The suitability of the private forest estate in Ireland for thinning

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Abstract
Government projections for timber supply from Irish forests assume that private forests will be managed and harvested in a similar way to State forests. However, little is know about the harvesting intentions of private forest owners and the suitability of their stands for thinning. A survey of a sample of 120 forest owners and their forests, stratified by afforestation grant scheme, was carried out in 2007. The average size of plantation was 8.8 ha, with plantations established under the Common Agricultural Policy (CAP) Scheme more likely to have a lower risk of windthrow and to be on sites with better ground conditions than those established under the Western Package (WP) Scheme. Almost three-quarters of the WP forest area was adjacent to a public road, while just over half of the CAP area was similarly situated resulting in higher road density requirements in the CAP area. Almost three-quarters (72%) of all forest owners surveyed planned to thin their forests in the future. The suitability of the area they planned to thin was assessed taking account of access, ground conditions and windthrow risk. Only one-half of this area was found to be suitable for thinning with poor ground conditions and/or excessive roading requirements the main constraints. While the self-selected nature of the sample makes it difficult to make inference to the population of private forest owners in Ireland, the results do raise questions as to whether the timber production targets as laid down in Government policy will be achieved.

Keywords
Thinning intentions, non-industrial private forest owners, access, windthrow risk, silvicultural suitability

Introduction

The aim of Government policy for forestry is to "develop forestry to a scale and in a manner which maximises its contribution to national economic and social well-being on a sustainable basis and which is compatible with the protection of the environment" (DAFF 1996). This scale of timber production, i.e. critical mass, was set at 10 million m^3 per annum, a substantial increase from the two million m^3 per annum being produced when the policy was being devised. Afforestation targets of 25,000 ha per annum to the year 2000 and 20,000 ha per annum thereafter to the year 2030 were set, with 70% to be undertaken by the private sector. To achieve critical mass, it was assumed that private plantations would be managed and harvested in a similar way to State plantations. This assumption was also made in the forecasts of roundwood production from Irish private forests produced by Gallagher and O'Carroll (2001) and more recently, Phillips et al. (2010).

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Research from other countries has identified however, that the silvicultural management that takes place in what are typically referred to as non-industrial private forests (sometimes known as small-scale forests or family forests) often differs from that undertaken in industrial forests (Herbohn 2006). Many of the owners of the non-industrial private forests place a low priority on timber harvesting and rate objectives such as wildlife, recreation and scenery as more important goals for their forests (e.g. Rickenbach et al. 1998 in the USA; Wiersum et al. 2005 in Europe). Owners' objectives are not the only factor influencing whether harvesting takes place in private forests. Dennis (1989; 1990) and Newman and Wear (1993) found that growing stock, species and productive area were important variables influencing whether stands were harvested. Prestemon and Wear (1998) also found that the distance to the forest road influenced the occurrence of harvesting.

In Ireland the national forest inventory has provided a range of statistical information on the private estate (Forest Service 2007a). However, little is known about the characteristics of private stands that influence thinning, including owners' objectives. There is an urgent need for such information as many private stands are, or soon will be, due to be thinned. It is not known whether forest owners will thin their stands, or indeed whether their forests are silviculturally suited to being thinned. The aim of this study therefore was to gather information in this regard. Specifically it set out to:

- characterise the private forest resource, with specific emphasis on aspects relating to the thinning of the forests;
- determine the harvesting intentions of forest owners;
- determine the suitability of the stands for thinning.

Methods

A random sample survey of private forest owners was conducted during the summer of 2007. The sample was drawn from the Forest Service database of landowners who had received afforestation grant-aid during the period 1981 to 2006. The database was divided in two; the first section comprised the names and contract numbers[1] of those that had received grant-aid under the Western Package (WP) scheme from 1981 to 1989 (1,860 records accounting for 20,517 ha), while the second section included those who had planted thereafter under the Common Agricultural Policy (CAP) scheme (16,239 records accounting for 198,584 ha) (Forest Service 2007b). To comply with Data Protection Legislation, the Forest Service was responsible for contacting respondents and they initially wrote to a random sample of 1,000 owners inviting them to take part in the study. Over 380 agreed to do so and from these a random sample of 120 forest owners (25 WP; 95 CAP) was selected for survey.

