Environmental and social enhancement of forest plantations on western peatlands - a case study

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Abstract

A case study was carried out on future management scenarios for Western Peatland Forests (WPFs) along the Western Seaboard. It indicates a change in emphasis from wood production alone to a broader ecosystem management approach with increased emphasis on environmental and social objectives. Productive and financial potentials of typical WPFs were examined, and redesign plans were developed, consistent with an ecosystem management approach. Both the productive and financial potential of WPFs were found to be challenging under current conditions; options to improve this situation are presented and discussed. The impact of redesign planning was quantified in terms of biodiversity enhancement, bog restoration and protection, enhanced watercourse protection and visual landscape improvement. Impacts were projected to a national level to indicate future management scenarios for WPFs.

Keywords

Peatland forests, redesign plans, sustainable forest management, financial appraisal.

Introduction

The first attempt at afforestation of western peatland dates to 1892, on an exposed impoverished blanket bog at Knockboy, near Carna in Co Galway. It ended in failure due to the unsuitability of the site for tree growth (Durand 1998). However, experimentation from the 1950s, on drainage and nutrition methods, enabled the establishment of forest plantations on peatland (OCarroll 1962, Farrell and McAleese 1972, Dickson and Savill 1974, Gallagher, 1974, Galvin 1976, Farrell and Mullen 1979, Gleeson 1985, Farrell and Boyle 1990).

The extent of afforested peatland has been estimated as 200,000 ha, with the greater part occurring in the west of Ireland (Farrell 1990). Since 1990, a further 22,633 ha of unenclosed land has been planted along the western seaboard (Forest Service 2006), bringing the total to over 223,000 ha. Overall ownership of Irish forests is 58% public (Coillte – The Irish Forestry Board), with the balance privately owned (Forest Service 2003).

Western Peatland Forests (WPFs) occur along the length of the western seaboard, from Donegal in the north to Kerry in the south. Peatlands in the region consist mainly of low-level and high-level blanket bog. The majority of WPFs were established between the early 1960s to the late 1980s, and served an important social function, whereby afforestation provided a means of employment in disadvantaged areas (Tiernan 2004). Today, afforestation of western peats has declined (Renou and Farrell 2005), largely due to the designation of peatland Special Areas of

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Conservation (SACs) – under the EU Habitats Directive - and as Natural Heritage Areas (NHAs), and the movement to better quality forest land.

At the time when most forests were being established on peatland, it was regarded as 'waste land', mainly because it was unsuitable for agriculture. Today, many peatlands are regarded as rare and endangered habitats with high ecological value. This is of particular importance as Ireland now retains one of the largest areas of peatlands remaining in Western Europe (The Heritage Council 1992).

Forests on western peatland are mainly first rotation. All were planted with the twin objectives of providing employment and adding to national wood production (Farrell 1997). As the forests mature it is clear that a single focus on wood production is not attainable from an economic, environmental or social perspective. There is a need to adopt a multi-objective management approach, with the view to redesign during reforestation to provide a greater range of services in the future.

The case study reported here sampled WPFs in the Coillte estate, in order to develop a range of redesign plans, with the view to balancing environmental and social benefits with future forests. The impact of the plans was analysed, and the results extrapolated to the full Coillte estate, to provide a basis for sustainable management of these areas into the future.

Objectives

The objectives of the case study were:

- to quantify the wood production potential of WPFs,
- to redesign WPFs for the second rotation so as to balance economic, environmental and social objectives,
- to analyse the possible impacts of redesign plans on the future management of WPFs and
- to conduct a financial appraisal of forestry on western peatlands.

