A review of small-scale harvesting systems in use worldwide and their potential application in Irish forestry

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First published in 2005 by COFORD, National Council for Forest Research and Development, Dublin, Ireland.

ISBN 1 902696 45 X

Title: A review of small-scale harvesting systems in use worldwide and their potential application in Irish forestry.

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Citation: Russell, F. and Mortimer, D. 2005. *A review of small-scale harvesting systems in use worldwide and their potential application in Irish forestry*. COFORD, Dublin.

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Réamhfhocal

Tá tionsclaíocht na foraoiseachta ag teacht chuig céim ina forbairt anois ina mbeidh cuid mhór de na luathphlandálacha foraoiseachta den earnáil phríobháideach ag teacht isteach ar chéim na bainte. Ó na luathochtóidí, tá an Stát, le cúnamh an Choimisiúin Eorpaigh, ag spreagadh úinéirí talaimh chun a ngabháltas talaimh go léir, nó cuid de, a fhoraoisiú. Bhí infheistíocht shuntasach ag an Stát i gceist sa chéad scór bliain den tionscnamh seo i dtéarmaí dreasachtaí airgeadais, agus ag úinéirí talaimh i dtéarmaí a sócmhainne talaimh. Bainfear an príomhshochar amach don dá pháirtí nuair a éireoidh na foraoisí seo aibí agus nuair a thosóidh siad ag táirgeadh roinnt táirgí cruinnadhmaid agus bithmhaise adhmaid.

Is léir go mbeidh an sochar don duine aonair i bhfoirm ioncaim ó adhmad a dhíol. Beidh an sochar don Stát ag fabhrú, áfach, ón ghníomhaíocht eacnamaíoch spreagtha ag an ngníomhaíocht bainte agus próiseála mar a aithníodh sa dá thuarascáil leis an Dr Peter Bacon agus Comhpháirtithe. Agus é ag smaoineamh ar an sochar féideartha seo d'fhostaigh COFORD seirbhísí PTR Teo. le tabhairt faoi léirmheas ar an trealamh bainte a úsáidtear le riachtanais na foraoiseachta ar an mionscála a sheirbhísiú.

Is léir ón tuarascáil seo, ainneoin go bhfuil tábhacht shofheicthe ag baint leis an trealamh agus bonneagar fisiceach, tá na córais bhainte/mhargaíochta níos leithne agus na hidirghníomhaíochtaí idir fástóirí, conraitheoirí agus ceannaitheoirí níos tábhachtaí fós.

Tá treoir cuimsitheach don trealamh bainte ar an mionscála curtha ar fail ag an mbeirt phríomhúdar, Fionan Russell agus Donal Mortimer. Glacaimid leis go mbeidh an foilseachán seo an-úsáideach ag úinéirí foraoise, agus conraitheoirí foraoiseachta agus bainte. Chomh maith leis sin táimid ag dúil le bheith ag obair le Teagasc, Institiúid Teicneolaíochta Phort Láirge agus grúpaí nach iad chun a oiriúnaí atá cuid mhór den trealamh seo do thosca na foraoiseachta in Éirinn a léiriú.

Is riachtanach go mbíonn gach earnáil den tionsclaíocht ag obair le chéile leis an táirgeadh fhéideartha a réadú ón earnáil phríobháideach ionas gur féidir linn bogadh níos deise don phríomhaidhm a ndearnadh cur síos imlíneach air i Ag Fás Don Am Le Teacht – tionsclaíocht foraoiseachta a chruthú atá iomaíoch ar bhonn idirnáisiúnta.

An tUasal David Nevins,
Cathaoirleach

An Dr Eugene Hendrick,
Stiúrthóir

Foreword

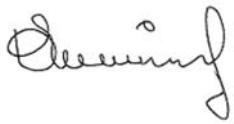
The forest industry is now at a stage of development that will see much of the early private sector forestry plantations enter the harvesting phase. Since the early 80s, the State, with the assistance of the European Commission, has been encouraging landowners to afforest all, or part of, their land holding. The first two decades of this initiative involved significant investment by the State in terms of financial incentives, and by the landowners in terms of their land asset. The primary return for both parties will be achieved when these forests mature and begin to produce various roundwood products and wood biomass.

The return to the individual will obviously be in the form of timber sales revenue. However, the return to the State accrues from the economic activity stimulated by harvesting and processing activity as identified in the two reports by Dr Peter Bacon & Associates. It is with this potential return in mind that COFORD engaged the services of PTR Ltd to undertake a review of harvesting equipment used to service the needs of small-scale forestry.

It is clear from this report that while the physical equipment and infrastructure is of obvious importance, the wider harvesting/marketing systems and the grower-contractor-buyer interactions are of greater importance.

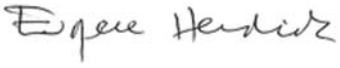
The two main authors, Fionan Russell and Donal Mortimer, have produced a comprehensive guide to small-scale harvesting equipment. We trust that this publication will of great use to forest owners, forester and harvesting contractors. In addition we look forward to working with Teagasc, Waterford Institute of Technology and other groups in demonstrating the suitability of much of this equipment to Irish forestry conditions.

It is vital that all sectors of the industry work together to realise the production potential from the private sector so that we can move closer to the principal aim outlined in Growing for the Future – the creation of an internationally competitive forest industry.



Mr David Nevins

Chairman



Dr Eugene Hendrick

Director

Summary

On the basis of an international review, this report has presented a number of generic harvesting systems and component operations suitable for use in the harvesting of small-scale forestry. One of the basic criteria used internationally in the assessment of systems suitable for small-scale harvesting[1] (and a criterion used in this study) is low capital cost of equipment. Low-cost equipment facilitates owners in becoming directly involved in harvesting operations, however its use presupposes competence and knowledge in timber harvesting systems and techniques.

Throughout the countries reviewed in this study the chainsaw is the only choice for cutting work for the majority of self-employed owners with small and medium sized properties. The most commonly used small-scale timber extraction systems involve the use of modified agricultural tractors (skidding or forwarding). In most countries such equipment is readily available to farmers. However, the skills required to harvest timber using this equipment have been developed mainly by farmers in those countries where there is a strong forestry culture. Internationally, commercial activity in small-scale forests is often left to professional forestry contractors.

Based on discussions with full-time forestry contractors working in the Irish forest industry, the most suitable systems and machinery presented in this report are modified agricultural tractors used in conjunction with either skidders or powered, driven trailers. Horses were also considered by many to have potential for logging small timber lots. Cable systems would most likely be used only by dedicated full-time contractors. The potential for small dimension machinery was considered to be very limited since it lacked the versatility of larger, robust machinery.

Generally it is difficult to fully mechanise self-employed wood harvesting since the profitable purchase of additional equipment requires such a large annual volume of felled timber that individual growers seldom have the required volume. It is notable that timber harvesting carried out by forest owners has decreased in the Nordic countries as professional harvesting becomes more mechanised and as profit earning capacity increases. In southern Europe, UK, and indeed Ireland, forest owners hardly do any harvesting work in their own forests; most work is contracted. In countries where contractor work dominates, advanced technology and adapted organisation as well as co-operation will be required in the profitable harvesting of small-scale forestry.

In countries where farmer forestry is relatively new, farmers are facing a steep learning curve. Harvesting systems, codes of practice, product specifications, occupational health and safety and knowledge of the market place are all matters that farmers need to appreciate. The importance of the entire wood supply chain must be recognised, along with the time it takes for such systems to develop. Evaluation is needed on all aspects of the system, and not just the harvesting equipment and its application.

The competitive position of small or part-time harvesting enterprises is difficult compared to bigger companies. A lack of co-operation between contractors, timber owners and timber buyers complicates small-scale timber harvesting, and timber supply tends to lack reliability and continuity. Co-operation between owners of small-scale forestry is a key factor in the exploitation of the small-scale forestry resource. In different countries there is much variation in the organisational structures of owners organisations and in many cases these have evolved in line with the natural development of the forest industries in those countries.

The harvesting of small-scale forestry does not necessarily preclude the use of large-scale equipment. In many of the Scandinavian countries harvesting technology used in small-scale forestry is the same expensive technology used in forestry in general in those countries. The technology associated with small-scale forestry can be both large-scale (when work is carried out by contractors) or small-scale (when carried out by forest owners). This blurs the distinction between small- and large-scale/conventional forestry. However, within optimal

1 *For the purposes of this review, small-scale harvesting is that which may be applicable to the emerging structure of the private forest estate in Ireland, namely that with an average plantation of less than 10 ha.*

organisational structures it demonstrates the possibilities for the utilisation of conventional large-scale equipment and all the associated benefits.

Modern information technology especially in the form of the Internet could be developed to improve information dissemination to forest owners. One of the challenges for the future is to exploit technologies (communications and logistical) which will enable owners of small-scale forests to participate fully in commercial wood markets. In Ireland it may be possible to fast-track the development of organisational structures by capitalising on the widespread availability of web-based technologies and utilising current logistical technologies, and available sophisticated timber harvesting equipment, to facilitate cohesive management of the fragmented small-scale timber resource.

The information given in this report is supplied with the understanding that no discrimination is intended and no endorsement by COFORD is implied.

Introduction

The primary objective of this study was to review small-scale harvesting technologies in use in other countries and their suitability for use in Ireland. Specific objectives included:

- The compilation of a database of small-scale harvesting systems currently in use in other countries;
- Discussion with a wide range of industry representatives;
- An assessment of the most promising systems suitable for use in small-scale forest harvesting in Ireland.

From an early stage it was apparent that non-technical factors had a greater bearing on the likely utilisation of small-scale harvesting systems than the technology itself. Such factors are cultural, social and traditional and require due consideration in the transfer of technology from one country or region to another. Countries with a strong forestry tradition and extensive private ownership of forest land tend to have a vibrant small-scale harvesting sector.

The main challenge for the private small-scale forestry sector lies in the development of organisation structures and the motivation of forest owners to become involved in the management of their forests.

The first stage of the project involved discussions with industry personnel, and a literature review. This helped to formulate an understanding of issues relating to small-scale harvesting systems and how they are, and can be, incorporated within the industry. Following this phase a workshop was held to discuss preliminary findings and to give further direction to the project team. This was attended by a wide range of interested parties from within the forestry sector.

The workshop presentation reviewed the requirement for small-scale timber harvesting in the context of the Irish forest industry. The first phase of the presentation outlined the way in which timber is currently harvested in the sector and how the industry has evolved in the context of the overall wood supply system. This system involves interdependence of contracting, harvesting, transport, purchasing and marketing disciplines, with harvesting being only one component of the system. The present wood supply system is tailored to suit the large forest owner; small forest owners will experience difficulties in accessing the system. The various stages involved in selling timber products was presented and this included an overview of the market place, the product, operational costs, decision support tools, preparation for sale, planning procedures and harvesting operations.

The next phase of the workshop presentation concentrated on harvesting systems and their components. Four broad categories were presented:

- tractor-based systems;
- cable systems;
- horse logging and
- small sized machinery and ancillary equipment.

The first stage of the project did not identify new small-scale harvesting systems which could to some extent be adapted to Irish conditions. All the systems presented at the workshop have been used in Irish conditions; the consensus was that there was little to be gained through further detailed assessment of these systems by the project team.

Not surprisingly, the debate raised a number of issues relating to the supply chain and where small-scale producers feature in the current system. It was apparent that evaluation was needed on all aspects of the system and not just the harvesting equipment and its application. The importance of the entire wood supply chain must be recognised, along with the time it takes for such systems to develop.

Direct farmer/owner involvement versus contracted harvesting was also discussed at the workshop. While it was recognised that owners need to be aware of the various possibilities available regarding small-scale systems the likelihood was that the actual operations would be carried out by skilled and trained personnel. Owners' involvement is the key to the realisation of the small-scale timber resource and they need to be targeted in the dissemination of information.

In order to consolidate the findings of this project the project team attended the International Forest Machinery Exhibition (the APF show) in Scotland from 25 to 28 September 2002 where many of the machines and systems described in the project were viewed. This also afforded an opportunity to discuss various systems and machinery with manufacturers and suppliers.

1. The requirement for small-scale harvesting in Ireland

The expected future increase in the number of private sector roundwood suppliers to the processing sector, combined with the composition and structure of privately owned woodlands poses a number of challenges to the development and adaptation of harvesting systems in Ireland. The current national harvesting fleet of highly productive harvesting machinery has evolved in accordance with industry requirements, with the capital outlay for many of these machines being subsidised by state and EU grants. The fleet is characterised by capital intensive, purpose built, sophisticated harvesting and forwarding equipment working shortwood (also known as cut-to-length) harvesting systems. The application of such systems with their requirement for a continuous supply of work may be limited in dealing with the needs of the smaller-scale private timber grower.

Forecasted round wood production estimates suggest that while only 29% of recent entrants to the Irish forest industry (through the Afforestation Grant Scheme) have plantations greater than 10 ha they account for as much as 69% of the area planted. Grant-aided plantation forests over 10 ha will in all likelihood, be viable stand-alone units and the harvesting infrastructure which is currently in place will cater for these plantations (with better land having been planted in recent years this threshold area may be less). Assuming targeted small-scale forestry plantations are most likely to be plantations less than 10 ha, there will be many individual growers (approx 6,000) falling into this category. Although the volumes of timber to be harvested from these small-scale plantations will have relatively little impact on national timber production over the next 10 years it is considered important to ensure such small-scale timber growers maximise their investment in forestry. Also since most of the roundwood harvested from private forests will be thinnings with small tree size, the economics of carrying out such operations are likely to be marginal.

With such a large number of new growers falling into the small-scale category, increased awareness of small-scale harvesting systems in use at home and abroad is desirable. There is also a need to develop and adapt systems suitable for use in small plantations. A threshold area of 10 ha was used as an approximate guide in this study. Systems and machinery identified may, however, be suitable on larger areas. Larger tracts, consisting of widely diverse tree species or uneven-aged forests may require less conventional and more flexible harvesting systems which may well fall into the small-scale harvesting category.

A database of harvesting systems/machinery characterised by their suitability for operation in small-scale forestry plantations has been compiled. Systems/machinery considered for inclusion in the database were categorised using the following criteria:

- Low capital cost (minimising capital investment);
- Low transportation cost and overhead;
- High manoeuvrability;
- Minimal access requirements;
- Flexibility to deal with different material sizes;
- Compatibility with agricultural equipment.

Initial research revealed the extent and range of equipment used in timber harvesting and extraction, along with the various configurations of equipment and methods. From this it is clear that the compilation of a comprehensive list of all equipment and methods available in North America, New Zealand, Australia, South Africa, Britain and Europe would be beyond the resources of this project. However, the generic components of the systems employed, and the types of machinery utilised in these areas are discussed. For each generic system a range of available machinery and key machine parameters are presented. These data have been compiled through discussions with forest industry personnel and by reference to relevant literature and manufacturers' specifications.

