FOREST RESEARCH REPORT

NOVA SCOTIA DEPARTMENT OF LANDS AND FORESTS
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# SMALL SCALE CHIPPING TRIALS IN NOVA SCOTIA

## INTRODUCTION

Production of energy by burning wood chips is a common practice in Scandinavian countries, parts of the United States and in some Canadian provinces. Through various committees and organizations, government and industry have been examining the potential for producing and burning wood chips from Nova Scotia's forests. The major reasons for the interest in chip production are: 1) job creation, 2) lower energy costs, and 3) forest improvement. A co-operative trial between the province of Nova Scotia and the Government of Canada was established to evaluate small scale chip production from various biomass sources. The objectives were:

1) to determine the feasibility of using a small roadside chipper in conjunction with conventional logging equipment for fuel chip production;
2) to determine production volumes, rates and costs associated with various harvesting operations and sources of raw material, and
3) to identify phases of this system which require modification.

## METHODS

Five sites were selected as trial locations:

1) Plympton 1, Digby County
   - pre-merchantable thinning
2) Plympton 2, Digby County
   - merchantable thinning
3) Lake Paul, Kings County
   - merchantable thinning
4) Guysborough, Guysborough County
   - softwood clearcut
5) Mitchell Lake, Guysborough County
   - low volume, small diameter balsam fir clearcut

Prior to treatment a point sample cruise was done at each location to determine stand characteristics (Table 1). Local woodsworkers or contractors were used to fell, extract and truck all products. No modifications were made to the extraction equipment for handling unmerchantable biomass.

In the thinning operations, extraction trails were cut 20 metres apart. Conventional products and unmerchantable biomass were piled manually beside the trails for extraction. The biomass used for chipping consisted of unmerchantable trees, tops

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and branches cut in lengths of five metres or less. Some wider spreading branches were left on site to maximize the amount of biomass forwarded per load.

An F-4 Dion forwarder was used to extract conventional products and unmerchantable biomass from the pre-merchantable and merchantable thinnings in Plympton. Initially, biomass was trucked to the user facility where it was chipped. Later on in the experiment the chipper was moved to the landing.

At the Lake Paul site, the wood was extracted with a CD-5 Tree Farmer forwarder. Initially, chips were blown directly into a chip van, but due to the excessive time required to fill the van, the chips were subsequently piled on the ground, loaded and hauled later. The stand was divided into two areas. Conventional products and unmerchantable biomass were felled and extracted from Area 1, while conventional products only were extracted from Area 2. Stand and site conditions were similar in both areas.

Logging slash left from a July 1985 clearcut at Guysborough was forwarded to roadside using a 520 Timberjack forwarder. Chipping was done at the landing and chips were blown directly into a chip van.

At Mitchell Lake, two stands typical of the dense, small diameter balsam fir found along the eastern shore of Nova Scotia were directionally felled. The full trees were forwarded to roadside using a Timberjack 230, 8-ton forwarder. Chips were piled on the ground and then loaded and trucked at a later date.

Although a variety of forwarders were used for extraction, all forwarded material was chipped with a Model TT1000 TU, trailer mounted disc chipper manufactured by Perusyhtyma Oy of Finland. The chipper was powered by a 160 h.p. Case farm tractor (Model 3294) and fed with a Fiskars grapple loader equipped with hydraulic stabilizers. The controls for the loader, the chipper infeed system and the direction of the chipper's discharge chute were located in the tractor's cab. The maximum stem diameter the chipper can process is 25 centimeters (10 inches). In small diameter material, multiple stems can be processed simultaneously.

