Applications of Small-Scale Forest Harvesting Equipment in the United States and Canada

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Executive Summary

The likelihood that an increasing share of the nation's timber supply will be obtained from relatively small tracts or uneven-aged, mixed-species stands poses a number of challenges to harvesting technology. Cost-effective and flexible harvesting systems must simultaneously meet evolving criteria for safety and minimal site/stand impact. While the current generation of highly productive, capital-intensive harvesting machinery is well-suited for working in clearcuts, especially in large stands, its application is limited in small stands or where partial cutting is prescribed. Small-scale equipment is becoming more readily available that can help minimize the capital and operating costs associated with partial harvests or when operating on smaller tracts. However, contractors and landowners may not have access to information about the costs and benefits of the new technology.

This report aims to address that information gap by 1) conducting a review of current literature germane to small-scale equipment applications and 2) summarizing information from separate surveys of suppliers/manufacturers of harvesting equipment, and forestry extension and engineering experts, respectively.

Tract size and heterogeneity are important determinants of in-woods operating costs. Smaller equipment with lower capital cost can optimize at lower levels of productivity, and also is easier to move between jobs. Few studies have assessed site or stand impacts as explicit functions of the size of small-scale timber harvesting equipment. Those that have note that, while lighter, more maneuverable machines generally result in less residual stand damage, they may also result in more skid trail construction than would be the case for larger equipment. Small-scale systems also require more operator skill to maximize productivity, are more labor intensive, and may be less safe to operate compared to larger equipment.

Tractor-based systems are the most common type of small-scale equipment, since generic farm tractors may serve as carriers for harvesting heads, loading grapples, skidding winches or forwarding trailers. Small excavators or skid-steers may also be adapted to a variety of tasks. Two-machine systems minimize the downtime that might be required for changing attachments, and therefore can maximize productivity. However, as some of these pieces of machinery were not designed with the appropriate safety features for working in the forest, the full costs of making the necessary machine modifications to ensure operator safety and comfort must be figured into the price of the system. One problem is that most specialized logging attachments and small-scale logging machines are imported from Europe or Canada, which increases their cost to the US buyer. Information regarding size, capacity, price and distributors for selected categories of small-scale equipment (harvesters, forwarders, trailers, skidders, yarders and winches) has been summarized in a series of tables in Appendix B.

A survey of timber harvesting experts revealed a consensus that smaller equipment minimized capital investment, but with a sacrifice of productivity. However, under certain conditions smaller equipment can be more efficient than large, less maneuverable machines. While a majority of respondents thought that future changes in the forest industry would favor increased use of small-scale equipment, they considered the relatively low productivity of such equipment to be a major obstacle to its adoption.

Introduction

The number of tracts of forest land less than 100 acres in size which are owned by nonindustrial private forest landowners has grown 16.4% since 1978 (DeCoster, 1998). The change in ownership patterns, combined with increasing restrictions on the availability of timber from federal forest lands, suggests that a larger proportion of the nation's future timber and fiber supply will have to come from small tracts of privately held land. Small non-industrial private forest (NIPF) landowners frequently do not place timber management as their primary objective, instead preferring to emphasize other resources, such as wildlife, recreation or aesthetics. At the same time, there are extensive acreages of pine plantations, particularly in the South, that will be reaching thinning age in the near future (Wilhoit and Rummer 1999). There is increasing interest in uneven-aged management in many parts of the country as markets evolve to utilize species that require that silvicultural system. Harvesting smaller timber from smaller or more heterogenous stands poses a number of challenges to harvesting technology. These arise from the need for cost-effective and flexible harvesting systems that simultaneously meet evolving criteria for safety and minimal site and stand impact. Some NIPF landowners may prefer smaller harvesting equipment because they perceive it as being more environmentally "friendly", thus providing a lucrative niche market where small-scale loggers can compete effectively (Marui et al. 1995).

Much of the development of harvesting technology in the United States has focused on highly productive equipment for clearcut harvesting. Because most of this equipment is relatively large in size, it is difficult to realize its full productivity potential when operating in small or heterogenous stands or when conducting uneven-aged management or thinning activities. As equipment productivity drops, operating costs may rise. Site impacts may also be exacerbated by the necessity of maneuvering large, heavy equipment in restricted spaces. The use of small-scale equipment[1] can help reduce capital investment and operating costs associated with intermediate stand treatments and smaller tract sizes. Minimizing capital investment and debt load is frequently cited as an important consideration by smaller operators (Van Goetham 1995, 1999).

The advantages of small-scale technologies have long been recognized in Scandinavia, where small-scale harvesting equipment has been available for some time. Importers in Eastern Canada and, to a limited extent, the US have begun to make this equipment available in North America. However, information about the costs and applications of this equipment is not widely available to most loggers and foresters in the US. Without exposure or access to such information, these individuals are less likely to modify their equipment purchasing decisions or timber sale prescriptions.

This project aimed to address this information gap based on separate surveys of 1) suppliers and manufacturers of forest harvesting equipment; 2) knowledgeable individuals in the field of forest harvesting, who provided informed speculation regarding potential applications for, and constraints on the use of, small-scale equipment. Manufacturers also provided specifications and prices for specific items of equipment currently available in the US and Canada. The summaries of survey information are prefaced by a review of literature relevant to the evaluation of

[1]For the purposes of this report, "small-scale" harvesting equipment is generally defined as meeting the following criteria for base machines: weight $\leq$ 9525 kg (21,000 lb), width $\leq$ 2.4 m (8 ft), engine power $\leq$ 60 kW (80 hp). Cable yarder tower heights are $\leq$ 15.3 m (50 ft). Selected equipment that met some but not all of the criteria has been included in Table 7 of Appendix A.

small-scale equipment systems.

The report is intended as a resource for forestry professionals, particularly extension personnel, who are interested in exploring or promoting the uses of small-scale harvesting technology. It describes the information-gathering procedures used, summarizes literature information available with respect to small-scale harvesting, and synthesizes the the informational survey of forest harvesting professionals. The detailed results the surveys of equipment manufacturers and harvesting professionals are provided in Appendices A and B, respectively. Finally, a reference list of bibliographic resources is included as Appendix C. The bibliographic list is composed largely of technical publications looking at the economic or environmental aspects of small-scale harvesting, or reviews of specific items of equipment.

Methods

In April 1999 a letter was mailed to about 100 forestry equipment manufacturers and distributors to request information regarding any small-scale equipment that they distributed (Appendix A). The mailing list was compiled from various sources, including industry lists and Websites (such as forestindustry.com), trade magazines, and University of Minnesota Forestry Extension lists. It included numerous European as well as North American manufacturers. A second letter was sent out to non-respondents two months later to repeat the request, and included a stamped postcard on which they could indicate whether they actually manufactured or distributed forestry equipment that conformed to the size specifications provided (see Footnote 1). Information from manufacturers/distributors, was compiled into tables that included basic size and capacity-related information, approximate price (where it could be obtained), and a contact number for the North American distributor who provided information for each item (Appendix A).

In August 1999 informal surveys were mailed to 40 forestry professionals throughout the US Their names were obtained based on personal acquaintance, industry and professional association lists. The object of this survey was to solicit their informed opinions about the appropriateness, potential applications for, and constraints on the use of small-scale harvesting equipment. While the initial mailing was not followed with a reminder, a number of survey recipients were contacted personally to urge their response to the survey. Survey results are summarized briefly below and in detail in Appendix B.

Literature Review

In order to place information about specific harvesting equipment and systems in a larger context it is necessary to scope out existing research on such systems. Applied research on harvesting systems has concentrated in three broad areas: engineering and operational efficiency, comparative site/stand impacts and economics. Because this review is concerned with both operational and economic benefits and costs, the gist of the available information is summarized in a Benefits *vs* Costs framework. This is followed by general descriptive information about the requirements for effective small-scale systems and system recommendations.

Benefits of Small-Scale Equipment

Small-scale harvesting technology offers distinct advantages to the owner who expects a majority of his/her work to be in small tracts, on sensitive sites or in uneven-aged management activities. In the specialized market for thinnings and small harvest units, operators with appropriately-sized equipment may have a competitive advantage over those with only larger equipment. A primary advantage is reduced capital investment and operating costs. Lower levels of residual stand and soil damage are also important considerations. Both economic and environmental considerations will be affected by site conditions, stand density, operator skill and other factors.

Harvesting costs are extremely sensitive to tract size (Cubbage 1983, Wilhoit and Rummer 1999). Increasing average costs with smaller tract sizes are largely a result of the higher setup and moving costs associated with large and complex equipment. The opportunity costs arising from increasing specialization of equipment (i.e., limited range of applications) can also inflate operating costs if machinery cannot be optimally employed. The development of forestry attachments such as grapple loaders, logging winches, harvesting and processing heads for general-purpose farm tractors can make mechanization more affordable for the small-scale operator (Nilsson 1982, Sennblad 1995, Johannsson 1997b). The lower fixed costs of small-scale equipment can more than compensate for its lower productivity, resulting in increased net revenues per harvesting unit. Operational differences between various equipment systems (load capacities, number of trips needed, maneuverability, operating and repair costs) also influence total harvesting costs.

