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MITIGATION FOR DORMICE AND THEIR ANCIENT WOODLAND HABITAT ALONGSIDE A MOTORWAY CORRIDOR

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Abstract: The M2 motorway-widening scheme in Kent, England was set within a constrained, environmentally sensitive corridor. Ecologists were involved from the earliest stages of the project and throughout the planning, development, and implementation phases they worked alongside the design engineers to develop pragmatic solutions to the potential impacts of the scheme.

One of the most significant impacts was on the areas of ancient woodland that abut the existing motorway. Since the widening was on-line or adjacent to the existing motorway, the widening proposals sought to minimize the ancient woodland land-take, but some loss was inevitable.

The scheme was discussed at length with the statutory consultees. One option considered was a contribution to off-site habitat creation (mitigation banking). Instead, a scheme for the creation of new woodland adjacent to the scheme was developed. However, rather than simply planting trees onto a bare site, an ambitious proposal to translocate the existing ancient woodland soil to the new site was implemented.

From the outset, the ancient woodland topsoil was identified as a valuable resource, having developed in shaded conditions for hundreds of years and containing a considerable diversity of woodland seeds, bulbs, micro-organisms, and invertebrates. The majority of the woodlands affected by the scheme were commercial sweet chestnut coppice of little intrinsic nature conservation value, but all of the woodlands supported the protected hazel dormouse.

Over a year before the contract to widen the M2 was let, the ecological advance works began on site. The trees within all of the strips of woodland where the motorway widening would take place were coppiced during winter, using hand-held tools and without permitting vehicles onto the ancient woodland soil. This work was timed to coincide with the period when dormice would be hibernating on the ground. On waking from hibernation in spring, the dormice moved into the canopy of the remaining woodland, where their habitat had been enhanced by the provision of artificial nest sites and woodland-management techniques, including selective coppicing and replanting.

The following autumn, the ancient woodland soil (with its seed-bank intact) was carefully excavated and re-spread on a specially prepared 'receptor site.'

One hundred mature coppiced hazel trees were transplanted from the area of the widening to the new site to provide food for dormice. Also, 60,000 new trees of an appropriate diverse species mix and of local provenance were planted. Piles of decaying timber were also assembled to provide a habitat for fungi and dead wood invertebrates.

The new woodland that has been created connects three existing woods, enhancing their nature conservation value and providing a linking function as a substantial 'wildlife corridor.' There is also a public footpath and bridleway, suitably fenced throughout the length of the site so that the new woodland can be enjoyed by local people.

The translocated ancient woodland soil will give the new woodland a valuable start in its development by providing many of the important components of a woodland ecosystem. The site is being monitored closely for at least the next 10 years, and each successfully transferred element of the habitat is being carefully logged and its progress to full establishment recorded. Five years on, the woodland is developing well. There is a distinct woodland ground flora, with carpets of bluebells in the spring, and woodland invertebrates are still present. The tiny fragment of retained woodland in the center of the site still holds a population of dormice. The translocated and new Hazel are beginning to fruit heavily so that a further eight hectares of habitat will soon be available to the population.

Introduction

This paper describes works to mitigate the effects of a motorway-widening scheme in the South-East of the UK on a species protected by national and international policies and legislation, the hazel dormouse (*Muscardinus avellanarius*), along with its ancient woodland habitat.

Advance mitigation works for this project began in 1998; construction took place between 2000 and 2003; and monitoring is intended to extend until 2013. This paper presents a summary of the results of the pre-construction surveys, outlines the main elements of the works to mitigate impacts on both dormice and valuable woodland habitats, and summarizes the interim results of the scheme.

Background to the Project

Authorization for the construction of the A2/M2 Widening between Cobham and Junction 4 in Kent was obtained as part of the Channel Tunnel Rail Link Act (1996). The Highways Agency (which is the Government Agency responsible for the trunk road network in England) agreed to a landscape- and ecological-mitigation strategy with English Nature (the Government's advisor on nature conservation issues) to address the loss of ancient woodland and impacts on populations of protected species adjacent to the road. These ancient woodlands had been fragmented when the motorway was originally constructed. Whilst the widening proposals sought to minimize the ancient woodland land-take, some loss was inevitable. The distribution of the woodland and related habitats along the route is shown on figure 1.

