Transformation of Sitka spruce plantations to continuous cover forestry at Dunranhill Forest, County Wicklow, Ireland

By Edward Wilson, Rainer Wirz and Liam Byrne

This case study describes recent developments at Dunranhill Forest, County Wicklow, Ireland. The forest was established in the early 1980s as a commercial Sitka spruce plantation. Currently it is being transformed to continuous cover forestry (CCF). The owners are among the first to join the new CCF Woodland Improvement Scheme launched in 2019 by the Irish Forest Service.

Introduction

There is growing interest in Continuous Cover Forestry (CCF) in Ireland. In recent years, a range of new initiatives and programmes have been introduced that are stimulating wider engagement among owners and managers (Wilson et al., 2020). Many established productive woodlands are now at a stage where thinning can take place in line with technical guidance on stand transformation to CCF (Teagasc, 2016). In this report we describe recent experience at Dunranhill Forest, near Newtownmountkennedy, County Wicklow, Ireland. This productive Sitka spruce (*Picea sitchensis*) woodland has been under active CCF management since 2014 and is one of the first woodlands to join the CCF Woodland Improvement Scheme (CCF-WIS), administered since 2019 by the Irish Forest Service, part of the Department of Agriculture, Food and the Marine (DAFM) (DAFM, 2019).

Location and site information

County Wicklow is located in the south east of Ireland. It is known as the Garden of Ireland but also has a rich tradition in forest management. Avondale House and Forest Park, at Avondale, County Wicklow, was purchased by the state in 1904 and is regarded as the historic home of Irish forestry and silviculture. The county has a forest area of 36,262ha, making it the second most-wooded of all counties in Ireland (17.9% of land area) (DAFM, 2020).

Dunranhill Forest (53.058°N, 6.121°W) is located approximately 5km (three miles) south of the village of Newtownmountkennedy. It is typical of productive forests in the region, occupying high ground in a landscape mosaic of farmland, moors and woods (**Figure 1**). Dunran Hill (342m) is a prominent landscape feature, with farmland to the west and north, and open moorland to the south. To the east, the property adjoins a mature woodland, Dunran Demesne, managed by Coillte, the state-owned forestry company. To the east, it adjoins a private woodland also committed to CCF (**Figure 2**). Overall, the altitudinal range for the forest is 170m. The climate is relatively warm and temperate (annual average 9.8°C) with annual precipitation of 1,100mm.

The total area of the Dunranhill property is 88ha. The majority of the productive forest is located to the north and east of the hill, and is relatively sheltered from prevailing winds. The soils are mostly shallow brown earths over shales, with frequent rocky outcrops. The soil nutrient regime is moderate, except in Compartment 2, which is richer. The site is free draining throughout. Slopes are generally moderate, although there are several steeper areas that are more challenging to access with harvesting machinery. Most of the site was unimproved upland pasture, except for two fields in the

