

Review of red squirrel habitat in central Wales

by

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Executive Summary

Two years ago a hair tube survey took place in the three largest Forest Enterprise woodlands of Central Wales (Tywi, Irfon and Crychan forest) and one of the adjacent privately managed woodlands (Bryn Arau Duon). This survey proved that a red squirrel population continues to exist in Central Wales. As a result it was decided that there was a need to review the suitability of the forests of Central Wales for red squirrels. This report discusses this habitat review with respect to the amount of suitable habitat available to the red squirrels at the present time and the consequences of the long-term planned forestry operations.

The amount and quality of available suitable habitat was determined by identifying stands of favoured tree species and taking into account the age of the trees, the stand size and the degree of fragmentation of the forest (which can lead to the isolation of suitable habitat). The current situation was then compared with that predicted from forest design plans for the following ten, twenty and fifty year periods. The results suggest that at present there is some suitable habitat in these forests but over the next twenty years the proposed clear felling programme will create highly fragmented forests that will isolate potentially good areas for red squirrels. This will make the forests far less suitable for red squirrels and the population size is likely to decrease considerably. In addition the proposed long-term planting of large seeded broadleaved species will make the forests ideal habitat for grey squirrels.

This report recommends specific alterations to the design plans that will reduce the effect of fragmentation by the felling of smaller coupes in certain areas. If this were carried out, together with a change in the proposed tree species to be planted in a few areas of the forests, then the red squirrel population would have a far greater chance of survival in Central Wales.

Crynodeb Gweithredol

Ddwy flynedd yn ôl cynhaliwyd arolwg tiwbiau blew yn nhri o goetiroedd mwyaf Menter Coedwigaeth yn y canolbarth (coedwigoedd Tywi, Irfon a Chrychan) ac yn un o'r coetiroedd cyfagos sydd dan reolaeth breifat (Bryn Arau Duon). Profodd yr arolwg hwn fod gwiwerod coch yn dal i fodoli yn y canolbarth. O ganlyniad penderfynwyd bod angen adolygu addasrwydd coedwigoedd y canolbarth ar gyfer gwiwerod coch. Mae'r adroddiad hwn yn trafod yr adolygiad cynefinoedd o ran faint o gynefinoedd addas sydd ar gael i'r gwiwerod coch ar hyn o bryd a chanlyniadau tymor hir y gwaith a arfaethir yn y goedwig.

Penderfynwyd ynglŷn â maint ac ansawdd y cynefinoedd addas sydd ar gael drwy nodi safleoedd y rhywogaethau coed perthnasol a rhoi cyfrif am oedran y coed, maint y safleoedd a'r graddau y mae'r goedwig wedi ei darnio (gan fod hynny'n gallu arwain at ynysu'r cynefinoedd addas). Yna cymharwyd y sefyllfa bresennol â'r hyn y mae cynlluniau dylunio'r coedwigoedd yn ei ddarogan ar gyfer y deg, ugain a'r hanner can mlynedd nesaf. Mae'r canlyniadau'n awgrymu bod rhai cynefinoedd addas ar gael ar hyn o bryd yn y coedwigoedd hyn ond tros yr ugain mlynedd nesaf bydd y rhaglen clirio coed yn creu coedwigoedd tameidiog iawn a gallai hynny ynysu ardaloedd a allai fod yn rhai da ar gyfer wiwerod coch. O'r herwydd bydd y coedwigoedd yn llawer llai addas ar gyfer wiwerod coch a bydd maint y boblogaeth yn debygol o leihau'n sylweddol. Yn ogystal yn y tymor hir bydd plannu rhywogaethau brasddeiliog sydd â hadau mawr yn gwneud y coedwigoedd yn gynefinoedd delfrydol ar gyfer wiwerod llwyd.

Mae'r adroddiad hwn yn argymhell gwneud newidiadau penodol i'r cynlluniau dylunio a fyddai'n lleihau'r effaith o ddarnio'r coedwigoedd drwy glirio safleoedd llai o faint mewn rhai ardaloedd. Pe câi hyn ei wneud, yn ogystal â newid y rhywogaethau coed y bwriedir eu plannu mewn rhai ardaloedd o'r coedwigoedd, byddai cyfle llawer gwell i'r gwiwerod coch oroesi yng nghanolbarth Cymru.

1. Introduction

In Wales, the red squirrel is now confined to just a few sites in Gwynedd, Clwyd and central Wales, where it remains seriously threatened. The Countryside Council for Wales (CCW) commissioned a preliminary study to collate all recent records of red squirrels to identify remaining refugia (Matthew et al, 2000). This was followed by a hair tube survey in sites believed to be potentially good for red squirrels in Tywi, Irfon, Crychan and Bryn Arau Duon forests (Cartmel 2001). The habitat requirements of red and grey squirrels have been studied considerably in Clocaenog Forest (Cartmel 2000) and were also discussed in detail in the hair tube report (Cartmel 2001). This information also sets the scene for this review and has been included in section 2 of this report.

