

# Status of Minnesota Timber Harvesting and Silvicultural Practice in 1996



A Report  
to the Minnesota Forest Resources Council

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Minnesota Forest Resources Council Report # MP0698

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## Acknowledgements

The authors gratefully acknowledge the assistance of numerous individuals who provided invaluable review and feedback on the design of the study questionnaires. We especially thank the Minnesota Logger Education Program which provided the mailing list used for the harvesting survey. 🌲

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## Executive Summary

This report describes surveys and results from a study designed to update the understanding of harvesting and silvicultural systems and practices in Minnesota. The study surveyed a sample of loggers and land managers with respect to the type and extent of application of systems and practices employed statewide during 1996. Results were compared to corresponding 1991 information from the Generic Environmental Impact Statement (GEIS) (Jaakko Pöyry Consulting, Inc. 1992a,b). The study obtained input covering a substantial portion of the acreage and timber volume harvested in the state.

Study findings indicate considerable variability in practices in any one year depending on weather and disturbance factors. However, various results are definitive and noteworthy:

- The statewide harvest increased 7.9 percent from the 1991 survey to 1996 and the acreage subject to harvesting increased 12 percent. A greater emphasis on thinning was a significant factor in the rise in total acreage harvested.
- There has been a shift toward more mechanization and softer or less intrusive practices. This trend is apparent in both the logging and silvicultural surveys. The logging survey indicated tree felling is increasingly done by felling machines (84 percent) rather than by chainsaws (16 percent). The in-woods transport of trees and logs is increasingly conducted with grapple skidders and forwarders rather than with cable skidders. The newer equipment and practices are more light-on-the land than older machines and practices. However, it is the larger logging firms that tend to have the newest and most highly mechanized equipment. Overall the average age of logging equipment has increased, probably slowing the trend to mechanization and light-on-the land practices.
- According to the silvicultural survey, over the period of 1991 to 1996, clearcutting has decreased from 89 to 85 percent of the acreage harvested. Additionally, residuals were left on 77 percent of the acreage harvested, a level nearly twice as high as in 1991.
- Reliance on natural versus artificial regeneration increased by 7 percent since 1991. At the same time, artificial regeneration efforts showed greater emphasis on site preparation rather than later release. Commercial thinning acreage also rose; and noncommercial thinning increased significantly on forest industry lands.
- The logging survey indicated a large number of small timber harvesting businesses had only one or two employees (61 percent). These smaller firms harvested only 17 percent of the total reported production for 1996, but they obtain more of their wood from nonindustrial private forest landowners than larger operators. Thus it will be important to draw these firms into logger education programs.

As indicated by the responses to the silvicultural survey, forest management trends in Minnesota are toward a more intensively managed but more diverse forest. Nevertheless, loggers and management agencies do not appear to have a common understanding of what constitutes certain practices, for example *clearcutting* and *clearcutting* with residuals. Also, less clearcutting favors shade tolerant tree species at the expense of more light demanding species such as jack and red pine, aspen, and birch. Consequently, silvicultural practices to regenerate light demanding species are complicated. The retention of residuals is also a complex issue. The residuals can slow the growth of the regenerating stand; and leaving certain species as residuals can limit the regeneration of those species in the new stand. 🌲

## 1 Introduction

In 1990, Minnesota initiated a Generic Environmental Impact Statement (GEIS) on timber harvesting and forest management. Part of that study collected and summarized basic information about silvicultural and harvesting systems in Minnesota. The summarized information proved to be a valuable resource for policy makers, industry groups, and others. Because of its utility for evaluation and planning, this information needs to be updated periodically.

This report describes surveys and results from a study designed to update the understanding of harvesting and silvicultural systems and practices in Minnesota. The study involved two surveys. The first survey was a questionnaire distributed to a sample of loggers and asking about the type and extent of harvesting systems employed statewide during 1996. The second survey was a similar questionnaire distributed to a sample of forest land managers and asking about silvicultural systems and practices employed statewide during 1996. In both surveys, the study obtained practitioner input covering a substantial portion of the acreage and timber volume harvested in the state. The following sections describe the harvesting and silviculture surveys, their analysis, and results. 🌲

## 2 History of Harvesting and Silviculture Practices

Land ownership patterns, forest types, and many other forest characteristics which exist in Minnesota today were strongly influenced by developments over the last 150 years. Drawing from Jaakko Pöyry Consulting, Inc. (1992c), in the early 1800s, Minnesota's forest area was 31.5 million acres and was dominated by conifers. White

pine attracted the most attention; it was heavily logged between 1880 and 1910. Later, logging declined and then moved to other species, particularly other conifers and the larger hardwoods. The harvest reached a low point in the mid-1930s and remained roughly stable until the 1960s. Since then, the trend has been gradually upwards.

Early land speculation and settlement led to much of the state falling into private ownership, primarily farmland. This began to change with the establishment of the national forests and then state forests early in this century. In the 1930s and 1940s, large-scale tax forfeiture occurred and public agencies acquired privately owned lands that were no longer viable as farmland. Importantly, lands considered viable for agriculture at one time distinguishes them, from a productivity standpoint, from the federal lands, as most of these never supported agriculture. Private owners generally retained the most productive agricultural land (and timberland) concentrated in south, central, and northwestern Minnesota. At first, state and county agencies did not have the personnel or funding at the time to manage the tax forfeited lands which came under their jurisdiction properly. Consequently, many of these acres gradually reverted to forest naturally. Portions of individual farms, in total comprising large acreages, also reverted to forest. This new forest was largely hardwood, even-aged, and had a large component of aspen, a pioneer species.

Most hardwood stands originated since the 1920s with the initiation of organized fire control. Many conifer stands originated from earlier logging of softwoods. The age class distribution of conifers is less concentrated than hardwoods because of earlier harvesting and steadier markets up to the middle of this century. Additionally, many acres have been cut several times, first for pine sawlogs, then for spruce or hardwoods and, more recently, for aspen pulpwood. Early cuts were conducted with felling by hand and with winter skidding by

horses. However, since the 1940s, logging has become more mechanized with chain saw felling and motorized skidding. More recently we have seen mechanized logging operations that are “light-on-the-land.” Because of the predominantly even-aged nature of the northern forests, pioneer species, pulpwood demand, and logging costs, clearcutting has been common. Among hardwood forests in the southern portion of the state, selection harvesting has been the most common practice.

A *silvicultural system* is defined as a process, following silvicultural principles, by which forest stands are tended, harvested, and replaced, producing a forest of distinctive form. Silvicultural systems are typically classified according to the reproductive method they employ since it has a decisive influence on the character of the resulting stand. Common designations are:

- clearcut
- group selection
- patch clearcut
- seed tree
- shelterwood
- single tree selection
- strip clearcut
- thinning

These designations are described further in appendix 1. These same designations are also used to describe *harvesting systems* in terms of impacts on the forest. In contrast, harvesting methods refer to the form in which wood is delivered to the access road, e.g., cut-to-length or shortwood, tree length, full tree, whole tree, and complete tree (Jaakko Pöyry Consulting, Inc. 1992a).

Early silviculture practice (circa 1900) was geared to restoration of forest lands and focused on regeneration practices. Research since the 1930s has led to regeneration and other management guides for most commercial species and covertypes (e.g., see appendix 1 of Jaakko Pöyry Consulting, Inc. 1992b). The most common silvicultural

system in Minnesota today is the clearcut (with or without leaving residual stems). However, the other systems are used depending upon the character of the stand to be harvested, the landowner’s objectives for the harvest and for the stand to be regenerated, available harvesting technology, and various operational or management considerations including costs, wildlife habitat, and aesthetics. 🌲

### 3 Surveys of Practices

The surveys of timber harvesters and forest land managers in Minnesota were developed and administered during Spring 1997. These surveys are shown in appendixes 2 and 3. Each questionnaire was accompanied by the definitions shown in appendix 1 and solicited information about operations during 1996. Survey questions were similar to those used in the 1991 surveys compiled for the GEIS (Jaakko Pöyry Consulting, Inc. 1992a,b). Each survey contained sections for background information, harvesting or silvicultural practice, and open-ended questions. Some of the questions used from the 1991 survey were revised to clarify their intent. New questions were added to facilitate collection of other information.

The timber harvesting survey was sent to individuals listed within a database maintained by the Minnesota Logger Education Program (MLEP) (survey population size n=1,562). That database contained the names of individuals who had purchased a public timber sale within the previous two years as well as the names of individuals who had contracts to deliver wood to the pulpwood and larger sawtimber consuming mills in Minnesota. The silviculture survey was sent to forest land managers (federal, county, state, private industry, Native Americans; survey population size n=30). Individuals familiar with the target survey groups reviewed both surveys several times before the

questionnaires were first mailed. Input from those reviewers was used to refine the questionnaires.

Each mailing to timber harvesters consisted of a cover letter, the questionnaire, and a stamped, pre-addressed return envelope. Each survey was initially numbered with an alphanumeric code to facilitate tracking of respondents. Respondents' names were kept anonymous to ensure a high response rate and an objective response. As the addresses for the timber harvesting survey were affixed by MLEP, survey administrators did not know the names of those individuals in the survey population or the response pool, unless a respondent chose personally to identify themselves. The initial survey was followed up with a postcard reminder one week after that survey was mailed in March. Approximately three to four weeks later, an additional questionnaire was mailed to individuals who had not responded. The final cutoff date for incorporating timber harvester surveys was July 31, 1997.

The questionnaires inquiring about silvicultural and forest management practices were distributed in April 1997 to timberland owners (two state agencies, 13 counties, two national forests, six forest industry firms, and seven Native American bands). Nonindustrial private forest (NIPF) landowners, which own almost half the timberland (Minnesota Forest Resources Council 1997) in Minnesota were excluded because a comprehensive address list was not available and there were doubts that landowners would know the needed details of silvicultural and harvesting practices on their lands. Telephone follow-up was also employed to increase the silviculture survey response rate.

## Analysis

The survey data was summarized to compare 1996 and 1991 survey results, primarily in terms of percent. Estimates were also developed for the total area with

harvesting and silvicultural activity statewide. This step assumed that (1) the relative proportions of harvesting and silvicultural systems used on nonsurveyed land was the same as on land covered by the surveys and (2) the average volume per acre harvested or treated under each harvesting or silvicultural system did not vary with ownership. The authors concluded that any deviation from these assumptions was likely to be small.

The survey responses were coded and analyzed using spreadsheet software. Figures and tables were then developed to aid in editing, understanding the data, and for reporting. Standard cords were the volume measurement unit used in the survey and analysis. To convert thousand board feet (MBF) and weight to cords, the following assumptions were made for all species:

Thousand board feet (MBF) to cords:

1 MBF = 2 cords

Weight to cords:

Hardwood species: 4,500 pounds = 1 cord

Softwood species: 4,200 pounds = 1 cord.

Where appropriate, comparisons were made to similar information prepared under the 1991 survey compiled for the GEIS (Jaakko Pöyry Consulting, Inc. 1992a,b) to discern trends. The 1991 survey was distributed to logging contractors within the Minnesota Timber Producers Association (TPA) and directly by mail to non-TPA members. There were 70 respondents to the 1991 survey. Thus while these survey populations may overlap to some extent, comparisons should be made with caution as each survey selected participants somewhat differently. 🌲

## 3.1 Harvesting

### Survey response

Forty-five of the original 1,562 names on the mailing list were returned as being undeliverable because the addresses were no longer current. Of the 1,517 deliverable questionnaires, 542 surveys were returned. Of that total, 390 (25.7 percent of the deliverable questionnaires) were either fully or partially completed and could be used in the analysis. Respondents may have failed to answer one or more questions in their response due to lack of detailed records or concern that the information would be traced back to them or might be used against them. Given the partial responses, the tables developed below have slightly different numbers of respondents. An additional 152

(10 percent of the deliverable questionnaires) were nonresponses according to the reasons noted in table 1. None of the nonresponse surveys were used in the analysis.

Most respondents provided answers to all questions. However, several respondents did not answer one or both questions that related to their estimated 1996 production levels and the current value of in-woods harvesting equipment. For the most part, it appeared that individuals who did not respond to questions about production levels or equipment value were larger operators who may have been concerned about divulging too much information about their business. Also, several larger operators did not itemize their equipment, perhaps because it would have taken too long to do so.

**Table 1. Reasons provided by respondents for not completing the 1996 timber harvesting survey.**

Reason For Not Completing the Survey	Number of Respondents
Retired or discontinued logging	67
Not a logger	48
Blank survey	20
Employee unable to answer questions	4
Firewood and/or part-time operator	4
Miscellaneous reasons (e.g., duplicate survey, respondent deceased, don't respond to surveys)	9

**Table 2. Logging contractor size: number of employees within respondent's logging business in 1996. The number of employees includes the logging business owner/respondent.**

Number of Employees	Number of Respondents	Cumulative percentage
1-2	235	61
3-5	104	87
6-10	42	98
11+	7	100

More than 95 percent of the respondents were owner/operators from north of the Twin Cities. Itasca, Koochiching, and St. Louis counties had the greatest number of respondents (see appendix 5).

