Peatland forestry in the 1990s.
1. Low-level blanket bog.

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SUMMARY

The afforestation of blanket peatland, the principal peatland type in forestry, commenced in the 1950s. Production in these forests has greatly exceeded expectations. Current yield class estimates of Coillte Teoranta forests on blanket peatland give a mean Yield Class of 13.3 for Sitka spruce (*Picea sitchensis* (Bong.) Carr.). However, investment in blanket peatland forestry cannot be expected to yield returns to compare favourably with those obtainable on good mineral soils. Treeless blanket peatlands are a characteristic feature of western Ireland. Their conversion to plantation forestry drastically disturbs the peatland ecosystem and if carried out on a sufficiently large scale, will profoundly alter the landscape of our western counties. In view of the marginal economic returns which can be expected from forestry investment on blanket peat, it may be in the national interest to reduce incentives for the afforestation of western peatlands.

Introduction

Low-level (or Atlantic) blanket peatland is confined to the western seaboard counties. It occurs at elevations under 150 m in regions where annual precipitation exceeds 1250 mm (Hammond 1981). Above 150 m elevation, it is classified as high-level, or montane blanket peatland (Barry 1954; Hammond 1981). These blanket peatlands represent the principal bog, or acid peatland types of the west. The other major bog type, raised bog occurs mainly in the midlands at low (below 150 m) elevation.

Blanket peatland is the principal peatland type in forestry. No accurate figures are available, but of the total effective forest area of 410,000 ha in the Republic (Anon. 1991), about 50% is on peatland. This represents far and away the largest managed use of peatland in the country. Of the approximately 120,000 ha of peatland in agriculture, most is in poorly managed grassland on reclaimed fen peats. Modern agricultural reclamation operations on peatland are small-scale, concentrating for the most part, on shallow, often heavily eroded hand- (often called farmer-) cutaway peatland.

In its chemical properties, blanket peat is typical of ombrotrophic peats, peats nourished by atmospherically borne nutrients. It is extremely acid and of very low fertility. Nutrients whose concentration in rainfall are low, are in particularly short supply. Phosphorous is the prime example of these elements. The response of the grass *Molinia*, a native peatland species, to rock phosphate in forestry plantations, is evidence enough of chronic phosphate deficiency. Close to the west coast, the atmospheric input of the principal nutrient elements of seawater, magnesium, calcium, potassium and sulphur, is such that, with the possible exception of potassium, supplies are always adequate for tree growth. Nitrogen reserves, however, are not particularly high. It is a common misconception, based on a misinterpretation of soil chemical analytical data, that peat soils contain vast reserves of nitrogen, waiting to be tapped. They do not; in fact, total nitrogen reserves of peat soils are often much less than those of mineral soils. Nevertheless, drainage, peat drying as a result of canopy interception of rainfall, the influence of the same phenomenon of canopy interception in scavenging nitrogen from the atmosphere, and the stimulating effect of fertilizer on organic matter decomposition, all contribute to an enhanced supply of nitrogen to the tree crop, so that fertilizer inputs of this element are required far less often than might have been predicted.

Despite the comparability in chemical composition between blanket peat and the surface peats of the midland (raised-type) bogs, they differ markedly in ease of drainage. Of all the peat types occurring in Ireland, whether surface peats, or peats exposed in the course of Bord na Móna peat harvesting operations, none is more difficult in physical properties than blanket peat. It occurs in the regions of highest rainfall and in the case of the low-level blanket peats, often in terrain of very poor gradients. Blanket peat has a saturated hydraulic conductivity of less than 1 cm per day (Galvin 1976; Gleeson 1985). This represents the maximum rate of water movement through the peat. Given that in the Glenamoy region of North Mayo, annual rainfall averages about 1400 mm and the number of rain days per annum is 270, there will inevitably be many days when the soil is saturated and unable to absorb or transmit incoming rainfall. The poor physical nature of this peat arises in large part, from the plant species which make up the peat. *Sphagnum* species which dominate the surface peats of the raised bogs and confer on them good physical properties, are less important in blanket bogs.

