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# Evaluation of Trans-Gesco TG88C and Tigercat 635 grapple skidders working in central Alberta

Contents



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**Abstract**

FERIC monitored a trial of the Trans-Gesco TG88C and Tigercat 635 grapple skidders working in central Alberta. Harvesting was done in the summer on cutblocks designed to minimize road construction. Skidding distances were up to 1500 m. The productivity and cost of the skidding operation are presented, and the two machines are compared.

**Keywords**

Trans-Gesco TG88C grapple skidder, Tigercat 635 grapple skidder, Harvesting, Skidding, Productivity, Costs, Alberta, Understory protection, Ecosystem management.

## Introduction

In response to new policies, regulations, and legislation that require land managers to achieve higher levels of environmental protection, forest-management objectives and practices in western Canada are changing rapidly. Timber-harvesting strategies for minimizing soil disturbance are being developed, tested, and introduced. Strategies include taking advantage of dry weather or frozen ground through flexible harvest scheduling, and substituting low ground pressure skidders for conventional skidding equipment. However, to successfully implement new strategies and technologies, reliable information is needed about their effectiveness and cost.

FERIC, in cooperation with Alberta-Pacific Forest Industries Inc. in northern Alberta, undertook an operational trial of a new technique for harvesting of mixedwood stands in summer. To minimize soil disturbance, and thereby promote post-harvest regeneration of aspen, Alberta-Pacific designed a roadside harvesting system utilizing a minimum of road construction and large-capacity skidders suitable for skidding long distances.

FERIC monitored the trial, and this report provides forest managers with information on the productivity and cost of both skidders. The report also discusses the feasibility of using the two types of large-capacity skidders, and makes suggestions on their implementation.

## Objectives

The primary goal of the study was to assess the economic and operational feasibility of using two large-capacity grapple skidders—the Trans-Gesco TG88C and the Tigercat 635—to skid stems over long distances. The specific objectives were:

- Determine and compare overall skidding productivities and costs of using the two machines under two harvesting prescriptions: Ecosystem Management and Understory Protection.
- Develop productivity and cost functions for both machines.
- Identify operational factors that influence productivity and cost of the skidding operation, and recommend improvements where appropriate.

- Evaluate the skidders as components of a roadside harvesting system.

## Site description

The two study blocks were located about 75 km north of Athabasca in central Alberta. The blocks were considered suited to summer harvesting provided that harvesting activities would be halted immediately if rainfall was heavy enough to induce rutting. The stand and site characteristics for both blocks are summarized in Table 1.

## Silvicultural systems

### Ecosystem management

Block A (Figure 1) and the north portion of Block B (Figure 2) were harvested following the ecosystem management rules designed by Alberta-Pacific.[1] A key premise of an ecosystem management prescription is that the post-harvest features of the block should be similar to those found following a forest fire on that site. These features include live merchantable trees of all types and ages, standing dead trees (snags), downed stems, and non-merchantable vegetation.

In this operation, the feller-buncher operators left single trees, clumps of trees and vegetation, and patches of unmerchantable vegetation. Clumps of different shapes and sizes (ranging from about 15 m in diameter to about 0.5 ha) were centered around snags, large spruce trees, natural gaps containing fallen trees, and areas of dense understory. Very small clumps of one to three trees included crooked or highly branched trees, as well as

[1] An operator's guide to stand structure, produced by Alberta-Pacific Forest Industries Inc., 28 pp., unpublished.

**Table 1. Site and stand description**

| | Block A | Block B |
|---|---|---|
| Total area (ha) | 29 | 46 |
| Prescription | LFN [a] | LFN [a] |
| CPPA terrain class [b] | 3.1.1. | 3.1.1. |
| Ecological area [c] | Boreal Mixedwood | Boreal Mixedwood |
| Natural subregion [c] | Central Mixedwood | Central Mixedwood |
| Ecosites [c] | Dogwood Pb-Aw | Low-bush cranberry Aw |
| Moisture regime | submesic | mesic |
| Compaction and rooting hazards | medium | medium to high |
| Species composition (% by volume) | | |
| Aspen and balsam poplar | 93 | 88 |
| White spruce | 7 | 12 |
| Density (trees/ha) | 570 | 709 |
| Net merchantable volume ($m^3$) | | |
| Per hectare | 260 | 179 |
| Per tree | 0.46 | 0.25 |

[a] In the LFN (Leave For Natural) method, aspen regeneration will be achieved by the natural suckering process.
[b] Mellgren 1980.
[c] Beckingham and Archibald 1966.

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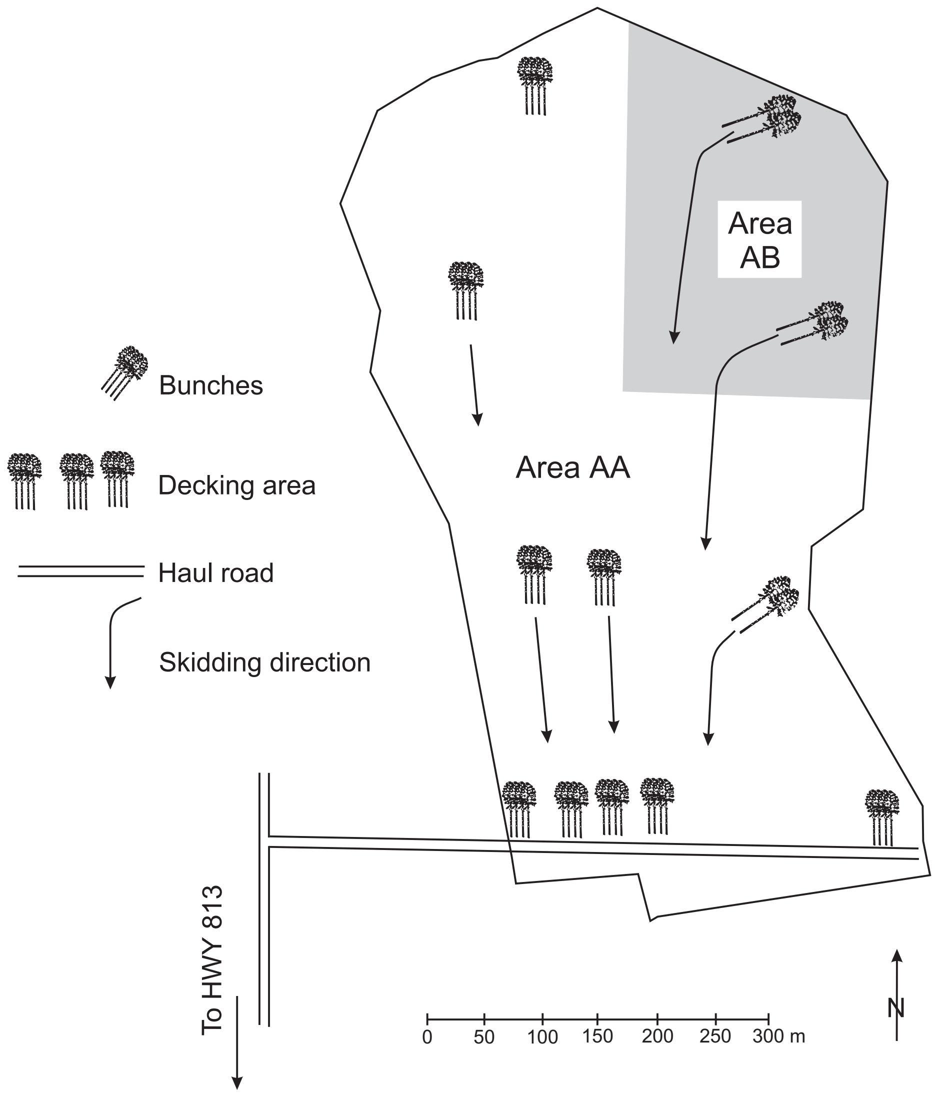



Figure 1. Layout of Block A.

some trees greater than 50 cm in diameter. These clumps were scattered randomly, with 8 clumps/ha. All snags were left standing, except when they were a safety hazard, e.g., snags within two tree lengths of the road or snags otherwise posing a risk to workers. All patches of non-merchantable vegetation were undisturbed by felling and skidding activities.