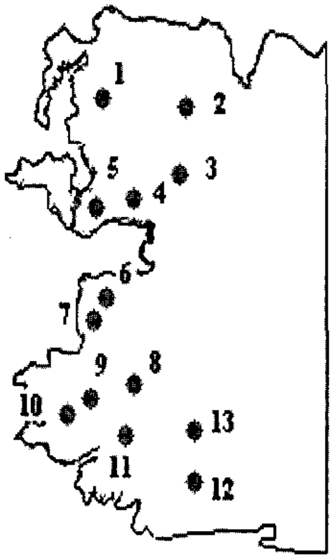
Materials and methods

Management redesign plans

A total of 13 forest properties in the Coillte estate was examined in counties Mayo (7) and Galway (6), covering an area of 7,926 ha (Figure 1). They represented a 3.9% sample of the total estimated area of afforested blanket peatland in the Republic of Ireland. The properties ranged from 42 ha to 3,008 ha, with an average of 610 ha. Each property was visited, assessed and mapped.

Redesign plans were drafted for each site using a standard approach, in order to address environmental and social issues, as well as future wood production (Table 1). The approach was developed by Coillte in 2003/2004 as part of an internal company project that investigated possible future management strategies for low production plantations on western peatlands (Tiernan 2004).

Redesign required both field visits and utilisation of Coillte's IT forest management tools. Comprehensive, long-term management plans were developed for each of the 13 properties. Planning consisted of five steps (Table 1):



	Coillte property name	*County*	*Inventory area (including open space) ha*
1	Drumanaffrin	Mayo	80
2	Corrovokeen	Mayo	376
3	Coolnabinnia	Mayo	183
4	Glendahurk & Glenamong	Mayo	724
5	Cartron	Mayo	957
6	Loughnamucka	Mayo	523
7	Tawnydoogan	Mayo	318
8	Shannaunnafeola	Galway	73
9	Finnisglin	Galway	52
10	Derrylea	Galway	42
11	Cappahoosh	Galway	1,241
12	Finnaun	Galway	3,008
13	Derreen	Galway	351

Figure 1: Coillte properties in counties Mayo and Galway that formed the sampling frame for the case study.

1. Forest details (before/after plan),
2. Planning considerations,
3. Assessment of wood production potential,
4. Redesign management prescriptions and
5. Management redesign plan.

Step 1: Forest details (before/after plan)
Forest areas in each property were allocated to one of 16 categories (Table 1). Areas were calculated before and after the redesign plan, using a combination of the Coillte GIS system and manual methods. Area-wise comparisons were made for each category.

Step 2: Planning considerations
A total of 26 planning considerations were applied to each redesign plan (Table 1). These considerations were broadly classified under wood production, statutory designation, environmental and social and visual. These considerations were evaluated for each property during the redesign process.

Step 3: Assessment of wood production potential
Yield class[2] was assessed for all crops in each property (Table 1) and was mapped using three colour-codes:

[1] Defined as potential maximum mean annual volume increment (to 7 cm top diameter), in units $m^3 ha^{-1} y^{-1}$.

Table 1: Overview of the methodology used in the redesign of western peatland forests (WPFs).

Step 1: Forest details (before/after plan)				
Total area	*Forest cover*	*Coniferous forest*	*Broadleaf forest*	*Extend to MMAI*
Inaccessible	Unsuitable for forestry	Unplantable	Water/Swamp	Turbary
Long term retention				
Buffer zones	Open space	Roads/ridelines	Undeveloped (stunted crops)	Bog restoration
Straight edge redesign				
Step 2: Planning considerations				
Timber production	*Statutory designations*	*Environmental*	*Social*	*Visual*
Wood production	SAC	Fisheries	Recreation	Improvement of visual appearance
Wood production potential	NHA	Avian	Archaeology heritage	Landscape sensitivity
Access roads	SPA	Wildlife	Adjacent residences	Landscape
Windthrow risk	National park	Forest health		Public view points
Exposure	Nature reserves	Climatic factors		Landform analysis
Soils	Freshwater pearl mussel catchments	Acid sensitive areas		
Step 3: Assessment of timber production potential				
Green (good) YC ≥ 16	Amber (intermediate) YC 12-14	Red (poor) YC ≤ 10		
Step 4: Redesign management prescriptions				
Retention of existing open space	Creation of extra wide buffer zones	Long term retention	Bog restoration & protection	Straight edge redesign
Step 5: Management redesign plans				
Forest details summary (before/after plan)	Main planning considerations	Assessment of wood production potential	Biodiversity plan	Water protection plan
Reforestation plan	Landscape design plan	Non-wood benefits plan		

