Bird communities along forest roads: preliminary findings of a long term study

Conor T. Graham, Mark W. Wilson, Sandra Irwin, Tom Gittings, Thomas C. Kelly and John O'Halloran

School of Biological, Earth and Environmental Sciences, University College Cork, Distillery Fields, North Mall, Cork

Ireland's landscape has undergone considerable commercial afforestation in recent decades, mainly with the non-native conifer Sitka Spruce *Picea sitchensis*. The diversity of birds and other taxa is typically lower in exotic conifer plantations than in native woodlands. Bird communities of these forests in Ireland are typically dominated by relatively few species that are common throughout the Irish countryside. Current forest management guidelines promote biodiversity within Ireland's plantation forests. The provision of adequate open space within plantations stimulates the development of shrub and non-crop broadleaved trees, providing suitable habitat for a range of bird species, many of which are relatively uncommon in the wider countryside and absent in closed canopy conifer plantations. An experimental study began in 2003 to investigate the impact on avian biodiversity of doubling the width of unplanted open space adjacent to forest roads in newly planted second rotation Sitka Spruce plantations. Preliminary results, six years after this long term experiment was initiated, show that the doubling of open space along roads has not yet resulted in enhanced bird diversity. However, during this time there were considerable changes in the bird communities of these sites. Open habitat specialists colonized the plantations following tree harvesting, but only six years after replanting these species had been largely replaced by ground nesting migrant species, presumably in response to extensive growth of shrubs. We expect that the benefits of increased open space adjacent to roads in these sites will only be realised when the plantation canopy starts to close, which will take approximately five more years. In order to quantify this impact and the contribution it makes to bird diversity as the forest matures, it will be necessary to continue monitoring of this long term experiment for several decades.

Introduction

Ireland's landscape has experienced a very high rate of commercial afforestation in the last number of decades, with plantation forests established during the last 60 years now accounting for approximately 10% of total land cover. Over 90% of total forest cover in Ireland is comprised of plantation forestry, more than in any EU member state except Malta (Forest Europe *et al.* 2011). Almost 75% of these plantations are composed of exotic conifers, the most commonly planted of which is Sitka Spruce *Picea sitchensis* (Forest Service 2007, O'Halloran *et al.* 2011). Canopy closure in Sitka Spruce plantations typically occurs 10-15 years after planting, resulting in reduced light penetration of the canopy and an associated reduction in the diversity of birds (Sweeney *et al.* 2010, Wilson *et al.* 2010) and other taxa (Gittings *et al.* 2006, Oxbrough *et al.* 2006). This is primarily due to the suppression of non-crop cover on which much of this biodiversity depends.

Diversity of birds and other taxa within forests is positively associated with structural complexity, both of and beneath the crop canopy (Hartley 2002, Sweeney *et al.* 2010, Wilson *et*

Plate 172. Robin (Mark Wilson).

al. 2010) and shrub cover in open spaces, both within and adjacent to the forest, including forest roads (Gilliam 2007, Gittings *et al.* 2006, Oxbrough *et al.* 2006, Wilson *et al.* 2010). Non-crop vegetation plays an important role in determining the avian diversity of Irish plantation forests (Sweeney *et al.* 2010, Wilson *et al.* 2010). The provision of open spaces within plantations promotes the development of such non-crop vegetation. Open spaces, which can be permanent or temporary in natural forest landscapes, are an important component of forest habitat and have been considered to be the single most important factor in the success or failure of biodiversity enhancement in plantations (Peterken 1996). Unplanted areas can contribute to biodiversity within plantation forests in a number of ways, by allowing open habitat species to persist in sites following afforestation, by providing habitat for specialists of forest edges and glades, and by accommodating other species whose ecological requirements lie between the extremes of the shaded forest interior and the surrounding intensively managed agricultural countryside (Carter and Anderson 1987, Peterken 1999, Sparks *et al.* 1996). In order to promote biodiversity in Irish forests, the Forest Biodiversity Guidelines (Forest Service 2000) state that 15% of forested area should be incorporated into Areas for Biodiversity Enhancement (ABE), and recommend that between five and ten per cent of the forest should be retained as open space in plantations over 10ha in size.