Minimizing residual stand and soil damage is a particularly important consideration for many NIPF landowners. Smaller, lighter equipment can help reduce this damage. Unfortunately, much of the evidence for reduced stand impact is anecdotal, as there have been few studies that rigorously documented site impacts in relation to equipment size. Available research has demonstrated that appropriate equipment should be combined with good sale planning to minimize the number of skid trails and the amount of machinery movement required (Ryder et al. 1994). Sale planning also should conform to the equipment that is locally available. A German study showed that when a harvester was used for thinning, residual stand damage was minimized by placing trails close enough together so that the harvester could reach all the trees in each block, rather than having inaccessible trees felled by hand and skidded out to the main trail (Bort 1994). Good planning and flexibility on the part of the logging crew were among the most important factors in limiting damage during harvesting trials in British Columbia (Kockx et al. 1993). The use of specialized forwarders or logging trailers can also help avoid skidding-related damage to residual trees and trail surfaces, reduce the necessity for constructing high-quality in-woods roads, and expand the range of feasible operating conditions (Jackson 1987, Lanford et al. 1991).

Another approach to minimizing environmental impact is through the use of cable (skyline) logging techniques. While these systems can require a larger capital investment than simple ground-based logging systems, trailer- or tractor-mounted yarders and lightweight carriages can make them feasible for the smaller operator. Performance of small yarding systems on steep slopes and soft soils has been evaluated in numerous studies (e.g., Fisher et al. 1980 and 1984, Baumgras and Peters 1985, Gorse et al. 1985, Huyler 1986, LeDoux et al. 1990 and 1991).

Residual stand and soil damage is generally reduced over skidder-based logging systems. The most effective protection is achieved when logs are shorter and can be completely suspended (LeDoux et al. 1994). However, harvesting smaller, shorter logs can nearly double per-unit costs.

Disadvantages of Small-Scale Equipment

Small machines are less productive than large machines, and loggers will sacrifice revenues if they attempt to use small-scale harvesting systems in stands or harvest types where larger machines could operate efficiently. Full-time loggers who expect to encounter a range of stand types, including trees larger than about 20-in dbh, steep slopes, or final rather than partial or intermediate harvests, will probably opt for larger equipment that will maximize productivity under those conditions (see Survey Results; Appendix B).

Because most of the currently-available specialized small-scale equipment is imported into the US from Europe or Canada, its cost is relatively high compared to machinery of domestic manufacture. This situation seems unlikely to change in the near future. In addition, there is not yet a substantial used market for such equipment. Buying used equipment offers an inexpensive way for smaller or entry-level owners to overcome prohibitive financial barriers.

Another issue for potential North American buyers is operator ergonomics and safety. Low-cost systems based on tractors and small excavators do not optimize operator comfort; for example, back and neck problems can result from prolonged travel over unprepared forest floors (Bjerkelund 1994), while the lack of a rotating seat can be a significant disadvantage when operating rear-mounted cranes or winches (Sennblad 1995). Incorporating after-market safety equipment on non-forest equipment, such as farm tractors, to make it safe for in-woods use can raise the machine price. The cost of machine modifications to improve operator comfort and safety must therefore form part of the overall cost estimates.

The environmental conclusions are also not all positive. Residual stand damage can actually be exacerbated under some circumstances, for example, if the number of trips or number of skid trails required by the smaller equipment outweigh its size advantages. Not only carrier capacity but its maneuvering characteristics must be considered when predicting site impacts. A small walk-behind tractor actually did more damage than a conventional tractor during a partial harvest of northern hardwoods, because of the need for extra maneuvering and directional felling to accomodate the former's loading characteristics (Huyler et al. 1994).

Another issue is that of relative tire sizes and the associated ground pressures. Small machines with narrow tires, such as conventional farm tractors, can cause more rutting than heavier machines that use high-flotation tires, especially on soft ground. It has been recommended that oversize tires be used to minimize soil impacts and maximize traction efficiency, and that inflation pressures be the minimum recommended by the manufacturer (Burt et al 1982, Koger et al. 1982). However, lower tire inflation pressures may also reduce fuel efficiency under some circumstances (Hassan and Sirois 1984).

Finally, the efficiency of small-scale harvesting systems is more dependent on operator training and skill than is the case with large harvesting equipment, due to the lower level of horsepower available. Obtaining and retaining reliable labor may be an issue in some areas, but

the retention of a skilled crew of equipment operators is critical to realizing the impact-reduction potential of small-scale systems. In addition to finesse with respect to equipment operation, it is more important to design timber sales so as to minimize the number of trips and trails that must be made. If, as noted above, the use of small-scale equipment is accompanied by a concomitant increase in the density of the trail network, the net result could be more residual stand and soil damage than if large machines with long reaches had been used. More trails can result in increased long-term loss of soil/site productivity.

Descriptions of Small-Scale Systems

There are a number of ways to minimize harvesting costs and site impacts while maximizing productivity in the harvest of small volumes. Wilhoit and Rummer (1999) and Vickers (1999) have provided criteria by which to evaluate the effectiveness of small-scale harvesting systems. These include low capital cost, low transportation cost and overhead, maneuverability, minimal access requirements, and the ability to optimize (load capacity) quickly and to deal with small-diameter or irregular material. A survey administered by the US Forest Service identified additional desirable characteristics for small-scale base machines (Beckley and Windell 1999).These included boom reaches of 25 feet, turning radius of less than 12 feet, and ability to work on slopes up to 65%. The authors noted that none of the machines currently available meet all of the criteria they identified.

Small-scale harvesting may be accomplished using either single- or two-machine systems. The single-machine system may involve a tractor or a tracked skid-steer type of machine that is either used exclusively for bunching and skidding or forwarding the felled timber, or alternately for felling and forwarding operations. Many tractors have been extensively evaluated for their potential in forestry applications (see below). Small, tracked skid-steers (Wilhoit and Rummer 1999) or small excavators (Greulich 1996, Johansson 1997a) can be appropriate carriers for shear heads or harvesting heads, capable of processing individual logs at the stump. Harvesting heads require stable base machines of sufficient weight and power rating (approximately 15,000 lbs and 80 HP, in the case of the Patu 400, a lightweight harvesting head). An increasing number of (mostly) European manufacturers are making light harvester heads suitable for mounting on small excavators or tractors. The flexibility provided by a harvester head on a boom can maximize productivity and minimize site impact by minimizing the amount of machine movement required. A key element in the single-machine system is the ease with which attachments can be interchanged. Therefore mounting systems need to be simple in order to facilitate a rapid changeover between attachments.

If a manual chain saw is used for a separate felling operation, the owner will benefit from a single machine that can bunch/forward/skid the wood as necessary, and also load it at the landing. Small excavators or skid-steer type machines can be adapted to these tasks. Three-wheel machines such as the Bell Logger[2] (Gleason 1985), or tracked skid-steers such as the ASV Positrack can be adapted for most forwarding and loading operations, as well as for felling.

[2]The use of trade, firm or corporation names in this paper is for the convenience of the reader. Such use does not constitute an official endorsement or approval by the University of Minnesota, the US Department of Agriculture or the US Forest Service of any product or service to the exclusion of others that may be suitable.

Grapple attachments may be mounted on small excavators weighing as little as 3,000 lb. Such light-weight machines have small footprints and high maneuverability, and can work very well in close quarters (i.e., dense stocking, narrow trails, small landings). However, some of these machines have limited usefulness under very steep conditions (slopes exceeding 40%).

A two-machine system, comprised of separate felling and forwarding/skidding machines, may be more cost-effective in the long run than a single machine, if machine downtime (due to the necessity for changing attachments) is a concern. In such a system the first machine will be dedicated to felling and possibly processing, while the second will forward or skid the cut material. Typically the transportation is accomplished with either a specialized forwarder or a 4-wheel-drive tractor with a skidding attachment or logging trailer. The tractor-based system is the lower-cost alternative. Wilhoit and Rummer (1999) estimated productivity at a maximum of 75 cords/week for a two-machine system based on a small tracked harvester and logging trailer pulled by a tractor.

Logging trailers or forwarders equipped with a loading boom can boost productivity while lowering overall costs. The cost savings result from minimizing the need to construct or improve access roads (Gaskin 1985), while enabling the transport of logs over relatively long distances from stump to roadside. In addition, loader-equipped forwarders can unload directly onto a truck at roadside. A variety of forwarder and trailer models suitable for smaller operations have become available from manufacturers such as Farmi (Normet) and Patu.

