How can forest management benefit bird communities? Evidence from eight years of research in Ireland

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Abstract

An extensive programme of research on the breeding bird assemblages of Irish forests has been undertaken since 2001 to improve our understanding of the ways in which forest management can influence bird populations. Data on bird communities were collected from 115 sites across the island of Ireland. The sites included monoculture plantations at various stages of the forest cycle, commercially mature mixed species plantations, native woodlands and open non-forest habitats. Although this work comprised several discrete studies, the overarching aim was to investigate ways in which commercial forest plantations could be managed to improve their value for birds. The bird communities of some open habitats, including low intensity agricultural land and peatland, can be negatively affected by afforestation, but afforestation has the potential to have a more positive impact on the bird communities of intensively managed grasslands. Bird assemblages of native oak (*Quercus* spp.) and ash (*Fraxinus excelsior* L.) woodlands are more diverse than those of commercially mature conifer plantations and provide a reference against which to compare plantation forests. The inclusion of native broadleaved trees in conifer plantations can be beneficial for bird populations, at least in part due to diversification of forest vegetation structure. Shrub cover, which is associated with higher bird species richness, is prominent in pre-thicket plantation forests, particularly in the second rotation. The loss of understorey structure after canopy closure leads to a less diverse bird assemblage in the mid to late stages of the forest cycle. In general, forest management practices that promote growth of non-crop vegetation and presence of deadwood, thereby enhancing structural complexity, increase the quality of forest habitats for bird communities. In this paper we provide a summary of the findings from the first eight years of these studies, and discuss their application in achieving "Sustainable Forest Management".

Keywords: *Afforestation, birds, biodiversity, conservation, forest management, growth stage, non-crop vegetation.*

Introduction

The Irish pollen record indicates a reduction in forest cover starting with the arrival of Neolithic farmers about 6,000 years ago, and continuing until the late 19th century when forests accounted for just 1% of Ireland's land area (Mitchell 1995, Rackham 1995, Cole and Mitchell 2003, Mitchell 2006). From the beginning of the 20th century, forest cover began to increase, predominantly due to the establishment of conifer plantations. Rapidly growing conifer species now dominate forested lands in Ireland,

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which cover around 10% of Ireland's total land area (Forest Service 2007). By contrast, native woodlands account for only 1% of Ireland's land surface area. Plantation forests therefore constitute the majority of forested habitat currently available to woodland flora and fauna in Ireland. However, although Ireland's native woodlands (those comprised of native species and not intensively managed for timber) are limited in their spatial extent, their value in terms of the biodiversity they support is relatively high, providing a reference point against which more recently established forests can be compared.

Forest management in Ireland over much of the 20th century focused almost entirely on wood production. In recent decades, however, the concept of "Sustainable Forest Management" (SFM) has gained increasing recognition with both the forest industry and statutory regulating and grant-aiding bodies. The concept of sustainable forest management in Europe was developed by FOREST EUROPE and contains guidelines and criteria to secure the optimal balance of goods and services (Rametsteiner and Mayer 2004). The member countries have agreed on the following joint definition of sustainable forest management: *the stewardship and use of forests and forest lands in a way, and at a rate, that maintains their biodiversity, productivity, regeneration capacity, vitality and their potential to fulfil, now and in the future, relevant ecological, economic and social functions, at local, national, and global levels, and that does not cause damage to other ecosystems*. Current obligations arising from international agreements and Irish society demand that modern forests be multifunctional, providing commercially viable timber yields in tandem with ecological and social services, which include maintenance of biodiversity, climate change mitigation and nature conservation (McAree 2000). Successful delivery of these services requires knowledge of the biota and prevailing ecological processes that underpin the potential environmental benefits of commercial forests. While there is still an emphasis on forest expansion, the nature of the forest estate in Ireland is changing, as first rotation forests are harvested and second rotation forests are planted to replace them. Conventional commercial conifers, such as Sitka spruce (*Picea sitchensis* (Bong.) Carr.) and lodgepole pine (*Pinus contorta* Dougl.) continue to be planted, but their dominance in the Irish forest estate is diminishing. Grant-aided new plantings are now required to incorporate a variety of tree species in accordance with the Irish Forest Biodiversity Guidelines (Forest Service 2000). The Irish National Forest Standard, the Code of Best Practice and Environmental Guidelines assist the Forest Service in implementing the environmental aspects of SFM in Ireland. Non-compliance with these guidelines can result in the withholding of grants and felling licences (McAree 2000). Many native broadleaved tree species, which are relatively unproductive in terms of their timber yield, are now included in commercial plantings, as well as in forests established as part of dedicated initiatives to increase their abundance, such as the Native Woodland Scheme. These recent developments provide an opportunity for the forest industry to achieve new ecological standards, and to ensure compliance with international agreements, using research-based knowledge.