2. International trends in small-scale harvesting

There is a wide range of definitions for small-scale forestry and this can make it difficult to compare and contrast experiences in different countries and regions. In Finland for example, small-scale forestry has been described as 'forestry run by individuals, their ownership of forests not being integrated with the wood-based industry or any governmental ownership'. In Scotland it has been defined as 'the farm woodland part of the community forestry sector and that part of the estate forestry comprising smaller units'. In Belgium small-scale forestry has been described as 'non-industrial forestry as practised by forest owners whose income from forestry is a small proportion of their total income'. Australian literature describes small-scale forestry as 'forest ownership and management by individuals, at a farm or individual property level'.

In some of the literature, threshold maximum areas are applied to distinguish small-scale forestry from conventional or 'industrial' forestry. Some examples of the upper threshold limits for small-scale forestry quoted in the literature are Germany 200 ha, Scotland 50 ha, Belgium 10 ha and Denmark 10 ha. The average size of forest lots in countries such as Italy and Spain is only 3 ha.

In many countries small-scale harvesting usually implies the use of inexpensive machinery operated on a part-time basis. There is a wide variation in the technologies employed in small-scale harvesting between countries. The reasons include economic, cultural, and traditional factors as much as technical ones. In the assessment of harvesting systems an evaluation on all aspects of the system is required, not just the harvesting equipment and its application.

2.1 Europe

Private forests have an important role in forestry in most European countries. In many countries private forestry supports employment in, and viability of, rural areas. Small-scale forestry can offer a basis for co-operation between forest owners. In many countries co-operation through local forest management associations has proved to be successful in assisting small forest owners to capitalise on their assets. In the Scandinavian countries there is an identifiable advisory and technical support system, and a level of knowledge about small-scale forestry related matters, which does not exist in many other European countries

Generally in Europe chainsaws and tractors are used in self-employed timber harvesting. In the Nordic countries professional forest machine contractors use efficient and expensive harvesting equipment; this trend is spreading increasingly in Europe and around the world.

The number of sawmills and pulp and paper mills has decreased in Europe in recent years, although total wood production has increased. The need to maintain international competitiveness has necessitated this increase in the size of production units, yet private forestry remains a major contributor to the total annual timber supply generally. Organisational structures provided by timber owner organisations facilitate co-operation between the mills and the numerous growers. The main activities of owner organisations include: forest management, timber sales services, harvesting services, and general silvicultural advice. Since fewer and fewer forest owners have the skills needed to carry out forest work or the capital needed for expensive machinery, the necessity for owner organisations becomes more pronounced.

In Scandinavian countries a significant proportion of the industry's wood intake is sourced from farm forests. Wood is purchased directly by agents of the mills or more commonly through farm-forestry co-operatives. Various contractual agreements between the buyer and the owner have evolved which allow degrees of involvement in the harvesting operation by the owner. Provision is often made to allow the farmer to do some work in collaboration with the co-operative or contractor. Much of the timber sold from private farm forests is sold at roadside. Many owners have direct involvement in the management of the harvesting and extraction operations.

In Sweden, where owner involvement is high, wood is mostly stockpiled at roadside, thus ensuring a continuous supply of material to the processors. This may be one of the key requirements for a high level of farmer involvement in harvesting operations. Forestry is part of the culture in the Scandinavian

countries, with owner involvement in all aspects of silviculture, from planting to weeding, tending and pruning, as well as harvesting.

Small-scale forest owners on Sweden and Finland have a greater involvement in managing their forests than their counterparts in the rest of Europe. This is not surprising given the national importance of forestry in these countries. It does, however, demonstrate the ability of small-scale forestry to supply internationally competitive industries with large volumes of wood using highly developed harvesting transport and marketing systems. Farm workers develop and practise forestry skills as a normal part of the annual farming cycle. Specialised equipment, such as 4-wheel drive farm tractors and trailers fitted with grapple loaders are widely used by private owners. However, harvesting operations are becoming more capital and skills intensive, with a trend towards harvesting being carried out by farmer co-operatives or specialised contractors who have the equipment and skill to harvest the forests in a profitable manner.

The contribution of the private sector to the annual harvest in Sweden ranges from 50% to 70%. Although large-scale methods using purpose built harvesters and forwarders are becoming more prevalent in the private sector there is widespread use of systems involving grapple loaders with trailers and agricultural tractors with self-employed forest owners. Processors attached to a tractor's 3-point hitch have become popular among self-employed forest owners and small contractors. The latest step in the development is to use an agricultural tractor as a base machine for a small crane-mounted harvester head. Also used are skidding winches and wire cranes. Old forwarders are becoming more common with self-employed owners. Other equipment used includes mini-skidders, mini-forwarders, ATVs and pedestrianised skidders. Horses are still in use, either with traditional equipment or newly developed equipment like grapple loaders, powered by small petrol engines.

In Finland private forestry accounts for 60% of the country's forest area and 80% of the annual harvest. In general the level of mechanisation is increasing in Finland. However, for roadside sales, where harvesting is generally organised by the owner, motor manual felling is still used. Extraction is mainly by agricultural tractor, equipped with hydraulic cranes and bogie trailers. Horses and tracked ATVs are used to a small extent; their use is often limited to harvesting of firewood and harvesting in amenity parks and forests.

In Norway private forestry ownership accounts for 40% of the country's forest area and 85% of its productive area. There is widespread owner involvement in roadside sales, although there is a trend towards the use of sophisticated systems provided through contractors.

Small-scale forestry is well developed in Estonia where forestry accounts for almost 50% of the total land area. In the harvesting of small timber lots felling is generally carried out using chainsaws and extraction by means of agricultural tractor. Larger loggers use the more conventional harvesters and forwarders.

In the UK small-scale harvesting is less well developed than in the Nordic countries. The management of small tracts of woodland has been more related to their amenity value than the production of timber. There is very little involvement by private forest owners in the harvesting of their own timber; these operations are usually contracted out to specialists, most of whom will have access to state-of-the-art Scandinavian machinery. The decline in the number of small sawmills and a rapid process of concentration on sawmill capacity may have undermined the utilisation of timber from small forests.

Roughly 80% of Austria's forests are privately owned and a large proportion of owners manage small areas between 5 and 20 ha. Extraction is predominantly carried out using skidders. Cable yarding is commonly used on more difficult and sensitive sites. Others methods employed include small sized machinery and horse logging.

Forestry covers approximately one third of the area of the Czech Republic with one fifth of this land area in private hands. Horse logging is used extensively in extracting timber from small forests. Although small-scale forwarders and skidders and ATVs are available they are not widely used.

In Denmark forestry accounts for 11% of the total land area, with private forestry accounting for almost half. Areas less than 10 ha tend to be owner harvested with felling carried out using chainsaws and extraction by means of agricultural tractor. Most of the wood in this sector is used as firewood. In areas greater than 10 ha work is generally carried out by contractors using a variety of processors, which are either tractor- mounted or purpose-built.

Almost 30% of the total land area of Germany is forested, of which private forest ownership accounts for 46%. Much of the timber harvested from small forests is consumed by the owners, there is a large number of private individuals involved in harvesting. Chainsaws and tractors are the most commonly used harvesting and extraction technologies.

In the Flanders region of Belgium 75% of the forest estate is privately owned. However, forestry contractors are responsible for almost all timber harvesting, both private and public. Most contracting companies are small and utilise large robust all purpose machinery and the use of specialised harvesting machines is quite limited.

In France 70% of productive forestry is in private ownership with a large number of owners of small tracts of forestry. As a result the harvesting and sale of much of the private volume is handled by co-operative organisations, with harvesting being carried out by contractors. Income from forestry is, however, not a significant proportion of the annual earnings of private forest owners. Mechanised felling accounts for less than 20% of harvested timber, much felling is motor manual.

In Italy forestry accounts for just over 20% of the total land area and is situated mainly in mountainous areas. The average size of privately owned forest plots is very small and essentially private forestry does not contribute to the industrial timber industry. Motor manual felling is common, with extraction based on adapted agricultural tractors and trailers. Cabling and animal extraction systems are also commonly used.

Although as much as 50% of the land surface of Spain is considered to be forest, large areas are not capable of producing commercial roundwood. Due to climatic and soil conditions much of the country's productive forestry is concentrated in the north. There are many private forest owners in Spain but few of them derive an income from wood sales. Timber harvesting is generally undertaken by contractors; owner involvement is rare. Felling is mainly by chainsaw, adapted agricultural tractors are used as prime movers in the forwarding and skidding of material.

2.2 North America

The number of small tracts of forest land owned by non-industrial private forest owners in North America has increased in recent years and this, combined with increasing restrictions on the availability of timber from federal forests, has focused attention on small-scale forestry. Current market structures, however, do not favour widespread adoption of these systems. Extensive use is unlikely until market conditions have evolved to recognise new constraints in timber supply.

Efficiency of small-scale equipment is more dependent on operator training and skill than is the case with large harvesting equipment. Although there is widespread recognition of the potential role of small-scale equipment in the total timber supply picture, the low productivity of small-scale systems and reliability factors, pose the greatest challenge to their future use. Production rates can only support part-time loggers with other sources of income. Although many American farmers own timberland, have farm tractors suitable for logging, and have a slack season during the winter, part-time farm tractor logging in North America is uncommon.

Small-scale harvesting operations are more prevalent in the eastern and southern US and the most common systems tend to be tractor skidding (winches or grapples) with chainsaw felling. Horse skidding is making a come back in some areas and the use of ATVs is becoming more conspicuous particularly in situations where timber production is not the primary objective. More wood is being cut by harvesters and processors, (in the American context this is often considered as small-scale), however much of this equipment must be imported which has the consequence of increased costs particularly in maintenance and spare parts.

2.3 Australia

Small-scale private or non-industrial forestry has the potential to make an important contribution to the national wood supply in Australia and represents a major opportunity for growth in Australia's long-term wood supply. Owners of this private forestry appear to have little involvement in production and the desire by small-scale forest managers to conduct their own harvesting operations has been the exception rather than the rule with most small-scale harvesting being carried out by contractors from the industrial sector.

Studies carried out in Australia on small-scale harvesting describe the sector as pioneering, with impoverished equipment, limited skills and short-term marketing arrangements. One study revealed 'an

infant industry with harvesting costs, operational impacts and occupational health and safety falling short of the standards being achieved in industrial-scale operations'. Case studies identified a need for basic forest management/business knowledge on the part of the forest owner whether operations were contracted or not.

To date forestry in Australia has focused on industrial-scale operations and in contrast small-scale forestry is at an early stage of development. It has been recognised that if small-scale forestry is to contribute to the national wood supply in an efficient manner the development of economically efficient wood supply systems for small-scale forests will be required. Forest industry log input demands are more or less continuous throughout the year and these need to be supported by wood supply systems which provide a continuity of supply. Without a collective or co-operative structure private small-scale forestry cannot provide this level of service.

Equipment used in the harvesting of small-scale forestry in Australia would typically include a chainsaw for felling and delimbing with adapted agricultural tractors used in timber extraction.

2.4 New Zealand

Experiences in NZ would suggest that while small woodland owners may attempt all or part of their harvesting with their own equipment very few are competent in harvesting and for the majority of forest owners the most satisfactory option is to employ a forestry contractor. An increased supply of wood from small private owners has been recognised and skills and equipment needs have been met in part through targeted training and small-scale research and development programmes.

In recognition of the contribution of forestry to the rural economy and the potential for timber supply from private sector small-scale forestry, the Ministry for Forestry and the New Zealand Logging Industry Research Organisation have developed literature intended to guide owners in the management of their small forests. Promotion and education are considered vital in order to encourage involvement by small-scale forest owners in the management of their timber crops. In recent years there has been widespread involvement by farmers in the establishment of new forests however in the absence of a forestry culture it has been recognised that subsequent management is unlikely without educational and promotional intervention at a national level.

Tree felling in New Zealand, particularly in the small-scale forestry situation is generally carried out using chainsaws and roundwood is extracted using adapted agricultural tractors and winches although purposed built processors and forwarders are becoming more prevalent.

2.5 South Africa

The bulk of forest land in South Africa consists of exotic plantation forests owned by large forestry companies the largest of which are Sappi and Mondi. Individual timber growers privately own approximately 10% of forestry. The democratic transition in South Africa in the early nineties changed management and ownership structures; 26% of the country's forests are now owned by the state and managed by the South African Forests Company Limited (SAFCOL).

There are a large number of individual small-scale forest owners actively involved in the management of small woodlots. Most grow exclusively for large companies such as Sappi and Mondi. These companies operate outgrower schemes providing marketing and production services to farmers under purchasing agreement contracts. Growers are provided with physical inputs, loans and extension services for the planting and management of small, mainly eucalyptus woodlots and in return sell the final crop trees, grown on a 6 to 7 year rotation to the companies. The average size of woodlots in these outgrower schemes is 2 ha, growing broadleaf species for pulp production. Harvesting is often carried out using hand tools; chainsaws are also widely used.

Cut to length systems are generally employed in harvesting conifers in the larger blocks of mainly company and state owned forestry. Cable yarding and skidding (both cable and grapple) are commonly used, as is animal extraction.

3. The harvesting decision

Timber harvesting is an integral part of the forest management cycle. Forest managers take the decision to harvest timber in accordance with management objectives and good forest practice. Due to the age structure of private forestry plantations in Ireland many owners and managers of such crops are coming to a stage where decisions must be made in relation to management and timber harvesting. The means by which timber is physically harvested and extracted requires detailed consideration. However, before proceeding with harvesting operations there are a number of factors which must be considered, including: the requirement for an understanding of the market place, silvicultural management and associated costs, timber sale procedures and harvest planning.

In the following sections the various factors referred to above are developed in the context of the small-scale forest owner with particular emphasis on first thinning.

The inclusion of this chapter is important in addressing the problems of the small timber grower since, as stated earlier, non-technical factors are likely to have a greater bearing on the utilisation of small-scale harvesting systems than the technology itself.

3.1 The market place and the product

In order that growers bring their timber to the point of sale they must have a reasonable understanding of the market place, the products required and the relative position of small-scale concerns in the context of the industry generally.

In Ireland the forest industry has grown and developed with one supplier, namely Coillte, dominating the industry and providing the vast majority of roundwood to the processing sector. The processing sector (sawmills and board mills) has been innovative in developing markets at home and abroad for timber products and there has been considerable change and rationalisation of the industry over the years. Currently 14 sawmills, with a wide geographical spread, process approximately 90% of all timber supplied in the country while two boardmills buy pulp material in the round (material in the form of dust and chips is purchased direct from sawmills). Excluding small local markets there are potentially 16 outlets nation-wide for roundwood from private forests. When geographical distribution of these processors is taken into consideration the number of potential outlets for individual timber sales is further reduced.

Sophisticated sales and marketing systems have been developed between Coillte and the sawmilling sector in order to ensure continuity, fairness, security and transparency in all aspects of sale and supply of their timber resource. Such systems rely on standardisation in relation to the advertisement of the timber, presentation for sale, log specification, the bidding system, timber harvesting and haulage, timber measurement and the invoicing of sales. This level of sophistication and standardisation has not yet been achieved by the private sector as a whole (that is not to say that individual growers have not been successful in marketing, presenting and selling timber).

Various examples of forest owners' organisations exist throughout the world. These structures have generally developed as the timber industries have developed and function best in countries with a strong forestry culture.