1. Green (good): yield class ≥16
2. Amber (intermediate): yield class 12-14
3. Red (poor): yield class ≤ 10.

Step 4: Redesign management prescriptions

Five redesign management prescriptions were considered for each property (Table 1):

1. retention of existing open space,
2. creation of extra wide buffer zones,
3. long term forest retention,
4. bog restoration and protection,
5. straight plantation edge redesign.

Open space occurred in all properties, corresponding to infertile areas left unplanted; these areas were retained. The creation of extra wide buffer zones was determined by the sensitivity of the adjoining watercourse and local topography. Current guidelines require widths of between 10 and 25 m, depending on slope. In comparison, the extra wide buffer zones varied in width from 50 up to 100 m, involving the creation of new buffer zones and the extension of existing ones. Long-term forest retention was determined solely by inaccessibility for harvesting. Bog restoration and protection were selected for areas on the basis of ecological reports (where available), areas with a physical or hydrological link to adjoining peatlands with statutory protection, areas containing swamps, and areas where the vegetation present suggested good potential for successful restoration. Straight edges were removed by designating boundary areas to be left unplanted at reforestation.

For all properties, bog restoration and protection and straight edge redesign occurred once the crop was felled, as did the installation of extra wide buffer zones. Retention of open space and long term forest retention could clearly be carried forward in the absence of felling, once the plan was in place.

Step 5: Management redesign plan

Each property had its own management redesign plan that contained eight key features (see also Table 1):

1. forest summary (before/after plan),
2. main planning considerations,
3. assessment of wood production potential,
4. biodiversity plan,
5. surface water protection plan,
6. reforestation plan,
7. landscape design plan and
8. non-wood benefits plan.

Financial appraisal of forestry on WPFs

A model was developed to guide financial appraisal of forestry on WPFs. The scope was limited to pure lodgepole pine crops, where the harvestable material was exclusively pulpwood. Other permutations, such as pine crops with additional pallet and/or small sawlog assortments, or crops containing other species or mixes were not considered. Therefore, the results from the model should be viewed with caution and only within the context of WPFs which contain pure lodgepole pine pulpwood crops.

Using current costs and revenues, a Microsoft Excel-based model was developed to calculate discounted revenue over a rotation for pure lodgepole pine, for yield classes 6-18. The discounted revenues provided an indication of the maximum amount of revenue potentially available for reforestation of typical WPFs. The model was:

$$\textit{Discounted revenue } (€/ha) = (\textit{Volume/ha} \times \textit{Stumpage}€/ha)/(1.0p)^n$$

volume/ha was obtained from a lodgepole pine (south coastal) yield model (Forest and Wildlife Service 1975),
stumpage was calculated as sales price (€/m^3) - harvesting cost (€/m^3) - transport cost (€/m^3), expressed on a hectare basis,
p was the discount rate, chosen at 5%,
n was the age at clearfelling.

Volumes (m^3/ha) were based on a no-thinning regime, at 2.0 m spacing. A stumpage of €6/m^3 was calculated, based on a typical price €32/m^3 for pulp, €19/m^3 harvesting costs and €7/m^3 haulage costs (assumed haulage to a local mill within an 80 km radius). A discount rate of 5% was chosen at it is the one commonly used for forestry financial appraisal. Output from the model is presented in Figure 2.

The impact on discounted revenue of changes in roundwood price was also assessed. For ease of analysis, only discounted revenues at MMAI were considered (Figure 3). The assessment indicated the expected roundwood revenues (per m^3) required for

- harvest and transport operations to break-even and
- harvest, transport and subsequent restocking operations to break-even.

