

CAPABILITIES OF A MODIFIED "TIMBERJACK"  
AND A "TERRAIN-MASTER" FOR DITCHING  
ON PEATLANDS

V. F. HAAVISTO and G. T. ATKINSON

GREAT LAKES FOREST RESEARCH CENTRE  
SAULT STE. MARIE, ONTARIO

REPORT O-X-264

CANADIAN FORESTRY SERVICE  
DEPARTMENT OF FISHERIES AND THE ENVIRONMENT  
JUNE 1977

*Copies of this report may be obtained  
from*

*Information Office,  
Great Lakes Forest Research Centre,  
Canadian Forestry Service,  
Department of Fisheries and the  
Environment,  
Box 490, Sault Ste. Marie, Ontario.  
P6A 5M7*

## ABSTRACT

A Timberjack Model 215 wheeled skidder equipped with a conventional backhoe, and a Bombardier Terrain-Master pulpwood forwarder equipped with a Prentice Loader and clam, were field tested to evaluate their respective capabilities for digging drainage ditches under various peatland conditions. Both machines were able to dig suitable ditches at rates of about 33 m (100 ft) per hour. Modifications are suggested which should increase the rate of digging by at least 50%.

## RÉSUMÉ

Une débusqueuse à roues de marque Timberjack, modèle 215, munie d'une bineuse arrière classique, puis une débusqueuse de bois à pâte Bombardier Terrain-Master, munie d'un chargeur Prentice et d'une benne, furent testées sur le terrain pour évaluer leur capacité respective de creuser des fossés de drainage dans divers genres de terrains tourbeux. Les deux machines purent creuser des fossés convenables à raison de 33 m (100 pieds) à l'heure. Les modifications proposées devraient augmenter la vitesse de creusage d'au moins 50%.

## TABLE OF CONTENTS

	Page
INTRODUCTION . . . . .	1
METHODS . . . . .	2
RESULTS AND OBSERVATIONS . . . . .	4
<i>Timberjack Skidder/John Deere Backhoe</i> . . . . .	4
<u>Assessment of Digging Capability</u> . . . . .	4
<u>Modifications</u> . . . . .	5
<i>Bombardier Terrain-Master/Prentice Loader</i> . . . . .	7
<u>Assessment of Digging Capability</u> . . . . .	8
<u>Modifications</u> . . . . .	9
CONCLUSIONS . . . . .	9
LITERATURE CITED . . . . .	11

## INTRODUCTION

Since the turn of the century peatland drainage has been used extensively as a practical silvicultural tool in Finland. During this time, digging ditches on forested peatland has changed from a manual operation to a mechanical one (Heikurainen 1960, Stoeckeler 1963). Explosives, conventional buckets, drag-lines, bucket-chains, endless-chains, and rotary ditchers have been used to dig open ditches. Tractor-pulled and cable-and-winch-pulled ditching plows have also been used satisfactorily. More recently, Aitolahti and Numminen (1968) assessed the potential of light excavators (backhoes) for forest drainage.

A prerequisite for satisfactory operation of mechanical equipment on organic soils is low bearing pressure. Allowable bearing pressures are dependent on, among other things, the presence or absence of tree, shrub, or lower vegetation roots; soil moisture content; and peat type (Huikari et al. 1964). Understandably, these conditions can change markedly within any area. Sufficient power to perform the work of pulling or digging efficiently must be maintained without sacrificing floatability.

Light-weight excavators provide many advantages. They are readily available and can be equipped with half tracks, full tracks, or tracks specially designed for peaty terrain (Aitolahti and Numminen 1968). Since the excavator straddles the ditch line, the right-of-way required need only be minimally wider than the machine. According to Huikari et al. (1964), for efficient forestry operations light-weight excavators should have diesel engines rated at 35-60 H.P., hydraulic systems capable of developing 5000 kg (11,000 lb) tearing power and 1500 kg (3300 lb) lifting power on the backhoe, a minimum boom swing of  $180^{\circ}$ , and a boom reach of 5 m (16 ft). In an intensive time study involving 12 combinations of UKKO-MESTARI backhoe units mounted on several sizes and models of tractor equipped with a variety of track designs, ditching rate varied from 31.6 to 117.7 m/hr (103-386 ft/hr) for a ditch with a cross-sectional area of  $0.95 \text{ m}^2$  ( $10.2 \text{ ft}^2$ ) (Aitolahti and Numminen 1968). They concluded that some combinations were more efficient than others.