Timber harvesting can be an exacting operation. In order, therefore, to maximise the revenue potential from a timber sale, growers must be aware of the various product dimensions or assortments that the processing sector requires. Log lengths required by mills are 2.5, 3.1 and 3.7 m for boxwood and 3.1, 3.7, 4.3, 4.9 and 6.1 m for sawlog. Typically boxwood logs have a minimum small end diameter of 14 cm while sawlogs have a minimum small end diameter of 20 cm. Many mills require flexibility in relation to log specifications and as a result approximately half of all Coillte timber sales are harvested directly by mills allowing them the facility to cut to their own requirement. Smaller dimension timber may be suitable for stake material if straight, while smaller dimension crooked material will be sold as pulp.

While there is a demand for timber, private growers, and particularly those with small volumes, may experience difficulty in selling their product. Thinnings may present particular difficulties, and as a result other potential markets are currently being

investigated. Chipping systems and processes associated with bioenergy are markets,which are considered by many to have particular promise. The development of local markets and on-farm use of timber products also warrants consideration.

The geographical location of a stand may have implications on marketability, since haulage is one of the main contributors to mill gate cost.

3.2 Silvicultural management and the cost of thinning

Costs associated with thinning may in certain situations exceed the revenues generated from the sale of the timber. The likelihood of this occurring increases as the volume and dimension of the harvested timber decreases. As a result forest owners may defer thinning on this basis alone. If plantations are left unthinned their future timber potential and value will be reduced significantly. Where thinnings are being deferred as a consequence of an expected negative income, this should be balanced by consideration of future revenue loss as a result of not thinning.

3.2.1 Long-term financial implications

It is possible to estimate this potential loss using a combination of forest growth models and valuation methodologies. There are a number of well established techniques available for the evaluation of forestry; the most widely used is Discounted Cash Flow (DCF). This uses discount rates to equalise or compare future costs and revenues in terms of today's costs and prices.

The choice of discount rate has a strong influence on the outcome of the analysis. Typical interest rates used in the private sector in Ireland for forest crops range from 3% to 7%. The valuation of a stand of timber produces a Net Present Value (NPV). NPV values for stands with different management regimes using a range of discount factors can be compared.

Where the financial viability of the thinning operation is the overriding factor in taking the decision to thin, consideration must be given to the long-term financial implications of the decision. Since it is relatively easy to assess the yield class (YC) of a site and the Net Present Values for a range of yield classes and discount rates, such estimates could be determined and used in the decision-making process. The use of conservative figures in the model will help to ensure prudent decisions. Alternatively a reduction factor may be applied to the NPV figures to reflect the owner's view of future developments.

For example, in order to illustrate the financial significance of thinning conifer crops a comparative NPV analysis (assuming a 6% return) for a number of thin and no thin scenarios for Sitka spruce plantations are presented in the table below, over a range of productivity classes.

	YC14	YC16	YC18	YC20	YC22
Thinned crop NPV/ha	€3723	€5494	€6318	€7384	€8954
Non-thinned crop NPV/ha	€3613	€4934	€6069	€6720	€7162

All scenarios presented assume crops have reached the age of normal first thinning. For example for productivity class YC16 at 22 years the difference between the thin and a no thin scenario is €560. Thus up to €560 can be spent per hectare (about €10/m^3) on first thinning without diminishing the overall return on the investment.

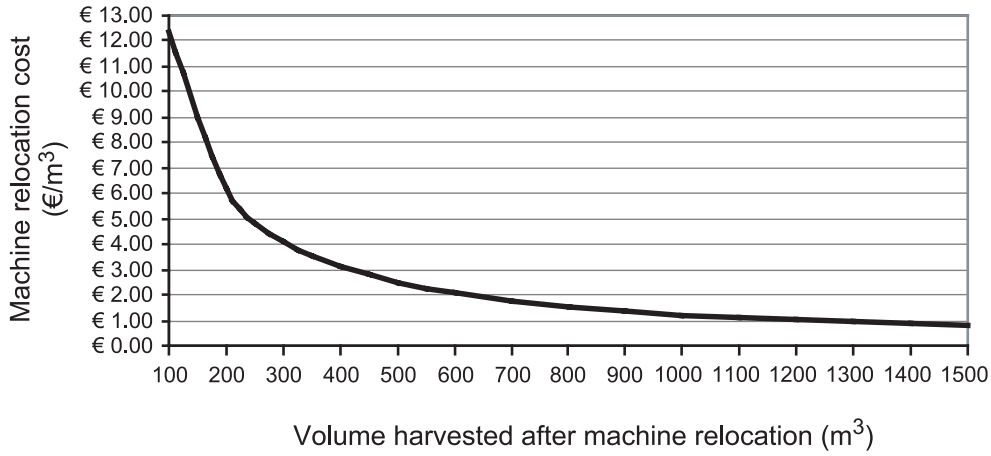
As the productivity of the crop increases so too does the difference between thin and no thin returns. For example for YC22 at 19 years the difference between the thin and a no thin scenario is €1,792, and up to this amount can be spent per hectare (about €27/m^3) on first thinning without diminishing the overall investment.

Further information on this topic is available in COFORD Connects information notes *Realising the potential of private plantations* and *Thinning to improve stand quality* (Phillips 2004).

3.2.2 The effect of scale on harvesting cost

Relocation costs can make a very large contribution to the unit cost of harvesting (€/m^3) timber particularly when small volumes of timber are being harvested. The following table illustrates how machine relocation overheads contribute to harvesting unit costs of harvesting contractors depending on the volume of timber harvested after relocation (Source: COFORD OptiLog Project 2002).

This example demonstrates the importance of developing systems of workload allocation between forest owners that foster geographically focused operations to facilitate optimum machine utilisation where possible.



Assuming harvesting operations are carried out using harvesting contractors the following flow chart may be of assistance to private growers in assessing their options.

Where owners are in a position to carry out some of the harvesting operations themselves this may reduce harvesting costs which may influence the decision.

3.3 Preparation of timber for sale

There are a number of steps involved in the preparation of a sale of timber. The first entails an initial inspection of the crop. In previously thinned or mature crops accessibility for inspection purposes is straightforward while unthinned crops will require the cutting of brash paths. Following inspection estimates of crop productivity and harvest volume

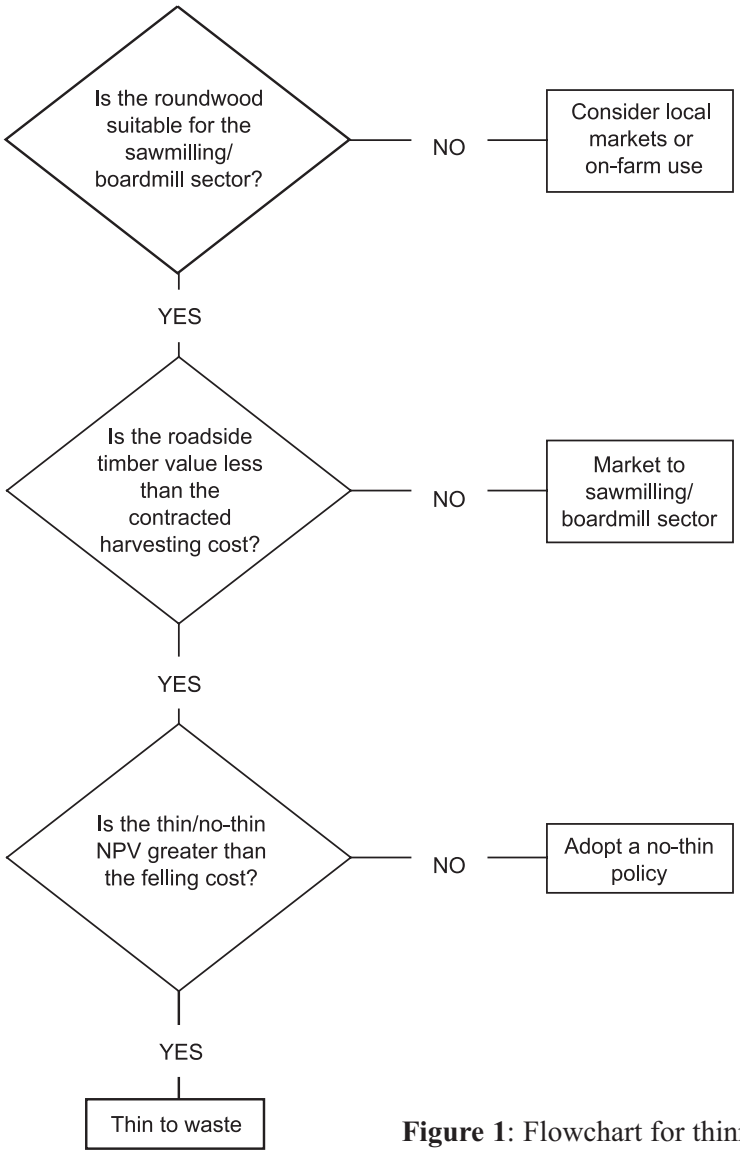


Figure 1: Flowchart for thinning decision.

and value are made to assist the owner in taking the decision to harvest or not.

Assuming the decision is to harvest it may be necessary to estimate the standing timber volume and assortments, particularly if the timber is to be sold standing. Such detail will be of benefit when applying to the Forest Service for a Felling Licence, which must be secured prior to felling. These data may also be used in the preparation of a sale advertisement.

The measurement method employed, for payment purposes, may have implications regarding such factors as the sale price achieved for the timber, the control of the movement of the extracted timber, timber security etc. Timber measurement methods vary greatly from country to country however they may be grouped into three main categories namely: standing measurement, roadside measurement and measurement at the final destination (sawmill). A fourth category used predominantly in Finland is harvester head measurement which utilises the computerised capabilities of sophisticated processors to measure the timber as it is being cut. Given the nature of the Irish harvesting fleet this method may have possibilities here, however the main method employed in Ireland currently employs final destination or mill gate measurement. For more detail on timber measurement refer to the COFORD Timber Measurement Manual.

Average standing timber prices for different tree sizes in Ireland are published on a regular basis by the Irish Timber Growers' Association (ITGA). These may be used as a guide to the value of standing timber. It should be noted that these are average costs, difficult harvesting/extraction conditions and long haulage distances may reduce these considerably. Also small lots of timber may attract no buyers if advertised as standing sales, while roadside sales (i.e. harvested and extracted to roadside) may be more attractive.

3.4 The harvest planning procedure

Following the decision to harvest there may be a requirement to develop a harvest plan for the site. In the case of small areas up to 10 ha, however, the harvest plan may be no more than an estimate of the volume to be harvested and the extraction method envisaged. Reference should be made to the Forest Service Forest Harvesting and Environment Guidelines in this regard. The harvest plan will address silvicultural, environmental and operational issues. This is the stage when the decision regarding the harvesting system and the machinery to be employed will be made.

When considering the harvesting system an initial site classification using a Terrain Classification system (refer to Forest Service Code of Best Practice – Ireland page 125) may prove useful in selecting suitable machinery. The application of a terrain classification system to a particular site may throw up a number of options relating to the choice of machinery suitable to the site. Costs associated with the use of such machinery should be determined for the particular site and the most cost-effective system selected.

Many variables contribute to harvesting and extraction costs, and these will often be different depending on factors such as the size of the plantation, the type of machinery used and the competence of the machine operator.

The Irish Forestry Contractors' Association (IFCA) provides a computerised rate mechanism, which facilitates their members in estimating rates per cubic metre for particular jobs. The mechanism takes into consideration such items as capital cost of machinery, business overheads, insurance, wages, profit margin sought, repair and maintenance and fuel costs. It also takes into consideration crop factors such as the estimated tree size and timber volume to be harvested, harvest type, ground condition, terrain classification, average extraction distance, number of products to be cut, species, environmental constraints, and site configuration.

Clearly criteria used by contractors to determine harvesting and extraction rates will be different than those used by forest owners who wish to become involved in the harvesting and extraction of their own timber. Forest owners working on their own land may not incur many of the costs incurred by contractors (e.g. relocation costs). Forestry work could be carried out by farmer/foresters during slack periods and could also extend the usage of existing farm equipment. Such savings may, however, be offset by reduced productivity and consideration should also be given to training and safety issues.

3.5 Harvesting operations

The principal forms of harvesting undertaken in the course of a rotation are thinning and clearfelling. Thinning involves the removal of a proportion of the crop and is undertaken periodically throughout the rotation. The objective is to improve growing

conditions for the remaining trees and to provide intermediate yields of timber. Clearfelling is usually carried out at the end of the rotation when all trees are harvested.

Thinning type refers to the way in which trees to be thinned are selected. Systematic thinning involves removal of lines of trees, normally from original planting rows, while selective thinning usually involves removal of suppressed, poorly formed, sub-dominant or competing trees to create an even distribution and size of final crop trees.

The most suitable harvesting methods and machinery are selected at the harvest planning stage. The choice of machinery and methods to be used will depend on factors such as harvest type, environmental constraints, terrain classification, machine availability and harvesting cost. On flat level sites there may be many options available while on more difficult sites the options become limited.

For example first thinning on flat even sites with good ground conditions (Forest Service Terrain Classification 1.1.1) will normally involve rack and selection thinning (systematic removal of trees along racks with selective thinning of trees between racks). In these conditions a wide variety of machinery can be used for the felling, processing and extraction of timber to roadside. First thinning on steeper, rougher sites with poor ground conditions (Forest Service Terrain Classification 3.3.3) may require an alternative approach such as systematic rack and chevron felling, in order to facilitate extraction. The choice of machinery in such cases will often be limited to chainsaw felling with cable extraction.

3.6 Site access

Site access is a major factor when considering timber harvesting. Financial viability of harvesting operations is often dependent on good site access. Forests are often planted in remote areas with poor public road access. Generally roundwood must be forwarded from the forest to a landing point for collection by lorry. Regardless of the quality of the produce, it is worthless if it cannot be extracted to a point where a lorry can collect and transport it for processing. Clearly extraction distance has an influence on harvesting cost, this should be minimised whenever possible. Forest road layout and general access to the site should be considered as part of the overall harvest plan.

Owners should be aware of the Forest Road Grant scheme which may contribute to the improvement of access to the plantation.

3.7 Training and skills

Forest owners wishing to become involved in harvesting their own timber must acquire a basic level of competence and skill. Almost all of the systems examined and presented in this report presuppose the use of chainsaws to fell trees prior to processing and extraction.

Chainsaws are widely used in most countries and although there has been a dramatic increase in the volume of timber harvested using sophisticated felling machinery, the nature of small-scale harvesting is such that the chainsaw is likely to continue to have widespread usage. In spite of major efforts and progress by regulators and manufacturers to improve chainsaws, they remain the single most dangerous piece of machinery in forestry. Most serious accidents and many health problems are associated with their use. Motor manual felling operators must be well trained and equipped and have a clear understanding of how trees are felled, trimmed and cross cut.

