CONVERSION OF FIRE-REGENERATED PINUS PINASTER TO PINUS RADIATA

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SYNOPSIS

This paper describes the conversion of a dense stocking of unmerchandable fire-regenerated Pinus pinaster to Pinus radiata. This stand resulted from the 1946 fire which destroyed the majority of Tahorakuri Block owned by N.Z. Forest Products Ltd. It covers the establishment and brief history of the 1946 fire, and details the resultant stocking. It explains the machine crushing and the preparation for burning. The method, description and results of burn are given, and the aerial sowing of the area after the burn is described.

INTRODUCTION

(1) Original Establishment: Tahorakuri Block was originally planted in 1931 and 1932. The gross area of the Block is 29,140 acres and was made up of the following species:

<table>
<thead>
<tr>
<th>Species</th>
<th>acres</th>
</tr>
</thead>
<tbody>
<tr>
<td>P. radiata</td>
<td>15,992</td>
</tr>
<tr>
<td>P. ponderosa</td>
<td>8,229</td>
</tr>
<tr>
<td>P. pinaster</td>
<td>2,961</td>
</tr>
<tr>
<td>Ps. taxifolia</td>
<td>304</td>
</tr>
<tr>
<td>Firebreaks, roads, etc.</td>
<td>1,654</td>
</tr>
<tr>
<td>Gross forest area</td>
<td>29,140</td>
</tr>
</tbody>
</table>

Pinus radiata and Ps. taxifolia were planted on Site Classes I and II where sufficient air drainage minimized frost damage, P. pinaster on Site Class II and IIIa where moderate frost damage occurred, and P. ponderosa was restricted to Site Classes IIIb and c, where severe frost damage was likely to occur.

(2) The 1946 Fire: A prolonged dry period occurred during December 1945 and January-February 1946. This resulted in an outbreak of serious fires throughout the Rotorua-Taupo area during February 1946. These fires burned unchecked in many areas, particularly in native cutover, until the beginning of March when heavy rain relieved the situation.

The fire which destroyed Tahorakuri Block and part of Afforestation Pty Ltd Block, had its origin in the vicinity of the Wairakei Hotel. Heavy scrub areas surrounded the hotel and bordered the forests mentioned above.

The fire burned in a north-easterly direction from the hotel on the southern side of the Waikato River. Unsuccessful attempts were made to check the fire at this stage but it crossed into Afforestation Pty Ltd's area and a wind change to the south-east caused the fire to jump the river from the Afforestation Pty Ltd Block and points further west into Tahorakuri Block, at approximately 2 p.m. on 9 February.

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Back-burning from the north side of the river and also from No. 5 Highway was considered, but was abandoned owing to the wind force and lack of manpower. By 7 p.m., that is, five hours after the first outbreak had been reported in the block, the fire, forced along by a gale force wind, had reached and jumped No. 5 Highway. Any attempts to control the fire at this stage were given up, the block was abandoned, and all manpower was withdrawn to fight fires which were threatening other areas.

Ground and aerial inspections immediately following the fire gave the approximate losses in acres as follows:

<table>
<thead>
<tr>
<th>Species</th>
<th>Intact</th>
<th>Partly Destroyed</th>
<th>Destroyed</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>P. radiata</td>
<td></td>
<td>400</td>
<td>15,592</td>
<td>15,922</td>
</tr>
<tr>
<td>P. ponderosa</td>
<td></td>
<td>1,030</td>
<td>7,193</td>
<td>8,223</td>
</tr>
<tr>
<td>P. pinaster</td>
<td></td>
<td></td>
<td>2,957</td>
<td>2,957</td>
</tr>
<tr>
<td>Ps. taxifolia</td>
<td>50</td>
<td></td>
<td>254</td>
<td>304</td>
</tr>
</tbody>
</table>

The above figures were only approximate as aerial photographs were not available for this assessment.

(3) Natural Regeneration: Many suggestions were considered as to what should be done with this large area of blackened forest. Eventually, through lack of finance, labour and suitable outlets for the salvage of the burnt timber, the devastated area was left to nature.

The resultant natural regeneration from two earlier fires in 1938 and 1942 indicated that the same result would occur in Tahorakuri.

In May 1947 a report by a consultant forester included the following comments:

“P. radiata regeneration generally ample; rather thin in some parts; on hill areas may have to fight with fern.”