As with forests throughout Wales, many of the trees were planted in the late 1930 to 1950's and these trees have reached economic maturity. Indeed, over the last 10 years much of these forests have been clear felled, and more is scheduled to be felled in the next ten years. This is of great concern in areas where red squirrel populations are believed to still exist. It was realised that there was an urgent need to obtain an overview of the forestry operations (felling and replanting) over the next ten years in these forests of central Wales and to assess the implications to the red squirrel population. This has been the aim of this project, which has been carried out by Sarah Cartmel in liaison with the appropriate forestry managers. The forests under consideration (see Map 1 in appendix) are:

- (i) Tywi Forest Area which includes:
 - Tywi (north and south) – managed by Forest Enterprise
 - Nant yr Hwch – managed by Tilhill
 - Bryn Arau Duon – managed by Huw Denman

- (ii) Irfon Forest Area which includes:
 - North Irfon and Esgair Dafydd – managed by Forest Enterprise
 - Dinas and Nant y Cerdin– managed by Tilhill
 - Nant y Bai and Erwr Hwch, Esgair Berfedd, Coed Ifan, Cwm Henog – managed by Woodland Management Wales (Peter Goodyear)

(iii) Crychan Forest Area which includes:

Crychan – managed by Forest Enterprise

Glyn Saer – managed by Woodland Management Wales (Peter Goodyear)

Although the main concern is the immediate future of these forests (i.e. the next ten years) the development processes within forests are very slow, with most conifers not producing seed until over twenty years old and many broadleaved species over 40 years old. Thus the food provisions for the squirrels in the forests will take time to develop. Therefore this review has extended the time scale to look at the long-term situation in these forests for red and grey squirrels for the next ten, twenty and fifty years.

2. Requirements of red and grey squirrels

Both species of squirrel feed primarily on tree seed although they will eat other plant matter, including fungi, flowers, berries and occasionally insects such as caterpillars (Moller, 1983). In Europe red squirrels are found in conifer forests consisting of Scots pine *Pinus sylvestris*, Norway spruce *Picea abies* and Siberian spruce *Picea obovata*, in Britain they are also found in broadleaved woodland where no grey squirrels are present (Gurnell, 1991). Grey squirrels originate from the dense broadleaved woodlands of eastern North America but in Britain they will occupy many habitats including broadleaved and conifer woodland, gardens, parks, hedgerows and urban woodland (Gurnell, 1991). Both species of squirrel are quite specific in their requirements but grey squirrels are more adaptable. It is necessary to gain knowledge of the ecology of the two squirrel species and of the habitat they are occupying to determine what these requirements are.

a) Tree species

In conifer forests the preferred food type of red squirrels has been found to be Norway spruce (Andren & Lemnell, 1992; Lurz et al., 1995; Cartmel, 2000) and Scots pine, although the latter is also favoured by grey squirrels (Gurnell et al., 1997; Smith, 1999; Kenward et al., 1998; Cartmel, 2000). Cartmel (2000) also found that Japanese larch was eaten by both squirrel species when it was available and that Norway spruce was often favoured for drey sites. Conifer seed is small and relatively low in energy compared to large seeds of broadleaves (e.g. oak, beech). Grey squirrels are much larger animals than red squirrels (mean red squirrel weight 300g, mean grey squirrel weight 550g, Gurnell,

1991); therefore grey squirrels have a much higher energy requirement (Gurnell et al., 2001). Grey squirrels living in conifer forests therefore require conifers that produce seeds of high energy content (e.g. Scots pine), or patches of large seeded broadleaves, or they will only occupy the forest in years when the conifers produce a large seed crop (mast year) (Cartmel, 2000). These mast years are occasional and depending on the tree species may occur anything from 3 to 10 years apart. For example Sitka spruce tends to produce a mast crop about every three years whereas Norway spruce produces a mast crop every 5 to 10 years (Gordon & Faulkner, 1992; Matthews, 1955, 1989; Staines et al., 1987). Between these mast years if there are no other suitable trees to feed on grey squirrels may move out of the conifers to areas of better feeding whereas red squirrels appear to be able to continue to find sufficient food (Cartmel, 2000). The critical point for grey squirrels is therefore the proportion of higher energy seed producing conifers and large seeded broadleaves present in the forest.

The main requirement for red squirrels is a sufficient proportion of their favoured tree species: Norway spruce, Scots pine and larch within the forest. The greater proportion of these species in the forest the greater the potential for increasing the number of red squirrels. Lurz et al. (1995) recommended that the area under consideration should consist of a minimum of 20% pine and Norway spruce and that Scots pine be used where possible as it supports higher densities of red squirrels than Lodgepole pine. Because grey squirrels also favour Scots pine it is important to keep the ratio of Scots to Norway spruce to no more than 1:3, therefore ideally about 5% of the forest should be Scots pine and 15% Norway spruce with perhaps another 5% consisting of Japanese larch.

Even a small group of broadleaved trees can be sufficient to maintain a grey squirrel population within a conifer forest. Smith & Gurnell (1997), studying grey squirrels in the Scots pine forest of Cannock Chase in Staffordshire, found a higher density of grey squirrels in their study site containing some peripheral broadleaves compared with their site containing no broadleaves. They suggest that even 1% broadleaves in a conifer forest could be enough to maintain a population of grey squirrels. Therefore to discourage grey squirrels from occupying a conifer forest it is necessary to keep the proportion of broadleaves that produce large seeds (e.g. oak *Quercus spp.*, beech *Fagus sylvatica*, hazel *Corylus avellana*) to an absolute minimum. Small seeded broadleaves such as birch *Betula*

spp., willow *Salix spp.* and rowan *Sorbus aucuparia* will not affect the squirrel population and so are acceptable in the forest.

Conifer forests in Wales tend to be dominated by Sitka spruce. This species is occasionally utilised by squirrels during mast years but it is generally not a favoured tree species by either squirrel species (Cartmel, 2000). This can be advantageous because a large buffer zone of Sitka around the forest can help to discourage the infiltration of the forest by grey squirrels.

b) Age structure

The age of trees within a forest can give an indication of the amount of conifer seed produced at a specific time and thus it is possible to predict how much food is available to the squirrels at the present time and in the future. Conifers do not produce cones until they are at least 15 years old (Table 5.1) and will not produce a good cone crop until at least 30 years old (Gordon & Faulkner, 1992). Therefore it is necessary to consider the forest in terms of the proportion of trees that are currently of coning age and therefore supporting the population, and the proportion of trees that will produce food in the future – including young trees not yet coning and areas that will be replanted.

