J M Gould

Ref. 47

FIRE PROTECTION OF SMALL PRIVATE FORESTS

N.P. Cheney
(CSIRO Division of Forest Research)

ABSTRACT

Small private forest owners are largely unaware of risks that bushfires present to their investment and are often unaware of bushfire protection measures in rural areas.

Private forests in Australia are in areas where large fires can be expected every 3-5 years somwhere in the district. Rural fire brigades are equipped to suppress grassfires and can be effective at quite high levels of grassland fire danger. Forest fires are more difficult to suppress at low levels of fire danger if the fuel loads within the forest are high. Small forests and woodlots can provide an unacceptable hazard to graziers and in the future, forest owners may be held liable for damages if fires cannot be controlled due to excessive fuels.

Fuel reduction and fuel modification measures are most effective if they are planned and carried out from the start of the plantation venture. These are most easily achieved when combined with good silvicultural practices but new approaches to pruning and disposal of slash are required. Agro-forests are just as vulnerable to wildfires as conventional forests unless good pasture management is carried out to reduce grass fuel loads in summer.

INTRODUCTION

For some years now the Institute has been promoting small private forests, either as small forest ventures, farm woodlots, production shelterbelts, or more recently, agro-forestry. Few papers have considered the problem fire protection poses to the small forest owner or have considered the complications to firefighters that arise when trees are introduced into a predominantly pastoral landscape. McArthur (1968) recommends prescribed burning for woodlots (native or exotic) on Australian farms and Borough (1980) suggests that an agro-forest system can be a very low fire risk, even during periods of very high fire danger, but produces no evidence other than reduced wind speeds near the ground in the agro-forest system to support his claim.

The need for fire protection of a forest enterprise really reduces to the simple issue of whether or not a conflagration of disastrous economic significance is likely to occur once or more per rotation (Cheney and Richmond, 1980). If it is, then the level of expenditure required for an adequate standard of protection can be determined from consideration of frequency of dangerous fire weather, rates of fuel accumulation and risk of ignition. If the fire environment is such that dangerous fires are unlikely to occur within the rotation then provision of fire protection measures by the individual forest owner are a waste of money. Thus in areas of low fire risk such as New Zealand and Northern Europe, small private forests have an excellent chance of surviving through the rotation and nuisance fires which may occur can be relatively easily controlled with rudimentary equipment and perhaps some assistance from a local fire brigade. In most parts of Australia, the fire climate is severe and it is the problems of providing fire protection in this country that will be addressed in this paper.

The perceived need for fire protection also depends on the reasons why private forest owners grow trees. At first thought, it may be assumed that the dominant reason is for profit, but a survey of small forest owners not connected with the timber industry by Oates (1980) suggests that this is not so. The only firm conclusion she could draw from the results of her survey is that individuals had their own reasons which were many and varied. While present tax benefits were considered helpful (particularly among professional and absentee land holders) and some looked for the possibility of some form of retirement income, Oates thought that these considerations were secondary and by and large intangible factors such as a liking for growing trees or a desire to see trees back in the landscape were more important reasons for most people. The hard-nosed business attitude of Smail (1980) is apparently not common in Australia.

In spite of the varied reasons given for entering into private forestry, most people now recognise their plantations have a tangible value. This becomes particularly apparent when they are burnt out and the liability for the damage caused by the fire is borne by an organisation with the capacity to pay (e.g. electricity authorities). The situation with woodlots of native species is not quite so clear cut but I have been asked for a valuation of the damage caused to a previously long unburnt stand of brittle gum (E. rossii) and red stringybark (E. macrorhyncha) burned by a fire caused by the ACT Electricity Authority installations, because the woodlot no longer has the peaceful tranquillity and 'natural' values desired by the owner (G.E. Moseley, personal communication).

For simplicity, I will assume that the owners of small private forests are healthy capitalists with a view to making a substantial profit from their trees at some time in the future. They plant P. radiata in areas receiving more than 600 mm of rain in southern Australia (this avoids questions of selecting fire resistant species although more fire tolerant trees such as P. caribbaea might be selected in northern

Australia or P. pinaster on special sites in WA). They know little of forestry and practically nothing about fire protection. It is the responsibility of the professional forester to advise them of the risks they are facing and practical measures which can be taken to reduce those risks.