### Understory Protection

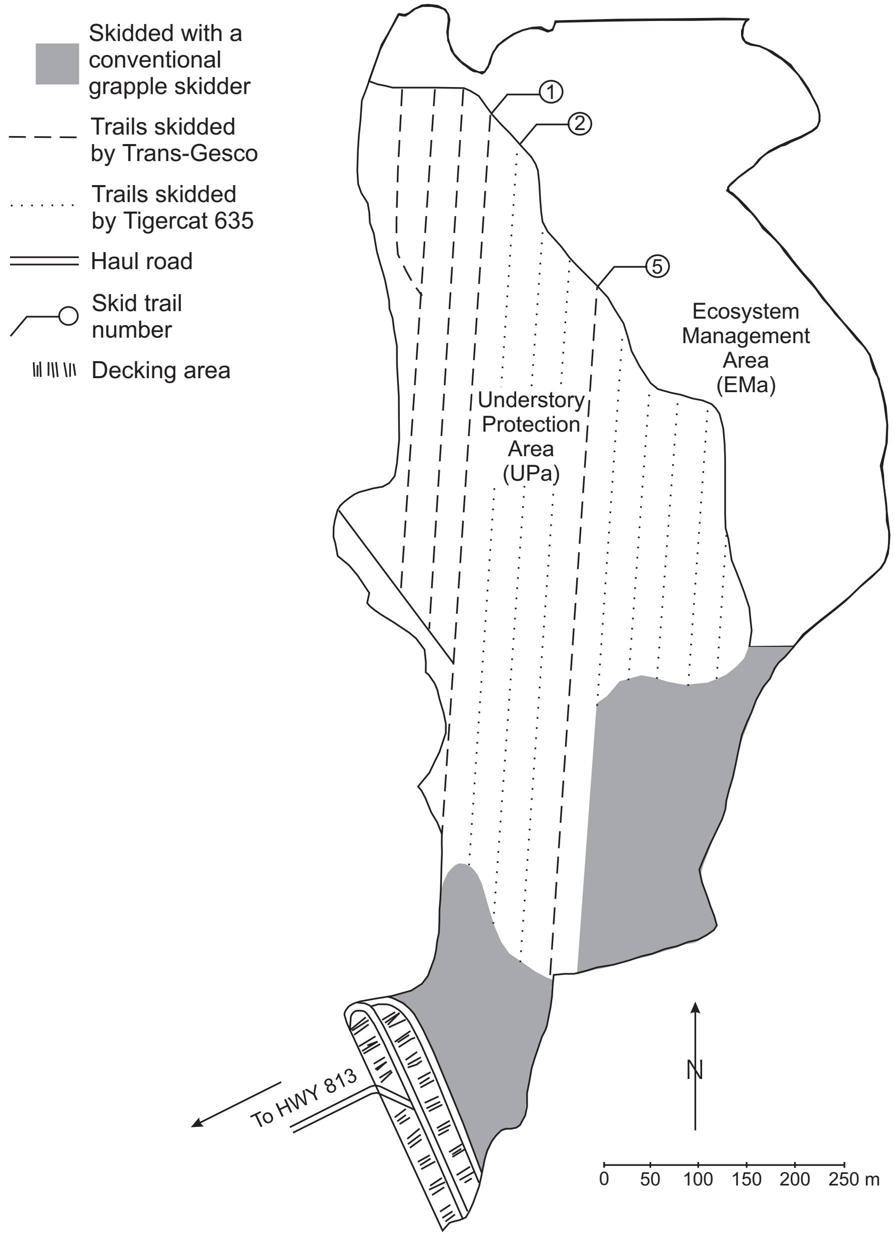
For the west portion of Block B, Alberta-Pacific employed a single-pass harvesting system to achieve understory protection (Figure 2). The feller-buncher cut all trees (aspen and spruce) to create an 8-m-wide skid trail, and almost all the aspen[2] in 8-m-wide strips on each side of the skid trail, for a total width of 24 m. The central 8-m-wide strips were left unharvested. The distance from centerline to centerline of the two adjacent skid trails was 32 m (Figure 3). This work pattern was designed to remove 75% of the original basal area of aspen and 25% of white spruce.

## Description of harvesting operations

The two study blocks were harvested in June and July. Skidding was stopped several times because of rainy and unstable weather.

[2] Some aspen were left in the strips adjacent to the skid trail if removing them would have caused excessive damage to understory and residual spruce.

Figure 2. Layout of Block B.




## Equipment

Harvesting operations, including road building, were performed by a full-phase contractor using a fully mechanized roadside system (MacDonald 1999) consisting of two feller-bunchers, two processors, a Trans-Gesco TG88C grapple skidder, a Tigercat 635 grapple skidder, a bulldozer, and a grader. The Trans-Gesco was owned and maintained by the manufacturing company, and the Tigercat was owned and maintained by the Strongco Equipment. The skidder operators received training because they had not run these types of skidders before. The primary machines were scheduled to work 11-h shifts, five days per week.

The Trans-Gesco TG88C is an 8-wheel-drive, rubber-tired, double-bogie grapple skidder designed to skid large loads of tree-length stems over long distances on steep or sensitive ground (Figure 4 and Table 2). A diesel engine drives four hydrostatic pumps that power two hydrostatic drive motors in each tandem. The hydraulic system (for the boom, grapple, steering, and dozer blade) is powered by two load-sensing pumps. The TG88C is fitted with a hydraulically operated grapple mounted on a dual boom

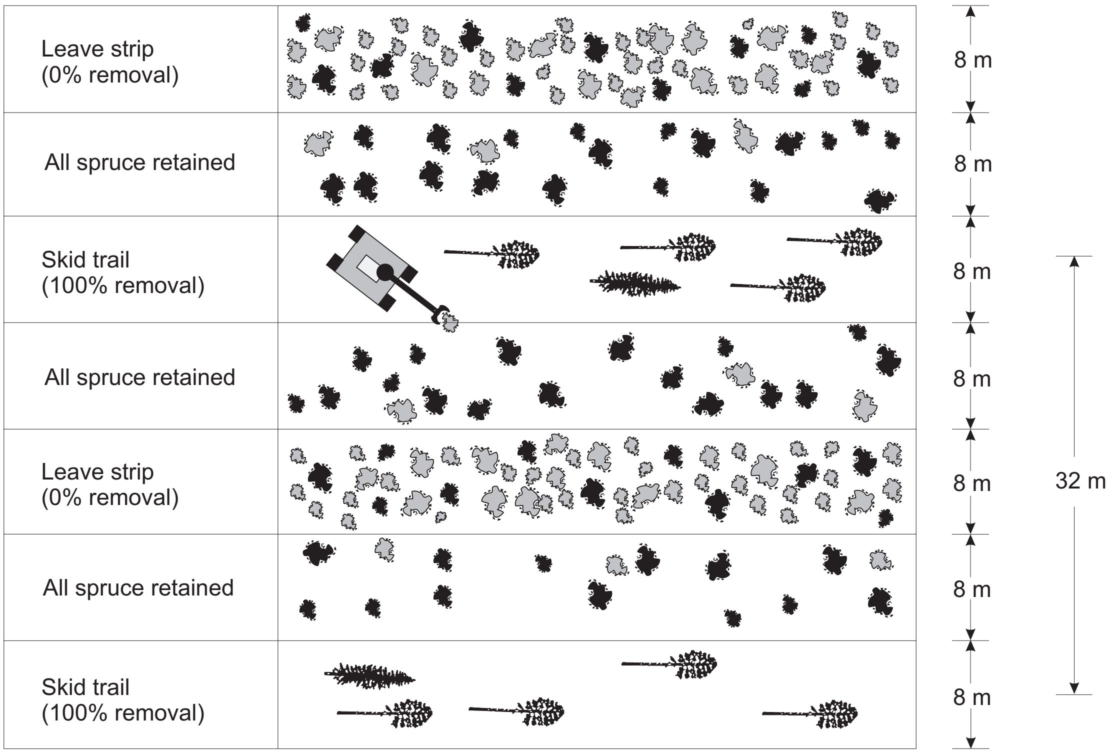



Figure 3. Harvesting pattern designed to remove 75 and 25% of the original basal areas of aspen and white spruce, respectively.

arch with a reach of 5.5 m. The arch folds over the main frame for better distribution of the payload weight between the rear and front tandems. The grapple has a maximum opening of 4.6 m and an accumulating area of 4.18 m². It is fitted with a Quadco snubber and a continuous rotation rotator. To lessen the ground pressure, the machine used in this trial was equipped with 1.4-m-wide standard flotation tracks. The standard travel speeds are 0 to 7.1 km/h. If required, the maximum speed can be adjusted and increased to about 7.4 km/h in the field by reducing the wheel motor displacement, or to about 8.5 km/h by changing the wheel planetary ratio at each wheel or installing tires with larger radii.

The Tigercat 635 is a 6-wheel-drive, rubber-tired, rear bogie, grapple skidder (Figure 5 and Table 2) designed to handle big loads in steep or soft terrain. It is powered by a diesel engine and fitted with a hydrostatic drive. The rear bogie axle lessens the ground pressure. The skidder is fitted with a hydraulically operated grapple with continuous rotation, attached to a dual-function, high-lift arch. The grapple has an accumulating area of 2.3 m². The machine used in this trial was equipped with chains on the front wheels and "banana" style tracks on rear bogie wheels.

Figure 4. Trans-Gesco TG88C grapple skidder.

**Table 2. Technical specifications for the skidders**

| | Trans-Gesco TG88C grapple skidder | Tigercat 635 grapple skidder |
|---|---|---|
| Engine | Cummins M11 | Cummins 6CTA8.3 |
| Power (kW) | 261@2100 rpm | 180@2100 rpm |
| Length (m) | 9.5 | 9.5 |
| Width (m) | 3.6 | 3.2 |
| Wheelbase (m) | 5.2 | 5.1 |
| Ground clearance (m) | 0.79 | 0.62 |
| Operating weight (kg) | 29 940 | 22 680 |
| Travel speed (km/h) | 0–3.5 and 0–7.1 | 0–12.2 |

Figure 5. Tigercat 635 grapple skidder.

### Harvesting design

In a typical cutblock with a maximum one-directional skidding distance of 300 m, the ratio of road to area would be 33 lineal m/ha of cutblock. In the interest of minimizing soil disturbance, the roadside harvesting system designed by Alberta-Pacific utilized long skidding distances. The harvesting sites were accessible only by a spur road located at the base of each block (see Figures 1 and 2). Therefore, the lengths of road—12.4 and 5.5 lineal m/ha of the cutblock area for Blocks A and B, respectively—were substantially less than for a block of conventional design.