According to the Minnesota Forest Resource Council’s landscape classification system, 20 percent of the respondents lived within Region 1, 16 percent within Region 2, 3 percent within Region 3, 43 percent within Region 4, 5 percent within Region 5, and 3 percent within Region 6. An additional 30 respondents (8 percent of respondents) lived within Beltrami County which is located within both Regions 2 and 4. The remainder of the respondents lived in the metro (n=2) and prairie (n=3) Regions and outside Minnesota (n=3) (see appendix 4).

Most respondents owned relatively small businesses and had been in business for many years. A total of 1,254 individuals were employed within these logging businesses, an average of 3.23 individuals per firm (table 2). According to the 1991 survey, the average number of employees per firm was 6.53 individuals. The majority of the 1996 survey respondents (61 percent) represented operations with one or two employees. Within the category of one to two employees, 164 respondents indicated

they were the only employee. The average duration that respondents worked within the logging profession was 22.8 years (range 1 to 60, n=388). Sixty percent of the respondents indicated they had been logging for at least 20 years. The average length of ownership of the logging businesses was 17.6 years (n=386). Forty percent of the respondents indicated they had owned their logging business for at least 20 years.

Annual volume produced varied greatly among the respondents (table 3). Many respondents to the 1996 survey were relatively small producers. Forty-four percent of the respondents produced fewer than 1,000 cords during 1996. Also, while 61 percent of the businesses had only one or two employees, their volume harvested was only 17 percent of the total production reported by respondents. In contrast, the ten largest operations accounted for approximately 27 percent of the reported volume. One percent of the businesses had more than 12 employees, but their volume harvested was 16 percent of the total. Therefore, the response to some questions in the 1996 survey was weighted according to the respondent’s annual production to reflect the impact of firm size. Similar weighting was used in the 1991 survey. This weighting, in effect, provides estimates

**Table 3. 1996 production levels reported by respondents.**

Estimated Volume Harvested (Cords)	Number of Respondents	Cumulative Percentage
Less than 500	102	28
501–1,000	58	44
1,001–5,000	110	75
5,001–10,000	49	88
10,001–15,000	28	96
15,001–20,000	4	97
20,001–30,000	5	99
30,001–50,000	3	99
> 50,001	2	100

reflecting percentage of harvest volume affected and thus the approximate acreage affected as well.

Table 4 summarizes much of the information in the harvesting survey and provides comparisons to the 1991 survey. When stumpage sources were weighted by 1996 production, 61 percent of the 1996 stumpage was from self-purchases and 39 percent was purchased or provided by others.

Nonindustrial private forest (NIPF) ownerships were the greatest source of stumpage in 1996. Table 4 shows 36 percent of the volume was harvested from nonindustrial private ownerships. State and county ownerships yielded the next highest estimated harvest volumes. The relatively high percentage of wood from public ownership may be due to the fact that the MLEP database, which served as the mailing list for the survey, was based largely on individuals who had purchased stumpage from public ownerships within the past two years.

The total volume harvested during 1996 by respondents was 1,623,571 cords. That total includes 532,395 cords of softwood pulpwood, 125,351 cords of softwood sawtimber, 859,385 cords of hardwood pulpwood, and 106,440 cords of hardwood sawtimber. According to Minnesota Department of Natural Resources consumer surveys, the total harvest for 1996 (including 0.2 million cords of fuelwood) was 3.81 million cords. Thus the harvesting survey volume represents approximately 43 percent of the estimated total harvest in the state. The 1991 survey reported 636,439 cords which was approximately 18 percent of the estimated annual industrial wood harvested in the period 1990–1 (excluding fuelwood). Average harvest or production per respondent was approximately 4,150 cords for the 1996 survey and 9,090 cords for the 1991 survey.

The average tract size harvested was estimated to be 79 acres (n=351) as

compared to 33 acres for the 1991 survey. However, the 1996 tract size should be interpreted cautiously as the first mailed questionnaire did not specifically state that respondents were to provide their “average” tract size harvested in 1996. Instead, some respondents appear to have reported their total acreage harvested during 1996. In fact, 64 respondents indicated their tract size was at least 100 acres. The largest tract size reported was 3,000 acres. A second mailing of the survey reworded the question to make the request for average tract size more explicit. The average tract size may also be inflated due to salvage operations resulting from severe windstorm damage that occurred during July 12–14, 1995.

The July 1995 windstorms caused severe damage to several hundred thousand acres of forest in northern Minnesota. Nearly half the blowdown timber was salvaged. However, in an effort to facilitate salvage, many landowners created larger than usual timber sales and clearcut harvests. As a result, many survey respondents reported in the comments section of the survey that their harvesting operations and practices would have been quite different in another year (e.g., a normal year would have consisted of smaller tracts and less clearcutting. Several respondents indicated the salvage of windstorm blowdown led to larger tracts, more timber felled with chain saws, and increased use of cable skidders).

Rather than speculate on what observations should be deleted as representing a response other than the average tract size, additional measures were calculated, notably the median tract size. The median is the middle observation when they are ranked from smallest to largest (i.e., half the observations are smaller). The median tract size reported was 29 acres. This is the same value one would get for the average if erroneous values, say those larger than 100 acres, were omitted. Additionally, the mode (i.e., the most frequently reported tract size) was 20 acres .

Nearly half the volume was harvested during the winter (47 percent) followed by fall (23 percent), summer (21 percent), and spring (9 percent). The percentage of winter harvesting increased and summer and fall decreased as compared to the 1991 survey. Respondents who produced less than 1,000 cords/year tended to be more part-time with lower production volumes during summer and fall. Several of those respondents also noted that they farmed for a portion of their income.

Eighty-three percent of the volume produced in 1996 was harvested under clearcutting or clearcutting with residuals. Despite the impact of blowdown and salvage mentioned, this figure is somewhat less than the 88 percent reported in the 1991 survey. Within the clearcut categories, 33 percent of the volume was from clearcuts greater than 40 acres, with 24 percent from sizes between 21 to 40 acres, and 19 percent from sizes between 5 to 20 acres. Six percent of the respondents reported clearcutting less than 5 acres (6 percent patch clearcutting).

### *Methods of operation*

The overall trend from 1991 to 1996 was toward increased mechanization during the felling, in-woods transportation, and delimiting/topping phases. Potential reasons for increasing mechanization include reduced concerns associated with safety and increased production.

Sixteen percent of the volume harvested by respondents during 1996 was felled using a chainsaw (table 4). Approximately 79 percent of the volume was felled using feller-bunchers. Most of this equipment requires driving to each tree to fell it. Five percent of the volume was felled using a cut-to-length feller-processor, a method not noted during the earlier surveys. In the 1991 survey, 27 percent of the volume was felled using a chainsaw and 73 percent using a feller-buncher. These results confirm the increasing mechanization of felling.

The use of forwarders increased compared to previous surveys (table 4). Of the respondents who reported using “other” methods to transport wood from the stump to the landing, five reported use of horses, one carried pieces by hand, and one used an all-terrain vehicle. For the 1996 survey, the percentage of volume transported using grapple skidding increased to 79 percent compared to 69 percent in 1991.

In 1996, most delimiting by volume was conducted with a chainsaw (table 4). Six respondents indicated they used a skidder to delimit material. One respondent used a gate delimitter. The percentage of volume delimited with a chainsaw decreased as compared to the 1991 survey; the percentage of volume was mechanically delimited and topped increased. The location of delimiting and topping in 1996 was essentially unchanged from 1991.

The percentage of volume bucked/slashed with a chainsaw decreased slightly as compared to 1991 (table 4). The location of bucking and slashing also changed little from 1991 to 1996. However, slightly more timber was not bucked or slashed in 1996 compared to the previous survey (21 versus 17 percent). Most of the volume not bucked was transported to mills as tree-length material. The importance of mechanical bucking and tree-length material increased. Approximately 1 percent of the volume was full-tree chipped (n=6) and 1 percent was processed with a chain flail-delimitter-debarker-chipper (n=3).

### *Harvesting equipment*

The average age of harvesting equipment in Minnesota from the 1996 survey ranged from 9 years for delimiters to 16 years for skidders, forwarders, farm tractors, and bulldozers (table 5). The average age of most types of equipment was older than what was reported during the 1991 survey. The majority (74 percent) of the machines from the 1996 survey were more than five years old as compared to 64 percent for the

1991 survey. New purchases (less than one year old) accounted for less than 1 percent of the total equipment. Most of the respondents were not able to estimate operating hours for their machinery.

Forty-eight percent of the respondents indicated the estimated value of their equipment on December 31, 1996, was less than \$50,000 (table 6). However, many respondents who reported larger production volumes did not provide information about the value, age, or make of their equipment. Respondents with older equipment also

tended to have lower annual production levels and to have a lower estimated value for their equipment.

Appendixes 8, 9, and 10 present a listing of the models of harvesting equipment indicated in the questionnaire responses. In addition, ground pressures were not available for all machines and vary considerably depending on tire size or track width and load size.

Ninety-three respondents included useful open-ended comments (see appendix 6).

**Table 4. Harvesting questionnaire results for Minnesota, 1996 (n=361 respondents) and 1991. All percentages are of total volume harvested.**

Survey Item	1996 Survey	1991 Survey
Number of employees (including self)	1,254	486
Stumpage source, percent:		
(a) Log own stumpage	61	48
(b) Log company purchased / owned stumpage	39	52
Ownership source, percent:		
Nonindustrial private forest (NIPF) lands	36	—
State lands	22	—
County lands	18	—
Industry lands	13	—
Federal lands	10	—
Native American lands	1	—
Volume harvested, cords:		
Softwood pulpwood volume harvested	532,395	188,071
Softwood log volume harvested	125,351	36,568
Hardwood pulpwood volume harvested	859,385	365,999
Hardwood log volume harvested	106,440	54,901
<b>Total</b>	<b>1,623,571</b>	<b>645,539</b>
Harvesting / silvicultural systems used, percent:		
Clearcutting > 5 acres (total)	76	80
(area > 40 acres)	33	—
(area 21 to 40 acres)	24	—
(area 5 to 20 acres)	19	—
Patch clearcutting (area < 5 acres)	6	5
Strip clearcutting	1	3
Clearcutting with standing snags and live trees	77*	41
Seed tree	3	1
Shelterwood	1	1
Single tree selection	4	5
Group selection	4	—
Thinning (commercial only)	5	14

\*From Silviculture Survey (see table 9)

Survey Item	1996 Survey	1991 Survey
Season of harvest, percent:		
Winter (December–February)	47	43
Spring (March–May)	9	9
Summer (June–August)	21	23
Fall (September–November)	23	25
Felling method, percent:		
Chainsaw	16	27
Feller-buncher	—	73
Felling machine moves to each tree		
Feller-buncher	46	—
Cut-to-length	1	—
Felling machine does NOT move to each tree		
Feller-buncher	33	—
Cut-to-length	4	—
In-woods transportation, percent.		
Cable skidder	15	30
Grapple skidder	79	69
Forwarder	5	1
Farm tractor	< 0.5	—
Bulldozer	< 1	—
Other	< 0.5	—
Delimiting / topping method, percent:		
Chainsaw	59	66
Mechanical	39	33
Other	2	—
Not delimited or topped	< 1	1
Delimiting / topping location, percent:		
In the cutover	67	68
At the roadside	31	32
Not delimited or topped	2	1
Bucking / slashing method, percent:		
Chainsaw	13	14
Mechanical	65	69
Not bucked / slashed	< 0.5	—
Full-tree	20	—
Tree-length	2	—
Other	—	17
Bucking / slashing location, percent:		
In the cutover	7	7
At the roadside	72	76
Not bucked / slashed	21	17
Other processing method, percent:		
Full-tree chipping	1	1
Chain flail-delimiter / debarker / chipper	1	—
Other	—	—
Not additional processing conducted	—	—
Average (median), [mode] for logging site area, acres	79 (29) [20]	33

**Table 5. Average age of timber harvesting equipment reported in the 1996 and 1991 survey.**

Machine Type	1996 Survey			1991 Survey
	No. With Age Reported	Average Age (Years)	Range (Years)	Average Age (Years)
Feller-bunchers	236	11	0–34	8
Skidders, forwarders, farm tractors, bulldozers	465	16	0–55	10
Delimbers	95	10	0–42	7
Slashers	146	9	0–42	7
Full-tree chippers	6	10	3–19	10

**Table 6. Estimated timber harvesting equipment values by category in Minnesota during 1996.**

Estimated Equipment Value by Category	No. of Respondents	Cumulative Percent
Less than \$25,000	123	33
\$25,000 but < \$50,000	54	48
\$50,000 but < \$75,000	35	58
\$75,000 but < \$100,000	20	63
\$100,000 but < \$150,000	30	71
\$150,000 but < \$200,000	23	77
\$200,000 but < \$250,000	16	82
\$250,000 but < \$300,000	18	87
\$300,000 but < \$400,000	20	92
\$400,000 but < \$500,000	6	94
\$500,000 but < \$750,000	12	97
\$750,000 but < \$1,000,000	5	98
\$1,000,000	6	100

Several of those respondents provided a description of their harvesting operation. Some respondents noted that the July 1995 windstorms affected their logging operations, with salvage being the main portion of their work in the 1996 season.