The suite of birds in Irish forests is conspicuously lacking in forest specialist species even when compared to forest bird assemblages in Britain, where there are far fewer forest specialists than in mainland Europe (Fuller *et al.* 2007). For example, in European natural woodlands such as Białowieza forest in Poland, the species found commonly in closed canopy areas (Red-breasted Flycatcher *Ficedula parva* and Wood Warbler *Phylloscopus sibilatrix)* are either absent from, or are extremely rare in, forests in Ireland (Fuller 2000). Those species found by the same study to be more common in gaps (Chiffchaff *Phylloscopus collybita,* Blackcap *Sylvia atricapilla* and Dunnock *Prunella modularis)* are widespread in Ireland. Fuller (1996) lists 17 British bird species that are confined to woodland habitats, and nine others that, while not confined to woodland, are more abundant within it. Of these 26 species, only one forest specialist breeds in Ireland (Crossbill *Loxia curvirostra)*, as opposed to seven (Goldcrest *Regulus regulus*, Blue Tit *Cyanistes caeruleus,* Great Tit *Parus major,* Coal Tit *Periparus ater,* Long-tailed Tit *Aegithalos caudatus,* Blackcap and Treecreeper *Certhia familiaris*) of the nine forest generalists. The near absence of bird species specialising in forest habitats in the Irish landscape means that the creation of open space in forests does not carry a risk of displacing forest specialist species. The generalist nature of the bird species that typically inhabit closed canopy plantation conifer forests in Ireland is largely attributable to the near absence of true forest specialists in Ireland (Wilson *et al.* 2006). This is most likely due to the lack of forest cover in Ireland for the last number of centuries (O'Halloran and Kelly 2012) in combination with Ireland's geographical location at the western extremes of Europe (Fuller *et al.* 2007). It is more likely that, in closed-canopy Irish plantations, bird diversity will largely be a function of the species supported by habitats found at the forest edge and in open spaces within the forest (Sweeney *et al*. 2010, Wilson *et al.* 2006, 2010).

Open spaces in typical conifer plantations include discrete open spaces (glades), plantation edges, road networks and rides. Although the primary function of roads and rides is to provide access for timber extraction and other forest management activities, the importance of these linear features for plantation biodiversity is increasingly being recognised (Gittings *et al.* 2006, Oxbrough *et al.* 2006, Peterken 1996), particularly as such areas represent the only permanent open spaces within some forests. However, the shade cast by the canopy of adjacent crop trees can limit the biodiversity supported by linear open spaces in forests (Gittings *et al.* 2006, Greatorex-Davies *et al*. 1994, Oxbrough *et al.* 2006). In this regard a number of authors have advocated the widening of linear open spaces to promote biodiversity (Gittings *et al.* 2006, Oxbrough *et al.* 2006, Warren & Fuller 1977). From a management perspective, the implementation of this recommendation is more practical at the planting stage than at a later phase of the rotation, as widening of open spaces adjacent to established edges can result in losses of crop trees to windthrow (Iremonger *et al*. 2006).

In Ireland, for them to qualify as ABEs, the width recommended for forest road corridors is 15m from trunk to trunk. Approximately 3-5m of this width is occupied by the road itself, leaving approximately 5-6m between the road edge and the base of the plantation trees (Ryan *et al.* 2004). However, crop trees tend to shade at least half of this area and the remaining open space is also frequently used as a convenient location to construct drains and ditches and can be heavily impacted by vehicles and timber stacking during harvesting operations. This can result in relatively low levels of undisturbed and unshaded open space along forest roads (Iremonger *et al.* 2006). As forest roads are rarely constructed in new plantations for a number of years post afforestation (Ryan *et al.* 2004), reafforestation offers an ideal opportunity to examine any impacts of forest road corridor width on plantation forest biodiversity.