Forestry began the move onto blanket peatland in the early 1950s. Low-ground pressure tractor units and and large heavy-duty ploughs became available and with the simple addition of phosphatic fertilizer, the "wet deserts" of the west could be turned to forest. Initially, this investment in peatland forestry was not evaluated on strict economic grounds. The so-called Cameron Report (Anon. 1951), the product of an FAO Forestry Mission to Ireland in 1950, recommended that 500,000 acres (202,000 ha) be acquired for a commercial forestry programme and an equivalent area of agriculturally sub-marginal land be afforested in the interests of "soil conservation, regulation of stream flow, stabilization of local populations through provision of employment in congested areas and reclamation of idle lands, such as the extensive blanket bog areas of Western Ireland". These poorer lands were not expected by Cameron "to produce forests as a profitable commercial operation". However, they would produce pitprops and pulpwood material and "would provide a great increase in attractiveness to tourists of large sections of Western Ireland by improving considerably the scenic and sporting amenities". It is hard to appreciate now, the atmosphere of optimism which existed at that time and the enthusiasm for western peatland development. In Mayo, the peatland experimental station at Glenamoy, the grassmeal factory at Gweesalia, the Bord na Móna Oweninny Bog development and the peat-fired power station it supplies, all opened in the late 1950s and early 1960s. Only the Bord na Móna operation and the power station, both now nearing the end of their days, still function. Forestry on blanket peatland is, it seems, the great survivor. In this paper, we examine this tenacity and the wisdom of continuing to support the afforestation of blanket peatland. We present an assessment of the productivity of blanket peatland forests, a financial evaluation of the investment and a preliminary review of the ecological impact of forestry plantations.

Productivity

Most of the blanket peatland forests are less than 25 years old and are only now coming to a stage where productivity estimates based on actual growth data can be made over extensive areas. Mean yield class, weighted by area, of the two major coniferous species, Sitka spruce (*Picea sitchensis* (Bong.) Carr.) and coastal lodgepole pine (*Pinus contorta* ssp contorta Critchfield), for a selection of forests in Co. Mayo, were calculated by species. The data are derived from the Coillte Teoranta (Irish Forestry Board), formerly the Forest Service, 1986 Inventory (Clinch, P., Coillte Teoranta, personal communication). The selection of forests was based on age and site type. These forests consist of crops for which, for the most part, measured estimates of yield class are available (for crops less than eight years of age, yield class is estimated visually without height measurement). In addition, these forests are located almost entirely on blanket peatland, both low-level and high-level (the data do not allow a separation).

Mean Yield Class for Sitka spruce in these forests is 13.3, for lodgepole pine 10.6 (Table 1). These yield projections represent a remarkable success for Irish forestry. While Cameron was content to say of the social forestry programme, that "the forests thus established will be of comparatively low productive capacity" (Anon. 1951), there is no doubt, based on his estimates for the commercial forestry programme, that yields from our peatland forests are many times greater than would have been projected forty years ago.

Table 1. Mean yield class estimates, weighted by area, for Sitka spruce and lodgepole pine in seven peatland forests in Co. Mayo. (After Farrell, 1990)

FOREST	SPECIES	AREA(ha)	YIELD CLASS
Glenamoy	Sitka Spruce	484.5	12.7
	Lodgepole Pine	1329.5	10.7
Ballycastle	Sitka Spruce	457.4	14.2
	Lodgepole Pine	1810.3	9.3
Crossmolina	Sitka Spruce	739.5	14.6
	Lodgepole Pine	1395.0	11.5
Doolough	Sitka Spruce	572.5	11.4
	Lodgepole Pine	1072.3	12.9
Nephin Beg	Sitka Spruce	578.1	11.8
	Lodgepole Pine	1720.3	9.1
Croagh Patrick	Sitka Spruce	760.9	12.9
	Lodgepole Pine	541.6	12.9
Glenhest	Sitka Spruce	790.9	15.2
	Lodgepole Pine	586.8	13.0
Mulrany	Sitka Spruce	103.6	10.5
	Lodgepole Pine	1641.8	9.9
All the above	**Sitka Spruce**	**4487.4**	**13.3**
	Lodgepole Pine	**10097.6**	**10.6**

Financial Returns

The evaluation of a forestry enterprise on unplanted land is based, in the first instance, on an estimate of the potential productivity of the site. This will vary with species, but the analysis presented here is for Sitka spruce, as it will generally prove to be the most productive and financially rewarding species on all but the least fertile peatland sites.