The farm tractor is the machine most frequently adapted for small-scale forestry operations. Some advantages of using a farm tractor (rather than a special forest tractor) as a base machine or multi-purpose carrier (Sennblad 1995) include its relatively low price (due to mass production), ease of obtaining parts and service, and well-proven technology. Since the tractor is a generalized machine, it can be adapted to several different tasks. It also has good resale value.

Applications of the farm tractor include harvesting, processing, skidding and loading. At a minimum, a special logging winch will need to be mounted on the tractor's 3-point hitch to enable tractor skidding (Shaffer 1992). However, equipment can be mounted on both the front and the rear of the tractor. Sennblad (1995) reports that a 4-wheel-drive, 115 HP tractor was tested both for harvesting and forwarding in 80-year-old mixed pine in Sweden. Total equipment costs were roughly $124,000, including the tractor, loader with grapple, harvester unit and trailer. The productivity of this system compared favorably with that obtained from a conventional harvester unit in similar stand conditions. In addition to carrying harvesting attachments, tractors can tow either conventional, bogie-wheeled or powered trailers for forwarding (Folkema 1987).

Farm tractors used for forestry will require modifications, both to improve functionality and to comply with safety standards, such as the OSHA Logging Safety Standard (29 CFR 1910.266). These modifications may include an OSHA-approved roll bar, reinforced belly pans, liquid-filled rear tires, radiator guarding, valve stem protection, engine guarding, cab protection, safety glass, a hydraulic tank, extra oil pump and crane mounting points (Nilsson 1982, Shaffer 1992, Johansson 1997b).

Wheeled loaders or tracked excavators may also be used as base machines. Wheeled machines have some advantages in very rough terrain since the rigid undercarriages of tracked excavators do not adapt very well to uneven surfaces. Loaders or excavators may also require extensive

modifications (e.g., drive chain guides, reinforced belly pans, safety glass windshield, quick connect hydraulic couplings, air compressor, oil pumps, separation of leak oil filter from the hydraulic motor) (Johansson 1997a). The better mobility and lighter impact of tracked machinery on soft ground, and the possibility of using excavators for other types of work such as ditching, scarifying and other earth-moving tasks increases the attractiveness of this option.

Skyline cable yarding systems can minimize soil disturbance by eliminating the need for off-road operation of heavy equipment. Low-cost cable yarding systems can be adapted from old two-drum hauling units for mounting on tractors or trailers (Simpson 1985). The carriages for these systems could range from simple blocks to sophisticated mechanized carriages. Cable systems for small operations can be rigged either through short lattice towers or trees, although the latter approach raises safety concerns.

In some areas, such as Quebec and parts of Scandinavia, woodlot owners use all-terrain-vehicles (ATVs) as base machines for small harvesting jobs (Office des Producteurs de Bois de le Région de Québec 1998). ATVs used for logging-related activities, principally hauling and skidding, must have at least 300 cc engine capacity and integral 4-wheel-drive. Desirable ATV modifications include the addition of tracks or traction chains to the rear wheels, weighting the tires with liquid and placing a counterweight on the front. Other equipment that may be added to an ATV include a front bumper, a protective belly pan under the engine, foot guards and a recovery winch. Grapples, pans or cones, mini-skidders, sleds and modified trailers are available for skidding or hauling logs under 16-in diameter, depending on the type of material and forwarding distance. ATVs may not be practical for forwarding distances exceeding $\frac{1}{2}$ mile.

Sources of Information About Logging Equipment

In the US, there is no unified source for technical and cost information about logging equipment. However, several of the research laboratories of the US Forest Service have conducted research and evaluations of harvesting systems and machinery over many years. Most of these laboratories are accessible via the World Wide Web, and provide publication lists. Laboratories that have been particularly active in this area include the San Dimas Technology and Development Center in California, which has published a comprehensive catalog of small-scale equipment (USDA Forest Service 1992), the Forest Operations Research Unit of the Southern Research Station in Auburn, Alabama, and similar units in the Forestry Sciences Laboratories in in Corvallis, OR, Morgantown, WV, and Houghton, MI. All of these units maintain Web sites that can be accessed through the USFS Research directory at www.fs.fed.us/research/reslocations.htm.

The Council on Forest Engineering (COFE), based in Corvallis, OR, also produces regular publications that present research on harvesting technologies. These are listed under Publications on their website at www.cofe.org.

In Canada, the best source for equipment-related information is the Forest Engineering Research Institute of Canada (FERIC), which has produced numerous publications that evaluate harvesting machinery and systems. Information about FERIC publications can be obtained from their website at www.feric.ca. FERIC has also developed a database of logging equipment currently in use across eastern Canada, based on information supplied by current users (McPhee

1992). At this point there is no Web-based access to this database, however, requests for information can be sent to:

FERIC - Eastern Division
Wood Harvesting Group - Logging Databank
143 Place Frontenac
Pointe Claire, Québec H9R 4Z7
Canada
(514)694-1140

For a broader focus, the International Union of Forest Research Organisations (IUFRO) maintains a working group (Research Group 3.08) for Small-Scale Forestry, which periodically sponsors or participates in conferences or symposia whose proceedings are published, in addition to releasing a newsletter. The newsletter and publications lists can be found through the Research Group Website at www.ersac.umn.edu/iufro/iufronet/d3/hp30900.htm.

Until 1998, the Swedish University of Agricultural Sciences Department of Forest Extension conducted an active engineering research program and published a biannual newsletter, "Small-Scale Forestry", which disseminated a wealth of research information regarding applications for small-scale forest equipment, including tractors. Although the newsletter is no longer published, back-issues are available by contacting Gottard Sennblad at Infoskog-Inforest AB (a consulting firm), email: gottard.022521062@telia.com. The mailing address is:

Infoskog-Inforest AB (www.garpenbergs-utv.se/ginfo1e.htm)
Garpenbergs UtvecklingsCentrum
S-776 89 Sweden

An extended bibliography of some relevant publications is presented in Appendix C.

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Potential Applications for Small-Scale Harvesting Equipment Survey Summary

An informal survey (Appendix B) was mailed to 44 forestry professionals in the US, Canada and Europe eliciting their opinions on the current and potential applications for small-scale harvesting equipment. The list of individuals was compiled based on personal references, industry and professional organizational listings. The survey was comprised of ten short-answer questions aimed at evaluating the extent of each respondent's experience with small-scale harvesting technology, and their judgements regarding its appropriateness and potential usefulness in the current economic and regulatory environment. Detailed results are presented in Appendix B, but some highlights are summarized below.

A total of 17 individuals responded to the survey. This was not a sufficient sample size on which to base any sweeping conclusions. However, the respondents represented a wide range of informed opinion from a variety of backgrounds. Four respondents were researchers, 5 were involved in extension, 1 in both research and extension, 4 in industry, 1 in public land management and one in forestry consulting. The majority of US respondents were from the eastern half of the country although individual responses came from Colorado and Washington. All the industry respondents were from Minnesota. One response was received from Canada and one from Denmark.

Current and former use. Small-scale harvesting operations are more prevalent in the eastern and southern US than in the West or Midwest. However, most harvesting operations in Europe are"small-scale" by US standards. The most common systems in the US appear to be tractor-skidding in combination with chainsaw felling. About half the respondents thought that small-scale systems were more used in the past than today, and that use levels had declined for economic reasons, such as rising labor costs that necessitated increased productivity per unit of labor. Higher safety standards, and the greater hazards of chainsaw-based felling, were also an issue.

Personal experience and applications. Over half of all respondents had some direct experience with small-scale equipment. They cited lower capital, operating and transport costs and lower site impact as advantages of small equipment. The main disadvantages were the lower payloads and productivity. Respondents thought that operator experiences with this type of equipment had been largely positive, but that reliability could be a problem. High levels of operator skill and training can be more critical where equipment capacity is limited. Business conditions for small-scale operators appear to vary by region.

Most respondents considered that small-scale equipment was more appropriate for small woodlots, commercial thinnings, specialty sales and sensitive sites. Sites where high productivity is essential, such as large clearcuts, salvage operations or harvests of large trees, were considered unsuitable for small-scale equipment.

Potential and challenges for future use. A majority of respondents thought that future changes in forestry markets and industry structure would favor the increased use of small-scale equipment. To support this viewpoint they noted the increasing frequency of partial cuts, increasing stumpage costs, and decreasing sale sizes. However, increasing stumpage and labor

costs were also cited as a justification for moving to larger, more productive equipment. In addition, a lack of markets and infrastructure for dealing with small, fragmented harvesting operations was cited as an impediment to the expansion of small-scale logging (see NC comment on page 39, Appendix B).

Part-time loggers, including NIPF owners and hobbyists, were generally considered to be the most likely users of small-scale equipment. Specialty loggers of high-value products such as cedar, which aren't amenable to highly mechanized processing, could also profitably operate small-scale systems. The main constraint is that the operator is not wholly dependent on logging income, and therefore can tolerate a lower level of productivity.