If, in fact, attitudes of small forest owners are as expressed by Oates, then it is unlikely that these people will spend much money on or become involved in rural fire protection. The question may not be one which is based on financial considerations but one which involves moral and legal obligations to the rural community.

FIRE HAZARD TO SMALL PRIVATE FORESTS

Good fire statistics for rural areas do not exist. Large fires are usually recorded but the area they burn and the damage caused are rarely well documented. The risk then to private forests is deduced from a fairly broad data base. In Victoria, Morrison and Langley (1980) found that most farm woodlots were situated on the northern side of the divide in an area where the large fires can be expected once every 5 to 10 years (Cheney 1976). A similar frequency of large fires can be expected in most areas where P. radiata is grown. This does not mean that every hectare of land is burnt every 5 to 10 years, but the combination of drought, fuel, dangerous fire weather and ignition source have occurred simultaneously at this frequency and fires have burnt large areas generally more than 10,000 ha per event.

Small private forests and particularly farm woodlots are mostly located in areas where they are adjacent to or surrounded by grasslands. The hazard from the surrounding fuels is less than woodlots adjacent to native forests as the grasslands remain green for most of the year and won't burn at times when forest fuels are highly flammable. However, when grasses cure, these isolated forests are vulnerable to fires which spread very rapidly under strong winds and can originate many kilometres away. In 1983 a grass fire travelled over 60 km before entering plantations near Mt. Gambier.

Small fires occur most frequently near towns and cities but large fires which burn under extreme fire danger conditions tend to occur from a variety of causes which may not be common under milder fire weather. The chances of being burnt out should be assessed by examining the occurrence of large fires on a regional basis as well as the local occurrence of small fires.

ECONOMIC CONSEQUENCIES OF WILDFIRES

P. radiata is a fire-sensitive species. It dies if the whole crown is scorched and in most stands this occurs when the fire intensity is less than 2500 kWm^{-1}.

Fires which are uncontrollable in a closed forest will cause death to most of the mature stand. However, fires which are quite controllable in grasslands , i.e. 2000-6000 kWm^{-1} will generate sufficient heat to kill mature P. radiata. The agro-forest thus does not offer security against severe losses particularly if heavy pastures are developed with it and fuel loads are supplemented by additional litter and slash among the grass.

A large forest owner can minimise the value of his loss from fire, particularly if his forest is managed for sustained yield. The loss (value of trees less salvage value) can be redistributed over time by various management strategies. Harvests at rotation age can be deferred and the timber lost replaced by cutting substitute stands. This way the value of loss may be deferred until after the planned rotation age by which time additional planting strategies can minimise the actual loss. If

the forest has more growing stock than the marketable cut, the fire may not show much tangible loss at all.

The single private grower is in a different situation. His stand represents a single investment which once burned may not be replaced in his lifetime. Markets may not be available or able to be negotiated for mature timber immediately after the fire and before degrade sets in. Small size timber is generally oversupplied and will always be unmarketable. In most cases any fire will result in a substantial loss both in real terms and in terms of expected returns at maturity.

SUPPRESSION CAPABILITY IN RURAL AREAS

Fire protection in rural areas of Australia is provided by volunteer bushfire brigades. Members are drawn from the rural community and are motivated largely by self-interest to provide mutual aid to each other. On the other hand, small private forest owners are mostly city-based absentee landlords (63%, Oates 1980). They have little knowledge of the rural volunteer firefighters and little involvement in the rural community. Like many city people they probably think that rural firefighting is carried out by paid firefighters and volunteers are called in from surrounding areas only when things get out of hand.

Rural brigades are mainly equipped to fight grassfires. There are large differences in the intensity and the weather conditions at which fires can be attacked in either forests or grasslands even using appropriate equipment. Small private forest owners need to appreciate these differences and realise that if they are not contributing to the community effort, rural firefighters are unlikely to be enthusiastic about undertaking direct suppression for them even if the task is within their capability.