All forest owners were visited and interviewed. During the interviews information on owners' objectives and on the management and silvicultural activities owners

[1] A unique contract number is assigned by the Forest Service to each individual application for grant-aid for afforestation.

had undertaken was obtained. The extent of the involvement of owners in extension activities was also recorded. A summary of the results of these interviews can be found in Maguire (2008). A survey of the forests owned by those interviewed was also undertaken. Where respondents owned more than one forest, only the forest associated with the contract number that had been selected by the Forest Service was surveyed. Two 0.01 ha plots were randomly assigned to this forest; where it was comprised of multiple stands, one stand was randomly selected and within it two plots were randomly located. Where mixtures of species were present, the plot size was extended.

A field sheet was drawn up to record site, forest and stand characteristics. Site characteristics, such as soil type, fertility, exposure, stability, elevation, topex, slope, ease of access, etc., were recorded on a forest basis (Table 1). The area of the forest and the stand were also recorded (forest and stand area were synonymous where a forest comprised only one stand). At the stand level, species, stocking levels, diameters and heights were recorded (Table 2).

Table 1: *Attributes recorded at forest level.*

Variable	***Category***	***Source where recorded***
Forest age	Years	*GIS database / Owner records*
Forest area	Hectares	*GIS database / Owner records*
Drainage status	Good = stable, dry, elevated, sloping site Average = Peaty/Gley base material with waterlogging potential, or where water cannot readily get away Poor/very poor = where surface water is visible	*Forest*
Ground bearing conditions	Good = stable, dry site Average = Rutting would occur in wet weather, dry weather site only Poor = Peaty/ Gley base material render site unstable. Rutting would occur Very Poor = where surface water is visible	*Forest*
Terrain classification	Smooth/Easy = with no obstructions present Moderate = where occasional obstacles occur Difficult/Hindrance = where movement is greatly prohibited	*Forest*
Forest slope	Degrees	*Forest*
Elevation	Metres above sea level	*GIS database / OSI Discovery Series Map (1: 50,000)*
Probability of windthrow occurring	Percentage	*Windthrow risk model (Ní Dhubháin et al. 2009)*

Variable	*Category*	*Source where recorded*
Thinned	Yes / no	*Forest*
Roading required		
Construction	Metres	*Forest*
Maintenance	Metres	*Forest*
Bellmouth	Number per forest	

Table 2: *Attributes recorded at stand level.*

Variable	*Category*	*Source where recorded*
Stand age	Years	*GIS database / Owner records*
Stand area	Hectares	*GIS database / Owner records*
Land status	Enclosed / unenclosed	*1910 Ordnance Survey (6 inch: 1 mile) map, to represent stand*
Fertility class	A = Agricultural pastures, herbaceous plants / rushes B = Bracken and Furze (old ditches/walls) C = Scruff pasture, *Calluna* / *Molinia* spp. X = Old Woodland	*Stand* *(OCarroll 1975)*
Soil type	e.g. Peat, Gley, Brown earth, Podsol, etc.	*Stand*
Tree species	Name	*Stand*
Stocking	Stems per hectare; recorded as live measurable stems within a 0.01 ha plot × 100	*Stand*
DBH (diameter at breast height)	Centimetres	*Stand*
BA (basal area)	m^2/ha	*Quadratic function of DBH*
Height		
Top	Metres	
Timber	Metres	
Yield Class	$m^3ha^{-1}yr^{-1}$	*Forestry Commission General Yield Class Curves (Edwards and Christie 1981)*

A number of sources were used to assign a thinning year to each stand including:
1. GROWFOR - Dynamic Yield Models (COFORD undated);
2. Forestry Commission (FC) Thinning Control Tables (Rollinson 1999);
3. Coillte Inventory Manual (Coillte 2002);
4. Growing Broadleaves (Joyce et al. 1998);
5. Silvicultural Guidelines for the Tending and Thinning of Broadleaves (Draft Version) (Short and Radford 2008).