The relatively low productivity of small-scale systems poses the greatest challenge to their increased future use. Changes in the forestry infrastructure (contracting, purchasing and transportation systems) could facilitate the wider adoption of such systems. The increasing importance of NIPF landowners will also shift the economics in favor of smaller equipment. Small equipment not only must cost less but must be powerful enough to handle a wide range of material, and safe enough to meet industry safety standards. Operators must learn different techniques to be efficient with smaller machines.

Conclusion. There is widespread recognition of the potential role of small-scale equipment in the total timber supply picture. Lower-cost equipment can help offset the higher labor costs and lower productivity, as well as mitigating the site impacts associated with harvesting small tracts, sensitive sites and mixed timber. However, the current market structure does not favor the widespread adoption of these systems. Technical improvements may result in lower costs and improved productivity for specialized forestry equipment. Nevertheless, these machines seem unlikely to see extensive use until market conditions have evolved to recognize new constraints in the timber supply.

Appendices

APPENDIX A

Equipment Data

This database includes a list of US-available equipment for which we were able to obtain specifications from the manufacturer or nearest distributor, including size/power specifications and operating criteria. Equipment without a US or Canadian distributor is not listed. The distributors are listed as suggested contacts and are generally those closest to Minnesota – in a few cases they are the only North American distributor. List prices (in $ US) were included where they could be obtained, and generally apply to the period of November 1999 – January 2000. These are approximate prices provided by distributors for new equipment in its most basic configuration. Actual prices may vary widely depending on location, shipping distance, options requested and local discounts. Because budget limitations as well as equipment size were a concern in the preparation of this report, individual items of equipment with quoted prices over $250,000, including most harvesters, were not included in this listing.

Table 1: Selected data for small-scale skidders, forwarders, trailers and loaders. Prices are as of December 1999.[1]

Item	HP	Weight (lb)	Width (in)	Reach (ft)	Load Capacity (lb)	Price $US	Distributor
SKIDDERS							
ATV Mini-Skidder 2001/Man. winch		200	45		2000	530	The Forest Universe, Inc.
Turboforest TF-42C(cable)	50	9,140	75		11,500	62,500	Lyons Equipment Inc.
Turboforest TF-42C(grapple)	50	9,140	75		13,000	75,000	Lyons Equipment Inc.
ZTS LKT50(cable)	64	10,000	75		8,000	79,665	Salix Trading
FORWARDERS							
ASV Positrack MD2800	70	7,450	69				Ziegler Inc.
ASV Positrack MD2810	75	7,450	69				Ziegler Inc.
ASV Positrack HD45	80	8,500	69				Ziegler Inc.
ATV Forwarding Arch					1,:000	1,475	Future Forestry Products Inc.
JM 2000	100	14,392	90		9920		North-American Forestry Distribution, Inc.
Jonsered Iron Horse 125 S	5	727	42			6,895	Tilton Equipment Co.
Jonsered Iron Horse 125-PWW[2] S	5	727	42			9,249	Tilton Equipment Co.
Jonsered Iron Horse 129-PWW[2]	9	926	42			10,459	Tilton Equipment Co.
Turboforest T605	74		79	15	10,000	90,000	Lyons Equipment Inc.
TRAILERS							
Vreten SVR10		3,340	89		22,046	8,531	Crane Inc.
Vreten SVR12		4,365	89		26,455	15,808	Crane Inc.
Vreten HVV7		2,116	75		15,432	5,035	Crane Inc.
Vreten HVV8.5		2,381	89		18,739	8,018	Crane Inc.
Métavic 1050A		1,975	10·5				Distributions Payeur
Métavic M95		1,375	9·6				Distributions Payeur

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[1]While small tractors and excavators are important as base machines for harvesting, skidding, yarding and loading attachments, it was decided not to include specific information on tractors or excavators in this report, since such information is readily available from local implement dealers.

[2]Powered winch model.

Table 1, Harvesters, skidders, forwarders, trailers and loaders, continued

Item	HP	Weight (lb)	Width (in)	Reach (ft)	Load Capacity (lb)	Price $US	Distributor
Farmi Normet MPV 7000		1,940	73		15,400	8,500	Northeast Implement Corp.
Farmi Normet MPV 9000		3,300	83		20,000	11,000	Northeast Implement Corp.
Farmi Normet MPV 12 4WD		6,600	88		26,500	24,200	Northeast Implement Corp.
JMS 900 R		850	54		3,500	1,030	The Forest Universe, Inc.
JMS FOR 1005			58		5,000	1,992	The Forest Universe, Inc.
JMS FOR 1205			73		10,000	2,541	The Forest Universe, Inc.
JMS FOR 1207			79		14,000	2,748	The Forest Universe, Inc.
Majaco R-Flex 410		800	55		12,000	2,793	LM Products
Majaco R-Flex 512		1,300	65		15,000	3,546	LM Products
Majaco R-Flex 612		1,565	77		20,000	3,869	LM Products
Patu 70		1,980	76		15,:400	2,410	Edney Distributing
Patu 80		2,180	82		17,600	2,727	Edney Distributing
Patu 80HD		2,580	82		17,600	13,900	Edney Distributing
Patu 110		3,280	87		22,000	10,500	Edney Distributing
Patu 110HD		4,800	89		22,000	22,700	Edney Distributing
Patu 110MD		7,020	98		22,000	32,400	Edney Distributing
LOADERS/LOADING CRANES							
Farma 106 crane		800		10	1,500	5,633	The Forest Universe Inc.
Farma 126 crane		900		12	1,750	6,319	The Forest Universe Inc.
Farmi HK-series cranes		2,789			26'3"	12,750	Northeast Implement Corp.

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Table 1, Harvesters, skidders, forwarders, trailers and loaders, continued

Item	HP	Weight (lb)	Width (in)	Reach (ft)	Load Capacity (lb)	Price $US	Distributor
JMS 900 SR		450		9	900	4,740	The Forest Universe Inc.
Majaco M-105	13	875		10'6"	1,500	6,661	LM Products
Majaco M-120	13	1,100		11'6"	2,300	9,245	LM Products
Majaco M-140	13	1,200		13'6"	2,500	10,165	LM Products
Majaco M-160	13	1,300		15'6"	2,400	11,236	LM Products
Majaco M-180	13	1,800		17'6"	2,100	14,017	LM Products
MK-1 Grapple Loader (20 HP)[3]		770		13	1,100	6,113	The Forest Universe, Inc.
MK-7 Grapple Loader (30 HP)[3]		1,430		15	1,760	9,273	The Forest Universe
MK-12 Grapple Loader (50 HP)[3]		1,980		17	2,200	10,922	The Forest Universe
Patu 405		1,260		14	11,560[4]	7,600	Edney Distributing
Patu 525		1,500		16	14,580[4]	8,300	Edney Distributing
Patu 545		1,690		21	14,150[4]	9,200	Edney Distributing
Patu 577		1,820		17	19,520[4]	9,200	Edney Distributing
Patu 597		1,950		21	18,050[4]	10,500	Edney Distributing
Patu 625		1,830		16	27,200[4]	11,800	Edney Distributing
Patu 655		2,070		21	24,300[4]	12,800	Edney Distributing
Patu 805		2,290		26	22,100[4]	15,600	Edney Distributing
Patu 915		2,690		21	31,700[4]	15,200	Edney Distributing
Patu 925		2,890		27	28,700[4]	17,000	Edney Distributing

[3]For mounting on 3-point hitch of tractor; HP rating is minimum required.
[4]Crane lift capacity rated in foot-lbs, not lbs.

Table 2: Selected data for small-scale yarders. Prices are as of December 1999.

Item	Skyline Cap (ft)	Tower Ht (ft)	HP	Weight (lb)	Price $US	Distributor
Skylead Tower C-40 16000	2000	40	174		205,690	Skylead Logging Equipment Corp.
Diamond Swing D210	2700	42	218	66,000		Diamond Manufacturing
Koller K300[6]	1200	23	50	9,000	65,000	Northwest Harvesters
Koller K501[6]	1600	33	112	17,500	165,000	Northwest Harvesters
Miller Mono-Cable[7]	2000		13	1,500	25,000	Miller Timber Services
Thunderbird Tower TY40[6]		40	175	26,000		Ross Corporation
Thunderbird Tower TMY40		40	175	34,000		Ross Corporation
Thunderbird Swing TSY6140 SLR	2000	41	230	64,500		Ross Corporation
Urus I 300 Tower[8]	980	33	100		110,000	Global Forest Equipment
Urus II 400 Tower[8]	1300	40	105		139,000	Global Forest Equipment
Urus II 600 Tower[8]	1970	40	185		169,000	Global Forest Equipment

[6]Trailer-mounted yarders.
[7]Uses zig-zag blocks. This unit is no longer in production but the company is selling residual inventory.
[8]Tractor-mounted yarders.