The estimation of yield class on bareland sites is highly subjective and subject to a wide margin of error. The Coillte data presented in Table 1 are therefore, particularly valuable as they represent the best available estimate of the productivity of blanket peatland forestry. However, it may be argued that it is unduly conservative to limit yield class estimates to the

Coillte average. Careful selection of site and good management may give crop yields of Yield Class 16 over substantial areas and Yield Class 18 on smaller areas. On the other hand, volume production estimates based on yield class assume that growth will follow the pattern predicted by the model throughout the rotation. This assumption may hold reasonably well on inherently fertile sites, but may not be justified on sites of extremely low natural fertility, which require fertiliser additions not alone for growth enhancement, but for the very survival of the forest crop. A decline in yield class over time has been observed in at least one forest fertilisation experimental trial on blanket peat (Farrell 1985).

There is a general acceptance today that a forestry enterprise can no longer be justified on the rather nebulous grounds proposed by Cameron. Peatland forestry must be commercially viable, capable of making a return which will compare favourably with forestry on mineral soils and with other broadly similar investments. The evaluation of viability is, to a degree, subjective, such is the complexity of management options, cost estimates, timber yield projections and financial yield expectations that face the investor. For the financial analysis presented here, the following information is required:

1. The timing and cost of management inputs during the life of the crop.
2. The timing and value of thinning and final crop harvests.

Conventionally, current costs and timber prices are used in the analysis. Thus the effect of inflation is removed from the analysis and returns are calculated in real terms. Forestry enterprises are of their nature, long term. Costs and revenues are discounted back to the start from the year in which they are expected to occur. Thus they are reduced in value at an appropriate compounded rate. This discount rate is again a real rate, net of inflation and represents the annual return which the investor expects from the investment. The rate selected may vary from as low as 3% in the case of some state investment to 6.5% for some private or institutional investors. The discounted value of all revenues, less the discounted value of all costs is known as the net discounted revenue (NDR). Land price is omitted from the analysis presented here. So too is plantation establishment cost. Net discounted revenue then, as we define it, is a residual value which, for a given rate of return, represents the maximum amount which can be paid for the land and crop establishment after grants. For blanket peatland forestry development, land prices are currently in the range £370-620 ha^{-1}. Development costs (estimated at April 1990), net of grants are in the range £370-490 ha^{-1}, £925 ha^{-1} then represents a reasonable working estimate of the combined cost of land and development net of grants.

Calculated net discounted revenue is very sensitive to rotation length and to discount rate. Table 2 shows net discounted revenues for unthinned Sitka spruce crops over a range of yield classes and discount rates. Yield estimates are based on Forestry Commission data (Edwards 1981). The costs and revenues assumed are in line with current experience in blanket peatland operations. Returns are given for the financially optimum rotation for each yield class. NDR values exceeding the £925 ha^{-1} threshold for land and establishment costs represent a return on the investment corresponding to the indicated discount rate. It is clear that blanket peatland forests can rarely be expected to yield more than 4% on investment. Only at Yield Class 18 can a return greater than 5% be expected.

The data presented are for pure Sitka spruce crops planted at 2 m spacing and managed without thinning. This is a conservative option making the assumption that the risk of windthrow prohibits the adoption of a thinning regime. While there is always an element of risk involved, some managers may argue that with good site preparation and careful management, it will be possible to thin and still run the full rotation on peatland sites. Many Coillte forests on blanket peatland are being thinned at present and while windthrow is a problem, losses are usually at an acceptable level. While returns are better from thinned than from unthinned crops, 4.5% is the best that can be expected from Yield Class 14.