Table 1 Age of trees (years) when produce first good cone crop, when produce maximum cone crop, and number of years between mast crops (from Anon, 1983; Gordon & Faulkner, 1992)

	First good crop	Maximum cone production	No. of years between crops
Norway spruce	30 – 35	50 - 60	3 – 7
Scots pine	15 – 20	60 - 100	1 – 3
Japanese larch	15 – 20	40 - 60	3 – 6

A recommended age structure for pine and Japanese larch is (Gurnell, 1996):

30% of trees 0 – 15 years old, 30% of trees 16 – 30 years old and 40% of trees >30 years old.

Norway spruce does not produce cones at such an early age as pine and larch and an alternative age structure for this species only would be (Cartmel, 2000):

30% of trees 0 – 30 years old, 30% of trees 31 – 45 years old, 40% of trees >45 years old.

c) Habitat links

In any population loss of connections can lead to increased isolation of local populations and a reduction in gene flow and recruitment rate. Red squirrels spend on average 67% of their time in trees (Kenward & Tonkin, 1986) and are often very reluctant to cross open ground, whereas grey squirrels only spend 14% of their time in trees and are not concerned about crossing open areas. Within conifer forests in particular, the quality of the habitat for red squirrels is very patchy with favourable feeding areas scattered through the forest and these patterns will change from year to year depending on the coning of each tree species. Red squirrels will move around in the forest taking advantage of what is currently producing seed, therefore they need to be able to travel safely through the forest preferably within the tree tops where they are less susceptible to predation (Cartmel, 2000). Forestry work such as clear felling breaks up the forest into a mosaic of patches of open areas and this may reduce the links available to the squirrels by creating large open spaces that red squirrels will not traverse. The distribution and size of open areas within a forest is therefore very important to red squirrels. Any large areas of clear fell would ideally require some form of link such as a hedgerow or thin group of trees bordering or crossing the area.

3. Methods

A digitised subcompartment database has been used for FE woodlands and restock information from maps has been inputted into a GIS system (MapInfo). For the other woodlands the areas have been roughly digitised (not accurately) from maps therefore this data is much less accurate but can be used to give an overall picture of the situation.

By using the available information (from the FE database, species maps and current forest design plans) of: present tree species, planting year, felling year and new planting species, habitat suitability indices (SI) have been produced for all compartments for the present day (2002), 10 years, 20 years and 50 years ahead. These indices have been produced for red and grey squirrels, ranging from 1 to 4 and indicate:

1 = areas of clear fell or young trees (<10 years) or open ground, all unsuitable for a squirrel to cross/traverse through.

2 = trees large enough for squirrels to traverse through safely but are not suitable food sources and therefore not likely to be used by squirrels except to travel through to other more suitable areas.

3 = trees that will provide a food source for the squirrels and are capable of supporting a population,

4 = the highest quality habitat providing the best/most favoured food sources.

Each compartment may consist of several different tree species and ages and these are considered together to give an average suitability. For instance if an area is predominantly Norway spruce then it is given a suitability index of 3 or 4 for red squirrels (depending on the age of the trees), but if this is mixed with large seeded broadleaves then the suitability will decrease for red squirrels and increase for grey squirrels. At all times the age of the trees are considered with respect to the age that they begin to produce seed and the age they can produce a maximum cone crop.

These suitability indices have been mapped using the GIS program to give a graphical picture of the suitability of these forests for each of the four time periods (see maps in appendix).

An estimate of the number of squirrels that each forest could support has been calculated using the calculated total area of suitable habitat (suitability indices 3 and 4) for each squirrel species. The calculations are based on a density of 0.32 red squirrels ha⁻¹ which was the red squirrel density estimate calculated from the study in Clocaenog Forest (Cartmel, 2000) and a grey squirrel density of 0.6 squirrels ha⁻¹ which was an estimate obtained by Smith (1999) in a mixed conifer habitat which is similar to the most suitable areas within these forests. Suitable habitat areas that are too small to support squirrels (red <3.3 ha, grey <1.6 ha) have been excluded from these calculations and so the numbers obtained will be the minimum that each forest can support. These figures can only be used as a guide as there is likely to be much variation in density between different forests (mixtures of tree species and ages will affect densities as well as connectivity of the forest), and a more complicated model would have to have been used to give a more precise picture (Gurnell et al., 2002).

4. Results

The effect of the design plans can be seen in the series of maps for present day (2002) 10, 20 and 50 years ahead (all maps are in the appendix). These maps give an overview of the amount of suitable habitat within each forest at the present time and in the future. By comparing maps it is possible to see the potential change in suitable habitat that will occur if the current design plans are implemented. The maps also give an indication as to how fragmented the forests are at each period in time.

Tables 2 to 4 and figure 1 show the potential size of the red and grey squirrel populations within each forest (and forest area).