“P. pinaster regeneration abundant throughout”

“Douglas fir regeneration sparse, and not likely to produce and adequate stocking.”

P. ponderosa regeneration nil.”

A revised schedule of species by areas was drawn up in 1962, based on information from recent aerial photographs and ground surveys.

<table>
<thead>
<tr>
<th>Species</th>
<th>Acres</th>
</tr>
</thead>
<tbody>
<tr>
<td>P. radiata first crop</td>
<td>2,076</td>
</tr>
<tr>
<td>P. radiata 1942 fire regen.</td>
<td>250</td>
</tr>
<tr>
<td>P. radiata 1946 fire regen.</td>
<td>17,104</td>
</tr>
<tr>
<td>P. pinaster first crop</td>
<td>208</td>
</tr>
<tr>
<td>P. pinaster 1946 fire regen.</td>
<td>2,377</td>
</tr>
<tr>
<td>P. ponderosa first crop and open spaces</td>
<td>6,810</td>
</tr>
<tr>
<td>Ps. taxifolia first crop</td>
<td>56</td>
</tr>
<tr>
<td>Depot and post yards</td>
<td>59</td>
</tr>
</tbody>
</table>

Gross forest area 29,140 acres

This assessment indicates that P. radiata has encroached into areas formerly occupied by other species and that much of the P. ponderosa which was considered earlier to have been destroyed, was in fact only scorched by ground fires.
Throughout the majority of the P. pinaster regeneration, scattered dominant P. radiata occurs, in some areas up to 70 and more stems per acre. Where a sufficient stocking of good form P. radiata occurs, the understorey of P. pinaster regeneration has been crushed and the area treated as P. radiata.

**CONVERSION OF PINUS PINASTER REGENERATION**

In March 1963, an assessment of P. pinaster fire regeneration was made to estimate standing merchantable volume and note stand conditions. All live stems were counted and measured. Figures quoted are on a per acre basis, from three ¼-acre plots.

<table>
<thead>
<tr>
<th>Category</th>
<th>Volume Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total S.P.A.</td>
<td>3,880</td>
</tr>
<tr>
<td>S.P.A. &lt;4.1 in. d.b.h.</td>
<td>1,690</td>
</tr>
<tr>
<td>Total B.A.</td>
<td>390</td>
</tr>
<tr>
<td>B.A. &lt;4.1 in. d.b.h.</td>
<td>270</td>
</tr>
<tr>
<td>Total stem vol.</td>
<td>6,550</td>
</tr>
<tr>
<td>Vol. to 4 in. top</td>
<td>2,350</td>
</tr>
</tbody>
</table>

In addition, two of the three plots had P. radiata amounting to 20 s.p.a. containing 24 sq. ft B.A. and 528 cu. ft volume.

Lack of suitable markets precluded the harvesting of any merchantable material and it was decided to crush and possibly burn and convert to P. radiata.

(1) **Preliminary Trials:** In April 1963, a trial of 8 acres was crushed by an Allis-Chalmers HD16 tractor then engaged in “crush-thinning” P. radiata fire regeneration.

This tractor had an 8 ft bar mounted on the front about 2 ft 6 in. from the ground. This tractor did the job very easily and no difficulties were encountered.

Windrowing of the crushed material had been considered; however the depth of the debris was 3 to 4 ft and windrowing could only have been done at an excessive cost.

A small area of about an acre was crush-thinned with this tractor in the same manner as the P. radiata. This thinning trial proved unsuccessful, as it was difficult to leave individual trees of good form while crushing the surrounding dense stand. The residual trees, freed from their dense support, were affected by wind and both wind-break and wind-blow occurred.

The trial area was successfully burnt the following January, nine months after crushing.

This trial area was planted the following winter using both 1/0 and 2/0 P. radiata stock. Some difficulty was experienced in the actual planting owing to the unburnt logs, but this problem was not insurmountable.

The planted area has been successfully established, with no competition from any P. pinaster regeneration, indicating that any seed shed by the crushed P. pinaster was destroyed by the fire. The only vegetation occurring two years after this burn are annuals, which are neither suppressing nor likely to suppress the P. radiata seedlings. Access through the area has improved over the past two years owing to the gradual settling down of the burnt debris.
PLAN OF TAHORAKURI BLOCK SHOWING LOCATION OF BURN

SCALE = 1 MILE TO AN INCH
A small-scale seeding trial was laid out in this burnt area. Four plots of 20 seeds each produced only 6 seedlings 36 days after seeding; all other seeds were removed or eaten, mainly by mice. About ¼ acre was broadcast by hand with treated seed and again very few seedlings resulted.