Despite their inherent dangers, chainsaws are one of the few pieces of forestry equipment for which international regulations on safety features exist. Forestry machines on the other hand are less well covered by international standards and there is often no specific national regulation regarding required safety features. Forestry machines may also have significant ergonomic deficiencies particularly where they have been adapted for use in forestry.

As with tree felling, operators involved in timber extraction must be trained and skilled in the particular extraction method being practised. More traditional extraction methods such as tractor skidding require a good safe working knowledge of the tractor. Often tractors will require modification for use in the wood. More sophisticated purpose-built forwarding equipment, although safer and ergonomically designed, requires training to operate efficiently and is generally used by full-time contractors.

Mechanised harvesting is safer and more ergonomically attractive than chainsaw felling, however a high degree of training and skill is required to operate harvesting machines and their use is generally restricted to full-time contractors.

Safety is a prime consideration when operating in woodlands and suitable training is a necessity. Studies in this area suggest the incidence of accidents and indeed fatal accidents is much more frequent where harvesting operations are carried out on a casual basis by forest owners. One such study compared the incidence of accidents in four European countries (Austria, Germany, Slovenia and Sweden) which have a tradition of forestry. The study found that while the incidence of accidents involving casual operators was considerably more frequent than for professional forest workers, there was a higher incident in countries where training and education was not available to the forest owning public.

4. Categorisation and demonstration of small-scale harvesting systems

Four broad systems have been identified as having potential for use in small-scale forestry in Ireland and these have been used as a basis for categorising systems reviewed in the course of this work:

- Tractor-based systems
- Cable systems
- Horse logging
- Small sized machinery and ancillary harvesting equipment

Within the broad categories each entry in the database is further described under predefined headings. Under certain headings where data were not available or could not be attained directly from the source, best estimates and the source of these estimates are entered in the database. For certain database entries additional information has been provided (e.g. safety features, interdependence on other machinery etc.) where this was considered necessary, to describe the machine/system in a more complete context.

A detailed selection of machinery for each of the above categories is presented in the Appendix. For each category, a number of specific machines are named with a brief description of key machine parameters along with supplier and manufacturer information. Guide prices which were available from the Association of Professional Foresters (APF) 2002, International Forest Machinery Exhibition which was held in Lockerbie, Scotland in September 2002, have been included in the database.

Equipment presented in the Appendix was selected with no intention to promote or exclude any particular equipment or supplier and the listing is not intended to be an exhaustive description of available machines. These tables of data are intended as an initial reference guide in assisting potential users or purchasers of forest harvesting equipment. A more comprehensive reference may be found on the web site generated by the SMALLFORE project team at www.tts.fi/smallfore/smallbase/.

5. Agricultural tractor-based systems

Due to their widespread use, farm tractors are often used as base machines in many forestry activities. Tractors have, however, been designed for use primarily in an agricultural rather than a forest environment. Where farm tractors are to be used regularly in forestry certain modifications will be required. These should address environmental, trafficability and ergonomics issues. Clearly tractors involved in full-time forestry will require substantial modification while those used occasionally may make do with minor modifications.

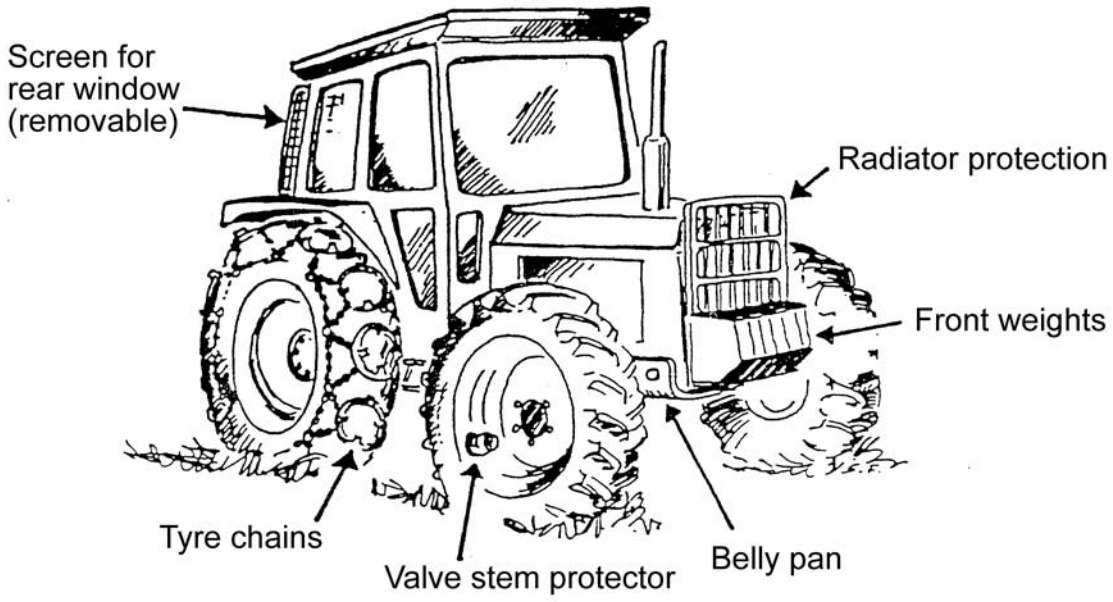
In Canada the most popular forestry implement is the tractor powered skidding winch. In Nordic countries farm tractors are still used extensively in forestry, particularly in farm woodlots. Nordic manufacturers have developed many forestry implements for farm tractors such as skidding winches, wire cranes, grapple loaders, processors and harvesters. These attachments for general-purpose farm tractors can make mechanisation more affordable to the small-scale operator.

5.1 Tractor features important for use in forestry

Forestry work can be very demanding on tractors. Basic modifications such as window and radiator protection screens/grills, belly pans, deflector bars and cab protection bars, valve stem protectors and front weights will be required. When PTO-driven attachments are used due care must be observed in covering the PTO. For some equipment the 3-point hitch is sufficient, while heavier equipment such as loaders require a firm attachment to the tractor.

One of the major problems in using the farm tractor in forestry is the orientation of the operator's cab. Almost all tractor cabs are designed exclusively for a forward facing operating position. Many forestry implements such as grapple–loader trailers, skidding and forwarding grapples, winch processors and processors require the operator to face the rear of the tractor. In most tractors operators have to twist their bodies or kneel on the seat in order to reach the levers. If a tractor has a less ergonomically suitable cab it is important that the operator tries to diversify the workload to minimise the time spent in awkward working positions. Reversible seats and controls and increased space at the rear of the cab can overcome this difficulty; some tractor manufacturers provide these features as standard.

Weight distribution ratio between front and rear axels and tractive power vary significantly between 2-wheel and 4-wheel drive tractors. Ideally a 50:50 front end to rear end weight ratio is desirable for forestry machinery. Weight distribution of 2-wheel drive tractors (with a front to rear ratio of 30:70) can be improved by adding weight to the front of the tractor. Weight distribution of 4-wheel drive tractors



(with a front to rear ratio of 45:55) improves stability and pulling power.

The ground clearance of most farm tractors is 35-45 cm while at least 50 cm is needed in forestry situations (mainly to prevent tractors getting hung-up on tree stumps). The drawbar is generally the lowest point on a tractor and sometimes it is possible to modify the drawbar bracket to increase the ground clearance marginally. Larger tyres help to increase ground clearance (they do however increase the height of centre of gravity and thus reduce the stability of the tractor). Farm tractors with four wheels of equal size tend to be very suitable for a wide range of sites.

The hydraulic pump capacity of modern tractors with power ratings greater than 37 kW (50 hp) ranges from 40 to 100 l/min. A tractor to be used in forest operations should have a hydraulic pump capacity of at least 50 l/min (grapple loaders). A separate PTO-driven pump and hydraulic system can be installed to increase hydraulic oil flow.

Tractors which are to be coupled with implements such as winch processors that perform multiple handling and processing functions require a rated PTO power of at least 60 kW (80 hp). Single grip harvesters have very large tractor power (75 kW; 100 hp) and weight (for stability). Power requirements for commercial chippers are even greater.

Three-point hitch systems allow attachments such as winches, skidders, grapples or processors. Stability deficiencies associated with 3-point linkage has been overcome using a 4-point hitch which are most suited to grapple-loaders, winch processors and double-drum winches.

5.2 Forestry implements for farm tractors

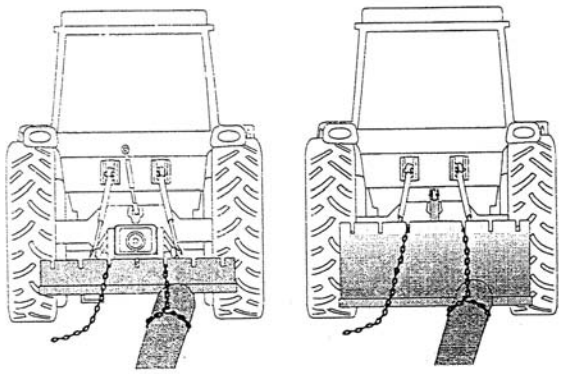
It is important that forestry implements are matched to tractors of appropriate size and power rating. For example it is not practical to mount a high capacity implement such as a processor on a small 30 kW (40 hp) 2-wheel drive tractor since the tractor would be unstable and the engine or the hydraulic system would be unable to power the machine. The suitability of forestry implements for their intended use must be clearly thought through; the requirements of the part-time operator versus the dedicated contractor will be quite different.

The cost of adapting an existing agricultural tractor for forestry use can vary depending on the intended use of the adapted implements. Adaptations should not preclude farm use unless it becomes dedicated to forestry. Purpose built farm-forestry tractors, particularly those manufactured in the Nordic countries are designed for dual roles and this may be a consideration for farm-foresters in Ireland when deciding to purchase a tractor. With the attachment of suitable implements, tractors are capable of carrying out a wide range of forestry operations from skidding and forwarding to loading and processing.

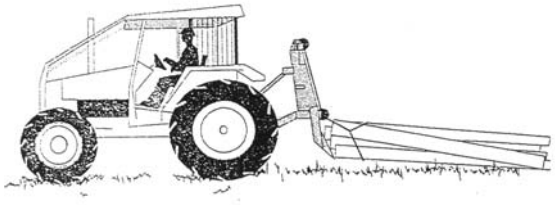
5.2.1 Equipment for terrain transport and loading

Extraction is the process of transporting whole tree stems or logs from the felling site in the forest to a landing or roadside for subsequent transport to the processing mill. Timber may be skidded, which involves transporting trees or logs with one end dragging along the ground, or forwarded which involves transporting logs clear of the ground. Various tractor implements used in timber extraction are described in the following sections.

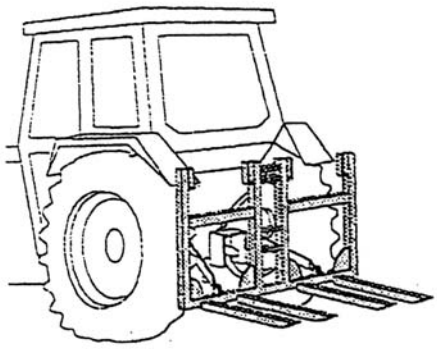
Implement	**SKIDDING BAR AND PLATE**
Description	The notched skidding bar is a device which is attached to the tractor's 3-point linkage and used for skidding logs which are choked and attached on the bar. This is a very simple piece of equipment and with the exception of increased front-end weights, requires very little modification to the agricultural tractor. Heavier steel plates or butt plates are larger and allow a higher pulling point, which is more effective at raising logs off the ground. Most wire cranes and skid winches are equipped with skidding bars.
Power Requirement	Suited to a range of tractors (22 to 37 kW; 30 to 50 hp).
Advantages	Low cost. Suited to a wide range of tractors.
Disadvantages	Productivity is low. Limited application in thinning. Weight distribution of many farm tractors may present safety risks. Not suited to more difficult or wet sites.



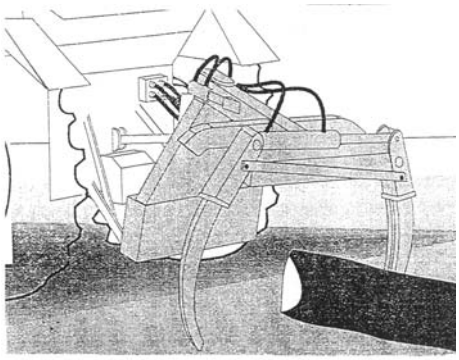
Implement	**SKIDDING WINCH**
Description	Skidding winches use a cable and choker to pull one or more trees to a tractor. The skidding winch is normally attached to the 3-point hitch and receives its power from the tractor PTO.
Power Requirement	Winches are made to suit a very wide range of tractors (22 to 75 kW; 30 to 100 hp).
Advantages	Low to medium cost. Suited to a wide range of tractors and sites. When using winches in difficult terrain the load can be dropped and tractor can move to more favourable terrain and winch the log from a distance.
Disadvantages	Limited application in thinnings. Skidding often produces dirty logs, which can cause difficulties at the processing stage. Can contribute to both soil and residual tree damage.



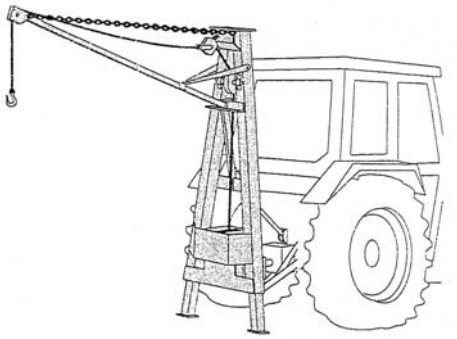
Implement	**BACK FORK**
Description	These are low cost extraction implements mounted on the 3-point hitch to allow logs to be forwarded from the site. Suits shortwood forwarding.
Power Requirement	Tractors need good front to rear weight ratio and therefore best suited to 4-wheel drive tractors with compensatory front weight attachments.
Advantages	Can be used for both forestry and agriculture. Wood held off the ground and therefore stays clean. Low cost.
Disadvantages	Requires manual loading. Needs fairly even site to ensure load stability.



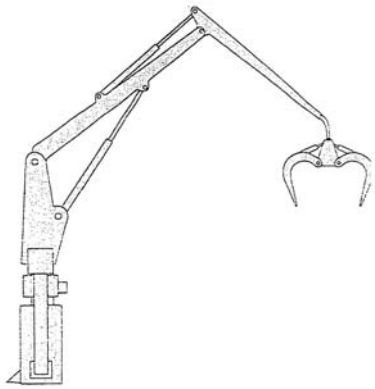
Implement	**SKIDDING AND FORWARDING GRAPPLE**
Description	Large hydraulic grapples mounted on the 3-point hitch can be used equally well for transporting cut-to-length logs or full pole length timber. The operator reverses up to the logs or timber stack and 'grapples' the load, which can then be hydraulically lifted for transportation.
Power Requirement	Tractors need good front to rear weight ratio and therefore best suited to 4-wheel drive tractors with compensatory front weight attachments. The actual size of the tractor depends on the size of the implement and the weight of the wood to be carried/skidded but minimum size requirement would be approximately 41 kW (55 hp).
Advantages	Relatively inexpensive. Shortwood can be extracted clean. Operator does not need to leave the cab.
Disadvantages	Requires good presentation of material and does not have the flexibility and versatility of skidders. Needs good sites, detailed planning and site layout is required especially in thinnings.