Figure 1 (left). A view of Dunranhill Forest from the north, 2020. The unplanted area is visible on the skyline to the left-centre of this scene.
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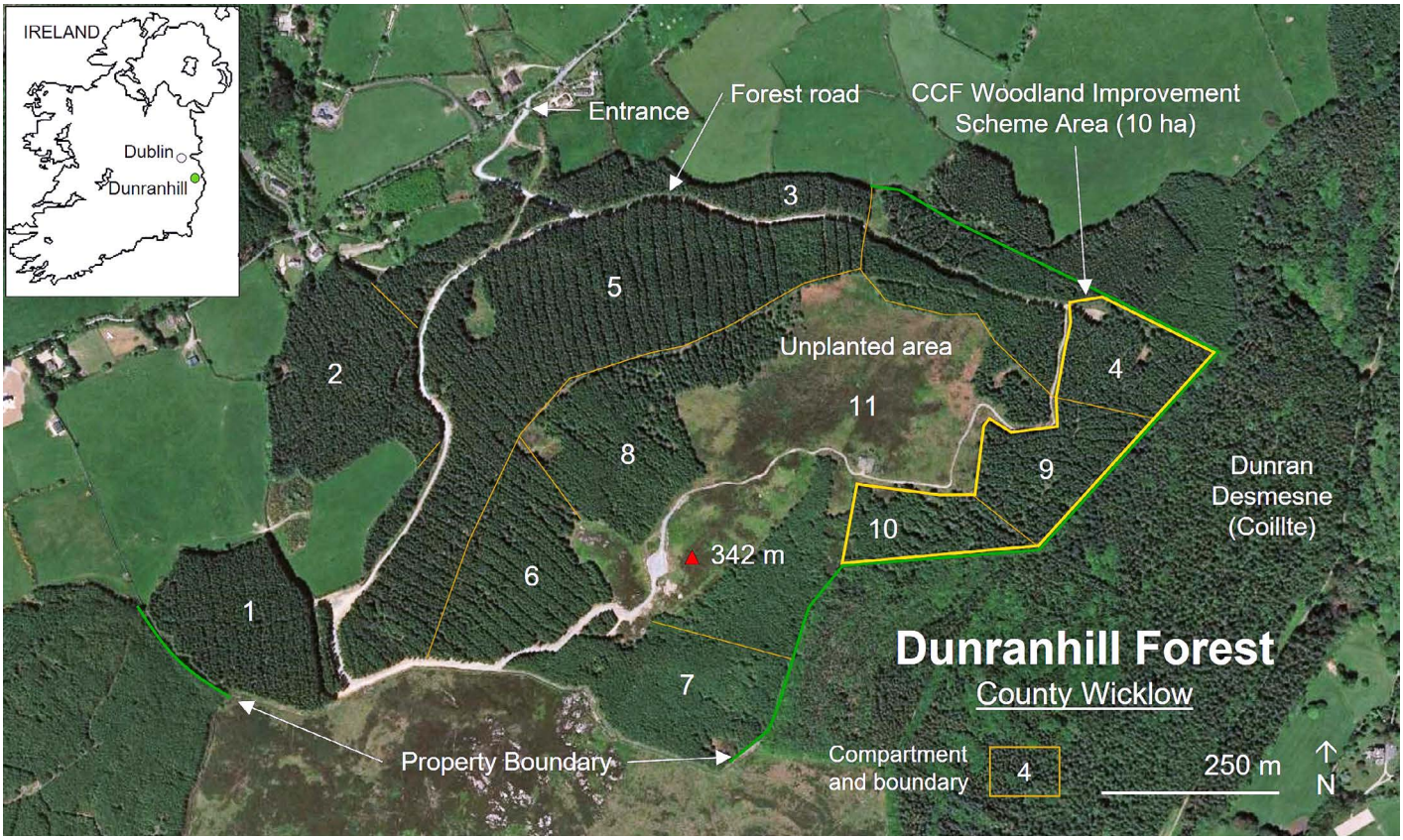

Figure 2. Aerial view of Dunranhill Forest showing the boundaries, compartments and main features of the property. The boundary of the area included in the CCF Woodland Improvement Scheme is identified. Base image: Google Earth.

west and north-west of the property (Compartments 1 and 2) that were actively farmed until the property was converted to forestry. Yield Class (maximum mean annual increment, m^3/ha/yr) ranges from 24 (lower, sheltered areas) to 16 (upper, exposed areas), with a significant area of the forest averaging YC 20–22.

Ownership and management policy

The Dunranhill property was owned by a local farming family until around 1980, then sold to new owners interested in converting the land use to forestry. Planning was initiated in 1981 under the woodland establishment scheme in operation at that time. The original objective was to establish a conventional even-aged forest, which would be clearfelled on a rotational management system. However, the forest was sold in 2013 to the present owners, a family with roots in Germany. The current manager, Rainer Wirz of Forst Service Wirz, has experience of German forestry practices and traditions (*Naturgemaeßer Waldbau*) and, in discussion with the owners, opted to embrace a CCF management policy following 'Pro Silva principles' (Pro Silva Europe, 2012). Pro Silva is a European confederation of professional foresters who advocate and promote 'close to nature' forest management as an alternative to rotation-based plantation systems. The objectives are to sustain a steady income from timber and deliver other ecosystem services, including biodiversity and landscape conservation.

Continuity of personnel has been an important feature of management at Dunranhill Forest. All thinning, harvesting and timber sales from 2007 onwards have been undertaken by Larry Byrne and Sons (Timber) Ltd. Road and other infrastructure operations have been completed by M and S Ryan Plant Hire Ltd. Since 2013, Forst Service Wirz has provided forest management services and acted as the property manager on behalf of the owners. Silvicultural prescriptions and tree marking activities are jointly implemented by Rainer Wirz and Liam Byrne (Larry Byrne and Sons (Timber) Ltd). Both are active members of Pro Silva Ireland. Deer management

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is coordinated by Rainer Wirz, working closely with the owners and neighbours.

