

# TWIN- AND SINGLE-ROPE GRAVITY ROLLERS — A SITE-PREPARATION TECHNIQUE DEVELOPED IN NEW ZEALAND

D. EVERTS\*

## ABSTRACT

*In New Zealand we have to look more seriously at steep scrub-covered hill country, much of it reverted farmland, for our steadily expanding afforestation programme. Manpower is not always readily available to prepare such land for a pre-planting burn. Techniques for the chemical desiccation of the vegetation are available but not preferred as the removal of all standing material is obviously a great advantage for manual planting.*

*Twin- and single-rope gravity rollers have been developed to overcome this land-preparation problem. Needing only minimal ridge-top tracking for the prime mover, these units come into their element on slopes greater than 25 degrees. With a controlled downslope reach of up to 250 m, contour tracking can often be avoided. The crusher-roller, up to 10 tonnes in weight, leaves the vegetation in a compacted, shattered, and quickly curing mass, ready for burning.*

*This paper discusses the development of this equipment, notes some specific characteristics of the existing units, the factors which contribute to productivity, and the advantages and disadvantages associated with their use.*

## INTRODUCTION

Traditionally, plantation forestry in New Zealand has been restricted to country not generally suited to farming. However, topographically easy land of this nature available for new afforestation is becoming increasingly scarce and expensive. Forest managers are having to look at steeper and more remote areas of the country such as those which were once cleared for sheep farming but have now reverted to indigenous scrub species.

Before such land can be planted with a forest crop, the scrub must be cleared. To do this, the forest manager has three options from which to choose:

---

\*Forest Research Institute, Rotorua.

*Manual Clearing by Slasher, Axe, or Chainsaw:* This is a labour-intensive operation not suited to large programmes. Suitably skilled and motivated labour is not usually available locally, so costs are also increased by the need to transport and accommodate workers. The cut material which remains in long lengths and is not compacted will, after burning, still present a difficult and dangerous planting site to the planting gang.

*Aerial Herbicide Application:* Although a herbicide could be applied to large areas at a reasonable cost, the technique has drawbacks. Quite apart from any environmental considerations, the dead but standing material is a considerable barrier to the planting gang and for subsequent tending operations. Again, unless the penetration of the chemical through the canopy is adequate, a lot of green material will still remain and detrimentally affect the quality of the prescribed burn. Tree crop survival and quality tend to suffer from inadequate land clearing.

*Mechanical Clearing:* Here "Kiwi ingenuity" has resulted in the development of gravity-roller equipment (see Fig. 1) which has seldom failed to impress forest managers with its production

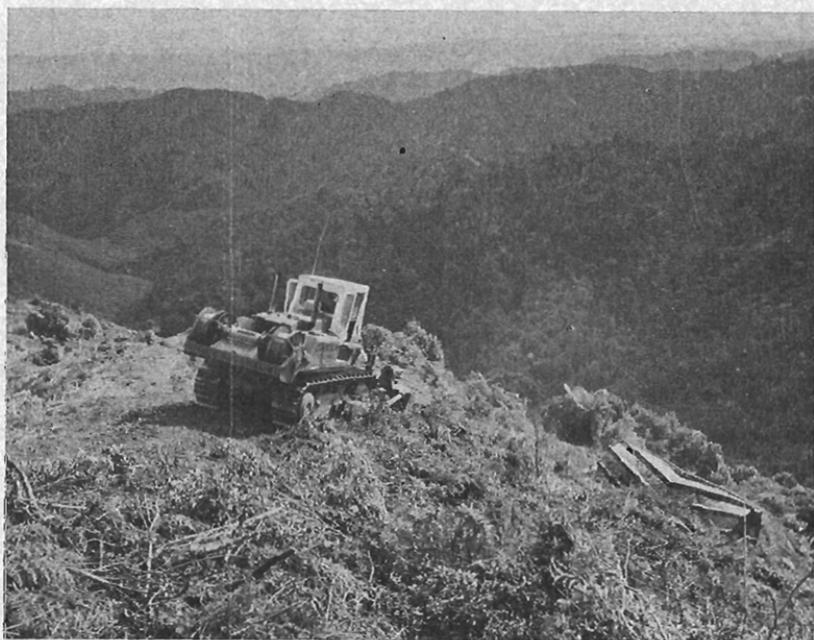


FIG. 1: A twin-rope gravity roller — the latest design.

capacity, and because of the terrain conditions and the range of vegetation types it has successfully coped with (Chavasse, 1969, 1971; Wilson, 1969).

