© Suoseura — Finnish Peatland Society
Helsinki 2006

ISSN 0039-5471
Suo 57(4): 97–107

Tomorrow's landscapes: studies in the after-uses of industrial cutaway peatlands in Ireland

Florence Renou, Tom Egan and David Wilson

Florence Renou, School of Biology and Environmental Science, Agriculture and Food Science Centre, University College Dublin, Belfield, Dublin 4, Ireland. Tel: + 353 1 716 7725 Fax: + 353 1 716 1102, e-mail: florence.renou@ucd.ie
Tom Egan, Bord na Móna, Boora, Leabeg, Tullamore, Co. Offaly
David Wilson, School of Biology and Environmental Science, Agriculture and Food Science Centre, University College Dublin, Belfield, Dublin 4, Ireland.

With the cessation of industrial peat harvesting, there is an opportunity to create new landscapes that can confer both socio-economic and ecological benefits. This paper reviews over 50 years of study in the after-use potential of industrial cutaway peatlands in Ireland. The options for after-use are determined to a large extent by the residual peat type, hydrological constraints, geographic location and economic considerations. Over the years, the main areas of investigation have included commercially driven options such as agriculture, forestry, and biomass production, as well as the more ecological and environmental options such as dryland recolonisation and wetland creation / restoration. In that time, the emphasis has continually changed as new research has emerged, in turn directing and shaping decision-making. By 2050, around 80000 ha of harvested peatlands will have become available for other uses. As such, a coherent post-harvesting strategy, underpinned by previous and future research, is essential in order to maximise the potential of these new ecosystems.

Keywords: cutaway peatlands, agriculture, biomass, forestry, restoration, wetland creation.

Introduction

Peatlands originally covered 1.17 million hectares or 17% of the area of the Republic of Ireland (Hammond 1981), a percentage only exceeded in Europe by Estonia (22%) and Finland (30%) (Lappalainen 1996, Montanerella et al. 2006). Peatlands in Ireland are generally grouped into three landscape units: raised bogs, blanket bogs and fens (Barry 1969, Hammond 1984). The Irish raised bogs, and specifically the midland examples, are unique and differ from raised bogs occurring elsewhere in the world due to their less domed shape and treeless landscape. They average 6 to 7 m in depth, although they may reach 14 m. The peat overlies alkaline moraine soils of limestone origin. The raised bogs of the midlands represent 80% of all commercially harvested bog, with 14.5 million m^3 of milled peat being extracted annually for the finite production of energy. Thus, a fourth type of peatland category or landscape unit has now emerged namely bogs that have been cutover by man.

Traditionally, peat has been hand cut as a source of fuel in Ireland since prehistoric times. Intense peat cutting occurred in the nineteenth century and was closely related to a large rise in population (Mitchell 1976). In the twentieth century, technological development resulted in further peatland being reclaimed for agriculture and extensive blocks of peatland being industrially harvested for fuel by the semi-state company Bord na Móna. These are located mainly in the raised bogs of the midlands and to a lesser extent on blanket bogs in the west of Ireland. About 18% (16000 ha) of Bord na Móna peatlands have so far been cut away. This area is increasing every year but at a variable rate and it is expected that 80000 ha of peatlands will become 'industrial cutaways' within the next three decades. The development of these large areas will be one of the great reclamation ventures undertaken in Europe and it has been compared in scale to the reclamation of the English fenlands or the polders in the Netherlands (Feehan & O'Donovan 1996). Cutaways are relatively new in the Irish landscape and as such they have not been included in many classic Irish landscape studies. Indeed the first impression one gets of a cutaway peatland is often a bleak one: a flat, bare, windswept, dark desolate area lacking macrotopography. Their hydrology can thus be quite complex and unique within each harvested 'bog unit'. The cutaway landscape looks deceptively uniform in appearance while in fact being extremely heterogeneous. It varies in type, thickness (because of the undulating topography of the bog floor), pH, nutrient status, moisture regime (drainage) and in the geomorphology of the underlying (pre-bog) relict mineral soil. All of these factors will influence future land-use programmes (McNally 1984, Hammond 1989, McNally 1995). Due to the complexity and the variety of cutaways, sound baseline information covering the nature and distribution patterns of the peat materials within each cutaway landscape unit should underpin any decisions on after-use.

The issue of the after-uses of Irish cutaway peatlands has already been the subject of several discussions at international (Healy 1980, McNally 1984, 1995, 1997), national (Healy 1978, Anon. 1979, Mollan 1989, McNally 1997) and county level (Egan 1998, Offaly County Council 2003). It is inevitable that policies, legislation and Ireland's commitment to international conventions and protocols should guide consideration of the rehabilitation of these lands. Local economic benefits are also important. Furthermore, decisions can have significant environmental, social and economic consequences, both positive and negative. Much research has been carried out since the 1950s, mainly driven by Bord na Móna and some aspects of this are on-going. The main areas of investigation have included: grassland (for silage production or grazing), crop production, horticulture, commercial forestry, biomass production, dryland recolonisation and wetland creation / restoration (Table 1). This study aims to review past and current research on the after-uses of Irish cutaway peatlands and to highlight issues that need to be addressed if the rehabilitation of these ecosystems is to be successful.