Table 2 predicted squirrel population size for Tywi Forest Area

a) Red squirrel

Year	N Tywi	S Tywi	Bryn Arau Duon	Nant yr Hwch	Total
2002	123	63	8	149	343
2012	169	70	17	149	405
2022	108	48	17	149	322
2052	135	136	17	149	437

b) Grey squirrel

Year	N Tywi	S Tywi	Nant yr Hwch	Bryn Arau Duon	Total
2002	49	97	280	6	432
2012	295	149	280	41	765
2022	192	98	280	42	570
2052	632	133	280	42	1087

Table 3 predicted squirrel population size for Irfon Forest Area

a) Red squirrel

Year	N Irfon	Esgair Dafydd	Dinas	Nant y Cerdin	Coed Ifan	Cwm Henog	Nant y Bai	Total
2002	58	12	18	25	0	11	11	135
2012	55	16	18	7	0	18	11	125
2022	32	15	7	0	0	18	11	83
2052	74	33	16	3	0	11	3	140

b) Grey squirrel

Year	N Irfon	Esgair Dafydd	Dinas	Nant y Cerdin	Coed Ifan	Cwm Henog	Nant y Bai	Total
2002	102	21	12	0	0	4	6	145
2012	91	31	12	0	0	12	6	152
2022	55	29	8	0	0	12	6	110
2052	111	3	26	0	0	12	6	158

Table 4 Predicted squirrel population size for Crychan Forest Area

a) Red Squirrel

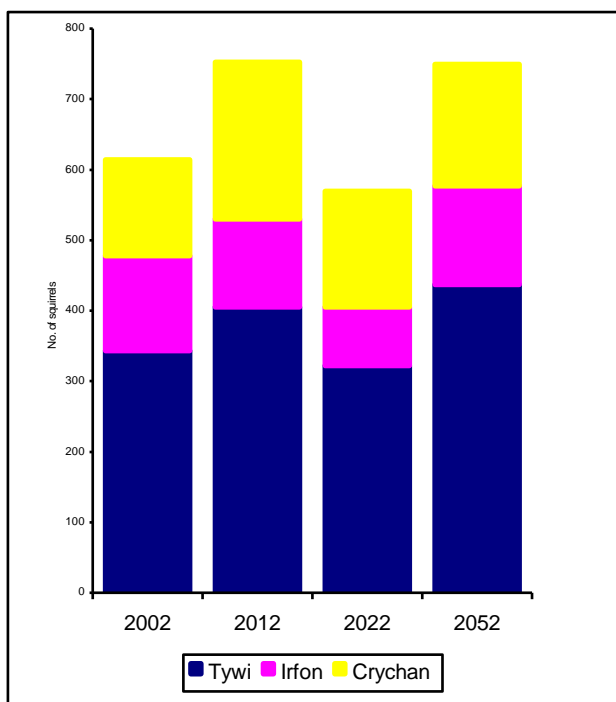
Year	Crychan	Glyn Saer	Total
2002	79	57	136
2012	165	57	222
2022	107	57	164
2052	115	57	172

b) Grey squirrel

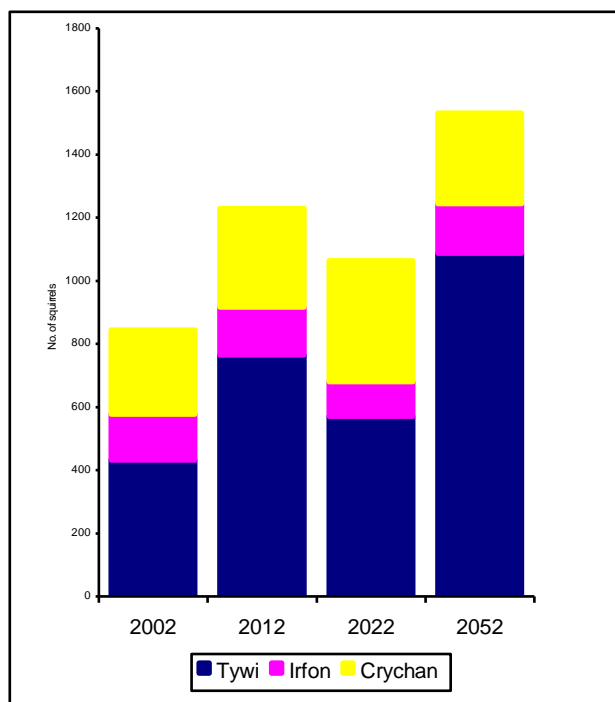
Year	Crychan	Glyn Saer	Total
2002	204	63	267
2012	249	63	312
2022	320	64	384
2052	220	66	286

Figure 1 Predicted population numbers for the Mid Wales Forests

a) Red squirrel



b) Grey squirrel



5. Discussion

Each forest area is discussed in relation to the maps in the appendix.

a) Tywi Forest Area (maps 3, 6 – 14)

This forest area is almost split in half by Llyn Brianne to the south and two large areas of open ground to the north thus dividing the forest into an eastern and western section. In the eastern section Nant yr Hwch forest provides a very important link between suitable habitat areas to the north and south. At the present time (2002) the borders of Nant yr Hwch forest contain the largest areas of suitable habitat for squirrels in this region. Both red and grey squirrels will favour these larch and pine borders. The present forest design plan states that these borders will be managed as permanent retention. Hence these areas will continue to be important feeding areas for red squirrels throughout the period of this review. They are extremely important source areas for the red squirrels in Tywi forest area and it is vital that they are retained and do not become fragmented. The interior of Nant yr Hwch is in the process of being felled, although this is not clear from the habitat suitability maps. It is important to maintain links through the centre of this forest for the red squirrels so that they can travel between the good feeding areas. Another very important area of Nant yr Hwch is the far northern section (called Esgair Bach and Esgair Cloddiad). This area links Nant yr Hwch to north Tywi but is also at the start of its second rotation and so much of this area will be uncrossable over the next twenty years.