Bird diversity is an important component of forest ecosystems (Sekercioglu 2006), influencing seed dispersal (Gómez 2003, Martínez et al. 2008), pollination (Cronk and Ojeda 2008, Mortensen et al. 2008) and exerting top-down control over insect communities including pests (Skoczylas et al. 2007, Gunnarsson et al. 2009). The increase in plantation forests across Europe (FAO 2007), has coincided with reported declines in the populations of some woodland bird species across the continent (Fuller et al. 2005, Gregory et al. 2007), though these trends vary between regions (Klvaňová et al. 2009). Ireland's woodland bird fauna comprises fewer species than are found in European countries (Fuller et al. 2007, Sweeney et al. 2012). Reasons for this include Ireland's long history of deforestation, which probably led to the loss of forest associated species such as capercaillie (*Tetrao urogallus*) and great spotted woodpecker (*Dendrocopus major*) (Yalden and Carthy *2004*); the relatively small size and isolation of the island - attributes that typically result in lower species richness (MacArthur and Wilson 1967); the competitive advantage of resident species over migrants resulting from Ireland's mild climate (O'Connor et al. 1986); and the lack of sufficiently large source populations for colonisation to take place (Kelly 2008). Although two of the four races of birds endemic to Ireland (coal tit and jay) are predominantly woodland birds, Irish forest bird communities are mainly comprised of generalist bird species that are also common in open habitats (Nairn and Farrelly 1991, Pithon et al. 2004, O'Halloran et al. 2011). A small number of common, generalist bird species dominate our forest bird communities, some examples of which are listed in Table 1.

Plantation forests can, however, potentially provide habitats for many birds that utilise naturally occurring woodland habitats (Brockerhoff et al. 2008). Although stands of native tree species support more local biodiversity than do monocultures of exotic conifers, in some cases exotic conifer plantations can support bird communities as diverse as those in native tree stands (Archaux and Bakkaus 2007). Direct comparisons between plantations and more natural woodlands are useful in identifying woodland features that contribute to bird diversity. As management is one way to influence the utility of plantations to birds (Lantschner et al. 2008, Luck and Korodaj 2008, Calladine et al. 2009), such comparative studies may reveal ways in which plantations can be improved to enhance their value to birds.

Prior to 2000, few studies of biodiversity had been conducted in Irish forests, particularly in commercial plantations. Research to address this information gap was undertaken between 2001 and 2006 by the COFORD (National Council for Forest Research and Development) and EPA (Environmental Protection Agency) funded BIOFOREST research project. This was followed by the COFORD funded PLANFORBIO programme, which will run until 2013. These projects represent over 10 years of comprehensive research on the biodiversity of Ireland's forests, including bird diversity. Detailed information on the methodologies employed in these studies can be found in the relevant peer-reviewed and published papers (O'Halloran et al. 2002, Pithon et al. 2004, Wilson et al. 2006, Wilson et al. 2009, Sweeney et al. 2010a, Sweeney et al. 2010b, Sweeney et al. 2010c, Wilson et al. 2010, Sweeney et al. 2011, Sweeney et al. 2012, Wilson et al. 2012). This paper reviews the results from 115 survey sites used during the first 8 years of this research (Figure 1), highlighting findings that may be of interest and relevance to forestry managers and practitioners aiming to enhance the value of forest plantations for birds.

Table 1: *Ecological characteristics of the bird species mentioned in this paper, described by habitat association (F=Forest, BF=Broadleaved Forest, CF=Conifer Forest, Gen =Generalist, P=Peatland, Gr=Grassland), tolerance to afforestation (+ = tolerant, - = intolerant). For further information see (Nairn and O'Halloran 2012).*