In most cases, GROWFOR was used. However, this model could not be used when the basal area in the stands was less than 10 m^2 per ha. In these instances, the BFC Thinning Control Tables were used. If the crop characteristics were outside the range allowed for those tables, an alternative method from the above list was used.

Suitability for thinning
The suitability for thinning of all stands visited was assessed under three headings:
1. Ground conditions;
2. Access;
3. Windthrow risk.

The stand areas were first classified subjectively according to the ground conditions on the sites, i.e. good, average, or poor-very poor ground conditions. This classification was used as an indicator as to whether a machine could extract timber on the site. The areas were further classified according to access, i.e. whether there was good or poor road access. Forests classed as having poor access were those requiring roads to be constructed at a density in excess of 20 m/ha. Densities in excess of this level are considered not economically viable (Henry Phillips pers. comm.). Finally the silvicultural suitability of the stand for thinning was estimated by assessing windthrow risk using Ní Dhubháin et al.'s (2009) windthrow risk model. This model takes into account top height, soil type, altitude, location and whether the stand has been thinned. Stands were classified according to three levels of risk;
1. Low – probability of windthrow < 11%;
2. Medium - probability of windthrow ≥ 11% but < 50%;
3. High - probability of windthrow ≥ 50%.

Stands on sites which had good to average ground conditions, good road access and where the risk of windthrow was less than 50%, were considered suited for thinning.

Results
The mean WP forest size was 6.8 ha, while the mean CAP forest area was slightly higher (9.2 ha) (Table 3).

Table 3: *Size distribution of forests surveyed.*

Area range	*All Forests*		*WP Forests*		*CAP Forests*	
Ha	*ha*	*%*	*ha*	*%*	*ha*	*%*
0 – 1.9	22	2	4	2	18	2
2 - 4.9	129	12	24	15	105	12
5 – 8.9	190	18	42	26	148	17
9 – 13.9	132	13	10	6	122	14
14 – 19.9	201	19	18	11	183	21
20 – 29.9	150	15	28	17	122	14
30 – 49.9	150	15	37	23	113	13
50+	61	6	0	0	61	7
TOTAL	1035	100	163	100	872	100
Mean	8.8		6.8		9.2	

Elevation

Less than one-fifth of the WP forest area was at elevations greater than 100 m, compared with 43% of the CAP forest area (Table 4).

Table 4: *Forest area by elevation.*

Metres above sea level	*All forests*		*WP Forests*		*CAP Forests*	
	ha	*%*	*ha*	*%*	*ha*	*%*
<50	104	10	49	30	55	6
50-99	527	51	85	52	442	51
100-149	217	21	16	10	201	23
150-199	104	10	13	8	91	10
>200	83	8	0	0	83	10
TOTAL	1035	100	163	100	872	100

Ground conditions, terrain classification and drainage

While half (52%) of the CAP forest area was considered to have 'good' ground conditions (Table 5) only 22% of the WP forest area was similarly classed. A greater percentage of the WP forest area had difficult terrain compared with the CAP forest area. Many of the sites visited were adequately drained and only 15% of the total forest area was poorly or very poorly drained (Table 5).

Table 5: *Ground conditions by forest area.*

	All Forests		*WP Forests*		*CAP Forests*	
	ha	*%*	*ha*	*%*	*ha*	*%*
Ground bearing conditions						
Good	482	46	36	22	447	52
Average	285	28	81	50	204	23
Poor - very poor	267	26	46	28	221	25
TOTAL	1035	100	163	100	872	100
Terrain classification						
Smooth	404	39	54	33	351	40
Moderate	476	46	64	39	412	47
Difficult	155	15	46	28	109	13
TOTAL	1035	100	163	100	872	100
Drainage status						
Good	673	65	104	64	569	65
Average	207	20	13	8	194	22
Poor - very poor	155	15	46	28	109	13
TOTAL	1035	100	163	100	872	100

Access

Almost three-quarters of the WP forest area was adjacent to a public road, while just over half of the CAP area was similarly situated (Figure 1). Road remediation works were required in 96% of the forest area surveyed (Table 6) with over two-thirds of the WP area requiring only a bell-mouth entrance. Over one-third of the CAP area surveyed required in excess of 300 m of roading (Table 6) largely because so many CAP forests were not adjacent to county roads (Figure 1). As a result, road density requirements were high in the CAP area with almost one-third requiring road construction at a density in excess of 20 m/ha (Figure 2).

