LAND CLEARING PROBLEMS
A Panel and Discussion

Chairman: E. H. BUNN, with G. M. O'NEILL, J. McLEAN, H. A. MILLS, G. J. MOLLOY and D. S. PREEST

The following is an abridged version of the panel discussion held on 19 May 1967, and transcribed subsequently by F. J. N. Williams.

E. H. BUNN

In opening this panel discussion, I am going to follow the example of the past by quoting a few texts. . . . First, I will refer to the Forest Service New Testament, the Annual Report of the F.R.I., 1965. It is there pointed out that "in Australia the easy terrain permits the extensive use of machines for site preparation, which by our standards is very thorough and very good. Widespread use is made of controlled burning in site preparation for planting. These are two fields where we can learn a great deal from Australia."

Now, from what Murray Goudie showed us so graphically on Wednesday afternoon, I think it is quite obvious that there is much that we can learn from Australia, and I am sure that later on he will be filling in some of the details that he has not had an opportunity to provide in his opening remarks.

The second text comes from the chapter on early tending—"in the forests the battle against weeds is increasing in intensity as forest management has to contend with steeper, rougher, weed-infested land in implementing expanded planting programmes. Inspection of past plantings on such land leaves no room for complacency. Numerous blank patches amid the green testify that too often the battle has been lost."

I think this is an important aspect. In evaluating land clearing methods, we must remember that the final result in terms of established forest is what counts, rather than just the cost of the job.

The next quotation comes from the section under rehabilitation of logged indigenous forest: "Logged indigenous forest that has reverted to a tangle of second-growth hardwoods and vines intermixed with logging debris and patches of residual forest is unquestionably one of the most expensive types of vegetation to clear in preparation for planting. Being neither scrub nor forest, but having the characteristics of both, it is an exceedingly difficult association to deal with. . . . Burning without preparatory treatment is seldom possible because of the quantity of non-inflammable leafage. Large hidden stumps and heads of trees impede tractors crushing or windrowing the secondary scrub, and the patches of residual forest preclude the use of ball-and-chain swath clearing. Clear felling is complicated by the mosaic composition and structure, and it frequently calls for a range of techniques. Special skills may be needed to deal with problems such as the felling of large, hollow, dead trees or 'combines', which must come down
because of the fire hazard they present. These obvious difficulties explain why the conversion of logged forest has been avoided when alternative land was available.” That is by way of an excuse for our neglect in the past.

The last text I would refer to comes from the Forest Service Old Testament (the Annual Report of the Forest Service, 1966). Again under the section on logged indigenous forest, “More and more attention is being paid to the problem of restoring to productivity areas of logged indigenous forest where there is little prospect of growing commercial crops of indigenous species. Land clearing is, of course, a basic difficulty.

“Properly used, fire is an invaluable tool in this type of operation, but mechanical methods of clearing have also given good results. No single method is universally applicable and improvements in technique are continually being sought. In areas where secondary growth and heavy scrub have developed since logging, treatment over a period of years is often necessary to bring the vegetation to a manageable state.”

Now, as I see it, the main task of this panel discussion is to try to quantify, or qualify, some of the statements we have just heard. In what circumstances and conditions have mechanical methods of clearing given good results? In what way do we need to improve our techniques for the various aspects that were mentioned in the quotations. . . .

Introducing the speakers: to begin with we have Mick O'Neill, who will consider the scope of machinery in land clearing and briefly state some of the forester’s requirements; Jim McLean will briefly describe the methods and machines used for clearing scrub; Allen Mills will outline methods and machines used for clearing cutover forest; Gavin Molloy will give an account of felling and burning problems, and Dave Preest will cover the scope for chemical desiccants in land clearing.

G. M. O’NEILL

First of all, what are we trying to do when we prepare land for planting? We are trying to get the land cleared as cheaply as we can to enable us to get maximum stocking of exotics; and we are also trying to prepare the land in such a fashion that subsequent operations, such as release cutting, are reduced to a minimum.