## DEVELOPMENT OF THE TWIN-ROPE GRAVITY-ROLLER

The use of towed scrub rollers has been a standard land-clearing practice for many years, but on firm ground the working limit of such machines is a 25 to 28° maximum slope. However, it was found that scrub could be crushed on steeper slopes by simply attaching the roller to the winch rope and then backing the tractor down to its safe limit. Then, by allowing the roller to be drawn down by gravity to the bottom of the slope or the extent of the rope, scrub was crushed. By strategically relocating the tractor, more scrub is crushed as the roller is winched up again. On good terrain, operator skill and patience enabled acceptable production rates of up to 0.5 ha/machine-hour to be attained. Although rope spooling was poor and thus abrasive, and any sort of roller control was limited to within a reach of 80 to 100 m, this system for clearing scrub from steep slopes did at least work.

The need for complete roller control, possibly with twin-ropes, was soon recognised and seen as a challenge, and led to the development of two designs. One design was first based on an Allis Chalmers HD21 (150 kW) tractor, but then rebuilt on to a Euclid TC-12 (now Terex 82-80), a twin-engined unit rated at 330 kW. The winch drums and control system were built on to a hydraulically driven turntable mounted on the rear of the tractor. Each winch was driven by one of the two motors through torque convertors and the p.t.o., and through a concentric gearbox and right-angled mechanical drives. Accelerator and brake controls for each spool operated independently. Three gear speeds were available for winching the 10 tonne,  $5.5 \times 2.3$  m roller. When fully wound in, the roller could be picked up by a pair of hydraulically operated cradle arms for realignment. This design, which required two operators, was capable of high line speeds (an average of 112 m/min under good conditions) and achieved average production rates of 1.2 ha/machine-hour. However, as the ropes did not run over fairleads, spooling was poor. Also, this unit's gross weight of 54 tonnes made it difficult to manoeuvre on often unstable country and created quite a transportation problem. This design has now been discontinued.

The other design was based on a Terex 82-30 (168 kW) tractor and had twin winches mounted behind the cab (see Fig. 2).

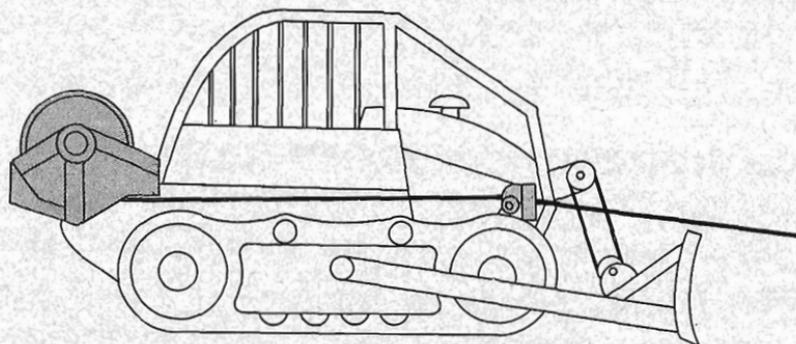


FIG. 2: *Sketched detail of the original unit.*

These winches were again separately powered from two sprocket wheels mounted on the shaft of a standard powershift logging winch and controlled through separate clutches and brakes. The winch ropes came forward above the tracks and through guide rollers mounted right forward on the engine housing. This design required only one operator and gave good rope-spooling control. The 21 tonne unit handled a 9 tonne,  $5 \times 2.4$  m roller, but with its lower horsepower had lower line speeds (65 m/minute) which dropped average production rates to around 0.65 ha/machine hour.

However, since the patenting of the rear winch and forward fairlead principle, considerable design changes have taken place (see Fig. 3). The operator's seat has been relocated right forward for maximum visibility and a suitable cab built around it. The blade was used to mount the fairleads on, which gave greater tractor stability and maximum fleet angle. The fairleads were redesigned to swivel on two planes. A hydraulic blade replaced the cable blade and the engine was uprated to 186 kW.