North Tywi contains a relatively high proportion of suitable habitat for red squirrels (10.4% of the forest has $SI \geq 3$) at the present time. There are small amounts of suitable habitat for grey squirrels (2.2% of the forest has $SI \geq 3$), although this is well scattered through the forest which could encourage the spread of grey squirrels into the forest. Gaps in the forest canopy, created by clear felling large areas, begin to appear in ten years time (Map 7) and two large areas with a suitability index of 3 for red squirrels become isolated in 2022 making them much less favourable and probably unusable by red squirrels (Map 8). This can be seen in table 2a, which shows a dramatic decline of 36% of the estimated number of red squirrels present in north Tywi between 2012 and 2022.

In general this northern area of Tywi forest is not very suitable for grey squirrels apart from Nant yr Hwch – which, being adjacent to an area of broadleaved woodland (in the southeast corner) could actually draw grey squirrels into the area. The suitability of north

Tywi for grey squirrels increases over the next twenty years and in 50 years time the forest will be highly favourable to grey squirrels. By 2052 over 29% of the Tywi forest area will be of suitable habitat for grey squirrels and their population will have increased to over one thousand animals (see table 2b). This is primarily due to the intention of Forest Enterprise to increase their plantings of broadleaved woodland in this northern section. In much of this area mixed blocks of broadleaved trees and pine will be planted - although the pine would be good for the red squirrels the broadleaved trees will favour grey squirrels once they begin to produce seed. Map 14 shows a predicted 'best outcome' for the area of North Tywi if the management in this area was more sympathetic to red squirrels. This would involve not planting large seeded broadleaved trees (small seeded such as birch and rowan could be planted), planting Scots pine rather than lodge pole pine and in some areas proposed as broadleaf plant with Norway spruce. The map shows that this would make the area generally unsuitable for greys and much more suitable for reds. When numbers are compared, Table 2 shows an estimate that by 2052 N Tywi could support 135 red squirrels and 632 grey squirrels, but if the management proposals were followed then the estimated numbers would be reversed and the area could support 431 red squirrels and only 30 grey squirrels.

Southern Tywi also contains some suitable habitat for both species of squirrel, particularly on the borders of Llyn Brienne. However, the central western section of Tywi (opposite Nant yr Hwch) will become very fragmented due to the clear felling of large areas over the next twenty years, and by 2022 links to the northern part of the forest will be lost. There is no direct link with Nant yr Hwch as this western side of the forest is separated from Nant yr Hwch by the Afon Tywi. It is possible that at times of very low water the squirrels may cross the river. Therefore any squirrels living in the south west area will not be able to move to better habitat in the north.

The amount of suitable habitat for red squirrels in Bryn Arau Duon at the present time is quite low (2.9% of the forest has $SI \geq 3$) and is even lower for grey squirrels (0.1% of the forest has $SI \geq 3$). It seems unlikely that a red squirrel population would be viable within this woodland as the available suitable habitat is estimated to only support a maximum of 17 red squirrels. It is possible that the squirrels are moving between this forest and the southwest block of Tywi by means of a thin connecting link of broadleaved trees (see Map 2) at the south eastern corner of the forest. There are some large blocks of suitable habitat

in the southwest block of Tywi and when combined with Bryn Arau Duon, this is likely to support a much greater number of red squirrels. However, this block of Tywi is also very isolated, as a finger of Llyn Brienne separates it from the main block. In twenty years time the interior of this southwest area becomes unsuitable for red squirrels, as the area is clear felled, creating a large area un-crossable by red squirrels. Also the south east end of Bryn Arau Duon will be clear felled in twenty years time cutting off the link with the southwest corner of Tywi forest thereby preventing any movement of squirrels between these two forests. In 50 years time the linkages appear to improve again but there will be no connection with the main Tywi block at any time. This has the potential to create an isolated population, which could have serious implications for any existing population. These two blocks of forest also contain some high quality areas of habitat for grey squirrels (suitability index of 4) including one large area of mature oak on the banks of Llyn Brienne. These areas are likely to be sufficient to sustain a much larger grey squirrel population than red squirrel population.

The quantity and size of areas to be clear felled over the next twenty years in Tywi forest will clearly have a dramatic and immediate affect on the red squirrel population. The forest is likely to become highly fragmented, making it far less suitable for red squirrels as they are unable to reach suitable feeding areas. If the design plans are amended, as will be discussed in section 7 'Recommendations', then this decline in the red squirrel population could be prevented.

In the long term (50 years ahead) the planned increase in large seeded broadleaved species within Tywi forest will create an increase in the number of grey squirrels present in the forest. This is likely to have a direct affect on the red squirrel population, decreasing the already declining population and ultimately red squirrels will become extinct in Tywi forest.

b) Irfon Forest Area (maps 4, 15 to 22)

The amount of suitable red squirrel habitat in this forest area is much lower than the other two forests; at present it is estimated that 135 red squirrels could be supported in the forest, this declines to just 83 in twenty years time and in fifty years time increases back to present day levels. At the present time the areas of suitable habitat for red squirrels are concentrated in north Irfon and Esgair Dafydd forests, although some suitable habitat is

scattered throughout. North Irfon forest is very fragmented at present, to such an extent that the northern section is completely isolated. If the current design plans are implemented then this area will remain isolated for at least 15 years.