**Table 1. Stand characteristics at each site.**

| Location | Treatment Type | Area ha | Age | Total BA[1] $m^2$/ha | Merch BA[2] $m^2$ /ha | Avg. Dia[3] cm | Total Vol[4] $m^3$ /ha | Merch Vol[5] $m^3$ /ha | cds/ac |
|---|---|---|---|---|---|---|---|---|---|
| Plympton 1 | Pre-Merchantable Thinning | 2.0 | 33 | 30.1 | - | 8 | 150.5 | - | - |
| Plympton 2 | Merchantable Thinning | 4.0 | 48 | 47.2 | 41.2 | 12.4 | 324.7 | 214.0 | 38.2 |
| Lake Paul | Merchantable Thinning | 5.8 | 50 | 42.7 | 39.1 | 13.0 | 318.1 | 232.6 | 41.4 |
| Guysborough | Slash Chipping | .64 | - | - | - | - | - | - | - |
| Mitchell Lake | Low Volume Stand Harvesting | .31 | 45 | 50.8 | 10.3 | 7.4 | 271.8 | 39.6 | 7.0 |

1. Total BA - total basal area; the sum of the cross-sectional area measured at breast height of all trees over 1 cm.
2. Merch BA - merchantable basal area; the sum of the cross-sectional area measured at breast height of all trees 9cm and greater.
3. Avg. Tot. Dia. - average total diameter; the average stand diameter measured at breast height for all trees over 1 cm.
4. Total Vol. - total volume; the sum of the volumes (inside bark) of all trees measured at breast height over 1 cm.
5. Merch. Vol. - merchantable solid volume; the sum of the volumes (inside bark) of all trees measured at breast height 9 cm or greater taken to 7 cm top and 15 cm stump.

# RESULTS AND DISCUSSION

## FELLING

Production rates and costs for felling at each location are summarized in Table 2.

**Plympton 1**

Average production for felling conventional roundwood products and chip biomass was 0.29 tonnes/man hour at a cost of $25.72/tonne. This production rate is about two thirds the production achieved in a recent merchantable thinning productivity study[1]. The lower production rate is attributed to the smaller tree size and the time required to move the unmerchantable biomass to the extraction trails .

1. Unpublished data, N.S. Dept. of Lands and Forests, Truro.

**Table 2. Production rates and costs for felling operations at each location**

| Location | Treatment | Volume Harvested (tonnes) Roundwood | Chips | Total | Felling Cost $/tonne | Tonnes/Man Hour |
|---|---|---|---|---|---|---|
| Plympton 1 | Pre-Merchantable Thinning | 73.9 | 36.0 | 109.9 | 25.72 | 0.29 |
| Plympton 2 | Merchantable Thinning | 129.1 | 74.0 | 203.1 | 21.97 | N/A |
| Lake Paul | Merchantable Thinning - Area 1 | 102.0 | 133.1 | 235.3 | 21.59 | 0.43 |
| | - Area 2 | 53.9 | - | 53.9 | 22.23 | 0.42 |
| Guysborough | Slash Chipping | - | 46.0 | - | - | - |
| Mitchell Lake | Low Volume Stand Harvesting | - | 65.0 | 65.0 * | 1.63 | 6.19 |

* Estimated: due to loading and trucking problems some chips were left on the ground.
Tonnes - Based on 0.79 tonnes/green m³ for softwood
0.88 tonnes/green m³ for hardwood

**Plympton 2**

Hourly production rates for this merchantable thinning were unavailable, however, the cost/tonne of $21.97 is close to the $21.59/tonne achieved at Lake Paul. Assuming similar wage rates at each site, production of conventional products and unmerchantable biomass at this site would be similar to the .43 tonnes/man hour achieved at Lake Paul. This represents a 48% increase in production compared to the pre-merchantable thinning at Plympton 1 due mainly to the larger diameter trees in the merchantable thinning. This production rate is also closer to the rates achieved in the previously mentioned productivity study.

**Lake Paul**

In part of this stand (Area 1), both roundwood and chip biomass were extracted while in the rest of the stand (Area 2) roundwood only was removed. The production rates and costs for felling were about the same in each area; 0.43 tonnes/hour in Area 1 and 0.42 tonnes/hour in Area 2, indicating that the unmerchantable biomass, even with its smaller size and branchiness can be felled at about the same rate.