Similar small-scale trials in two other burnt areas gave the same results.

The indication from these three trials was that the seeding of a small burnt area would fail as a result of seed predators.

(2) Description of the Areas Crushed: The majority of the areas crushed were flat to undulating and presented no difficulty to the tractor to crush in any direction. Narrow, steep-sided gullies which occur frequently in pumice areas and in particular adjacent to Taupo, were present only in a small area in Block 5. As this portion of Block 5 had remnant patches of first crop *P. pinaster* on it, which were felled with chainsaws, no tractor problems arose.

The tree cover in Blocks 1 to 4 consisted of dense *P. pinaster* regeneration with scattered dominant *P. radiata* ranging in density from nil to up to 50 or 60 stems per acre. The dense stockings of *P. radiata* occurred adjacent to the original radiata areas. Approximately 10 to 15% of the original *P. pinaster* in this area had been taken over by *P. radiata* fire regeneration.

About 40 acres of the denser stocked *P. radiata* areas in isolated blocks had been clearfelled and utilized for fencing material prior to the crushing.

Block 5 consisted of a similar mixture, as above, with about 20 acres of first crop *P. pinaster* situated in the south-western corner of the block.

Block 5a consisted mainly of partly burnt *P. ponderosa* with large gaps carrying manuka (*Leptospermum* spp.) scrub and monoao (*Dracophyllum* spp.) where the original *P. ponderosa* had been destroyed by the fire.

Block 6 situated south of No. 5 Highway consisted of a mixture of *P. pinaster* and *P. radiata* with the *P. radiata* stocking varying considerably. Nearer the highway, almost pure *P. radiata* occurred. This area was clearfelled and utilized for fencing material. This block was surrounded on three sides by an area planted to *P. contorta* in 1963 which had originally carried *P. ponderosa*. The *P. ponderosa* had been completely destroyed by the fire and had reverted to tussock and monoao.

Block 7 consisted of almost pure *P. pinaster* regeneration, first crop *P. pinaster*, partly destroyed *P. ponderosa* with manuka and monoao patches scattered throughout, and a strip of fire-scarred first crop *P. radiata* adjacent to one boundary.

(3) Machine Crushing: In February 1965, the crushing of Blocks 4 and 5 was commenced, using a Caterpillar D7E previously engaged in "crush-thinning". This tractor was equipped with a straight 8 ft bar made up in the form of a box from two pieces of 8 in. angle iron. Serrated steel teeth were welded at each end of this bar to prevent the stems sliding outwards while being pushed over.

This "bumper" bar was attached to the tractor by four bolts and could be attached and detached quite readily. The winch blocks for the cable-controlled blade were removed as any pro-
jecting equipment on the tractor was liable to be damaged during the operation.

The crush-thinning of *P. radiata* had demonstrated the necessity of heavily guarding the driver and vulnerable parts of the tractor, being forced in between the grilles on either side of the machine. No serious accidents occurred from this cause either in the *P. radiata* crush thinning or the *P. pinaster* crushing. The heavy guarding of the tractor restricted the driver’s forward vision considerably and there was no vertical vision at all.

The main danger associated with this operation was the ever-present risk of fire, originating from the tractor itself or from the exhaust. One tractor had been damaged by fire shortly after crush-thinning commenced, but fortunately had not started a
forest fire. This fire was caused by dry material collecting around the manifold and eventually igniting. Because of this experience the contractors engaged on this work regularly cleaned their machines twice daily and at least twice a week stripped the guards off and cleaned out the sumps, etc., with compressed air. The exhaust pipes were extended up through the canopy and then turned at right-angles towards the rear of the machine. On several occasions needles and cones collecting on top of the canopy were ignited by red-hot carbon from the exhaust. On these occasions only the vigilance of the driver who noticed burning cones on the ground behind the tractor prevented a fire from starting in the crushed material.

To minimize this fire risk, crushing was stopped during the period November to March unless weather conditions had reduced the fire risk.
(4) Method of Crushing: The method of crushing was to start on the perimeter of a block, and completely encircle it with an 8 ft strip. From the perimeter the tractor would work inwards, covering an 8 ft swath each round, as is done in most agricultural work. This method ensured that the majority of the material from the previously crushed strip was lying away from the tractor in the same direction as the tractor was moving. This minimized the danger to the driver and the machine from broken material.