In this paper we examine the early impacts of experimental widening of forest roads in second rotation Sitka Spruce plantations on bird communities during the first six years after replanting.

Study areas and methods

Eight manipulation study sites were established in the winter of 2003/2004 in second rotation Sitka Spruce plantation forests. Two sites were located in Co. Wicklow (Bawnogue and Ballingate), two in Co. Laois (Fossy Hill and Cardtown), two in Co. Waterford (Lismore and Tooranaraheen) and two in Co. Cork (Cloontycarthy and Carrigagulla) (Figure 1). Planting was conducted in the winter of 2003/2004 at all sites except Carrigagulla, which was planted in the following winter.

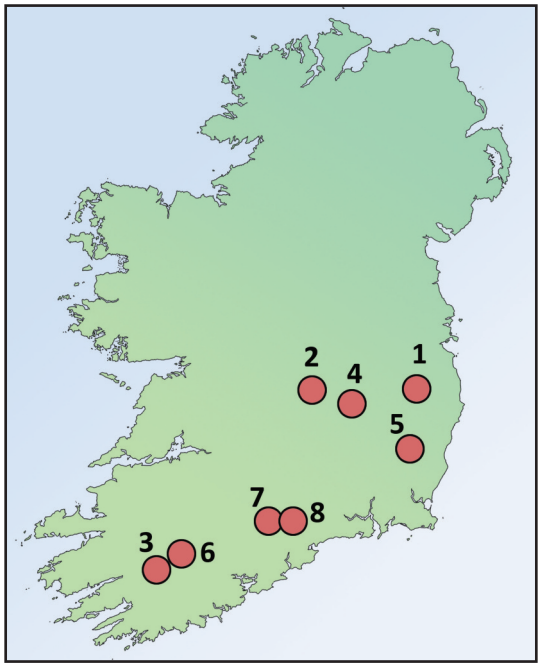

Figure 1. The location of the eight study sites:
1 = Ballingate; 2 = Cardtown; 3 = Cloontycarthy;
4 = Fossy Hill; 5 = Bawnogue; 6 = Carrigagulla;
7 = Lismore; 8 = Tooreenaraheen.

As the study sites were located in second rotation forest, the road structures were already in place, and at each site manipulation concerned the configuration of tree planting in relation to these roads. Each site included two experimental road sections, a 'standard' treatment and a 'wide' treatment. These treatments were each at least 500m long, were typically adjacent to each other and, as far as possible, differed only in the width of unplanted land at the side of the road. The 'standard' treatment represents normal forestry practice under Irish forestry guidelines (Ryan *et al.* 2004). In this treatment the total width of the forest road gap was 15m, consisting of a 5-6m open space gap at each side of the 3-5m wide road surface. The 'wide' treatment was a modification of normal forestry practice for biodiversity enhancement, with total width of the forest road gap being 30m, comprised of a 12-14m open space gap at each side of the 3-5m wide road surface. The experimental difference between these treatments was, therefore, in the width of the open unplanted roadside space (hereafter referred to as 'road gap') at each side of the pre-existing road surfaces (Figure 2).

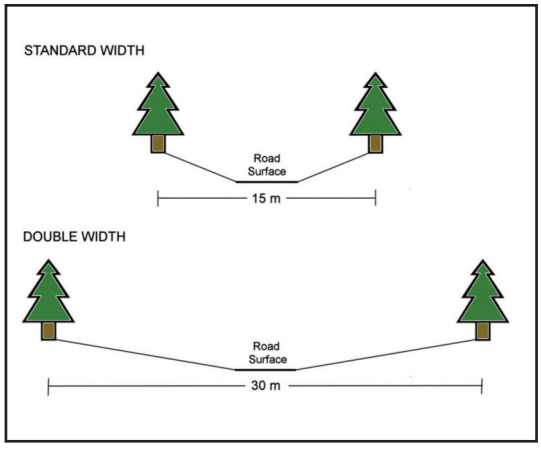

Figure 2. Schematic of the two treatment types in each of the road width experimental sites. In the standard treatment there was a 15m gap between tree bases on either side of the road while in the double width (wide) treatment this distance was increased to 30m. The width of the road (3-5m) was the same in each treatment type.