Results

Assessment of wood production potential

Results (Table 2) indicated that 650 ha (11%) of the 6,257 ha sampled had good wood production potential (YC 16+), 3,031 ha (48%) were intermediate (YC 12-14), while 2,578 ha (41%) had poor wood production potential (YC $\leq$ 10). As expected, the range differed significantly between properties. Of the properties examined, those with good wood production potential ranged from 0-47%, while the corresponding ranges for the intermediate and poor categories were from 0-79% and 5-100%, respectively. Of the 13 properties examined only nine contained all categories (good, intermediate and poor wood production potential). Four properties did not have any areas with good wood production potential (YC $\geq$ 16); of these, only two (Derrylea & Drumanaffrin) were categorised as having only poor wood production potential (YC $\leq$ 10).

Table 2: Assessment of wood production potential by property.

Property	*Wood production potential*						
	Forest area	*Good (YC ≥ 16)*		*Intermediate (YC 12-14)*		*Poor (YC ≤ 10)*	
	ha	*ha*	*%*	*ha*	*%*	*ha*	*%*
Cartron	459.0	-	0	128.5	28	330.5	72
Coolnabinnia	135.7	12.2	9	10.9	8	112.6	83
Corrovokeen	341.6	68.3	20	194.7	57	78.6	23
Glendahurk & Glenamong	685.3	41.1	6	294.7	43	349.5	51
Loughnamucka	499.1	79.9	16	394.3	79	25.0	5
Tawnydoogan	264.3	44.9	17	23.8	9	195.6	74
Cappahoosh	926.0	9.3	1	518.6	56	398.2	43
Derreen	320.5	73.7	23	192.3	60	54.5	17
Derrylea	32.7	-	0	-	0	32.7	100
Drumanaffrin	75.6	-	0	-	0	75.6	100
Finnaun	2,408.6	289.0	12	1,228.4	51	891.2	37
Finnisglin	44.5	-	0	17.8	40	26.7	60
Shannaunnafeola	67.1	31.5	47	27.5	41	8.1	12
Total	6,257.3	650.0	11	3,031.4	48	2,578.6	41

Management plans by redesign management prescriptions

Of the total area of 7,926.1 ha (including open space), 21% (1,666.1 ha) consisted of unplanted open space, with the remaining 79% comprising the forest area. Following redesign, the forest area was subdivided as follows:

- 13% (842.9 ha) suitable for long term retention,
- 8% (500.1 ha) for the creation of extra wide buffer zones,
- 8% (487.4 ha) suitable for bog restoration and protection and
- 1% (62.8 ha) for straight edge redesign.

Existing open space ranged between properties from 4-52%. Ranges for long term retention areas were from 0-96%. Areas for extra wide buffer zones ranged from 0-27%, while areas suitable for bog restoration and protection ranged from 0-13%. Finally, areas used for straight edge redesign ranged from 0-4%.

Financial appraisal of forestry on WPFs

Despite favourable price assumptions, discounted revenues were low and would place a limitation on revenue available for reforestation on typical WPFs (Table 3). Using the stumpage discounted revenue criterion, the maximum available spend for reforestation ranged from €170 and €658/ha, for the range of yield classes from 6 to 18 (Table 3).

Table 3: Available spend for reforestation on WPFs based on discounted revenue.

Yield class $m^3\ ha^{-1}\ y^{-1}$	*Rotation* *years*	*Discounted revenue* *€/ha*
6	37	170
8	35	246
10	33	327
12	30	409
14	30	482
16	29	590
18	28	658

For all yield classes observed, the maximum discounted revenues had rotation lengths of between 28 and 37 years for yield classes between 6 and 18 (Figure 2).