The extensive use of machines in forest harvesting operations is now a fact. Many of these machines have been designed, or more recently modified, to operate efficiently on the peatland sites that occur in northern Ontario. It was felt that with additional modification some of this readily available machinery could be used to dig drainage ditches on forested peatlands. To this end, we field tested a Model 215 Timberjack wheeled skidder (see Fig. 1) and a Bombardier Terrain-Master pulpwood forwarder (see Fig. 2).



## METHODS

Two concepts in mobility (wheels and tracks) and two digging attachments were observed in the field tests.

In place of the conventional winch and fairlead on the wheeled skidder (Timberjack Model 215), a John Deere Model 93 backhoe was mounted onto a home-made bunk (Fig. 1). A loading bucket with suitable hydraulics was installed in place of the usual piling blade. The testing was done about 1½ km (1 mi.) southeast of Longlac, Ontario. The ditching capability of the machine was evaluated in an area of aspen (*Populus tremuloides* Michx.) — willow (*Salix* sp.) bordering a 15-year-old cutover, in the cutover area where well-established alder (*Alnus rugosa* [Du Roi] Spreng.) and/or labrador-tea (*Ledum groenlandicum* Oeder) occurred, and in a forested area with various densities and sizes of black spruce (*Picea mariana* [Mill.] B.S.P.).

The pulpwood forwarder (Terrain-Master), with articulating frame, which has continuous power to all four of its 75-cm (30-in.)-wide tracks, was equipped with a Prentice Loader mounted on the rear of the front unit (Fig. 2). The loading clam was used for digging. The testing was done in Avon Township, about 48 km (30 mi.) northwest of Cochrane, Ontario. The capability of the machine was evaluated in a 12-year-old burned cutover with well-rotted stumps and much labrador-tea, in a sedge (*Carex* spp.)-dominated area, in an area with dense, vigorous alders, and in uncut black spruce stands of various densities.

Prior to field testing, the capability of each machine and its attachments was reviewed with the operator. It was ascertained that each machine could travel in typical peatland conditions, but neither had been used to dig ditches in forested conditions. The operators had no previous ditching experience.

Each operator was instructed as follows: (1) to dig a ditch, about .75-1.00 m (2½-3 ft) deep and the width of his bucket or clam, (2) to follow a centre-line as marked, with freedom to deviate a maximum of 5 m (16 ft) from the centre-line to circumvent larger trees or groups of trees, and (3) to pile the spoil into heaps back from the ditch edge rather than in a continuous spoil mound along the bank which could impede water movement into the ditch.

The degree of sinkage of the machine, the ease of forward movement, the effects of trees and other obstacles on forward progress, and the ability of the attachment to dig ditches were observed and evaluated. Some measurements on the rate of digging were made.



Fig. 1. Model 215 Timberjack wheeled skidder equipped with a rear-mounted Model 93 John Deere backhoe. Note: 1) the front-mounted loading bucket in place of the piling blade, 2) the considerable distance between the two control locations.



Fig. 2. The Bombardier Terrain-Master pulpwood forwarder equipped with a Prentice Loader and shortwood loading clam. Note the wide tracks and the open design of the clam.



## RESULTS AND OBSERVATIONS

Timberjack Skidder/John Deere Backhoe

The extensive use of wheeled skidders in harvesting operations has prompted numerous modifications, especially to wheel design (Letkeman 1970), to assure lower bearing pressures for satisfactory operation on forested peatlands. Wheeled skidders with front-mounted blades are capable of clearing their own right-of-way, carrying a digging attachment, and digging ditches.