The next thing to consider is where we can use mechanical means of preparing the land. I consider that mechanical methods are very much a last resort in scrub or cutover bush because they are costly. We should be using fire wherever we can; but in many cases machines prepare land for burning. There are obvious limitations as to where and how machinery can be used. Topography is the first limitation. You cannot use tractors on very steep country. From our experience, slopes in excess of 15° to 20° are getting too tough for tractors to work on — but much of our forest country is on slopes of 15° plus. The second limitation would be drainage — on the West Coast the water-table is about six inches above the ground. There are obvious limitations there! Another limitation is the soil type — in Southland peat may limit the use of heavy machines. The free-draining pumice-lands are of course
no real problem, but parts of the Mamaku Plateau are fairly difficult. The fourth limitation is the type of cover, since machines can only operate where it is relatively light. The heaviest of cover cannot be tackled without special equipment.

A major concern is the type of vegetation. What has got to be knocked down to get it into a burnable condition? The simplest and easiest, of course, is grass and light scrub on easy country. The normal type of preparation here involves discing, which is very cheap. Forest Products have done a good deal of this and, I understand, have got very good results. Sometimes we need to use heavy equipment for deep-ripping to break up pans. I think Peter Olsen did this in Kaingaroa and there has been a good deal done in Eyrewell Forest. This is normally no great problem as formations are usually found on easy country.

Medium cover (manuka or second growth, about twenty to thirty feet high) can be flattened by tractors with some sort of ancillary equipment in preparation for burning. Timing is important, there being an optimum time for the operation, depending on the size of the material and the (expected) time of burning.

The greatest problem is the preparation of cutover forest. The forester recognizes two broad categories of cutover: areas that have just been logged, and areas that have been logged and have since reverted to a fairly heavy cover of second-growth scrub. Normally there is a fairly substantial amount of secondary, non-merchantable, hardwoods left in the area. In the first case the obvious method is to burn, which can be done without preparation, as has been done in Southland with tremendous success. In some cases, however, preparation is needed.

In areas logged in the last five years much work has been done using machines and a fair measure of success has been achieved, but the obvious weakness with this method is that at least 10 to 20% of the area is left non-productive.

In old logged areas the second growth prevents burning. We are forced into using heavy equipment and here we are facing tremendous difficulties. The accumulation of these areas over the years has left us with an enormous back-log to catch up on.

Mr Goudie showed us with his slides that the standard of preparation in Australia was terrific—it was probably too high. Generally, we seem to have based our practices on what the agriculturists do. They have to clear an area and sow it, so they windrow the material. I do not think this is necessary in clearing cutover forest. The ideal is to do the minimum amount of shifting material and the maximum amount of uprooting. I think the idea should be to have small piles of material scattered over the area indiscriminately. We should not try to get total clearance but should try to get the second-growth scrub and the bigger trees out of the ground to enable the planters to get through. We should also try to leave the ground in such a condition that we would not get competition from regrowth and second-growth scrub. There have been some good results using windrowing, but we still have long strips of what could be called “sterile” country on which we cannot grow anything. That is why I advocate the small piles and the minimum of carrying. If these piles of slash are going to be burned, we should obviously use root rakes instead of the ordinary tractor blade. We do not want to remove the topsoil and reduce what
fertility there is on the site, and also we do not want to push a lot of rubbish into piles we cannot burn.

Another factor to consider is the varying types of cutover. It is not possible to apply any one method universally. In the very heavy stands at Minginui, exceeding 20,000 cu. ft/acre, when you have logged the area there is not a great deal left; whereas in parts of Southland there is a tremendous growth of secondary hardwoods such as kamahi, which poses a completely different problem. We have to take each case on its merits and the type of cutover is going to influence the selection of the type of tractor and the ancillary gear behind it.

J. McLEAN

The method and degree of clearing depend on the intended use of the land. If the first operation is done to the required standard development work becomes much easier.

The main factors in deciding what machines to use are the availability of plant, contour, rainfall and the cover itself. Different methods include crushing with roller, crushing with tractor and blade, crushing with ball and chain, windrowing, or pushing into gullies and hand-cutting.