**Guysborough**

No felling costs above those which normally occur in a clearcut were incurred at this site. However, a proper trail cutting pattern may have improved forwarder productivity.

**Mitchell Lake**

The closely spaced balsam fir were directionally felled at the rate of 6.19 tonnes/ man hour and a cost of $1.63/tonne. The felling costs incurred here are lower than those for the thinning operations at Plympton 2 and Lake Paul because the power saw operators were not required to select trees for cutting. As well, the cutters did not have to delimb or buck the trees and there was no manhandling of felled trees.

## EXTRACTION

Table 3 summarizes production rates and extraction costs at each site.

**Plympton 1 and 2**

The cost of extracting merchantable material using F-4 Dion forwarders at these sites was based on $18 and $15 /cord respectively for Plympton 1 and 2. Cost per tonne was determined by using a conversion of 1.8 tonnes/cord for softwood and 2.0 tonnes/cord for hardwood.

Payment for extracting unmerchantable biomass was based on the above rates. Volume was determined by scaling the piles and expressing the results in terms of cords. The loads of unmerchantable biomass were estimated to weigh 50-60% of an equivalent volume of roundwood. If payment was made per tonne, the operator would have to charge about $16 /tonne to extract unmerchantable biomass compared to $8 or $9 /tonne extracting roundwood products to maintain the same revenue per load.

**Lake Paul**

Average production of the CD-5 Tree Farmer forwarder was 6.4 tonnes/hour hauling roundwood products and 3.3 tonnes/hour hauling unmerchantable biomass. The reduction in load weight increased extraction costs from $9.08/tonne for roundwood products to $17.65/tonne for unmerchantable biomass. The branchiness and small size of the unmerchantable biomass makes it difficult to get a substantial load on the forwarder. The loader can be used to compact the biomass, however, this increases the time to offload and chip, because of difficulty in pulling apart the compacted piles.

**Guysborough**

A Timberjack 520 forwarder extracted the brush and tops to the landing. The average load size of 1.9 tonnes is about 15% of this machine's 12 tonne capacity. The cost/tonne was $19.73 compared to a cost of about $5 /tonne for pulpwood extraction.

**Table 3. Production rates and costs for forwarding at each location.**

| Location | Treatment | | Volume Forwarded (tonnes) | | | Unit Cost | Tonnes | Tonnes Chip |
|---|---|---|---|---|---|---|---|---|
| | | | Roundwood | Chips | Total | $/tonne | /hr | material/load |
| Plympton 1 | Pre-Merchantable Thinning | | 73.9 | 36.0 | 109.9 | 9.00 | - | 2.0 |
| Plympton 2 | Merchantable Thinning | | 129.1 | 73.8 | 203.1 | 7.49 | - | 2.0 |
| Lake Paul | Merchantable Thinning - Area 1 | -Roundwood | 102.0 | - | 102.2 | 9.08 | 6.4 | - |
| | | -Chip Biomass | - | 133.1 | 133.1 | 17.65 | 3.3 | 3.3 |
| | - Area 2 | | 53.9 | - | 53.9 | 8.44 | 7.3 | - |
| Guysborough | Slash Chipping | | - | 46.0 | 46.0 | 19.73 | 2.8 | 1.9 |
| Mitchell Lake | Low Volume Stand Harvesting | | - | 65.0 | 65.0 | 8.32 | 5.9 | 4.5 |

Trail cutting could have reduced loading time and improved piling on the machine and at the landing. The operator piled the material beside the machine before loading. This helped improve the condition and size of the load but the loading time was also increased.

**Mitchell Lake**

At this location a 230 Timberjack, 8-ton forwarder, extracted full trees at the rate of 5.9 tonnes/hour. Average load size was 4.5 tonnes or about 60% of the machine's capacity. The average load size compared to that at Lake Paul, was about 70% greater due to the overhang of the full trees and greater compaction attributable to the small crowns. Increased load size combined with a short haul distance (max. 100 meters) resulted in extraction costs of $8.32/tonne.