After-Uses Of Cutaway Peatlands

Agricultural and horticultural production

Conversion of both fens and bogs to agricultural (especially grassland) production has taken place all over northern Europe. In Ireland, fens were initially favoured, with drainage activities starting in the early medieval period, but some ombrotrophic bog reclamation also took place at an early stage. Experimentation into grassland production on industrial cutaways has been a recent affair, starting in the 1950s. It was thought that the conversion of cutaway into grassland would play an important role in enabling farmers to increase the size of their holdings and to improve their viability (Collins 1998). Several experiments were carried out in the Peatland Research Station at Lullymore, Co. Kildare and these have been critically reviewed over the years (Anon. 1979, Mollan 1989, Anon. 1991). Initially, grass was sown directly onto the peat surface, but major problems were soon encountered, including the emergence of fossil timber and the uneven subsidence of the peat surface. Other problems included poor grass yields due to inadequate mixing of peat and lime, and trafficability difficulties (McNally 1984). An extensive reclamation process was initiated to make the cutaways suitable for a range of agronomic production purposes, primarily grass. This reclamation process involves drainage, deep ploughing, weathering and the removal of exposed fossil timber in year one; the peat and subsoil are thoroughly mixed with a cultivation disc, limed and levelled in year two; and in the third year, the area is finally levelled, cultivated, fertilised and sown with perennial ryegrass (*Lollium perenne*) and clover (*Trifolium repens*). The growing of grass was most successful on milled cutaway peatland from which the maximum amount of peat had been removed so that deep ploughing allowed the remaining peat to be mixed with the subsoil (Drennan et al. 1984). Destroying the contact horizon (between the peat and sub-peat mineral soil) by roto-tilling or ploughing was crucial to improve the physical and chemical quality of the soil. It was thereby important to reclaim shallow cutaway peats mainly for grassland production.

When peat soils are reclaimed for agriculture, the characteristics of their surface horizons change rapidly with a reduction in moisture content, an increase in ash content, bulk density and pH, enhanced humification and structure development and reduced water infiltration rates (Kreshtapova et al. 2003). These changes are influenced significantly by microbial (Hammond 1981, Williams et al. 1985, Boyle & Curry 1997) activity. Improved grass growth responses were attributed to enhanced organic matter decomposition and mineralisation. To date, 1500 ha of cutaway peatland have been turned into good quality grassland by Bord na Móna and have been subsequently sold to local farmers.

Problems with mineral deficiencies have been encountered and some cutaways, such as the ones established in the 1980s in Bellacorrick, Co. Mayo, were shown to be unsuitable for grassland development as problems with mineral deficiencies in grazing animals occurred (Doyle & Ó Críodáin 2003). The utilisation of reclaimed cutaway bog for sheep grazing also encountered difficulties with, for example, the premature loss of incisor teeth (‘broken mouth’) due to mechanical stress (grass impaction); a phenomenon usually confined to unimproved hill pastures (Daly et al. 1984). The irreversible loss of organic material after reclamation has also been a problem, especially on very shallow soils. Mineral deficiency, excessive acidity, drought and difficulties with soil texture were also recurrent problems in attempting to establish arable crops, including cereals, beets and vegetables (Cassidy 1969, Cole 1969, MacNaeidhe et al. 1984). It was found that horticulture was feasible on cutaway peat but with a minimum depth of 1.5 m and preferably with peat of woody fen origin (Cassidy 1969, Robinson & Lamb 1975). The production of good, even-quality produce was difficult due to the variations encountered in the growing medium as the residual peat can change over short distances in terms of peat depth, peat type and nutrient concentrations. Weeds are also a much greater problem than would be the case on mineral soils (May 1975).

Table 1. Current and predicted land use category for the cutaway peatlands owned by Bord na Móna.
Taulukko 1. Nykyiset ja arvioidut Bord na Mónan omistamien suonpohjien jälkikäyttömuotojen pinta-alat Irlannissa.

After uses	Cutaway peatland area			
	Current		2050	
	ha	%	ha	%
Forestry (inc biomass)	4000	43.2	16000–20000	20–25
Alkaline wetland	3000	32.4	14400–16800	18–21
Acidic wetland (inc restoration)	700	7.6	15200–17600	19–22
Dryland re-colonisation	900	9.7	20000–28000	25–35
Conserved bog	400	4.3	4000–5600	5–7
Landfill; extraction etc.	20	0.2	700	0.8
Total	9270		*ca.*80000	

In conclusion, arable and vegetable production has been disappointing and has not been further researched and it is accepted that no significant areas will be reclaimed for such purpose in the future. Similarly, while Bord na Móna has acquired an excellent expertise over the years in developing cutaway peatlands for grassland, no future cutaways have been designated for grassland development. The new decoupling regime under the Common Agriculture Policy means that support funding to agriculture is now fixed, tied to specific land areas and based on historical outputs. In this context, grassland is not seen anymore as a viable alternative use of cutaway for the moment (Bord na Móna 2005).

Forestry

Research into the afforestation of cutaway peatlands began in the 1950s in Ireland and focused on one large sod-peat cutaway bog in Clonsast, Co. Offaly. The experimental area, commonly called 'Trench 14' was the first area (*c.*13 ha) leased by Bord na Móna to the Forest and Wildlife Service in 1955 for experimental purposes and site details are documented in several papers (O'Carroll 1967, Carey & Barry 1975, Carey et al. 1985, McCarthy 1986). An account of the bog before it was cutaway is given in Mitchell and Ryan (1997). The importance of Clonsast is that it was the first substantial bogland area, comprising several peat types, to be cut away by Bord na Móna and was therefore considered to be the best testing ground for decision-making on the after-uses of cutaways. Over the years, a series of basic investigations were set up, looking mainly at tree species performance (including biomass) and the effect of peat depth and fertilisation (Anon. 1965a, 1980, Carey et al. 1985, O'Flanagan 1988). Results were encouraging with great successes recorded for a wide range of conifers, a finding that provided much of the impetus for plans to afforest Bord na Móna cutaway peats. From the 1980s onwards, peatlands have been harvested by milling, leaving behind in effect a completely different soil profile, which required new techniques of rehabilitation and hence new research.