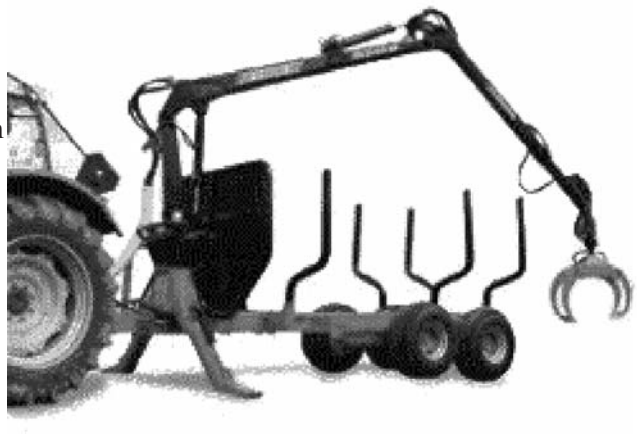
Implement	**WIRE-CRANE LOADER**
Description	The wire crane comprises a PTO powered winch with a high A-frame and stabiliser legs. Wire cranes are commonly used with a forestry trailer for winching, loading and forwarding wood. The operator walks up to each bundle, puts a wire around it and follows the bundle as it is winched back to the tractor.
Power Requirement	Suited to nearly all tractor sizes.
Advantages	Suitable for thinnings with widely spaced racks. Shortwood can be extracted clean. Wire-crane loaders are the least expensive mechanical loading system available.
Disadvantages	Operator safety is a consideration. Substantial wood handling and walking is required. Productivity tends to be lower than for grapple loaders. Requires well trained operators.



Implement	**GRAPPLE LOADER**
Description	These are hydraulic cranes with a grapple, which can be used to pick up single trees, or bunches of logs for loading or unloading a trailer. They can be mounted on the tractor itself, its 3-point hitch or on the trailer.
Power Requirement	The hydraulic pump capacity requirement of 25 to 50 l/min can be easily supplied by most tractors.
Advantages	Allows fast efficient loading and unloading of logs and eliminates manual handling. When used with trailers larger payloads can be moved than by skidding systems. Suits shortwood extraction. Can be used for both forestry and agricultural operations. If mounted on the trailer, tractor stability is not affected.
Disadvantages	High cost.
Comments	The position of loaders on tractors should be considered. A longer loader reach is required if the loader is mounted on the tractor but a shorter trailer drawbar may be used giving a tighter turning ability. Loaders mounted on the trailer drawbar may need stabilising legs, which are susceptible to damage when moving off. Loaders on the tractor (3-point linkage) have flexibility for use in non-forestry operations.



Implement	**FORESTRY TRAILER**
Description	There is a wide range of timber trailers available for agricultural tractors from non-driven units to more sophisticated power driven trailers. Most popular tractor drawn models may have a pay loads ranging from 3 to 8 m3 with 5 tonne models being most common. 3-5 tonne trailers are suitable for lower powered tractors (< 37 kW; < 50 hp) and part-time usage. Forestry trailers are of skeletal construction in order to maximise payload capacity. The smallest capacity trailers may have only 2 wheels but usually most forest models have a 4-wheel 'bogie' construction.
Power Requirement	Most tractors can be used with forestry trailers.
Advantages	High load capacity to remove large volumes at once. Shortwood can be extracted clean. Can be used in agricultural applications.
Disadvantages	Detailed planning and site layout is required especially in thinnings. Can be expensive particularly for more sophisticated ones.
Comments	Driven trailers increase trafficability greatly. One common design entails hydraulically driven rollers, which can be put in contact with tyres on demand. The investment level for a tractor and trailer is substantially lower than for a conventional forwarder. However, although the tractor is often narrower than the forwarder the tractor/trailer does not have the flexibility of the forwarder and is less suited to narrow thinning racks.

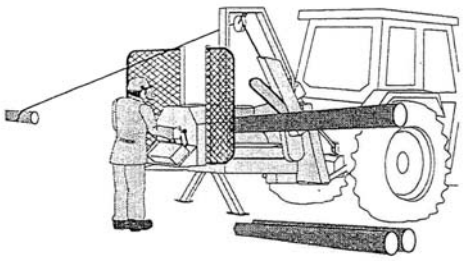


5.2.2 Harvesting and processing equipment

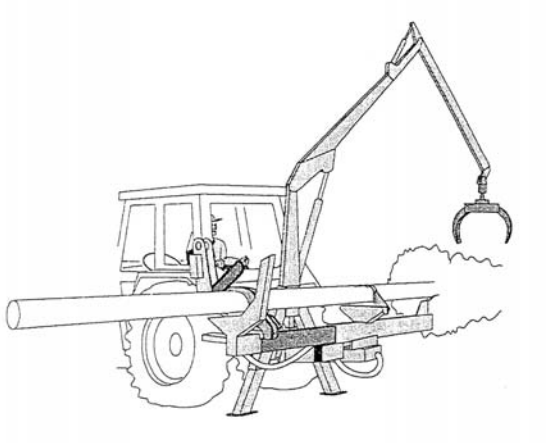
Generally speaking the difference between a harvester and a processor in forestry terms is that a harvester fells, delimbs and cross cuts trees into products while a processor takes previously felled trees and delimbs and cross cuts them. There are two categories of processor: grapple and wire. The first uses a grapple loader to bring the tree to the processor, while the wire processor uses a winch.

A double grip harvester is a grapple processor with a harvesting head on the end of the loader boom. A tree is felled using the felling head, and brought in and placed in the processor where it is processed. A single grip harvester has a felling head loaded at the end of the loader boom. The harvesting head not only fells the tree but also delimbs and cross cuts the tree. Single grip harvesters are most commonly used in Ireland.

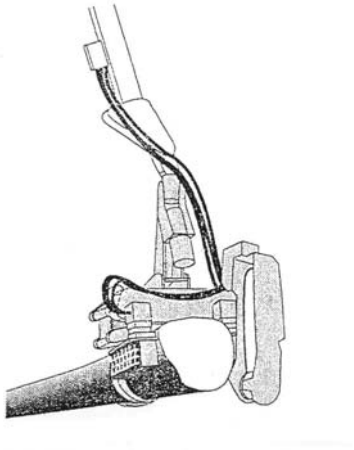
Implement	**WINCH PROCESSOR**
Description	Winch processors combine a winch and a processor to winch in, delimb and cross cut trees which have already been cut by a chainsaw operator. Most winch processors are designed to have an operator standing beside the machine.
Power Requirement	The minimum tractor horsepower requirement is a 37 kW (50 hp) tractor with a hydraulic oil flow capacity of at least 50 l/min. Larger processors require in excess of 60 kW (80 hp) tractors and 80 l/min hydraulic oil flow capacity.
Advantages	Reduces the workload on chainsaw fellers dramatically. Brash mats on extraction racks minimise soil compaction and rutting. Moving costs between sites can be lower than for forwarder which often needs to be moved by lowloader.
Disadvantages	Expensive, particularly for part-time operation. Requires skilled operators. Unsuited to heavily branched trees.



Implement	**GRAPPLE LOADER PROCESSOR**
Description	Uses grapple loader mounted on the 3-point hitch to present trees to the processor. Stroke type processors use a stroking motion to delimb trees while roller feed processors propel the tree through delimbing knives by means of feed rollers.
Power Requirement	A 4-wheel drive 60 kW (80 hp) tractor is required, due mainly to the weight of the implement.
Advantages	Reduces the workload on chainsaw fellers dramatically. Safe operation from within the cab.
Disadvantages	Expensive, particularly for part-time operation. Continuous use will require alterations to the cab for ergonomic reasons.
Comments	Operator's seat should rotate to allow ease of operation. Front balancing weights will be required.



Implement	**SINGLE-GRIP HARVESTER**
Description	Single-grip harvesters have a head mounted on a loader boom, which both fells and processes the tree.
Power Requirement	Needs large 75 kW + (100 hp+) tractors. Hydraulic power flow requirements will range from 70 to 100 l/min.
Advantages	Reduces the workload on chainsaw fellers dramatically. Safe operation from within the cab. Potential for high productivity.
Disadvantages	Requires highly trained and skilled operators. Very costly.
Comments	Operators seat should rotate to allow ease of operation. Front balancing weights will be required. Single-grip harvesting heads are generally mounted on purpose built machinery and these outfits are the mainstay of the national harvesting fleet in Ireland. They are expensive machines and generally require all year round operation to justify purchase.



5.3 Purpose-built forestry forwarders

Buying used forwarding equipment offers an inexpensive way for small or entry-level owners to overcome high capital costs associated with conventional systems. The low fixed cost of used equipment can help to compensate for its lower productivity and may result in increased net revenue per harvested unit. Additionally forwarding equipment may have a use in carrying out agricultural operations such as slurry spreading; this dual-purpose use may increase their utility for farmer-foresters. Clearly when buying used machinery the owner may forego reliability, sophistication and productive potential of a new machine.

The operation of second-hand machinery by woodland owners themselves may further reduce costs associated with productivity since such operations may be carried out in less busy times. This, however, assumes owners have a certain level of competence and skill in carrying out these often demanding operations. Older machinery also requires more maintenance. However, the use of second-hand forwarders is quite common in farm forestry in Sweden.

5.4 Chippers

There is a growing interest in the use of chipping systems in Irish forestry particularly in the context of the projected increase in the volumes of pulp material coming on stream over the next decade, and in light of an increased awareness of the potential of using thinnings as an energy assortment. Since the aim of the European Union is to increase the share of renewable energy in total energy use the demand for energy wood should grow considerably in the future. With a limited number of outlets for pulp (refer to section 3.1) there are clear advantages to the grower in the development of such markets.

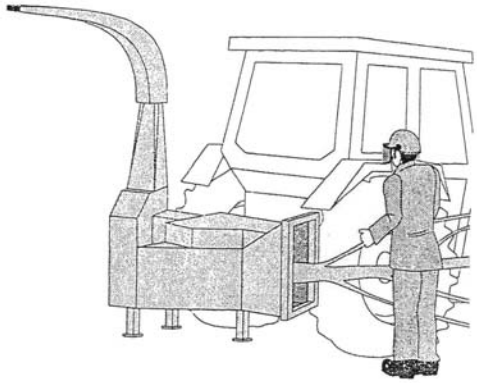
The extent and nature of wood fuel chip production in Ireland was summarised at a recent COFORD conference: Wood Energy Conference 2002 – White Coal Green Energy. In his paper 'Technology for wood fuel chip production in Ireland' Seamus Hoyne from the Irish Bioenergy Association separated wood chipping technology currently in use into three categories namely

- Small-scale chipping;
- In-forest chipping;
- Large-scale chipping.

Small-scale chipping is used mainly by tree surgeons when disposing of individual trees. The chip is generally used for landscaping or mulching. There is a wide range of small-scale chippers currently in use in Ireland, many of which can be powered by agricultural tractors.

Mobile in-forest chipping is not currently practised in Ireland, however it is considered by many to have real potential. Technology developed in the Nordic countries could be adapted to Irish conditions. Large-scale chipping occurs where the chips are being used and involves large, static machinery.

Implement	**CHIPPER**
Description	Mainly disc chippers mounted on the 3-point hitch and powered by the PTO.
Power Requirement	Depends on the diameter of the tree to be chipped. A 37 to 45 kW (50 to 60 hp) tractor will chip logs up to 15 cm in diameter.
Advantages	Can produce fuel chip from unmerchantable timber. Leaves sites neat and tidy and allows unwanted material to be transported efficiently off-site.
Disadvantages	Expensive. Feeding chippers by hand is hazardous.
Comments	Use in forest plantations will be dependent on policy in relation to renewable energy.



6. Cable logging systems

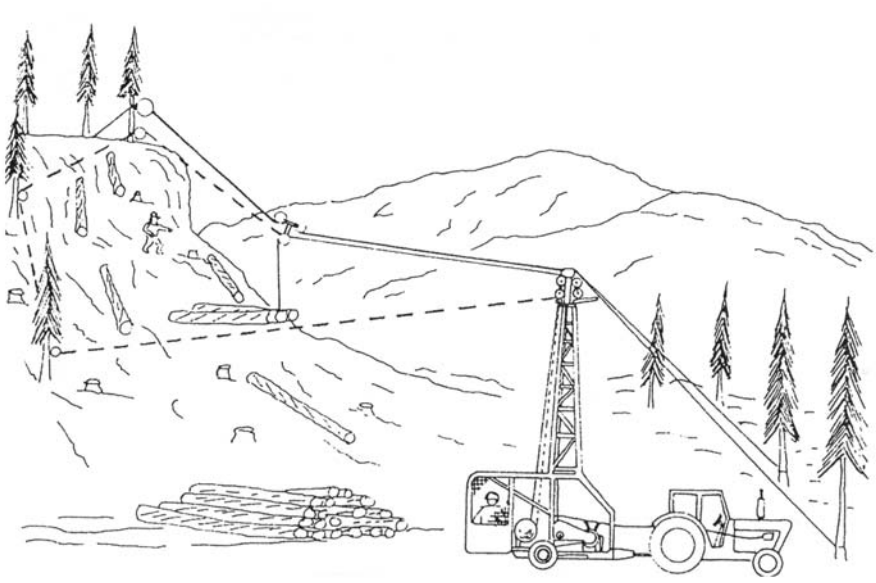
Also known as yarders or cable cranes, cable logging systems involve the transport of logs within the forest by means of a carriage moving along suspended steel cables, the load being partially or wholly lifted off the ground. In its most basic form cable logging consists of a fixed winch with two cables – one to pull the line out to the trees and the other to pull the logs in once attached to the line. Much more sophisticated systems have been developed using winches driving four or five lines. In such cases quite complicated rigging systems may allow the load to be lifted clear of the ground.

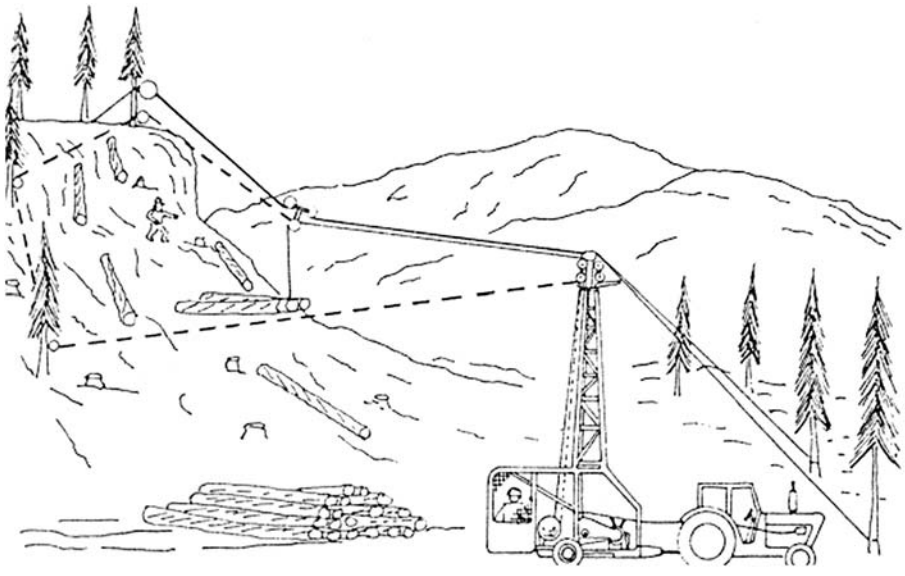
Generally speaking, cable systems do not fit the criteria for small-scale harvesting equipment as set out in Section 1. However since they may be the only means by which timber can be harvested on difficult sites they have been included.