Others indicated it was difficult for small operators to compete with larger firms. A few comments concerned the length of the questionnaire, sometimes confusing questions, and privacy issues.

## *Impact of annual production on survey results*

As noted above, there was great variability in the annual volume produced among the respondents. As compared to smaller operators, the larger operators:

- Had more of their stumpage purchased or provided by others (e.g., brokers, forest industry purchase);
- Were much less reliant on timber from nonindustrial private ownerships;
- Were less dependent on winter stumpage as a source of their harvested volume and therefore are more full-time businesses;
- Harvested more of their volume from clearcut areas;
- Harvested more of their volume from larger tracts;
- Used more highly mechanized equipment to fell, transport wood to the landing, and to process trees;
- Conducted more delimiting, topping, bucking, and slashing at the roadside; and
- Reported using newer equipment (e.g., felling machinery, skidders, slashers) and were the early adopters of newer techniques (e.g., cut-to-length).

## *Trends in harvesting practice*

Overall, logging results suggest a continuing move toward more mechanization and a modest shift toward softer harvesting approaches. In 1991, the amount of clearcutting and clearcutting with standing snags and residuals totaled 88 percent of operations. In 1996, clearcutting of all types totaled 83 percent. However, interpretation is clouded by the salvage of timber affected by the July 1995 windstorms. Also, it appears the smaller and less mechanized operators drew more of

their harvest from NIPF lands than larger operators. 

## 3.2 Silviculture

### *Survey response*

Twenty-five respondents completed the silviculture survey questionnaire. These respondents represented 100 percent of state, county, and federal land; 50 percent of industrial; and 86 percent of Native American ownerships. In addition, one survey reported no harvesting for 1996, while two others were incomplete and thus not included in the database.

The silviculture survey questionnaires asked for the source of information, i.e., whether the numbers reported were directly from a database or whether they were estimates. Obviously, the databases varied between timberland owners. Some owners provided estimates to all questions, while others, e.g., state and federal, have a formal database with sufficient detail to answer the questions directly.

The acres reported as harvested with different silvicultural systems were typically documented in the landowner databases, but the size class distribution of the clearcuts was frequently estimated. Also, few respondents had information about the regeneration, site preparation, and release questions in their databases. In particular, the area regenerated through natural regeneration was poorly documented. As expected, the proportion of different slash treatments as well as the seasonal distribution of harvests were mostly estimated.

State and federal owners have written standards for “residuals” in clearcuts and many organizations keep records of the area “clearcut with residuals.” However, respondents could provide only an estimate of the number of trees left behind, their spatial distribution, etc.

Because the respondent pool and the acreage covered by the silviculture survey was similar (1 percent smaller) to the 1991 survey (Jaakko Pöyry Consulting, Inc. 1992b), the data obtained for 1996 are comparable to 1991 survey responses. The following discussion focuses on this comparison, but is limited to land holdings that responded to both surveys. However, any interpretation should consider the special circumstances that influenced forest management during 1991 or 1996. The major factor listed by the respondents was the July 1995 windstorms, which resulted in considerable salvage harvesting during 1996. Also, because many of the estimates presented are based on tabulating responses that were themselves estimates, small changes need to be interpreted with caution.

Since state and industry personnel are also involved in management of NIPF land, we also tried to obtain information about the extent of silvicultural practices used on these lands (appendix 2, part 8). However, the responses were not complete or detailed enough to allow more than anecdotal comparison of NIPF results with state and industry practice. Most comments (see appendix 7) mentioned that management on NIPF land was similar to management on

land owned by the employer of the respondent.

Table 7 indicates the respondents' ownerships cover a total of 7,720,204 acres, approximately 52 percent of the 14,723,200 acres of timberland in the state (see Miles et al. 1995). A volume of 1.97 million cords was harvested from timberland managed by the survey respondents. This figure was 51 percent of the 1996 statewide harvest of 3.81 million cords tabulated by Krantz (1998) (see table 8). The overall harvest level in the state grew 8 percent from 3.53 million cords in 1991 to 3.81 million cords in 1996 (Krantz 1998). The harvest volume removed per acre timberland (0.25 cords) and per acre with harvesting activity (19.8 cords) were similar to the harvest volumes in 1991 (0.24 and 20.6 cords, respectively, as reported in Jaakko Pöyry Consulting, Inc. [1992b]).

Table 8 also presents statewide estimates for harvest area and silvicultural systems. Note that the results for the 1991 survey have been updated to reflect the statewide timberland acreage from Miles et al. (1995). Also, the estimates of harvest for 1991 have been adjusted to those provided by Krantz (1998). Of special note is that fuelwood cut from growing stock is included in these harvest figures. In 1991 this fuelwood was

**Table 7. Summary of silvicultural survey response for acreage and volume harvested - 1996.**

Survey Item	No. of Responses	Total Reported	Minimum	Maximum
Timberland (acres)	25	7,720,204	5,400	2,600,000
Volume harvested (total)		1,965,164		
Total (cords)	25	1,901,696	1,474	533,000
Fuelwood (cords)	25	63,468	50	20,000
Average clearcut (acres)	25	24	6	50
Average partial cut (acres)	21	27	3	200
Total acres in silvicultural systems	25	99,297	126	41,546
Cords harvested / acre timberland	—	0.25	—	—
Cords harvested / acre logging activity	—	19.79	—	—

estimated as 530,000 cords. In 1996, the fuelwood component is estimated at 200,000 cords (Krantz 1998).

The statewide estimates for 1996 were calculated as simple expansions of the figures reported by respondents. This approach assumes the harvest per acre by silvicultural system and the proportional application of silviculture systems was the same on surveyed and nonsurveyed land. The expansion factor used throughout was the known approximately statewide harvest divided by the respondent reported harvest, i.e.,  $3,810,000 \div 1,965,164 = 1.93877$ . Adjusted estimates for 1991 were calculated in a similar manner. The resulting expansion factor for 1991 was  $3,530,000 \div 1,858,849 = 1.89902$ . An alternative expansion factor can be derived from statewide timberland acreage divided by respondent acreage (e.g.,  $14,723,200 \div 7,720,204 = 1.90710$ ), but the difference between this factor and that based on volume is small. Further, in this study volume reporting was considered slightly more reliable than acreage information, and use of volume based expansion guarantees consistency with the known statewide harvest. Silvicultural systems data were expanded statewide by the same factors as volume. Regeneration, site preparation, timber stand improvement and other silvicultural activity data were not expanded statewide because they were perceived to be less precise than total harvest and silvicultural systems data, and because they were not necessarily related directly to harvest activity in the subject year. However, respondent acreage data on these activities does help identify relative levels of activity and trends.

Careful readers will note that expansion factors in the 1991 report (Jaakko Pöyry Consulting, Inc. 1992b) differ somewhat with the variable being considered. We suspect that was due to varying detail in reporting among respondents. However, lacking more detail now, we thought it best to update these data in the most straightforward way possible, i.e., using one

volume based expansion factor throughout, to aid consistency in comparisons.

Based on the 1996 survey, the estimated area with harvesting activity (192,514 acres) was 11 percent greater than in 1991. The increased harvest area is partially due to thinning activity on federal and state ownerships. On national forest lands, final harvest activity declined by 19 percent between 1991 and 1996 (see table 9). However, for the same volume of wood, thinning results in harvesting more acres than would be the case with clearcutting. For example, Jaakko Pöyry Consulting, Inc. (1992b) noted removal volumes of 21.6, 17.2, 8.6, 11.9, and 8.8 cords per acre in harvests by clearcuts, seed tree cuts, shelterwood cuts, selective cuts, and thinning.

### *Silvicultural systems*

Overall the relative proportions of the various silvicultural systems and thinning activities changed little between 1991 and 1996 (see table 8). Clearcutting is still the dominant silvicultural system, but the proportion of clearcut land declined from 89 to 85 percent. Clearcutting was also the predominant silviculture system used for all timberland ownerships (table 9). From table 7, the average clearcut size is 24 acres and the average partial-cut size (acreage in sale) was 27 acres (table 8). Both these values are very similar to the 1991 survey. Weighting by the total area cut by each respondent, the average partial cut size falls to 23 acres, while the average clearcut size remains unchanged. Drawing from table 9, 62 percent of the area clearcut on industry land was in clearcuts greater than 40 acres. Clearcut sizes between 20 and 40 acres were most common on state and federal land. Clearcut sizes on county land were evenly split between clearcuts greater than 40 acres, 20 to 40 acres, and 5 to 20 acres.

The amount of acres harvested by patch, strip, seed tree and shelterwood, group selection, and single tree selection accounted

**Table 8. Silviculture questionnaire results for Minnesota - 1996 and 1991.**

Ownership	1996 Survey	1991 Survey	1996 Statewide Estimate	1991 Statewide Estimate
Area of timberland ownership, acres	7,720,204	7,848,031	14,723,200	14,723,200
Total volume harvested, cords	1,965,164	1,858,849	3,810,000	3,530,000
Area with logging operations, acres	99,297	90,128	192,514	171,155
Natural regeneration, acres	69,220	64,428	134,202	122,350
Artificial regeneration, acres	18,880	20,563	36,604	39,050
<b>Silvicultural Systems and Thinning, Acres (Percent)</b>				
Clearcut (> 5 acres) with or without residuals	(85) 84,567	(89) 80,214	(85) 163,956	(89) 152,328
Patch clearcut	(1) 727	(2) 1,803	(1) 1,409	(2) 3,434
Strip clearcut	(0) 234	(1) 901	(0) 454	(1) 1,711
Seed tree cut	(1) 1,356	(0) 0	(1) 2,629	(0) 0
Shelterwood	(1) 789	(0) 0	(1) 1,530	(0) 0
Selective logging	(1) 1,022	(2) 1,802	(1) 1,981	(2) 3,422
Thinning	(11) 10,602	(6) 5,408	(11) 20,555	(6) 10,270
Regeneration areas, acres				
Planting (total)	11,530	14,600		
Underplanting	1,957	—		
Seeding	5,036	5,963		
Cuttings (e.g., hybrid poplar)	357	—		
Natural regeneration	69,220	64,428		
Total	88,100	84,991		
Site preparation areas, acres				
Chemical - aerial	2,251	456		
Chemical - ground	3,099	2,962		
Prescribed burning	388	1,237		
Mechanical	8,212	9,619		
Total	13,950	14,273		
Timber stand improvements, acres				
Chemical release - aerial	3,184	5,252		
Chemical release - ground	3,138	3,914		
Hack and squirt release	100	20		
Mechanical / manual release	4,795	5,506		
Noncommercial thinning	3,055	1,444		
Residual stem felling	361	9,001		
Pruning	339	201		
Underburning (acres)	135	—		
Total	15,107	25,337		
<b>Other Silvicultural Activities</b>				
Slash disposal (acres)				
Untreated	62,801	—		
Piled or windrowed	8,232	—		
Removed (whole tree skidding)	9,223	—		

**Table 9. Silviculture questionnaire results by ownership for Minnesota - 1996.**

Survey Item	Ownership					
	1996 Survey	State	County	Federal	Industry	Native American
Area of ownership, acres	7,720,204	2,605,400	2,543,909	1,206,147	838,000	526,748
Total volume harvested, cords	1,965,164	554,094	618,427	324,580	360,181	107,882
Area with logging operations, acres	99,297	41,914	26,883	15,106	9,839	5,555
Natural regeneration area, acres	69,220	22,080	21,851	11,488	8,777	5,024
Artificial regeneration area, acres	18,880	8,145	3,089	3,140	3,572	934
Silvicultural Systems and Thinning, Acres (Percent by Ownership)						
Clearcutting > 40 acres	(23.3) 23,149	(12.6) 5,270	(30.3) 8,157	(10.8) 1,625	(62.1) 6,114	(35.7) 1,983
Clearcutting 20–40 acres	(42.5) 42,189	(57.3) 24,000	(27.4) 7,377	(45.7) 6,907	(21.4) 2,107	(32.4) 1,798
Clearcutting >5 and < 20 acres	(19.4) 19,229	(12.2) 5,118	(29.2) 7,852	(27.8) 4,195	(13.4) 1,318	(13.4) 746
Patch clearcutting	(.7) 727	(0) 0	(.9) 246	(0) 0	(.5) 50	(7.8) 431
Strip clearcutting	(.2) 234	(0) 0	(.7) 184	(0) 0	(0) 0	(.9) 50
Seed tree	(1.3) 1,356	(1.2) 494	(3) 817	(0) 0	(0) 0	(.8) 45
Shelterwood	(.8) 789	(.1) 62	(2) 546	(1.2) 181	(0) 0	(0) 0
Selective logging - single tree	(.6) 612	(.2) 93	(1.3) 339	(0) 0	(.3) 30	(2.7) 150
Group selection	(.4) 410	(.8) 347	(0) 0	(0) 0	(0) 0	(1.1) 63
Thinning	(10.7) 10,602	(15.6) 6,530	(5.1) 1,365	(14.6) 2,198	(2.2) 220	(5.2) 289
Residuals, Acres (Percent)						
Clearcut > 5 acres, with or without residuals	(85.1) 84,567	(82) 34,388	(86.9) 23,386	(84.2) 12,727	(96.9) 9,539	(81.1) 4,527
Clearcut > 5 acres with residuals	(76.5) 64,735	(79) 27,170	(83.3) 19,490	(95) 12,090	(34.3) 3,276	(59.8) 2,709
Percent residuals alive	(87)	(80)	(81)	(85)	(90)	(85)
Percent acres with residuals scattered	(67)	(57)	(72)	(82)	(75)	(60)

for only a small proportion of the area logged in 1996.