Woodland creation

The site was prepared using a shallow plough to create suitable microsites for planting. Furrows were at approximately 1.8m spacing on the lower ground and slopes. At higher elevations the spacing was more varied due to the roughness of the terrain and increased prevalence of rocky outcrops. The initial plan was to maximise the productive forest area and to plant the entire site with Sitka spruce. A small number of Japanese larch (*Larix kaempferi*) seedlings were mixed in with the spruce during planting. This was a common practice at the time to enhance the aesthetic and amenity value of the woodland.

Compartments 1 to 5 were planted at a spacing of approximately 1.8m x 1.8m. Further up the hill this extended to between 2m and sometimes 3m (particularly in Compartment 8). Following establishment, trees in this higher area were adversely impacted by deer browse and vegetation competition, which has led to an irregular spacing.

A combination of rocky outcrops and a shortage of planting stock resulted in an area of 14ha of higher ground being left open and unplanted. Several years after the initial planting, a grass fire jumped the fence and into the forest along the southern margin of the property. This destroyed a significant area of thicket-stage woodland, most of Compartment 7 and part of Compartment 10, which was subsequently re-stocked.

Taking into account roads and landing areas, the stocked woodland area amounts to 70ha.

More recent assessments of the forest have shown that timber quality is good in sheltered areas and at lower elevations. This is likely a function of genetics (although no nursery records have been retained) and the high planting density. At higher elevations, where the trees are more widely spaced and exposed, the timber quality is noticeably more variable. Trees are generally shorter and coarser in appearance; stem straightness is lower and branches are often heavier compared with sheltered areas.

Thinning strategies

The first thinnings were initiated in 2007–08. This was later than recommended practice (Farrelly, 2012), due to logistical difficulties with establishing roads and infrastructure. At this time, stand top heights were 15m-plus in the sheltered and more productive areas. This dictated a conservative thinning policy. The key consideration was to initiate density management without adversely affecting stand stability. Wherever possible, a harvester and forwarder team was engaged to fell and extract the timber. However, manual felling was also necessary in some of the steeper areas.

The forest has always been nurtured with an adaptive management philosophy aimed at keeping options open for the future. Conventional thinning regimes were applied in the early stages, but some consideration was given to CCF from the start. Rack spacings are mostly every ninth row (i.e. 16–20m, average 18m), although there was significant variation due to site factors and differences in initial tree spacing. In addition to racking, a low thinning was applied to the matrix. Some areas, mostly on the south side of Dunranhill, remained unthinned at the first intervention due to their younger age and poor access.

Since 2013, thinning operations have been planned on a three to four year cycle with the aim of extracting 50–70m³/ha of roundwood at each intervention (**Figure 3**). This level of production provides consistent quantities of timber that underpin the economic sustainability of the forest. The second thinning took place in some sections in 2011. This was followed by operations in 2014, 2016, 2018, 2019 and 2020. Further expansion of the road network in 2015–16 allowed improved access to the entire forest, so that by 2020 most areas had been thinned two to four times.

Figure 3. A view of the stand in Compartment 5 after four thinning interventions, 2021. The best-quality trees have been retained and released from competition. Competitor and poor-quality trees are gradually being removed. The stand is being managed on a crown thinning regime with a conscious effort to create a diversity of microsites so that regeneration can be established in small patches at different stages in the transformation. © ER Wilson

In 2020, Compartment 2 (6.2ha), one of the most productive areas of the forest, was clearfelled. Two reasons for this decision were the strong timber markets and the poor prospects of securing natural regeneration. As a legacy of past land use, dense swards of grass had taken hold across the compartment. This represented a barrier to natural regeneration and the option to under-plant was considered too costly. The compartment will be restocked with a mixture of broadleaf and conifer species in group planting, with consideration to the future potential for CCF.

Operations are timed, as much as possible, to avoid the active growing season and wettest period. This minimises the risk of damage to the residual standing trees. Extra care is required with operational racks to

minimise soil impact and rutting, as most racks are used repeatedly into the future within a CCF management system.