Nant y Cerdin only contains 2.3% of the whole forest areas' red squirrel suitable habitat, however this forms 19.3% of Nant y Cerdin forest at the present time. A large block of suitable habitat will be removed in the next ten years and the remaining good areas will become isolated thus rendering them unsuitable (see Map 16). In twenty years time all suitable areas will have been removed and by year 50 we can see that only one block is to be replanted with suitable species. However in the Tilhill forest design plan it is noted that 'red squirrels have been seen in the forest and they will be encouraged by planting small seed species such as Birch, Rowan, Willow and Aspen and mixtures of Scots pine and Norway spruce in groups along the valley bottom. Also restocking of the Sitka spruce coupes will include 5% Scots pine in robust groups along the edges to give linking corridors for Red squirrel.' This is very encouraging and may help to ensure the survival of red squirrels in this forest.

A similar situation occurs in Dinas forest, where much of the forest is due to be felled over the next twenty years. At the present time 17% of the forest is suitable for red squirrels but this will decline to just 6% in twenty years time and as can be seen on Map 17, this suitable habitat becomes isolated and therefore unusable. However, Tilhill have recognised that red squirrels are important in this forest and are proposing to replant some areas with suitable tree species.

There are generally fewer areas of suitable habitat for grey squirrels in Irfon Forest Area and only a small proportion of broadleaved trees have been or will be planted. The main concentration of broadleaved habitat follows the road from Abergwesyn to Llanwrtyd Wells. This will act as a source area; grey squirrels can spread further into the forest from this area when there is a good conifer seed year (mast year). There is also a small area of high quality grey squirrel habitat in Nant y Bai/Erwr Hwch forest. It is likely that the greys will not move into the forest from here as a large block of Sitka spruce surrounds it. Although the maps show Coed Ifan as being unsuitable to both squirrel species, it is intended that the southern half of this forest will be felled over the next three years and 10% of this will be replanted with broadleaved species (ash, birch, oak and rowan).

Depending on the distribution of the trees through this area it may encourage grey squirrels to move further into the forest.

This region contains many of the privately managed forests. Their inclusion in this review is essential as it can be seen from the maps how important a link these forests provide throughout the forest areas. This is particularly true of the Irfon forest area. Forests such as Cwm Henog, although not providing much suitable habitat contain trees old enough to provide safe connections to the northern areas. Also Coed Ifan provides a close link with Crychan Forest Area (although they do not quite link up as there is an area of steep open ground between). There is a block of woodland to the north of Esgair Berfedd which links up Nant y Bai/Erwr Hwch. This is also privately owned and managed by Tilhill but I have no details of the species composition or management proposals of this area.

If the spread of grey squirrels can be controlled in this region then it is possible that red squirrels can survive here. However, there is a major problem with fragmentation of north Irfon that could reduce the overall viability of the red squirrel population in this forest.

c) Crychan Forest Area (maps 5, 23 to 30)

Crychan forest area can be divided into a north and south area managed by Forest Enterprise, and Glynsaer (managed by Woodland Management Wales) which is a block on the north west side locally known as Sugar Loaf picnic site. The eastern finger of southern Crychan is currently managed by the MOD and no discussions have taken place with this authority so management for this area is based on current tree species and ages only.

Glynsaer contains a relatively large amount of suitable habitat for red squirrels (long strips of larch and pine) but this is also suitable habitat for grey squirrels. There is a small suitable area for red squirrels in north Crychan that increases considerably by 2012 and the forest area remains largely unsuitable for grey squirrels for the whole 50 years. Both of these forests remain well connected during the 50 year period of this review.

At the present time southern Crychan contains the majority of suitable habitat for red squirrels in this area, but this forest is very fragmented with the most southerly suitable block completely isolated and therefore isolating any squirrels that may be present (see Map 23). The linkages improve by ten years time and there is an increase in suitable habitat. In 50 years time the suitability has decreased slightly in this area apart from the

finger of MOD land, which could potentially become an important area for red squirrels (assuming management is correct – need to liaise with them).

Southern Crychan forest is also very suitable for grey squirrels, particularly the southwest area where there are a large number of broadleaved trees, mostly beech and oak. The amount of grey squirrel suitable habitat peaks in 20 years time (Map 29) and although it then decreases in size the proportion of high quality habitat (suitability index of 4) rises to 25% of the total suitable area by 2052 (see table 5). In twenty years time (2022) the amount of high quality habitat for red squirrels has decreased to just 8% of the total suitable habitat. As the grey squirrel population reaches its peak, the red squirrel population would be at a low point and this will accelerate the decline in the red squirrel population.

Ultimately Crychan forest will be far more suitable for grey squirrels than red squirrels. It is possible that North Crychan could retain its red squirrel population with the right management, although the population would be very small.

Table 5 The maximum amount of suitable habitat for grey squirrels in Crychan Forest Area

	Suitability Index 3	Suitability Index 4	Proportion of total area with SI4	Total area
	Area (ha)	Area (ha)	(%)	(ha)
2002	454.1	21.7	5	475.8
2012	451.8	111.5	20	563.3
2022	535.1	151.4	22	686.5
2052	396.9	133.0	25	526.9

Table 6 The maximum amount of suitable habitat for red squirrels in Crychan Forest Area

	Suitability Index 3	Suitability Index 4	Proportion of total area with SI4	Total area
	Area (ha)	Area (ha)	(%)	(ha)
2002	381.8	57.4	13	439.2
2012	642.0	104.0	14	746.0
2022	509	46.8	8	555.8
2052	443.3	118.0	21	561.3