Increased forwarder productivity at this location could have been achieved with an operator more experienced loading full trees. As well, the addition of a heel on the boom would have made loading and unloading of the full length trees easier and improved piling which could have further increased average load size. Due to wind direction, the trees were felled with the tops towards the landing. This meant the forwarder had to load travelling into the area, turn and drive to the landing. Turning with the long overhang was difficult and increased turn around time. Forwarder productivity can be increased by felling the trees so the operator can drive in, turn empty and load on the way out.

## CHIPPING

The chipper operated a total of 67.6 productive hours and produced 355 tonnes of chips. Production ranged from 2.9 to 8.0 tonnes/hour. Table 4 summarizes the production rates at each site. Chipping costs were determined using an hourly rate of $73.00 which includes the operator and was based on information collected during the trial and from the manufacturer and supplier.

Prior to this trial, the operator, who was provided by the supplier, had only one hour of experience on the machine. As the operator became more experienced, productivity increased. The chipping trial started at Plympton, then moved to Lake Paul, Guysborough and finished at Mitchell Lake.

**Table 4. Summary of chipper productivity and production costs at each location.**

| Location | Treatment Type | Area (ha) | Chip Production Tonnes /ha | Tonnes /ac | Tonnes /hr | Chipper Costs*/tonne |
|---|---|---|---|---|---|---|
| Plympton 1 | Pre-Merchantable Thinning | 2.0 | 18.0 | 7.3 | 5.8 | 12.59 |
| Plympton 2 | Merchantable Thinning | | | | | |
| | -Roadside Chipping | 4.0 | 18.2 | 7.4 | 6.3 | 11.59 |
| | -Trucked to Facility | - | - | - | 4.4 | 16.89 |
| Lake Paul | Merchantable Thinning - Area 1 | 3.5 | 38.0 | 15.3 | 6.0 | 12.17 |
| Guysborough | Slash Chipping | .64 | 71.9 | 29.2 | 2.9 | 25.17 |
| Mitchell Lake | Low Volume Stand Harvesting | .31 | 209.7 | 88.4 | 8.0 | 9.12 |

* Based on a cost of $73/prod. man hr for the chipper and operator.

**Plympton 1 and 2**

Due to small landings at these sites and the unavailability of chip vans, the unmerchantable biomass was trucked to the chipper located at the facility where the chips would be used. Initial production was 4.4 tonnes/hour increasing to 5.8 tonnes/hour as the operator became more experienced and piling improved.

When material was piled higher than 6 feet, the operator could not see the top of the pile. As well, the piles were unstable causing material to roll down and criss-cross on the end making grapple loading difficult. High piles also required extra time for the operator to swing a grapple load from the top of the pile to the infeed chute.

Multiple handling of the material created compact piles which were difficult for the light loader on the chipper to pull apart. Production increased to 6.3 tonnes/hour when the chipper was moved to the landing at the mechantable thinning.

The diameter of the biomass was suitable for the chipper, however the short length (2-5 meters) made it difficult to continuously feed the material into the machine.

**Lake Paul**

Average production was 6.0 tonnes per hour. Again, the length of the material made it difficult to maintain a continuous feed into the chipper. Also, the narrow intake chute made it difficult to feed the chipper especially when multiple stems were processed and one or several would lodge crossways on the chute.

**Guysborough**

Chipper production fell to 2.9 tonnes/hour due to the unsuitability of this machine for chipping slash. The intake chute is too narrow, and the feed chain is too short making it very difficult to feed the slash into the machine. The light loader on the chipper had difficulty pulling apart the twisted tightly packed slash piles.

**Mitchell Lake**

The highest chipper production was achieved at this site, 8.0 tonnes/hour. Several factors influenced this increased production: 1) the operator was now more experienced, 2) piling techniques improved, and 3) the diameter and length of the trees were suited to this chipper. The length of the trees (average 10 meters) allowed the operator to maintain a nearly continuous feed into the chipper increasing significantly the percentage of time the machine was actually chipping compared to other locations.