The main essential in crushing this type of stand is to keep the machine moving. To this end, therefore, when the much larger scattered dominant *P. radiata* were encountered they were left standing and pushed over at a later date.

The crushing of this material proved to be easier than the “crush-thinning” of *P. radiata* as the individual stem size was much smaller and the larger amount of green material had a cushioning effect for the tractor. Far less mechanical breakage occurred in the *P. pinaster*, when compared with the *P. radiata* “crush-thinning”.

Portions of Blocks 4 and 5 were crushed during February and March 1965. The remaining blocks were crushed in the following order: April — the remainder of Block 4 and most of Block 5; May — Block 3 and portion of Block 1; June — remainder Block 1 and Block 2; July and August, Block 7. Block 6 was commenced in July and completed in November 1965, after all merchantable radiata pine had been removed.

Approximately 70 acres of first crop *P. pinaster* in Blocks 5 and 7 and a strip of first crop *P. radiata* in Block 7 were cut by power saw, after the fire-regenerated *P. pinaster* had been crushed. It was considered to be more economical to fell these by hand than attempt to push them over with the tractor. This work was carried out during September and October.

Following a mechanical overhaul to the tractor during September, a bull blade was fitted to the tractor to enable the dominant *P. radiata* to be pushed over. This work was done in conjunction with the firebreak preparation, block by block, and was completed by mid-December for the entire area to be burnt.

THE BURN-OFF

(1) Firebreak Preparation: Blocks 1 to 5 are bounded on the western and northern sides by crush-thinned *P. radiata*, in which 70 to 80 crop trees per acre have been pruned to 32 ft. This silvicultural treatment has probably reduced the risk of a major crown fire, but the layer of crushed material provides an ideal start for a ground fire (Fig. 1). The eastern and southern sides of these blocks are bounded by a forest road and No. 5 Highway, respectively.

A break varying in width from 1½ to 2 chains was constructed around the perimeter of Blocks 1 to 5. All material, including stumps, was cleared off this break and pushed into the crushed area.

The area was divided into the blocks, at this stage, making use of existing roads or tracks where possible. The sizes of the individual blocks are shown on the sketch plan. The breaks between
inflammable material in the block divisions varied between \( \frac{1}{2} \) chain and 1 chain in width.

A track negotiable by all vehicles was formed around each block and the external boundaries where necessary, when the firebreaks were being constructed.

Vehicle access only was formed around the majority of the *P. contorta* boundary in Block 6, but elsewhere a 2 to 1½ chain break was formed.

Block 7 is separate from the other blocks and is completely surrounded by trees of various species and ages. The north-western boundary consists of first crop *P. ponderosa*, crushed *P. pinaster* regeneration and first crop *P. pinaster*. The north-eastern boundary consisted in the main of an old post-drying yard and first crop *P. ponderosa*. The Gordon Road boundary consists mainly of post-thinned *P. radiata*, while Bet Road bounds crushed *P. pinaster* regeneration with an overstorey of first crop *P. pinaster*. This block was divided into two areas by a chain break, with vehicle access, running from Bet Road, in a northerly direction, to the old post yard. A 1½ to 2 chain break was constructed around the external boundary.

(2) *Trial Burn*: On 23 and 24 January 1964, the 8-acre trial area was successfully burnt. Although most of the stems remained, all branches and small litter were destroyed, leaving the area open enough to plant.

Although few weed species appeared later the area is still quite open after two years.

Conditions prevailing at the time of this burn are indicated by the following Standards: \( \frac{1}{2} \) in. Stick weight, 10 grams; 2 in. Stick weight, 8 grams; fire danger rating, 6.5; temperature, 67°F; relative humidity, 46%; wind, S.E.3 Beaufort; days since rain, 8.
The area was surrounded on three sides by tussock land and standing *P. pinaster* regeneration on the fourth. The tussock had been machine-planted the previous winter and there was very little danger of the burn spreading.

Having ringed the area with fire, the updraught (Fig. 2) caused the smoke to lift several hundred feet into the air before drifting away over the forest. At no time were the men subjected to smoke nuisance, nor was there any danger from falling sparks.