Table 3: Selected data for motorized and slackpull skyline carriages. Prices are as of December 1999.

Item	Skyline (in)	HP	Load Cap (lb)	Weight (lb)	Price $US	Distributor
Eaglet Maki II Carriage					35,000	Skylead Logging Equipment Corp.
Eaglet Sky Carriage	$1\frac{1}{8}$	12	12,000	1,300	35,000	Eagle Carriage and Machine
Eagle II Carriage	$1\frac{1}{4}$	20	15,000	2,600		Eagle Carriage and Machine
Koller SKA 1	$\frac{5}{8}$			330	11,000	Northwest Harvesters
Koller SKA 2.5	$1\frac{1}{4}$			550	12,500	Northwest Harvesters
Maki III 2S Carriage	$1\frac{3}{8}$	22	20,000	2,800		Ross Corporation

Table 4: Selected data for harvesting heads and processors which can be mounted on small-scale harvesters or tractors. Prices are as of December 1999.

Item	Max Tree Diam (in)	Weight (lb)	Carrier Wt (min, lb)	Carrier HP min needed	Price $US	Distributor
Little Mite Tree Cutter	10	1,450		50	7,000	Renaissance Metals Inc.
Hahn HSG140	16.5	1,850	15,000	50	50,750	Hahn Machinery Inc.
Hahn HSG160	18	2,050		65	54,922	Hahn Machinery Inc.
Denharco HT 550	22	4,900	40,000	115		North Country Equipment
Fabtek Series 2000	13	2,400	16,000	55	59,000	Fabtek Inc.
Mighty Axe Tree Shear	15	570			5,250	MightyAxe.Com, Inc.
Patu 400 SH	18	870		80	32,000	Edney Distributing
Patu 405 RH	18	1,060		90	40,000	Edney Distributing
Patu stroke delimber	16	1,190	16,000			Edney Distributing
Ponsse H53	20.5	1,580		120	110,000	Ponsse USA
Ponsse H60	25	1,980		120	110,000	Ponsse USA
Valmet 945	22	1,584			50,000	Road Machinery & Supplies
TRACTOR-MOUNT PROCESSORS						
Hypro Thinning Processor 350	14	1,848		55	32,000	Scandinavian Forestry Tech
Hypro Thinning Processor 450	18	1,958		70		Scandinavian Forestry Tech
Hypro Thinning Processor 500	20					Scandinavian Forestry Tech
NIAB-5-15B Processor	20	2,271		40		Silvana Import Trading

Table 5: Selected data for tractor winches. Prices are as of December 1999.

Item	Max Line Pull (lb)	Max Line Speed (fpm)	Max Cable Diam (in)	HP	Price $US	Distributor
Allied Tractor Winch W3C	51,000	95	$\frac{3}{4}$	85	9,870	Allied Systems Co.
Farmi Skidding Winch JL 290	6,400	17			1,940	Northeast Implement Corp.
Farmi Skidding Winch JL 351	7,720	17			2,450	Northeast Implement Corp.
Farmi Skidding Winch JL 351 P	7,720	17			2,540	Northeast Implement Corp.
Farmi Skidding Winch JL 501	11,025	40			3,290	Northeast Implement Corp.
Fransgard Tractor Winch V-2800	6,200	25			1,889	Edney Distributing
Fransgard Tractor Winch V-4000	8,800	40			2,475	Edney Distributing
Fransgard Tractor Winch V-6500	14,300	80			3,853	Edney Distributing
Fransgard Tractor Winch TW-3500	15,400	70			5,392	Edney Distributing
Mechanical Winch PW-1	5,500		$\frac{3}{8}$		1,305	The Forest Universe, Inc.
Mechanical Winch PW-2	6,200		$\frac{3}{8}$		1,442	The Forest Universe, Inc. QC, Canada, 418/667-5756
Hydraulic Winch RG-28	8,800		$\frac{1}{2}$		2,061	The Forest Universe, Inc.
Hydraulic Winch RG-34	15,000		$\frac{1}{2}$		3,091	The Forest Universe, Inc.

Table 6: Selected data for tractor skidding grapples. Prices are as of December 1999.

Item	Weight (lb)	Max Opening (in)	HP Needed	Price $US	Distributor
IMx 4836R	650	48	25	5,611	ImpleMax Equipment Co., Inc.
IMx 6042R	940	60	50	6,632	ImpleMax Equipment Co., Inc.
IMx 4836Rw grapple/winch	740	48	30	7,420	ImpleMax Equipment Co., Inc.
IMx 6042Rw grapple/winch	1,118	60	55	8,520	ImpleMax Equipment Co., Inc.
Little Red Logger	750	35	50	5,000	Renaissance Metals Inc.
Little Red Logger Jr.	500	36	<50	3,500	Renaissance Metals Inc.
Tractor grapple	638	78		1,717	The Forest Universe, Inc.

Table 7: Selected data for harvesters, feller-bunchers, skidders and forwarders which marginally exceed "small-scale" size specifications. Prices are as of December 1999.

Item	HP	Weight (lb)	Width (in)	Reach (ft)	Load Cap (lb)	Price $US	Distributor
HARVESTERS							
JM 2000 CS 440	140	21,000	84	19			North-American Forestry Distribution, Inc.
JM 2000 444B[9]	100	14,400	90	20	9,920	179,190	North-American Forestry Distribution, Inc.
Rocan T	113	14,110	83	22		227,436	Rocan Forestry Service, Ltd.
FELLER BUNCHERS							
Franklin 3600 HTFB, shear	152	15,100	108			133,000	Tree Farmer Sales
Franklin 3600 HTFB, saw	152	15,100	108			151,600	Tree Farmer Sales
MN, 218/751-5253							

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[9]Converts from forwarder to harvester by switching from a loading grapple to Patu harvesting head.

Table 7, Larger harvesters, continued

Item	HP	Weight (lb)	Width (in)	Reach (ft)	Load Cap (lb)	Price $US	Distributor
Franklin C 4500, shear	152	22,200	105			155,500	Tree Farmer Sales
Franklin C 4500, saw	152	22,200	105			174,100	Tree Farmer Sales
Hydro-Axe 321, shear (Blount)	116	20,150	112			125,000	Road Machinery & Supplies Co.
SKIDDERS							
Allied Ranger F65C (cable)	116	16,280	104			114,600	Allied Industries
Allied Ranger F65G (grapple)	116	19,400	107			137,260	Allied Industries
Caterpillar 515 Wheel Skidder	159	27,550				128,600	Ziegler Inc.
John Deere 540G (cable)	121	21,990	110			110,000	RDO Equipment
KMC SoftTrack 1000 (cable)	118	23,860	96			220,000	Kootenay Manufacturing
Timberjack 360 (cable)	148	22,464	98			117,000	St Joseph's Equipment
FORWARDERS							
Fabtek FT344B	125	24,500	104	17	16,000	144,000	Fabtek Inc.
Ponsse Caribou S10	122	26,180	104			246,000	Ponsse USA
Rottne Rapid G	118	26,235	104	22'8"	22,046	235,000	Blondin Equipment
Rottne Rapid (6WD)	118	22,487	104	22'8"	26,455	215,000	Blondin Equipment
Rotobec F2000B	116	18,500	103	18	9,920	134,500	Rotobec USA Inc.
Valmet 640 (4WD)	116	15,000				140,000	Road Machinery & Supplies
Valmet 840 (6WD)	127	25,798	102	22	24,000	250,000	Road Machinery & Supplies

Table 8: Address and contact data for distributors listed in Tables 1–7. Where distributors could provide neither an email nor a World Wide Web address, the manufacturer Web page is referenced.

Company Name	Address	Phone	Email address or URL
Allied Industries Inc.	267 Camp Lake Rd, Iron River MI 49935	906/265-4752	www.alliedsystemsco.com
Allied Systems Co.	2300 Oregon St., Sherwood, OR 97140-9799	503/625-2560	www.alliedsystemsco.com
Blondin Equipment	PO Box 1287, Indiana, PA 15701	724/349-9240	www.rottneusa.com

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Table 8, List of distributors, continued

Company Name	Address	Phone	Email address or URL
Crane Inc.	5118 State Route 365, Verona NY 13478	315/363-3390	www.vreten.se[10]
CTR Manufacturing	Route 1 Box 254, Union Grove, NC 28689	704/592-9011	www.ctrmfg.com
Diamond Manufacturing	3603 136th St. N.E., Marysville, WA 98271	360/653-4993	www.forestindustry.com/dmi/index.html
Distributions Payeur Inc.	5379 King St. East, Ascot Corner, Sherbrooke, QC J0B 1A0 Canada	819/820-0490	payeur.distribution@videotron.net
Eagle Carriage and Machine	2104 26th Street, La Grande, OR 97850	541/963-4646	www.forestindustry.com/eaglecarriage
Edney Distributing	8485 215th St. W, Lakeville, MN 55044	612/469-5267	edneyco@frontiernet.net
Fabtek Inc.	N1715 - US Hwy 41, Menominee, MI 49858	906/863-9977	www.fabtek.com
Future Forestry Products, Inc.	PO Box 1083,Willamina, OR 97396	503/876-4488	www.futureforestryprod.com
Global Forest Equipment	1109 Comox Rd., Courtenay, BC V9N 3P7 Canada	250/397-9050	www.globalforest-equipment.com
Hahn Machinery Inc.	PO Box 220, County Road 200 South, Two Harbors, MN 55616	218/834-2156	www.hahnmachinery.com
ImpleMax Equipment Co., Inc.	PO Box 549, Bozeman, MT 59771-0549	800/587-6656	www.implemax.com
Kootenay Manufacturing	606 Lakeside Drive, Nelson, BC, V1L 5S7 Canada	800/562-5303	www.forestindustry.com/kootenaymfg
LM Products	PO Box 452, 27601 County Rd. 50, Cold Spring, MN 56320	320/685-8672	www.tznet.com/newco/majaco.htm

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[10]At last check the English version of this web-page wasn't working.