An approach adopted in recent years has been to plant Sitka spruce in mixture with a slow growing provenance of lodgepole pine. There is some evidence that the pine may stimulate the growth of the spruce (probably

Table 2. Net discounted revenue from unthinned Sitka spruce plantations over a range of yield classes and discounted rates. *Land prices and establishment costs are omitted from the analysis.* All values are in Irish £ ha^{-1}. (After Farrell, 1990)

Discount			**Yield Class**		
Rate %	**10**	**12**	**14**	**16**	**18**
3.0	960	1877	2689	3611	5493
3.5	613	1254	1808	2547	3897
4.0	370	822	1202	1801	2783
4.5	194	514	774	1264	1983
5.0	66	291	468	869	1398
5.5	-30	127	246	575	965
6.0	-101	7	84	355	641
6.5	-155	-82	-34	188	396

*Analysis is based on the financially optimum rotation, over an infinite number of rotations for pure Sitka spruce crops at 2 m x 2 m initial espacement, with a no-thin regime. Fertilization at establishment only is assumed. Roading is assumed at 10 m ha^{-1} and £20 m^{-1} in year preceeding clearfell. Insurance (rate 0.35%) and annual management charge (£13 ha^{-1}) are included in the analysis. Costs estimates are based on April 1990 data, revenue assumptions on 1976-1989 CPI adjusted mean timber prices (1989 IR£).

through a mycorrhizal influence). This is accompanied by the expectation that in time, the spruce will supress the pine giving a "self-thinning" effect. Analysis of the most appropriate growth model gives a higher return for Yield Class 14 crops (£1058 at 4.5%). If it is assumed that the expected growth stimulation will produce Sitka spruce Yield Class 16, then the residual sum available for land and development at 5% is £1156.

Ecological Impacts

The potential impact of land use in an ecosystem is inversely related to the complexity of the ecosystem. Oak woodlands, for instance are characterised by a large number of plant and animal species distributed over several vegetation layers. They are remarkably resilient and even after conversion to coniferous plantation many of the ground vegetation species persist and often reappear as the coniferous stand approaches maturity. Ombrotrophic peatland ecosystems by contrast, are simple. Only a limited number of species are adapted to the harsh regime characterised by high moisture and low nutrient supply. Peat soils too are far simpler in composition and in behaviour than mineral soils, lacking as they do the range of soil minerals which by their complex chemical interactions, confer diversity on the processes of ionic retention and release.

Conversion of a previously undisturbed blanket peatland to plantation forest initiates a process of change which profoundly alters the ecosystem and impacts on neighbouring ecosystems. The impact on the ecosystem itself is without doubt, drastic and virtually irreversible. The natural vegetation is eliminated, some species for much of the rotation, others permanently. Peat subsidence occurs, as a result of dewatering and peat oxidation. It is important to appreciate the essential difference between the impact of peatland afforestation and the afforestation of, for example, wet mineral soils of drumlins. The landscape of the drumlin regions is profoundly influenced by forestry, the hydrology of the catchment is modified but the soil with its tough mineral skeleton and complex buffering system, is relatively little altered.

It is reasonable to ask, "Do these changes matter?" All resource development involves modification and often the complete destruction of the natural ecosystem. However, the potential benefits resulting from the development of the resource should be set against the losses, the alteration of the natural environment and the less tangible returns which it may carry, aesthetic benefits, attraction to tourists etc. We need to find the correct balance between economic progress and the conservation of the natural (or what is perceived to be the natural) environment. We also need to understand that there are costs involved in conservation and environmental protection and to identify the means by which these costs should be covered.

The arguments in favour of conserving representative examples of our blanket peatlands are compelling, but a decision on the area that should be conserved is more difficult to arrive at. The government target, set in 1987, is to conserve 40,000 ha of blanket bog, 5% of the total area of this peatland type. However, if all the remainder were to be developed, the open treeless vistas of western Ireland would disappear forever.