In 1965, 'An Foras Talúntais' (later Teagasc) conducted probably the first planting on milled cutaway (at Lullymore, Co. Kildare). Unpublished results from an assessment carried out in the 1980s show that both Sitka spruce (*Picea sitchensis* (Bong.) Carr.) and lodgepole pine (*Pinus contorta* var. *latifolia*) crops were suffering from the effects of underlying high-pH marl (Anon. 1965b). A series of species trials were set up in Turraun, Co. Offaly in 1983. A range of conifer and broadleaved species were planted directly into the *Phragmites* peat. The peat depth ranged from 0 to 1 metre and was underlain by highly calcareous alluvium, which has a clay loam texture, and in some part by shell-marl (Anon. 1985). After five years, lodgepole pine, pedunculate oak (*Quercus robur* L.), and common alder (*Alnus glutinosa* (L.) Gaertn.) had performed well, while results from ash (*Fraxinus excelsior* L.), beech (*Fagus sylvatica* L.) and sycamore (*Acer pseudoplatanus* L.) were not encouraging (O'Flanagan 1988). Where shell-marl was near the surface, trees were considerably poorer. As in Lullymore, periodic flooding also impeded tree growth in some places.

Consideration was given to the fact that *Phragmites* peat and bottom peat layers in general are often relatively compact. This was caused by the in-situ consolidation from the overlying peat layers and from peat harvesting machinery. However results from cultivation trials established in 1988 showed that cultivation did not have any beneficial effects on the growth of Scots pine (*Pinus sylvestris* L.) (Anon. 1997) while Sitka spruce had suffered heavy frost damage.

By the late 1980s, the afforestation of milled cutaway peatlands was perceived as offering great potential despite the fact that very little research had been carried out (O'Carroll 1962, Ó Maoláin et al. 1979, Gallagher & Gillespie 1984). Prospects were promising based largely on the assumption that these cutaways were homogeneous in botanical origin and in character, that they were drainable, available in large, accessible units and that they ought to be productive without any requirements for cultivation. In 1984, the state forestry board Coillte undertook an extensive planting programme on the cutaway peatlands and by 1992 had planted 4000 ha of cutaway bogs with mainly Sitka spruce (accounting for 76% of the total plantings) and lodgepole pine (10%). Norway spruce (*Picea abies* (L.) Karst.) and oak made up 2% each. However, the percentage of successful establishment was very low due to a variety of reasons such as frosts, competition with vegetation, nutrient deficiency, edaphic factors (depth or compaction of peat), drainage and pest damage (Lynch & McGuire 1993, Jones & Farrell 1997). Despite Coillte's efforts to concurrently establish trials investigating cultivation, fertilization, herbicides and species provenances (Murphy 1991), there was a progressive recognition of the serious problems encountered on milled cutaway bogs requiring further research and the planting programme had to be abandoned.

In 1996, an intensive research programme, BOGFOR was jointly conducted by Bord na Móna, Coillte, the Forest Service (Coford) and University College Dublin. These research trials have provided indicators towards the successful establishment of commercial plantations on cutaway peatlands by investigating a range of issues such as cultivation methods, species selection, drainage, vegetation control as well as edaphic and climatic limitations. Early results have been reviewed by Renou and Farrell (2005) and guidelines are being drafted which will allow the selection of management practices best adapted to specific site conditions which may lead to renewed planting in the future. While there is still little knowledge of long-term performance of different species on cutaway peatland, there seems to be a range of species that the forester will be able to choose from. Taking into account that a site assessment is necessary prior to selecting a species and that certain site preparation and management practices will be required, the following species can be generally regarded as suitable for the afforestation of cutaway peatlands: Norway spruce, Sitka spruce, Scots pine, Corsican pine (*Pinus nigra* var. *maritima* (Ait.) Melville), hybrid larch (*Larix x eurolepis*), western red cedar (*Thuja plicata* Donn ex D. Don), pedunculate oak, silver birch (*Betula pendula* Roth), downy birch (*Betula pubescens* Ehrh.) and common alder. This range of suitable conifer and broadleaved species affords the forester the opportunity to create interesting landscapes that will later provide options for entering a range of markets, as well as being aesthetically pleasing and ecological acceptable. The variation in site conditions encountered in any given cutaway peatland means that not one but several species should be planted in that site.

The afforestation of industrial cutaway peatlands would make a significant contribution to attaining the targets set out in the government's forest strategy, that is to bring the national forest area from 8% (in 1996) to 17% of the total land area by 2030 (Department of Agriculture Food and Forestry 1996). In an environment where prospects are limited for further forestry development on both blanket bog and intact raised bogs (Renou & Farrell 2005), industrial cutaway peatland offer great interest for the government as they have the chief benefit of being state owned. Furthermore, it would also give an impetus to rural-based employment and income, as well as providing an opportunity to emphasise the non-timber benefits of forestry, for example, through designing plantations that maximise recreational benefits. Thinnings and residues could also provide an opportunity for wood energy production. These are suitable for co-firing in the newly established peat-burning power stations and would extend their generation life, as well as reducing carbon dioxide emissions (Lappi & Byrne 2005). It would, however, require that the infrastructure constructed for peat production (road, ditches and electricity) could be utilised after peat harvesting had ceased.