Crown thinning and natural regeneration

The first two interventions were conventional thinnings, with an emphasis on promoting quality trees. The more recent policy has been to adopt crown thinning which is advocated for transformation of even-aged plantations to CCF (Vitková and Ní Dhubháin, 2013; Wilson et al., 2018; Cameron, 2020). In crown thinning, the best-quality trees (with good stability attributes) are selected for retention; competitors and larger, poor-quality trees are marked for removal. Other trees, especially smaller individuals, are retained for future selection. Release of the best-quality trees at an early stage in the transformation has a positive impact on stability (Price, 2021). Increased wind forces acting on these trees, along with increased growth rates, lead to alterations in photosynthate allocation to the stems and roots. This adaptive growth results in lower height:diameter ratios, a key index of tree and stand stability (Cameron, 2020; Mason, 2002). This form of thinning also delivers the necessary structural differentiation and irregularity in spacing to facilitate and control natural regeneration (Malcolm et al., 2001; Cameron, 2020).

Table 1. Compartment inventory data for Dunranhill Forest (March 2021). Variation between compartments is due to differences in establishment, thinning interventions and site exposure.

Compartment	Mean DBH (and range) (cm)	Mean top height (m)	Mean H:D ratio[1] (dominant trees)	Stand density (N/ha)	Mean BA (m^2/ha)
CCF-WIS Area (4,9,10)	33 (19–48)	24	59	383	34
3	29 (19–35)	25	71	500	34
5	27 (14–42)	24	64	533	33
6	32 (28–36)	22	54	600	47
7	26 (22–33)	16	49	700	38
8	26 (18–39)	18	46	500	29
Forest average	**29 (14–48)**	**21**	**59**	**536**	**36**

Note: [1]Height:Diameter (H:D) ratios for individual compartments are the mean of trees with the largest DBH in each survey plot. Values <80 are considered stable (see Cameron, 2020).

By the third thinning, many trees had reached maturity and were producing seed, which is essential for initiating the transformation. Patches of seedlings then started to occur in some of the more open microsites where larger trees had been removed, most notably in Compartment 5 (**Figure 4**). This prompted an adaptive strategy for tree marking. Small gaps are now being gradually opened to provide the necessary light for continued seedling recruitment and growth, effectively a process of 'light management'.

Figure 4. A patch of Sitka spruce seedlings established in a small canopy gap in Compartment 5, 2019. Thinning prescriptions aim to create a diverse forest canopy with variable light levels on the forest floor. It is anticipated this will support further development of an irregular stand structure. © ER Wilson

Basal area (BA; the cross-sectional area of all stems/ha measured at breast height) in m^2/ha is an important metric used to guide the management of stand transformation (Page et al., 2001; Kerr, 2008). The mean BA across the forest is approximately 35m^2/ha (**Table 1**). However, there is considerable variation due to past management and the timing of thinning operations. Sitka spruce has intermediate shade tolerance and natural regeneration typically takes place in the BA range 25–35m^2/ha, though for more shade tolerant species the ranges are higher; the optimum range for establishing seedlings is 30–35m^2/ha and for sustained seedling growth is 25–30m^2/ha (Kerr, 2008). As a result, some areas are regenerating more quickly than others.

The basal area is regulated by the timing, intensity and pattern of thinning operations. In unthinned stands, BA can increase to over 50m^2/ha. Getting the basal area down to the target range for natural regeneration requires careful consideration. Removing too much timber in one operation, or delaying thinning interventions, can destabilise the stand. Taking too little does not facilitate natural regeneration. In most cases, on windfirm sites, a maximum of 20% of the basal area is removed in any one thinning intervention. However, as the stand immediately responds and the basal area increases again, it can take several thinning interventions to achieve the target basal area for natural regeneration to occur and be sustained.