Common name	Scientific name	Habitat association	Afforestation tolerance	Migrant/ Resident
Capercaillie	*Tetrao urogallus*	F	NA	M
Great spotted woodpecker	*Dendrocopus major*	F	+	R
Jay	*Garrulus glandarius hibernicus*	BF	+	R
Blackbird	*Turdus merula*	F, Gen	+	R
Robin	*Erithacus rubecula*	F, Gen	+	R
Wren	*Troglodytes troglodytes*	F, Gen	+	R
Chaffinch	*Fringilla coelebs*	F, Gen	+	R
Meadow pipit	*Anthus pratensis*	P, Gr	-	R
Skylark	*Alauda arvensis*	P, Gr	-	R
Hen harrier	*Circus cyaneus*	P, F	+[1]	R
Merlin	*Falco columbarius*	P, F	?	R
Red grouse	*Lagopus lagopus*	P	-	R
Quail	*Coturnix coturnix*	P, Gr	-	M
Golden plover	*Pluvialis apricaria*	P, Gr	-	M
Lapwing	*Vanellus vanellus*	P, Gr	-	R
Dunlin	*Calidris alpina*	P	-	M
Curlew	*Numenius arquata*	P, Gr	-	M
Redshank	*Tringa totanus*	P, Gr	-	M
Whinchat	*Saxicola rubetra*	P	+[1]	M
Stonechat	*Saxicola torquata*	P, F	+[1]	R
Ring ouzel	*Turdus torquatus*	P	-	M
Twite	*Carduelis flavirostris*	Gr	-	R
Goldcrest	*Regulus regulus*	CF, Gen	+	R
Coal tit	*Periparus ater*	CF, Gen	+	R
Blackcap	*Sylvia atricapilla*	BF	+	M
Blue tit	*Cyanistes caeruleus*	BF, Gen	+	R
Bullfinch	*Pyrrhula pyrrhula*	BF, Gen	+	R
Chiffchaff	*Phylloscopus collybita*	BF	+	M
Great tit	*Parus major*	BF, Gen	+	R
Long-tailed tit	*Aegithalos caudatus*	BF	+	R
Treecreeper	*Certhia familiaris*	BF	+	R
Willow warbler	*Phylloscopus trochilus*	F	+[1]	M

[1] These species are tolerant of afforestation only during the pre-thicket growth stage, before the forest canopy closes.

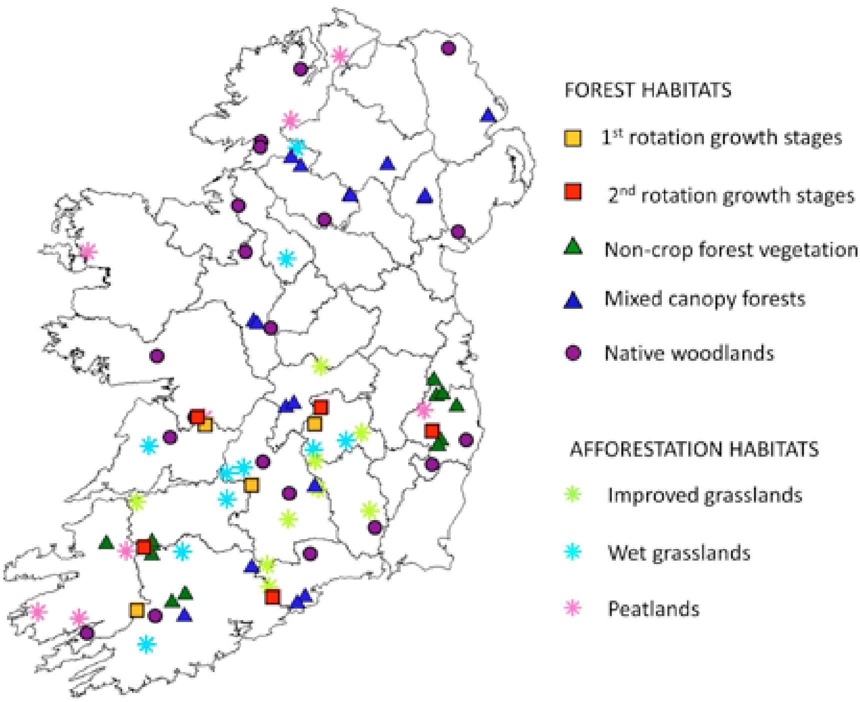

Figure 1: *Location of the 115 forest and afforestation habitat sites used in the studies reviewed in this paper. Each of the square symbols represents a cluster of four 1st or 2nd rotation forest sites at different growth stages (pre-thicket, thicket, mid-rotation and commercially mature).*

Forest management and Irish bird communities

Afforestation of open habitats

Afforestation fundamentally changes ecosystem structure, and the impact of forest plantations on bird communities depends on the type of habitat that is replaced (Thompson et al. 1995). Up until 1986, peatland (Figure 2) was the most commonly afforested land type in Ireland (Wilson et al. 2012). Since then afforestation has predominantly taken place on gley soils, with rates of afforestation on other soil types (including agriculturally improved soils see Figure 2) remaining low.