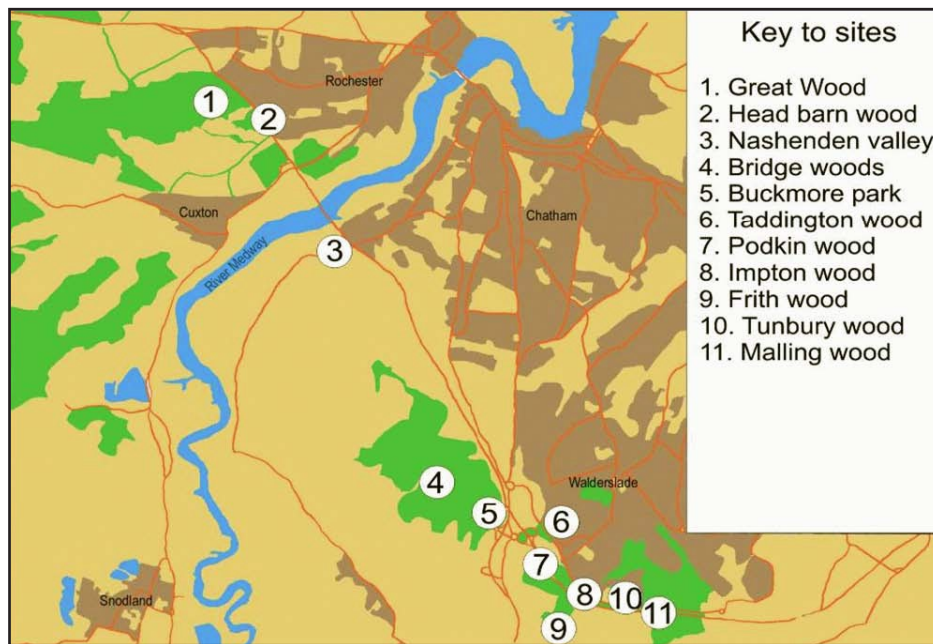


Figure 1. Distribution of woodland and related habitats along route.

The woodlands and some associated habitats were known to support populations of hazel dormice. Proposals were made to ensure the maintenance of these populations and the protection of individual dormice. Allied to this were measures to create replacement woodland habitat. Rather than simply plant new woodland areas, a proposal to translocate the existing ancient woodland soil to a new site was implemented along with a new planting scheme. The principal aim of this soil translocation, along with the translocation of coppice stools, was to create a new broad-leaved woodland of nature conservation value which would support a diverse fauna and flora, including plants, animals, and invertebrate species present in the original woodlands prior to translocation. Whereas from the outset, the ancient woodland topsoil was identified as a valuable resource (having developed in shaded conditions for hundreds of years and containing a considerable diversity of woodland seeds, bulbs, micro-organisms, and invertebrates), the majority of the trees were not. These largely comprised commercial sweet chestnut (*Castanea sativa*) coppice of little intrinsic nature-conservation value.

Nevertheless, each of the woodlands supported dormouse populations. The new woodland creation proposals formed one of three principle elements of a mitigation strategy for these animals:

- Displacement of dormice from the working areas
- Capture and release of dormice from isolated sub-populations into woodlands managed to benefit them
- Creation of the new woodland site

Attention to detail was paramount in this scheme and a partnership between the employer, contractor, engineers, landscape architects, and ecologists was crucial in developing the detailed working methods on site, using standard civil engineering plans.

Background Information on the Hazel Dormouse

Status and protection in the UK

The hazel dormouse is listed on Annex IVa of the EC Habitats Directive. The requirements of this directive are implemented in the UK by the Conservation (Natural Habitats &c) Regulations (1994). The species is protected under Schedule 5 of the Wildlife and Countryside Act 1981 (added in 1988) and Schedule 2 of the Conservation (Natural Habitats & c.) Regulations 1994. The hazel dormouse is also identified as a species of principal importance for biodiversity in England under Section 74 of the Countryside and Rights of Way (CROW) Act (2000), which requires government departments to take or promote steps for its conservation. The hazel dormouse is identified as a Priority Species in the UK Biodiversity Action Plan, for which a Species Action Plan (SAP) has been produced (JNCC 2004; UKBAP 1995). The plan aims to maintain and enhance dormouse populations in all the counties where they still occur and to re-establish self-sustaining populations in at least five counties where they have been lost. The dormouse is also identified as a Priority Species in the Highways Agency Biodiversity Action Plan (HABAP). The main aim of the SAP for dormice is to ensure that new road developments avoid or adequately mitigate any potential impacts on dormice (Highways Agency 2002).

Due to the effects of habitat loss and fragmentation, dormouse numbers and distribution have declined significantly as a result of the isolation of their woodland habitats and inappropriate woodland management. The animals are reluctant

to cross open ground and consequently, are vulnerable to local extinctions when woodland is lost. In addition, the 'grubbing-out' of hedgerows in recent decades has removed wildlife 'corridors' between woods that might have allowed dormice to move more freely to alternative sites. As a result of its serious decline, dormice are classified as 'Lower Risk-near threatened' by the IUCN and 'Vulnerable' in the UK.