(3) *The Main Burn*: Following several days of light winds from an easterly quarter, and with the long-range forecast predicting similar conditions, a decision was made to commence burning on the evening of 14 March 1966. Burning continued throughout the night and the following day. The last block was lit on the evening of the 15th and continued burning until approximately 3 a.m., when all burnable material had been consumed just 34 hours after commencing the burn.

All areas were patrolled until heavy rain fell on 20 and 21 March.

Conditions prevailing on the day of the burn are indicated by standard readings at 1.0 p.m.: ¼ in. Stick weight, 7 grams; 2 in. Stick weight, 11 grams; fire danger rating, 6.0. At 5.0 p.m. the temperature was 74°F, relative humidity 33%, and wind was calm to NE.3.

(4) *Method of Burning*: Ignition was carried out with knapsack flame-throwers burning diesel. Two men with burners were used to light up each side of a block, starting from the same corner. Spare flame-throwers were on hand in case of blockage or breakdown, it being important to keep a continuous line of fire to induce a “draw” and control the spread of the fire.
Eventually the burners joined up around the whole periphery. The fire was then left to burn out, which it did very rapidly, before the next block was started.

Approximately thirty men with shovels were used to patrol the area in case sparks jumped into adjacent blocks or surrounding trees. These men were backed up with two tankers and a bulldozer. A Coventry Climax pump with 1,300 ft of overland hose was set up at a small creek in order to provide water, should it be necessary, but this was never used.

Fuel was continuous and even, and lit very readily in all blocks with the exception of the *P. ponderosa* in Block 7. However, after the *P. pinaster* in this block had been ignited, the updraught was sufficient to draw the fire through the *P. ponderosa*. Although it swept over the entire area, the *P. ponderosa* only charred and very little actually burned.

Burning continued throughout the first night and by 8.0 a.m. five blocks had been burnt. Very few smoulders were visible on the previous four blocks and these were mainly along the edges where the bulldozer had heaped the slash when forming the firebreaks.

Although the heat generated by the burn was particularly great, only three edge trees showed signs of scorching, and these only very slightly. This confirmed the centripetal character of the fire, away from the surrounding forest and other inflammable material. The centripetal draught was so great that after daylight on the 15th a bird flying past the burn was seen to be sucked into the flames although it vainly tried to fly away. Edge trees also swayed although there was no wind evident. Cones on the surrounding *P. radiata* could be heard opening all night from the heat. The greatest heat generated was from the first crop *P. pinaster* that had been hand-felled.

At no time did the men complain about the heat, smoke or long hours, and this appeared mainly due to the hot food and drink made available to them from the food trailer throughout the night. A relief crew took over at approximately 8.30 a.m. and Block 6 was burnt using the same method during the morning.

As the day progressed, small whirlwinds were noticeable in Block 6 and although those near the edge of the burn had to be carefully watched, only one carried sparks across the break. The resultant smoulders were quickly extinguished. however, and Block 5A was burnt without incident during the afternoon.

On the evening of the 15th, Block 7 was lit and, although the heaped *P. ponderosa* on the edge ignited rapidly, it did not spread into the block. In fact the fire appeared to go out altogether in several places until the *P. pinaster* was well under way, when the draught caused the smoulders to relight and spread over the whole area.

By daylight on the 16th only 10 to 12 smoulders were observed on the previous burns and these were extinguished by water. Further smoulders occurred in the area, which was continually patrolled until half an inch of rain fell on 20 and 21 March.

No signs of whirlwinds were seen during the hours of darkness, although just after daylight small eddies became evident and continued throughout the day. These were seen only on areas actually burning and not on the burnt-out blocks. Eddies are
FIG. 3: Depth of slash before burning.
generally caused through an unstable atmosphere, and demonstrate the need for a steady wind while burning during daylight hours. The possibility of having to light the blocks from the centre prior to ringing was considered but was not found to be necessary in the circumstances.

At no time during the burning was any attempt made to extinguish smouldering material until the whole operation was complete. The objective was to consume as much fuel as possible in order to achieve an area sufficiently clear of material to enable successful establishment.

(5) Results of the Burn: All blocks, with the exception of those containing crushed P. ponderosa, burnt reasonably cleanly. The fire consumed all duff, twigs and most of the branches, but material larger than 4 in. to 5 in. in diameter was only charred. Areas which had been 3 ft to 4 ft deep in slash prior to the burn, were readily accessible after the burn (Figs. 3 and 4).