Overall there were no major breakdowns. Chipper knives were changed, on average, every 6 productive machine hours although this varied widely depending on the condition of the material. Thirty to 45 minutes were required to change knives. During the project the chipper discharge chute clogged three times for no apparent reason causing a 1/2 hour delay each time. The tractor and loader were both new and except for a broken hydraulic hose on the loader were free from mechanical breakdowns. A minor modification to the discharge chute was required so that chips could be blown into the van.

## TRUCKING

Several methods were used for trucking the chips. The trucking costs for each location are included in Table 6 as part of the overall cost summary.

**Plympton 1 and Plympton 2**

Initially chip material was trucked in tree sections to the chipper. Load size was about 50% of the truck's capacity for hauling pulp. Therefore the cost/tonne using this method was about $16.00. Studies indicate that trucking tree sections is only practical on hauls less than 30 km (Kipping and Associates 1985). Also, this multiple handling compacted the load and reduced chipper productivity.

When the chipper was moved to the landing the chips were blown directly into dump trailers which increased chipper productivity. However, the dump trailers were not built up to the legal road height and, therefore, could not carry a large enough load, so trucking costs remained high ($14.28 per tonne). Trucking costs using chip vans would have been considerably lower, about $8/tonne (pers. comm. Harold Alexander, Sissiboo Forest Management Co. Ltd.)

**Lake Paul**

Low chipper production resulted in a loading time of over 4 hours per van. Chips were subsequently piled on the ground and loaded into the van at a later date. This method including loading costs was more economical than having the tractor and trailer waiting.

**Guysborough**

Chips were blown directly into the van. Direct trucking costs were $7/tonne plus an additional charge of $2/tonne while the tractor and trailer waited during loading. Piling on the ground and loading would have eliminated the waiting charge.

**Mitchell Lake**

At this location chips were piled on the ground, loaded and hauled at a later date. Loading was done with a truck mounted pulp loader with a bucket attachment replacing the grapple. This bucket attachment could also be used on a forwarder loader. This system resulted in a trucking cost of $9.61/tonne.

The use of detachable dump boxes to deliver the chips could eliminate the waiting time for vans or the necessity of loading at a later date with a grapple loader. This could prove to be more economical than the other delivery systems.

## VOLUME PRODUCTION

Volume production is summarized for each location in Table 5. Hardwood and softwood pulp was stack-scaled then converted to tonnes. Softwood sawlogs were scaled using the New Brunswick Log Rule. Log volume was converted to m$^3$ then converted to tonnes. The weight of the chips was determined by weighing individual loads.

Research indicates that 30 to 60% of total tree volume is unmerchantable depending on the species, size, site and stand conditions under which the tree is growing (Duinker 1981, Ker 1984, Young et al 1980). Therefore whole tree chipping of merchantable trees could increase production by 30 to 60% depending on the stand and logging method. Full tree operations would tend to recover a greater portion of the unmerchantable biomass compared to shortwood operations where branches on the merchantable stem would not be recovered.

**Plympton 1**

This pre-merchantable thinning operation produced 43.6 m$^3$/ha (37.4 tonnes/ha) of conventional proucts and 18.0 tonnes/ha of chips. Chip production increased the total yield by 48%.

**Plympton 2**

The volume of conventional products harvested during this thinning operation was equivalent to 19% of the total merchantable volume in the stand. Most thinning operations remove about 30% of the merchantable volume. Therefore the volume of chips produced (18.5 tonnes/ha), equivalent to a 57% increase in yield, is lower than would normally be expected. In a similar stand if 30% of the volume is removed and chip production is equivalent to 57% of the merchantable volume produced then the expected volume of chips would be about 28.9 tonnes/ha.