6. Recommendations

a) Forest Enterprise

Tywi Forest

1. It is vital to prevent the isolation of good red squirrel habitat in Tywi Forest. Over the next twenty years the forest is likely to become extremely fragmented. There are certain compartments marked on maps 7, 8 and 9 that could be split into smaller coupes and felled with at least a 5 year interval, this would help to maintain some safe areas for the squirrels to move through to reach their feeding sites. All proposed clear felling around areas of suitable habitat for red squirrels should be reduced to a smaller coupe size and the felling process staggered over a ten year period.
2. The southwest area of Tywi provides important links with Bryn Arau Duon. By 2022 this area will become extremely fragmented and a large block of suitable habitat for red squirrels will be clear felled. This block contains a mixture of Sitka and lodgepole pine and it is recommended that this be kept to biological maturity. To avoid loss of links to Bryn Arau Duon one block marked on Map 8 should not be felled for 10 years to give the surrounding felled and replanted areas time to re-grow and provide canopy cover.
3. Refrain from planting large seeded broadleaved trees in north Tywi and replant with Norway spruce instead. By altering the tree species composition of the proposed broadleaved areas this will not reduce the size of area planted for economic forest and hence there will be no loss in revenue.
4. Avoid creating large clear fell areas adjacent to the northern section of Nant yr Hwch as, this area provides essential links for the red squirrels between the two forests.

Irfon Forest

1. Retain links, particularly to the northern part of the forest. This is likely to mean a need to delay the clear felling of some areas (see maps) and close liaison with Tilhill to ensure adjacent blocks are not clear felled in the same period.
2. No large seeded broadleaved trees to be planted away from road corridors.

3. Increase suitable habitat by planting more Norway spruce.

Crychan Forest

1. Because of the amount of broadleaved trees already present in this forest it is unlikely to be able to be defended from grey squirrels. The exception may be the far northern section where any suitable red squirrel habitat should be retained and more considered. Grey squirrel control may also be required in the northern section.

b) Tilhill

Nant yr Hwch

1. Maintain larch and pine borders to Nant yr Hwch by applying some form of continuous cover forestry. It is important to prevent over spacing of the trees, as canopy connections are essential for red squirrel movements.
2. Ensure there are links of trees over 20 years old across the centre of this forest to provide safe travel through this area for red squirrels.
3. Ensure that no large clear fell areas are created on the northern border at Esgair Llygoden, Esgair Bach and Esgair Cloddiaid as this section provides essential links for the red squirrels with the Forest Enterprise managed area. Liaison with Forest Enterprise about this area is important.

Nant y Cerdin

1. Maintain links to good habitat for 10 years by postponing the clear felling of some sections until the next felling cycle.
2. The policy of replanting Scots pine with the Sitka is good, but it is recommended to plant more Norway spruce (as too much Scots pine can encourage grey squirrels).
3. The one large suitable area (consisting of Norway spruce, Douglas Fir and Sitka spruce) is to be clear felled and replanted with a similar mix but with Sitka spruce

dominant. If possible increase the proportion of Norway spruce to be replanted in this block (perhaps by replacing the Douglas Fir component with Norway spruce).

Dinas

1. If possible fell smaller coupes to maintain a link to the area of suitable habitat in the far east of this forest (see map 17). Increase the amount of Norway spruce to be replanted in the forest.

c) Woodland Management Wales

Cwm Henog

1. This acts as an important link with North Irfon. Do not clear fell large areas or adjacent blocks so that links can be maintained.
2. If possible increase the area of suitable habitat to be replanted (by replanting with Norway spruce and pine).
3. Avoid planting any large seeded broadleaved trees.

Coed Ifan

1. Avoid re-planting with any large seeded broadleaved species.
2. In the design plan it is proposed to replant 18% of the area with Japanese larch. It would be more beneficial for red squirrels if this could be altered to 5% Japanese larch, 10% Norway spruce and 3% Scots pine. This will provide a more constant food source for the red squirrels.

Glyn Saer

1. Keep the southern boundary planted with Sitka spruce to attempt to keep grey squirrels out of the forest. There may need to be some grey squirrel control here. Linked with north Crychan it could be a red squirrel refuge but grey squirrels are likely to overrun southern Crychan.

2. Any areas of larch to be felled should be replanted with Norway spruce if possible and no large seeded broadleaved trees should be planted.

Nant y Bai/Erwr Hwch

1. This block is on the extreme west of Irfon Forest Area and depending on the management of the neighbouring area to the east, could become isolated from the main block.
2. It is important that no large seeded broadleaved trees or large blocks of pine are planted in this block as it could serve to draw grey squirrels further into the forest area. At the present time the large amount of Sitka spruce in this forest may well help to discourage grey squirrels from exploring into the forest.

d) Bryn Arau Duon

1. Clear fell smaller areas to prevent isolation of south east corner. Ensure there are good links throughout the forest.
2. Consider increasing the amount of good habitat for red squirrels by planting more Norway spruce and Scots pine within the forest.
3. Implement grey squirrel control when deemed necessary.

e) Other

Liaise with the MOD to discuss southern Crychan.

Obtain details of the section between Esgair Berfedd and Nant y Bai from Tilhill.

7. Conclusions

According to the current design plans for the forests in Mid Wales, red squirrels are likely to decline considerably. Over the next twenty years there will generally be a decrease in suitable habitat for red squirrels and what remains will become more fragmented. Also many of the forests will have an increase in large seeded broadleaved trees. Thus all the

forests will become less suitable for red squirrels and more suitable for grey squirrels. This is especially true of southern Crychan forest, which already has a high proportion of broadleaved species and of northern Tywi, which will have a much larger broadleaved element in the future. Irfon forest has broadleaved species running through the centre of the forest that act as a focus for grey squirrels but in general this forest is less suitable for greys than for red squirrels, particularly if the intentions of Tilhill are carried out.