Table 8, List of distributors, continued

Company Name	Address	Phone	Email address or URL
Lyons Saw Mill & Logging Equipment & Supl. Co. Inc.	Ltl Valley Slmnc Road, Little Valley, NY 14755	716/938-9175	www.lyonstimbertalk.com
MightyAxe.Com, Inc.	RR #1 Box 174, Independence, KS 67301	888/322-2068	www.mightyaxe.com
Miller Timber Services	24745 Alsea Highway, Philomath, OR 97370	541/929-2840	
North-American Forestry Distribution, Inc.	194, du Carrefuou, St-Antonin, Riviére-du-Loup, QC, G0L 2J0 Canada	888/376-6233	www.icrdl.net/nafd
North Country Equipment	3603 West Highway 2, Grand Rapids, MN 55744	218/326-9427	www.nortrax.com
Northeast Implement Corp.	Box 15A, Spencer, NY 14883	607/589-6160	www.valbysales.com
Northwest Harvesters Inc.	8828 N.E. Killingsworth, Portland, OR 97220	503/257-7696	www.forestindustry.com/northwestharvesters
Ponsse USA	PO Box 578, 987 Air Park Rd., Rhinelander, WI 54501	715/369-4883	www.ponsseusa.com
RDO Equipment	12500 Dupon Avenue S., Burnsville, MN 55337	612/890-8880	www.rdoequipment.com
Renaissance Metals Inc.	PO Box 194, New Richmond, WI 54017	715/246-4464	rmetal1@pressenter.com
Road Machinery & Supplies Co.	5633 W Hwy 13, Savage, MN 55378	612/895-9595	www.rmsequipment.com
Rocan Forestry Service, Ltd.	703 Malenfant Blvd, Dieppe, NB, E1A 5TB Canada	506/859-9906	www.rocan.com
Ross Corporation	460 North Danebo, PO Box 2577, Eugene, OR 97402	541/689-5031	www.thunderbird.net

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Table 8, List of distributors, continued

Company Name	Address	Phone	Email address or URL
Rotobec USA Inc.	162 Rotobec Drive, Littleton, NH 03561	717/235-0840	www.rotobec.com
Salix Trading Inc.	800 Hendry Ave., North Vancouver, BC, V7L 4C9 Canada	604/980-1182	www.forestindustry.com/salix
Scandinavian Forestry Tech	PO Box 427, Kingston, ID 83839	208/682-2002	www.forestindustry.com/forestrytech
Silvana Import Trading	4269 rue Sante-Catherine Ouest, suite 304, Montréal, QC, H3Z 1P7 Canada,	514/939-3523	silvana@total.net
Skylead Logging Equipment Corp.	PO Box 880, Enderby, BC, V0E 1V0 Canada	250/838-6845	www.forestindustry.com/skylead
St Joseph Equipment	4311 Haines Road, Duluth, MN 55811	218/727-3038	www.stjosephequipment.com
The Forest Universe Inc.	19 St-Edmond, Beauport, QC, G1E 5C9, Canada	418/667-5756	forest@oricom.ca
Tilton Equipment Co.	PO Box 68, Lafayette Rd., Rye, NH 03870	800/447-1152	tilton@nh.ultranet.com
Tree Farmer Sales Inc.	3735 New Hwy 71 N, Bemidji, MN 56601	218/751-5253	trfarm@mail.paulbunyan.net
Ziegler Inc.	901 W. 94th St., Minneapolis, MN 55420	612/888-4121	www.positrack.com or www.zieglerinc.com

APPENDIX B

Survey of Harvesting Experts

In order to collect some first-hand information regarding the current status of small-scale forestry applications, 44 forestry professionals in the US, Canada and Europe were informally surveyed regarding their opinions on the current and potential uses of small-scale harvesting equipment. The list of individuals was compiled based on personal references, industry and professional organizational listings. The survey attempted to solicit input from a substantial sample of professionals likely to be knowledgeable about small-scale forestry issues.

The survey was comprised of ten short-answer questions aimed at evaluating the extent of each respondent's experience with small-scale harvesting technology, and their judgements regarding its appropriateness and potential usefulness given the current status of markets and regulatory constraints. A single mailing was sent, with no follow-up reminders. A copy of the survey instrument is followed by detailed summaries of the 17 responses. Because of the small sample size, no attempt was made to provide a demographic breakdown of responses.

Cover Letter and Survey

FIELD(title) FIELD(firstname) FIELD(lastname)
FIELD(dept)
FIELD(company)
FIELD(address)
FIELD(city), FIELD(state) FIELD(zip)

February 24, 2000

Dear FIELD(title) FIELD(lastname),

The use of small-scale harvesting equipment can make thinnings or the harvest of limited volumes from small acreages more economical and feasible for loggers and landowners. However, information concerning the relative benefits and costs of small-scale equipment is not readily available to most loggers and foresters. Without access to such information, these individuals are less likely to modify their mix of equipment to adequately meet the requirements of the timber sale prescriptions for small acreages or thinnings.

We are preparing a review summarizing various small-scale timber harvesting equipment options for felling, forwarding, skidding, and yarding operations. Individual attachments that facilitate small-scale harvesting (e.g., harvester/processor or feller-buncher heads, grapples, winches and carriages) also fall within the scope of the review. We have defined small-scale as being those machines that are no more than 8 feet (2.4 m) wide, whose total weight does not exceed 21,000 pounds (9,110 kg), with under 80 horsepower (60 kW). For yarders, the tower height of small-scale equipment is less than 50 feet (15.3 m). The review will focus on the productivity, costs, and site and stand impacts of this equipment as compared to full-sized equipment.

We would like to benefit from your knowledge of timber harvesting operations. We would appreciate your completing and returning the enclosed questionnaire, which addresses some issues relevant to the use of small-scale equipment. Please respond to as many of the questions as possible. Feel free to attach additional sheets of paper if needed. Please return your completed questionnaire in the enclosed envelope, before August 31, 1999.

If you have any questions please don't hesitate to call me at (612) 625-0298, or email me at upde0003@tc.umn.edu. Thank you very much for your help and cooperation.

Sincerely,

Karen Updegraff
Research Assistant

Charles R. Blinn
Professor and Extension Specialist

Small–Scale Equipment Questionnaire P. 1

1. Your name, title and address:

In what capacity are you involved in timber harvesting activities (circle one)?

Industry Public Lands Mgt Contractor Research Extension

2. Are there any small–scale logging machines are currently in use in your area? YES / NO
If so, which types? Who are the primary users of these small–scale machines (full–time professional loggers, part–time professional loggers, non–industrial private forest owners, hobbyists (part– time operators not dependent on logging income), other _____)?

3. Was such equipment used in the past but not today? If so, when and why was its use discontinued?

4. Do you have experience with small–scale equipment? YES / NO . If yes, please describe that experience, and note any particular benefits or disadvantages that you have observed of using small–scale equipment, such as reduced damage to the site or residual stand?

Small–Scale Equipment Questionnaire P. 2

5. In your experience, have you identified situations where you feel small–scale harvesting equipment may be more suitable than more traditionally sized/large equipment? If so, can you describe the conditions where you think it may be most appropriate?

6. Similarly, are there situations where small–scale harvesting equipment may be less suitable than more traditionally sized equipment? Can you describe the conditions where you think the use of small–scale equipment may be least appropriate?

7. What has been the experience of operators who have used small–scale equipment? What benefits and/or problems have they cited?

8. Do you anticipate future changes in forest management guidelines and timber markets that might affect the use of small–scale equipment? YES / NO . If yes, could you speculate on what these changes might include?

Small–Scale Equipment Questionnaire P. 3

9. Do you think the potential use of small–scale equipment is primarily with full–time professional loggers, part–time professional loggers, non–industrial private forest owners, hobbyists, or other _____? Please explain your answer.