Biomass

Short rotation energy crops for producing biomass as a source of energy are a relatively new concept in Ireland. The first trials using short rotation crops with coniferous species (mainly lodgepole pine and Sitka spruce) showed better yields on cutaway peatlands than on raised or blanket bogs (McCarthy & Keogh 1984). While experimental work indicated that 20 t DM ha^{-1} a^{-1} could be achieved on cutaway peatlands (Healy 1980), the results from further large-scale demonstration trials established with hardwoods (mainly willow, poplar and alder) in the late 1970s were disappointing. Of the 400 ha of energy crops planted on Bord na Móna land, only 10% performed moderately well (Bord na Móna 1988). The target yield of 12 tonnes of dry matter per hectare per year (Healy 1980) was not achieved in any of the coppice plantation trials, either in the midlands (Clonsast) or in the west of Ireland (Bellacorrick) (Bord na Móna 1988, Doyle & Ó Críodáin 2003). It was concluded that the cost of preparing the sites (mainly increasing pH and cultivation) were too high for the economically viable production of energy crops and all trials were abandoned. While poplar, aspen and willow have been named as likely biomass candidates to be grown on cutaway bogs, conclusive experimental results are lacking. Bord na Móna has recently renewed research and established trials growing willow (*Salix* spp.), elephant grass (*Miscanthus* spp.) and reed canary grass (*Phalaris arundinacea*). Currently, energy crops are not economically attractive on any land type in Ireland. Without governmental grants, it is unlikely that they will become a significant source of energy. Obligations under the Kyoto Protocol, committing Ireland to reduce greenhouse gas emissions to 13% above the base year (1990) emissions combined with spiralling costs of fossil fuel imports, could bring biomass production back to the forefront. A recent study showed that a yield of 9.2 t DM ha^{-1} a^{-1} was required from the second harvest cycle to obtain a positive income from the land with a wood chips price of £40 t DM (Rosenqvist & Dawson 2005). Research on arable land showed yields of willow and poplar between 7–11 t DM ha^{-1} a^{-1} similar to those experienced on cutaway peatlands (Rice et al. 1997). Given that most power plants are located in the midlands and that the infrastructure for transport already exists, producing biomass on the cutaway peatlands may well be a viable activity and new research should certainly be initiated.

Natural after-uses

It is likely that some cutaway areas will not support a commercial productive after-use due in part to their hydrology. For example, peat harvesting is currently facilitated in large areas adjacent to the River Shannon by the mechanical pumping of drainage water. With the cessation of harvesting, the economic rationale to continue this practice will be gone. As such, up to 50% of the cutaway areas will be incapable of supporting either grassland or forestry and other options such as dryland recolonisation and wetland creation / restoration have recently been investigated.

Dryland re-colonisation

Most cutaway peatlands are still bare peat and spontaneous revegetation is limited by extreme abiotic conditions left after peat harvesting (Quinty & Rochefort 1997, Lanta et al. 2004). Colonisation will be affected by the drainage conditions, the characteristics of the remaining peat and also by the surrounding land uses as this land acts as a seed bank. The initial vegetation communities are rarely bog communities and are in a state of rapid change in their succession to more stable plant communities. If left untouched, a cutaway peatland will be colonised by pioneer species such as birch (*Betula* spp.) and willow (*Salix* spp.), just as it was in the wake of the last Ice Age (Feehan 2000). *Juncus effusus* can also exclusively colonise some of the wetter parts of the cutaway peatlands where the water table fluctuates (McCorry & Renou 2003). Depending on the characteristics of the remaining peat layer and sub-peat mineral soil, numerous vegetation communities can evolve to maturity (Rowlands & Feehan 2000a, 2000b). This can be an advantage in the reclamation of certain sites for biodiversity.

The restoration of the ecological values of a cutaway bog by letting it develop a natural ecology are determined by the new biotic and abiotic factors prevailing on the cutaway (Feehan 2000, Rowlands & Feehan 2000b). At Turraun industrial cutaway peatland in Co. Offaly, Rowlands and Feehan (2000a, 2000b) have demonstrated that cutaways, given the right conditions, have the potential to revegetate naturally into a diverse range of communities. The natural colonisation of cutaways provides a great opportunity to enable natural biodiversity to redevelop, and reach a new wilderness status that was lost once machines began to harvest the peat. This option is becoming more and more of a reality as new projects are developed for the creation of national wetlands wilderness parks (Feehan 2004).

Wetland creation / restoration

It is important to distinguish between bog restoration in the strictest sense and the creation and management of a new wetland that provides some of the functions and features that the land had prior to its exploitation. In terms of the latter, there have been successful wetland creations on cutaways in the Irish midlands and the development of parks and amenities centred on semi-artificial wetlands have been impressively demonstrated at Lough Boora Parklands, Co. Offaly (Egan 1998, 2004). These wetland areas provide a wide range of flora and fauna (O'Connor & Reynolds 2000, Higgins & Colleran 2006) but their richness will depend on factors such as time and the lake creation strategy, which influences the sediment characteristics, water chemistry and extent of revegetation (Higgins & Colleran 2005). In addition, this type of after-use can create a wide range of educational, artistic, amenity and tourism activities that can stimulate local community enterprise.