**Lake Paul**

The yield of conventional products from this merchantable thinning totalled 37.2 m$^3$ or about 15% of the available merchantable volume. However the chip yield of 38 tonnes/ha indicates that a portion of merchantable wood may have been chipped rather than put into pulp.

**Table 5. Summary of volume production at each location.**

| Location | Area ha | Softwood Pulp m$^3$/ha | Softwood Pulp tonnes*/ha | Hardwood Pulp m$^3$/ha | Hardwood Pulp tonnes**/ha | Logs m$^3$/ha | Logs tonnes*/ha | Chips tonnes/ha | Total tonnes/ha |
|---|---|---|---|---|---|---|---|---|---|
| Plympton 1 | 2.0 | 18.4 | 14.6 | 24.5 | 21.1 | 2.2 | 1.7 | 18.0 | 55.4 |
| Plympton 2 | 4.0 | 34.8 | 27.7 | 5.2 | 4.6 | - | - | 18.5 | 50.8 |
| Lake Paul | | | | | | | | | |
| Area 1 | 3.5 | 19.9 | 15.8 | 11.0 | 9.7 | 6.3 | 5.0 | 38.0 | 68.5 |
| Area 2 | 2.3 | 15.4 | 12.3 | 12.6 | 11.1 | - | - | - | 23.4 |
| Guysborough[1] | 0.64 | 77.6 | 61.3 | 17.4 | 15.3 | - | - | 42.0 | 118.6 |
| Mitchell Lake | 0.31 | - | - | - | - | - | - | 193.0 | 193.0 |

* based on 0.79 tonnes/m$^3$ for softwood

** based on 0.88 tonnes/m$^3$ for hardwood

1 volume obtained from original scale after clearcutting operation

**Guysborough**

Chip production totalled 42 tonnes/ha increasing the yield over conventional products by 55%. The increased yield could be overestimated since the volume of conventional products is based on the average volume harvested from a larger area than the area from which the unmerchantable biomass was extracted.

**Mitchell Lake**

Using tables developed by Young et al (1980) the available biomass at this site was estimated to be 250 tonnes/ha. The actual recovery of 193 tonnes/ha was 23% below the estimate. These stands are very dense resulting in small crowns therefore the volume of branches is less than would be available in more average stand conditions. Also trucking problems meant some chips were left on the site requiring the final volume to be estimated. These factors would account for a large part of the difference between the estimated and the actual volume recovery.

## COSTS

Table 6 summarizes the production rates and costs of each job phase at each location while Table 7 summarizes the total production costs and revenues for each location. These cost figures and production rates represent the results of short term studies, sometimes using equipment not well suited to the operation and personnel lacking experience at some of the particular tasks. A longer term study using different types of equipment and workers with greater experience, would provide additional data needed to identify the most efficient operations.

The only profitable operation was the conventional merchantable thinning carried out at Lake Paul (Area 2). All chipping operations incurred a negative net revenue varying between $5.74/green tonne up to $29.84/green tonne even after FRDA assistance was included (Table 7).

For the thinning operations, felling of unmerchantable biomass was no more costly than conventional operations. The major costs were in forwarding and chipping the unmerchantable biomass. Reduction of forwarding costs would be difficult without major modifications or a switch to another extraction method, possible full tree skidding. A more suitable chipper could also reduce costs. Higher output chippers tend to produce chips more cheaply and provide opportunities for diversified uses compared to the relatively specialized chipper used in this case.

Chipping of slash forwarded from cutovers for chipping by the TT1000 TU is impractical. The Bruks off-road chippers would be a much more practical method for chipping logging slash, because of the substantial reduction in forwarding costs and the fact that the Bruks is a more suitable machine for chipping slash.

The Mitchell Lake operation had the smallest negative net revenue and with some modification, costs could be reduced to a reasonable level.