Crushing by roller reduces the cover to a condition when it can be burnt, but at a cost of $3.50 to $4.00 per acre this method should only be used where the cover would not readily take a burn. The roller is also limited to relatively flat land.

The tractor and blade is used extensively on heavier scrub or on steeper land where a roller cannot be used. The cost of this method is around $14.00 per acre.

As O'Neill pointed out, a root rake is often much more effective than a blade for getting a fire through the resultant heaps.

The ball and chain method, although not used to a great extent in this country, has been used in the Rotorua district mainly on pine trees and scrub. The results on scrub were generally not good. The object is to pull the material down but if the material is too small there is a tendency for the chain to ride over it. On pine trees, however, the method is most effective.

Windrowing and pushing into gullies is used more extensively in the south than in the north and the D7E type tractor has proved to be a very useful machine for this operation because of its quick reversing.

Handcutting costs $14.00 to $20.00 per acre, and the advent of the portable circular saw has not appeared to reduce this.

H. A. MILLS

Tractors and blades or tractors and rollers have given good results where cover is not too heavy and dense. Tractor and root rake is the ideal system under certain conditions, particularly where the cover is very heavy. I favour a root rake with detachable tines — where the soil is cohesive and inclined to pick up with the slash as it is windrowed it is better to remove every other tine, to give a spacing of 18 in. apart. Such a rake produces a very clean windrow. I do not agree with Mr O'Neill that windrowing results in a large sterile area. If care is taken and the correct
methods are used, a very clean burn can be obtained, which practically eliminates the windrow.

The stinger, which works on a system of high leverage, can only be used to advantage in bowling over large or stubborn trees with a large root system. The resultant mess is not good and leaves the area like a battle field. I favour felling these trees with a power saw and leaving the stumps.

Using two tractors and a heavy chain is a very effective and cheap way of dealing with scrub in country that is easily contoured, provided the scrub is not too whippy. With this method we have cut the cost to around $2.00 per acre.

I agree with Mr McLean that the application of the ball and chain method is limited to self-seeded pine areas where the topography is not too steep and where there are no cut stumps to foul the equipment. In heavy bush the ball does not produce sufficient leverage to pull over the large trees. A bridle of two inch wire rope well ahead of the ball and chain can overcome this problem by riding up the trees and providing additional leverage.

Under certain conditions power-saws and slashers are more effective than heavy machinery. This applies in very steep country, or alternatively where the soil limits the use of tractors. Tarawera ash is an example of this.

The best way to tackle cutover bush is either within a year of milling or after 15 to 20 years have elapsed. The resultant second growth is dense but still comparatively light and it is possible to get a good clean windrow that will burn, even though it is green. The heavy slash and tree heads left from the earlier milling have now decayed so that machinery can effectively crush them while tackling the second-growth bush. I do not agree with the comment that windrowing up to five chains apart is economic. Two or two-and-a-half chains is the maximum economic distance between rows. At wider spacing the bulldozer tends to slow up towards the end of a long push, building up costs. I am also very much in favour of using two machines in clearing heavy land, one being available to help the other should it get into trouble. In my opinion burning, whether it be of windrows or heaps, should always be done in the height of the fire season. I am very strong on this one.

In land clearing I favour being fussy. The first cost is thus the last cost. While it does load the cost of the first crop, over several rotations this is surely an advantage.

Regarding costs: on very easy country, using ball and chain or a quick run-over with the blade, we can do it for $2.00 to $10.00 per acre. In medium to heavy cover, with slightly tighter contours, we find costs about $12.00 to $24.00 per acre. In really difficult country, costs range between $24.00 and $30.00 per acre, but this can be improved on.