### *Clearcut with residuals*

Compared to the 1991 survey, the 1996 survey asked more detailed information about the condition of clearcuts after harvesting. Table 9 shows residuals (trees left in a clearcut for reasons other than regeneration) were left on 77 percent of the acres clearcut. This proportion is almost twice as high as in 1991. This shift can be attributed largely to changes in the

management of public, especially federal land. For example, respondents indicated the acreage on which residual stems were felled dropped from 9,001 in 1991 to 361 acres in 1996 (table 10).

The definition of a clearcut with residuals is not consistent across ownerships. While the DNR and USDA Forest Service have written standards, others do not have a formal criteria. Overall, respondents indicated the average site had 14 trees per acre left as residuals, but the density varied tremendously with site and species. Because

**Table 10. Area of annual silvicultural operations by treatment method reported by respondents - 1996.**

Survey Item	Total Area (Acres)	Average for All Ownerships (Acres)	No. of Respondents	No. of Respondents With Activity	Range (Acres)
Regeneration Methods					
Planting (total)	11,530	462	25	22	8–4,053
Underplanting	1,957	78	25	11	4–500
Seeding	5,036	201	25	12	11–3,584
Cuttings	357	—	25	1	—
Natural regeneration (sprouts)	62,374	2,495	25	24	20–17,900
Natural regeneration (seed)	6,846	274	25	16	10–4,000
Total	86,143	—	—	—	—
Site Preparation Methods					
Chemical - aerial	2,251	90	25	6	68–904
Chemical - ground	3,099	124	25	9	15–1,040
Prescribed burning	388	16	25	7	3–144
Mechanical	8,212	329	25	18	38–2,781
Total	13,950	—	—	—	—
Timber Stand Improvements					
Chemical release - aerial	3,184	127	25	6	174–898
Chemical release - ground	3,138	125	25	7	12–1,500
Hack and squirt release	100	4	25	1	100
Mechanical / manual release	4,795	191	25	13	15–1,932
Noncommercial thinning	3,055	122	25	8	20–2,326
Residual stem felling	361	14	25	5	6–300
Pruning	339	15	23	10	2–200
Underburning	135	6	23	4	0–78
Total	15,107	—	—	—	—
Slash Disposal					
Untreated, left on site	62,801	2,730	23	20	250–20,000
Piled or windrowed	8,232	358	23	12	30–2,500
Removed (whole tree skidding)	9,223	401	23	14	30–2,500
Total	80,256	—	—	—	—

of the various standards and the diversity of forest conditions in Minnesota, sites labeled clearcuts with residuals might be hard to distinguish from partial cut sites.

Most residuals (87 percent) were alive at the time of harvesting (see table 9). However, several respondents noted that approximately 10 percent of the residuals die in the first few years after harvesting. The

residuals were generally scattered throughout the site (67 percent of the acres with residuals) rather than being associated in clumps (33 percent). Typically, residual trees were left for wildlife habitat and as a riparian buffer. Other reasons included visual quality, seed production, nonmerchantability or immature trees, poor markets, public relations, Best Management

Practices (BMPs), and species diversity. Most respondents indicated that all these concerns were considered within their organization, but priorities varied by site.

## Thinning

Table 9 indicates 16 percent of the area with harvesting operations on state land were thinned, followed by 15 percent on national forests, 5 percent on county, 5 percent on Native American, and 2 percent of forest industry land. The increased emphasis on commercial thinning compared to the 1991 survey is paralleled by a doubling of noncommercial thinning activities to 3,055 acres (see table 10). While commercial thinning increased on public land, the main increase in noncommercial thinning was owned by forest industry respondents (2,751 acres, compared to 203 acres in 1991; table 11).

## Regeneration

Table 10 shows a total of 86,143 acres were regenerated during 1996. The discrepancy between the number of acres on which a final harvest took place and the area with regeneration is due to the time lag between the two activities. Most sites regenerated in 1996 were harvested in 1995. A trend to rely more on natural regeneration (69,220 acres of natural seeding and sprouting, a 7 percent increase over 1991) rather than artificial regeneration (16,566 acres for planting and seeding, a 19 percent decrease) was evident on all but federal lands (see table 11). Managers relied on natural regeneration through sprouting or suckering on 62,374 acres (90 percent of the area with natural regeneration). Regeneration by natural seeding was limited to 6,846 acres or 10 percent of the natural regeneration acreage.

The amount of artificial regeneration declined from 1991 to 1996, with 21 and 16 percent fewer acres planted and seeded, respectively. In the 1991 survey,

underplanting was not documented separately, thus it was not possible to compare this practice with results for 1996 (table 8). Short rotation intensive culture is known to have increased from 1991 to 1996. Some evidence of this trend is the planting of hybrid poplar cuttings on 357 acres owned by forest industry.

## Site preparation

The delay between site preparation and planting or seeding explains the difference in total acreage with site preparation and regeneration activity (see tables 10 and 11). While the overall area with site preparation activities (13,950 acres) was similar to the acreage in 1991, the proportion of the area that was treated chemically increased to 38 percent. On land with chemical site preparation, 42 percent of the acreage received an aerial application of herbicides. Table 10 shows the range in acreage treated among respondents. Aerial application is common on land owned by forest industry (1,260 acres; see table 11). Aerial application is cheaper than ground application, but residual overstory trees hinder or eliminate low altitude overflights.

Acreage with mechanical site preparation declined by 15 percent. With decreased release efforts, more emphasis is placed on site preparation and chemical treatments which are considered more effective (by preventing sprouting or suckering). Burning activities are strongly influenced by weather patterns and thus vary tremendously from year to year. Thus, the decrease in burning activity (see table 8) in 1996 more likely reflects a difference in rainfall during the burning seasons rather than a trend away from using prescribed burning.

## Release

The compilation of timber stand improvement efforts in table 8 show the amount of regeneration release (11,217 acres) declined by 24 percent between 1991

**Table 11. Area of annual silvicultural operations by treatment method and ownership reported by respondents - 1996.**

Ownership	Total Area (Acres)	State	County	Federal	Forest Industry	Native American
Regeneration Areas, Acres						
Planting	11,530	4,061	2,118	1,739	2,958	654
Underplanting	1,957	500	72	1,305	0	80
Seeding	5,036	3,584	899	96	257	200
Cuttings (e.g., hybrid poplar)	357	0	0	0	357	0
Natural regeneration, sprouts	62,374	18,080	20,062	11,438	8,300	4,494
Natural regeneration, from seed	6,846	4,000	1,789	50	477	530
Total	86,143	30,225	24,940	14,628	12,349	5,958
Site Preparation Areas, Acres						
Chemical - aerial	2,251	748	243	0	1,260	0
Chemical -ground	3,099	1,040	999	0	1,060	0
Prescribed burning	388	147	19	150	0	72
Mechanical (scarification, etc.)	8,212	2,781	1,133	1,050	2,764	484
Total	13,950	4,716	2,394	1,200	5,084	556
Timber Stand Improvements, Acres						
Chemical release - aerial	3,184	767	574	0	1,843	0
Chemical release - ground	3,138	677	961	0	1,500	0
Hack and squirt release	100	100	0	0	0	0
Mechanical / manual release	4,795	1,133	316	2,685	50	611
Noncommercial thinning	3,055	100	40	0	2,751	164
Residual stem felling	361	300	45	6	0	10
Pruning	339	10	66	33	200	30
Underburning	135	0	0	113	0	22
Total	15,107	3,087	2,002	2,837	6,344	827
Slash Disposal, Acres						
Untreated, left on site	62,801	20,000	24,771	8,800	5,120	4,110
Piled or windrowed	8,232	2,500	1,945	3,500	200	87
Removed (whole tree skidding)	9,223	2,688	1,634	2,201	2,450	250
Total	80,256	25,188	28,350	14,501	7,770	4,447

and 1996. This decline was evident in all release methods with the exception of hack and squirt application, which is rarely done (a total of only 100 acres on state land; table 11). Reducing release efforts, a trend which is most apparent on county-owned land and, to some extent, on federal land, might suggest more efficient site preparation (with

increased use of chemicals) and/or a trend to acceptance of mixed species stands.

### *Other silvicultural issues*

Slash disposal treatments can greatly influence the nutrient status of the site. Consequently, additional information about

slash treatment after harvest was collected in 1996. Based on a subset of 23 respondents, most trees were delimiting in the stand and the slash was left on the site (62,801 acres or 79 percent of the area harvested; see bottom of table 8). Piling or windrowing, which concentrates the slash, and thus the nutrients, was applied on 10 percent of the area (see table 10). Whole tree skidding, i.e., delimiting at the landing, was conducted on 11 percent of the area harvested.

More than 70 percent of the respondents assess site conditions using the soil atlas, biophysical data, ecological classification systems, county soil surveys, field examination, or site index. Of those who did provide information (20 respondents), 95 percent used only one or two sources of information, mainly the soil atlas and soil survey (A percent) followed by biophysical inventory data and site index. State and federal managers consulted multiple sources (four or more).

Respondents indicated harvesting operations occurred primarily during the winter (54 percent) followed by summer (21 percent), fall (16 percent) and spring (8 percent). This seasonal distribution is very similar to that reported in the 1991 harvesting survey. Winter conditions provide greater access, i.e., access to areas that are unaccessible in summer, and frozen soils prevent compaction and rutting. Other reasons for winter harvests are that trees cut during winter sucker or sprout more vigorously than those felled in the summer. Thus season of harvest can also favor one species over another in regeneration. 🌲

## 4 Status and Trends

During the 1990s prices for forest products, especially pulpwood, increased. Simultaneously the public concerns about the ecological consequences of harvesting deepened. The forestry sector has reacted to both of these factors. The responses to the

silviculture survey indicates a trend in forest management in Minnesota toward an intensively managed, but more diverse forest. This trend is expressed as a shift toward leaving more residuals after harvest and increased emphasis on thinning, natural regeneration, and site preparation.

The increased attention to wildlife habitat quality, riparian protection, aesthetics, and nutrient retention is reflected in the change of silvicultural systems used in Minnesota. While clearcutting was still listed as the dominant silvicultural system used, a higher proportion of clearcuts had residual trees, snags and/or logs left after harvest. The areas clearcut with residuals can take on a variety of forms and in some cases are hard to distinguish from partial cuts. The authors speculate that field recognition, or lack thereof, explains the difference in the amount of clearcutting reported in the logging survey and silvicultural survey. Because of the amount of trees left behind, loggers may have reported a logging operation as partial harvest, while it was listed as “clearcut with residuals” by the forest manager. This issue is not limited to Minnesota, but part of an ongoing discussion by silviculturists, i.e., whether the “old” nomenclature for silvicultural systems are sufficient to characterize the diversity of systems used today.

While the benefit of a “legacy” in the form of residual trees and logs is well recognized, it is important to point out that residual trees may have a variety of negative impacts. Direct impacts include shading and competition for water and nutrients with the regeneration. Leaving a residual overstory favors shade tolerant species, like sugar maple or balsam fir. More light-demanding species, like quaking aspen, paper and yellow birch, and jack and red pine, might germinate or sprout. However, their growth, quality, vigor, and survival will be lower under residuals than in more open conditions. Another concern is that leaving certain species as live residuals (e.g., maple after aspen harvest) may discriminate

against regeneration of that species. Live residuals will not sprout and may not be vigorous enough to produce seeds. In addition, regeneration costs may increase as mechanized operations, from skidding to herbicide applications, have to be modified to accommodate the residuals.

All organizations surveyed recognized the importance of thinning to ensure a healthy, vigorous forest and the increases in stumpage values have made thinning more feasible. Overall thinning activities have increased. Commercial thinning activities became more common on public land, while precommercial activities increased on industrial ownerships. This difference might be due to different stand age classes on the ownerships.