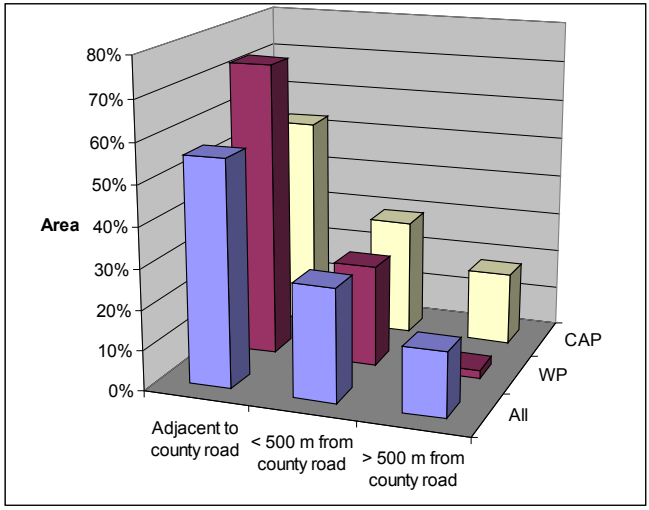

Figure 1: *Distance of forest properties to county road.*

Table 6: *Road remediation requirements by forest area.*

Road length (m)	*All Forests*		*WP Forests*		*CAP Forests*	
	ha	*%*	*ha*	*%*	*ha*	*%*
None	43	4	6	4	37	4
Bell-mouth only	412	40	108	66	304	35
30-99	80	8	18	11	62	7
100-199	108	10	19	12	89	10
200-299	96	9	12	7	84	10
300-499	163	16	0	0	163	19
500-749	105	10	0	0	105	12
750-999	25	2	0	0	25	3
1000+	3	< 1	0	0	3	0
TOTAL	1035	100	163	100	872	100

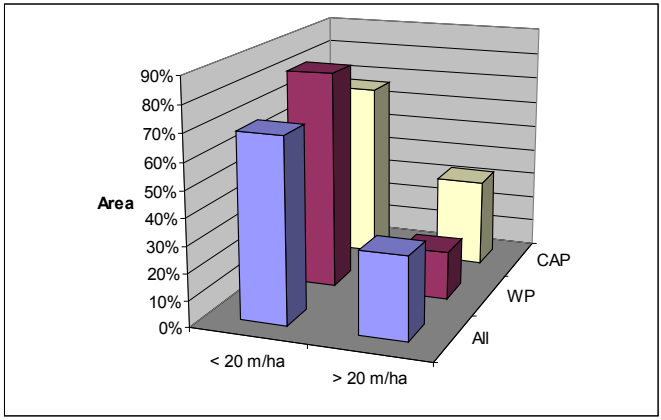

Figure 2: *Roading density requirements.*

Windthrow risk

Only 25% of the total forest area had greater than a 20% chance of windthrow (Table 7). Reflecting the older age classes within the WP area, the risk of windthrow was greater in these areas, with 63% of the area having at least a 1 in 5 chance of experiencing windthrow.

Table 7: *Windthrow probability in forests surveyed.*

% probability of windthrow occurring	*All Forests*		*WP Forests*		*CAP Forests*	
	ha	*%*	*ha*	*%*	*ha*	*%*
0 – 10	743	72	50	31	693	79
11 – 20	36	3	3	2	33	4
21 – 30	108	10	53	33	55	6
31 – 40	53	5	37	22	16	2
41 – 50	78	8	12	7	66	8
51 – 60	8	1	8	5	0	0
61 – 70	0	0	0	0	0	0
71 – 80	9	1	0	0	9	1
81 – 90	0	0	0	0	0	0
91 – 100	0	0	0	0	0	0
TOTAL	1035	100	163	100	872	100

Soil type and land status

Poorer quality soil types were commonly found in the WP forests with peats accounting for 72% of the WP stand area (Table 8). However, brown earth soils were the most common soil type encountered in the CAP stands (39%). The majority of the WP stand area was unenclosed (66%) compared with only 18% of the CAP area.