Table 8 shows estimated costs of operating the systems at each site on a longer term basis. Comparing the actual costs in Table 6 to the estimated cost/tonne in Table 8 indicates production costs in some parts of the operation would rise. In particular the cost of felling and extraction at both Plympton sites would increase to ensure the cutters and forwarder operators maintain the wage they earn when doing conventional thinning operations.

**Table 6. Summary of production rates and costs for each job phase at each location.**

| | Plympton 1 Pre-Merch | | Plympton 2 Merch. Thin. | | Lake Paul - Merch. Thinning Area 1 | | Area 2 | | Guysborough Slash Chipping | | Mitchell Lake Remnant Felling | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Job Phase | t/hr | $/tonne | t/hr | $/tonne | t/hr | $/tonne | t/hr | $/tonne | t/hr | $/tonne | t/hr | $/tonne |
| Felling[1] | .30 | 25.72 | - | 21.97 | .43 | 21.59 | .42 | 22.23 | - | - | 6.2 | 1.63 |
| Forwarding | | | | | | | | | | | | |
| - Roundwood | - | 9.00 | - | 7.50 | 6.4 | 9.08 | 7.3 | 8.44 | - | - | - | - |
| - Chip Biomass | - | 9.00 | - | 7.50 | 3.3 | 17.65 | - | - | 2.8 | 19.72 | 5.9 | 8.32 |
| Chipping | 5.8 | 12.59 | 6.3<br>4.4 | 11.59[a]<br>16.89[b] | 6.0 | 12.17 | - | - | 2.9 | 25.17 | 8.0 | 9.12 |
| Loading[2] | - | - | - | - | 25.0 | 1.80 | - | - | - | - | 25.0 | 1.80 |
| Trucking[2] | - | 16.00[c] | - | 14.28[d]<br>16.00[c] | - | 9.00 | - | - | - | 9.00 | - | 9.61 |
| **Total[3]** | - | **63.31** | - | **55.34** | - | **62.21** | - | - | - | **53.89** | | **30.48** |

1 Felling cost/tonne includes cutters' wages and benefits for felling roundwood products plus chip biomass. For the thinning operations, felling included felling, limbing, and piling on the extraction trials.
2 Chip biomass only
3 Total cost/tonne for chip production

a Chipping roadside into dump trailers
b Chipping at user facility
c Trucking tree sections
d Trucking with dump trailers

**Table 7. Summary of costs and revenues per hectare for each location.**

| | Plympton 1 Pre-Merch | Plympton 2 Merch Thin | Lake Paul Merch Thin Area 1 | Lake Paul Merch Thin Area 2 | Guysborough Slash Chipping | Mitchell Lake Low Volume Harvesting |
|---|---|---|---|---|---|---|
| Area (ha) | 2.0 | 4.0 | 3.5 | 2.3 | 0.64 | 0.31 |
| Costs ($/ha) | 3,180.00 | 2,609.75 | 3,375.43 | 817.83 | 3,873.44 | 6,419.35 |
| Revenues | | | | | | |
| Roundwood ($/ha) | 803.50 | 722.25 | 699.14 | 502.60 | | |
| Chips ($/ha) | 450.00 | 462.50 | 684.57 | | 1,509.38 | 4,822.58 |
| FRDA ($/ha) | 862.50 | 862.50 | 862.50 | 862.50 | 218.75 | 393.55 |
| Total Revenue ($/ha) | 2,116.00 | 2,047.25 | 2,246.21 | 1,365.10 | 1,728.13 | 5,216.13 |
| Net Revenue ($/ha) | - 1,064.00 | - 562.50 | - 1,129.22 | 547.27 | - 2,145.31 | 1,203.22 |
| Total Volumes (t/ha) | 55.0 | 50.8 | 67.2 | 23.4 | 71.9 | 209.7 |
| Net Revenue ($/t) | - 19.35 | - 11.07 | -16.80 | 23.39 | - 29.84 | - 5.74 |