The long-term trend to rely more on natural regeneration continues to be evident in Minnesota. The range of acceptable species and species mixtures has expanded, thus providing more opportunity for natural regeneration. Declining budgets may also be responsible for this trend, as natural regeneration is generally cheaper. On the other hand, natural regeneration from seed requires that harvesting operations are timed to coincide with good seed years. Delays in regeneration can effectively lengthen the period to achieve full stand establishment. Also, natural regeneration will likely not achieve the desired stocking or spacing to achieve the level of productivity obtained with planting.

Site preparation and release operations go hand-in-hand to provide good growing conditions for tree regeneration. In the last few years the emphasis has shifted to more intensive site preparation and less reliance on release treatments. Since crop trees are not yet present, site preparation allows for more efficient use of large machinery. Also, the choice of herbicide and timing of application does not have to be compromised to avoid injury to seedlings. Chemical site preparation was used more frequently, except on federal and Native

American ownerships. For many sites chemical site preparation is cheaper than most alternatives. It also may be more effective because of the ability of some herbicides to prevent perennials from sprouting. Another explanation for the reduction of release operations is that many organizations accept mixed species stands and species once considered weeds and treated, are now left to grow. 🌲

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## 6 Appendix

- **Appendix 1.** Definitions of harvesting and silvicultural systems.
- **Appendix 2.** Survey of logging business owners and harvesting practices in Minnesota, 1996.
- **Appendix 3.** Survey of forest managers and silvicultural practices in Minnesota, 1996.
- **Appendix 4.** MFRC Landscape Regions.
- **Appendix 5.** Harvesting survey respondents by county and Minnesota Forest Resources Council region.
- **Appendix 6.** Listing of open-ended comments from the harvesting questionnaire (Part 8).
- **Appendix 7.** Listing of open-ended comments from the silviculture questionnaire (Part 8).
- **Appendix 8.** Types of feller-bunchers identified by harvesting survey respondents.
- **Appendix 9.** Types of skidders and forwarders identified by harvesting survey respondents.
- **Appendix 10.** Types of delimiters, slashers, and chippers identified by harvesting survey respondents. 🌲

## *Appendix 1. Definitions of harvesting and silvicultural systems*

**Clearcut:** Removal or felling, in a single cutting, of essentially all trees in the stand to prepare the site for natural or artificial regeneration of a new even-aged stand. In some cases, varying numbers of residual trees, or groups of trees, are not harvested to achieve a variety of purposes such as wildlife habitat improvement.

**Group selection:** A method of regenerating uneven-aged stands in which trees are removed in small groups or patches and new age classes are established in the openings created. The maximum width of the group is approximately twice the height of an average mature tree within the stand.

**Patch clearcut:** A clearcutting method (as above) in which the areas that are cut create an opening with a width greater than twice the height of an average mature tree and which are less than 5 acres in size.

**Seed tree:** An even-aged regeneration method in which an area is clearcut except that certain trees, called seed trees, are left standing singly or in groups for the purpose of producing seed to restock the cleared area. Seed trees are removed after regeneration is established.

**Shelterwood:** A method of regenerating an even-aged stand by a series of partial cuttings, resembling thinnings, which extend over a small fraction of the life-span of the stand. The residual canopy of mature trees provides protection and conditions for establishing new seedlings.

**Single tree selection:** A method of creating new age classes in uneven-aged stands in which individual trees of all size classes are removed more-or-less uniformly throughout the stands to achieve a desired stand structure.

**Strip clearcut:** A clearcutting method (as above) in which areas are cleared in strips. The residual strips are left as sources of seed for the cleared area.

**Thinning:** Commercial harvest of selected trees in a stand. Often the harvest trees are marked. It is generally done to (1) remove less desirable trees (species or form) from a stand, and (2) decrease stand density and increase future growth of remaining desirable trees. 🌲

## Appendix 2. Survey of logging business owners and harvesting practices in Minnesota, 1996

ID Number \_\_\_\_\_  
(For mailing purposes only)

### SURVEY OF LOGGING BUSINESS OWNERS IN MINNESOTA

We would like to learn more about the status of the timber harvesting industry in Minnesota during 1996. If you wish to comment on any questions or expand on your responses, please feel free to use the space in the margins or attach a separate sheet of paper, if needed. Your responses will be kept confidential.

Several questions ask for information about your 1996 production levels. You can respond to those questions by either indicating a percentage or the total volume harvested during 1996. If you respond by indicating the total volume harvested during 1996, please indicate whether that number is in cords, thousand board feet (MBF), or tons. For example, if you want to indicate that your volume harvested was 500 cords, please write the number 500 and then circle the word "cords."

#### PART 1. BACKGROUND INFORMATION

The questions below apply to you and your logging business. The information will only be used to report comparisons between groups of people. Your responses will be kept confidential.

1. Indicate the name of the county where you live: \_\_\_\_\_ County.
2. On average during 1996, how many people were employed within your logging business. **Please include yourself within your answer:** \_\_\_\_\_ People.
3. How many years have you been working within the logging profession? \_\_\_\_\_ Years.
4. How many years have you been a logging business owner? \_\_\_\_\_ Years.
5. Please indicate the approximate average tract size in acres that you harvested in 1996. If there were multiple cutting blocks within a timber sale, consider each block separately:  
\_\_\_\_\_ Acres.
6. Please indicate your 1996 stumpage sources for wood that your logging business harvested. (If you indicate percentages, please ensure that the total equals 100 percent. If you indicate volumes, please circle the appropriate volume unit for each stumpage source.)

Stumpage Source	Percent (%)		
Volume			
Log your own stumpage purchases	_____ %	_____	Cords/MBF/Tons
Log stumpage purchased/provided by others	_____ %	_____	Cords/MBF/Tons
<b>Total</b>	<b>100%</b>		

7. Considering all of the stumpage sources, please indicate the percentage or the actual volume that your business harvested from the following owners during 1996. **Please indicate the landowner, not the permit holder.** (If you indicate percentages, please ensure that the total equals 100%. If you indicate volumes, please circle the appropriate volume unit for each stumpage source.)

<b>Landowner Group Volume</b>	<b>Percent (%)</b>		
Private, nonindustrial	_____ %	_____	Cords/MBF/Tons
American Indian	_____ %	_____	Cords/MBF/Tons
Forest industry	_____ %	_____	Cords/MBF/Tons
County	_____ %	_____	Cords/MBF/Tons
State	_____ %	_____	Cords/MBF/Tons
Federal	_____ %	_____	Cords/MBF/Tons
<b>Total</b>	<b>100%</b>		

8. Please indicate the total volume that your business harvested during 1996 within each of the species/products listed below. For each species/product, please circle the appropriate volume unit (cords, MBF, or tons).

1996 Softwood pulpwood volume harvested	_____	Cords/Tons
1996 Softwood log volume harvested	_____	Cords/MBF/Tons
1996 Hardwood pulpwood volume harvested	_____	Cords/Tons
1996 Hardwood log volume harvested	_____	Cords/MBF/Tons

9. Please indicate either the percentage or the actual volume that your business harvested during 1996 in each season listed below. (If you indicate percentages, please ensure that the total equals 100%. If you indicate volumes, please circle the appropriate volume unit for each season.)

<b>Season Volume</b>	<b>Percent (%)</b>		
Winter (December–February)	_____ %	_____	Cords/MBF/Tons
Spring (March–May)	_____ %	_____	Cords/MBF/Tons
Summer (June–August)	_____ %	_____	Cords/MBF/Tons
Fall (September–November)	_____ %	_____	Cords/MBF/Tons
<b>Total</b>	<b>100%</b>		

10. Please indicate the harvesting methods that you used during 1996. The harvesting methods are defined on a separate sheet of colored paper. (If you indicate percentages, please ensure that the total equals 100%. If you indicate volumes, please circle the appropriate volume unit for each harvesting method.)

<b>Harvesting Method Volume</b>	<b>Percent (%)</b>		
Clear-cutting (with or without residuals)			
(area 40 acres)	_____ %	_____	Cords/MBF/Tons
(area 21 to 40 acres)	_____ %	_____	Cords/MBF/Tons
(area 5 to 20 acres)	_____ %	_____	Cords/MBF/Tons
Group selection	_____ %	_____	Cords/MBF/Tons
Patch clear-cutting	_____ %	_____	Cords/MBF/Tons
Seed tree	_____ %	_____	Cords/MBF/Tons
Shelterwood	_____ %	_____	Cords/MBF/Tons
Single tree selection	_____ %	_____	Cords/MBF/Tons
Strip clear-cut	_____ %	_____	Cords/MBF/Tons
Thinning (commercial only)	_____ %	_____	Cords/MBF/Tons
<b>Total</b>	<b>100%</b>		

**PART 2. INFORMATION ABOUT YOUR METHODS OF OPERATION**

11. Please indicate the approximate percentage or the actual volume that your business harvested during 1996 for each of the following felling methods. (If you indicate percentages, please ensure that the total equals 100%. If you indicate volumes, please circle the appropriate volume unit for each felling method.)

<b>Felling Method Volume</b>	<b>Percent (%)</b>		
Chain saw felled	_____ %	_____	Cords/MBF/Tons
Felling machine moves to each tree:			
Feller-buncher	_____ %	_____	Cords/MBF/Tons
Cut-to-length (CTL)	_____ %	_____	Cords/MBF/Tons
Felling machine does NOT move to each tree:			
Feller-buncher	_____ %	_____	Cords/MBF/Tons
Cut-to-length (CTL)	_____ %	_____	Cords/MBF/Tons
<b>Total</b>	<b>100%</b>		

12. Please indicate the approximate percentage or the actual volume that your business harvested during 1996 for each of the following methods of transporting wood from the stump to the landing. (If you indicate percentages, please ensure that the total equals 100%. If you indicate volumes, please circle the appropriate volume unit for each method of transporting wood from the stump to the landing.)

<b>In-woods Transportation Volume</b>	<b>Percent (%)</b>		
Cable skidder	_____ %	_____	Cords/MBF/Tons
Grapple skidder	_____ %	_____	Cords/MBF/Tons
Forwarder	_____ %	_____	Cords/MBF/Tons
Farm tractor	_____ %	_____	Cords/MBF/Tons
Bulldozer	_____ %	_____	Cords/MBF/Tons
Other (please specify)	_____ %	_____	Cords/MBF/Tons
<b>Total</b>	<b>100%</b>		

13. Please indicate either the approximate percentage or the actual volume that your business harvested during 1996 for each of the following delimiting and topping methods. (If you indicate percentages, please ensure that the total equals 100%. If you indicate volumes, please circle the appropriate volume unit for each delimiting and topping method.)

<b>Delimiting/topping Method Volume</b>	<b>Percent (%)</b>		
Chain saw	_____ %	_____	Cords/MBF/Tons
Mechanical	_____ %	_____	Cords/MBF/Tons
Other delimiting or topping (please specify):			
_____	_____ %	_____	Cords/MBF/Tons
_____	_____ %	_____	Cords/MBF/Tons
_____	_____ %	_____	Cords/MBF/Tons
Not delimited or topped	_____ %	_____	Cords/MBF/Tons
<b>Total</b>	<b>100%</b>		

14. Please indicate either the approximate percentage or the actual volume that your business harvested during 1996 at each of the following delimiting and topping locations. (If you indicate percentages, please ensure that the total equals 100%. If you indicate volumes, please circle the appropriate volume unit for each delimiting and topping location.)

Delimiting/topping Location Volume	Percent (%)		
In the cut-over	_____ %	_____	Cords/MBF/Tons
At the roadside/landing	_____ %	_____	Cords/MBF/Tons
Not delimited or topped	_____ %	_____	Cords/MBF/Tons
<b>Total</b>	<b>100%</b>		

15. Please indicate the approximate percentage of your actual volume that your business harvested during 1996 for each of the following bucking/slashing methods. (If you indicate percentages, please ensure that the total equals 100%. If you indicate volumes, please circle the appropriate volume unit for each bucking/slashing method.)

Bucking/slashing Method Volume	Percent (%)		
Chain saw	_____ %	_____	Cords/MBF/Tons
Mechanical	_____ %	_____	Cords/MBF/Tons
Not bucked/slashed:			
Full-tree	_____ %	_____	Cords/MBF/Tons
Tree-length	_____ %	_____	Cords/MBF/Tons
Other (please specify):			
_____	_____ %	_____	Cords/MBF/Tons
_____	_____ %	_____	Cords/MBF/Tons
_____	_____ %	_____	Cords/MBF/Tons
<b>Total</b>	<b>100%</b>		

16. Please indicate either the approximate percentage or the actual volume that your business harvested during 1996 at each of the following bucking/slashing locations. (If you indicate percentages, please ensure that the total equals 100%. If you indicate volumes, please circle the appropriate volume unit for each bucking/slashing location.)

Bucking/slashing Location Volume	Percent (%)		
In the cut-over	_____ %	_____	Cords/MBF/Tons
At the roadside/landing	_____ %	_____	Cords/MBF/Tons
Not bucked/slashed	_____ %	_____	Cords/MBF/Tons
<b>Total</b>	<b>100%</b>		

17. This question considers the volumes that your business harvested in 1996 which were not delimited and/or not bucked/slashed. Please indicate the approximate percentage or the actual volume that your business harvested during 1996 for each of the following processing methods. (If you indicate percentages, please ensure that the total equals 100%. If you indicate volumes, please circle the appropriate volume unit for each processing method.)