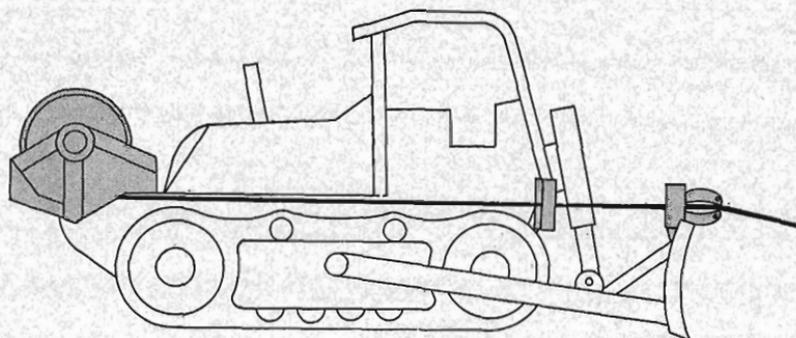


FIG. 3: *The major design changes that have been made.*

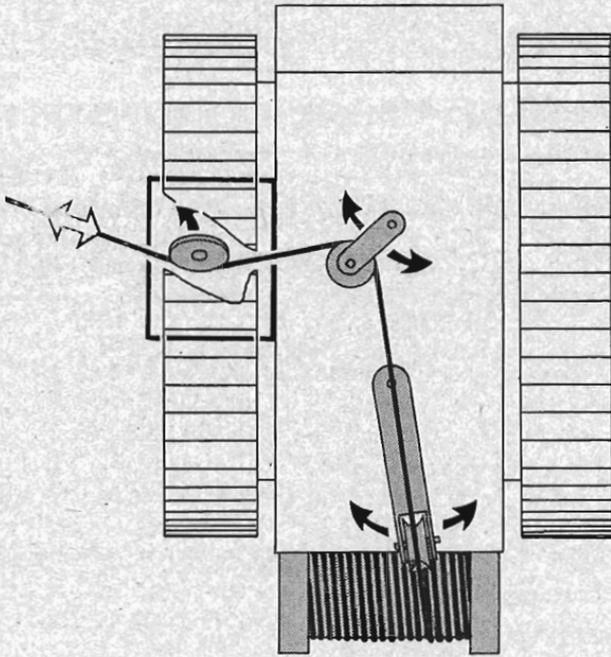


FIG. 4: *Worm's-eye view of this design layout.*

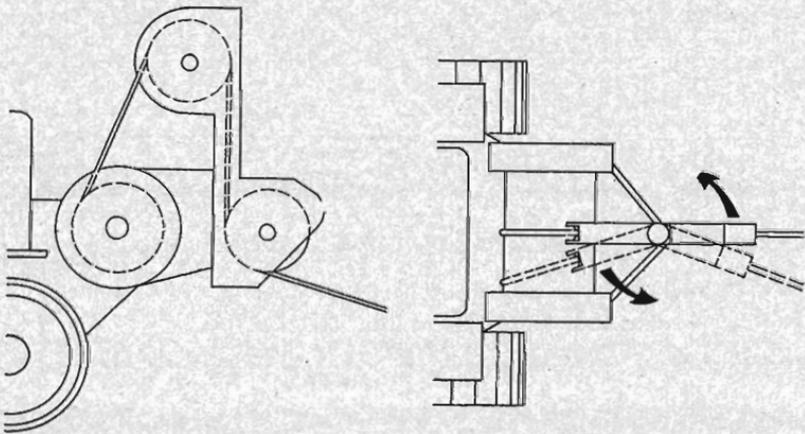


FIG. 5: *The Bush-Block attachment for single-rope units.*

This modified machine has now been operating successfully for 3 years in its current configuration. Cumulatively, these modifications have resulted in 12% higher linespeed (73 m/min) and production rates now average 0.8 ha/machine-hour. The unit's designer/owner/operator and patent holder, M. Johnson, has now built another, more powerful unit, which has just started production. It features a Terex 82/40 (240 kW) engine and a fully enclosed cab for operator comfort and protection. Other modifications include twin-pad disc brakes (replacing band brakes) on each winch drum and modified winch gearing incorporating a semi-planetary design. Preliminary tests indicate line speeds of 97 m/min and production rates of around 1 ha/machine-hour. The same roller dimensions have been retained.

Still incorporating the patented principles, a number of owner/operators have now developed their own units, modifying a range of prime movers to suit individual needs and choices. The smallest successful unit is based on a Caterpillar D7 (95 kW). Although its roller is smaller ( $3.5 \times 1.8$  m) and lighter at 6 tonnes, it has the advantages of a lower development cost and has better manoeuvrability on steep terrain, and is easier to transport. It is therefore more suitable for farm-size development blocks where scrub is being cleared for pastoral development.

### THE SINGLE-ROPE GRAVITY ROLLER

Very high development and operating costs of the twin-rope units have ensured a continuing interest in single-rope gravity rollers, and these have also undergone some modifications, although rollers straight off the winch are still used.