Characteristics and ecology

Hazel dormice are small, arboreal rodents, which can easily be distinguished from mice by their long, fluffy tails. They have golden fur on the back and a pale, cream-colored underside. The dormouse has large eyes that betray its strictly nocturnal existence. Dormice tend to weigh between 10 and 30 g, with a head and body length of approximately 50 mm and a tail length of a further 50 mm. They are relatively long-lived for small mammals, surviving up to five years in the wild (Corbett and Harris 1991; Bright et al. in press).

In the UK, dormice are largely restricted to the south of England and Wales, where they live in dense, deciduous woodland, coppice, dense areas of shrubs, and hedgerows. Hazel coppice is a preferred habitat. During their active period, dormice build spherical nests situated a few feet from the ground. Here dormice spend the greater part of the day before emerging after dark to forage in the woodland and understory canopies. They eat flowers and pollen during the spring and fruit in the summer and nuts, particularly hazelnuts in autumn. It is thought that insects are also important components of their diets. This variety of food must be available within a relatively small area, a requirement which limits the suitability of some sites for dormice. Good quality dormouse habitat will comprise a variety of species that will ensure availability of food throughout the period of dormouse activity (April to late October/early November). Furthermore, because dormice tend to feed in the upper branches of their woodland or scrub habitat and they do not make use of food sources available on the ground, this availability of sequentially flowering and fruiting species linked by arboreal route-ways, is crucial (Morris 2004). Bright (1998) also demonstrated the importance of habitat connectivity for dormice.

Recent studies have indicated that the majority of hazel dormice seek suitable places to hibernate on the ground in late-October or early-November (Morris 2004; Bright et al. in press). The majority of animals found active after this time are thought to have been aroused from hibernation, either to search for food, if their fat reserves are not adequate enough to sustain them through the hibernation period, or as a result of mild temperatures (Bright et al. in press; Juskaitis 2005; Csorba 2003; Bright et al. 1996). Hazel dormice in the UK normally hibernate until mid to late April (although, once again, mild conditions and warm locations can induce dormice to become active earlier in the year). As a result, their breeding season occurs relatively late in the year compared to other small mammals and litters are less likely to be found before mid-June. Females generally give birth to one successful litter a year. This usually consists of no more than four young (Juskaitis 1999; Morris 2004).

Methodology and Results of Pre-Construction Investigations

Dormouse surveys

There were existing records of dormouse populations in several of the woodlands that were unavoidably to be affected by the widening works (see figure 1). Additional surveys by consultants during earlier stages of scheme development revealed the presence of dormice in additional locations.

Prior to the advance mitigation works in 1998 and 1999, further investigations of areas of landscape planting were undertaken to confirm the presence/absence of dormice in remaining areas of potentially suitable habitat. This comprised a combination of searches for characteristically-chewed hazelnuts, searches for dormouse nests, and inspections of artificial nest boxes (Bright et al. in press).

The surveys confirmed that dormice were present in each of the areas of established woodland bordering the scheme. In addition, dormice were found to inhabit strips of landscape planting and roadside hedgerows along and within the highway boundary. In several locations, these narrow 'belts' of landscape planting (planted approximately 30 years previously when the motorway was first built and comprising a diversity tree and shrub species) appeared to represent particularly suitable habitat for dormice. In one section of the motorway, along the Nashenden valley, the subsequent mitigation operation for dormice involved a comprehensive capture operation, which served to produce reasonably reliable data on the numbers of dormice present (see below). Transects were walked through this vegetation in order to record its structural and species diversity. The results of these are presented in Appendix I.

Surveys of woodland habitat

Eight woods along the route of the A2/M2 were included in the woodland soil-translocation scheme as 'donor sites' (Brewers Wood, Great Wood, Head Barn Wood, Bridge Wood, Taddington Wood, Frith Wood, Tunbury Wood, and Malling Wood). Quadrat-based surveys of seven of these woodlands were undertaken by consultants during earlier stages of the project in October through November 1997 and repeated in July 1998. Analysis of these data revealed that these would be classified as *W10 Quercus robur-Pteridium aquilinum-Rubus fruticosus* woodland, but some individual quadrats supported a slightly different flora which showed strong affinities to *W8 Fraxinus excelsior-Acer campestre-Mercurialis perennis* woodland (Rodwell 1991). Malling Wood was not surveyed at this time, but a brief walkover survey undertaken in spring 1999 revealed that it would also be classified as *W10* woodland.

Brewers Wood, Great Wood, Bridge Wood, Tunbury Wood, and Malling Wood all comprised neglected sweet chestnut (*Castanea sativa*) coppice, whilst Taddington Wood and Frith Wood comprised neglected hornbeam (*Carpinus betulus*) coppice. Most of the woodlands were shown to support a limited range of woodland ground flora species. This was, in part, due to the time of year that the baseline surveys were undertaken (e.g. wood anemone (*Anemone nemerosa*) was not recorded in any of these woodlands, although it has been recorded post-translocation) and in part due to heavy shading by dense growth of the coppice stools. Nevertheless, most of these woodlands supported ground-flora herbs associated with ancient woodland, together with those associated with disturbed/more open habitats.