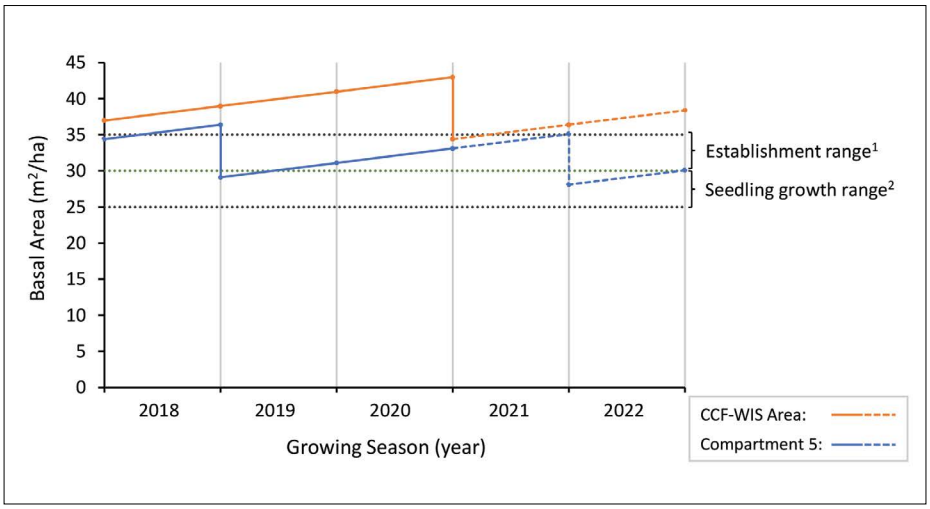

Figure 5. Basal area dynamics in Compartment 5 and the CCF-WIS area at Dunranhill Forest. The inventory took place prior to the 2021 growing season, and illustrates past (solid line) and projected (dashed line) stand development through five growing seasons (2018 to 2022). The estimated ingrowth is 2m²/ha/yr. The basal area ranges are shown for: [1] seedling establishment (30–35m²/ha) and [2] sustained seedling growth (25–30m²/ha) (Kerr, 2008).

How this works in practice can be demonstrated by comparing the development of Compartment 5 with the CCF Woodland Improvement Scheme (CCF-WIS) area (Compartments 4, 9 and 10) (**Figure 5**). At an inventory prior to the 2021 growing season, the BA in each of these areas was broadly similar at 33 and 34m²/ha, respectively, but management history was different. Compartment 5 was last thinned in 2018–19. Approximately 20% of the standing basal area was removed at that time, giving a residual BA of 29m²/ha. Assuming ingrowth of 2m²/ha/year, the stand BA increased to 33m²/ha over two growing seasons, still within range for natural regeneration. Nevertheless, after the 2021 growing season, the BA will likely rise above 35m²/ha, and the potential for natural regeneration is expected to diminish. If a thinning operation were to take place in 2021–22, as planned, the stand BA will remain within the appropriate range to allow for sustained seedling recruitment.

Conversely, in the CCF-WIS area, the most recent thinning operations took place during winter 2020–2021. Prior to this, the overall BA was estimated to be 43m²/ha (lower in Compartment 4 due to more frequent interventions). As a result, the basal area in growing seasons 2018, 2019 and 2020 was mostly above the threshold levels for natural regeneration of Sitka spruce. Following the latest thinning the residual basal area dropped to 34m²/ha, but it will likely be another two or more thinning cycles before the stand can be managed within the appropriate range for sustained recruitment and development of Sitka spruce seedlings.

An understorey survey in March 2021 highlighted the impact of thinning on natural regeneration in the CCF-WIS area and Compartment 5 (**Figure 6**). Linked to the adaptive management philosophy, several unthinned plots have been retained in the forest to demonstrate the effect of thinning and basal area management on stand regeneration. In Compartment 5, for example, the control plot has a basal area of 62m²/ha, compared with 33m²/ha elsewhere. All the regeneration in Compartment 5 was Sitka spruce, recorded as seedlings (with secondary shoots) or germinants (with cotyledons only). The seedlings were under 30cm tall and not yet free from browse damage. The profusion of germinants arose from the mast year in 2020; high mortality is expected. Under more shaded conditions in the CCF-WIS area, there was less natural regeneration, but greater species diversity. This is due to dispersal of seed from shade tolerant species (grand fir and western hemlock) from the adjoining property.

At the present time, there is little competing vegetation in the understorey, and limited evidence of bramble taking hold. Rhododendron and laurel, which

