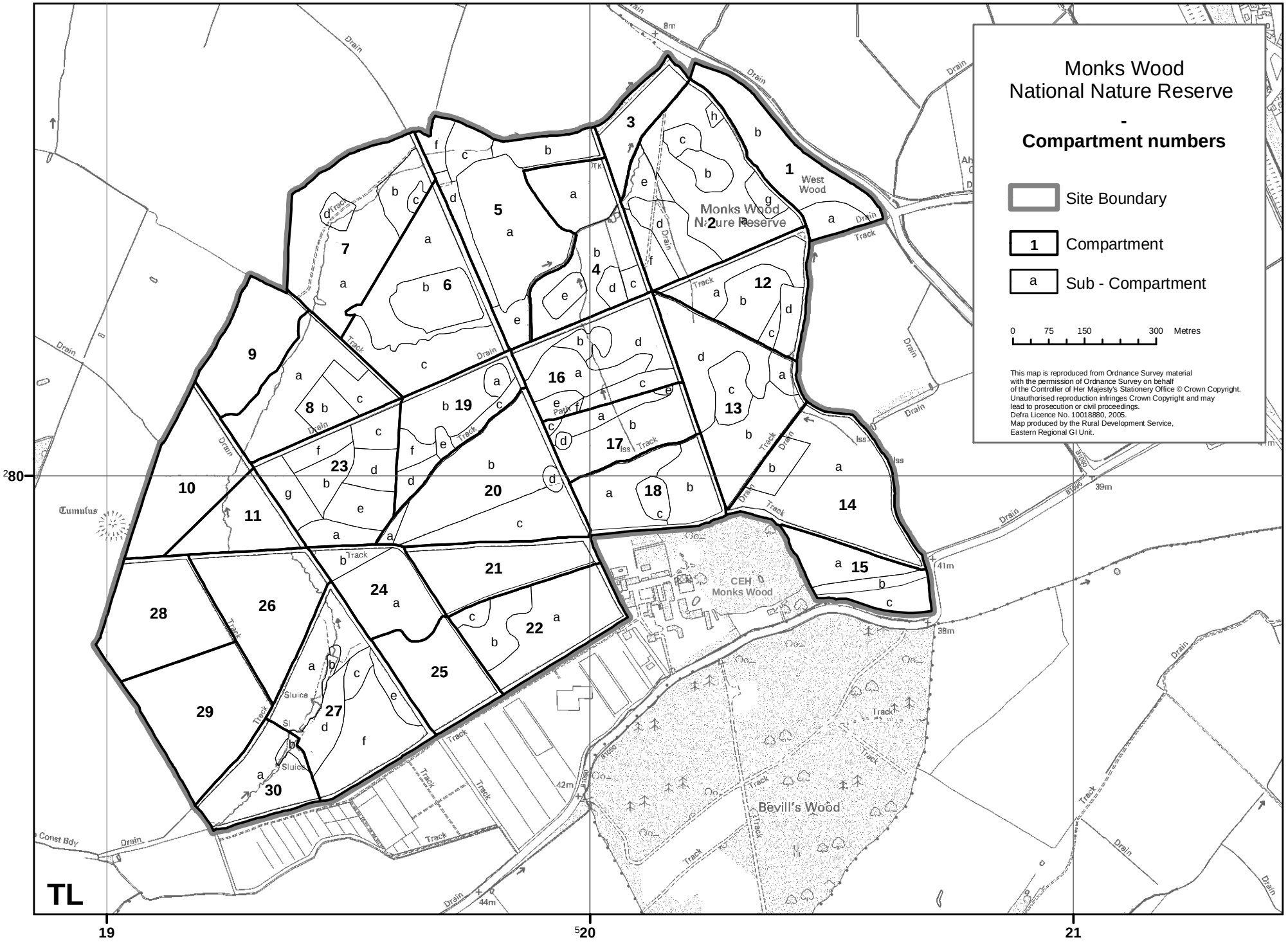
Monks Wood
National Nature Reserve
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Compartment numbers
Site Boundary
1 Compartment
a Sub - Compartment
0 75 150 300 Metres
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Monks Wood Nature Reserve
West Wood
CEH Monks Wood
Bevill's Wood
Tumulus
Sluice
Track
Drain
TL
280
19
520
21

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Paul Glendell/English Nature 24,888
Middle left: Using a home-made moth trap.
Peter Wakely/English Nature 17,396
Bottom left: Co_2 experiment at Roudsea Wood and Mosses NNR, Lancashire.
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