The maximum skidding distance ranged from 900 to 1500 m, which is three to five times longer than the conventional 300 m. The roadside decking areas in a "cold logging" system—i.e., where one phase does not start until the previous phase is complete or well advanced—would not be able to accommodate the large numbers of stems skidded by the Trans-Gesco and Tigercat. Instead, a "hot logging" system—where phases occur simultaneously—was planned for both study blocks. In this operation, skidding and processing were scheduled to start at the same time.

In Block A, the processors at roadside made 10-m logs. However, tree-length stems were produced in Block B to improve efficiency.

## Study methods

FERIC observed the harvesting operations, collected shift-level data, conducted detail-timing of the skidding operation, and gathered information on numbers and volumes of stems felled, skidded, and processed.

Shift-level data on all harvesting machines were collected daily using mechanical datalogger charts.[3] These were supplemented by information from machine operators' written reports about production and major delays (>15 min/occurrence). Net harvest volumes were obtained from Alberta-Pacific weigh scale records.

Skidding cycles were detail-timed at frequent intervals throughout the study period. Each timed cycle was divided into five elements: travel unloaded, load, travel loaded, deck, and in-cycle delays.[4] Travel distances—both unloaded and fully loaded, number of bunches per cycle, and reasons for observed delays were also recorded.

In the northeast Area AB (Figure 1), a conventional grapple skidder gathered two or three adjacent standard-sized bunches to create single, larger-than-average bunches. (This activity was undertaken for experimental purposes, to test the performance of the skidder.) In the rest of the block (Area AA), the standard-sized bunches prepared by the feller-bunchers were not modified.

Using regression techniques, the timing data were analyzed to determine relationships between cycle time elements and skidding distances, and number of bunches per turn. The results of the regression analyses were then used to develop equations to predict delay-free cycle time and to derive productivity and cost functions.

Hourly skidder costs were calculated using FERIC's standard costing methods (Appendix I).

[3] The logging contractor equipped all his harvesting machines with mechanical dataloggers. Datalogger charts are submitted by operators and used by the contractor as a base for production control and payment calculations.

[4] For definitions of timing elements see Kosicki 2002.

## Results and discussion

### Block A, Ecosystem Management area

The Trans-Gesco skidded Areas AA and AB, and its skidding distances varied from 20 to 700 m. The Tigercat skidded larger-than-average and standard sized bunches from Area AB with long distances only (550 to 700 m). During the six-shift monitoring period in Block A, 4 280 aspen stems[5] with volume of 3 146 $m^3$ were skidded by the Trans-Gesco TG88C and the Tigercat 635. Table 3 shows the production of volumes, bunches, and stems per productive machine hour (PMH) and scheduled machine hour (SMH) for the two skidders.

For the Trans-Gesco in Area AA, multiple regression analysis based on the detail-timing data found a significant linear relationship between delay-free cycle time and the variables of skidding distance and number of bunches per cycle (Equation 1, Appendix II). The derived cycle time equation and assumed long-term utilization of 85% for the Trans-Gesco skidder were combined to estimate productivity during scheduled skidding time (Equation 6, Appendix II). This can be used to predict wood flow and to schedule processing and hauling activities on a shift-level basis.

Figure 6 shows the predicted skidding productivity for the Trans-Gesco skidder as a function of skidding distance and number of bunches to complete a full payload.

Figure 7 shows unit skidding costs for the Trans-Gesco as a function of skidding distance and number of bunches to complete a full payload. The predicted skidding cost of \$2.93/$m^3$ based on the detailed-time study is close to the average cost of \$2.67/$m^3$ calculated for the shift-level study.

For the Trans-Gesco in Area AB, regression analysis found a significant relationship between delay-free cycle time and skidding

[5] Single stems and small bunches of spruce scattered over the entire block were skidded with a conventional grapple skidder.

**Table 3. Shift-level summary for Trans-Gesco TG88C and Tigercat 635 grapple skidders: Block A, Ecosystem Management area**

| Description | Trans-Gesco TG88C | Tigercat 635 |
|---|---|---|
| Productive shifts (no.) | 5 | 1 |
| Total productive time (PMH) | 39.3 | 7.5 |
| Volume ($m^3$) | 2 817 | 329 |
| Stems (no.) | 3 805 | 475 |
| Average stem volume ($m^3$) | 0.74 | 0.69 |
| Bunches (no.) | 399 | 43 |
| Cycles (no.) | 152 | 27 |
| Average payload | | |
| Bunches/cycle (no.) | 2.6 | 1.6 |
| Stems/cycle (no.) | 25 | 18 |
| Volume/cycle ($m^3$) | 18.5 | 12.2 |
| Skidding distance (m) | 360 (20–700) | 640 (550–700) |
| Productivity | | |
| Volume/PMH ($m^3$) | 71.6 | 43.9 |
| Volume/SMH [a] ($m^3$) | 60.9 | 37.3 |
| Cost (\$/SMH) | 163.13 | 130.48 |
| Skidding cost (\$/$m^3$) | 2.67 | 3.50 |

[a] For assumed long-term utilization of 85%.

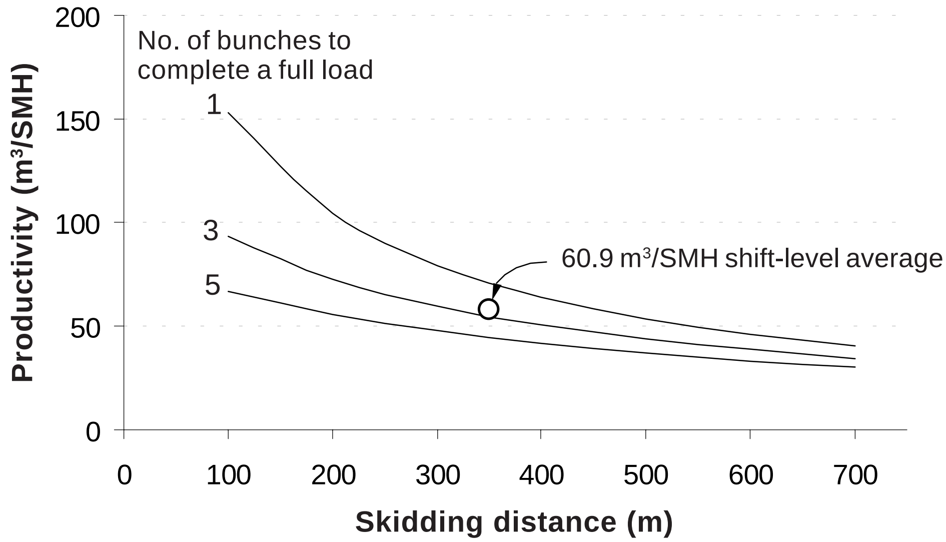



Figure 6. Predicted skidding productivity for the Trans-Gesco TG88C grapple skidder as a function of skidding distance and number of bunches to complete a full payload, Ecosystem Management.

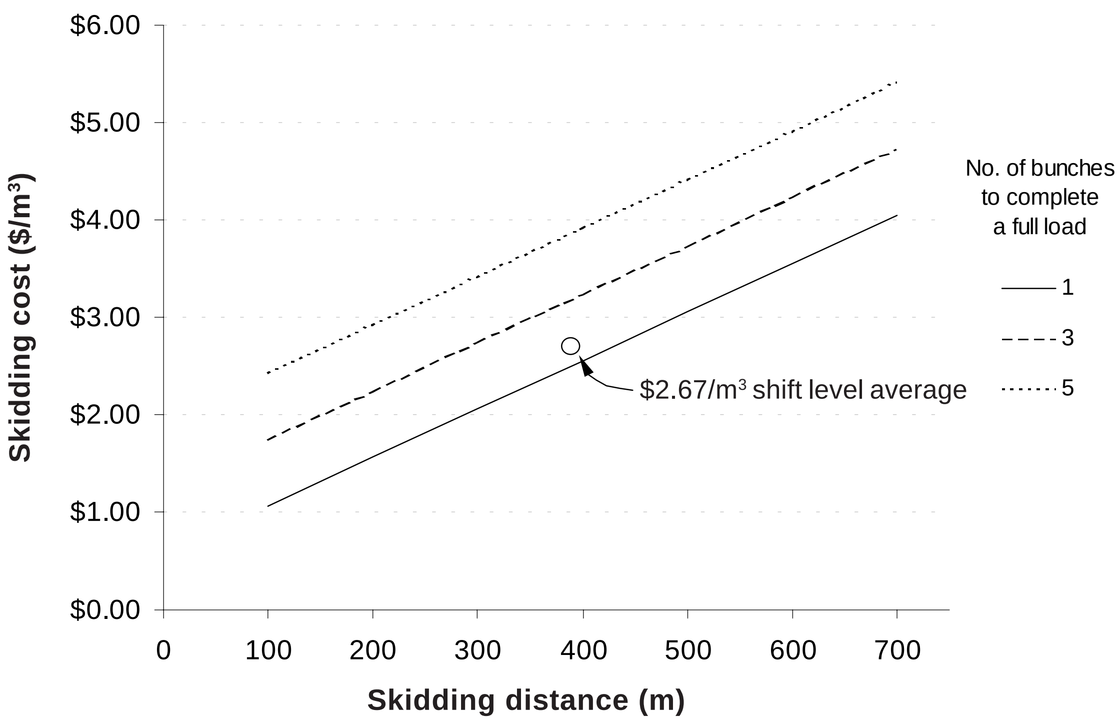



Figure 7. Predicted unit skidding cost for the Trans-Gesco TG88C grapple skidder as a function of skidding distance and number of bunches to complete a full payload, Ecosystem Management.

distance (Equation 2, Appendix II). For the Tigercat, the cycle time and productivity were calculated as averages for the skidding distance of 640 m. Predicted skidding productivities for both skidders are shown in Figure 8. Because of its greater payload volume of 18.1 $m^3$/cycle in this area, the Trans-Gesco compensated for its greater cycle time. It achieved productivity of 54.4 $m^3$/PMH at the average skidding distance of 640 m, 24% greater than the productivity of the Tigercat. For the Trans-Gesco's average skidding distance of 540 m, the predicted productivity was 61.6 $m^3$/PMH.