Baseline surveys of bird communities were conducted in 2005, after the road verges had been left for one full growing season to recover from disturbance caused during the planting operations. Bird communities were resurveyed five years later in 2010. In each year birds were sampled by transect count twice during the breeding season, once in May and once in June, between 08.00-18.00 hours. Birds were not counted during persistent or heavy rain or in windy (Beaufort scale 4 or more) conditions. The number and species of all birds detected within 100m of the observer while walking along the road were recorded, along with their estimated position and distance from the observer using range finding binoculars. Two observers conducted bird transects in 2005, while in 2010 only one of these observers carried out the bird counts. Both had considerable experience and the maximum distance of birds observed was relatively low (100m). Therefore, any bias due to observer was most likely negligible. Road section length was measured from aerial photographs. Birds flying over the forest canopy were excluded from the analyses.

As birds differ in their ecological requirements, and hence their response to the plantation forest cycle, we tested for

differences between the two treatments in the density of ground-nesting shrub-associated birds and of open habitat associated birds as well as in total density and species richness of birds. Differences between treatments were tested separately between treatments within year, and within treatment between years using Mann-Whitney U-tests. Skylark *Alauda arvensis,* Stonechat *Saxicola torquatus* and Meadow Pipit *Anthus pratensis* were classified as open habitat associated birds and Chiffchaff, Willow Warbler *Phylloscopus trochilus*, Blackcap, Whitethroat *Sylvia communis,* Grasshopper Warbler *Locustella naevia,* Sedge Warbler *Acrocephalus schoenobaenus* and Reed Bunting *Emberiza schoeniclus* as ground-nesting shrub-associated birds (Nairn and O'Halloran 2012). All statistical analyses were conducted on the number of bird detections within 100m of the road, as this provided comparable density estimates in these habitats, which had low levels of scrub and tree cover. In order to counteract the increased risk of a Type I error occurring as a result of multiple comparisons, the P-values from the Mann-Whitney U-tests were corrected according to the False Discovery Rate method described by Verhoeven *et al.* (2005). All analyses were conducted using PASW Statistics 18 (SPSS Inc. 2010).

Results

A total of 32 bird species was recorded across all sites, with the most frequently encountered species along forest roads being Willow Warbler, Wren *Troglodytes troglodytes*, Robin *Erithacus rubecula,* Meadow Pipit and Chaffinch *Fringilla coelebs.* These five species accounted for almost 70% of all detections (Table 1).

Table 1. Summary counts of birds recorded in experimental standard and wide road gaps in 2005 and 2010.

	2005		2010	
Species	**Standard**	**Wide**	**Standard**	**Wide**
Blackbird *Turdus merula*	0	1	5	3
Blackcap *Sylvia atricapilla*	0	0	4	0
Bullfinch *Pyrrhula pyrrhula*	2	2	1	1
Chiffchaff *Phylloscopus collybita*	0	0	2	4
Chaffinch *Fringilla coelebs*	6	5	10	18
Coal Tit *Periparus ater*	0	1	0	1
Dunnock *Prunella modularis*	1	0	1	1
Goldfinch *Carduelis carduelis*	0	0	0	0
Goldcrest *Regulus regulus*	1	2	0	1
Grasshopper Warbler *Locustella naevia*	0	0	1	4
Great Tit *Parus major*	0	0	0	2
Hooded Crow *Corvus cornix*	1	0	0	0
Lesser Redpoll *Carduelis cabaret*	3	1	0	2
Magpie *Pica pica*	1	1	1	0
Meadow Pipit *Anthus pratensis*	13	16	2	3
Pheasant *Phasianus colchicus*	1	2	6	5
Pied Wagtail *Motacilla alba*	1	1	0	0
Robin *Erithacus rubecula*	1	5	17	10
Reed Bunting *Emberiza schoeniclus*	0	1	1	3
Rook *Corvus frugilegus*	1	0	0	0
Skylark *Alauda arvensis*	0	1	0	0
Stonechat *Saxicola torquatus*	3	5	0	0
Sparrowhawk *Accipiter nisus*	1	0	0	0
Siskin *Carduelis spinus*	0	1	0	4
Swallow *Hirundo rustica*	0	2	1	0
Song Thrush *Turdus philomelos*	0	1	2	2
Sedge Warbler *Acrocephalus schoenobaenus*	0	0	0	6
Wheatear *Oenanthe oenanthe*	1	0	0	0
Whitethroat *Sylvia communis*	1	1	5	2
Wren *Troglodytes troglodytes*	23	36	24	28
Willow Warbler *Phylloscopus trochilus*	2	2	42	35
Woodpigeon *Columba palumbus*	2	6	1	4
Total no. of species	**19**	**21**	**18**	**21**
Total no. of individuls	**65**	**93**	**126**	**139**