10. What do you think will be the challenges to the introduction and further use of small–scale equipment? How might those challenges be addressed?

11. Have you conducted or are you aware of any research on the productivity, economics, and/or site impacts of any small–scale logging machine(s)? If so, please elaborate.

Survey Responses

1. Respondent Demographics

The first question queried the occupation of each respondent. Of the 17 individuals who responded, 4 were directly engaged in research, 5 in extension, one in both research and extension, 4 in industry, one in public land management, and one in forestry consulting. The majority of US respondents were from the eastern half of the country although responses were also received from Colorado and Washington. All the industry respondents were from Minnesota. One response was from Canada and one from Denmark.

Each question is listed below, along with a summary of responses. Where comments from different respondents were very similar they have been folded together, otherwise all relevant comments are presented, with slight editing for reasons of space and clarity. Where a listed comment came from a single respondent, his/her state or province is noted in parentheses, for geographic context.

2. Are there any small-scale logging machines currently in use in your area? (Y/N) If so, which types? Who are the primary users (professional loggers [PL], part-time loggers [PT] non-industrial private forest (NIPF) landowners [NI], hobbyists [HO], other [OT])?

The following table summarizes the number of responses received (out of a total of 15) for each category, using the acronyms referenced above. Each respondent could indicate more than one category.

Yes	No	PL	PT	NI	HO	Other
14	1	4	7	6	3	2

Comments associated with these responses are summarized below:

A wide variety of equipment meet the criteria for small-scale and are in use by a wide range of operators, although the majority are small operators (not full-time professional loggers). There is, anecdotally, more small-scale equipment in the Eastern and Southern US than in the Midwest or West. Low-impact systems may have a marketing advantage in residential developments. Most of the equipment in use in Europe meets our definition of "small-scale", and therefore the employment of such equipment by European loggers is widespread.

Chainsaws are the most frequently used felling method in US small-scale operations. These are most often used in conjunction with tractors for forwarding operations. Small cable skidders or horses are also often used in combination with chainsaw felling. Small feller-bunchers with shears are used in some locations, in combination with appropriate yarding equipment. One respondent noted that some contract loggers use small cut-to-length systems. Powered trailers and trailers pulled by all-terrain vehicles (ATVs) also see some use. Tractors were the most frequently cited item of equipment overall, often in combination with appropriately-sized winches, cables or grapples.

3. Was such equipment used in the past but not today? If so, when and why was its use discontinued?

Of the 14 respondents to this question, 7 stated that small-scale equipment was used more in the past, 6 that it was not, and 1 that use levels had not changed. The main reasons cited for declining usage were economic: the greater efficiency and productivity of large, automated equipment yielded economies of scale for logging businesses faced with rising labor costs. Small operators went out of business. Some respondents noted that that larger equipment had a lower environmental impact because it left fewer ruts and required fewer trips.

A few of comments, transcribed below, related to actual or potential increases in usage levels.

- (NS [Nova Scotia]) Horses were more common in the past but are making a comeback. Tractors are holding their own. ATVs are more common. More wood is being cut by harvesters and processors. Most done by contractors, and high labor prices contribute to increased mechanization.
- (Denmark) The equipment has always been small and will likely remain so. Danish forests don't lend themselves to large-scale operations.
- (AL) Past small-scale system was a bobtail truck with chainsaws. Change to tree-length wood delivery eliminated most of these crews, [but] some bobtail crews still work yard jobs and real estate cuts.

4. Do you have experience with small-scale equipment? If yes, please describe that experience, and note any particular benefits or disadvantage that you have observed.

Nine of the 15 respondents to this question had direct experience with small-scale equipment, while 6 did not. Some of the observations of those who had experience included:

- (NS) (Yankee Yarder) Advantages - inexpensive, no rutting. Disadvantages - slow, labor intensive, must be used close to road or trail.
- (NC) (1) Prebunching winch made by Nordfor in early '80s - labor intensive, low productivity. (2) Prototype JD450 w/ loader boom and winch studied by Peters (Northeastern Forest Experiment Station) mid-'80s. (3) Bitterroot firewood yarder, 16hp, trailer mount; used for small stem harvesting. (4) Zig zag cable system, used for firewood/Christmas trees.
- (GA) (Mules) No damage to site, owners liked it. Low productivity, low stumpage values are reasons [the] system is not used now.
- (MN) Benefits include low equipment and transport costs. Disadvantages: slower, less productive, not as environmentally compatible.
- (CO) Advantages are less capital cost, lower environmental impact, lower operating costs; disadvantage is limited payloads. In our area "defensible space" (fire protection of

developments in wildland areas) is becoming important. Smaller equipment maneuvers more easily and doesn't threaten homeowners.

- (DC) Generally these systems do an environmentally acceptable job; it's just the economics.
- (Denmark) Generally small stands ... with high density ...; we need smaller machines. Forests are used extensively for recreation, which also puts pressure on contractors to do a proper job.

5. In your experience, have you identified situations where you feel small- scale harvesting equipment may be more suitable than large equipment? Describe the conditions where you think it may be most appropriate.

Fifteen of the 16 respondents to this question considered that at least some conditions were better suited to the use of small-scale than to large-scale equipment. Similar responses have been combined.

- (VA) I have observed forest landowners using small-scale harvesting equipment to conduct part-time logging on their woodlots in Scandinavia. The forest industry infrastructure was set up to accomodate this (i.e., periodic pick-ups of small volumes of wood piled at roadside, by industry-owned log trucks with self-loaders).
- (NS) 1) Commercial thinnings where trees are spaced 8-12 feet apart; 2) woodlot owners who want to haul their own wood, but can't justify the price of large equipment.
- Thinning small diameter (< 12" dbh) hardwood coves, especially in steep terrain; individual tree salvage sales.
- Small sensitive-site or specialty sales, or residential areas.
- (MN) The transition zone of central and western MN. This is where our contract loggers can harvest mixed aspen/hardwood stands and move from site to site easily.
- (NS) Best in small-woodlots, greenways, parks and other small wooded areas in which small equipment does minimal site disturbance. Other uses include the development of wooded lots for housing. Much of this small equipment can be used to harvest roadways and housing sites with out causing damage to the residual stand. This type of harvesting can be done at minimal cost to the developer or landowner. Another use for small-scale equipment has been in woodscaping woodlands. Much of this type service is at the cost of the landowner; it is not done as a timber harvest to generate money to pay for the operation. Many landowners are interested in improving their land for aesthetics, recreation, and wildlife and are interested in hiring small-scale equipment operators to thin stands, develop recreation trails, harvest small areas for wildlife, regeneration, etc. to improve their woodlot. If they can harvest enough timber to help offset the cost they are often willing to harvest a portion of timber as long as it fits into their goals and objectives.
- (DC) Mostly with owner/operator on small farms and land holdings. Works best on 1-5 acres because of mobility.

- (AL) Select-cutting on private lands, forest health treatments, small tracts with easy road access.

6. Are there situations where small-scale harvesting equipment may be less suitable than more traditionally-sized equipment? Can you describe the conditions where you think the use of small-scale equipment may be least appropriate?

All of the 16 respondents to this question conceded that some types of timber sales were unsuitable for small-scale equipment. Similar responses were combined.

- (VA) The overall performance of small skidders inferior to large [skidders] in corridor thinnings of pine plantations.
- Large clearcuts, large timber, tightly-scheduled sale contracts, where productivity is essential. For example: volume > 20,000bf /acre, slopes > 40%, rocky (rugged) terrain, average dbh > 17in.
- (NH) (Small-scale equipment) may not be able to move enough wood to make a profit in marginal sales.
- (MN) Large equipment with wider tracks/tires has less ground pressure and can go where smaller, older and heavier ground pressure machines can't.
- (MN) Timber salvage operations; where production reliability is critical.
- (Denmark) In some cases [large equipment may be more appropriate] on clearcut areas, or big trees. However these are usually done manually since the total (large timber) area is very small, investment in big machines not justified.

7. What has been the experience of operators who have used small-scale equipment? What benefits and/or problems have they cited?

Only 10 respondents had relevant comments on this topic.

- (NS) Mostly positive, but reliability and productivity can be problems.
- (NC) There is a need for skill and finesse rather than horsepower.
- (MN) Benefits are lower costs. Problems - not as productive; dangerous due to more and more overmature stands, as well as more blowdown of extended rotation trees.
- (MN) There was better utilization [and the] site looked better. Biggest benefit is ease of operation in confined areas with residual trees. Also (with CTL) only have to move 2 pieces of equipment.
- (NC) In North Carolina most small-scale equipment operators have plenty of work and are not operating under a competitive business since there is a lack of small-scale operations.

- (CO) Minimal problems with equipment; problems come from combination of stumpage prices, volume available and volume being moved.
- (MN) It is difficult finding jobs and staying in business.
- (WA) Winches work well.
- (Denmark) Mostly good experiences, the equipment suits the circumstances.