Of all the commonly afforested habitats, the bird assemblages of peatland habitats are the most distinct from those of plantations (Wilson et al. 2012). Most grassland habitats (Figure 2) support very low densities of birds in open areas, and birds are many times more abundant in hedgerows or patches of woodland and scrub. However, some open habitat specialists present in these grassland habitats, such as meadow pipit (*Anthus pratensis*) and skylark (*Alauda arvensis*) (Table 1), are intolerant of afforestation (Wilson et al. 2012). The quality of grassland habitats for birds is negatively related to the intensity of agricultural management. Most of the bird species that breed in agriculturally improved grasslands are birds that can also be

Figure 2: *From left to right: Peatland, Wet grassland and Improved grassland habitats (Photos: Mark Wilson and Catherine Bushe).*

found in forest plantations. Because of its relatively low value for bird communities, afforestation of intensively managed grassland has a more positive impact on bird diversity than afforestation of low intensity agricultural grassland, particularly where the latter has high levels of in-field shrub cover or supports open habitat specialists (Wilson et al. 2012). Peatland sites tend to have low bird diversity, but support relatively high densities of the open habitat specialists, meadow pipit and skylark.

Among the birds that breed in peatland sites are several species of conservation importance, including birds of prey, game-birds, waders and song-birds (Table 1). The bird assemblages of peatland or unimproved agricultural sites proposed for afforestation should be examined prior to afforestation, to ensure that important open habitat species are not negatively affected.

Native woodlands and non-native plantations

Many aspects of forest management can affect the value of forests for birds, including planting, fertiliser application, pest and weed control, thinning, harvesting, and creation of associated habitats and structures such as roads (Avery and Leslie 1990, O'Halloran et al. 2002, Roycroft et al. 2008, Calladine et al. 2009). Unmanaged native oak (*Quercus* spp.) and ash (*Fraximus excelsior* L.) woodlands (Figure 3) support more diverse bird assemblages than both mid-rotation and commercially mature Sitka spruce plantations (Sweeney et al. 2010a). The most common two bird species in both mature and maturing conifer plantations in Ireland are goldcrests (*Regulus regulus*) and coal tits (*Periparus ater*), which feed predominantly on small invertebrates that can be plentiful in such habitats (Gibb 1960, Sweeney et al. 2010a). Removing these two species from the statistical analysis reveals that the densities of all other bird species are twice as high in native woodlands as they are in conifer plantations, even when the latter are relatively mature (Figure 3). This is principally due to higher densities in native woodlands of several bird species associated with broad-leaved trees and shrubs (Table 1).

There are several reasons that native woodlands are better quality habitats for these species than conifer plantations. The influence of deciduous trees allows for greater structural complexity of sub-canopy vegetation due to increased light penetration through the forest canopy. Greater structural complexity creates a wider range of foraging and nesting opportunities for many bird species. There is a substantial body of evidence in Britain (Fuller et al. 2007, Gill and Fuller 2007, Hopkins and Kirby 2007) and Europe (Cherkaoui et al. 2009, Nikolov 2009) highlighting the importance of vegetation structure to woodland birds (Pienkowski et al. 1998, Ferris et al. 2000). In Ireland, the number of bird species supported by forests has been shown to be positively associated with understorey cover (Wilson et al. 2006, Sweeney et al. 2010c, Wilson et al. 2010). Dense canopies suppresses understorey vegetation in plantation forests (Smith et al. 2008), so mature conifer plantations tend to have low structural diversity in the field and shrub layers (Ferris et al. 2000). This results in lower quality habitat for birds than unmanaged, structurally heterogeneous native woodlands. Measures that reduce canopy cover and allow more light penetration would therefore ultimately benefit bird diversity (Quine et al. 2007, Ding et al. 2008). Increasing the structural complexity of forests is likely to increase their value for birds.