G. J. MOLLOY

Under Westland’s rainfall conditions, the first essential for good exotic forest establishment is that sites be well drained. The only sites we have available that are well drained and suitable for planting exotics are the steep slopes fronting the coastal plain. These slopes range up to 45°, are dissected by guts and drop-overs,
and are generally unsuitable for machine clearing—with the exception of outwash slopes fronting these hills and the toes of spurs. The cost of transporting machines into these localized areas of one to five acres would be prohibitive. We have found from experience that the main areas, the hillside slopes, can be felled economically by using chainsaws. Some 9,000 acres have been cleared in Westland since 1957 in this way, and over the last few years we have stepped up the rate to around 2,500 acres per annum. Two private companies have come in this last year, and are also felling hillside cutover for later exotic establishment.

We have found that costs range from $10.00 to $24.00 per acre on sites that have been recently logged. On country logged more than five years ago, where we are running into the second-growth problem the cost can rise to $36.00 per acre.

Logging is such a useful tool in clearing that we should be using or regulating it to suit the requirements of conversion. Unlike Olsen, who put in a plea for sophistication, I would go along with Crequer’s thinking and put in a plea for “controlled vandalism”. If the logger will devastate as much of his area as possible during logging, it makes our subsequent task so much easier. We would specify or encourage a skyline system of logging, rather than a high-lead system. With the former you can devastate up to 70% of the residual non-merchantable cover, whereas with the latter you can devastate only 20% to 50%. We are keeping our clearing right up behind logging. I would go so far as to say that we should keep the period between felling and burning down to about two years. After that we would start running into a second-growth problem.

In Westland burning is our biggest difficulty. Under our climatic conditions we might be favoured with three spells, or fewer, of fine weather per year, and the period during which it is suitable to burn might be from one to three days. As an index I consider that it is suitable to burn when I can sit down in the scrub under a canopy and get up dry. When we get humidities down to 50% and lower, temperatures climbing up over 70° and wind coming in force two, three or four, then conditions are right in Westland.

We still have a lot of work to do on the problem of lighting-up. We could use napalm or controlled-delay fuses to get a sequence of lighting-up. Cutting access routes enables people to get in and light-up and then get out quickly if they have to. We have problems with second growth where we have to defer burning and here we have used desiccants successfully during this last year.

D. S. PREEST

It would be generally agreed that, where ground conditions permit, the use of tractors and allied equipment give the best value for money and some hope of attaining the sort of land clearing acreage targets we are looking for. However, on wetter or steeper country the main drawback with manual felling is the small acreages that can be covered with the labour available for this work. We have therefore looked at the aerial application of desiccants primarily as a means of dealing with the vegetation in this latter type of situation.
It is now 10 to 12 years since aerial application of chemical desiccants was commenced in this country. Those used initially included contact weedicides such as sodium arsenite, sodium chlorate/borate, diquat, PCP and the phenoxy “hormone” weedicide 2,4,5-T. These were all applied in water at volumes between 25 and 70 gal per acre. Because of their relatively ephemeral effect, the contact desiccants were dropped from further testing in favour of the slower acting systemic weedicide 2,4,5-T and mixtures of 2,4,5-T and 2,4-D, first in water and later in diesel oil carriers. Diesel is clearly the more effective carrier, although fortification of a water carrier with surfactant and a small quantity of diesel oil can greatly improve its effectiveness.

The speed of action of 2,4,5-T and 2,4-D is very variable, depending on the species. The desiccation of some important second-growth elements, five finger for instance, is so slow that by the time they are dry enough to burn the foliage has been lost from the more easily desiccated species. Furthermore, these chemicals have little significant effect on most ferns, including bracken and tree ferns. This has led to the recent trial use of contact weedicides (such as sodium chlorate/borate, ammonium sulphamate and paraquat) in mixture with the slower-acting 2,4,5-T or 2,4,5-T/2,4-D mixture.

Fixed-wing aircraft capable of operating from nearby topdressing strips with loads of 100 to 200 gal are most commonly used for application. Because helicopters are relatively few in number, and are much more costly to run, they have had only limited use so far. They have a capacity of 50 to 100 gal and usually operate from a landing pad adjacent to the spraying area. Helicopter application usually costs about twice as much as application by fixed-wing aircraft. The price advantage of a fixed-wing aircraft largely disappears if the distance between landing-strip and target exceeds 3½ to 4 miles.