Cable logging systems must be operated by trained operators. Safety is a major consideration, particularly since cabling involves the use of tensioned cables and heavy loads. Hazards occur during installation, operation and dismantling. The utilisation of cabling systems as a means of timber extraction is a specialised operation and should only be undertaken by dedicated trained and certified operators.

The commonest systems are:

- Highlead – Simple two cable system requiring only two winch drums with a tail rope to pull out the block (to which logs are attached) and a main rope to pull the logs in. Both lines form an endless cable, which can move clockwise and anticlockwise.
- Skyline systems – Usually have a third cable along which a carriage runs, the carriage being pulled in and out by the tail and main ropes. Logs are attached to the carriage in various ways. Where the skyline is fixed at some distance above the ground the logs can be lifted up to the skyline before being winched in. The carriage travels along a pre-tensioned, static cable known as the skyline.
- Skylines with motorised carriages.





Timbermaster Skyline

EX350 Excavator-based skyline

6.1 Trends in the use of cable systems

Cable systems have been used traditionally throughout the world to extract timber from difficult, steep sites. Expertise has been developed, not surprisingly in countries such as Austria, the Czech Republic, Japan, Norway and Scotland, where a large proportion of forestry is located on steep terrain.

There has been a decline in recent years in the use of cable systems in Ireland and indeed throughout Europe (with the exception of Austria where the utilisation of cabling systems has doubled over the past 10 years). This has been due mainly to the cheaper cost and increased capability of harvester and forwarder combinations on steep terrain.

The relatively low productivity of cable systems when compared to ground-based systems can significantly reduce profit margins. Some feel the utilisation of cabling systems will increase as more stringent environmental constraints are imposed on sensitive sites. Additional harvesting costs will have to be met if operations are to be carried out in such a manner.

In 1999/2000 there were six skylines in operation in Ireland with approximately 20 lying idle. The Timbermaster skyline is the most commonly used in Ireland. The average age of the national fleet is around 20 years. These systems are however very robust, maintenance is relatively straightforward and there is a ready supply of spare parts.

6.2 Cost and innovation

Since cabling systems are generally costly to operate planning the operation is vital particularly roading. Road construction should take the extraction system into consideration. Set up costs can be high particularly when harvesting small sized material, as is often the case when harvesting first and second thinnings.

Recent innovation in relation to continuous processing and delayed processing techniques has made cabling systems more productive. Excavator-based yarders are often considered to be cost effective alternatives to conventional yarders. Excavator-based units are converted into cabling systems by adding winches to the excavator and modifying the boom to act as a tower. The main advantages of excavator-based yarders are fast set-up times, ease of operation and good off-road ability.

7. Horse logging

Animals were the main source of power used to extract timber throughout the world until the advent of the farm tractor and its widespread usage. Between the 1940s and the 1960s the predominance of animal extraction in forestry shifted to mechanised extraction mainly through the use of tractors fitted with skidding winches. The decline in the use of horse extraction has continued, while the once popular tractor and winches have in turn been replaced with purpose built forwarders and processors.

Horses provide a solution for the small woodland owner in relation to timber extraction in that they are highly manoeuvrable, have the flexibility to handle a variety of timber sizes and lengths and have low transportation and capital costs. Horse logging is however a physically demanding operation which, coupled with the unavailability of skilled operators, has limited its use.

Horse extraction can be cost-effective in appropriate circumstances and can work alongside and complement forwarders, processors and skylines. It is used in areas that are too sensitive for, or inaccessible to, tractor skidding and/or conventional machinery, and in areas too small to be harvested using conventional methods.

As the forest size decreases and landowners' concerns about environmental issues and aesthetics increase, horse logging may have a niche, working small and sensitive areas, which would not be feasible for mechanised logging.

Many different breeds of horse are used in timber extraction. For example in Finland the traditional breed is the Finnhorse, while in Sweden the North Swedish or Mountain Ardennes breeds are preferred. The Dole horse or the Norwegian Fjord horse is used in Norway. The Ardennes horse from Belgium is considered to be a breed very suitable to horse logging. A recent report carried out by the Irish Forestry Contractors' Association (IFCA) recommended the introduction and registration of this breed with the Irish Horse Board.

The following are some of the advantages and disadvantages of horse logging:

Advantages

- Low overhead and investment costs.
- Lower move in costs.
- Lower rack density.
- Damage to residual stand is light.
- Stands do not have to be thinned as heavily as normal.
- Soil disturbance is low.
- Beneficial in pulling down hung-up trees.
- High level of acceptability with the public.

Disadvantages

- Takes longer to log an area.
- Horses are limited to working with smaller logs.
- Limited availability.
- Limited extraction distances.
- Continuous attention required for the horse.

A renewal in the interest and the utilisation of horse logging has been assisted through the efforts of dedicated organisations such as the British Horse Loggers Association (BHLA), Skogshasten in Sweden, Interessengemeinschaft Zugpferde (IGZ) in Germany and Forening Arbeidshesten in Norway. Such organisations provide training courses in horse logging with recognised certification.

A survey of horse logging in Ireland was carried out by the IFCA in 1999. The number of businesses in operation was three full-time and five part-time, with nine operators interested in resuming work if economic conditions became more favourable. Thus a potential pool of 17 operators existed throughout the country in 1999. Clearly with such a small number of operators the likelihood of owners of small area of forest using horse logging is limited.

7.1 Specialised equipment

Ground conditions, crop type, product type and extraction distance all have a significant part to play in selecting the appropriate equipment. Many loggers have built their own attachments or have modified old designs to meet their needs under certain terrain conditions. Equipment such as harness and chains with a spreader bar has been used to extract large volumes of timber. The Scandinavians have developed arches and sledges of different types. A selection of implements used in horse logging is described below.

Implement	**WHEELED LOGGING ARCH**
Description	This simple apparatus is used to transport logs. The arch is reversed over the load and the log(s) are secured to the arch (usually using a hand winch) and skidded to the landing.
Advantages	Minimises the effect of skidding on soil and vegetation. Low cost.
Disadvantages	-
Comments	The Norwegian Arch has been used by contractors in Britain.

Implement	**FORWARDER**
Description	There is a wide range of timber trailers available for horses, from non-driven units to more sophisticated power driven trailers. Trailers tend to be of skeletal construction in order to maximize payload capacity.
Advantages	Suitable for longer extraction distances than skidding. Shortwood can be extracted clean. Can be used in non-forestry applications.
Disadvantages	The more sophisticated ones can be expensive.
Comments	The EP Wagen is an example of a horse pulled trailer that has been used by contractors in Britian. It has good safety features such as swivel mechanism connected to the shafts allowing the horse to remain upright should the trailer turn over. It is extendable for different log lengths and has four pairs of independently suspended bogies to facilitate smoother forwarding.

Implement	**WIRE CRANE LOADER**
Description	The wire crane comprises a mechanically powered winch with a high A-frame and stabiliser legs. Wire crane loaders can be used in conjunction with horse drawn forwarding trailers. They are commonly used with a forestry trailer for winching, loading and forwarding wood. The operator walks up to each bundle, puts a wire around it and winches it back to the trailer.
Advantages	Wire-crane loaders are one of the least expensive mechanical loading system available. Good manoeuvrability.
Disadvantages	Requires a degree of manual loading. Operator safety is a consideration. Needs well trained operatives.
Comments	Suitable for timber extraction on sensitive sites (e.g. riparian zones).

Implement	**GRAPPLE LOADER**
Description	These are hydraulic cranes with a grapple, which can be used to pick up single trees, or bunches of logs for loading or unloading a trailer. They can be mounted on the trailer and the loader is powered by a separate power pack driven by a petrol engine.
Advantages	Allow fast efficient loading and unloading of logs. Eliminates manual handling. Suits shortwood extraction. Can be used in non-forestry applications.
Disadvantages	-
Comments	This method of horse extraction is often employed in the Nordic countries.

8. Small-scale machinery

Small-scale machinery is often equated with small-scale timber harvesting, and there has been a growing interest in both in recent years. The interest in Britain and Ireland in small-scale machinery may be as a result of the use of ATV type machinery in recreational, agricultural and horticultural applications and the possibilities they have for use in forestry. The versatility and relative low capital cost, low transportation costs, and high manoeuvrability of these machines, increases the likelihood of private forest owners acquiring and using them for various applications.

In Scandinavian countries the tradition of small-scale forestry management and the advent of low capital cost, small-scale machinery has evolved to provide numerous possibilities in relation to timber harvesting of small areas of forestry. For various reasons however, such machinery and systems are not always readily transferable to other countries. Part of the reason is undoubtedly the variation in site conditions between different countries. However, tradition and the well developed forestry culture of Scandinavian countries has a large part to play in the management and harvesting of small-scale forests.

Small-scale machinery tends to be considerably smaller and lighter than agricultural tractors and although this may have positive environmental implications, operational factors must be considered with small machinery working in physically difficult conditions. Planning is therefore very important particularly in thinning situations where a predetermined rack system can help to maximise productivity through the avoidance of obstacles and the facilitation of directional tree felling towards the best point of access for the forwarder.

The use of small-scale machinery requires specific skills, and training is essential to provide operators with a good knowledge from which to develop their skills and to ensure all aspects of health and safe operation of equipment are addressed.

A number full-time harvesting contractors interviewed during the course of this study were of the opinion that small-scale machinery was not sufficiently robust for use in the types of conditions in which they were operating in Ireland. This opinion was based on both first hand experience gained in the use of small-scale equipment particularly throughout the late eighties and early nineties, and on an appreciation of site conditions and the demands these have on machinery. Also since there is limited experience in the use of certain small-scale machinery in this country those considering purchasing specialised equipment need to take account of the extent of back-up services and maintenance and the availability of spare parts.

8.1 All-terrain vehicles

All-terrain vehicles (ATVs) are 3- or 4-wheeled motorised vehicles designed primarily for off road use. They have handlebars like a motorcycle, and the rider straddles the body of the vehicle. With large, soft tyres, ATVs have a relatively high centre of gravity. Some can reach speeds of 50 mph. ATVs are approximately 1 m wide and typically weigh from 200-300 kg. ATVs have been developed mainly as recreational vehicles but have found widespread use due to their versatility and low price tag.

In forestry ATVs can be used primarily for transporting individuals or materials such as plants, fertilisers, tools etc. With appropriate attachments ATVs can also function as prime movers in the extraction of timber. ATVs used for logging related activities should have at least 300 cc engine capacity and 4-wheel drive. Desirable modifications may include the addition of tracks or traction chains, weighting tyres and placing counterweights on the front of the vehicle. Other equipment that may be added to an ATV include a front bumper, a protective bellypan under the engine, foot guards and a recovery winch.

The characteristics of an ATV for forestry work will vary depending on the terrain conditions and the type of work it will be required to perform. Timber extraction is one of the most demanding forestry operations undertaken by ATVs and their limitations must be taken into account when deciding on the job to be done and the choice of equipment. Generally the total load hauled should not exceed the weight of the ATV and its driver and operators are advised to follow the manufacturers' recommendations in this regard.

ATVs can be transported from site to site on a trailer pulled by a car or jeep. Also they can be brought home every evening, which is an important consideration in light of the susceptibility of forestry machinery to vandalism. Safety and training are major considerations when using ATVs particularly in forestry conditions. There has been a high incidence of accidents with ATVs mainly on public roads and many countries where these vehicles are popular have enacted regulations relating to their use. Where accessories or attachments are used their compatibility with the ATV and the safety implications should be considered. Track conversion can greatly improve ATV traction, flotation and stability.

Many accessories and attachments have been developed for use with ATVs and some of those used in timber extraction are described in next section.

8.2 A selection of accessories for use with ATVs

Implement	**SKIDDING ARCH**
Description	This simple 2-wheeled apparatus is used to transport logs. The arch is reversed over the log and a chain choker is passed round the log and secured to a notched bar. When the assembly is pulled forwards the arch rises from the inclined to the vertical position and is held against metal stops in front of the wheels. Reversing the assembly lowers the log. 
Advantages	Minimises the effect of skidding on soil and vegetation. Low cost.
Disadvantages	Load size may be limited by the power capabilities of the ATV.
Comments	-

Implement	**WIRE CRANE LOADER**
Description	The wire crane comprises a mechanically powered (or electrically from the battery of the ATV) winch secured to the body of the trailer (headboard) for stability. The winch enables one person to conduct the loading and unloading with the minimum of physical effort. The winch can also be used for winching in wood that is inaccessible to the ATV itself. 
Advantages	Minimises manual handling. Good manoeuvrability.
Disadvantages	Requires a degree of manual loading. Operator safety is a consideration. Needs well trained operatives.
Comments	It may be quicker and more convenient to unload manually.

Implement	**GRAPPLE LOADER**
Description	These are lightweight hydraulic cranes with a grapple, which can be used to pick up single trees, or bunches of logs for loading or unloading a trailer. They can be mounted on the trailer. The loader is powered by a separate power pack driven by a petrol engine. 
Advantages	Shortwood can be extracted clean.
Disadvantages	Needs separate power source to the prime mover.
Comments	-

Implement	**TRAILER**
Description	There are a number of manufactures providing timber trailers for use with ATVs. Trailers tend to be of skeletal construction in order to maximise payload capacity which typically would be approximately 1.0-1.5 tonnes.
Advantages	Suitable for longer extraction distances. Shortwood can be extracted clean. Can be used in non-forestry applications.
Disadvantages	Payload is small.
Comments	ATV manufacturer's recommended towing capacities are likely to be exceeded if trailers are at full capacity. Generally ATVs and trailers are not suited to off-road/track forwarding and their use in the wood (to extract from the stump) is limited. Forestry trailers need good clearance, need to be same width as the ATV and need loading aids.

8.3 Mini-tractors/forwarders

These purpose-built machines are commonly used in Scandinavian countries. Trials of this type of machinery in Britian and Ireland are limited. Mini-tractors have good built-in safety features such as roll-over protection systems (ROPS) and a PTO, 3-point linkage and a towbar to facilitate the attachment of a wide variety of accessories which give these machines a clear advantage over ATVs.

Like ATVs many of these small sized machines are light enough to be transported from site to site on a trailer pulled by a car or jeep. They can therefore be easily transported between sites and be available for immediate deployment on arrival. Also they can be brought home each evening.