Other Processing Method Volume	Percent (%)		
Full-tree chipping	_____ %	_____	Cords/MBF/Tons
Chain flail-delimiter/debarker/chipper	_____ %	_____	Cords/MBF/Tons
Other processing (please specify):			
_____	_____ %	_____	Cords/MBF/Tons
_____	_____ %	_____	Cords/MBF/Tons
_____	_____ %	_____	Cords/MBF/Tons
No additional processing conducted	_____ %	_____	Cords/MBF/Tons
<b>Total</b>	<b>100%</b>		

**PART 3. HARVESTING EQUIPMENT**

18. Please indicate the make and model for each felling machine or processor that your business used during 1996. For each make and model, indicate the number of felling machines in your operation, the age of each machine, and the approximate total number of machine hours for each machine through December 31, 1996 since the machine was new.

Felling Machine or Processor Make and Model	Number of Machines	Age (in Years)	Approximate Total Number of Machine Hours / Machine
1.			
2.			
3.			
4.			

19. For each felling machine or processor identified in Question 18, please indicate:

- a) the dimensions of the standard tires, tracks, or bogeys that you used during 1996,
- b) the dimensions of other tires (e.g., duals, wide tires), tracks, or bogeys that you used during 1996, and
- c) the approximate percentage or the actual volume that your business harvested during 1996 using each set of tires, tracks, or bogeys. (If you indicate percentages, please ensure that the total equals 100%. If you indicate volumes, please circle the appropriate volume unit for each set of tires, tracks, or bogeys.)

Felling Machine or Processor	Tire, Track, or Bogy Dimensions	Percent or Actual Volume Harvested in 1996	
Felling machine or processor #1:			
Standard tires, tracks, or bogeys		%	Cords/MBF/Tons
Other tires, tracks, or bogeys		%	Cords/MBF/Tons
Felling machine or processor #2:			
Standard tires, tracks, or bogeys		%	Cords/MBF/Tons
Other tires, tracks, or bogeys		%	Cords/MBF/Tons
Felling machine or processor #3:			
Standard tires, tracks, or bogeys		%	Cords/MBF/Tons
Other tires, tracks, or bogeys		%	Cords/MBF/Tons
Felling machine or processor #4:			
Standard tires, tracks, or bogeys		%	Cords/MBF/Tons
Other tires, tracks, or bogeys		%	Cords/MBF/Tons
<b>Total</b>		<b>100%</b>	Cords/MBF/Tons

20. Please indicate the make and model for each skidder, forwarder, farm tractor, and bulldozer that was used by your business in logging during 1996. For each make and model, indicate the number of machines in your operation, the age of each machine, and the approximate total number of machine hours for each machine through December 31, 1996 since the machine was new.

Skidder, Forwarder, Farm Tractor, or Bulldozer Make & Model	Number of Machines	Age (in Years)	Approximate Total Number of Machine Hours / Machine
1.			
2.			
3.			
4.			

21. For each skidder, forwarder, farm tractor, and bulldozer identified in Question 20, please indicate:

- a) the dimensions of the standard tires, tracks, or bogeys that you used during 1996,
- b) the dimensions of other tires (e.g., duals, wide tires), tracks, or bogeys that you used during 1996, and
- c) the approximate percentage or the actual volume that your business harvested during 1996 using each set of tires, tracks, or bogeys. (If you indicate percentages, please ensure that the total equals 100%. If you indicate volumes, please circle the appropriate volume unit for each set of tires, tracks, or bogeys.)

Skidder, Forwarder, Farm Tractor, or Bulldozer Machine	Tire, Track, or Bogey Dimensions	Percent or Actual Volume Harvested in 1996	
Skidder, forwarder, farm tractor, or bulldozer machine #1:			
Standard tires, tracks, or bogeys		%	Cords/MBF/Tons
Other tires, tracks, or bogeys		%	Cords/MBF/Tons
Skidder, forwarder, farm tractor, or bulldozer machine #2:			
Standard tires, tracks, or bogeys		%	Cords/MBF/Tons
Other tires, tracks, or bogeys		%	Cords/MBF/Tons
Skidder, forwarder, farm tractor, or bulldozer machine #3:			
Standard tires, tracks, or bogeys		%	Cords/MBF/Tons
Other tires, tracks, or bogeys		%	Cords/MBF/Tons
Skidder, forwarder, farm tractor, or bulldozer machine #4:			
Standard tires, tracks, or bogeys		%	Cords/MBF/Tons
Other tires, tracks, or bogeys		%	Cords/MBF/Tons
<b>Total</b>		<b>100%</b>	Cords/MBF/Tons

22. Please indicate the make and model for each delimeter that your business used during 1996. For each make and model, indicate the number of delimeters in your operation, the age of each machine, and the approximate total number of machine hours for each machine through December 31, 1996 since the machine was new.

Delimeter Make & Model	Number of Machines	Age (in Years)	Approximate Total Number of Machine Hours / Machine
1.			
2.			
3.			
4.			

23. Please indicate the make and model for each slasher that your business used during 1996. For each make an model, indicate the number of slashers in your operation, the age of each machine, and the approximate total number of machine hours for each machine through December 31, 1996 since the machine was new.

Slasher Make & Model	Number of Machines	Age (in Years)	Approximate Total Number of Machine Hours / Machine
1.			
2.			
3.			
4.			

24. Please indicate the make and model for each chipper that your business used during 1996. For each make and model, indicate the number of chippers in your operation, the age of each machine, and the approximate total number of machine hours for each machine through December 31, 1996 since the machine was new.

Chipper Make & Model	Number of Machines	Age (in Years)	Approximate Total Number of Machine Hours / Machine
1.			
2.			
3.			
4.			



## Appendix 3. Survey of forest managers and silvicultural practices in Minnesota, 1996

ID number \_\_\_\_\_  
(For mailing purposes only)

### SURVEY OF SILVICULTURAL PRACTICES IN MINNESOTA

We would like to learn more about the silvicultural practices applied by your organization during 1996. If you wish to comment on any question or expand on your response, please feel free to use the space in the margin or the last page. Your response will be kept confidential. Please note the source of the information provided by either circling D (Database) or E (Estimate) after each answer. With the exception of the question about regeneration by cuttings, all answers should be based on forest land only. See enclosed sheet for definitions of the silvicultural systems.

#### PART 1: ANNUAL FOREST MANAGEMENT OPERATIONS IN 1996

1. Please circle the category that applies to your organization:

National / State / County / Private/ Forest Industry / Native American Ownership

2. Area of timberland owned = \_\_\_\_\_ acres D / E

3. Volume harvested

Total, excluding fuelwood: = \_\_\_\_\_ cords

Fuelwood = \_\_\_\_\_ cords

4. Average clear-cut size = \_\_\_\_\_ acres

5. Average partial cut size (acreage in sale) = \_\_\_\_\_ acres

6. Information used to determine soil productivity (e.g. soil atlas, biophysical, ECS): \_\_\_\_\_

---

#### PART 2: SILVICULTURAL SYSTEMS USED

Clear-cut, with or without residuals:

(area 40 acres)	= _____ acres
(area 21 to 40 acres)	= _____ acres
(area 5 to 20 acres)	= _____ acres
patch clear-cut	= _____ acres
strip clear-cut	= _____ acres
shelterwood	= _____ acres
seed tree	= _____ acres
group selection	= _____ acres
single tree selection	= _____ acres
thinning (commercial only)	= _____ acres

**PART 3: REGENERATION METHODS**

planting:  
 total = \_\_\_\_\_ acres  
 underplanting = \_\_\_\_\_ acres  
 seeding = \_\_\_\_\_ acres  
 cuttings (e.g., hybrid poplar) = \_\_\_\_\_ acres  
 natural regeneration from sprouts or suckers = \_\_\_\_\_ acres  
 natural regeneration from seed = \_\_\_\_\_ acres

**PART 4: SITE PREPARATION METHODS**

chemical-aerial = \_\_\_\_\_ acres  
 chemical-ground = \_\_\_\_\_ acres  
 prescribed burning = \_\_\_\_\_ acres  
 mechanical (scarification, root raking, etc.) = \_\_\_\_\_ acres

**PART 5: TIMBER STAND IMPROVEMENTS**

chemical release - aerial = \_\_\_\_\_ acres  
 chemical release - ground = \_\_\_\_\_ acres  
 hack and squirt = \_\_\_\_\_ acres  
 mechanical release = \_\_\_\_\_ acres  
 noncommercial thinning = \_\_\_\_\_ acres  
 residual stem felling = \_\_\_\_\_ acres

**PART 6: OTHER SILVICULTURAL ACTIVITIES**

pruning = \_\_\_\_\_ acres \_\_\_\_\_ trees/acre  
 underburning = \_\_\_\_\_ acres  
 slash disposal:  
 untreated, left on site = \_\_\_\_\_ acres  
 piled or windrowed = \_\_\_\_\_ acres  
 removed (whole tree skidding) = \_\_\_\_\_ acres  
 Percentage of acres harvested during 1996 (Total percentage should add to 100):  
 Winter (December–February) = \_\_\_\_\_ %  
 Spring (March–May) = \_\_\_\_\_ %  
 Summer (June–August) = \_\_\_\_\_ %  
 Fall (September–November) = \_\_\_\_\_ %

**PART 7: RESIDUALS AFTER CUTTING**

1. Minimum number of residual trees or residual basal area (please circle the appropriate measure) that would qualify a site as a clear-cut with residuals (if available, please include a copy of guidelines with your response): = \_\_\_\_\_ trees/basal area per acre
2. Acres that are clear-cut with residuals, by your definition listed above: = \_\_\_\_\_ acres
3. Average density of residuals on sites that were clear-cut with residuals: = \_\_\_\_\_ trees/basal area per acre

4. Average proportion of the residual trees that are:  
 alive = \_\_\_\_\_ %  
 dead = \_\_\_\_\_ %  
 (Percent should add to 100)

5. Average % of the acreage where the residuals are:  
 scattered throughout = \_\_\_\_\_ %  
 in clumps = \_\_\_\_\_ %

A site on which trees were left in clumps as well as scattered throughout should be listed in both categories, i.e. percentage could be greater than 100.

6. Please state the % of the acreage of sites that were clear-cut with residuals on which residuals were left for following reasons. List sites in all categories that apply, i.e., percentage could be greater than 100. In addition, please indicate your priority by ranking the reasons (1 = highest priority, use ranks only once).

		<b>Rank</b>
wildlife	= _____ %	_____
visual quality	= _____ %	_____
riparian buffer	= _____ %	_____
other reasons (please specify):		
	= _____ %	_____
	= _____ %	_____

**PART 8: OTHER**

1. If you have contact through your organization with non-industrial private landowners, please indicate how many acres of these ownerships you managed in 1996? = \_\_\_\_\_ acres.

2. Please state to the best of your ability how these ownerships were managed in terms of:

a. silvicultural systems used: \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

b. regeneration methods: \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

c. other silvicultural practices: \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_



## *Appendix 4. Minnesota Forest Resources Council Landscape Regions*

### Appendix 5. Harvesting survey respondents by county and Minnesota Forest Resources Council Region, 1996

County	No. of Respondents	Region	County	No. of Respondents	Region
Aitkin	28	4	Olmsted	3	6
Becker	6	4	Ottertail	2	3
Beltrami	30	2 and 4	Pine	9	5
Benton	1	5	Ramsey	2	Metro
Blue Earth	1	Prairie	Redwood	1	Prairie
Carlton	10	1	Rice	1	6
Cass	19	4	Roseau	8	2
Clearwater	14	4	St. Louis	43	1
Cook	16	1	Todd	3	3
Crown Wing	11	4	Wabasha	1	6
Fillmore	3	6	Wadena	5	3
Freeborn	1	6	Other	3	—
Goodhue	1	6			
Houston	1	6			
Hubbard	23	64			
Isanti	1	5			
Itasca	64	54			
Kanabec	3	5			
Koochiching	42	2			
Lake	10	21			
Lake of the Woods	11	2			
Mahnomen	1	4			
Marshall	1	2			
Mille Lacs	4	5			
Morrison	2	5			
Mower	2	6			
Nichollet	1	Prairie			