Dormouse Mitigation and Habitat Translocation Works

Dormouse mitigation works

These advance mitigation works began more than a year in advance of construction. The measures to mitigate impacts on the resident dormice were designed specifically around seasonal variations in dormouse behavior and habitat use. The works were undertaken under license as appropriate.

Vegetation clearance during the hibernation period

Along the majority of the widening scheme, where the adjacent areas of woodland and associated 'belts' of landscape planting were well connected, the following approach was adopted:

During the winter prior to construction (1998/9), all of the trees and shrubs within the working width were coppiced (cut back to ground level) using hand-tools and avoiding ground disturbance as far as possible. A narrow haul route was 'sacrificed' in terms of preserving the ancient woodland soils and a finger-tip search of this also ensured that hibernating dormice were not killed accidentally. From this haul route, felled timber was extracted using an appropriate lifting plant and lighter material was moved by hand.

A further strip of vegetation was also subject to selective coppicing with the intention of establishing a more 'natural' new woodland edge to help limit the problems of wind throw in subsequent years and to maximize the fruiting capacity and hence productivity of young trees and shrubs within the edge of the woodland into which dormice would be displaced. A total of approximately 250 artificial dormouse nest boxes were also established along these woodland boundaries to provide additional shelter and breeding sites.

Earthworks in these areas were then delayed until late summer/early autumn of the following year (1999). This not only allowed any dormice hibernating within the working width to emerge, but also meant that vegetation translocated at that time of year (see the following) had the best chance of survival.

From the point of view of the resident dormice, the rationale behind this element of the mitigation works was as follows: In any one location, the width to be cleared tended not to exceed approximately 50 m and thus the home ranges of most of the resident dormice were likely to extend beyond the vegetation to be removed (Bright et al. in press). For this reason, the intention was to retain the animals in situ rather than attempt translocation. Cutting the vegetation back in winter avoided the probability of killing or injuring dormice using the tree and shrub canopies, particularly breeding animals and young, and working practices were adopted which sought to avoid the mortality of any animals which would be hibernating within the working width.

Previous studies of dormice released into open areas have shown them to be able to orientate themselves and regain access to cover over distances of this kind (Bright 1998). In addition, shortly after emergence the organization of dormouse home ranges and territorial behavior tends to be in a greater state of flux than at other times of the year (partly as a result of the effects of over-winter mortalities) and thus animals displaced into adjacent habitat would be expected to have a greater distance of establishment and survival in late spring than later in the year.

Capture and Release of Dormice from Isolated Sub-Populations

Capture operations

In certain locations along the route, areas of landscape planting were identified that supported dormice but which were not well connected to the suitable habitat that would be retained post-construction. Thus any animals which might hibernate in these locations would have had difficulty in regaining access to suitable habitat once the vegetation had been removed. Every attempt was made to capture and remove dormice from these isolated areas prior to construction.

A total of approximately 200 artificial nest boxes (Bright et al. in press) were installed within these isolated areas of landscape planting. These were checked regularly during the summer and autumn of 1999. Any dormice found were captured and relocated to a number of release sites (see below). Towards the end of the dormouse 'active' season in 1999 (during October and early November), the vegetation in these isolated areas was cleared with care and under close supervision, with the intention of capturing any remaining individuals.

A total of 36 individual dormice were captured and relocated during this operation. It has been possible, on the basis of these capture data, to estimate population densities in some of the 'belts' of species-rich landscape planting. An overall late season (post-breeding) average of approximately 10 individuals/Ha was estimated, although in the more suitable areas, locally higher densities up to the equivalent of 30/Ha were recorded.

Dormouse receptor site selection, preparation and subsequent management

A proportion of the dormice captured (where very small numbers were encountered in a particular location that was fairly close to suitable retained habitat) were simply released into the retained habitat nearby. However, the majority were released into selected areas of woodland where dormice were either uncommon or absent, but where the habitat appeared to be potentially suitable and worthy of improvement.

Two areas of woodland in particular were chosen as 'dormouse receptor' sites: Impton Wood and Podkin Wood. Impton Wood was a relatively large, isolated area of woodland, largely comprising sub-optimal habitat for dormice, which was thought to support a small, declining population. Podkin Wood was a small area of woodland, again supporting sub-optimal dormouse habitat, but linked to a larger area of more suitable habitat (Frith Wood) with its own large and healthy dormouse population.