Figure 9 presents predicted unit skidding costs for the Trans-Gesco and the Tigercat. For its average skidding distance of 640 m, the Tigercat's lower hourly cost compensated for its lower productivity, and unit skidding costs for both skidders at this distance are the same.

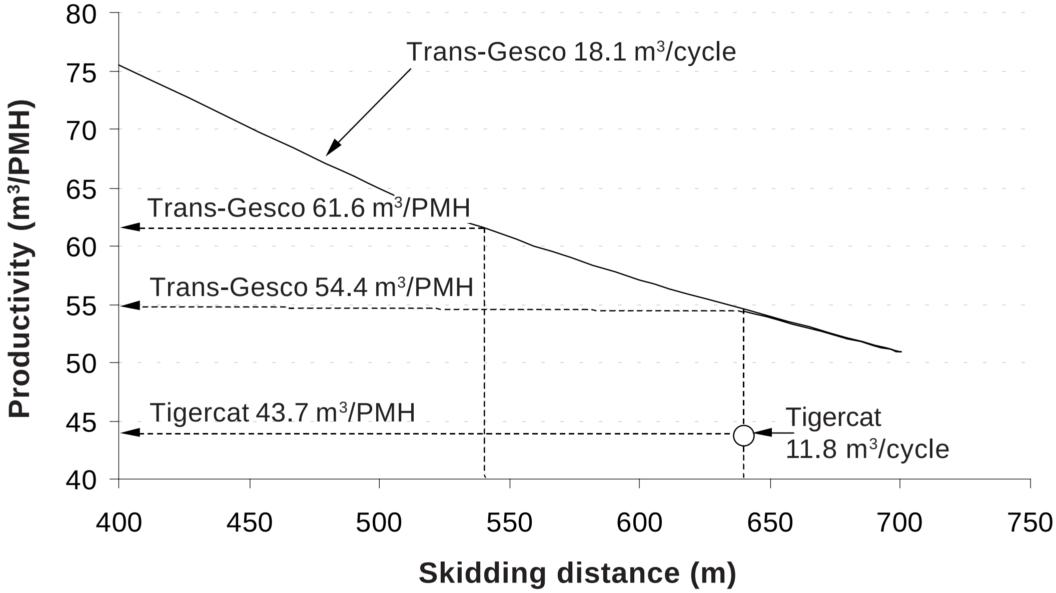



Figure 8. Predicted skidding productivity with the Trans-Gesco TG88C and the Tigercat 635 grapple skidders in the Area AB.

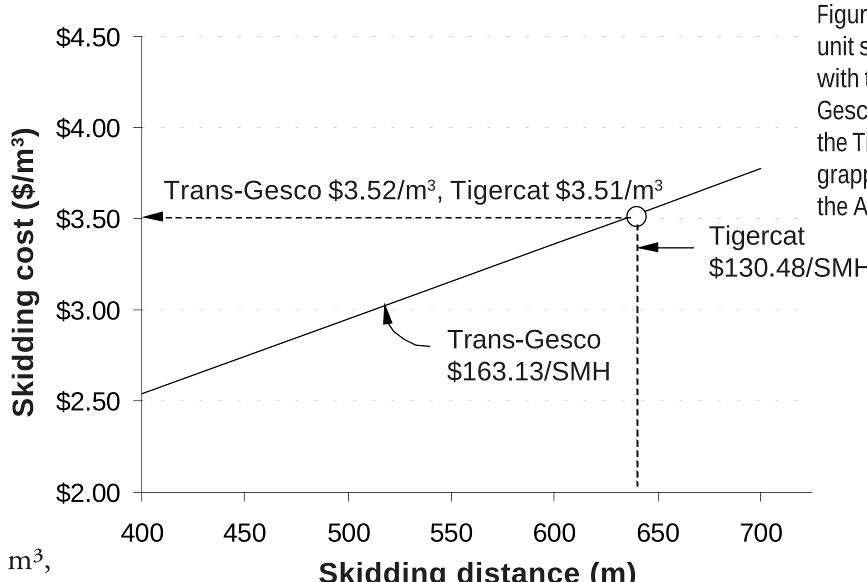



Figure 9. Predicted unit skidding cost with the Trans-Gesco TG88C and the Tigercat 635 grapple skidders in the Area AB.

### Block B, Understory Protection and Ecosystem Management areas

In Block B, the Trans-Gesco TG88C and the Tigercat 635 skidded 12 400 stems with a total volume of 4 162 m³, consisting of 3 595 m³ of aspen and 567 m³ of spruce. Volumes extracted from the Understory Protection area and the Ecosystem Management area were 2 802 and 1 360 m³, respectively. The average stem volume for both species and both areas was calculated at 0.33 m³. Table 4 summarizes the shift-level results by skidder and treatment.

In the Ecosystem Management area—where conditions were easier for travelling, maneuvering, and completing payloads—the average load volumes for both skidders were about 35% greater than those in the Understory Protection area. In both treatments, the average payloads for the Trans-Gesco were about 47% greater than those for the Tigercat. For similar average skidding distances in the Ecosystem Management area (1 100 m for the Trans-Gesco and 950 m for the Tigercat), the Trans-Gesco's productivity was about 17% greater than that of the Tigercat. Because of the difference in average skidding distances in the Understory Protection area (790 m for the Trans-Gesco and 500 m for the Tigercat), a direct comparison of the skidding productivities is not possible and their evaluation will be based on detail-timing results.

On skid trail no. 1 of the Understory Protection area, the Trans-Gesco was detail-timed before its travel speed was adjusted, and on skid trail no. 5 and in the Ecosystem Management area it was timed after the travel

**Table 4. Shift-level summary for Trans-Gesco TG88C and Tigercat 636 grapple skidders: Block B, Understory Protection area (UPa) and Ecosystem Management area (EMa)**

| Description | Trans-Gesco TG88C | | Tigercat 635 | |
|---|---|---|---|---|
| Area | UPa | EMa | UPa | EMa |
| Productive shifts (no.) | 5 | 3 | 4.5 | 2.5 |
| Total productive time (PMH) | 38.6 | 23.0 | 41.0 | 22.2 |
| Volume ($m^3$) | 1 131 | 745 | 1 671 | 615 |
| Cycles (no.) | 69 | 34 | 150 | 41 |
| Average cycle time (min) | 33.6 | 40.6 | 16.4 | 32.5 |
| Average payload | | | | |
| Bunches/cycle (no.) | 4.9 | 6.6 | 3.3 | 4.5 |
| Volume/cycle ($m^3$) | 16.4 | 21.9 | 11.1 | 15.0 |
| Average skidding distance (m) | 790 | 1 100 | 500 | 950 |
| Productivity | | | | |
| Volume/PMH ($m^3$) | 29.3 | 32.4 | 40.7 | 27.7 |
| Volume/SMH [a] ($m^3$) | 24.9 | 27.5 | 34.6 | 23.5 |
| Cost ($/SMH) | 163.13 | 163.13 | 130.48 | 130.48 |
| Skidding cost ($/$m^3$) | 6.55 | 5.93 | 3.77 | 5.55 |

[a] For assumed long-term utilization of 85%.

speed adjustment. The detail timing of the Tigercat was performed on skid trail no. 2 of the Understory Protection area. For the Ecosystem Management area, only the total cycle times and skidding distances were recorded.

In the Understory Protection area, regression analysis on the Trans-Gesco's and the Tigercat's cycle time elements found significant linear relationships between travel times and skidding distances. Cycle times for the Trans-Gesco on skid trails no. 1 and 5 (before and after speed adjustment, respectively), and for the Tigercat on skid trail no. 2 are given in Appendix II, and are shown as functions of skidding distances in Figure 10. For the Trans-Gesco, the differences in cycle times on skid trails no. 1 and 5 reflect the combined effect of the speed adjustment and numbers of bunches in payloads. The parallel nature of regression lines for the Trans-Gesco after the speed adjustment (skid trail no. 5) and the Tigercat (skid trail no. 2) indicates that the travel speeds of both skidders were similar. The differences in cycle times for these skidders resulted mainly from differences in loading and decking times.

The detail-timing data and an assumed long-term utilization of 85% were combined to estimate productivities shown in Figure 11. Because of its payloads, the Trans-Gesco compensated for its greater cycles times and achieved productivities at least equal (skid trail no. 1) or greater (skid trail no. 5) than that of the Tigercat.