On the other hand, restoration of cutaway peatlands into peat-forming systems or 'growing' bogs has not been widely pursued in Ireland. While the regeneration scenario is becoming increasingly popular in other countries such as Canada and Finland (Price et al. 2002, Campbell & Rochefort 2003, Chapman et al. 2003, Vasander et al. 2003, Cobbaert et al. 2004), it is more difficult to achieve in Ireland given that the emphasis is on harvesting the peat for its fuel rather than for its horticultural resource. Milled peat production typically removes several metres of peat in the harvesting life span of the bog, with the result that the residual peat substrate is the more alkaline *Phragmites* or fen peat. As a consequence, establishment of typical bog plant species, such as Sphagna, is more problematic. However, in a study of a rehabilitated cutaway blanket bog in the west of Ireland, Farrell and Doyle (2003) suggested that the presence of transitional species such as *Sphagnum subnitens*, which is able to tolerate high pH, may create a suitable environment for the establishment of more ombrotrophic Sphagna species.

Future considerations

In recent years, the effect of land-use change on the greenhouse gas balance of peatlands globally has received much attention (Tuittila et al. 1999, Waddington & Price 2000, Waddington & Warner 2001). In Ireland, various after-use strategies have been assessed for their ability to restore cutaway bogs as carbon sequestering ecosystems (Byrne et al. 2000). In a two-year study of carbon gas exchange at Turraun, Co. Offaly, Wilson et al. (In press) reported considerable losses of carbon dioxide and a return of methane emissions with rewetting of the cutaway. The results indicated the need for improved post-harvesting planning to minimise potential C losses from the cutaways. No conclusive results have been found where the cutaway vegetation cover consists of trees (either feral or planted) but studies are on-going (Cabral et al. 2005). Other future after-uses for the cutaways that have been suggested include gravel extraction, wind farm, landfill, airport; all of which arise where there is a specific local requirement or local economic benefits that can be critical in certain peat producing areas.

Due to the complexity and the variety of cutaways, sound baseline information covering the nature and distribution patterns of the peat materials within each cutaway landscape unit should underpin any decisions on after-use. New technologies (remote sensing combining GIS with satellite imagery) have proven to be a useful source of information, for example showing current land cover types in production peatlands (McGovern et al. 2000). This should be developed further with the acquisition of accurate data regarding the soil resource and drainage possibility.

It is inevitable that policies, legislation and Ireland's commitment to international conventions and protocols should guide consideration of the rehabilitation of these lands. For example, there is currently an obligation under the terms of the Convention on Biological Diversity to take account of the 'multifunctionality' when considering the future development and use of cutaway. The new Rural Development Regulation 2007–2013 may also affect greatly the choices of after-uses as new grants may be available for the afforestation of non-agricultural land such as cutaway, allowing a state company such as Bord na Móna to eligible for these grants.

Conclusion

A new landscape is about to emerge by 2050, a century after research on the after-uses of cutaway peatland was initiated (Table 2). The potential exists to construct a fascinating, rich mosaic of habitats that could be productive as well as bio-diverse. The results obtained so far, combined with the intrinsic nature of the cutaway peatlands themselves, suggest that future decisions as to their after-use should be flexible. More research is required in order to better equip the decision-makers. The process is a steep learning curve as more information is steadily becoming available regarding the different types of emerging cutaway peatlands. Whatever options are chosen, the cutaway will require dedicated management in order to insure that their rehabilitation achieve their objectives and potential. Fundamentally, the success of the after-use depends on: (1) the quality of the planning, (2) the knowledge of the particular cutaway peatland features and (3) the correct decisions concerning the most suitable options. This can be provided by the establishment of forums, which have already been suggested by Bord na Móna (Egan 2006) and which should include all relevant agencies, research, administration and community to work at local and national level. These forums should help see tomorrow's landscape emerge in a wise-use fashion.

Acknowledgements

Grateful thanks to the two anonymous referees for their comments.

Table 2. Timeline overview of the development of scientific research on cutaway peatlands in Ireland.
Taulukko 2. Irlantilaisen suonpohjia koskevan tieteellisen tutkimuksen virstanpylväitä.

1950	Experiment in grassland production and arable crops
1955	Establishment of first cutaway peatland forest experiments in Clonsast (Trench 14)
1958	Lullymore research station opens to investigate the potential of cutaway peatland for grassland, livestock, tillage and vegetables
1965	First plantation trial on milled peat, Lullymore
1967	Vegetable and horticultural trials
1972	Bord na Móna established the Land Development Unit to develop best practice techniques for the cutaways
1977	Biomass trial with willows, poplars and alders
1983	Cultivation trial (66 ha), Lullymore
1988–92	Large-scale planting of Bord na Móna cutaways by Coillte (4000 ha)
1991	Wetland construction in Turraun Coillte workshop on establishment problems on the cutaways
1992	Series of Coillte forest experiments at Tullamore
1995	Wetland creation in Tumduff (6 ha)
1996	Creation of Finnamore Lakes: 2 angling lakes and a wetland (30 ha)
1998	Lough Boora Parkland: angling lakes, wetland, natural colonisation, grassland and forestry (250 ha)
1999–06	BOGFOR Research Programme on the afforestation of cutaway peatlands
2000	Wetland construction in Clongawney (12 ha)
2006	Biomass trials with willow, elephant grass and reed canary grass

References

Anon. 1965a. Cutover peatlands. In, Forest Research Review 1957–1964, Department of Lands Forestry Division. The Stationery Office, Dublin, pp. 31–32.

Anon. 1965b. Soils division — Research Report: Teagasc nutritional trial at Lullymore. An Foras Talúntais, Dublin.

Anon. 1979. Report of the inter-departmental committee appointed by the Ministry for Industry, Commerce and Energy to consider possible uses of Bord na Móna cutaway bogs. The Stationery Office, Dublin.