In one unit (see Fig. 4) the winch rope is passed down around a roller on a swinging arm (which allows good rope spooling), forward to another fairlead under the belly-pan, and sideways from there over a swinging fairlead mounted on the trackgear. One operator stands in a cage on the side from where he operates the winch, while another operator moves the tractor forwards or backwards as required, on a prepared track. For a fairly reasonable development cost, production rates of 0.5 ha/machine-hour are possible.

Another, and now the most popular development associated with the single-rope roller, is the Bush-Block attachment (see Fig. 5) — a unit developed and patented in New Zealand — which fits on to the tractor's winch housing and back plate. It consists of two fairleads mounted one above the other on a ver-

tical shaft, around which they can swivel. The winchrope goes up and over the top sheave, then down and out under the bottom sheave. The lower sheave can swivel in the direction of the pull, and the other swivels with the laying of the rope on the winch drum. This allows the roller to be flected in from any angle, while good rope spooling is retained. Although production rates remain around 0.5 ha/machine-hour, ropes can last for up to 200 ha (a 20 to 30% advantage).

### ROLLER DESIGN AND MOUNTING

Early roller models carried conventional parallel cutters, but to prevent sideslip on the contour (which is very important when working the roller out of sight) all the later cutters were placed in a chevron pattern, with the apex of one blade at least overlapping the line joining the ends of the next cutter (see Fig 6). As well as different types of steel, different methods of constructing the cutters have been used. The inverted angle-iron with a raised edge added along its back is popular. Other rollers have the cutter gusseted every 30 cm or so, or have a plate welded all the way along. Still others are designed with the cutters raised on the gussets, 5 cm above the roller surface; it is claimed this absorbs shock-loads better.

Internal strengthening of the roller is essential. Usually they are converted steam boiler or spiral-welded drums internally strengthened with a number of diaphragms or a series of diagonal braces.

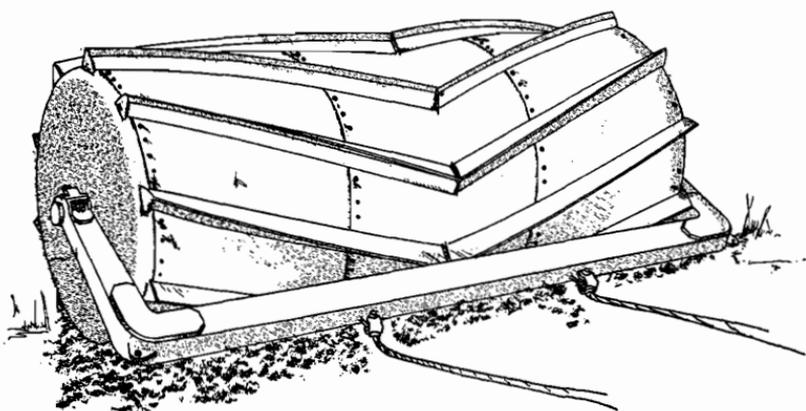


FIG. 6: Basic roller design with the cutters placed in a chevron pattern.

The types of bearings which hold the roller in its C-frame vary with nearly every roller: bronze bushes, hardwood blocks, synthetic padding material, or a tractor trunnion pin and cap have all been used.

The manner of attachment (and location) of the ropes to the C-frame again varies widely, and a number of "scientific" explanations are available for every variation. Basically, the closer the attachment is to the C-frame corners, the more positive the control. However, a point is reached where across-contour-travel control is lost and sledging occurs on the uphill pull. Roller balance is also related to roller width:diameter ratio, which ideally should be nearly 2:1. Roller weight to tractor weight ratio is also critical, and should not be more than 1:3.

### FACTORS AFFECTING PRODUCTIVITY

A wide range of factors affect productivity of both single- and twin-rope machines. Operator skill is an obvious factor. Line speeds relate to engine horsepower, winch gearing, and torque conversion. Terrain conditions such as length and steepness of slope, even or broken surface, and concave or convex slope shape, will all affect productivity. The presence of large trees, old stumps, or rocks will affect productivity in direct proportion to their density. When there are more than about 450 obstacles/ha, production becomes seriously affected.

No standardised classification has ever been prepared to describe our New Zealand scrub types, which range from light fern to dense broadleaf scrub. However, by amalgamating the data collected during the various machine evaluation projects, three broad classes have been identified in Table 1. Mean canopy height in light scrub is up to 5 m, in medium scrub it is 5 to 7 m, and in heavy 8+ m.

Production rate analyses indicate that in heavy scrub (but on favourable terrain) machine productivity is about half of that in light conditions.