## *Appendix 6. Listing of open-ended comments from the harvesting questionnaire (PART 8)*

### **Description of harvesting operation (numbers refer to individual respondents)**

4. I do mostly select cutting of hardwood on private property for housing developments, or for problem tree removal. I also bring the sawmill to the landing in the wood in the winter so I do not have trucking expenses.
5. I build birch bark canoes. My logging consists of cutting approximately 20 cedar trees per season. I fell them with a chain saw. I limb them with a chain saw. I cut them to length by chain saw. I carry the pieces out on my shoulder. I need fresh cut cedar because I split the wood by hand into thicknesses I need for use in the canoes. Kiln-dried or air-dried cedar won't work for my use.
7. These figures are harvesting poor quality wood that is over age and a lot of rot from being too old cutting cycles should be reduced and quality would improve. Harvesting time and cost would reduce.
8. In a small one man operation you don't have all that big expensive equipment and you (or at least I) can not afford tracts of more than 200 cd. But I have built a reputation of being neat, land caring and most of all honest. I do what the land owner wants done, and patch any damage I do. Because of this I am still finding wood for under \$20 per cord when average is 25-30. A lot of my wood I get for under 10 or free!! Just because of the mess others leave!! And I don't!! I am pissed at loggers and their reputations and I am one!
10. Lease or rent all equipment but skidder.
11. My main business is operating a sawmill and manufacturing stakes and bridging. I usually log about 100 cords of pine each fall. I do not own any logging equipment. I fell, limb, and buck with a chain saw. And I hire another logger with a cable skidder to skid.
14. I do mostly hauling for others. Pulp logs and firewood. I have a 1975 GMC 671 Detroit-13 speed and a Barko rear mount loader. Also own 1969 John Deere 440A cable skidder-which is rented by someone else. It is in Wadena area. Used in hardwood. I haul most of the wood to mill in Wadena. I have 4 stumpages one state-thinning-hardwood (about 200 cords) started in March 1997- 3 county- one tamarack 300 cords 2 hardwood about 200 cords select cut. Also use truck to haul hay-rock-set rafters on buildings and take down buildings-etc.
15. I cut wood in the winter to make it pass faster and for a few extra dollars. I farm in the summer.
16. I do not buy any stumpage, I only do custom work for other loggers. Many of these questions do not apply to me.
17. I believe my operation does not apply here. I do custom lumber milling sawing between 150 MBF and 200 MBF a year. My logging consists of select cuts on private land.
19. This is a part time seasonal business using minimal investment in equipment above the equipment already used in farming. Cutting is limited to small stands close to home and no more than 50 cords per year.
21. The county cutting of 27% was done on a 4 acre site with all trees in the area cut, except balsam fir. The remainder of the cutting, 73%, on private land, was done in 6 different sites of about 5 acres each. Each area was clear cut with the exception of balsam fir. I did not include firewood in

the totals listed. But the total cut was about 50 cords which included ash, red and soft maple, and birch. The cutting was all done in St. Louis County.

23. Although being a small time operator, the equipment I use is an efficient method because of ebbing environmentally agreeable to the land and forest in primarily two ways: 1) Using a tractor and skidder cuts down on rutting up the forest for the reason, if its too wet, you just can't go. You have no choice but to let the ground firm up. Less damage is done therefore to the forest floor. 2) A tractor and shortwood skidder combo is not capable of harvesting vast amounts of timber per day as other equipment is. The forest naturally will last longer and go farther operating in this way.
24. I've been a piece-cutter, western sawlog feller, purchase pulpwood operator and company logging contractor, but now at age 73 with power saw and 1 old skidder I log my own land, looking out for future timber, and enjoying logging more than ever!
29. I cut private wood most of the time for farmers who want their area thinned out and tops pushed up on a pile. The big outfits waste more wood than I take out in a year.
35. For the past 13 years, I've worked in the woods full time, until 2 years ago. Divorce and life changes has caused a pay slow down to my business. Until this time, I specifically cut private property. I patch cut mature stands. The owner has changed his decision from before. Stumpage rates are extremely high for a small business owner as myself. I will continue to log. I work at a small contractor business in the summer. Again self-employed I pride myself on doing a good job, clean, and effective.
42. It's a hobby for me just to get in the woods.
43. I do not believe in clear cutting timber. Ninety percent of all my logging practice is selective cutting only as most all my practice are selective cut. Selective sorting of all species of logs I cut for many smaller mills and cut many logs to utilize the most of the trees.
46. All equipment has been repowered or rebuilt this is the reasoning for value. Slasher and Barko 80 loader are hydraulically operated by a stationary power unit with 1100 operating hours on it, it is a 6VT Cummins.
47. Wood purchased from loggers, flocked and split to stove wood. I am over 70 years old and maybe this will be my last year. I am presently working on about 80 cords for next winter sales.
49. I do mostly cutting for my sawmill, I am setting up a log home management operation. Sawing, shaping, notching all done by machine. I'm steering toward white cedar, etc. this equipment isn't being classified as in woods harvesting equipment, I don't know if this is what you are referring to it as. Also the skidder is at another location so I'm not sure of the tire sizes.
50. I am a part-time logger because I love the woods. I'm currently working road construction driving a belly dump truck. Log spare time and winter months. Buy only small sales. Mostly sales that are not suitable to a big logging company. I also slashed 1000 cords for other loggers during the winter of 1996. Will retire from logging and working with logging equipment in the coming year 1998.
51. Approximate yearly average cords per year: 2000-3000, Acres: 40 to 100. Majority of 1996 time spent on Lake Co. Forestry Sale bought in 1990-designated method clear-cut. All timber sales have been of uneven proportions. Remaining tracts we have are state of MN land— cutting methods require leaving mature hardwood prefer Aspen trees per acre. Majority of species to be harvested are hardwood Aspen Birch. 1-Skidder grapple, 1-Slashing Unit, 1- tandem axle loader truck, chain saws and support equipment. Considering purchase of small feller-buncher capable of thinning in the next year.

52. I am retired and hand cut a few loads, mostly on my own property. This is not a typical example of wood harvesting.
54. Not really a logging business. Logging only own land.
56. We do not do wetlands.
58. We are conservation-minded people who try to take good care of the land as we would our own. Private parties are pleased with the work we do.
61. We hire most of the pulp and bolts hauled. Our truck isn't large enough to haul the distance it has to be trucked.
62. I am just a one man operation.
63. I log in a corporation with my father. We own 190 brood cows, 150 red deer and 50 llamas. We also run a feed store and a hay equipment sales business. We only log in the fall after all fields work is done until calving in April. In the summer we only cut 1 or 2 days if we get the time to. In the winter we have chores on the farm to do so we only get to work in the woods from about 12 noon until dark and work 7 days a week.
64. I work alone and use a farm tractor. I log and harvest. I am on Social Security and this is my last year of logging.
65. Being a lumber mill we only own one piece of logging equipment. Which is a forwarder. The numbers in this survey reflect the volumes of wood harvested from sales and contracts under our own ownership.
67. I am retired and nearly 70 years old. I do purchase any stumpage. Our timber comes off our own land. All our timber we cut is to supplement our Social Security.
68. I only cut firewood mostly. Cut only pulp or logs if I can get small sale from state or private parties. Cut on own land in 1996. Small sales are hard to get also from state. Would like to get firewood sale only.
69. We do all select hardwood cuts using draft horse for skidding to landing. We use chain saws for felling, bucking and limbing. We do at times use a crawler or farm tractor for laying out main skid trails and road building if necessary. The tractors are also used to deck and load logs.
70. Our company is not in the logging business per se. We do own the three skidders listed which we lease to independent loggers. The owner of the business began as a log producer in the early 60s and started our current business in 1976. We have not employed a logger in 10–12 years. We do employ three foresters as explained in questions 3 and 4. A single tree selection most accurately describes our harvesting system. We harvest mature and over mature trees according to a harvest plan developed by our foresters and the landowner.
71. Added Barko 1080C feller-buncher in February 1997.
72. The feller-bunchers and operators were hired out.
73. Most of the harvesting is done during early summer and late fall when soil conditions are at their best. My cutting operation is based on climatic condition. I stress low compaction of the soil and leaving as much residual in the woods. Except where landowners want a nice, neat job. (Remove all slash/plantations). Also no harvesting of aspen or northern hardwood during the heat of the summer.

74. Myself and my partner share equally in all ways, our logging is pretty much done the old-fashioned way, however our profit margin is very good. We also are starting to thin Norway pine plantations which we do not allow the use of heavy machinery, the county does not want the ground in these pine stands compacted, we may also begin thinning of red oak stands for the county and state.
75. I harvest hardwood on a hobby basis. Average: 20-30 thousand feet/year.
79. Operation was thinning red pine plantation. Equipment is Belarus 420 forward tractor with modified hydraulic system. It carries a Patu 575 rear mounted loader. The LF-40 Patu stroke delimber mounts to the loader and delimbs and bucks the tree to 100" length, when done on a landing (winter) slash is burned and wood picked up by truck at that point. At other times wood is processed in the stand. The delimber is dismounted. The loader remains and a trailer with dual 7.50x16 tires is pulled by the tractor. This is used to forward wood to the landing. The tractor, loader, and delimber combo weighs about 10,000 lbs. This is the first year using this equipment configuration so there is a debug/learning curve here.
90. I am not a logging owner, my father owns the business, I am an employee of his.
92. We cut about 194 cords in 1996. Actually 100 cords were cut by a feller buncher from off the property. It was a bad year for us. We normally cut over 100 MBF.

### **Blowdown impacted 1996 operations**

13. Last year there was quite a bit of blowdown cleaned up and that directly effects how or what is being used in production.
39. I also subcontract slashing, some skidding, all trucking. I also cut blowdown timber for all of November-December 1995 to Jan-Feb- March-Nov and Dec 1996-Feb 97. All sales were blowdown sales with approximately 20% standing trees in cutting blocks.
40. Because of a windstorm in 1995 we have been salvaging for 2 years. This changes our usual operation. Example, much larger tracts, higher volumes.
41. From May to Sept all harvesting was of blowdown timber on state and federal lands. Deep snow in Jan-March 1996-Dec 1996. All timber was hand fell.

### **It is difficult to compete with large businesses**

18. The high stumpage is putting the small logger out of business.
20. I have seen many changes in my lifetime in the timber industry and paper mills . Being born and raised on a farm you were always able to sell a few loads of wood as a supplement to farming. I did, and many others using horses to skid on drags—using cross cut saws, 4 foot saws, and Swede saws. All hard work-loading trucks by hand! This helped build the paper mills and board plants. It was the beginning. Now these companies have turned to big operations to produce the majority of wood! Giving very small contracts to a few loggers who cannot get any bigger than a old skidder and power saw operation barely able to exist. Many have been in the woods all their life, and never was allowed to get bigger. Companies keep saying we have to give the majority of wood to large operations. Wood stumpage is way too high there is no margin left. It now takes 50 people to do the job-manage forest- 4 people did 50 years ago. Let's give everyone a piece of the pie and give more people a chance and not just a few. This is America!
25. The high stumpage price is putting the small logger out of the business.

38. There are a lot of small tracts of land where the small logger can do a lot better job than the logger with all the big equipment. The hardest thing is to get contracts to get rid of the wood. The bigger logger are pushing the little logger out where it is harder to get rid of the wood. I would like to see the state make the big company like Potlatch to buy a certain percent of wood from loggers with small contracts like 100 cords a year.
45. Common sense in purchasing equipment-Its generally the ones with big payment and loans that are logging when it's only natural to shut down because of weather. Many loggers are getting discouraged due to high operating costs, availability of wood and regulations. Over the last few years any raises we've seen has gone for stumpage. The logger (small) hasn't seen anything for himself. The cost of certification, wider tires and safety equipment all cost money that isn't there. Hope the changes that take place in the next few years will remember that small logger.
88. As a small operator, the logging business is almost non-existent. The method of sales regarding stumpage squeezes the little guy right out of business. The stumpage war is a cut throat business. Who ends up bleeding the most- the guys on the bottom of the bottom of the pile, guys like me. I'll wait my three years to get a chance to cut off some piece nobody else will take. Meanwhile, I'll cut off lots and road right of ways. The best thing I can do financially is stay away from harvesting wood. I can't afford to make everyone else a bunch of money.
89. We were not able to make any money in 1996 logging. We are a small logging operation and business seems to be weeding out the small operators.

### Comments related to the survey

26. I feel many of these questions violate my rights to privacy. Some of the management I have seen done by our state forester makes me wonder if and what we hire people like this for. My grandfather homesteaded in Northern Minnesota. Forest management can't be done out of the book or with a computer. We have all together too many do nothing people. A forester has to be in the woods. Not running to a bunch of meetings just to provide people with do nothing jobs. We need a lot of change, the worst thing that happened to Minnesota DNR is when establish all the so called regions what a waste. All state DNR people should live within ten minutes of his place of work. Too much time is spent running up and down the road doing nothing. We are over-staffed with too many chiefs and not enough indians. If you want to see waste management by our DNR forester its time to get out of the office and see what's going on. Maybe timber should be cut and not wasted.
27. Some questions you asked two times.
30. This survey took more time than I wanted to spend on it. I work in the office (not in the woods) so I do not know the number of hours on these machines. Those figures are not important to us until we are ready to sell a machine.
32. Received 2 questionnaires.
33. Question #19 is somewhat confusing. A Hahn machine delimbs and processes at the roadside or landing. Tire size or dimensions are not significant. Please share survey results with all.
53. There was no mention of Cats-bulldozers earth-moving equipment needed to make roads-landing-or other support equipment such as very expensive pickups- shops offices-computers.
55. As a very small operation, a lot of this is guess work as we don't have the time to keep track of a lot of this information.