During the season prior to release of relocated dormice, both woodlands were subject to woodland-management operations (largely selected felling and coppicing) designed to increase the fruiting capacity of selected shrubs in an effort to increase their productivity for dormice in the shortest time possible. No further works were then undertaken in Podkin Wood, whereas a comprehensive management plan was produced for Impton Wood and is being implemented. This seeks to reduce the dominance of sweet chestnut coppice and to increase structural and species diversity within the woodland through a phased treatment of selective felling, coppicing, and replanting over the next two decades.

In addition to the monitoring scheme for dormice (see the following), the effects of the management works on the woodland vegetation are also subject of a monitoring scheme, with the intention of informing subsequent phases of management.

Creation of the 'New Woodland' site

The location of the new woodland site is shown in figure 2.



Figure 2. Location of new woodland site.

Soil Translocation Works

Receptor site

The receptor site for the translocated soil comprised a large arable field that links three of the 'donor' woodlands (Frith Wood, Tunbury Wood, and Malling Wood). This site was chosen because it provides a link between existing woodland blocks that will form a substantial wildlife corridor and enhance the nature-conservation value of the existing areas of woodland. In addition, the isolated fragment of woodland that comprises Tunbury Wood was found to support a small, vulnerable population of dormice. Linking these animals to those in the adjacent woodlands offered a chance of long-term survival for this population.

Preparation of the receptor site for ancient woodland soils

In September and October 1999 topsoil was stripped (to a depth of approximately 300 mm) from the receptor site and used elsewhere on the widening scheme as a planting medium for landscaped areas. To ensure that there was no loss of function in the subsoil (in particular over-compaction which would lead to a reduction in drainage through the soil profile) the works were carefully planned, including the use of predefined haul routes to minimize the number of vehicle passes over the subsoil surface. To ensure that there was no deterioration in subsoil drainage capacity, the subsoil was also 'ripped.' Subsoil characteristics were also assessed and found to match well with more of the different donor sites.

Excavating soil from the donor sites

The soils on the donor sites were silty clay loams and clay loams. These soil textural types have low plastic limits and are prone to structural degradation if traversed by vehicles or handled when too wet. To avoid problems of soil compaction (which can have consequent effects on drainage, nutrient cycling, and microbial function) site works were only permitted when the soil was at or below field capacity (i.e. the soils did not contain any freely draining water). Haul routes were predefined to ensure the minimum number of vehicle passes over the majority of the site. In total, 10,000 tonnes of topsoil of varying depths were removed using tracked excavators and transported by dumper truck to the receptor site. Depths of excavation and soil horizons were identified on site and care was taken to avoid mixing topsoil and subsoil layers. Large roots (those over 50 mm in diameter) and foreign materials were removed from the soil prior to transportation. A proportion of the cut timber was retained for use in the creation of large dead wood piles on the edge of the new woodland to create habitat for fungi and invertebrates. The remainder of the cut material was disposed of off site.

Transferring the soil and coppice stools

The receptor site was zoned so that soil from the individual woodlands was not mixed together and was spread in well-defined separate areas. No tracking over the newly laid soil was permitted. Soil was loosely tipped (to avoid compaction or smearing) and spread to depths varying between 150 mm and 300 mm to replicate the topsoil depth at the donor sites. Approximately 125 hazel (*Corylus avellana*) coppice stools were also moved from two of the donor woods using a 'tree spade' and placed to create a linear link across the receptor site in order to promote the early development of a corridor of more-mature vegetation to connect the currently isolated fragments of woodland.

Establishing the woodland habitat

A diverse mix of nursery-grown native trees and shrubs of local provenance was planted across the site at 1-m spacings, with a total of 60,000 trees and shrubs being planted. A planting mix was developed to produce the tree and shrub flora typically associated with W8 *Fraxinus excelsior-Acer campestre-Mercurialis perennis* woodland. The adjacent woodlands were each known to support dormice. The new woodland block was intended to form a valuable link for these isolated populations, as well as providing habitat for other wildlife. The mixture used was therefore biased to include a large number of fruit- and nut-bearing species to enhance the value of the developing woodland for dormice.

Woven plastic mulch mats were placed around the bases of the trees and shrubs to prohibit the growth of weedy species and help retain soil moisture. A piped irrigation system, fed by a large tank filled with rainwater, was also installed as an additional water source for the new habitat. Dead or diseased trees and shrubs were replaced as part of a maintenance contract. The use of herbicides and pesticides was prohibited to prevent any damage to the developing flora and fauna. Large clumps of vegetation (mainly grasses) that grew over the mulch mats were pulled away from the tree and shrub stems to reduce the likelihood of field vole damage. To reduce costs, tree shelters were not used, but the larger trees were staked. Rabbit-proof fencing was installed around the boundaries of the site and on the edge of the footpaths created through parts of the site. The trees and shrubs were planted densely in order to create shade as quickly as possible. It was identified that thinning would be required in future years to create suitable light conditions for the woodland ground flora.