Boom and nozzle equipment is commonly used and probably gives the most satisfactory overall results in terms of uniformity of coverage and penetration. “Swathmaster” equipment is sometimes employed on fixed-wing aircraft and, although it is claimed to give better penetration, it gives far less uniform coverage than boom and nozzle. Rotary atomizers have lately been used for desiccation trials but proved unsatisfactory for small areas (10 ac) because of the excessive drift off the target. This could be less important where larger tracts are being treated, but wind conditions would be much more critical with this type of equipment.

Other methods include the use of high volume ground application with pump and tanker units, and back-pack mistblowers. Large capacity, tractor-mounted or tractor-drawn mistblowers (e.g., “Rotogas”), capable of fairly uniform coverage for distances up to 55 or 60 ft are used in the United States and would seem to have potential uses on easier terrain in this country. The advantage of such ground-based equipment is that its use is much more independent of the weather than is the case with aircraft.

Provided application is made at the right time in relation to growth, present single-shot aerial desiccant treatments of relatively short vegetation (such as gorse, broom and lupin) with 2,4,5-T or 2,4,5-T/2,4-D type mixtures in 20 to 30 gal water per acre...
can be regarded as fairly satisfactory. Likewise, adequate results are being obtained with mixtures of sodium chlorate/borate and 2,4,5-T or 2,4,5-T/2,4-D in water on three- to four-year-old mixed hardwood and fern regrowth in reverting, clearfelled areas which have missed a burn. The relative shortness of the regrowth, the fact that it has not closed canopy, and the exposure of most of the constituents to the spray are the important factors in obtaining a high proportion of desiccated material.

When, however, we come to multi-storied vegetation, such as old indigenous second growth, dense residual forest, or old reverted cutover, the probability of getting a burn following a one-shot aerial treatment becomes more remote. The main problem is that the great bulk of the chemical applied (80% or more) is intercepted by the uppermost canopy, so that the tiers which are important in providing much of the fuel for a ground fire are relatively little affected. While desiccation of the upper canopy foliage may be rapid, the branches and even the twigs can remain green for months after the leaves have fallen. As we seldom, if ever, have the fuel and climatic conditions conducive to the development of crown fires, we must rely almost solely on the thin irregular carpet of leaves that fall from the desiccated upper canopy, in the often forlorn hope of obtaining a creeping ground fire before they rot away under the moist floor conditions maintained by the largely intact lower tiers. When, as is often the case, the burn fails or is patchy, the now exposed lower tiers are released and enlivened, new seedlings flourish and a rapid development of coppice and epicormic shoots occurs on some of the upper canopy species—so that in terms of inflammability the latter condition may, in a short time, be worse than the former.

When we consider the total amount of material being applied per acre, it is evident that the chemicals now being used are amazingly active. In fact, the amounts being applied in some instances are probably sufficient to desiccate or even kill the whole of a multi-storied vegetation complex, if proper penetration and coverage could be achieved. Increasing the amount of chemical, or the volume of carrier, does not lead to an increase in desiccation or kill commensurate with the extra cost involved.

It has become evident that, for the taller, more complex, multi-storied types of vegetation with which we are having to deal increasingly, the single-shot aerial application has failed to give the desiccation in depth that is needed. It is suggested that in future trial work we should adopt a piecemeal approach with repeat or supplementary treatments aimed at attacking different components of the vegetation. Obviously, multiple treatments such as those suggested will cost much more than the single aerial treatments tried so far—perhaps three times as much—but the cost could be justified in view of the high cost of alternative methods, their inability to cope with the scale of land clearing required and the end results achieved. Also they have the important advantage that they leave the soil intact. So often with mechanical methods the topsoil disappears or is displaced on to sites where trees cannot be planted and the resultant crop growth is very much poorer.
Bunn: I think we should examine the criteria to be adopted in deciding whether machines or felling is the better approach to the job.