Low-level blanket bogs exhibit considerable diversity, both between regions and within individual bog units. This diversity is based on peat depth, vegetation structure, geographical location and water regime. Rare and protected species of plants flourish in these nutrient poor habitats, each finding its niche in the undulations in the microtopography of the peatland surface. Blanket peatlands are large landscapes and complete hydrological blanket bog units need to be conserved intact, to maintain the integrity of the system. These extensive, open peatlands are rare in Europe, certainly at latitudes as low as ours. These fragile ecosystems are extremely sensitive to change and only by the protection of large units, will the complete range of ecological relationships be maintained.

The role of land-use change and in particular coniferous forestry in the acidification of surface waters has been a matter of study and concern in the United Kingdom in recent years (see Ormerod *et al.*, 1991). It has been concluded that the degradation of aquatic ecosystems in upland Wales is a consequence of air pollution effects (acid rain), but that it is exacerbated by the presence of coniferous forests which trap the air-borne particles in their canopies, thus increasing pollutant deposition beneath the canopy (Gee and Stoner 1989). Increased acid deposition on the soil beneath the forest canopy results in an accelerated rate of soil acidification, increased aluminium solubilisation and the acidification of streamwater. Aluminium is potentially toxic to plants and animals, particularly in certain ionic forms and its presence in excessive concentrations in stream waters leads to physiological disorders and death of fish.

Connemara is famous for its salmonoid fisheries and it is natural that there should be concern over the possible impact of coniferous forestry in the region. However, air quality is believed to be very good and if appropriate safeguards are taken, surface water acidification should not be a serious problem. The limited research carried out to date, however, does give some cause for concern. Two studies on water quality in Connemara were published in 1990. In one (Western Regional Fisheries Board 1990), it was reported that virtually all surface waters in Connemara are sensitive to acidification. In the second (Allott *et al.* 1990) it was concluded that afforestation did result in an increase in acidity and aluminium concentrations in particularly sensitive (poorly buffered) catchments in Connemara and South Mayo. Since the publication of these reports, two new multidisciplinary, inter-institutional projects have been initiated, to examine in greater detail the relationship between forestry and streamwater quality in Connemara, Wicklow and in Munster.

Conclusions

While the productivity of forest crops on western blanket peatlands is remarkably high, the potential financial return to the investor must be considered marginal. Most corporate, institutional, or major private investors aim for a real return from forestry of between 5.5 and 6.5% per annum. While this is attainable over a range of, mainly mineral, sites, blanket peatland cannot yield returns of this magnitude.

Few would argue with the idea that representative examples of blanket peatland should be conserved. More controversial is the area of land which should be set aside and the means by which this should be done. While the government target of 40,000 ha would seem to meet satisfactorily the requirement for the conservation of the blanket peatland ecosystem *per se*, the maintenance of the expansive character of our western landscape would require a significant increase on this target area. Given the limited attraction of this site type to the forestry investor, a case can be made for reducing the rate of afforestation on blanket peatlands in the western counties.

The means used to protect blanket peatland to date have been crude and such blunt instruments inevitably inflict unnecessary damage. The declaration that a particular tract of blanket peatland is an Area of Scientific Interest (ASI) effectively protects it from the developers, as no grant-aid will be forthcoming for such an area, but it may be considered as rough justice by the owner, who sees the opportunity to sell or develop the land taken away, without consultation. While there is undoubtedly a need for the demarcation of Areas of Scientific Interest, the scheme might be more effective in the long run, if it were used with greater sensitivity. Perhaps the best solution would be to apply an informative, consultation procedure, along with the scientific identification of ASIs and to combine it with a modification of the grant schemes, adjusted so as to reduce incentives for blanket peatland afforestation. With this approach, areas which are of scientific importance would be more acceptably protected and afforestation directed towards the most productive sites.

Conservation comes at a price. The owners of land declared as ASIs should be compensated. We must decide if we are prepared to pay that price. The European Community supports the restoration of our forest resource, because it is important to the Community. If the conservation of blanket peatlands is also important to Europe, then the European Community should be asked to contribute to the cost of the conservation of representative areas.

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