Table 8: *Stand area by soil type.*

Soil type	*All stands*		*WP stands*		*CAP Stands*	
	ha	*%*	*ha*	*%*	*ha*	*%*
Peat	276	37	43	72	233	33
Brown earth	268	36	0	0	268	39
Gley	128	17	6	10	122	18
Podsol	62	8	11	18	51	7
Lithosol	12	1	0	0	12	2
Alluvium	6	1	0	0	6	1
TOTAL	752	100	60	100	692	100

Crop composition

The WP stand area was almost exclusively conifer high forest with only 70% of the CAP area similarly classed (Table 9). Sitka Spruce accounted for three-fifths of the stand area surveyed while ash was the most common broadleaved species planted (16%).

Table 9: *Stand area by land use type and canopy composition.*

Land Use Type	*All stands*		*WP stands*		*CAP Stands*	
	ha	*%*	*ha*	*%*	*ha*	*%*
Conifer High Forest Pure	408	54	47	78	361	52
Conifer High Forest Mixed	113	15	13	21	101	15
Broadleaf High Forest Pure	76	10	<1	<1	76	11
Broadleaf High Forest Mixed	37	5	0	0	37	5
Mixed High Forest	117	16	0	0	117	17
TOTAL	752	100	60	100	692	100

Stocking

Almost half (47%) of the Sitka spruce stand area had stocking levels (live stems) in the region of 2001-2500 stems per ha.

Productivity

All species greater than nine years of age were assigned a yield class. Half of the area of Sitka spruce established under the WP programme was of yield class 22 to 24, while a further 26% was of yield class 24+ (Table 10). Over half (54%) of the WP Norway spruce was of yield class 14 to 16. Given the relative youth of the CAP plantations a considerable proportion of the area was too young to be assigned a yield class. Yield classes were relatively high where assigned. For example, 65% of the Norway spruce area had a yield class between 22 and 24. Similarly, 44% of the Sitka spruce area was assigned a yield class greater than 24.

Table 10: *Coniferous area by yield class and species.*

	Species						
Yield class	*DF*	*EL*	*JL*	*LP*	*NS*	*SP*	*SS*
All Forest				*%*			
None (< 10 years)	0	71	73	11	29	43	33
<14	13		4	13			3
14-16		29	23	76	6	57	12
18-20					5		2
22-24	87				59		9
24+							41
Area ha	2	2	11	60	41	3	457
WP forest							
None (< 10 years)							
<14			100				
14-16				100	53		13
18-20					41		11
22-24					6		41
24+							24
Area (ha)	0	0	<1	2	5	0	52
CAP forest							
None (< 10 years)		71	77	12	33	43	37
<14	13			13			2
14-16		29	23	75		57	11
18-20							2
22-24	87				67		4
24+							44
Area ha	2	2	10	57	36	3	407

DF: Douglas fir, EL: European larch, JL: Japanese larch, LP: lodgepole pine, NS: Norway spruce, SP: Scots pine, SS: Sitka spruce.

The only broadleaved species recorded under the WP programme was ash, which had a yield class of between 4 and 6. Broadleaves were more common under the CAP programme, with one-quarter of the sycamore assigned a yield class between 8 and 10 and one-third the alder with a yield class of 4 to 6.

Thinning history and thinning intentions

Only seven percent of stands visited (i.e. 31 ha), had been previously thinned. Sixty-five percent of the area thinned was in WP plantations of which 83% was pure Sitka spruce with an average general yield class of 22 $m^3ha^{-1}yr^{-1}$. All thinning performed was for merchantable purpose, including firewood production. Over three quarters (77%) of forest stands (or 85% of stand area) were in pre-thin status at time of survey.