8. Do you anticipate future changes in forest management guidelines and timber markets that might affect the use of small-scale equipment? If yes, could you speculate on what these changes might include?

A majority (9) of the 16 respondents considered that future changes would favor increased use of small-scale equipment, while 7 did not. Some of the reasons given for increased use included:

- (NS) More partial cutting and thinnings of small diameter material, compared to clearcutting, that will occur on smaller tracts.
- (MN) As harvest areas become smaller and the vitality of the remaining timber becomes more of a a focus, a smaller, less intensive harvest method may be viable. Also, as prices paid at the mill increase, it may become more lucrative for private individuals to log small volumes. As wood becomes more difficult to obtain mills will likely become more willing to purchase small quantities from a wider range of suppliers. A similar rationale applies to summer wood.
- (MN) Most loggers in central/western MN have trouble finding stumpage and are forced to smaller timber sales. They have to learn to be more efficient with smaller volumes and move easily.
- (CO) As fire mitigation and forest health issues increase, more thinnings of small diameter timber will be done. However, current restrictions on logging on slopes $> 40\%$ will affect the use of yarders and harvesters.
- (DC) There will probably be more opportunity, [arising from] a niche market and applications.
- (KY) Growing hardwood pulp markets might spur some small-scale logging to harvest low quality hardwoods, especially on holdings of < 50 acres.
- (WA) Riparian zone management [may drive increased small-scale harvest applications].

Some of the comments associated with the negative viewpoint included:

- (NC) The difficulty in getting work done with small equipment is the lack of markets and infrastructure to move wood from the roadside to the market. I do not see this changing in the near future, but if market prices increase and such operations as roadside pick-up become available, I would expect an increase in the use of small-scale equipment operations.

- (NH) It is becoming less profitable to log, particularly in pulpwood operations.
- (MN) Higher stumpage costs (due to reduced cutting on public lands) force loggers toward more efficient and flexible (larger) equipment. Another factor is increased costs associated with blowdown timber, insurance and labor.

8. Do you think the potential use of small-scale equipment is primarily with full-time professional loggers [PL], part-time loggers [PT], NIPF owners [NI], hobbyists [HO] or other [OT]?

The following summarizes the number of responses received for each of the above categories, out of a total of 16 responses. Note that a single respondent could check several categories.

PL	PT	NI	HO	Other
2	6	8	6	2

Many of the respondents expanded on their answers by explaining their selections:

NIPF or Part-Time (both marked)

- (VA) Production rates could only support part-time logging with other sources of income.
- (NC) Also agricultural landowners, small contractors, arborists.
- (NS) Full-time loggers want large, reliable, productive equipment. Some believe in the benefits of smaller equipment (i.e., lower payments) that lead to a lower productivity requirement. However, biggest market will be among part-time, NIPF and hobbyist [loggers].
- (KY) Also cedar loggers [in addition to NIPF or part-time loggers]. Full-time professionals are busy trying to scale up production, to gain a competitive edge and earn favorable treatment from large consumers. Cedar loggers are a special case; delimbing is very labor intensive but yields high returns.

Hobbyists or NIPF (both marked)

- (GA) People with high-value trees in small quantity. The Nordfarm system that Westvaco used never was profitable.
- (MN) I don't see much potential use of small-scale equipment in any of these categories except the hobbyists and farmer/loggers: people who have some small-scale equipment for other things (farming, recreation etc.).
- (MN) NIPF possible, hobbyists probable. Wood produced by "non-professional" loggers is not desired by timber industry consumers, based on AF&PA [American Forest and Paper Association] standards with SFI [Sustainable Forestry Initiative].

- (AL) Most full-time professionals need modern, safe workplaces for employees; modified farm equipment in the woods is rarely safe.

Part-time or Hobbyists (both marked)

- (Denmark) Real small-scale equipment based on farm tractors might be used by part-time loggers [as well as hobbyists].
- (NC) Currently it appears to be a part-time logger and hobbyist business. Many of the operators are having to supplement their logging business working full-time in other professions to make ends meet.
- (NC) As it currently stands, the volume of wood full-time loggers are required to move to cover their expenses requires a large, efficient operation.

Full-time Professional Loggers

- (CO) Adequate maintenance and regular use [of equipment] will occur primarily with full-time loggers.

9. What do you think will be the challenges to the introduction and further use of small-scale equipment? How might those challenges be addressed?

Comments are summarized below.

- (VA) Forest industry infrastructure in the Southern US is appropriate for full-time, production-driven professional loggers. Small-scale operations don't fit this model. This could be addressed by changing to an infrastructure similar to Scandinavia that encourages low production, part-time harvesting by landowners. Unlikely.
- (NS) For woodlot owners, the challenge is to make it inexpensive yet reliable and somewhat productive. Cost is the biggest problem with most equipment. Many owners solve the problem by building their own equipment.
- (NC) How to make a living with low productivity, and labor problems.
- (NH) Economic feasibility, terrain and cost [are all issues].
- (GA) Individual trees are not valuable enough for such low volume systems. For example, The Log Hog Skidder (converted Ford tractor made by Dunham Mach.) could never produce enough to be profitable.
- (MN) Less wood is being sold. Timber sales should be expanded. Poor productivity could be addressed by better engineering. Fewer loggers (small loggers are going the way of small farmers); selling more wood would help. Restricting logging to winter [on many sites] [creates an operational handicap] that could be addressed by allowing more summer harvesting.
- (MN) Becoming more efficient and profitable while producing smaller volumes.

- (MN) Keeping cost down while building equipment stout enough to handle large trees and limbs (i.e., large, old aspen).
- (NC) The challenges in introducing and using the small-scale equipment will be in marketing its use as a low-impact logging alternative for small acreages. I do not think it will have the economics of scale to harvest large operations. Much of the driving force for using small-scale equipment will come from the fragmentation of land, the development of the urban-rural interface, and the demand placed on land managers by an increasingly environmentally aware society.
- (CO) It is primarily an economic issue. The combination of stumpage [prices], log quality, total volume and product prices will dictate the direction taken. Hence in the West, the problem of timber supply from public lands is a major factor.
- (DC) Economics, safety, availability and usefulness [are all issues].
- (KY) Safety; need reliable OSHA-approved cages and tractor protection by manufacturers or after-market. More European-style tractors are in the US market (Valmet, Holder). [But there needs to be a] recognition by manufacturers of what the tractors are being used for. Technique is also a concern: working with lower capacity machines means operators need to be more skilled. Better technical support of producers, and [wider] availability of publications like FERIC HB-11 will be needed.
- (WA) Cost of equipment, durability, and production capacity [are issues].
- (Denmark) Bringing down investment costs and simplifying complex machinery.
- (AL) The smaller machines will need to meet safety standards, and somehow be integrated into industrial procurement plans that favor high production, reliable output contractors.

10. Have you conducted or are you aware of any research on the productivity, economics and/or site impacts of any small-scale logging machines? If so, please elaborate.

Of 15 respondents to this last question, 10 replied in the affirmative and provided the references listed below. Similar responses have been combined. Geographic references are not provided for these responses. See Appendix C (Extended Bibliography) for selected publications by most of the cited sources.

- Forest Service, NE Research Station (Huyler, Ledoux et al) have done some. Should be reviewed cautiously.
- FERIC (headquarters in Montreal); also the PEI (Prince Edward Island) and Newfoundland Forestry Depts have done several studies (PEI doesn't any more).
- [Personal observations follow.., mostly reiterates previous questions]. "If you have a large, old tree leaning against your house, you will want a well-trained professional in the cab of a

piece of equipment that can handle the tree ... These givens (due to cost, insurance, training etc.) rule out the small piece of equipment that cannot accomplish enough tasks to keep its owner viable in today's market. Only someone who is financially secure can afford to spend the time and effort required to have small equipment - (wealthy hobbyist) - who has fun on weekends working at his hobby farm, tree farm or lake cabin."

- North Carolina State University has a small-woodlot research unit that has conducted research in the past on small-scale equipment. The contact person on this research is Carlyle Franklin, 919-515-3566, email: carlyle_franklin@ncsu.edu [the woodlot program has a web page at www2.ncsu.edu/ncsu/forest_resources/ woodlot/woodlot_web but it's not very informative].
- Dr Dennis Lynch has done some demonstration projects.
- At Auburn: Bob Lanford. At Burlington VT: Neil Huyler (ph. 802-951-6771)
- Scandinavian sources are the best (Swedish Agricultural University). Also, studies by R. Ewing at FERIC. Recently did a logging winch demo at the National Walnut Council meeting; [it has] great safety advantages and low cost.
- Our [Danish Forest and Landscape Research] Institute does research on these subjects but it is difficult to find funding. Plan to hire a professor to do operational research for 5 years.

APPENDIX C

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