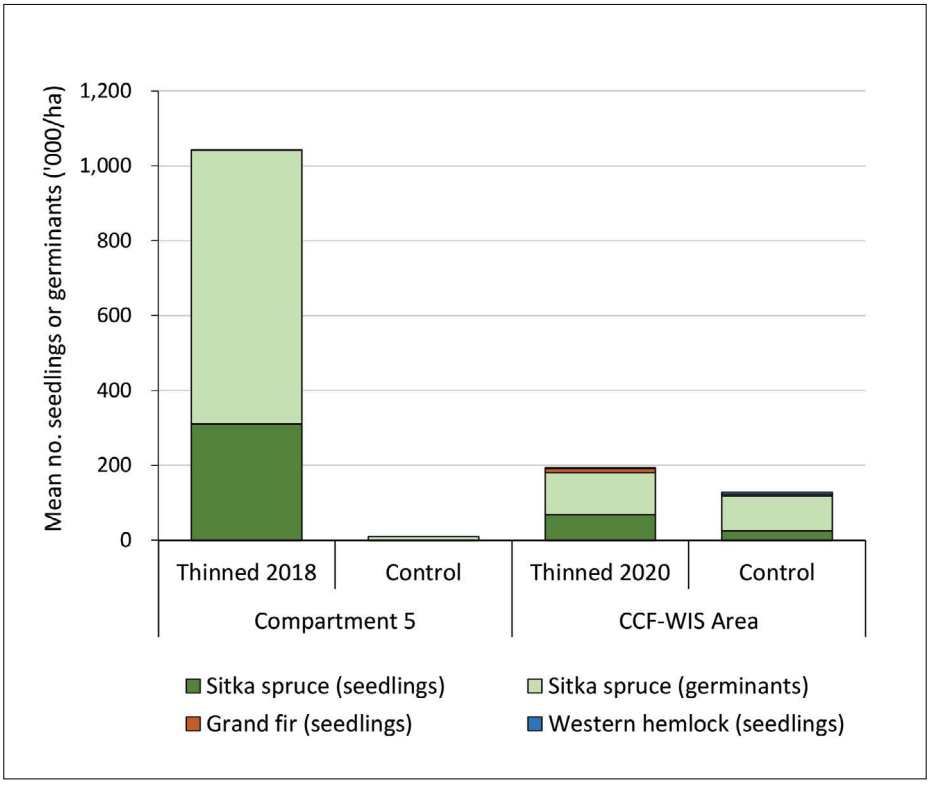

Figure 6. Comparison of natural regeneration in Compartment 5 and the CCF-WIS area at Dunranhill Forest (March 2021). Sitka spruce was categorised by seedlings (with secondary shoot development) and germinants (with cotyledons only). Unthinned plots are retained in each area to inform management of these stands.

Figure 7. A mini exclosure located around a patch of naturally-regenerating Sitka spruce seedlings in Compartment 5, 2021. The fences are 1.7m tall and cover an area of approximately 50m^2. It is anticipated the fencing will be moved to other locations in the forest once the seedlings are fully established and free from the risk of browsing. © ER Wilson

are much in evidence throughout County Wicklow, are not significant issues at Dunranhill. Slightly heavier thinnings are now being trialled in some of the sheltered areas to release established patches of seedling regeneration. Care needs to be taken in managing light levels to facilitate seedling establishment while minimising the risk of grass and other competing vegetation dominating the site (Price, 2021). The absence of significant wind damage is a source of cautious optimism with respect to crown thinning and gap expansion.

Deer management

County Wicklow is noted for the high number of sika deer (*Cervus nippon*) now resident in most woodlands. Ongoing and active control of deer is an essential component of a CCF management policy if natural regeneration is to be secured. In 2019, a series of mini exclosures were installed to reduce the risk of deer browse on natural regeneration (**Figure 7**). Monitoring browse damage is important for designing and planning the next cycle of thinnings.

Amenity features

The owners have a deep appreciation of the historic and landscape attributes of the forest. The ruins of two ancient farm dwellings have been preserved and stabilised, several wolf trees have been retained for habitat and landscape purposes, and legacy broadleaves have been given more space to grow (**Figure 8**).

CCF Woodland Improvement Scheme

Dunranhill Forest was among the first applicants to join the new CCF-WIS. Details of the scheme are described by Wilson et al. (2020) and on the Teagasc Forestry website (Teagasc, 2021). The most important criteria for entering the scheme are:

1. Free-draining mineral soils (peats, deep peats, wet peats, waterlogged sites and gleys are to be avoided)
2. Capability to grow Sitka spruce to Yield Class 14 or greater
3. Sites subject to severe and persistent threats (e.g. rhododendron, deer) must have a comprehensive action plan
4. Elevations above 300m should be avoided due to the increased windblow risk.

In terms of financial support, the applicant must devise a CCF Transformation Management Plan that will run for 12 years. Three instalments of up to €750/ha can be claimed for planned activities. The first payment is at year one with the final payment at year 12, based on completion of the approved schedule of works. The middle payment can be paid at any stage during the intervening period. A maximum area of 10ha can be included in the plan.