Almost three-quarters (72%) of all forest owners surveyed planned to thin their forests in the future. However, a much smaller proportion (56%) of WP owners than CAP owners (77%) planned to do so.

The owners' estimates of the timing of thinning were assessed. Half of those intending to thin planned to do so before 2010. However, stand growth data suggested that only half of those forests would be ready within that timeframe. Additionally, over half (57%) of those WP respondents planning to thin did not realize that their forests had passed their "appropriate" first thin age. CAP respondents intending to undertake thinning were relatively accurate with their intended timing of proposed thinning.

Suitability for thinning

The suitability of all stands for thinning was assessed taking into account owners' intentions. First, the area, which owners planned to thin, was considered. Just over three-quarters (77%) of it was classed as having average to good ground conditions (Figure 3). Of this area, 41% (470 ha) was classed as having good road access, with the majority (454 ha) of this have a low to medium risk of windthrow. On this basis, out of a total area of 854 ha, only half (53%) was "suitable" for thinning.

Seven percent of the total area surveyed was owned by respondents who were unsure as to whether or not to thin their forest. Three-fifths (59%) of it was classed as having average to good ground conditions (Figure 4). Of this area, one-half (22 ha) was classed as having good road access, with all of that area having a low risk of windthrow. On this basis, out of a total area of 74 ha, less than one-third (30%) was "suitable" for thinning.

Ten percent of the area surveyed was owned by respondents who had no intention of ever thinning their forest (Figure 5). A review of this area indicated that 57% (60 ha) of it was classed as having average to good ground conditions. Of this area, one-half (30 ha) was classed as having good road access and having a low to medium risk of windthrow. On this basis, out of a total area of 106 ha, one-quarter (28%) was "suitable" for thinning.

Summary of results

1. Sampled forests had generally low elevations;
2. CAP forests had high road density requirements;
3. There were poorer ground conditions in WP areas;
4. Sampled forests had high productivity;
5. Sampled forests had a low windthrow risk at the time of survey;
6. Only one half of the area that owners had planned to thin was identified as suitable for thinning.