Preliminary studies conducted by the Forestry Commission in Britain suggest mini-tractors/forwarders can compete on a productivity basis with heavy duty modified tractors, particularly in smaller, less uniform thinnings. An additional benefit of such lighter machinery is their reduced environmental footprint. Mini tractors and forwarders have greater terrain and load capabilities than ATVs with timber trailers. This is mainly achieved through the use of power driven trailers where the main driving force, when laden, comes from the driven trailer itself. Also there is much greater control of the trailer load when descending slopes because the brakes act on the trailer. Due to their small size their operation on rough sites may present difficulties and carrying a winch to assist in debogging operations is recommended.

There is a wide range of machinery on the market from the 12 kW (16 hp) VIMEK minimaster to the 62 kW (83 hp) Riko MARS 8.90RS, to the purpose-built Terri ATD, equipped with its single grip harvesting head. Some of the main accessories used in forestry with mini tractors/forwarders are described in the following section.

(Mini-tractors/forwarders can also be used as prime movers with attachments such as wire crane loaders and skidding arches as described in Section 8.2.)

Vimek Minimaster101

Terri ATD with AM280 Head

8.4 A selection of accessories for use with mini-tractors/forwarders

Implement	**GRAPPLE LOADER**
Description	These are lightweight hydraulic cranes with a grapple, which can be used to pick up single trees, or bunches of logs for loading or unloading a trailer. They can be mounted on the 3-point hitch or on the trailer itself. The loader is usually powered directly from the tractor hydraulics.
Advantages	Allows fast, efficient loading and unloading of logs and eliminates manual handling. Suits shortwood extraction.
Disadvantages	The designs of some mini-forwarders are ergonomically poor and require the operator to kneel on the seat to operate the loader.
Comments	-

Implement	**TRAILER**
Description	Suitable trailers tend to be purpose-built for use with mini-tractors, most of which tend to be power driven. Trailers tend to be of skeletal construction in order to maximise payload capacity which typically would be 2-4 t.
Advantages	Shortwood can be extracted clean. Can be used in agricultural applications.
Disadvantages	-
Comments	Good thinning rack layout and planning can effect productivity. This machinery has been developed for use in the Scandinavian countries and has not been extensively tested in British or Irish conditions.

Implement	**HARVESTING HEAD**
Description	Single grip harvesting heads developed for use specifically with small dimension purpose built forest machinery.
Advantages	Eliminates the necessity for chainsaw felling.
Disadvantages	-
Comments	This machinery has been developed for use in the Scandinavian countries and has not been tested in British or Irish conditions.

8.5 Other small-scale harvesting equipment

There is a variety of other timber harvesting equipment which may be considered as ‘small’ and while some of the main equipment/accessory categories have been covered in previous sections there are a number of ancillary devices which have not been covered. A selection of ‘other’ small-scale equipment is described in this sub section.

Proper techniques employed in the motor manual felling of trees can be greatly assisted through the use of various hand tools such as felling levers, felling wedges and small winches. Techniques employed in delimbing and crosscutting can be assisted through the use of lifting hooks, tongs, cant hooks and logger tapes (for measuring log length). Other tools such as thinning rollers may be used on flat sites to provide a comfortable working height for delimbing and stacking of timber. The efficient use of these hand tools will be greatly dependent on the skills and techniques employed by the operator.

Fetching arches are manually operated arches which can be of assistance in taking down trees which get hung up in thinning and for skidding full poles or logs in early thinnings.

Skidding cones are used to assist the extraction of trees or logs by reducing ground friction and the likelihood of the load getting caught or snagged in debris, stumps etc. Skidding cones can be used with a variety of small-scale prime movers such as Mini tractors/skidders, ATVs, pedestrianised skidders, horses and winches. They are particularly useful

Implement	**PEDESTRIANISED SKIDDER**
Description	Pedestrianised skidders are small tracked machines, guided by a handle, which are used in the transportation of wood. They are operated by a person walking in front of the unit. It can support one end of a log(s) for skidding or alternatively pull a trailer.
Advantages	Can be operated by an individual operator. Often used in other applications such as carrying and distribution of fencing materials, fertiliser etc. In Scandinavia a special attachment is available for hauling moose or other big game out of the woods.
Disadvantages	Logs must be felled using a chainsaw and then lifted (winched or felled) onto the skidder.
Comments	In Scandinavia pedestrianised skidders are often used in conjunction with a trailer or a sleigh. Many are fitted with wire loaders or winches. Some incorporate a broad roller bench onto which trees are felled and this allows for trees to be delimbed without the operator having to bend over and the logs can be advanced over the trailer for cross-cutting.

Implement	**MOTORISED WINCH**
Description	Small motorised winches, which can be attached or anchored to a suitable ‘winching tree’ (an individual standing tree) and all produce can be pulled towards this point.
Advantages	A low cost skidding option.
Disadvantages	Some of the more powerful winches are heavy, making this work very labour intensive.
Comments	Some of the larger motorised winches are boat shaped for easy transportation around the wood. Many winches are fitted with capstan systems which ensure tractive force and cable speed are kept constant. Positioning of the winch on the ‘winching tree’ can affect the accumulation of extracted produce. Chainsaw winches attached to the chainsaw by substituting the chain bar can prove versatile and useful. The use of a skidding cone at the smaller end of the log is generally considered to be beneficial.

when winching in loads to a central point when subsequent loads can be winched up and on top of others to form a stack. Skidding cones or pans are generally made from fibreglass.

Regardless of the equipment employed planning is key to successful operations in small-scale harvesting and good route planning particularly in thinnings features largely in efficient practices. Regular maintenance and machine inspection is essential in maintaining safety standards and good working condition of machinery.

Bibliography

COFORD. 2003. Optilog Report. *An efficiency analysis of the sale, purchase, harvesting and haulage of timber in the Irish forestry sector.* COFORD, Dublin.

Department of Forest Extension at the University of Agricultural Sciences, Sweden 2/89. Newsletter. *Small-scale forestry.*

Dewar, J.A. 1993. *Timber trailers for agricultural tractors.* Forestry Commission Research Division Information Note 02/93.

Dewar, J.A. 1993. *Horse extraction in thinning.* Forestry Commission Work Study Branch Report 13/93.

Drake-Brockman, G.R. 1996. *Secondary timber extraction by all terrain cycle.* Forestry Commission Research Division Technical Note 11/96.

Drake-Brockman, G.R. 1997. *ELMIA Wood 1997 Review of small-scale forestry equipment.* Forestry Commission Research Division Technical Note 13/97.

Drake-Brockman, G.R. 1997. *Harvesting options in small woodlands: Cottshayne Wood experience.* Forestry Commission Research Division Technical Note 22/97.

Drake-Brockman, G.R. 1998. *An evaluation of small-scale forwarding methods in a broadleaf thinning operation*. Forestry Commission Research Division Technical Note 40/98.

Dunnigan, J. *Evaluation of the J.M.S. self-loading trailer for All Terrain Vehicles (ATV's).* Forest Engineering Research Unit of Canada Field Note No. 14.

Dunnigan J., Beaulieu, L. and Folkema, M.P. *All Terrain Vehicles for forestry work*. Forest Engineering Research Unit of Canada Technical Note TN-109.

Dykstra, D. and Poschen, P. *Wood harvesting.*

Ewing, Rod and Lireet, Jacques. 1998. *Semi-mechanized commercial thinning with extraction by horses.* FERIC Field Note: Partial Cutting 22, November 1998.

Ewing, Rodrick H. 2001. *Use of a portable capstan winch and associated hand tools in manual thinning.* Forest Engineering Research Unit of Canada Vol.2 No. 28, May 2001.

Forestry Commission Work Study Branch Report 28/91. *Small-scale Forestry: ELMIA 1991.*

Forestry Commission Research Division Technical Note 13/98. *Strategic Review of Cableway Systems.*

Forestry Commission Technical Development Branch: Report 2/97. *Small-scale Mechanised Extraction: Case Studies*.

Forest Service. 2000. *Code of Best Forest Practice – Ireland.* Forest Service, Ireland.

Fitzpatrick, Donal. 2000. *Evaluation of horse logging as a means of timber extraction in Irish forests 1999/2000.*

Folkema M.P. 1997. *Logging trailers for farm tractors.* FERIC Woodlot Technology Technical Note TN-97.

Hakansson, Michael. *Mini skidders at work.*

Hamilton P.S. 1998. *Logging with horses in riparian zones.* FERIC Field Note: Partial Cutting 21, October 1998.

Irish Timber Growers' Association Yearbook 1999.

Irish Timber Growers' Association Yearbook 2000.

Johansson, J. 1997. Small tree harvesting with a farm tractor and crane attached to the front. *Journal of Forest Engineering*, January 1997. Vol.8 No. 1.

Jones, D.H. 1997. *An evaluation of small-scale forwarding in a broadleaf thinning operation.* Forestry Commission Research Division Technical Development Branch Report 2/97.

Jones, D.H. 1997. *Log chute extraction of a broadleaved crop.* Forestry Commission Research Division Technical Note 10/97.

Jones, D.H. 1996. *Using farm tractors and machinery in woodlands*. Forestry Commission Research Division Technical Note 20/96.

Jones, D.H. 1996. *Evaluation of the VIMEK Minimaster.* Forestry Commission Research Division Technical Note 20/96.

Jones, D.H. 1995. Timber Trailers for Agricultural Tractors. Forestry Commission Research Division Technical Note 28/95.

Jones, D.H. 1997. *Evaluation of the Star Wire Loader*. Forestry Commission Research Division Technical Note 8/97.

Jorgen, A. *Future challenges for small-scale forestry – examples from the West Coast of Norway.*

Kantola, M. Role of forestry in small farms. *Unasylva* No. 85.

Kerruish, B.and Reed, J. 1996. *Small-scale harvesting of trees on farms, 1996.*

Lyons, J. 1994. *Low ground pressure small-scale harvesting machines, July 1994.*

McCormack et al. *A Report for the RIRDC/LWRRDC/FWPRDC Joint Venture Agroforestry Programme Harvesting Trees on Farms.*

McGonagil. 1979. *Horselogging at Latour*. US Forest Service Production Study, 1979.

Medved, M. *Accidents in small-scale private forests and their economical aspect.*

Ministry of Forestry and New Zealand Logging Industry Research Organisation, Small Forest Management 7, March 1996. *Harvesting a small forest.*

Murgatroyd, I. R. 1997. *Hillier 1.9 TDI tracked ATV.* Forestry Commission Research Division Information Note 4/97.

Murgatroyd, I. R. 1996. *Slope limits for specific ATCs* . Forestry Commission Research Division Technical Note 11/96.

Murgatroyd, I. R. 1998. *The ATC TRU_TRAX System.* Forestry Commission Research Division Technical Note 25/98.

Murgatroyd, I. R. 1998. *ATC and ATV on road use*. Forestry Commission Research Division Technical Note 38/98.

Purser, P. 2000. *Timber Measurement Manual*, COFORD, Dublin.

Saunders, Colin J. 1997. *Horse drawn wireloader forwarder*. Forestry Commission Research Division Technical Note 4/97.

Sennblad, Gotthard. 1993. *Eurofortech Thinning Harvesting and Extraction (Small-scale Technology),* November 1993.

Shaffer, R.M. *Farm tractor logging for woodlot owners.*

SMALLFORE project (QLRT-1999-01493), TTS Institute's Publications 380. *European small-scale forestry and its challenges for the development of wood harvesting technology, 2001.*

SMALLFORE project, Final Report (QLRT-1999-01493), TTS Institute's Publications 385. *Small-scale wood harvesting technology in European forestry and its contribution to rural development, 2002.*

Tiernan, D., Owende, P.M.O., Kanali, C.L., Spinelli, R., Lyons, J., Ward, S.M. *The ECOWOOD project (Cable Systems). Selection and operation of cable systems on sensitive forest sites.*

Updegraff, Karen and Blinn, Charles R. 2000. *Applications of small-scale forest harvesting equipment in the United States and Canada, March 2000.*

Wang, Lihai. 1999. *Environmentally Sound Timber Extracting Techniques for Small Tree Harvesting, July 1999.*

APPENDIX

Table A: Selected data for Farm Tractor Adapted Forestry Implements

† Guide price figures are based on available data from the APF International Forest Machinery Exhibition which was held in Lockerbie, Scotland in September 2002

Item	Tractor requirement hp	Weight kg	Width m	Reach m	Load Capacity	Location of Distributor	Guide Price† Stg £	Manufacturer/Distributor/URL
SKIDDING and FORWARDING GRAPPLES								
IMx 4836 R	30 – 110					US		www.implemax.com
IMx 6042 R	30 - 110					US		www.implemax.com
IMx 4836 Rw grapple/winch						US		www.implemax.com
IMx 6042 Rw grapple/winch						US		www.implemax.com
Nokka						Sweden		Nokka, Sweden
SKIDDING WINCHES								
Farmi front mounted EV300		140	0.7	60/90	3T	UK	£1,095	Normet, Finland/Corwen Forestry Ltd., UK
Farmi Skidding Winch JL 351P	15	170	1.3	60/90	3.5T	UK	£1,095	Normet, Finland/Corwen Forestry Ltd., UK
Farmi Skidding Winch JL 501	35	250	1.5	80/100	5T	UK	£1,250	Normet, Finland/Corwen Forestry Ltd., UK
Farmi Skidding Winch JL 601	60	390	1.8	100/130	6T	UK	£1,895	Normet, Finland/Corwen Forestry Ltd., UK
Farmi Skidding Winch JL 60 T	80	660	2.0	70/80	8T	UK	£4,395	Normet, Finland/Corwen Forestry Ltd., UK
EGV 30A	16 - 27	235	1.22	70	3T	UK	£880	Tajfun, Slovenia/Andrew Holmes andCo., UK
EGV 40A2	24 - 47	310	1.4	100	4T	UK	£1,030	Tajfun, Slovenia/Andrew Holmes andCo., UK
EGV 50A	40 - 54	335	1.5	80	5T	UK	£1,380	Tajfun, Slovenia/Andrew Holmes andCo., UK
EGV 60A	54 - 90	490	1.65	110	6T	UK	£1,780	Tajfun, Slovenia/Andrew Holmes andCo., UK
EGV 80A	75 - 120	540	1.8	95	8T	UK	£2,200	Tajfun, Slovenia/Andrew Holmes andCo., UK
Fransgard V-2800	25	150		40/45	2.8T	UK	£1,033	Fransgard, Grastorp, Sweden/A T Osborne Ltd., UK
Fransgard V-4000	40	250		50/60	4T	UK	£1,337	Fransgard, Grastorp, Sweden/A T Osborne Ltd., UK
Fransgard V-6500	80	400		50/80	6.5T	UK	£1,796	Fransgard, Grastorp, Sweden/A T Osborne Ltd., UK
WIRE CRANE LOADERS								
Star 45	30 - 40	180		40-60		Sweden		Star, Virserum, Sweden
Vasekranen		190		40		Sweden		Vasekranen, Sweden