**Table 8. Estimated chip production costs for long term operations using the TT1000 TU Chipper based on results of initial trials.**

| | Location | | | | |
|---|---|---|---|---|---|
| Job Phase | Plympton 1 | Plympton 2 | Lake Paul | Guysborough | Mitchell Lake |
| Felling[1] ($/t) | 40.00 | 29.00 | 29.00 | | 1.80 |
| Forwarding[2] ($/t) | | | | | |
| Roundwood | | | | | |
| Chip Biomass | 17.00 | 15.00 | 15.00 | 15.00 | 7.00 |
| Chipping[3] ($/t) | 9.00 | 9.00 | 9.00 | 25.00 | 8.00 |
| Loading Chips ($/t) | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 |
| Trucking Chips ($/t) | 8.00 | 8.00 | 9.00 | 7.00 | 9.60 |
| Total ($/t) | 75.50 | 62.50 | 63.50 | 48.50 | 27.90 |

1 Felling of conventional products and chip biomass based on a daily wage of $100.00/day including benefits.
2 Based on the production of an 8 ton forwarder.
3 Based on the estimated production of the TT1000 TU with an experienced operator and the use of good piling techniques.

# CONCLUSIONS AND RECOMMENDATIONS

The study provided some valuable insights into the factors which most affect the efficiency of chipping operations. In particular, it provided information on:

(i) the increase in yields which can be achieved from various harvesting operations;
(ii) the types of chip operations and stand types which show the greatest promise for producing chips at an economical price, and;
(iii) the relative costs and production associated with various types of small scale chip operations.

**Plympton 1 and 2 and Lake Paul**

The results indicate harvesting unmerchantable biomass from thinning operations is impractical with the harvesting system used in these trials. A possible alternative would be full tree extraction with separation at roadside into conventional products and unmerchantable biomass. This would significantly reduce extraction costs and manhandling by the cutters.

Definite reductions in trucking costs would occur if vans were used to haul the chips even if they were piled on the ground and loaded later. This may be a problem on small woodlots where landings tend to be small. Chipping operations require large landings to operate efficiently.

The TT1000 TU chipper was not suitable for chipping the unmerchantable material from the thinning operations due to its infeed system and the size of the material.

Higher chip prices could improve the economics of some chipping systems. However, it is unlikely that in the short term prices will rise enough to make the system used in these trials economically viable.

**Guysborough**

The low productivity and high costs indicates that the use of the Timberjack 520 forwarder and the TT1000 TU chipper is a totally inappropriate system for converting slash from cutovers to chips. The forwarder could not be loaded heavily enough to make extraction economical. The chipper was inadequate for chipping slash due to its narrow infeed chute, light loader and disc rather than drum cutting head. Bruks chippers are better suited to these types of operations due to chipper design and mobility.

**Mitchell Lake**

In comparison to the Guysborough and thinned sites, the low costs and higher productivity at this site indicates that felling high density, unmerchantable stands and forwarding whole trees to the chipper may prove to be one of the most economic sources of chips. The tree length material resulted in increased forwarder loads. Larger bunks and the addition of a heel boom to the loader could further increase forwarder productivity. The size of the material from this site was suited to the TT1000 TU resulting in significantly increased production. Greater operator experience may make this a practical operation, however, the chipper appears to be limited to working with small diameter full tree material only. This lack of flexibility reduces its attractiveness. The possibility of further reducing the costs of producing chips from these types of stands by utilizing on-site mobile chippers should be investigated.

**Volume Production**

Production of wood chips significantly increased total yields per hectare as expected. These increases ranged from 48% to 125% over the weight of merchantable products extracted in the thinning operations. In the slash chipping operations, chip production totalled 42.0 tonnes/ha representing an increase of 55% in the total weight extracted. In the Mitchell Lake operation the total yield of chips was 193.0 tonnes/ha using available conventional harvesting methods.

In the thinning operations, the cutters determine what trees will be utilized for what products. Part of the wide range in chip yields in the thinning operations can be attributed to this cutter selectivity.

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**FOREST RESEARCH SECTION**
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