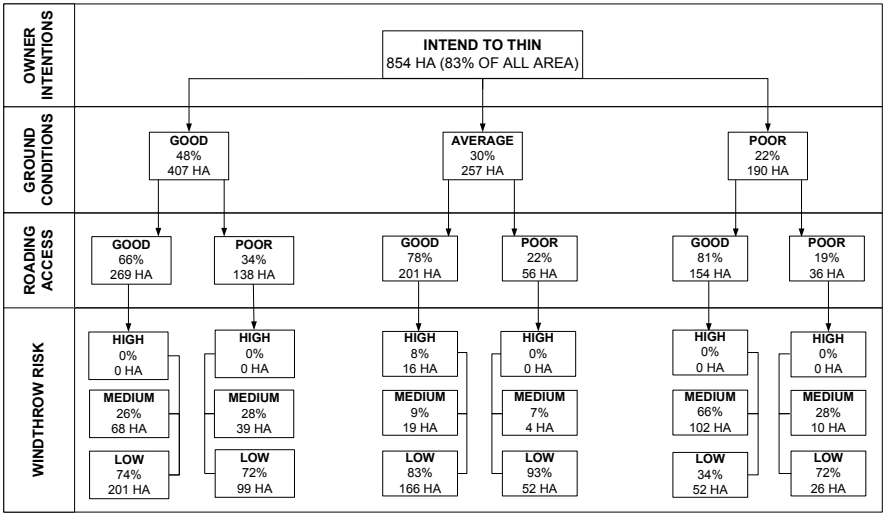

Figure 3: *Constraints on areas respondents planned to thin.*

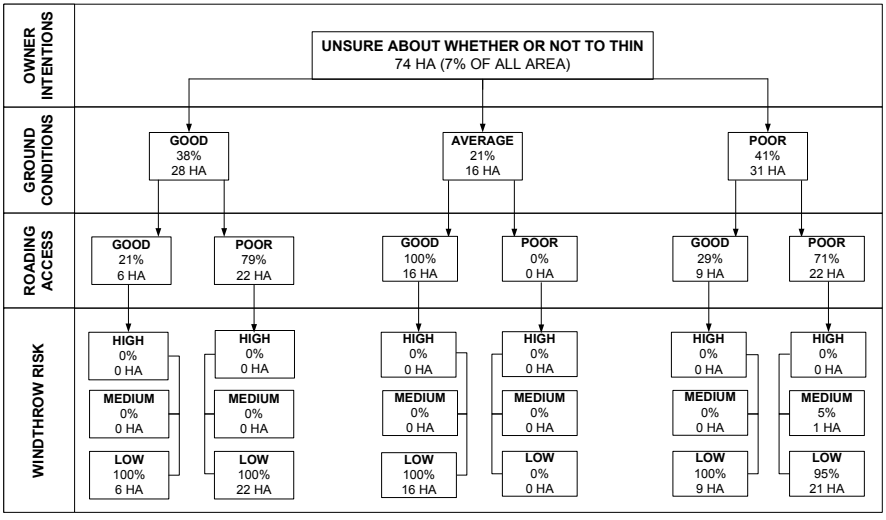

Figure 4: *Constraints on areas respondents were unsure about thinning.*

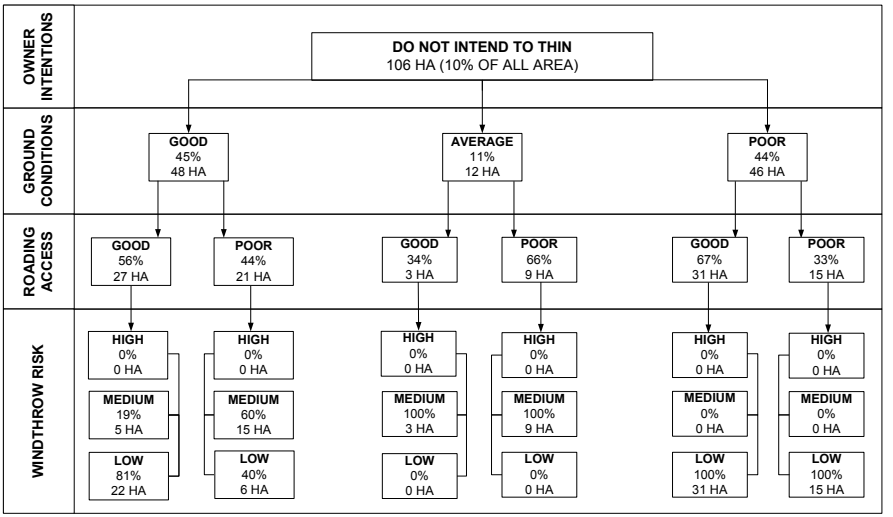

Figure 5: *Constraints on areas respondents planned not to thin.*

Discussion

Private forests now account for 45% of the forest estate in Ireland. The Government's plan to achieve critical mass relies on these forests being managed and harvested. This study first identified whether forest owners plan to thin their forests. It then attempted to assess the "suitability" of the owners' thinning intentions in light of the location and composition of their forest resource. In this section some of the findings in relation to the forest resource are discussed, followed by a discussion of the links between these findings and owners' plans to thin.

Access

Doyle (2002), Prestemon and Wear (2000), and Ryan et al. (2007) indicated that road access is an important factor influencing thinning/harvest practice. Access refers both to access from public roads to facilitate the transport of the harvested timber and to access within the stand, i.e. will the site support the movement of machines. Contrary to anecdotal evidence regarding the poor access to WP plantations, the results showed that 66% of the WP stands required only a bell-mouth entrance to be constructed to provide access to the site for a harvester, forwarder or truck-trailer. This finding agrees with that of Redmond et al. (2003), who discovered that 51% of the WP area they surveyed was accessible to timber trucks. The estimated average road construction density required for the stands surveyed in this study was 20 m/ha. The main factor contributing to this relatively high density was the fact that so much of the CAP forest area was not close to the road.