At Dunranhill, the 10ha block included in the CCF-WIS incorporates Compartments 4, 9 and 10 (part) (**Figure 2**). These are located along the eastern boundary of the property and adjacent to Dunran Demesne. One of the reasons for selecting these compartments is the diverse range of species in the neighbouring property,

Figure 8. An oak tree finding its way through a boundary wall (Compartment 9), 2019. Landscape and other natural heritage features are retained wherever possible. They are a source of joy and satisfaction for the woodland owners, and enhance the overall amenity value of the property. © ER Wilson

Year	Compartment	Proposed Actions
2020	9	- Preparation of a site-specific CCF management plan - Pre-thinning tree marking - Improvement felling of malformed trees - Ground preparation, light scarification - Deer management - Enrichment planting where necessary
2026	9	- Pre-thinning tree marking - Improvement felling of malformed trees - Ground preparation, light scarification - Deer management - Enrichment planting where necessary - Management and respacing of natural regeneration
2032	9	- Pre-thinning tree marking - Improvement felling of malformed trees - Ground preparation, light scarification - Deer management - Enrichment planting where necessary - Management and respacing of natural regeneration

Table 2. Example management schedule for 2020–2032 in Compartment 9, Dunranhill Forest, which is part of the area within the designated area of the Woodland Improvement Scheme for CCF.

including Douglas fir, grand fir, western hemlock, beech, oak and other native species. Early indications are that seed is spreading into Dunranhill, which will help increase species diversity into the future. In addition, this is the most sheltered part of the forest and at the lowest risk of wind damage, making it possible to apply different intensities of thinning and to modify gap sizes in response to the developing natural regeneration (**Figures 9 and 10**).

The CCF Transformation Management Plan was approved in 2020. The schedule for Compartment 9 is provided in **Table 2.** Most important is support for the costs of tree marking and deer management. It is hoped that natural regeneration will be the primary method for securing the next generation of trees. Enrichment planting makes it possible to diversify the species composition, and enhances the resilience of the forest to threats from climate change, pests and diseases.

Final comments

Dunranhill Forest demonstrates many features of contemporary forest management in Ireland. An adaptive management philosophy has given the owners and forest management team an opportunity to respond to both the forest's development and innovations taking place in the forestry sector. Application of crown thinning is increasing the diversity and irregular structure of the forest. The new CCF Woodland Improvement Scheme is supporting a range of activities and interventions that will sustain the continued production of high quality timber, facilitate natural regeneration and deliver additional ecosystem benefits.

Figure 9. View of Compartment 9 in 2021 after the completion of a thinning operation in December 2020. The variable size of stumps reflects the evolution of management practices, with some of the smaller trees being removed in the early thinnings, and larger trees being removed more recently. Care in all operations is essential to minimise the risk of mechanical damage to residual trees, and also to minimise damage to the site. © ER Wilson

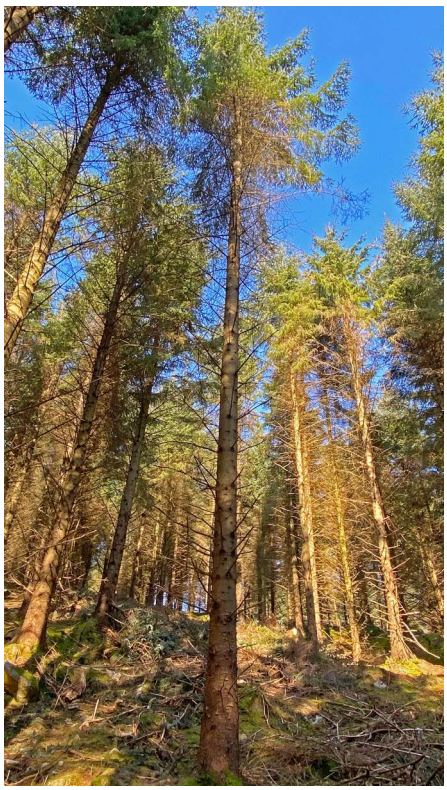

Figure 10. Controlled release of a future quality tree in the CCF-WIS area (Compartment 9), shown here in 2021. Gradual removal of competitors allows for crown development on the best quality individuals and creates gaps for natural regeneration. © ER Wilson

Acknowledgements

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