Assessment of Digging Capability: The digging was done on the line straddled by the skidder, and hence the right-of-way was only about 2.5-3.0 m (8-10 ft) wide, just slightly wider than the unit (Fig. 3). In the cutover area



Fig. 3. View of ditch dug by the wheeled skidder/backhoe on dense immature black spruce/labrador tea swamp site. Note the narrow right-of-way and the spoil on both sides of the ditch.

where the aspen-willow changed to vigorously growing alder (about 2.5 m, or 8 ft high), the subsoil was an amorphous black muck, and some pools of open water were present. Labrador-tea and alder undergrowth were not sufficiently dense to provide a firm root layer, and the slash had decayed considerably since cutting. Under these ground conditions the wheels penetrated the surface deeply (>30 cm, or 1 ft) allowing the mounting bunk of the backhoe to snag the still firm stumps. Difficulty was also encountered in lifting and removing the clonal alders in this area. Even with these problems, about 23 m (75 ft) of suitable ditch were dug per hour.

Where there were only a few scattered black spruce trees and a ground cover of labrador-tea underlain by a substratum of relatively undecomposed sphagnum moss (*Sphagnum* spp.), ditching progressed at about 34 m (110 ft) per hour. The ground was not as wet, and the wheels rode higher because of the root mat, with the result that there were fewer hangups on stumps.

Where the black spruce stand was denser but where there still was no difficulty in avoiding larger trees, the rate of digging was about 42 m (137 ft) per hour. A dense root mat and an increase in the number of stems of advance growth combined to provide a better traction mat in this area, and resulted in the higher rate of digging.

In the dense black spruce stand, where trees attained a DBH of 18 cm (7 in.), maneuvering was more difficult. Here, considerable numbers of trees were pushed over by the skidder while it was clearing its own right-of-way (Fig. 4). These trees would lodge lengthwise under the skidder, and it proved very time-consuming and difficult to move them out of the way or break them off (Fig. 5). It was also more difficult to swing and empty the bucket of spoil between the trees. Therefore, the rate of digging averaged only about 20 m (65 ft) per hour. To alleviate this problem, the larger trees in the right-of-way were felled manually at right angles to the ditch line. This procedure improved the forward progress of the machine by partially corduroying the right-of-way, and the operator was able to use the backhoe to push the boles laterally and clear the ditch line. This resulted in an increase in ditching rate to about 23 m (77 ft) per hour.

Modifications: Several modifications to the Model 215 Timber-jack/John Deere Model 93 backhoe combination would improve the ditching rate.

To improve the flotation of the machine and increase its ability to traverse the more amorphous sites, either dual tires or high flotation tires should be installed on the rear axle. This would also improve stability during digging and decrease the amount of sinkage experienced. The stabilizers on this machine were designed for harder soil surfaces and could not effectively be used in this trial because of sinkage. If larger pads were fitted, these could be used to more advantage.





Fig. 4. View of the loading bucket felling trees to make the right-of-way in a black spruce stand.