Figure 12 presents unit skidding costs for the two machines as a function of skidding distances. For the Trans-Gesco, the differences between unit costs on skid trail no. 1 and skid trail no. 5 reflected the combined effect of the travel speed adjustment and increased payload. These differences, depending on the skidding distance, were in a range of 10 to 20%. The Tigercat's lower hourly cost compensated for its lower productivity, and the skidding costs with this machine on skid trail no. 2 were, on average, 25% lower than the skidding costs for the Trans-Gesco on skid trail no. 1. Although the travel speed adjustment and the increase in payload improved competitiveness of the Trans-Gesco, its unit skidding costs on skid trail no. 5 for distances up to 650 m were still greater than those for the Tigercat. However, for the

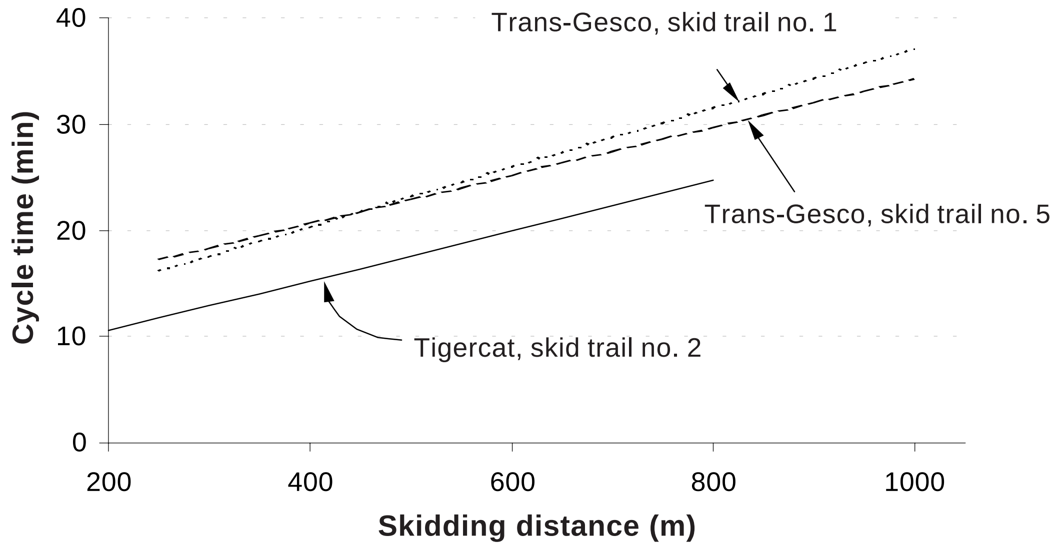



Figure 10. Cycle times as a function of skidding distance for the Trans-Gesco in skid trails no. 1 and 5, and for the Tigercat in skid trail no. 2, Understory Protection.

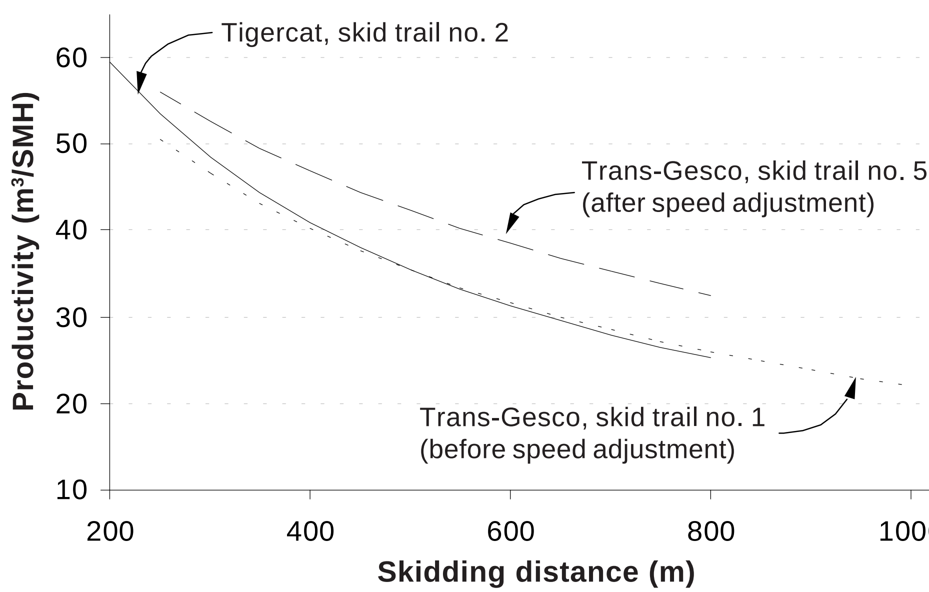



Figure 11. Skidding productivities as a function of skidding distance for the Trans-Gesco in skid trails no. 1 and 5, and for the Tigercat in skid trail no. 2, Understory Protection.

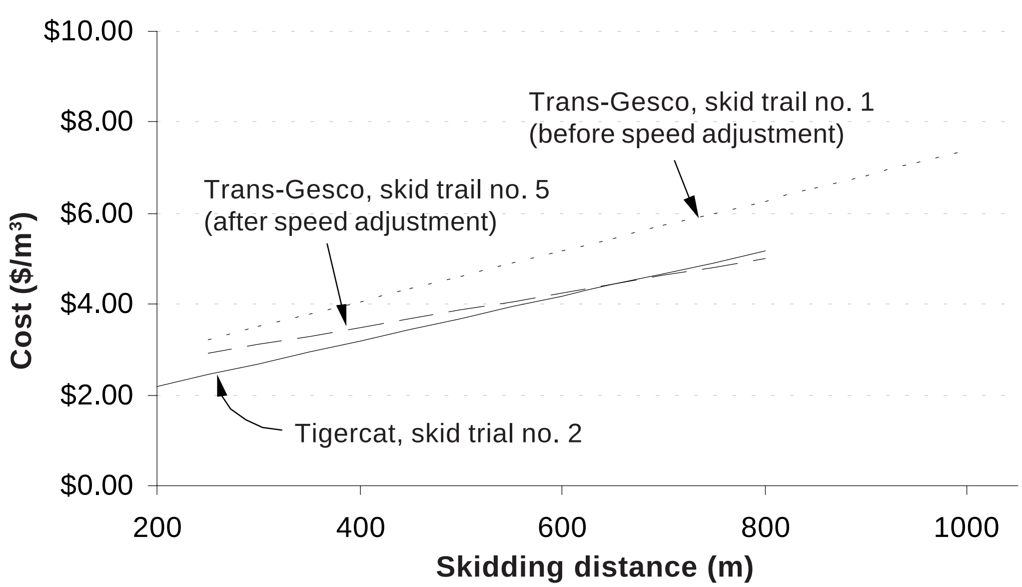



Figure 12. Skidding costs for the Trans-Gesco and the Tigercat in skid trails no. 1, 2, and 5 as a function of skidding distance, Understory Protection.

distances from 500 to 800 m, the differences in unit skidding costs for both skidders were small and did not exceed 5%.

For the Ecosystem Management area with a narrow range of skidding distances (900–1125 m for the Trans-Gesco, and 800–1000 m for the Tigercat), regression analysis did not find significant relationships between cycle time elements and the variables of distance and number of bunches in the payload. The cycle times, productivities, and unit skidding costs for both skidders are given as average values in Table 5. For similar average skidding distances, the Trans-Gesco's productivity was about 25% greater than the productivity achieved by Tigercat. However, because of the lower hourly cost for the Tigercat, the unit skidding costs for the two skidders were similar.

**Table 5. Productivities and costs, based on detailed timing, for the Trans-Gesco and Tigercat 635 grapple skidders: Block B, Ecosystem Management area**

| | Trans-Gesco | Tigercat |
|---|---|---|
| Average skidding distance (m) | 1 000 | 950 |
| Average payload ($m^3$) | 22.4 | 15.0 |
| Average cycle time (min) | 33.9 | 28.0 |
| Productivity ($m^3$/SMH) | 33.7 | 27.3 |
| Cost ($/$m^3$) | 4.84 | 4.78 |

## Summary of skidding productivities and costs

Figure 13 summarizes cycle times for both skidders in the Understory Protection and Ecosystem Management areas in Blocks A and B.[6] The average cycle times for the Ecosystem Management area in Block B agree closely with corresponding regression lines. For the Trans-Gesco, the less steep slope of the regression line for Block B compared to Block A demonstrates the effect of the travel velocity adjustment on cycle time.[7]

Table 6 presents information about average payloads for the Trans-Gesco and Tigercat in Blocks A and B. For both blocks and both treatments, the average payload for the Tigercat was about two-thirds of the Trans-Gesco's payload. For both machines in Block B, the payloads skidded in the Ecosystem Management area, where conditions were easier, were about 35% greater than those for the Understory Protection area. Due to gained experience and improved skills of the operators, the average payloads in the Ecosystem Management area were greater in

[6] To make the cycle times in both blocks comparable, the cycle time for the Trans-Gesco in Block A in Figure 13 was plotted for five bunches/cycle.

[7] A steeper line indicates a slower travel speed.