Methodology and Results of the Monitoring Activities to Date

Monitoring the effects on dormice

This monitoring scheme began in 2000 and is intended to continue until 2013.

Dormice in retained woodlands

Using the artificial nest boxes installed as part of the mitigation operations for dormice in the retained woodlands close to the scheme where management to improve their productivity for dormice was/is being undertaken, one aim of the monitoring strategy was to monitor the status of dormouse populations in these areas.

To achieve this, the dormouse nest boxes have been inspected monthly between July and October of each year. Several boxes have been vandalized and sequentially replaced to maintain a total of approximately 220. To date, dormouse have been found still to be present in each of the areas in question, with (in most years) evidence of breeding in each area.

Dormice in the two release sites

As explained above, dormice were captured from isolated habitats along the route and released into Impton Woods and Podkin Woods, each of which having been the subject of initial management to increase their productivity for dormice and with Impton Wood being the focus of on-going management operations. As with the retained woodlands, artificial nest boxes were installed in these woods to provide suitable alternative nesting and breeding sites and to facilitate monitoring.

In Podkin Wood, 21 nest boxes were initially installed, then an additional 25 new dormouse boxes were installed in May 2002. For Impton Wood, the majority of originally installed boxes were removed and/or vandalized over the course of the first two years of monitoring. Fifty new boxes were installed in 2002.

As with the retained woodlands, dormouse nest boxes in Podkin Wood and Impton Wood were checked and cleaned on a monthly basis between mid June and mid October each year. Nests belonging to rodents other than dormice and old, disused birds' nests were removed from the boxes to minimize competition for nesting sites. To date, occupancy of the boxes by dormice has remained fairly constant since 2000, fluctuating between an annual average of 6 percent and 11 percent. So far, breeding has not been recorded in any of the boxes, although on the basis of the ages of the animals captured, it is clear that dormice are breeding elsewhere within the woodlands.

Monitoring the Development of the New Woodland Area

Methodologies

The monitoring program involved five elements. The first element was an annual survey to assess the survival and success of translocated hazel coppice stools. For this, the height, canopy spread, fruiting abundance, and level of die-back was recorded every September.

Secondly, surveys to monitor the composition and structure of ground flora on the created site were undertaken to give an insight into the successional processes within the woodland and to determine the success the woodland creation in terms of its similarity to the surrounding woodland communities. During the first year of monitoring (April 2000), permanent quadrats were established in each of the sub-areas of the receptor sites corresponding to the different woodland soils that had been translocated. In each woodland sub-area, a series of five nested quadrats of 10 x 10 m and 4 x 4 m were established to record the scrub and field-layer vegetation. When developed, canopy layer trees will be assessed in five 50 x 50 m quadrats across the site. In each quadrat, the percentage cover of each species was recorded, a general species list compiled to record species outside of the permanent quadrats, and a permanent photographic record taken. These data were recorded each year.

The third element of the monitoring program focussed on invertebrates. By monitoring the composition of invertebrates at the receptor site, the presence and absence of 'indicator' species was to be used to assess whether the created woodland was developing appropriately. To date, two such surveys have been carried out, one in 2000 and one in 2004, with further surveys to be carried out in 2009 and 2013. During these surveys, the ongoing development of the newly created woodland was assessed by monitoring invertebrates associated with dead wood habitats. For this, log piles created on site were sampled using flight-inception traps. In addition, pitfall traps were used to monitor the success of the translocation of the invertebrate fauna from donor woodlands to the receptor site and the subsequent colonization by woodland invertebrates from neighboring habitats.

The fourth and fifth elements of the monitoring program related to fungi and birds: Fungal surveys have also been undertaken annually during the autumn to investigate the value of the dead wood habitat features and the developing woodland generally for these groups. A survey of breeding birds was undertaken in 2004, with further surveys to be undertaken in 2009 and 2013 to assess the value of the developing habitats for these species.

Summaries of Results to Date

Hazel coppice fruiting and re-growth

The results of this element of the mitigation have been very encouraging. Canopy width and height of the translocated stools has increased steadily between 2000 and 2004, with approximately 50 percent of the stools now over 2 m in height. Approximately 95 percent of the plants fruited in the year following their translocation. The majority of the plants have exhibited no die-back. The corridor of translocated coppice shrubs now forms a continuous, potentially functional link between Tunbury Wood and Frith Wood, which would be expected to permit the dispersal of individual dormice to and from Tunbury Wood.