Tree species mixtures

Tree composition of forest plantations may be important for biodiversity, with mixed conifer-broadleaf (Figure 4) stands often holding richer bird communities than pure conifer plantations (Donald et al. 1998, Farwig et al. 2008, Felton et al. 2010, Sweeney et al. 2011). A study of the bird communities of Norway spruce plantations in Ireland found that diversifying these forests with either oak or Scots pine (*Pinus sylvestris* L.) had only a modest effect on bird communities (Sweeney et al. 2010b). However bird species composition in intimately mixed stands was similar to that found in native woodlands composed entirely of either Norway or Sitka spruce (Sweeney et al. 2011). Possible reasons for this include the greater level of shrub cover in the mixed forests (which may be a consequence of increased light penetration due to a more open canopy), and also the direct influence of the native tree species. Both of these factors increase structural complexity beyond the levels found in typical pure conifer stands. In the case of Norway spruce and oak mixes, the influence of the oak component probably did not reach its full potential, due to oak trees being out-competed by the faster growing conifers. In most of the oak mixes studied, this resulted in planted oak trees being relegated to the sub-canopy layer, which reduced their size and influence on forest vegetation and bird communities. Oak planted in an intimate mix among conifers may therefore be less beneficial to birds than larger patches of oaks interspersed among a stand. When planted in clumps, oaks will be less affected by shading from surrounding conifers, allowing them to contribute to the forest canopy and be of greater benefit to local bird assemblages (Sweeney et al. 2010b).

Non- crop vegetation

The lower diversity of bird communities in closed canopy plantations, relative to native woodlands, is in part due to the scarcity of under-canopy, non-crop vegetation and broadleaved shrubs and trees (Figure 5). As mentioned earlier the opportunities for such vegetation to develop is typically limited by the low levels of light in closed canopy plantations. Bird diversity at the stand and forest scales was positively related to the percentage cover of deciduous, broadleaved trees non-crop vegetation in Irish

Figure 3: *From left to right: native oak woodland, native ash woodland and mature non-native Sitka spruce plantation forest (Photo: Mark Wilson).*

Sitka spruce plantations (Wilson et al. 2010). Non-crop vegetation in roads, rides and other unplanted areas was also associated with higher bird diversity. The higher bird species richness in these areas was, in large part, due to the presence of species that are known to be associated with broadleaves, and so responded to the increase in the cover of shrubs and broad-leaved trees (Figure 5). Non-crop vegetation can also have a positive effect on birds by enhancing the structural complexity of forest vegetation. This suggests that providing an opportunity for native trees and shrubs to grow by leaving unplanted areas in stands may partly compensate for the simpler structure and lack of broadleaved vegetation in areas of closed canopy conifers (Roycroft et al. 2008, Wilson et al. 2010). The magnitude of the positive effect of such unplanted areas will likely be determined by their overall size, with larger areas providing habitat for a greater number and diversity of birds. When incorporating an unplanted or open area in a forest there are advantages both of dispersing this area between a number of individual small spaces (to maximise the influence of non-crop vegetation on the wider forest (Bibby et al. 1989)) of configuring it as a single large area (to better suit species with large habitat requirements (Langston et al. 2007)).

Rotation and growth stage

Several studies have examined the effect on bird assemblages in plantation forests of growth stage (from planting through to harvest) and rotation (Patterson et al. 1995, Donald et al. 1998, Wilson et al. 2006, Sweeney et al. 2010c). Differences between commercial plantation rotations are generally not as marked as those between different growth stages, which are in large part due to changes in percentage cover of shrubs over the commercial forest cycle (Wilson et al. 2006). In Ireland, few areas of conifer forest are left unharvested beyond 50 years of age and, as a result, features associated with old-growth forests such as high volumes of standing and lying deadwood, tree hollows and regenerating areas of shrubs and sub-canopy trees in gaps left by fallen trees, are rare in Irish forests (Sweeney et al. 2010c). Old growth forests may help the re-establishment of the great spotted woodpecker (Coombes et al. 2009). Nevertheless, differences have been reported between the bird communities of first and second rotation forests. Throughout the second rotation, but especially during

Figure 4: *Mixed Norway spruce and oak plantation forest (Photo: Linda Coote).*

the pre-thicket stage, levels of non-crop shrub cover are higher than in equivalently aged, first commercial rotation forests. As a result, several species of birds that breed in shrub-rich habitats are more abundant in second rotation pre-thicket forests (Figure 6) than in recently established afforested sites. Migrant songbird species have been found at significantly lower densities in closed canopy than in Thicket and Pre-thicket forests (Figure 6). The bird communities of these early stages are markedly distinct from those of closed canopy plantations. In addition to holding high densities of several migrant songbird species, second rotation pre-thicket stands also support resident species of conservation concern (Table 1). However, these species are not found in plantations following canopy closure at the mid rotation stage (Figure 6), but are replaced by a more generalist bird community, with high densities of just a few common species.