There were no significant differences in the number of species detected within 100m of the road either between width treatments on either sampling date, or in each treatment between years (Table 2). While there was no significant difference in bird density within 100m of the road in the wide relative to the standard treatment in 2005, higher densities of birds were recorded in the standard treatment in 2005 compared to 2010 (U = 1, P = 0.005) (Table 2, Figure 3).

Table 2. Summary of Mann-Whitney tests to compare species richness, density of total birds, ground-nesting shrub-associated birds and open habitat associated birds recorded within 100m of experimental standard and wide road gaps in 2005 and 2010. Significant results are highlighted in bold and P values are false discovery rate adjusted.

Comparison	U	P
Species Richness		
2005 standard versus 2005 wide	19	0.35
2005 standard versus 2010 standard	16	0.25
2005 wide versus 2010 wide	16.5	0.25
2010 standard versus 2010 wide	23	0.51
Total Density		
2005 standard versus 2005 wide	12	0.12
2005 standard versus 2010 standard	**1**	**0.005**
2005 wide versus 2010 wide	17	0.26
2010 standard versus 2010 wide	31	1
Density of ground nesting birds		
2005 standard versus 2005 wide	31	1
2005 standard versus 2010 standard	**0**	**0.002**
2005 wide versus 2010 wide	**2**	**0.005**
2010 standard versus 2010 wide	26	0.7
Density of open habitat associated birds		
2005 standard versus 2005 wide	23	0.5
2005 standard versus 2010 standard	22	0.5
2005 wide versus 2010 wide	**8**	**0.04**
2010 standard versus 2010 wide	32	1

There were no significant differences between treatments in the numbers of ground nesting birds or open habitat associated birds at the start of the experiment. However, there were changes in the community composition of birds between the two sampling years. The number of ground-nesting shrub-associated birds within 100m of the road increased significantly in both treatments between 2005 and 2010 (standard treatment: U = 0, P = 0.002; wide treatment: (U = 2, P = 0.005). There was a corresponding decrease in the number of open habitat associated birds detected in the wide treatments between 2005 and 2010 (U = 8, P = 0.04) (Table 2, Figure 4).

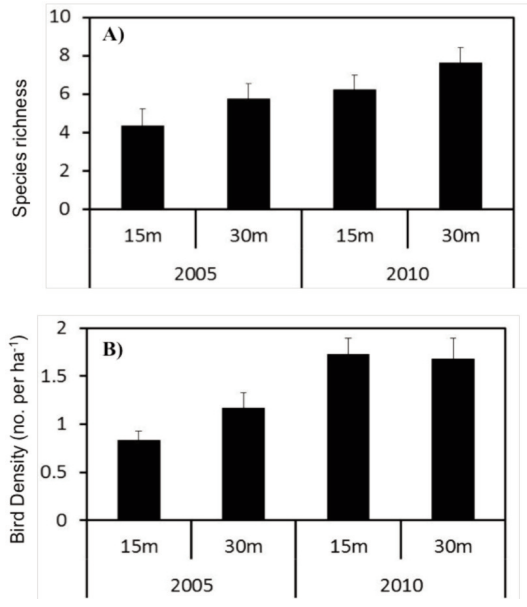

Figure 3. Mean (± SE) of (A) species richness of birds and (B) total density of birds detected within 100m of the road in the standard and wide road gap treatments in 2005 and 2010.