Item	Tractor requirement hp	Weight kg	Width m	Reach m	Load Capacity	Location of Distributor	Guide Price† Stg £	Manufacturer/Distributor/URL
GRAPPLE LOADERS								
NOKKA 3000		680		5.4		Finland		Nokka-Tume OY, Finland/ Falcon Agricultural Machinery, England
Patu 600		775		6.0	310	Sweden		Patu, Jonkoping, Sweden,
Patu 700		750		7.5	230	Sweden		Patu, Jonkoping, Sweden
Farmi HK2955		680		5.5	975 – 400	UK	£6,500	Normet, Finland/Corwen Forestry Machinery Ltd., UK
Farmi HK3861		750		6.1	995 – 500	UK	£7,438	Normet, Finland/Corwen Forestry Machinery Ltd., UK
Farmi HK4166		940		6.6	1520 - 600	UK	£8,975	Normet, Finland/Corwen Forestry Machinery Ltd., UK
Farmi HK4581		1110		8.0	1225 - 400	UK	£10,995	Normet, Finland/Corwen Forestry Machinery Ltd., UK
FORESTRY TRAILERS								
Iglund		2,360	2.2		7.5 – 9.5	Norway		Iglund AS, Norway
Farmi Normet MPV 7000		880	1.9		7.0	US		Farmi Normet, Finland/www.valbysales.com
Farmi Normet MPV 8000 (no brakes/steering)		890	1.86		8.0	UK	£3,848	Normet, Finland/Corwen Forestry Machinery Ltd., UK
Farmi Normet MPV 8000 (with brakes/steering)		890	1.86		8.0	UK	£4,995	Normet, Finland/Corwen Forestry Machinery Ltd., UK
Farmi Normet MPV 9000		1,500	2.1		9.0	US		Farmi Normet, Finland/www.valbysales.com
Farmi Normet MPV 12 4WD		3,000	2.2		12.0	US		Farmi Normet, Finland/www.valbysales.com
Farmi Normet Vario 100J (with brakes/steering)		1,350	2.03		10.0	UK	£5,875	Normet, Finland/Corwen Forestry Machinery Ltd., UK
Farmi Normet Vario 100 4WD (with brakes/steering)		1,440	2.03		10.0	UK	£11,495	Normet, Finland/Corwen Forestry Machinery Ltd., UK
Farmi Normet Vario 120 4WD (with brakes/steering)		2,050	2.4		12.0	UK	£12,395	Normet, Finland/Corwen Forestry Machinery Ltd., UK
Vreten HW			1.9		6.5	Sweden		Vreten, Skovde, Sweden
FMV 8S					7.0	Sweden		FMV, Hudiksvall, Sweden
Mowi WO 8			1.8		7.0	Sweden		Mowi, Backefors, Sweden
Patu Allgripen 75		900	2.0		8.0	Sweden		Patu, Jonkoping, Sweden
Hypro HV 8		965	2.2		8.5	Sweden		Hypro, Lonnsboda, Sweden
Nokka 90			1.9		9.0	Sweden		Nokka, Nykoping, Sweden
Nokka 10 4WD			1.9		10.0	Sweden		Nokka, Nykoping, Sweden

Item	Tractor requirement hp	Weight kg	Width m	Reach m	Load Capacity	Location of Distributor	Guide Price† Stg £	Manufacturer/Distributor/URL
Patu 85		1350	2.2		10.0	Sweden		Patu, Jonkoping, Sweden
Patu 95		2560	2.2		10.0	Sweden		Patu, Jonkoping, Sweden
WINCH PROCESSORS								
Hypro Thinning Processor 350	65	890	1.8	50		North America/Sweden		HYPRO AB, Sweden/www.forestindustry.com/forestrytech
Hypro Thinning Processor 450	65	930	1.6	50		North America/Sweden		HYPRO AB, Sweden/www.forestindustry.com/forestrytech
Hypro Thinning Processor 500	70	1070	1.8	50		North America/Sweden		HYPRO AB, Sweden/www.forestindustry.com/forestrytech
NIAB 1501	55	985				Sweden		Niab, Hammerdal, Sweden
Vimek G30	50	750		40		Sweden		Vimek AB, Vindeln, Sweden
GRAPPLE/BED PROCESSORS								
Nokka P400 RS (KP 40 head)	54	700			35 cm	Finland		Nokka-Tume OY, Finland/Falcon Agricultural Machinery, England
Patu 30	38	640			30 cm	Finland		Patu, Jonkoping, Sweden
Hypro 455	70	830	1.8		40 cm	North America/Sweden		HYPRO AB, Sweden/ww.forestindustry.com/forestrytech
Hypro 555	70	900	1.8		40 cm	North America/Sweden		HYPRO AB, Sweden/ww.forestindustry.com/forestrytech
CHIPPERS								
Vermeer BC2000	200	5000			51 cm	North America		Vermeer Manufacturing, Iowa, USA/www.vermeer.com
Vermeer BC606	60	612			15 cm	North America		Vermeer Manufacturing, Iowa, USA/www.vermeer.com
CMS 100	25	580	1.3		10 cm	Australia		Redroo, Keysborough, Australia/www.redroo.com
.Farmi CH 260	60				26 cm	UK	£6,995	Normet, Finland/Corwen Forestry Machinery Ltd., UK

TABLE B: Selected data for Small-scale Cable Systems

Item	Tractor Hp Requirement	Weight T	Reach m	Load Capacity T	Location of Distributor	Guide Price† Stg £	Manufacturer/Distributor/URL
CABLE SYSTEMS							
Koller K300	50	1.5	420	4.4	North America		Koller Areal, Kufstein, Austria/ ww.forestindustry.com/northwestharvesters
Savall Gravity Skyline (needs 30% slope)	50		350	1	Austria		Interforst, Bundesstrabe, Austria
Timbermaster	60		550	3.0	Scotland	£31,500	AandB Services, Pertshire, Scotland/www.abs-scotland.co.uk
AT650					Scotland	£42,000	AandB Services, Pertshire, Scotland/www.abs-scotland.co.uk
EX350					Scotland		AandB Services, Pertshire, Scotland/www.abs-scotland.co.uk
Larix 3T		3.1	700	2.5	Czech Republic		www.slpkrtiny.cz

TABLE C: Selected data for Horse Logging Equipment

Item	HP	Weight kg	Width m	Reach m	Load Capacity T	Location of Distributor	Manufacturer/Distributor/URL
HORSE LOGGING EQUIPMENT							
Ep Vagen					5 – 15	Sweden	
Vimek 362 Grapple Loader		235		3.6	0.25	Sweden	Vimek AB, Vindeln, Sweden/www.vimek.se

† Guide price figures are based on available data from the APF International Forest Machinery Exhibition which was held in Lockerbie, Scotland in September 2002

TABLE D.1: Selected data for Small-Scale Forwarders - ATVs

Item	HP	Weight kg	Width m	cc	Towing Capacity kg	Location of Distributor	Guide Price† Stg £	Manufacturer/Distributor/URL
Suzuki LTF 250		183	1.045	246	330	UK	£3,149	Suzuki GB PLC, Crawley West Sussex, UK/ www.suzukiatv.co.uk
Suzuki LTF 300	22	280	1.130	280	410	UK	£4,599	Suzuki GB PLC, Crawley West Sussex, UK /www.suzukiatv.co.uk
Suzuki LTF 400 F		252	1.130	376		UK	£4,999	Suzuki GB PLC, Crawley West Sussex, UK/ www.suzukiatv.co.uk
Suzuki LT A 500		281	1.170	493	410	UK	£5,499	Suzuki GB PLC, Crawley West Sussex, UK/ www.suzukiatv.co.uk
Kawasaki KLF 250	16.8	185	1.210	228	317	UK	£2,900	Kawasaki Motors (UK) Ltd., Bucks, UK/www.kawasaki.co.uk
Kawasaki KLF 300 B	19.2	229	1.160	290	317	UK	£3,650	Kawasaki Motors (UK) Ltd., Bucks, UK/www.kawasaki.co.uk
Kawasaki KLF 300 C	19.7	263	1.210	290	317	UK	£4,400	Kawasaki Motors (UK) Ltd., Bucks, UK/www.kawasaki.co.uk
Kawasaki KLF 650 A	41	275	1.169	633	567	UK	£5,850	Kawasaki Motors (UK) Ltd., Bucks, UK/www.kawasaki.co.uk
Yamaha Bear Tracker 250X		199	1.080	230	330	UK	£2,999	Yamaha Motor UK Ltd. Surrey, UK/www.ex-scape.co.uk
Yamaha Big Bear 400FW		273	1.155	386	500	UK	£4,849	Yamaha Motor UK Ltd. Surrey, UK/www.ex-scape.co.uk
Yamaha Kodiak 400AN		233	1.085	401		UK	£3,999	Yamaha Motor UK Ltd. Surrey, UK/www.ex-scape.co.uk
Yamaha Kodiak 400FWAN		248	1.085	401		UK	£4,799	Yamaha Motor UK Ltd. Surrey, UK/www.ex-scape.co.uk
Yamaha Kodiak 450FWAN		250	1.085	421		UK	£5,349	Yamaha Motor UK Ltd. Surrey, UK/www.ex-scape.co.uk
Yamaha Grizzly 660FWA		272	1.155	660		UK	£5,949	Yamaha Motor UK Ltd. Surrey, UK/www.ex-scape.co.uk

† Guide price figures are based on available data from the APF International Forest Machinery Exhibition which was held in Lockerbie, Scotland in September 2002

TABLE D.2: Selected data for Small-Scale Forwarders - Mini Tractors

Item	HP	Weight kg	Width m	cc	Towing Capacity kg	Location of Distributor	Guide Price† Stg £	Manufacturer/Distributor/URL
Logbear F4000 +powered trailer	66	4100	1.8		4.0T	Finland		Logbear, Finland
Terri ATD (All Track Drive)								
+ powered trailer	28	2,890	1.46		3.5T	Sweden		THT AB, Sweden
Terri S2000	23	1,190	1.46			Sweden		THT AB, Sweden
Scorpion 903	23	1,890	1.5		2.0T	Sweden		Compaktskotaren I Arjang AB, Sweden
Scorpion 1205	34	2,125				Sweden		Compaktskotaren I Arjang AB, Sweden
Vimek 606D	20	1,925	1.6		3.0T	Sweden		Vimek AB, Sweden/www.vimek.se
Vimek Minimaster 101	16	789	1.12		2.0T	Sweden		Vimek AB, Sweden/www.vimek.se
Alstor 8X8	16	780	1.46		1.2T	Sweden		Bohus Traktor AB, Sweden
Vivid 300DT	26	860kg	1.384	1028		UK	£8,500	BCS, www.kilworthmachinery.co.uk
Ferrari Vipar 30 AR	26	850	1.390	1029		UK	£7,641	Ferrari UK,/www.bcs.ferrari.it
Ferrari Vipar 40 AR	35	880	1.390	1372		UK	£8,498	Ferrari UK,/www.bcs.ferrari.it
Ferrari Vipar 30 RS	26	860	1.315	1029		UK	£7,799	Ferrari UK,/www.bcs.ferrari.it
Ferrari Vipar 40 RS	35	890	1.315	1372		UK	£8,666	Ferrari UK,/www.bcs.ferrari.it
Riko AGT 835T	35	1125	1.130	1551		UK	£8,300	Riko UK,/www.alpinetractors.com
Riko Vanth 6.30	26	860	1.087	1029		UK	£8,900	Riko UK,/www.alpinetractors.com
Riko Vanth 6.40	35	890	1.087	1372		UK	£8,300	Riko UK,/www.alpinetractors.com
Riko Ergo 6.60	50	1475	1.354	2084		UK	£13,500	Riko UK,/www.alpinetractors.com
Riko Ergo 6.80	75	1515	1.354	2084		UK	£15,000	Riko UK,/www.alpinetractors.com
Riko MARS 8.90RS	83	1945	1.291	2776		UK	£19,500	Riko UK,/www.alpinetractors.com

† Guide price figures are based on available data from the APF International Forest Machinery Exhibition which was held in Lockerbie, Scotland in September 2002

TABLE D.3: Selected data for Small-Scale Skidders, Trailers and Loaders

Item	HP	Weight kg	Width m	Reach m	Load Capacity T	Location of Distributor	Guide Price† Stg £	Manufacturer/Distributor/URL
SKIDDERS								
Turboforest TF-42C (cable)	50	3,400	1.9		5.5	North America.		www.lyonstimbertalk.com
Turboforest TF-42C (grapple)	50	3,400	1.9		5.9	North America.		www.lyonstimbertalk.com
TRAILERS								
Terri, unpowered for S2000						Sweden		THT AB, Sweden
Terri, unpowered, tracked for S2000						Sweden		THT AB, Sweden
Kolpe Trailers for ATCs								Kolpe Maskin KB, Sweden
RMT 280		190	1.28		1.5	UK	£1,200	Caledonian Forestry Services Ltd./ www.caledonianforestryservices.co.uk
Novajack		200	120		0.9	North America		www.novajack.com
Vimek 4WD Bogie trailer		314	1.32		2.0	Sweden		Vimek AB, Sweden/www.vimek.se
LOADERS								
RMT 280		165		2.8	0.22	UK	£3,550	Caledonian Forestry Services Ltd./ www.caledonianforestryservices.co.uk
Vimek 362		235			0.25	Sweden		Vimek AB, Sweden,/www.vimek.se
Vimek 420		285			0.30	Sweden		Vimek AB, Sweden,/www.vimek.se

† Guide price figures are based on available data from the APF International Forest Machinery Exhibition which was held in Lockerbie, Scotland in September 2002

TABLE D.4: Selected data for Other Small-Scale Harvesting Equipment

Item	HP	Weight	Width	Reach	Load Capacity	Location of Distributor	Manufacturer/Distributor/URL
PEDESTRIANISED SKIDDERS							
Oxen	11			20	1.0	England	Image Forestry, West Sussex, UK.
Goliat	7	297	1.030		1.0	Ireland	F.M. Marr and Sons Ltd., Foxrock, Dublin 18
Wood Caddy	5	205	1.08		1.0	Scotland	ElectroMekan AB, Sweden/A.Maclarty Ltd.,Pertshire, Scotland
Iron Horse Piraya	5	430	1.08		1.0	Scotland	ElectroMekan AB, Sweden/A.Maclarty Ltd.,Pertshire, Scotland
Iron Horse Pro	5	300	1.08		1.2	Scotland	ElectroMekan AB, Sweden/A.Maclarty Ltd.,Pertshire, Scotland
WINCHES							
Kolpe 500						England	Image Forestry, West Sussex, UK.
Kolpe Radio-tir 740	6	150		150	0.8	Sweden	Kolpe Produkter AB, Filipstad, Sweden
Kolpe Radio-tir 1200	10	170		110	1.2	Sweden	Kolpe Produkter AB, Filipstad, Sweden
Sollid “Timberjack”	5.5	50		40	1.0	Norway	Sollid MEK, Verksted A S, Surna, Norway
Flying saucer winch	16	450		125		Sweden	Nordfor Teknik AB, Virkmanshyttan, Sweden
OTHER EQUIPMENT							
JR Hand Logging Arch		25			40 cm diam.	US	www.futureforestryprod.com
Sk00idding cones						US	www.futureforestryprod.com