Anon. 1980. Fertiliser requirements of reedswamp peat sites. In, Research Report 1980. Dept of Fisheries & Forestry, Dublin, pp. 7.

Anon. 1985. Experiment working plans at Turraun. Forest and Wildlife Service, Research Branch, Soils and Nutrition Section, Bray, Co. Wicklow.

Anon. 1991. Report of the independent committee on the future uses of Bord na Mona cutaway bog. Department of Energy, Dublin.

Anon. 1997. Experiment report on the cultivation trials at Lullymore: 32/88. Coillte, Newtownmountkennedy.

Barry, T. A. 1969. Origins and distribution of peat-types in the bogs of Ireland. Irish Forestry 26: 40–52.

Bord na Móna. 1988. Options for development of Bord na Móna cutaway bogs.

Bord na Móna. 2005. Report on Corporate Social Responsibility 2004/2005. Bord na Móna, Newbridge, Co. Kildare.

Boyle, K. E. & Curry, J. P. 1997. Influence of earthworms on soil properties and grass production in reclaimed cutover peat. Biological Fertility of Soils 25: 20–26.

Byrne, K. A., Farrell, E. P. & O'Toole, P. 2000. Greenhouse gas emissions in restored industrial cutaway peatlands in central Ireland. 11th International Peat Congress, pp. 873–877.

Cabral, R., Farrell, E. P. & Byrne, K. A. 2005. Seasonal dynamics of soil CO_2 efflux in Sitka spruce and birch growing on industrial cutaway peatlands. Cost Action E38: Woody Root processes — Impact of different tree species. 5–9 June 2005, Tartu, Estonia, pp. 13.

Campbell, D. R. & Rochefort, L. 2003. Germination and seedling growth of bog plants in relation to the recolonization of milled peatlands. Plant Ecology 169: 71–84.

Carey, M. L. & Barry, T. A. 1975. Coniferous growth and rooting patterns on machine sod-peat bog (cutover) and Trench 14, Clonsast. Irish Forestry 32: 18–29.

Carey, M. L., Hammond, R. F. & McCarthy, R. 1985. Plantation forestry on cutaway raised bogs and fen peats in the Republic of Ireland. Irish Forestry 42: 106–122.

Cassidy, J. C. 1969. Suitability of peat soils for the production of vegetable crops. Peat as a medium for horticultural crop production, Dublin, An Foras Taluntais, pp. 55–61.

Chapman, S., Buttler, A., Francez, A.-J., Laggoun-Defarge, F., Vasander, H., Schloter, M., Combe, J., Grosvernier, P., Harms, H., Epron, D., Gilbert, D. & Mitchell, E. 2003. Exploitation of northern peatlands and biodiversity maintenance: a conflict between economy and ecology. Frontiers in Ecology and the Environment 1: 525–532.

Cobbaert, D., Rochefort, L. & Price, J. S. 2004. Experimental restoration of a fen plant community after peat mining. Applied Vegetation Science 7: 209–220.

Cole, A. J. 1969. Suitability of peat soils for the production of agricultural crops. Peat as a medium for horticultural crop production, Dublin, An Foras Taluntais, pp. 62–3.

Collins, T. 1998. The economic importance of agriculture on the cutaways. Future Use of Cutaway Bogs. Proceedings from the first comprehensive conference on cutaway bogland rehabilitation, Lough Boora Parkland, Brosna Press, pp. 17–21.

Daly, P. J., Farrell, C. & Egan, T. M. 1984. Investigation into premature loss of permanent incisor teeth (broken mouths) in ewes grazing reclaimed peatland. Proceedings of the 7th International Peat Congress, Dublin, IPC, pp. 238–254.

Department of Agriculture Food and Forestry. 1996. Growing for the future: a strategic plan for the development of the forestry sector in Ireland. The Stationery Office, Dublin.

Doyle, G. J. & Ó Críodáin, C. 2003. Peatlands — fens and bogs. In: Otte, M. L. (ed.), Wetlands of Ireland. University College Dublin, Dublin, pp. 79–108.

Drennan, M. J., Cole, A. J., O'Dwyer, J. & McNally, G. 1984. Beef production from grass grown on peatland. Proceedings of the 7th International Peat Congress, Dublin, pp. 264–270.

Egan, T. 2006. Bord na Móna industrial cutaway boglands. Peatland utilisation and research in Ireland 2006, Dublin, Irish Peatland Society, pp. 30–35.

Egan, T. M. 1998. A pilot project for the utilisation of cutaway boglands in West Offaly. In: Gormley, F. (ed.), Towards a conservation strategy for the bogs of Ireland. Irish Peatland Conservation Council, Dublin, pp. 119–126.

Egan, T. M. 2004. Human interactions with a raised bog in midland Ireland. 12th International Peat Congress, Tampere, Finland, International Peat Society, pp. 538–544.

Farrell, C. A. & Doyle, G. J. 2003. Rehabilitation of industrial cutaway Atlantic blanket bog in County Mayo, north-west Ireland. Wetlands Ecology and Management 11: 21–35.

Feehan, J. 2000. Back to the future? Limnological reflections on peatland change in Ireland. Verh. Internat. Verein. Limnol. 27: 1165–1173.

Feehan, J. 2004. A long-lived wilderness - The future of the North Midlands peatland network. Department of Environmental Resource Management, Dublin.

Feehan, J. & O'Donovan, G. 1996. The bogs of Ireland. An introduction to the natural, cultural and industrial heritage of the Irish peatlands. The Environmental Institute, University College Dublin, Dublin.