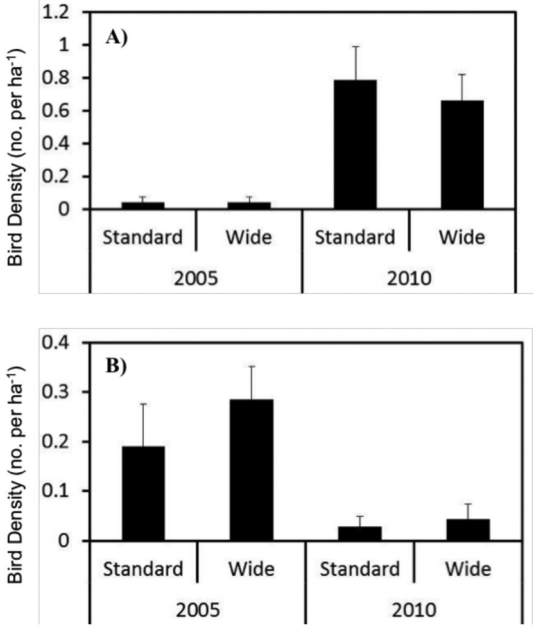

Figure 4. Mean (± SE) density of (A) ground nesting and (B) open habitat associated birds detected within 100m of the road in the standard and wide road gap treatments in 2005 and 2010.

Plate 173. Coal Tit (www.carlmorrowphotography.com).

Discussion

The experimental widening of the road corridor in second rotation Sitka Spruce plantations had little impact on the number or species richness of birds detected in the first six years after planting. This result is perhaps not surprising as the benefits of widened forest road gaps for forest birds, which will be mediated through enhanced light levels relative to standard 15m road widths, will not be fully realised until the crop canopy is tall and dense enough to cast considerable shade on adjacent vegetation. It is anticipated that these benefits will result in the bird communities supported by the two road width treatments becoming increasingly divergent as the adjacent conifers mature (Peterken 1996, Sparks *et al.* 1996).

Positive effects of ride lines on the bird diversity of mixed Irish woodlands have previously been reported (Duffy *et al.* 1997, Roycroft *et al*. 2008), and Nairn and Farrelly (1991) found that the preferred habitat of summer migrants in a semi-natural woodland in Co. Wicklow was along the edge of a wide road. However, these studies were all conducted in mature woodlands and forests, while the exotic conifer plantations in our study sites were composed of relatively young (newly planted and six year old) trees in the pre-canopy closure stage. The pre-canopy closure stands of Sitka Spruce adjacent to both treatments in 2010 comprised habitat that can support bird assemblages more typical of open, unforested habitats which are lost during the later parts of the forest cycle (Wilson *et al.* 2006). This is particularly true of young second rotation plantations, which support higher densities of such birds than first rotation plantations (Sweeney *et al.* 2010).

Although there was little impact of the experimental widening of the road gaps six years after planting, there were noticeable changes in the bird communities of the study sites during this time. This study is among the first to look at the bird communities of recently clearfelled sites, and it is noteworthy that in 2005, an average of 18 months after felling and reafforestation, these sites supported reasonable numbers of Stonechat and Meadow Pipit (5.1 and 18.4% of total birds detected, respectively), both of which are typical open habitat associated species. Skylark and Wheatear *Oenanthe oenanthe*, also associated with open habitats, and both of conservation

concern in Ireland (Lynas *et al.* 2007), were also recorded in 2005, albeit in very low numbers. These species are typically absent from mature conifer plantations, and even in five year old pre-canopy closure stands their relative abundance is far less than was found just after reafforestation in the present study (Sweeney *et al.* 2010, Wilson *et al.* 2006). This indicates a rapid recolonisation of clearfelled and reafforested habitat by these open habitat specialists that has not previously been noted in studies of Irish plantation forests. However, the window of opportunity for these open habitat specialists in Irish plantations appears to be short, as all had either disappeared or dramatically decreased in numbers by the time these sites were resurveyed in 2010.