TABLE 1: VEGETATION CLASSES (STEMS/HA)

	<i>Stem Diameter (cm at 1.4 m)</i>				
	< 7.5	7.5—15	15—22.5	22.5—30	> 30
Light	10 000 — 20 000	< 250	< 50	—	—
Medium	5 000 — 10 000	250 — 500	50 — 100	< 50	—
Heavy	2 000 — 5 000	> 500	> 100	> 50	> 25

Continuous forward planning can keep unproductive machine time to a minimum, especially where weather conditions and ground stability dictate the safe working limits, or where vegetation types cause problems.

A dense stand of heavy scrub along the top of the slope makes it difficult for a roller to get started and a support machine is needed to track the ridges and spurs to create access and also crush areas which are unsuitable for gravity rolling — *i.e.*, areas with slopes less than 20°.

Productivity is directly related to the way the roller is controlled on both its downward and upward movements. The controlled roller must be allowed to retain momentum down the slope and be winched up on a new track, often steered in such a way that large stems are pulled over rather than smashed down. This continuous roller and tractor repositioning requires a high degree of operator skill and concentration, particularly as the crushing of strips which have been missed because of poor control can represent considerable unproductive roller movement and an increase in time taken for the overall task.

Rope wear, and therefore costs, are an important factor of the operation and account for 3 to 5% of the operational costs under normal conditions, and up to 15% on the more abrasive sites. Standard 27 mm, 6 × 19, steel-core, logging rope is generally used. Rope life can vary from 80 ha to 300 ha for a set, with skill and care being needed to keep rope wear even along the whole length. Generally between 200 and 250 m of rope are carried on each winch spool, and used to their full reach under good conditions.

### ADVANTAGES AND DISADVANTAGES

When considering operating costs such as ropes, fuel, transport of tractors, operators, mobile servicing, and repair units (quite apart from any development, replacement, and wage costs) the contract rate per hectare is high. However, gravity rolling equipment can deal with a wide range of terrain and vegetation types. Any slope over 20° is suitable and even broken terrain does not markedly reduce productivity. It can also operate when vegetation types range from light scrub and fern to dense broadleaf scrub. Access into an area need not be more than a four-wheel drive track and only minimal contract supervision is required. With the capacity to prepare large areas, management planning can be much more efficient.

Provided a well-designed and well-built roller is used, the vegetation is crushed into short lengths and packed down in a dense layer requiring only a short 4- to 6-week curing period before burning. Under light scrub conditions a pre-planting burn may not be necessary, although the potential for a very hot burn is there. It has been found that the extra fire heat close to the ground gives prolonged freedom from weed regrowth.

Soil disturbance is minimal — the stems are crushed off at ground level rather than being pushed over, so that root systems remain in the ground.

However, in common with all mechanical systems, this equipment also has its disadvantages. Because it is most often used in poorly roaded and/or remote areas, nearly all mechanical repairs have to be carried out on-site which requires considerable mechanical skill on the part of the operator. Also, few operators in this type of work would consider working unless the standby machine is mobile, and vice versa, and so, if one machine breaks down, the other usually stops as well until repairs have been made.

Another major problem is the cost and scope of the transportation requirements — three trips are needed to get the two tractors and a big roller to the site. These fixed transport costs tend to limit the minimum area suitable for the various machines.

The biggest single problem associated with this operation is caused by the variation in the stability of the soil types during wet weather conditions. Clay country creates serious problems for traction and stability, thus the extent of the wet season often dictates the annual programme. When the conditions are right, very long days are worked and a relief operator is needed. This creates another productivity problem because of the very considerable operator-skill requirement which can be achieved only by a long training period.

## CONCLUSION

As a land-preparation technique for steep terrain, the work of gravity rollers is superior in both quality and quantity of output to the noted alternatives. The development and perfection of the equipment have been dependent on the ingenuity and perseverance of only a few owner/operators but, as a result of their skills, many thousands of hectares of otherwise unproductive country have been and will continue to be developed into commercial assets.

## R E F E R E N C E S

- Chavasse, C. G. R. (ed.), 1969. Land preparation for forestry in New Zealand. *N.Z. For. Serv., For. Res. Inst. Symp. No. 11.*
- (ed.), 1971. Mechanization of nursery production, forest establishment and tending in New Zealand. *N.Z. For. Serv., For. Res. Inst. Symp. No 13.*
- Wilson, J. L., 1969. Land clearing machines. Pp. 47-52 in Chavasse, 1969.