The sensitivity analysis (Figure 3) showed that the discounted revenues for lodgepole pine crops were directly proportional to increases in roundwood prices, with greater values associated with the higher yielding crops. The break-even roundwood price for the cost of harvest operations, including transportation to a local mill but excluding subsequent restocking, for all yield classes was 26 €/m^3. When the cost of restocking was included, the price required to break-even was dependent on yield class, with lower yield classes requiring higher roundwood prices to break-even. For example, assuming a restocking cost of €2,500/ha, the roundwood price

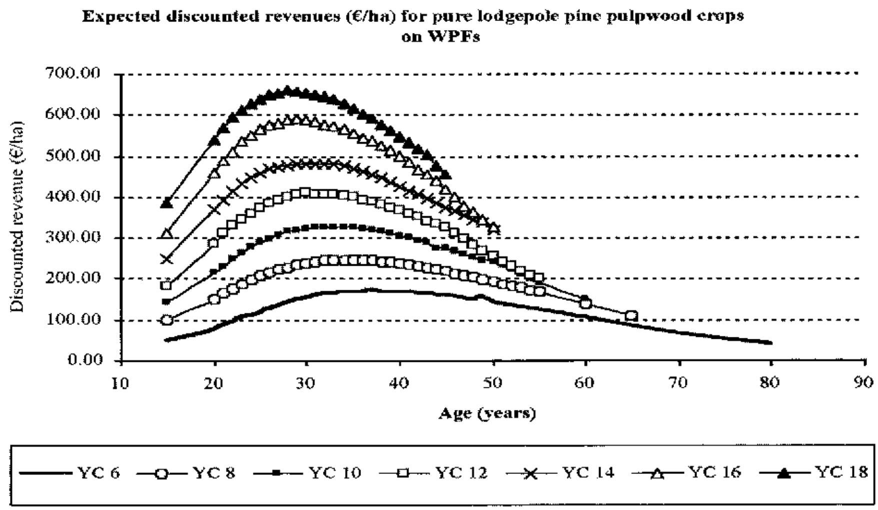


Figure 2: Effect of yield class and rotation length on the discounted revenue of pure lodgepole pine pulpwood crops on WPFs.

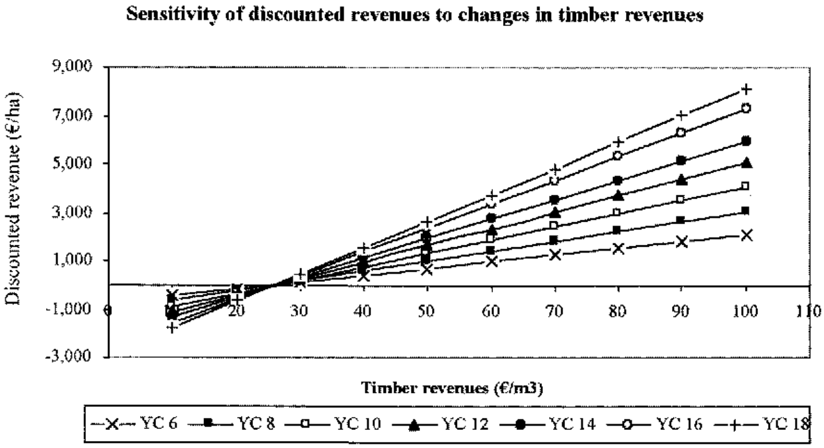


Figure 3: Sensitivity of discounted revenue at maximum mean annual increment (MMAI) in lodgepole pine crops (YC 6- 18) to roundwood price.

required to break-even was in the range of 49-115 €/ m^3 for yield classes 18 and 6 respectively.

Discussion

Over 40% of WPFs were found to have poor commercial potential, with the remainder having good or intermediate potential. Achieving future commercial investment (reforestation) in these areas will be challenging, with break-even costs limited to between €170-658/ha. However, the 1946 Forestry Act requires all forests that are felled to be replanted. A possible solution consistent with the Act would be to reforest using reduced stocking densities (1,000–1,500 stems/ha), with no ground preparation and minimal management. This could be justified economically, as the cost would be within the break-even range indicated. However, the role of these forests would change from a commercial function to the provision of a biomass crop and the retention of carbon stocks.