Beveridge: The results we saw at Mamaku obviously improved with increase in slope. The flat areas are the toughest of all to do. I agree with most things that Dave Preest said on chemical desiccation, but I do not know what application it is going to have to standing forest. Generally they can be used on regrowth where you fail to get an initial burn.

When I was in Queensland several years ago, I found that they had abandoned stingers. In an area which is fairly steep, they used to clear by tractor, but are now hand clearing because of problems such as the stoniness of the ground.

Goudie: The problems we are facing are those of a large-scale operation and, while I am sure that in some circumstances hand-clearing methods would be cheaper, we just have not got the labour. Secondly, we are trying to look well ahead with our operations and are anticipating a shortage of labour through tending and thinning, and ultimately harvesting. We believe that the extra money spent at the time of clearing will be recovered in subsequent operations. I think this is borne out in our planting costs alone.

I disagree with not using tree-pushers. They are no particular disadvantage to put on the blade of a tractor. Where we are doing a 100% clearing we are getting those few big trees, which can cost $4.00 to $6.00 per acre if you cannot push them over in one hit.

Regarding terrain — I think some hand felling on steep country is a good method, if you are satisfied that a good burn is possible. I could not imagine us 100% hand felling the sort of country we saw yesterday. We have not got the labour. I think hand felling of the bigger trees, with sufficient of the bigger scrub to start a burn, is well worth looking at in freshly cutover areas.

I also think all methods of clearing vegetation must be employed sooner or later. We tend to use our equipment in situations where other methods might possibly be more economical. Our object is to get 2,000 machine-hours per machine per annum. This, with an early replacement policy, and large scale of operations, brings the unit cost of our machines down to a fairly low level.

Chavasse: I think the panel might have slid past the real problem on very steep country with heavy cover. In spite of the great efficiency of Gavin Molloy and his boys, manpower on this job is fairly costly — he quotes figures of 2 to 3 man-days per acre. He has, however, pointed the way to a possible solution. In fact, vandals do a lot of the work with logs on ropes. It does seem to me that there is a case for some type of special machinery. Forget about the tractor, which is eliminated by the slope — but it might be a hauler with a steel beam or ball. I feel that hand clearing does not necessarily give a good fuel for burning; whereas any heavy bar, ball or machinery cracks up the crowns of the trees and concentrates them in suitable conditions for burning.

Mr Goudie's contour tracks have been at close intervals for tractors, but I think with a hauler type it would be a question of contour tracks 20 to 25 chains apart. This would be a considerable saving.
Mills: I think you are still limited by the natural contours. We have found machines with a heavy chain very effective on very long steep slopes where there is a flat below and a natural ridge on the top, with one machine on each level. Variation of contours does, however, produce problems.

Molloy: In Westland State forests, where the sawmiller is working on steep country that we think is suitable for exotic conversion, we will write into the licence conditions making it mandatory for the sawmiller to fell all the residual cover on his area. We make compensating reductions in the upset value of stumpage to allow for this. The sawmillers will concentrate on trying to knock over as much of the non-merchantable cover during logging as possible as this will reduce their costs..., for subsequent hand clearing.

Skudder: Talking of scrub, rather than of second growth, I do not think we do enough "advance burning", particularly in areas where the fern will come back. If you pick the good burning years you could "advance burn" where the fern would come back fairly well and then you could reburn. This also helps your releasing problem with the regrowth of fern. I do not think we make enough use of this method.

Mills: I think there is a lot of merit in pre-burning, and I have seen it very effectively applied in the very whippy type of scrub. After a year it has become very brittle and can be dealt with by the heavy chain.

Conway: We have heard a lot about the loss of area resulting from sterilization due to windrows. I think we can take the point that Mr Olsen made yesterday by keeping windrows narrow, in order not to lose area or productivity. If we keep our windrows down to 16 or 20ft wide there will be many internal margins, and therefore our trees will grow better on the edge of the stand. With this kind of improvement we could possibly end up with greater productivity.