Conclusions

Afforestation profoundly changes the bird communities of many open habitats, particularly following canopy closure. The establishment of forests in intensively-managed grassland sites is preferable to afforestation of marginal habitats, such as species rich grassland, intact peatland habitats or habitats with a high percentage cover of shrubs. The low species richness of closed canopy Sitka spruce monoculture plantations, relative to that of native Irish woodlands, demonstrates the importance of structural complexity and components such as understorey cover for bird species richness. Mixed plantations support more diverse bird communities than monocultures, due to their increased structural diversity. If planting slow growing trees such as oak as a diversifying mix component within a conifer plantation, their contribution to forest biodiversity can be enhanced by ensuring that they do not become outcompeted by the more vigorous conifer component. The persistence of trees through a number of rotations may improve availability of nest sites and foraging habitat for several woodland species, including hole-nesting species such as the recently colonised great spotted woodpecker. The presence of a variety of forest age classes will increase the chance of required habitat conditions being available for many terrestrial bird species in Ireland. Additionally, leaving unplanted areas (e.g. forest margins, wide rides and glades) in and around plantations and establishing plantations near to existing broadleaved woodland may have an overall positive effect on forest bird communities. Forest management strategies should particularly target the closed canopy stage to increase habitat heterogeneity and enable plantations to benefit a wider range of species.

Management recommendations

1. Use improved grassland sites for afforestation where possible.
2. Carry out more extensive thinning in mid-rotation forests.
3. Plant broadleaved trees in patches throughout mixed species plantations or with slower growing, more open canopy species such as Scots pine.
4. Allow some trees to persist through several rotations (to complete their life cycle).
5. Include all growth stages of the forest cycle within a forested landscape.
6. Leave vegetation to develop in unplanted areas within forest plantations.

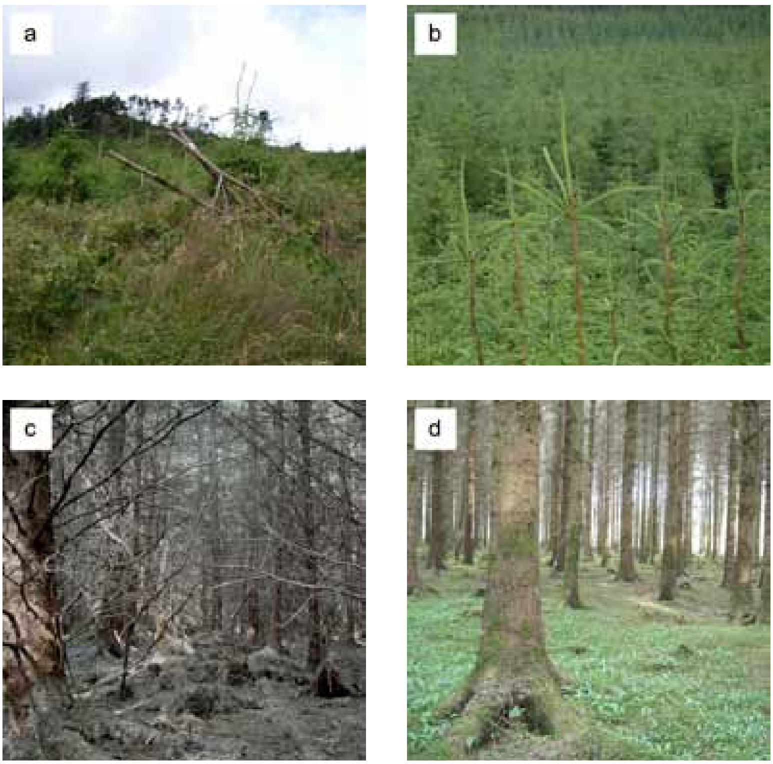

Figure 6: *Different growth stages of Sitka spruce forest: a. pre-thicket, b. thicket, c. mid-rotation and d. commercially mature (Photo: Mark Wilson).*

By implementing at least some of these management recommendations the bird communities of Irish forests should benefit from a more diverse and heterogeneous forest structure. This will enable plantation forests to realise their potential as important conservation areas for Ireland's biodiversity.

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