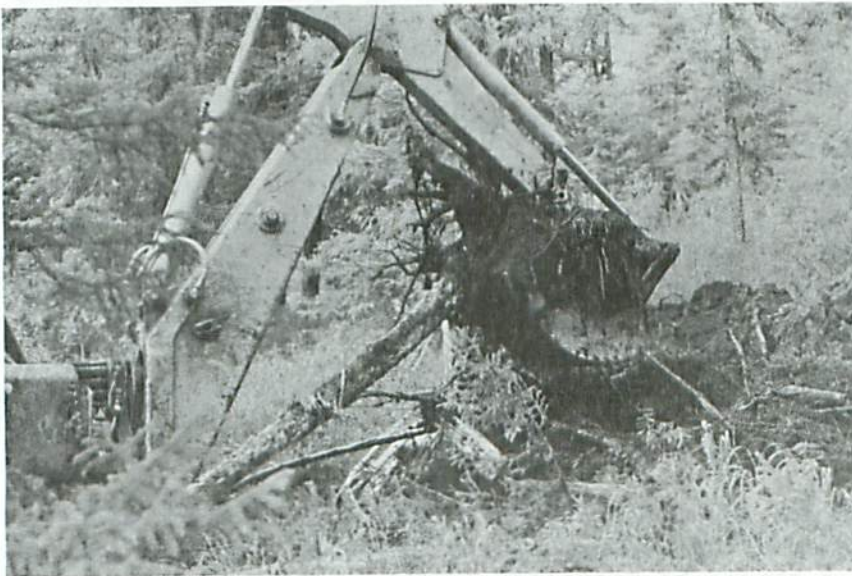


Fig. 5. View of the backhoe showing the difficulty encountered in removing downed trees that are under the machine in the ditch line.

With a longer boom, digging ability would be improved and fewer moves would be necessary (average move in the present test was about 1.5 m, or 5 ft); this would result in an increased rate of digging. The mounting of the backhoe is critical. The swivel-point must be far enough back to allow a minimum rotation of  $180^{\circ}$ . The mounting must be high enough (the bottom at least even with the bottom of the skidder) to minimize the chance of hangups on stumps and debris. A higher mounting will also facilitate breaking and removing of debris, tree boles, and vegetation such as clonal alders.

In this test, the spoil tended to adhere to the sides of the conventional bucket. The operator often had to either shake the material out or knock the bucket against trees to loosen the debris. This was time-consuming and caused considerable damage to trees bordering the ditch. More satisfactory cleaning might be possible if the bucket was somewhat flared. The properties of most peats are such that an open-tine type of bucket, constructed of bar steel, is sufficient to tear the peat from the ditch, carry the spoil material well, and spill it easily.

As so much difficulty was encountered with the trees that had been knocked down and were lodged under the machine, it might be advisable to construct a hydraulically operated plow-like device for the front of the skidder. This could be made of heavy bar steel, and in operation would open a right-of-way by pushing trees down so that they were diagonal or perpendicular to the machine's line of travel.

Remote controls for operating the skidder (clutch, steering, accelerator) from the backhoe seat are essential. One man could then do all digging operations and move the machine forward when necessary. The operator should have a protective cage around his seat.

#### Bombardier Terrain-Master/Prentice Loader

Most large excavators are slow-moving tracked vehicles which, because of their great mass, require some form of flotation pad from which to operate in soft ground conditions. Several relatively light-weight excavators are available which are equipped with backhoe digging devices, and also have wider and longer tracks to decrease the bearing pressure.

A new concept in forest harvesting machinery is realized in the Bombardier Terrain-Master (Fig. 2). This machine is a pulpwood forwarder with articulating frame and 75-cm (30-in.)-wide tracks. The forwarder is designed to carry its load or drag tree-lengths with the butt ends resting on the rear unit. The Prentice Loader was equipped with a loading clam and attached to the back of the front unit.



Assessment of Digging Capability: With the Prentice Loader located on the back of the front unit, it was necessary to dig the ditch to the side of the machine (Fig. 6). This necessitated a right-of-way about 5 m (16 ft) wide. The spoil was torn out, swung and deposited at the rear of the machine. The boom was too short to deposit the spoil sufficiently beyond the far edge of the ditch. Because the clam tore material out rather than cut it, the ditch had ragged edges. The clam could dig a flat-bottomed ditch about 60 cm (2 ft) wide if used lengthwise, i.e., opening and closing the clam parallel to the ditch line; when the clam was used crosswise, the ditch had a rounded bottom, and was more than 135 cm (53 in.) wide.



Fig. 6. View of ditch being dug to the side of the Terrain-Master. Note the spoil being piled behind the machine.