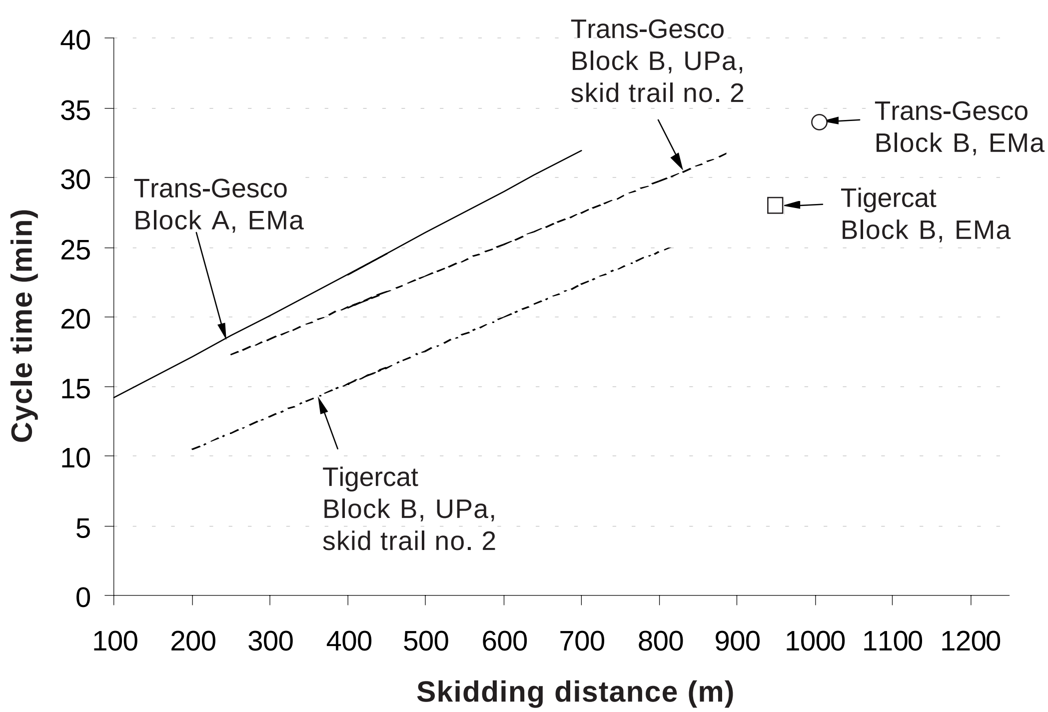



Figure 13. Cycle times for the Trans-Gesco and Tigercat 635 in Blocks A and B.

| Table 6. Payloads for the Trans-Gesco TG88C and the Tigercat 635 grapple skidders: Blocks A and B | | | |
|---|---|---|---|
| | Payload | | Ratio (2)/(1) |
| | Trans-Gesco TG88C ($m^3$/cycle) | Tigercat 635 ($m^3$/cycle) | |
| | (1) | (2) | |
| Block A | | | |
| Ecosystem Management area | 18.5 | 12.2 | 0.66 |
| Block B | | | |
| Understory Protection area | 16.4 | 11.1 | 0.68 |
| Ecosystem Management area | 21.9 | 15.0 | 0.68 |

Block B than in Block A.

Productivities and costs for the Trans-Gesco and the Tigercat are shown in Figures 14 and 15, respectively. For Block B and skidding distances close to 1000 m, productivities for both skidders in the Ecosystem Management area were slightly greater than in the Understory Protection area, and the differences can be attributed to average payloads for both areas (see Table 6). Greater productivities and unit costs for the Trans-Gesco in Block B than in Block A resulted from the combined effect of the travel speed adjustment, increased payloads, and improved skills of the skidder operator.

In Block B, the unit costs for both skidders in the Ecosystem Management area were less than those in the Understory Protection area. For the Ecosystem Management area in Block B and skidding distances close to 1000 m, the Tigercat's lower hourly machine cost compensated for its lower productivity, and unit costs for both skidders at this skidding distance were the same.

### Other observations

Weather-related delays in construction of the road into Block A caused hauling to be delayed, so the processor operators had to build very high log decks. This reduced processor productivity.

To help improve productivity in Block B, the processors switched from processing 10-m logs to tree-length logs. Block B had even less road per unit area, so a decking area was designed to accommodate two windrows

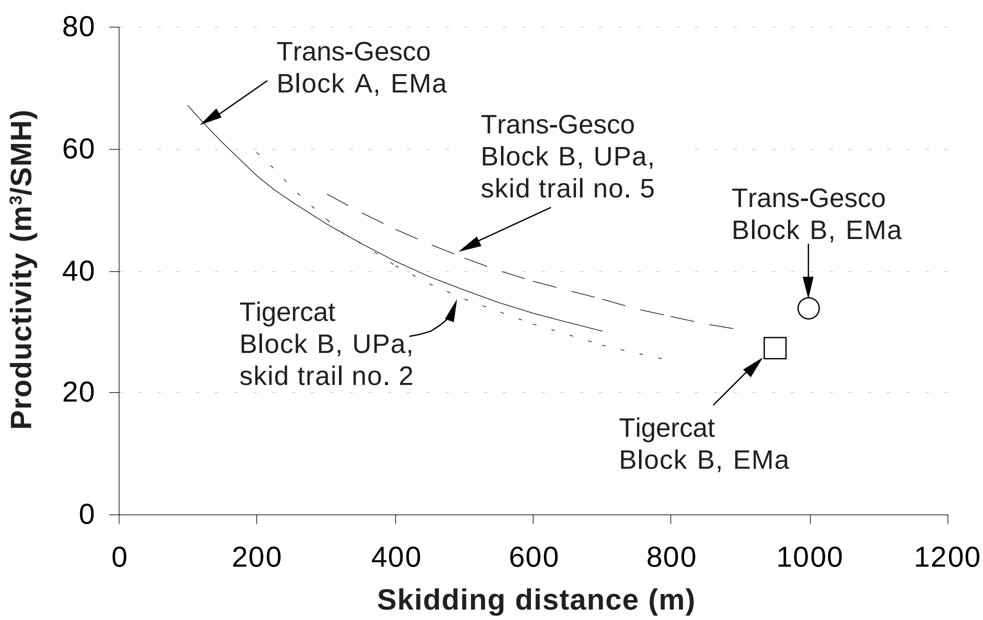



Figure 14. Skidding productivities for the Trans-Gesco and the Tigercat 635 grapple skidders in Blocks A and B.

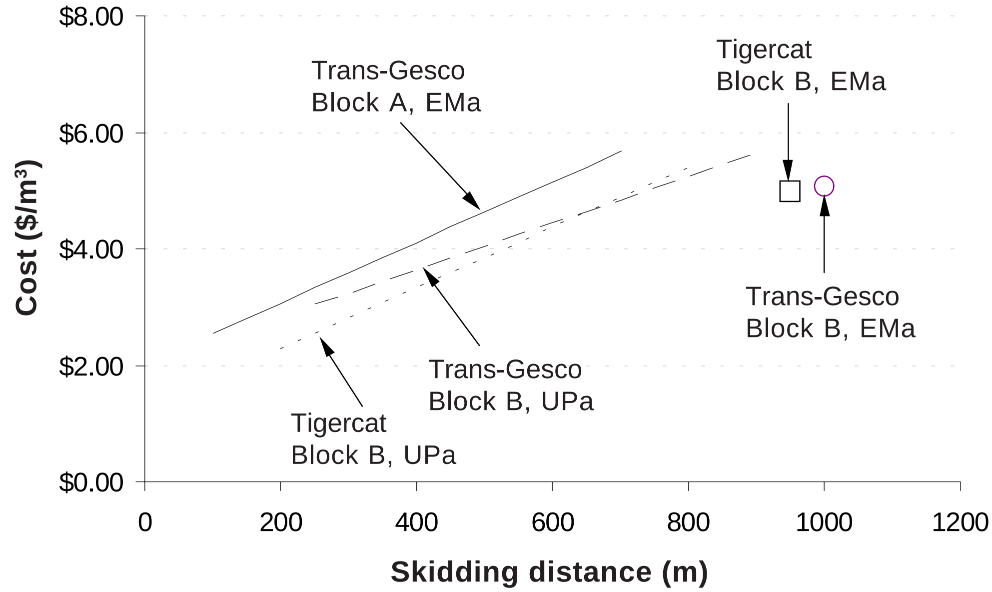



Figure 15. Skidding costs for the Trans-Gesco and Tigercat 635 grapple skidders in Blocks A and B.

of skidded stems. These changes resulted in a increase in processing productivity, from 71 to 116 stems/PMH.[8]

Because the roads and decking areas in this operation accounted for much less area than in a more conventional harvesting design, processing debris accumulated into an excessively thick mat at roadside. To alleviate the problem, skidders experimented with picking up some debris each time they left the road, and spreading it on the block as they returned to the bunches. This method was not very efficient, and other solutions need to be investigated.

The Trans-Gesco could build large payloads even from small bunches. However, when fewer bunches were required, loading time decreased, productivity increased, and skidding costs were less. Since a feller-buncher cannot often create bunches matching the load capacity of the Trans-Gesco, the loader-forwarder technique[9] may be a feasible solution and should be operationally tested.[10]

After the skidding distances exceeded certain limits and skidding productivity dropped below the processing productivity, some idle time in processing was observed.