- 66. Can't compete with big business.
- 78. Our address should be changed.
- 80. Question #2 does not include contract truckers.
- 82. Filled out and sent two surveys.
- 91. I have found during 69 years experience that the information I have provided for similar surveys has been used against me. Furthermore, there is no way you can guarantee that this information will be kept confidential. Therefore I do not wish to participate.

### Other comments

- 1. Moved to Wisconsin June 1996
- 2. 1996 was a slow year logging, fought a lot of time.
- 3. With added restrictions and regulations including stumpage and equipment costs, I feel that we never get compensated for the job we do. Each year we are asked to do more. I understand the reasons we need to do this. My question is when will the public realize what a good job loggers do?
- 6. Please send me the results of the study.
- 9. Due to single tree selection of hardwood saw bolt and harvesting blowdown, hand felling and bucking on landing and grapple skidders are not usable or feasible.
- 12. There should be something done about the high cost of workman compensation, so a person could afford to hire someone if he wished to.
- 22. 1) I would like to increase the size of my operation but will not because of the high price of work-comp rates, 2) Logging is a high financial risk business and requires long hours of work under difficult weather conditions with low return on investment, 3) I would not recommend logging as a business to anyone.
- 28. I don't think loggers should be forced into state licensing.
- 31. I do hope that this survey is not going to be used against loggers or logging. Working on the woods is getting harder every year- stumpage prices, machinery costs, etc. are growing while the market for the wood is remaining the same and somewhat dropping.
- 34. Instead of more regulation forced on the loggers we need to find more common sense ways to continue to log or the logger is going to be a lost issue in Minnesota.
- 36. Being a small logger I believe logging equipment has gotten too big. Lighter "in woods" machines are better—less compaction, less rats, less damage to residual trees.
- 37. I would like to comment on the way the state and county(DNR) sends false prices to the public. They don't offer enough sales and they sell them as appraised. Which means you only pay for estimated volume. When you can buy 1000 cords of wood and only pay for 600 cords. That means since this is an auction the loggers will pay higher prices for example if you bought a 600 cord job for \$30 per cord. Then when you harvest it you would actually be 600 x 30=\$18000/1000=\$18 per cord. But when a private landowner hears that a logger paid \$30 per cord on a state or county auction they have to wonder why their wood is not worth \$30/cord. It is really simple why their wood is not worth \$30 per cord. Because I pay them for every cord I

remove. My family has been involved in logging for over 30 years. Now I am being forced to join the Minnesota Logger Education Program (MLEP) they say it is voluntary but the place I sell which has my biggest contract (7000 cords/year). They told me if I am not a member within 2 years they will not purchase wood from me. Is that voluntary? I think not. I have been to 3 different meetings so far and I think it might be a good thing to have organization to keep government out of logging since the government has proved many times to fail. In my eyes they have done nothing with all of their regulations and welfare programs. Why don't we create an environment where small business can grow instead of continually discouraging people from running their own business. This way they won't need CRP and other programs. I thank you for giving me this chance to tell you some of my concerns. I think what we get out of this MLEP will be directly related to how much all of the loggers in the state put into it. Because you have to put full effort into everything you try or you won't get it.

44. What percentage of profit do most loggers have 2%? 5%? 10%?
48. Clear cut destroys all unwanted hardwood. Not good. Some elm, oak maybe boxelder and ash would be nice for the next generation.
57. Go back to horse and Swede saw.
59. After 50 years of logging I thought it was time to retire.
60. Stumpage hard to get high price. Getting old to work.
76. I think horse logging will become my preferred method of skidding. There are several horse loggers in our area (Central Minnesota). They are struggling to make a living with logging and work other jobs to earn what they need. But they have high hopes of setting up businesses that would take care of the community's needs while providing a good income for themselves. They are not as efficient as skidder operators so they charge more. The way they leave a site is worth the extra money.
77. Please do not send surveys. All I do is cut tepee poles. I buy them from county or state mostly thinning plantation trees. I'm not a logging business.
81. I am retired and the amount of timber harvesting I do amounts to very little.
83. Did not ask how many deer us loggers keep alive during the winter months? I fed 30 deer all winter of 1997 out of my own pocket. Why don't we get more feed to help us out? I think the loggers in Northern Minnesota are helping all the natural resources. Send me a copy of your findings.
84. There's got to be changes done in the stumpage prices and methods of pulp, bolts, and log prices. Right now there is no incentive to cut bolts and logs because the stumpage price goes up if not used for pulp. If you can't get a contract for pulp you have to go to other markets. And the loggers get higher stumpages with no higher product pines.
85. This isn't my business. It helped our boys get a job. I tried to sell the skidder and its still for sale. I have a back injury and can't work it.
86. Big Falls Forest Products Inc, has sold out to Knaeble Inc. and is no longer in business. Please take their name off your list.
87. I know you will not care for my answers particularly due to your narrow view of logging. The purchase of stumpage, layout of logging operations, road construction that I do, scheduling, and marketing of various products is every bit as important as loading trees, skidding or felling all I have

done in the past. People I work with have some of the newest most efficient machinery in the business, most of which have not answered your questions most of which focus on your narrow viewpoint of logging. Today's timber harvesting operations begin with purchasing the stumpage and run to the marketing of the timber. The management of cash, regulation, and marketing, take up much time and effort. The reason I exist at all is that the forest industry has backed away from this effort. Leaving the logging industry with very little support both financial and physical.

93. Building a motel. Also looking for a job, pays health plan retirement, etc. Tired of working for less than minimum wage. 🌲

## *Appendix 7. Listing of open-ended comments from the silviculture questionnaire (PART 8)*

### **Re NIPF, please state how these ownerships were managed in terms of silvicultural systems (numbers refer to individual respondents)**

2. Most of the acres managed in the previous section are owned by individual trust allotments.
3. Silvicultural systems used: Clear-cut. Regeneration (by) natural, aerial seeding.
12. Silvicultural systems used: Probably all as defined (used all silvicultural systems), used planting, under planting, cutting, natural regen for suckers, natural regen from seed. Many silvicultural practices (used) include provision for wildlife & aesthetics or their implementation.
13. Silvicultural systems used: Same as company lands.
14. Most cuts are clear-cuts, but significant amount is commercial thinning in plantations. Regeneration methods: Aspen suckers (95%), Conifer planting (2%).
20. Answers on previous pages reflect the answer to these questions. On Indian lands you often have 3 types of ownership in Minnesota. These ownerships being: 1) Tribal - Minnesota Chippewa Tribe, 2) Band - Leech Lake Band, 3) Allotted - Individual Indian heirs - may have 1 or as many as 100 on a given parcel. On Leech Lake Reservation these ownerships account for approximately the following percentages: a) Tribal –45%, b) Band –10%, c) Allotted –45%.
31. Silvicultural systems used: Merchantable clear-cut –i.e., clear-cut with residuals. Regeneration methods: With spot planting in understocked areas. Other silvicultural practices: Direct seeding (small area, approx. 3 ac.)

### **Is there anything else you would like us to know about your silvicultural practices?**

3. Water quality and visual BMPs are part of the company's standards and guidelines. No efforts are made to track partial harvest data, although BMPs and non merchantable factors certainly cause it to occur with our operations.
4. Seed orchard expansion from 20 acres to 35 acres.
5. Severe windstorms in 1995 leveled thousands of acres of timber here. For the past 18 months, timber salvaging has been, almost exclusively, our only forest management activity. This has severely increased our normal level of harvest, as well as altered our silvicultural practices temporarily.
6. White pine is being reserved more and increased emphasis is being placed on white pine mangement.
24. Some of us realize that our regeneration with reserves is basically counter-productive, and is only being done for political reasons. But such is forest management... these days. 🌲

## Appendix 8. Types of feller-bunchers identified by harvesting survey respondents

Model	Number	Machine Weight	Standard Tire	Model	Number	Machine Weight	Standard Tire
Barko 775	5	27,000	23.1-26	Hydro Ax 411	3	22,800	23.1-26
Barko 1080C	2	—	—	Hydro Ax 511	7	30,550	28L-26
Barko (generic)	1	—	—	Hydro Ax 611	3	31,200	28L-26
Bobcat	3	—	track	Morbell/Morbark Wol.	1	13,600	18.4-26
Bobcat 1080 (track)	6	17,475	track	Terex front-end loader	1	—	—
Bobcat Cat: C4/C5	2	—	—	Timbco 420 (23" pad)	10	43,500	track
Case 880	1	—	—	Timbco 2518/2620	6	—	—
Case 1187 (24" track)	8	51,050	track	Smalley	1	—	—
Case (generic)	1	—	—	Clark 1080C	3	—	—
Can-Car Clipper	2	—	23.1-26	Komatsu PC120	1	—	—
Drott 40 (30" track)	10	49,280	track	Bell	1	—	—
Drott (generic)	1	—	—	Homemade	2	—	—
Franklin 170 PSL	8	—	—	Tiger Cat 720	1	—	—
Franklin (generic)	1	—	—	Ponsse H315	1	—	—
JD 350 (crawler)	2	10,600	track	Timberjack 1270	2	—	—
JD 450 (crawler)	7	15,930	track	Kochums 880	2	—	—
JD 490	1	—	track	Siira Hydralogger	1	—	—
JD 544 (rubber tire)	15	28,500	28.1-32	Master 501 Pettibone	2	—	—
JD 643	28	36,900	30.5-32	Other	2	—	—
JD track machine	1	—	—	<b>Total</b>	<b>180</b>	—	—
JD 590D	1	—	—				
JD 640	2	—	—				
JD 653E	5	—	—				
JD (generic) JD 743	2	—	—				
Hydro Ax	12	25,680	23.1-26				
Hydro Ax 311	3	19,200	18.4-26				

*Appendix 9. Types of skidders and forwarders identified by harvesting survey respondents*

Model	Machine Weight	Standard Tire	Number	Model	Machine Weight	Standard Tire	Number
Catepillar 508	18,730	23.1-26	1	Timberjack TJ 208	12,300	16.9-30	3
Catepillar 518 (grapple)	27,525	23.1-26	1	TJ 225E	14,850	18.4-26	3
Catepillar (generic)	—	—	6	TJ 230	15,500	23.1-26	10
Clark 664 (wt for cable)	15,890	18.4-26	6	TJ 230 (forwarder)	19,532	24.5-32	1
Clark 665 (wt for grapple)	20,140	23.1-26	2	TJ 350	19,995	23.1-26	5
Clark 666 (wt for cable)	18,450	23.1-26	3	TJ 380 (grapple)	24,800	28L-26	10
Clark (generic)	—	—	6	TJ 450 (grapple)	25,040	28L-26	11
Franklin 100	—	23.1-26	2	TJ (generic)	—	—	18
Franklin 170 cable	19,960	24.5-32	3	TJ 460	—	—	3
Franklin (generic)	—	—	2	Tree Farmer C4	11,900	16.9-30	12
Int'l. Harvester S8 (forwarder)	—	—	3	Tree Farmer C5	13,440	18.4-26	23
Int'l. Harvester skidder	14,000	—	2	Tree Farmer C6	16,660	23.1-26	5
Int'l. Harvester tractor 3514	—	—	1	Tree Farmer C7	—	—	17
Int'l. Harvester (generic)	—	—	1	CDT	—	—	1
JD 440 (cable)	14,300	18.4-26	23	Homemade	—	—	2
JD 540 (cable)	16,150	18.4-26	30	Horse	—	—	1
JD 548 (grapple)	18,040	23.1-26	23	Valmet	—	—	1
JD 640 (cable)	20,180	24.5-32	5	Prentice	—	—	2
JD 648 (grapple)	26,250	24.5-32	33	Hill	—	—	1
JD 455 (crawler)	—	—	1	Other	—	—	16
JD (generic skidder)	—	—	4	<b>Total</b>	—	—	<b>320</b>
JD 380	—	—	1				
JD 748	—	—	3				
JD (generic)	—	—	10				
Pettibone (master 12)	—	16.9-30	1				
Pettibone (generic)	—	—	1				

*Appendix 10. Types of delimiters, slashers, and chippers identified by harvesting survey respondents*

Make & Model	Number	Make & Number	Number
<b>Delimiters</b>	<b>97</b>	Barko	25
Can-Car Processor	2	CTR	2
CTR	6	Hood	13
Denis combination	6	Husky	1
Hood	4	Lemco	20
Hydro Ax chain fall	1	Siira	33
Hahn harvester	21	Homemade	8
JD 693, 743, 555	11	Prentice	13
Siira	11	Hahn	7
North Shore grapple	1	Chain saw	2
Other (homemade)	20	Northshore	1
Chain saw	8	Gersha	1
Barko	1	<b>Full-tree Chippers</b>	<b>6</b>
Timberjack	3	Morbark 20	5
Timberline	2	Trelan	1
<b>Slashers</b>	<b>126</b>		