The machine had a very low bearing pressure (3.4 psi for the front unit, 1.8 psi for the unloaded rear unit) and was able to traverse almost any condition with only minor compaction. In the alder drainageways, the machine sank slightly (max 5 cm, or 2 in.). The Terrain-Master is capable of pushing down trees of up to 15 cm (6 in.) DBH with ease, eliminating the necessity for manual or mechanical right-of-way clearing.

Digging in the raw sphagnum peat of the burned cutover site dominated by labrador-tea was not difficult, and the rate of digging averaged about 30 m (97 ft) per hour. In the sedge-dominated area, the well-developed root mat acted as a binding agent and facilitated the removal of larger masses of spoil. Ditching rate in this condition averaged about 40 m (131 ft) per hour. Little digging difficulty was encountered even with clonal alders. The open-sided clam was able to contain amorphous black muck surprisingly well, and the digging rate was about 30 m (97 ft) per hour.

In the forested area, the Terrain-Master easily trampled its own right-of-way. The downed trees improved the flotation afforded by the root system. Trees up to 10 cm (4 in.) DBH were easily removed from the ditch line. Even though the machine had sufficient power to pull out larger trees, the boles were difficult to grip since the clam normally hangs downward. In this treed situation, the rate of digging was about 24 m (80 ft) per hour. The rate of digging was increased to 27 m (87 ft) per hour by cutting the larger trees in the right-of-way, and leaving high stumps which the clam could easily grasp and remove.

Modifications: Some modifications to the Terrain-Master would change it from a pulpwood forwarder to a practical forest ditching machine. A longer horizontal boom on the Prentice Loader would allow spoil to be deposited between the trees on the opposite side of the ditch. An alternative would be to mount the loader on the rear unit. Digging would be done directly behind the machine, allowing spoil to be deposited on either side of the ditch. The right-of-way would then be only about 3 m (10 ft) wide. If this alternative was chosen, the operator's controls would have to be relocated to allow an unobstructed view of the digging operation, and suitable protection for the operator would have to be provided.

## CONCLUSIONS

If forest drainage is to become an accepted silvicultural technique, one must know the potential of various types of machines and assess their capability from several viewpoints, i.e., bearing pressure and flotation, capability to clear their own right-of-way, digging capability, etc. We feel that it is more advantageous to modify available forestry equipment than to develop or purchase specialized machines. Forest drainage operations will not likely be undertaken in stands that are either very dense or have trees larger than 15 cm (6 in.) DBH.

Two machines were tested. The wheeled skidder is very common in forest harvesting areas and requires relatively little modification other than the attachment of a backhoe. The other, the Terrain-Master, is more specialized and less common.



Even in their present forms, both of these machines were capable of digging acceptable ditches at rates of about 33 m (100 ft) per hour. On the basis of 1977 prices, ditching would cost about \$0.60 per m (\$0.20 per ft). With the modifications suggested, and with operators more experienced in forest ditching, the rate of digging should increase by at least 50%.

As a result of our tests, we believe that the tracked Terrain-Master is more suitable for traversing peatland conditions as it creates less disturbance to the soil surface, and less compaction to the underlying layers. The backhoe, however, is superior to the clam for actual excavating since it gives better control of ditch depth and of where the spoil is placed. With contoured buckets, desired ditch profiles can be obtained readily.

## LITERATURE CITED

- Aitolahti, M. and E. Numminen. 1968. Metsäojakaivureiden työteho ja ehdotus kaivu vaikeusluokitukseksi. Comm. Inst. For. Fenn. 67(2):1-48.
- Heikurainen, L. 1960. Metsäojitus ja sen perusteet. Werner Söderstrom Oy., Porvoo, Helsinki. 378 p.
- Huikari, O., S. Muotiala, M. Wäre. 1964. Ojitusopas. Kirjayhtymä, Helsinki. 244 p.
- Letkeman, R. 1970. Spruce Falls rides swamps with extra-flotation tires. Can. For. Ind. 90(11):24-27.
- Stoeckeler, J. H. 1963. A review of forest swamp drainage methods in northern Europe. J. For. 61:99-104.