Gallagher, G. & Gillespie, J. 1984. The economics of peatland afforestation. 7th International Peat Congress, Dublin, International Peat Congress, pp. 271–285.

Hammond, R. F. 1981. The peatlands of Ireland. Soil Survey Bulletin No. 35. An Foras Taluntais, Dublin, Ireland.

Hammond, R. F. 1984. The classification of Irish peats as surveyed by the National Survey of Ireland. Procs. 7th Int. Peat congress, Dublin, pp. 168–187.

Hammond, R. F. 1989. The characteristics of Irish midland peatlands which can influence future land use programmes. In: Mollan, C. (ed). The utilisation of Irish midland peatlands. Royal Dublin Society, Dublin, pp. 49–62.

Healy, J. 1978. Some Aspects of the Development and Utilisation of Cutaway Bog. Irish Society of Agronomy and Land Use Symposium 'Future Use of Midland Bogs', Tullamore, pp. 39–49.

Healy, J. 1980. Industrial Cutaway Bog Development in Ireland — Food and Energy. 6th International Peat Congress, Duluth, pp. 387–397.

Higgins, T. & Colleran, E. 2005. Lake creation on cutaway peatlands. Bord na Móna and Environmental Change Institute, Galway.

Higgins, T. & Colleran, E. 2006. Trophic status of experimental cutaway peatland lakes in Ireland and implications for future lake creation. Journal of Environmental Science & Health, Part A: Toxic/Hazardous Substances & Environmental Engineering 41: 849–863.

Jones, S. M. & Farrell, E. P. 1997. Survey of plantation forests on Bord na Móna cutaway bog. Final report. Forest Ecosystem Research Group Report Number 20, Department of Environmental Resource Management, University College, Dublin.

Kreshtapova, V. N., Krupnov, R. A. & Uspenskaya, O. N. 2003. Quality of organic soils for agricultural use of cutover peatlands in Russia. In: Ilnicki, P. (ed). Organic soils and peat materials for sustainable agriculture. CRC Press, Boca Raton, pp. 175–186.

Lanta, V., Dolezal, J. & Samata, J. 2004. Vegetation patterns in a cutaway peatland in relation to abiotic and biotic factors: a case study from the Sumava Mts., Czech Republic. Suo 55: 33–43.

Lappalainen, E. 1996. Mires of Finland and their use. In: Lappalainen, E. (ed.), Global peat resource. International Peat Society, Saarijärvi, pp. 69–74.

Lappi, S. & Byrne, K. A. 2005. Greenhouse gas benefits of co-firing biomass with peat for energy in Ireland. IEA Bionergy, Task 38, Graz, Austria.

Lynch, B. & McGuire, A. 1993. Survey report on lands leased from Bord na Mona. Unpublished Coillte internal report, Coillte, Mullingar.

MacNaeidhe, F. S., Jelley, R. M. & Burke, W. 1984. Soil amelioration and reclamation studies on Bord na Mona milled-over peatland, 1984. Third progress report. An Foras Taluntais,

May, M. J. 1975. Weed control. In: Lamb, J. G. D. (ed.), Peat in horticulture. Academic Press, London, pp. 71–86.

McCarthy, R. 1986. Visit to forest experiment area Trench 14, Clonsast Bog; Research and development trials on milled peat cutaway bog — Lullymore 1986. Coillte, Bray, Co. Wicklow.

McCarthy, R. & Keogh, R. M. 1984. Biomass potential of conifers on peatlands. 7th International Peat Congress, Dublin, Ireland, The Irish National Peat Committee, pp. 398–416.

McCorry, M. J. & Renou, F. 2003. Ecology and management of *Juncus effusus* on cutaway peatlands in the Irish midlands. Forest Ecosystem Research Group Report Number 69, Department of Environmental Resource Management, University College Dublin, Dublin.

McGovern, E. A., Holden, N. M., Ward, S. M. & Collins, J. F. 2000. Remotely sensed satellite imagery as an information source for industrial peatlands management. Resources, Conservation and Recycling 28 67–83.

McNally, G. 1984. Development of Industrial Cutover Bog in Ireland. 7th International Peat Congress, Dublin, pp. 442–449.

McNally, G. 1995. The utilisation of industrial cutaway peatland. The key factors influencing the various afteruse options. Proceedings of the Conference on the Peat Industry and the Environment, Tallin, Estonia, pp. 84–86.

McNally, G. 1997. Peatlands, power and post-industrial use. In: Ingram, H. A. P. (ed.), Conserving peatlands. CAB INTERNATIONAL, London, pp. 245–251.

Mitchell, F. 1976. The Irish landscape. Collins, London.

Mitchell, F. & Ryan, M. 1997. Reading the Irish Landscape. Town House and Country House, Dublin.

Mollan, C. (ed). 1989. The Utilisation of Irish Midland Peatlands. Royal Dublin Society,

Montanerella, L., Jones, R. J. A. & Hiederer, R. 2006. The distribution of peatland in Europe. Mires and Peat 1: 1–10.

Murphy, G. 1991. Workshop on establishment problems on the BNM cutaway bogs. Report and Recommendations. Coillte Research Report No. 20/91 (R). Coillte Teoranta, Bray, Co. Wicklow.

Ó Maoláin, D., Collins, S., Rowan, J., Ó Muirgheasa, N., Rhatigan, L., Healy, J. & Matthews, T. 1979. Interim report of the inter-departmental committee appointed by the Ministry for Industry, Commerce and Energy to consider possible uses of Bord na Móna cutaway bogs. The Stationery Office, Dublin.