Stand productivity

The inventory found relatively high yield classes for the stands surveyed. For example, Sitka spruce, which accounted for 87% of the WP stand area, had a weighted average

general yield class of 20 $m^3ha^{-1}yr^{-1}$, which agrees with the findings of Redmond et al. (2003). In the CAP stands, Sitka spruce accounted for 59% of the area and also had a weighted average yield class of 20 $m^3ha^{-1}yr^{-1}$. These high yield classes contributed to the fact that 56% of the WP area surveyed was past first thinning age; only 10% of the CAP area was similarly classed. Carrying out a delayed thinning could have serious consequences for crop stability. The assessment of windthrow risk indicated that the risk of windthrow (post thinning) was less than 20% in 75% of the area surveyed. This low level of risk can be attributed to a number of factors, including, the predominantly low elevations and inland location of many of the sites. However, the relatively low top heights (mainly as a result of young age classes) of the stands were also a factor and windthrow risk will increase as top height increases (Ní Dhubháin et al. 2009). On the positive side, the high yields suggest that a considerable volume of timber can be removed during thinning making it more likely that the thinning operations will be economically viable, *ceteris paribus*.

An analysis was undertaken to assess the suitability of the forest resources surveyed for thinning. This analysis only took into account two factors, i.e. can the stands be thinned and should the stands be thinned. Access and ground conditions were the two factors chosen to determine whether stands "could" be thinned. Crop stability, post thinning, was the sole factor considered when determining "should" a stand be thinned. It is important to note that the results from the analysis are sensitive to this choice of factors. Furthermore, assumptions were made regarding levels of factors. For example, the "good" and "bad" access categories were determined by a recommendation by Henry Phillips (pers comm.) that roading densities in excess of 20 m/ha were not economically viable ("bad" access). Similarly, a subjective decision was made by the authors that where the risk of windthrow, post thinning, was less than 50%, according to the Irish Windthrow Risk Model (Ní Dhubháin et al. 2009), the risk was classed as low or medium. Others might consider a lower threshold more appropriate.

Taking the assumptions outlined above into account the results showed that only one-half (i.e. 448 ha) of the area respondents plan to thin is suitable for thinning. A further 22 ha of forest, owned by those unsure as to whether they will thin, is suitable for thinning while 30 ha owned by those planning not to thin is suited for thinning. The main constraints were:

- poor ground conditions – 22% of the area owners planned to thin was classed as having poor ground conditions. These areas were composed of peaty and gley soil types which have inherently poor drainage capacity. Remediation works within this category are unlikely;
- unfeasible roading network – 27% of the area owners planned to thin was classed has having poor road infrastructure, which was considered economically unfeasible to improve.

Conway et al. (2000) and Loyland et al. (1995) highlighted similar constraints impacting on their respondents harvesting propensity in the USA and Norway respectively.

Limitations to the study

The main limitation to the study was that only those forest owners who agreed to take part in the study were included. Thus the sample was self-selected. Nevertheless, the response rate of 38% was relatively high compared to previous studies (e.g. Ní Dhubháin and Greene 2009). Due to restrictions associated with the Freedom of Information Act it was not possible to obtain any details on non-respondents. Hence it was impossible to determine whether this self-selection had biased the sample. However, given that the letter of invitation to participate in the survey specifically mentioned that the survey would deal with the harvesting and management intentions of owners, it may be that those who had not considered harvesting may have thought that the survey was not relevant to them and may have opted not to participate. This would suggest that the percentage of owners who indicated that they planned to harvest may be overestimated. Another limitation to the study is the relatively small sample size. However, the high costs of site visits meant this was the maximum number of respondents that could be interviewed.

Conclusion

Because of the limitations outlined it is difficult to make inference to the population of forest owners in Ireland. However, the results do raise questions as to whether the timber production targets as laid down in Government policy will be achieved. There is a strong willingness amongst owners to thin their stands but only half of the area they planned to thin was identified as being suitable for thinning. Poor access and ground conditions were the major limiting factors. While little can to done remediate the poor ground conditions, the access issue could be addressed by providing higher roading grants. Furthermore the results highlight the need for further targeted education of forest owners to ensure that silviculturally and economically sound decisions are made regarding thinning.

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