Development of woodland ground flora

The composition of the developing ground flora has been monitored for four consecutive years. As might be expected, the woodland ground flora species varied in abundance across the site. Some areas were dominated by woodland ground flora species, including Bluebell (*Hyacinthoides non-scripta*) and Wood Anemone (*Anemone nemorosa*). Other areas supported, and in places were dominated by, grassland species and plants associated with open, unshaded habitats, including Common Bent (*Agrostis capillaris*), Creeping Bent (*Agrostis stolonifera*), and Yorkshire Fog (*Holcus lanatus*).

The relative abundance of woodland plants appears to be correlated with the level of wind and sun exposure across the site. The more sheltered areas supported larger numbers of woodland plants and the exposed areas contained more plants characteristic of open habitats and disturbed ground. These included a number of invasive weeds, including Common Ragwort (*Senecio jacobaea*), Broad-leaved Dock (*Rumex obtusifolius*), and Spear Thistle (*Cirsium vulgare*).

By 2003, the abundance of woodland herbs had increased in parallel with the growth and establishment of the shrubs and trees on the site. As the canopy develops further, it is expected that the abundance of woodland herbs, grasses, and weeds will progressively change over time to become more characteristically similar to surrounding woodlands.

Development of invertebrate communities

The most recent results have indicated that the area is still in an early stage in its development as woodland ecosystem, but there were indications that the faunal composition may be changing. For example, a number of grassland species had been lost or their abundance had diminished since the first survey. These include *Calathus fuscipes* and *Pterostichus melanarius* (both Common ground beetles; Carabidae), *Liogluta pagana* (a Notable B rove beetle; Staphylinidae), *Staphylinus fortunatarum* (a Notable B rove beetle; Staphylinidae), and *Enicmus transverses* (a Common mold beetle; Lathridiidae). However, only a small number of the woodland specialists recorded in the donor sites in 2000 and 2001 were present in the receptor site. In particular, many species typical of woodland habitats were not recorded in the receptor site in 2004, including *Calathus piceus* (Carabidae: a Common ground beetle), *Cychrus caraboides* (Carabidae: a Local ground beetle), *Acalles misellus* (Curculionidae: a Local litter weevil), *Acelles roboris* (Curculionidae: a Notable B litter weevil), *Platycis minuta* (Lycidae: a Notable B net-wing beetle), *Euophryum confine* (Curculionidae: a Naturalised woodworm beetle), *Dirrhagus pygmaeus* (Eucnemidae: a RDB3 false click beetle), and *Orchesia minor* (Melandryidae: a Notable B false darkling beetle).

Despite the absence of a large proportion of the donor site invertebrate community, the presence of some woodland or woodland edge species in the created woodland and, particularly, the colonization of certain species appeared to be a good indication that a woodland succession is occurring. For example, although *Acelles ptinoides* (the least specialist of the three woodland species of *Acelles*) was the only one currently present in the created woodland, it is reasonable to expect that the other two (*A. roboris* and *A. misellus*) will be recorded in the receptor sites in the future as the woodland matures. In addition, the survival of *Plinothus* spp. (a genus of predatory rove beetles) and *Tropiphorus elevatus* (a broad-nosed weevil commonly linked to Dog's mercury) is encouraging. It is to be hoped that increases in such species will be observed in the future.

Use of the developing habitats by breeding birds

The first of the monitoring surveys in 2004 recorded a total of 26 species using the new woodland site. The majority of these species were not found to be nesting within the site boundary, but did appear to use the new woodland for foraging and/or roosting. Four UK BAP species were recorded within or near the site: Skylark (*Alauda arvensis*), Linnet (*Carduelis cannabina*), Song thrush (*Turdus philomelos*), and Grey partridge (*Perdix perdix*).

The newly created woodland is still very much a developing feature and at present offers nesting opportunities for few woodland species. However, it is likely that as this woodland develops, the nesting and foraging opportunities that it offers to the local breeding-bird population will increase and the species that it attracts will change through the successional process. Its proximity to other woodlands should ensure that it is colonized by woodland bird species at an earlier stage than might otherwise be the case.

The results of the fungal surveys are not yet available.

Discussion and Conclusion

The results to date of the monitoring of dormouse populations along the boundaries of the retained woodlands, along with the results of the careful supervision during the pre-construction and construction works, indicate that the operations to protect dormice during construction and to relocate the dormice were successful.

Similarly, although the populations in question still appear to be in the process of becoming established, the short-distance translocation of dormice to woodlands that are being managed to benefit them also appear to have been successful.

With regard to the establishment of the new woodland site, the interim monitoring results also appear encouraging. It is possible to confirm that many of the woodland ground flora plants recorded in the 'donor' woodlands have been successfully translocated. In addition, most of the woodland species recorded in the first monitoring year, post-translocation, have persisted across the site, although their growth has been more luxuriant in the most sheltered parts of the site. The growth of trees and shrubs across the site appeared to be slower than expected and thus offered only limited shelter. Where woodland plants were present, they appeared to be maintaining a similar proportion of ground cover as they did in the first year of monitoring, despite having to compete with increasingly vigorous grasses.