WPFs occur in a part of Ireland that has some of the best fishing rivers in the country; in a landscape that is dominated by extensive blanket peatlands and in a local economy that is increasingly reliant on tourism. For these reasons, adopting an ecosystem management approach for WPFs is wholly appropriate. In addition, the social and environmental contribution of forestry to the national economy is currently estimated at between €88 to €97 m per year (Bacon 2004, Fitzpatrick Associates 2005). Adopting an ecosystem management approach for WPFs would improve the environmental contribution by providing a variety of additional environmental services such as bog restoration, protection of watercourses and biodiversity and enhanced visual landscapes.

Bog restoration
Peatlands are unique and endangered habitats worldwide. After Finland, Ireland has the largest proportion of peat cover of any EU country (Hammond 1981). Yet despite this, 94% of raised bogs and 86% of blanket bogs have been damaged or destroyed in Ireland. As a result, less than 112,000 ha of blanket bog and 18,000 ha of raised bog remain relatively intact in Ireland (The Heritage Council 1992). Recent EU LIFE projects have restored 1,212 ha of blanket bog and 571 ha of raised bog of formerly forested peatlands to a peatland habitat (Donnellan 2006). Based on the case study reported here, 8% of WPFs have the potential to be restored to their original peatland habitat, representing a potential total area at the national level of 12,640 ha (Table 4).

Table 4: A possible national scenario for land-use allocation and management of WPFs based on case study.

Scenario	*ha*	*% of total inventory area*	*% of total forest area*
Retain existing open space	*42,000*	*21*	-
Forest cover (excluding open space)	158,000	-	100
Wood production (economically justifiable)	17,380	-	11
Wood production (economically questionable)	75,840	-	48
Wood production (economically unjustifiable)	17,380	-	11
Extra wide buffer zones	12,640	-	8
Bog restoration & protection	12,640	-	8
Long term retention	20,540	-	13
Straight edge redesign	1,580	-	1
Total inventory area (including open space)	200,000		

Protection of watercourses
Unlike many other European countries most large Irish rivers still support salmonid populations, with the best of these occurring along the western seaboard (The Heritage Council 1992). Salmonids and the freshwater pearl mussel (*Margaritifera margaritifera*) are water quality indicators; most rivers in WPFs still support these species. In the case study, 8% of the area was designated as extra wide buffer zones, in recognition of the importance of protecting water quality. Replicating this practice for all WPFs would result in an additional 12,640 ha being devoted to riparian management (Table 4).

Protection of biodiversity
Biodiversity in WPFs is of significant value, and is often understated. In this survey 21% of the area was classified as open space, most of which adjoined statutory designated areas. They were deemed to be too poor to plant and often comprised

valuable wetland and/or peatland habitats. Extrapolating the survey to the national level suggests that 42,000 ha of WPFs contain open space that is contributing to national biodiversity. In the survey 13% of the area was designated for long term retention. This was based solely on their inaccessibility for harvesting. At a national level, this suggests that approximately 20,540 ha of WPFs may not be harvestable. While these areas contribute to structural age diversity, their overall biodiversity contribution is uncertain and further research is required on how best to manage them.

Enhanced visual landscapes

There are strong demands to improve the visual impact of forest plantations and integrate them with the surrounding landscape, especially in sensitive landscapes (Price 1997). One of the added benefits of the ecosystem management approach is that is caters to a large degree for visual aspects of forests. However, plantations with highly visible straight edges may not be fully catered for, and this study suggests that the removal of 1% of areas, or 1,580 ha nationally (Table 4) is required to redesign plantation edges in WPFs.

Future scenarios for WPFs

Forest management in WPFs should, in the future, place more emphasis on the provision of environmental goods. Forestry will continue on western peatlands but within a context that takes account of environmental, social and wood production – sustainable forest management. In the majority of cases environmental and social values will take precedence. Forest redesign should occur in a manner that enhances the environmental and social dimension, in the context of a national land use policy for western peatlands. Table 4 summarises these conjectures by presenting a future management scenario for WPFs, based on the findings presented here.

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