O'Carroll, N. 1962. The progress of peatland afforestation in the Republic of Ireland. XIX(1) 93–101.

O'Carroll, N. 1967. Early growth of conifers on machine-cutover peatland. Proc. XIV IUFRO Congress, Munich, pp. 471–482.

O'Connor, A. & Reynolds, J. 2000. Aquatic macro invertebrate colonisation of artificial water bodies on cutaway oceanic raised bog in Ireland. Sustaining our peatlands: Proceedings of the 11th International Peat Congress, Québec, Canadian Society of Peat and Peatlands and the International Peat Society, pp. 742–750.

Offaly County Council. 2003. Offaly County Development Plan 2003–2009. Offaly County Council, Tullamore.

O'Flanagan, L. 1988. The role of forestry on the midland cutaway peats. In: Mollan, C. (ed.), The Utilisation of Irish Midland peatlands. Proceedings of a workshop held in the Royal Dublin Society from September 21–24, 1988. Royal Dublin Society, Dublin, pp. 63–70.

Price, J. S., Rochefort, L. & Campeau, S. 2002. Use of shallow basins to restore cutover peatlands: hydrology. Restoration Ecology 10: 259–266.

Quinty, F. & Rochefort, L. 1997. Plant reintroduction on a harvested peat bog. In: Jeglum, J. K. (ed.), Northern Forested Wetlands. CRC Lewis Publishers, Boca Raton, pp. 133–145.

Renou, F. & Farrell, E. P. 2005. Reclaiming peatlands for forestry: the Irish experience. In: Madsen, P. A. (ed.), Restoration of boreal and temperate forests. CRC Press, Boca Raton, pp. 541–557.

Rice, B., Bulfin, M., Kent, M., Frohlich, A. & Lenehan, J. J. 1997. Potential for energy poduction from agricultural and forest biomass in Ireland. Teagasc, Dublin.

Robinson, D. W. & Lamb, J. G. D. (eds). 1975. Peat in horticulture. Academic Press, London.

Rosenqvist, H. & Dawson, M. 2005. Economics of willow growing in Northern Ireland. Biomass and bioenergy 28: 7–14.

Rowlands, R. & Feehan, J. 2000a. The ecological future of industrially milled cutaway peatlands in Ireland. Aspects of Applied Biology 58 263–269.

Rowlands, R. & Feehan, J. 2000b. Maximising the natural ecological potential of industrial cutaway peatlands in Ireland. In: Daigle, J.-Y. (ed.), International Peat Congress, Commission V. pp. 678–683.

Tuittila, E.-S., Komulainen, V.-M., Vasander, H. & Laine, J. 1999. Restored cut-away peatland as a sink for atmospheric CO_2. Oecologia 120: 563–574.

Vasander, H., Tuittila, E.-S., Lode, E., Lundin, L., Ilomets, M., Sallantaus, T., Heikkila, R., Pitkanen, M.-L. & Laine, J. 2003. Status and restoration of peatlands in northern Europe. Wetlands Ecology and Management 11: 51–63.

Waddington, J. M. & Price, J. S. 2000. Effect of peatland drainage, harvesting and restoration on atmospheric water and carbon exchange. Physical Geography 21: 433–451.

Waddington, J. M. & Warner, K. D. 2001. Atmospheric CO_2 sequestration in restored mined peatlands. Ecoscience 8: 359–368.

Williams, B. L., Boggie, R., Cooper, J. M. & Mitchell, J. W. 1985. Changes in some physical and chemical characteristics of peat following reseeding and grazing. Irish Journal of Agricultural Research 24: 229–236.

Wilson, D., Tuittila, E.-S., Alm, J., Laine, J., Farrell, E. P. & Byrne, K. A. (In press). Carbon dioxide dynamics of a restored maritime peatland. Ecoscience.

Received 2.11.2006, Accepted 29.12.2006

Tiivistelmä: Tutkimuksia suonpohjien jälkikäyttömahdollisuuksista Irlannissa

Turvetuotannosta vapautuneet suonpohjat ovat pinta-alaltaan merkittävä maisematekijä Irlannissa. Niiden jälkikäyttö tarjoaa kuitenkin mahdollisuuksia monenlaisten uusien elinympäristöjen ja maisemaelementtien rakentamiseen, joista saadaan sekä ekologista että sosio-ekonomista hyötyä. Tässä artikkelissa tehdään yhteenveto Irlannissa 50 vuoden aikana suonpohjien jälkikäyttömuotoihin kohdistuneista tutkimuksista. Suonpohjan jälkikäyttötapa riippuu merkittävästi sen jäännösturpeen ominaisuuksista, alueen hydrologisista rajoitteista, maantieteellisestä sijainnista ja taloudellisista näkökohdista. Jälkikäytön tutkimus on pääasiassa keskittynyt taloudellisesta näkökulmasta järkeviin käyttömuotoihin, kuten maanviljelyyn, metsittämiseen ja biomassantuotantoon. Toisaalta on myös tutkittu suon luonnontilaan palauttamista. Vuosien saatossa tutkimuksen painopiste on muuttunut uusien tutkimusongelmien esiinnousun myötä. Vastaavasti tutkimus on ohjannut ja muotouttanut käytännön päätöksentekoa. Vuoteen 2050 mennessä noin 80000 ha suonpohjia vapautuu turvetuotannosta Irlannissa. Tulevaisuudessa tarvitaan selkeää suonpohjien jälkikäytön strategiaa, joka tukeutuu kiinteästi sekä olemassa olevaan että uuteen tutkimustietoon.