Studies of mature woodland soils have revealed that the seedbank is largely comprised of opportunistic species associated with more open habitats and that, unless the woodland contains open areas which support these species, it does not reflect the composition of the stable woodland-plant communities above ground (Buckley 1989). Disturbance of woodland soils and an increase in light levels at the ground surface through woodland clearance or translocation operations would be expected to cause dormant seeds to germinate. The increase in the number of 'ruderal' herbs recorded following the translocation of these woodland soils is, therefore, an inevitable consequence of the soil disturbance associated with transference. However, the occurrence of these species does not appear to have had a detrimental affect on the typical woodland ground flora species associated with ancient woodlands.

Species that have failed to appear following soil translocation are those few woodland species that require a degree of shading to germinate, notably the bryophytes and ferns. These species have also failed to appear six years after the soil translocation exercise associated with the CTRL (Helliwell et al. 1996). It was anticipated that the ferns would not

survive translocation and it was for this reason that mature mail-fern (*Dryopteris filix-mas*) plants that were found in the areas of woodland affected by the road scheme were translocated directly into the retained areas of woodland.

The new woodland that has been created connects three existing woodlands, enhancing their nature conservation value and providing a linking function as a substantial wildlife corridor. The translocated ancient woodland soil is providing the new woodland with a valuable start in its development by providing many of the important components of a woodland ecosystem. The site will continue to be monitored closely and each successfully transferred element of the habitat will be carefully logged and its progress to full establishment recorded. The data gathered will provide important guidance for similar projects in the future.

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Appendix 1

Typical transects through embankment vegetation (maturing landscape plantings and self-seeded scrubs)

| Transect 1 | Transect 2 | Transect 3 |
|--|--|--|
| Trees: very open canopy 10-16 m (expressed as total number per 30m section) | Trees: no large trees (expressed as a total number per 30 m section) | Trees: scattered trees (expressed as a total number per 30 m section) |
| <i>Betula pendula</i> 6 <i>Fraxinus excelsior</i> 4 <i>Carpinus betulus</i> 2 <i>Sorbus aria</i> 2 <i>Pinus sylvestris</i> 1 <i>Malus domestica</i> 1 | | <i>Fraxinus excelsior</i> 3 <i>Sorbus aria</i> 1 <i>Malus domestica</i> 1 <i>Salix spp.</i> 1 <i>Acer pseudoplatanus</i> 1 |
| Understorey: very dense 1.5-3 m (expressed as DAFOR scale) | Understorey: very dense 1.5-3.5 m (expressed as DAFOR scale) | Understorey: dense, very dense in places (expressed as DAFOR scale) |
| <i>Cornus sanguinea</i> A <i>Viburnum lantana</i> F <i>Acer campestre</i> F <i>Rosa spp.</i> F <i>Betula pendula</i> F <i>Sambucus nigra</i> O <i>Salix spp.</i> O <i>Euonymus europaeus</i> O <i>Crataegus monogyna</i> O <i>Ligustrum vulgare</i> O <i>Prunus spinosa</i> R <i>Quercus robur</i> R <i>Acer pseudoplatanus</i> R <i>Fraxinus excelsior</i> R | <i>Cornus sanguinea</i> D <i>Viburnum lantana</i> O <i>Acer campestre</i> R <i>Rosa spp.</i> F <i>Betula pendula</i> O <i>Salix spp.</i> F <i>Crataegus monogyna</i> R <i>Ligustrum vulgare</i> R <i>Fraxinus excelsior</i> R <i>Rhamnus cathartica</i> O | <i>Malus domestica</i> R <i>Cornus sanguinea</i> D <i>Viburnum lantana</i> O <i>Acer campestre</i> O <i>Rosa spp.</i> F <i>Betula pendula</i> O <i>Sambucus nigra</i> R <i>Salix spp.</i> F <i>Euonymus europaeus</i> A <i>Crataegus monogyna</i> O <i>Ligustrum vulgare</i> R <i>Acer pseudoplatanus</i> R <i>Fraxinus excelsior</i> R <i>Rhamnus cathartica</i> O <i>Corylus avellana</i> R <i>Buddleja sp.</i> R |
| Climbers etc: throughout understorey and up to 5 m into trees | Climbers etc: throughout understorey and up to 5 m into trees | Climbers etc: throughout understorey and up to 5 m into trees |
| <i>Rubus fruticosus (agg.)</i> A <i>Clematis vitalba</i> F | <i>Rubus fruticosus</i> F <i>Clematis vitalba</i> F <i>Lonicera periclymenum</i> R | <i>Rubus fruticosus</i> F <i>Clematis vitalba</i> F <i>Lonicera periclymenum</i> R |