Visual assessment of soil disturbance by both skidders was made continuously throughout the study.[11] Generally, the Trans-Gesco, with a large ground contact area showed less soil disturbance than the Tigercat equipped with chains on the front wheels and "banana" style tracks on the rear bogie wheels.

The actual road occupancy indices in Blocks A and B were 0.60 and 0.53%, respectively, far below the permitted level of 5% of the block area. Because less road construction is required with long skidding distances, the associated cost is also less.

## Comparisons with other studies

The productivity and cost results of this study were compared with FERIC studies of conventional grapple skidding conducted with Alberta-Pacific in similar stand and terrain conditions (Kosicki 2002) and on alternative ground-skidding operations on moderate to steep slopes in northwestern

8 Processing productivity of 71 stems/PMH agreed very closely with results presented by Kosicki (2002) for a system producing 10-m logs.

9 Loader-forwarding is the use of hydraulic log loaders to extract stems from the falling site to the roadside or skid trail. This technique was successfully used while preparing bunches from dispersed stems for the Trans-Gesco clambunk skidder (Kosicki 2001).

10 A theoretical analysis based on several of FERIC's studies suggested that loader-forwarding might be a feasible method to increase skidding productivity. Results of this analysis are available from FERIC upon request.

11 Alberta-Pacific is in the process of the soil disturbance and compaction assessment. The survey started late fall of 2001, was terminated because of the frozen ground, and will be continued in 2002. Assessment of the natural regeneration is scheduled for 2002 and 2003.

British Columbia (Henderson 2001; Kosicki 2001). Figure 16 shows productivity for a conventional grapple skidder, the Tigercat 635, and the Trans-Gesco TG88C. For short skidding distances, approximately up to 100 m, the conventional grapple skidder had greater productivity than its large capacity counterparts.

Figure 17 presents a summary of the predicted skidding costs for a conventional grapple skidder, Tigercat 635, and Trans-Gesco TG88C. For short skidding distances, approximately up to 200 m, a conventional grapple skidder is a cost-effective solution. For distances from about 200 to 700 m, the Tigercat 635 has the lowest unit skidding costs. The location of the coordinates of the intersection points for the cost lines is, however, very sensitive to the hourly machine costs and productivities of the skidders. For example, an increase of the Trans-Gesco's average payload by 10% would move the intersection point of the Tigercat and Trans-Gesco cost lines from 700 to 400 m.

The results of this study were compared with those for large capacity skidders employed on moderate to steep slopes in interior British Columbia (Table 7). High productivities and low unit skidding costs in this study are due to favourable terrain conditions and the more effective loading and unloading with grapples than with the clambunk skidder's loading boom.

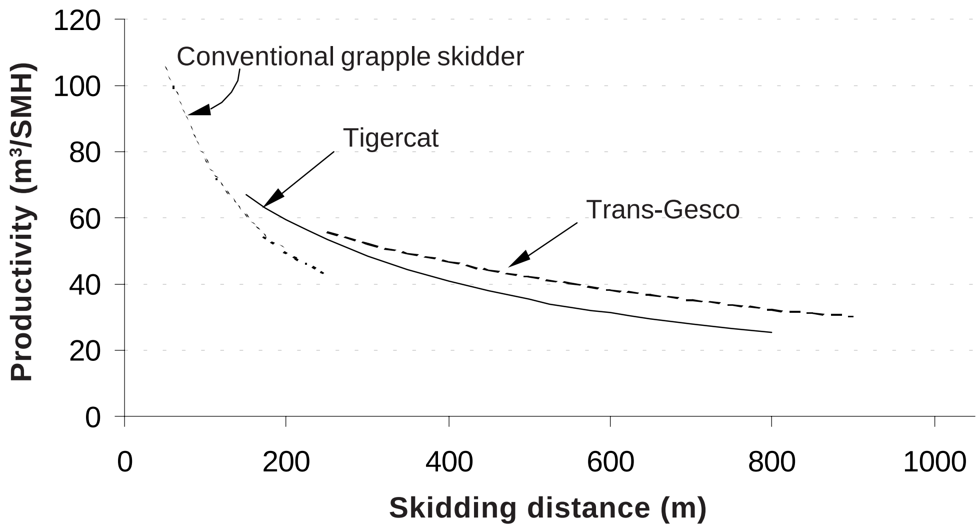



Figure 16. Skidding productivity for a conventional, Tigercat 635, and Trans-Gesco TG88C grapple skidders.

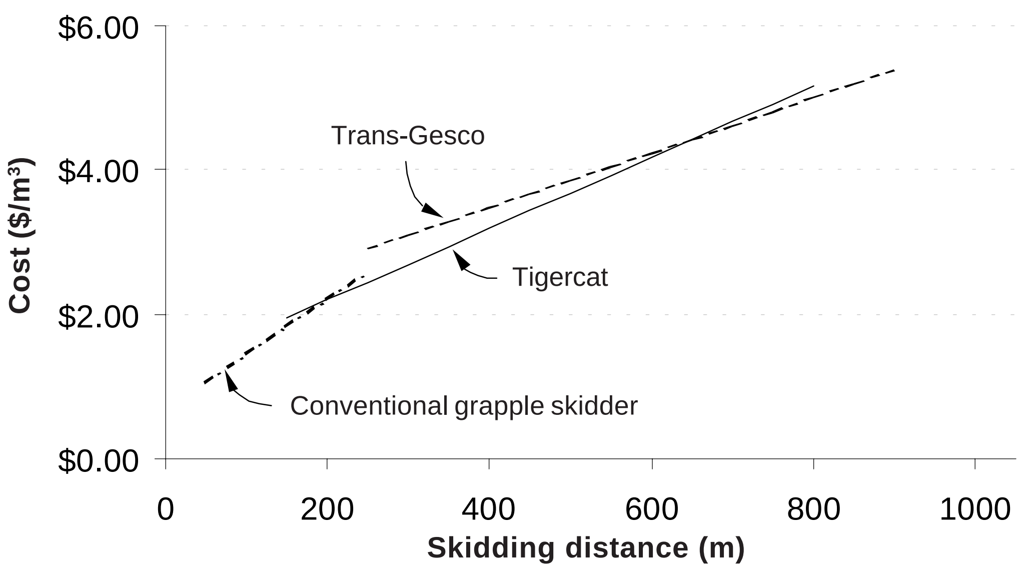



Figure 17. Predicted costs for a conventional, Tigercat 635, and Trans-Gesco TG88C grapple skidders.

## Conclusions

The study demonstrated that the Trans-Gesco TG88C and Tigercat 635 grapple skidders were capable of working efficiently in roadside harvesting operations in the Ecosystem Management and Understory Protection areas. Both skidders met the basic expectations: they were able to build large payloads from small bunches and skid these payloads over long distances without a large loss in productivity.

In the Ecosystem Management area, the clumps, single trees, snags, and patches of unmerchantable vegetation did not impede the travelling and loading operations, although in several cases the edge trees in clumps were damaged by the skidded load. In the Understory Protection area, the 8-m wide skid trails permitted unobstructed travel by both skidders. However, the machines' ability to build payloads was affected, and the average payload volumes in the Understory Protection area were about 75% of those in the Ecosystem Management area. The layout of the skid trails did not create any difficulties for the skidders while entering or leaving the trails, and no damage to the residual trees and skidded stems was recorded.

For both skidders, travel speeds in the Understory Protection and the Ecosystem Management areas were similar.

Overall, the Tigercat had shorter cycle times for all skidding distances than the Trans-Gesco. For both skidders, cycle times in the Ecosystem Management area were slightly less than those in the Understory Protection area. Speed adjustment for the Trans-Gesco resulted in a moderate reduction in its cycle time.

For both blocks and both treatments, the average payload for the Tigercat was about two-thirds of the payload for the Trans-Gesco. In the Ecosystem Management area, with its easier conditions, the payloads skidded by both skidders were about 35% greater than those in the Understory Protection area. As time passed and the skidder operators' skills improved, the average stem and bunch volumes did not appear to affect the payload sizes. In the Ecosystem Management area of Block B, with an average volume of 3.3 m³/bunch, the Trans-Gesco and Tigercat built larger payloads (21.9 and 15.0 m³/cycle, respectively) than in Block A (18.5 and 12.2 m³/cycle for the Trans-Gesco and Tigercat, respectively) where the bunch volumes were much larger and averaged 7.1 m³.

Productivity functions developed from detail-timing data showed that both skidders were highly productive over the full range of skidding distances encountered in this study. For the skidding distance of 300 m, the skidders' productivities were in the range of

**Table 7. Comparison of productivities and costs for four large-capacity grapple skidders**

| | Trans-Gesco TG88C with grapple [a] | Trans-Gesco TG88 clambunk [b] | FMG Timberjack 933C clambunk [c] | Tigercat 635 with grapple [a] |
|---|---|---|---|---|
| Silvicultural system | shelterwood | clearcut | clearcut | shelterwood |
| Slope (%) | 0 | 30 | 15 | 0 |
| Load size (m³) | 19 | 30 | 20 | 12 |
| Hourly cost ($/SMH) | 163 | 165 | 161 | 130 |
| Productivity (m³/SMH) [d] | 45 | 32 | 32 | 38 |
| Cost ($/m³)[d] | 3.67 | 5.16 | 5.03 | 3.43 |

[a] Current publication.
[b] Kosicki 2001.
[c] Henderson 2001.
[d] For a uniform skidding distance of 450 m and utilization of 85%.