The decrease in these open habitat species in the five years after reafforestation was concomitant with an increase in the abundance of migrant warblers, including Chiffchaff, Willow Warbler, Blackcap, Whitethroat, Grasshopper Warbler and Sedge Warbler, all of which nest in vegetation on or near the ground. Some of these species are in considerable decline throughout Britain (Baillie *et al.* 2005) and amber-listed in Ireland (Lynas *et al.* 2007). These changes in bird communities are consistent with the findings of previous studies, and with the association of migrant species with pre-thicket forests that such studies have emphasised as being of particular significance for bird diversity in forested landscapes in Ireland (Sweeney *et al.* 2010, Wilson *et al.* 2006, 2010). This shift in bird community appears to be driven by development of under-canopy vegetation, and in particular by shrub cover. During the interval between 2005 and 2010, successional changes in the vegetation of both the road gap and the planted area would have made these sites increasingly suitable for migrant warblers.

The predominant impact of forest establishment on bird communities is the change from an open habitat associated to a forest associated bird community (Wilson *et al.* 2012). However, this change is typically sequential, following from changes in habitat due to the growing forest. As the plantation forests in the study sites mature, we can expect to see considerable changes in the bird communities of the forest interior, similar to those recorded by Wilson *et al.* (2006) and Sweeney *et al.* (2010). We expect that open habitat-associated species will continue to decline, being replaced by species that depend on a high degree of shrub cover and a well-developed understory, before these are, in turn, supplanted by bird species characteristic of Irish closed canopy forests. This will result in the cessation of use of the interior areas of the forest by several Irish birds of conservation concern, such as Skylark, Grasshopper Warbler, Stonechat, Whinchat *Saxicola rubetra* and Linnet *Carduelis cannabina,* and the establishment of a generalist forest bird assemblage dominated by relatively few species that are common throughout the Irish countryside (Sweeney *et al.* 2010, Wilson *et al.* 2006).

We anticipate that the major benefit of experimental widening of forest roads will be realised from the time of canopy closure onwards. At this stage of the commercial forest cycle, much of the bird diversity depends on the available open space, and the associated cover of shrubs and non-crop trees. The increased light penetration in the wide road gap treatment will result in greater availability of shrub cover than in the standard treatment, supporting several bird species that rely on such cover for both nesting and foraging (Wilson *et al.* 2010). We anticipate that the experimentally widened road gaps will augment the bird species diversity and richness of these Sitka Spruce plantations by providing suitable habitat for scrub-dependent species such as Chiffchaff, Willow Warbler, Blackcap, Whitethroat, Sedge Warbler, Dunnock and Lesser Redpoll *Carduelis cabaret,* many of which are relatively uncommon in much of Ireland, and absent from many closed canopy conifer plantations. In addition, as the non-crop vegetation matures within these wide road gaps, broadleaf-associated species such as Blue Tit, Great Tit, Long-tailed Tit and Bullfinch *Pyrrhula pyrrhula,* are likely to utilise these road corridors, which will provide new opportunities for a wider range of both resident and migrant birds. The long-term aim of this experimental design is to investigate whether doubling road gap widths from 15m to 30m can augment the avian biodiversity supported by exotic conifer plantations. This information would allow the development of forest management strategies to more effectively sustain and enhance biological diversity. However, it is likely that the impact of these road width treatments will only start to be realised towards the end of the pre-thicket stage, in approximately five years' time. In order to observe this impact and the contribution it makes to different growth stages of the forest from thicket stage through to commercial maturity, it will be necessary to continue monitoring of this long term experiment for several decades. However, realising the potential benefits of providing more open space in plantation forests depends on several additional factors including management of the wider forest estate, browsing by ungulates and invasion of non-native plant species.

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