The dominant P. radiata regeneration which was pushed over during October and November, was not as readily burnt as the P. pinaster. However, the P. pinaster acted as kindling, and a reasonably good clean-up was achieved.

An extremely hot fire, which resulted in a clean burn, occurred in the area of first crop P. pinaster that had been felled by chain saw.

The poorest results were obtained in the crushed P. ponderosa areas and were due to the P. ponderosa remaining green after crushing and to lack of sufficient fuel to carry a fire. When crushed, P. ponderosa pushes over easily, rather than breaking off as P. pinaster does, and this allows a proportion of the rooting system to remain in the ground and maintain a sap flow to the crown.
AERIAL SOWING

A decision to sow most of the burn was made shortly after the burn took place.

One of the aerial topdressing and spraying firms based in the Rotorua-Bay of Plenty area agreed to a trial, using a Cessna 182 equipped with a "Swathmaster" attachment. This is a wing-shaped attachment fitted below the hopper. It is 14ft wide and has a series of channels inside it, which conduct liquids, seed or DDT prills throughout its length. These materials are then sucked out from the "Swathmaster" by the slipstream through numerous holes drilled on its skin.

(1) *Initial Sowing Trial*: A trial using treated seed was conducted on a topdressing strip adjacent to Tahorakuri Block. There was no "metering device" fitted to the seed hopper, so the rate of flow of seed from the hopper was effected by adjusting the hopper door. This proved to be a somewhat awkward method of metering the quantity of seed to be spread over a given area, but eventually the correct aperture was found to release one pound of treated seed per acre at a given height and ground speed.

The effective swathe width proved to be about 50ft with treated pine seed which is somewhat less than is usual with grass seed or prills. A good distribution pattern was achieved up to this width but thereafter the distribution became fairly erratic and quantity of seed tapered off.

A decision, based on the results obtained in this trial, was made to sow the whole area as soon as possible, with the exception of Block 6 and those portions of Blocks 5 and 7 that contained crushed *P. ponderosa*.

(2) *The Sowing Operation*: A total of 980 acres was sown on 26 March out of the total area burnt of 1,200 acres. 1,050 lb of treated seed were distributed in an actual flying time of just under 6 hours, which included ferry time from the loading strip to the seeding areas and return. The flying distance varied from 3½ to 7 miles, according to which block was sown.

The aircraft hopper could take up to 500 lb of treated seed, bulk and not weight being the critical factor. Each block was sown separately, so that at no time was the aircraft carrying more than 300 lb of seed. The largest block to be seeded was 276 acres.

The pilot endeavoured to maintain a constant ground speed of 100 mph and a constant height of 100 ft above ground, when sowing.

CONCLUSIONS

(1) *Crushing*: The minimum size of tractor suitable for this type of work is a Cat. D7 or equivalent. Any machine engaged on this work needs to have extra guards fitted to protect both the driver and the machine.

(2) *Burning*: The unburnt material left following the burn was greater than originally expected and must be attributed to one or both of the following factors: (a) Rate of burning (b) Time lapse between crushing and burning.
In the former instance the method used resulted in a burn which covered the area very quickly. Had a different method been adopted and the burn slowed down, it is probable that a greater quantity of fuel would have been consumed. However, the longer the burning period, the more hazardous the operation becomes, especially as weather conditions change so rapidly.

The latter instance indicates that, although the time lapse between crushing of the *P. pinaster* and burning gave sufficient drying to obtain a reasonable consumption of material up to 4 in. in diameter, the *P. radiata* was crushed only 3 to 4 months before burning and, because of the larger individual piece size, did not have sufficient time to dry out. Cutting rather than crushing would have promoted quicker drying.

This last comment also applies to *P. ponderosa*, as straight crushing of this species is not effective in obtaining a satisfactory burn.

(3) Sowing: This operation has shown that a fixed-wing aircraft using a “Swathmaster” attachment can achieve a good distribution of seed for swathes up to 50 ft in width.

However, an accurate device to control rate of sowing would be desirable. The ability to sow successfully small areas of broken topography surrounded by standing forest has still to be demonstrated, before the use of a fixed-wing aircraft can be recommended.

Germination results to date indicate that rodent depredation has been fairly serious and that some supplementary planting may be required on the areas sown.

ACKNOWLEDGEMENT

The authors acknowledge use of data on stand histories and treatment, derived from unpublished reports of Owen Jones (1947) and A. B. Bowers (1964).