If the recommendations discussed above are implemented then it is possible that, certainly Tywi forest area, and possibly Irfon forest area could retain their red squirrel populations. This will basically mean ensuring good links between suitable habitats within the forests and not planting large seeded broadleaved species. For northern Tywi this will not only increase the total area of suitable habitat for red squirrels but will make the forest far less suitable to grey squirrels and I suggest that this area in particular could be suitable as a red squirrel refuge as it is relatively isolated being surrounded on most sides by open moorland (see maps). Irfon forest will probably always have some grey squirrels but if these remain focused on the river/road valleys then red squirrels may be able to survive in the conifer areas.

If Forest Enterprise managed woodlands do not implement red squirrel management then there is little point in the private forests doing so as grey squirrels will overrun the woodlands.

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References and bibliography

Andrén, H. & Lemnell, P. (1992) Population fluctuations and habitat selection in the Eurasian red squirrel *Sciurus vulgaris*. *Ecography*, **15**, 303 - 307.

Anon. (1995). *Biodiversity: the UK Steering Group report*. London, HMSO.

Cartmel, S. (1997). A study of red and grey squirrels in Clocaenog, north Wales: a preliminary study. In *The conservation of red squirrels Sciurus vulgaris L.* (Eds. J. Gurnell & P.W.W. Lurz), pp. 89-95. People's Trust for Endangered Species, London.

Cartmel, S. (2000). *Squirrel ecology in a conifer forest of North Wales. Unpublished PhD thesis*, University of London.

Cartmel, S. (2001). Red squirrel survey of central Wales 2001. CCW Contract Science Report no. 475.

Corbet, G. & Harris, S. (Eds.) (1991). *The handbook of British mammals*. 3rd Edition. Oxford, Blackwell.

Gordon, A.G. & Faulkner, R. (1992) Identification and assessment of cone and seed crops. In *seed manual for forest trees*. Ed. A.G Gordon. *Forestry Commission Bulletin 83*.

Gurnell, J. (1991) Red squirrel *Sciurus vulgaris* and grey squirrel *Sciurus carolinensis*. In *The Handbook of British Mammals*. Eds. Corbet, G. & Harris, S. Blackwell scientific publications, London. pp 176 - 191.

Gurnell, J. (1994). *The red squirrel*. The Mammal Society, London.

Gurnell, J. (1996). The grey squirrel in Britain: problems for management and lessons for Europe. *Proceedings of the 1st European congress of mammalogy*, Lisbon. pp 67 – 81.

Gurnell, J. & Lurz, P.W.W. (Eds.) (1997). *The conservation of red squirrels Sciurus vulgaris L.* London, People's Trust for Endangered Species.

Gurnell, J. & Pepper, H. (1991). *Conserving the red squirrel*. Farnham, Forestry Commission (Forestry Commission Research Information Note 205).

Gurnell, J. & Pepper, H. (1993). A critical look at conserving the British red squirrel *Sciurus vulgaris*. *Mammal Review*, **23**, 125-136.

Gurnell, J., Lurz, P.W.W. & Pepper, H. (2001). Practical techniques for surveying and monitoring squirrels. *FC Research practice note 11*. Forestry Commission, Edinburgh.

Gurnell, J., Clark, M., Lurz, W., Shirley, M., and Rushton, S. (2002). Conserving red squirrels (*Sciurus vulgaris*): mapping and forecasting habitat suitability using a Geographic Information Systems Approach. *Biological Conservation*, **105**, 53-64.

- Harris, S., Morris, P., Wray, S & Yalden, D. (1995). *A review of British mammals: population estimates and conservation status of British mammals other than cetaceans*. Peterborough, JNCC.
- Joint Nature Conservation Committee (1996). *UK strategy for red squirrel conservation*. Peterborough, JNCC.
- Kenward, R.E. & Tonkin, M. (1986) Red and grey squirrels: some behavioural and biometric differences. *Journal of Zoology*, London, **209**, 279-81.
- Lucas, A. (1997). *Mammals in Carmarthenshire*. Andrew Lucas.
- Lurz, P.W.W., Garson, P. & Rushton, S. (1995) The ecology of squirrels in spruce dominated plantations: implications for forest management. *Forest Ecology and Management*. **79**, 79 - 90.
- Matthew, N.R. & Bevan, J.M.S. (2000). *The red squirrel in central Wales: a preliminary study*. Countryside Council for Wales, Bangor.
- Matthews, J.D. (1955) *Production of seed by forest trees in Britain*. HMSO, London. Forestry Commission Report on Forest Research. 64 - 78
- Matthews, J. D. (1989) *Silvicultural systems*. Oxford Scientific Publications.
- Moller, H. (1983) Foods and foraging behaviour of red (*Sciurus vulgaris*) and grey (*Sciurus carolinensis*) squirrels. *Mammal Review*, **13**, 81 - 98.
- Pepper, H. & Patterson, G. (1998). *Red squirrel conservation*. Edinburgh, Forestry Commission (Forestry Commission Practice Note).
- Smith, D. (1999). Grey squirrel population dynamics and feeding biology in a conifer forest. *Unpublished PhD thesis*, University of London.
- Smith, D. and Gurnell, J. (1997) The Ecology of the grey squirrel in conifer forest. In: *The conservation of red squirrels, Sciurus vulgaris* L. Eds. Gurnell, J. and Lurz, P.W.W. pp 109 -120. PTES, London.
- Staines, B., Petty, S. & Ratcliffe, P. (1987) Sitka spruce forests a habitat for birds and mammals. *Proceedings of the royal society of Edinburgh*. Sec B, 168 – 179.