Barr: I still think it is essential to do something about the under-scrub that we have in forests like the Mamaku. No amount of crushing or raking will kill the underscrub, which could be such a great help in carrying a fire through and getting a good burn. I personally favour the hand approach to this problem, and I think that men will be available. The axemen are not here but there are plenty of young blokes who would like to get on the end of a chainsaw. This is exemplified in North Auckland where large areas of scrub are being cleared by these chaps in the off-season. I do not think the machines leave a good base for planting, but the manual approach to underscrubbing and perhaps the use of livestock should be looked at more seriously.

Cameron: One small but important matter that has been passed over is the fact that in many of these old cutover areas there is a residual stocking of merchantable timber. The problem is whether to attempt to remove this, or whether conversion can be made compatible with the salvage operation. At Slopedown salvage was used as a means of reducing conversion costs.
**Bunn:** Enrichment planting possibly has a place where the remaining crop has a potential value. We did some trials testing this at Mamaku about 1960-61. The results of the plantings are still inconclusive, but the simplest method was to go through where there was a considerable overstorey left, crushing narrow lanes with a tractor and planting with a shade-tolerant species at 275 trees per acre. This cost around $12.00 per acre, using a TD18. Another method was to clear groups, linked by crushed lines, but to plant only the small clearings at around 200 trees per acre. This cost almost $14.00 per acre. Wider parallel cleared lanes at 300 trees per acre cost $18.00 and total clearing with windrowing of debris cost $34.00 to establish 940 trees per acre.

I think it is a matter of the relative value of the residual crop and of assessing how much you can afford to spend on site preparation.

By and large, partial clearing and planting operations have not been as successful as we had hoped. Only in circumstances where the residual crop does have a value can you contemplate doing it.

**Beveridge:** In the high rainfall areas, if you are felling and burning, I think it is absolutely essential that every stem be cut. There are a lot of examples where farmers have been clearing recently on the Mamaku plateau and have got a very poor burn. It has been shown that you can actually cut everything, including the vines, with a power saw and I think this is absolutely essential.

I wonder if our engineers are really satisfied with the design of the root rake. One I saw yesterday had a lot of close tines about a foot high and they would have made a worse job than a blade would have.

**Preest:** At the moment we are involved in planting around 30,000 acres per year. We are being forced on to steeper country all the time. Can anybody give any indication of how long tractor-type country will last? Is the majority of the 30,000 acres in fifteen years' time going to be non-tractor country? If that is the case, this is the field we should be looking at. Will hand methods cope with such a large area?

**Bunn:** The proportion of non-tractor country is increasing and this is why so much attention has been paid to the use of desiccants and other alternative methods.

In summarizing, I think the first and most obvious conclusion we can draw is that there is still plenty of scope for improvement in our methods. As far as the quality of the job is concerned, we have only to look across the Tasman and see what is going on in Australia.

Another important point is that we should not evaluate clearing methods as a separate entity. We must look at the whole, including planting costs and access—as was very well brought out by Murray Goudie when he said that their planting costs had been halved and their access had been improved considerably.

Scrub clearing methods do not appear to have changed radically. On easy grass and scrub country there is probably more scope for cultivation than there has been in the past.

The consensus of opinion on clearing of logged indigenous forest
is that the sooner it is done the better. There is no merit in allowing logged cutover to revert if you are wanting to re-establish it or convert it to exotic conifers. Where areas have been allowed to revert there is possibly some merit in allowing a delay.

Felling with light power-saws and burning is likely to remain the main method of clearing on steep hill country in the foreseeable future. With all due respect to APM's bench roading and clearing by machine, our broken hill country does not lend itself to this method.

In high rainfall districts, the critical factor is going to be creating good conditions for burning. We will have to look at modern aids for burning, which may possibly allow burning in sub-optimal conditions.

There has been a tendency to regard desiccants as the "maid of all work" of site preparation, especially as a one-shot application. This is not correct, but it does appear that they are still a useful tool. Perhaps two applications will enable us to use desiccants more effectively than we have in the past.