50 m³/SMH. At 900 m, the productivities were reduced to about 30 m³/SMH. The Trans-Gesco had slightly higher productivity at all skidding distances because its greater payload volume offset the Tigercat's shorter cycle time. For both skidders, the productivities in the Ecosystem Management area were slightly greater than the productivities in the Understory Protection area.

For the distances up to 650 m, the skidding cost with the Tigercat was less than with the Trans-Gesco, which became more cost-effective as skidding distance increased. However, for the range of 500 to 800 m, the differences in unit skidding costs for both skidders were small and did not exceed 5%. The unit skidding costs for both machines in the Ecosystem Management area were less than those in the Understory Protection area.

After receiving training, the skidder operators quickly learned to operate the Trans-Gesco and Tigercat effectively and efficiently. This was likely because they were already experienced operators of conventional skidders with an interest in learning new skills. A continuous improvement in handling bunches was seen throughout the study period and resulted in increased volume of skidded payloads.

Overall, this trial demonstrated that high-capacity grapple skidders can work efficiently in roadside harvesting operations. As a skidding team, the Trans-Gesco and the Tigercat complement each other very well. The Tigercat's better maneuverability, shorter loading times, and lower hourly costs make it better suited for short skidding distances. The Trans-Gesco's large payload volume makes it more efficient for long-distance skidding, and its track system makes it more suitable for operating on more sensitive areas. Also, the Trans-Gesco's ability to build higher decks was an advantage in this project because the decking space was limited.

## Implementation

During the observed harvesting operation, FERIC identified conditions for successful and effective use of the Trans-Gesco TG88C and the Tigercat 635 grapple skidders:

- The Trans-Gesco TG88C and Tigercat 635 can be employed in roadside harvesting operations in both Ecosystem Management and Understory Protection prescriptions.
- To facilitate unobstructed travelling and loading, the recommended width of skid trails is 8 m. Junction angles of at least 140° between the skid trails and haul roads will facilitate a smooth movement of the grapple skidders and loads, and reduce damage to the residual trees.
- Although both skidders are able to build large payloads from small bunches, the feller-buncher operators should try to maximize bunch volumes. Combining standard sized bunches with a loader-forwarder to create large bunches matching the payload capabilities of the Trans-Gesco or Tigercat is a promising technique to be tested. In both cases, larger bunches will result in less maneuvering, shorter loading time, increased productivity, and reduced soil disturbance.
- Substantial reduction in the length of the in-block roads and, consequently, decking areas, requires a hot logging system. To minimize potential delays related to the interaction between processing and skidding phases, the skidder should skid alternate loads from two or more locations with different skidding distances so that the average skidding productivity will match the more consistent productivity of the processing equipment.
- Strategic planning is necessary to determine the long-term capability of the company to support the Trans-Gesco TG88C or the Tigercat 635 as substitutes for, or to work in conjunction with, conventional skidders. The company should identify suitable sites, timber volumes, financial outcomes, and aspects of soil protection and natural regeneration.

## References


Beckingham, J.D.; Archibald, J.H. 1996. Field guide to ecosites of northern Alberta. Special Report 5. Canadian Forest Service, Northwest Region, Northern Forestry Centre, Edmonton, Alberta.

Henderson, B. 2001. Roadside harvesting with low ground-pressure skidders in northwestern British Columbia. FERIC, Vancouver, B.C. Advantage Report Vol. 2 No. 54. 24 pp.

Kosicki, K.T. 2001. Evaluation of a Trans-Gesco TG88 clambunk skidder working in northwestern British Columbia. FERIC, Vancouver, B.C. Advantage Report Vol. 2 No. 26. 19 pp.

Kosicki, K.T. 2002. Productivity and cost of summer harvesting in a central Alberta mixedwood stand. FERIC, Vancouver, B.C. Advantage Report Vol. 3 No. 6.12 pp.

MacDonald, A.J. 1999. Harvesting systems and equipment in British Columbia. B.C. Ministry of Forests, Forestry Division Services Branch, Victoria, B.C. Co-published by FERIC, Vancouver, B.C. as Handbook No. HB-12. 197 pp.

Mellgren, P.G. 1980. Terrain classification for Canadian forestry. CPPA, Montreal, Que. 13 pp.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# Appendix I

## Machine costs[a] ($/scheduled machine hour (SMH))

| | Trans-Gesco TG88C | Tigercat 635 |
|---|---|---|
| **OWNERSHIP COSTS** | | |
| Total purchase price (P) $ | 775 000 | 485 000 |
| Expected life (Y) y | 8 | 8 |
| Expected life (H) h | 15 840 | 15 840 |
| Scheduled hours/year (h) = (H/Y) h | 1 980 | 1 980 |
| Salvage value as % of P (s) % | 20 | 20 |
| Interest rate (Int) % | 7.0 | 7.0 |
| Insurance rate (Ins) % | 3.0 | 3.0 |
| Salvage value (S) = ((P • s)/100) $ | 155 000 | 97 000 |
| Average investment (AVI) = ((P + S)/2) $ | 465 000 | 291 000 |
| Loss in resale value ((P-S)/H) $/h | 39.14 | 24.49 |
| Interest ((Int • AVI)/h) $/h | 16.44 | 10.29 |
| Insurance ((Ins • AVI)/h) $/h | 7.05 | 4.41 |
| Total ownership costs (OW) $/h | 62.63 | 39.19 |
| **OPERATING COSTS** | | |
| Fuel consumption (F) L/h | 51 | 47 |
| Fuel (fc) $/L | 0.50 | 0.50 |
| Lube & oil as % of fuel (fp) % | 20 | 20 |
| Annual tire consumption (t) no. | 2 | 2 |
| Tire replacement (tc) $ | 2 500 | 2 500 |
| Annual repair & maintenance (Rp) $ | 62 000 | 48 500 |
| Shift length (sl) h | 11 | 11 |
| Wages (W) $/h | 23.00 | 23.00 |
| Wage benefit loading (WBL) % | 38 | 38 |
| Fuel (F • fc) $/h | 25.50 | 23.50 |
| Lube & oil ((fp/100) • (F • fc)) $/h | 5.10 | 4.70 |
| Tires ((t • tc)/h) $/h | 2.53 | 2.53 |
| Repair & maintenance (Rp/h) $/h | 31.31 | 24.49 |
| Wages & benefits (W • (1 + WBL/100)) $/h | 31.74 | 31.74 |
| Prorated overtime (((1.5 • W-W) • (sl-8) • (1 + WBL/100))/sl) $/h | 4.33 | 4.33 |
| Total operating costs (OP) $/SMH | 100.51 | 91.29 |
| **TOTAL OWNERSHIP AND OPERATING COSTS** (OW + OP) $/SMH | 163.13 | 130.48 |

[a] These costs are estimated using FERIC's standard costing methodology for determining machine ownership and operating costs for new machines. The costs shown here do not include supervision, profit and overhead, and are not the actual costs for the contractor or the company studied.

# Appendix II

## Regression and productivity equations

### Linear regression equations for delay-free cycle time

$CT = a + b_1SD + b_2(B)$ and n, $R^2$, $r^2$ and S.E.E.

where

| | | |
|---|---|---|
| *CT* | = | delay-free cycle time (min) |
| *SD* | = | skidding distance (m) |
| *B* | = | bunches to complete a full payload (no./cycle) |
| *a* | = | intercept |
| $b_1$, $b_2$ | = | regression coefficients |
| *n* | = | number of cycles used in regression analysis |
| $R^2$, $r^2$ | = | coefficients of determination |
| *S.E.E.* | = | standard error of estimate |

Equation 1: Trans-Gesco TG88C, Block A, Area AA

$CT = 0.57 + 0.0296(SD) + 2.13(B)$

*n* = 79 cycles $R^2$ = 72% *S.E.E.* = 3.13

This equation is applicable for the following ranges:

*SD*: 20–700 m

*B*: 1–5 bunches/cycle

Equation 2: Trans-Gesco TG88C, Block A, Area AB, larger-than-average bunches

$CT = 5.13 + 0.0232(SD)$

*n* = 16 cycles $r^2$ = 40% *S.E.E.* = 1.99

This equation is applicable for one bunch/cycle and *SD* = 400–700 m

Equation 3: Trans-Gesco TG88C, Block B, Understory Protection area, skid trail no. 1

$CT = 9.22 + 0.02790(SD)$

This equation is applicable for 4.8 bunches/cycle and *SD* = 450–975 m

Equation 4: Trans-Gesco TG88C, Block B, Understory Protection area, skid trail no. 5

$CT = 11.61 + 0.02267(SD)$

This equation is applicable for 5.7 bunches/cycle and *SD* = 225–825 m

Equation 5: Tigercat 635, Block B, Understory Protection area, skid trail no. 2

$CT = 5.77 + 0.02366(SD)$

This equation is applicable for 3.7 bunches/cycle and SD = 200–850 m

### Productivity equation

Equation 6: Productivity = $\dfrac{60(CV)(U)}{CT + DT}$

where

| | | |
|---|---|---|
| *Productivity* | = | predicted productivity measured in m³/SMH |
| *CV* | = | average volume per skidding cycle (m³) |
| *U* | = | utilization (%/100) |
| *CT* | = | cycle time from appropriate cycle time equation (min) |
| *DT* | = | “in-cycle” delay time/cycle (min) |