Table I. Fire intensities above which direct fire suppression is ineffective (preliminary data - not for publication)

Fuel type	Suppression Technique	Intensity (kWm^{-1})	Fuel load (tha^{-1})	ROS (kmh^{-1})	FDI MK5 FOREST
Forests including P. radiata	Hand tools	800	10	0.16	14
			15	0.10	6
			20	0.08	4
	Bulldozers or tankers from a forest road	2000	10	0.4	35
			15	0.26	15
			20	0.2	8
	Tankers from 40m firebreak	3500	10	0.7	60
			15	0.46	25
			20	0.35	15
					MK4 GRASSLAND
Grassland	direct with water	6000	2	6	47
			4	2.5	20
			6	2	16
	Tankers from 30 m break	10,000	2	10	75
			4	5	40
			6	3.3	25

Grassfires are easier to suppress than forest fires (Table I). Bulldozers or tankers operating from a forest road cannot suppress a forest fire much beyond an intensity of 2000 kWm^{-1}. Grassfires can be controlled directly with water at an intensity of 6000 kWm^{-1} and if operating from a road or firebreak, grassfires up to an intensity of 10,000 kWm^{-1} can be controlled.

The fuel load dramatically affects both the rate of forward spread and the fire danger conditions at which both forest and grass fires are controllable. For example, a grassfire travelling at 6 kmh^{-1} in a sparse fuel (2 tha^{-1}) can be suppressed directly with water while a fire in a heavy pasture of 6tha^{-1} cannot be controlled if it is spreading at more than 2kmh^{-1} or an FDI of 16.

The data provided in Table I are generalised and assume that sufficient forces are available to handle short distance spotting. If spotting is severe fires may be uncontrollable at intensities lower than given here.

It is also clear from Table I that grassfires are controllable at a higher fire danger index than are forest fires. Because meteorological and fuel factors affect fire behaviour in grasslands and forests in different ways, quite different grassland and forest fire danger indices are derived for the same combination of weather variables (Table II). Thus under light to moderate winds fires which are very difficult to control in forests are easy to control in grasslands.

Table II.
Comparison of forest and grassland fire danger indices at different windspeeds (Drought Factor 10, Curing 100%, Temperature 35°C, RH 20%)

Wind Speed (kmh^{-1})	Grassland Fire Danger Index	Grassland Fire Danger Danger Class	Forest Fire Danger Index	Forest Fire Danger Danger Class
10	7.5	Mod-high	24	High-V.high
20	16	High	31	Very high
30	33	Very High	39	Very High
40	58	Extreme	50	Extreme

A private forest or woodlot owner will find it impossible to control almost any fire in his forest by himself even when grassfires are easy to control. Volunteer rural fire brigades are generally not equipped to fight forest fires and in many areas the volunteers do not have the training and experience to engage in forest fire suppression even though the fire may be controllable by hand tools. So a forest owner may well find that rural brigades will not enter his forest to suppress even a small fire. On large fires, brigades will inevitably fall back to the forest/grassland interface and burn out from that boundary in order to rapidly secure the fire perimeter. Often the back burning operation is more severe than the fire itself but can be justified if rapid and secure control of the fire edge is obtained.

Most Australian forest services have found that they have been unable to provide adequate protection for isolated plantations in rural areas and these have largely been abandoned and plantings concentrated in large units both for better fire protection and cheaper management. Even so, in recent years there have been huge plantation losses from large fires under very high to extreme fire weather. Most of these fires have travelled some distance across pastoral country before entering the forest.

LEGAL AND MORAL OBLIGATIONS

If you havent thought about it, that dry grass in the paddocks is the grazier's asset. The more grass he saves from fire the more stock he can maintain without the additional costs of agistment. It is just as important to the grazier to prevent his grass from burning as it is to the forest owner to save his trees. In fact traditional graziers are quite happy for a forest to burn out to gain better grazing in subsequent years.

In spite of their rapid spread, grassfires are easy to suppress and control until trees are involved. Many grassfires are successfully held on narrow roads and firebreaks but are later lost from spotting from a single tree. Large fires can be successfully confined with a flank attack even under extreme fire dangers until treed areas are encountered. The flank attack normally stops at this point. If the woodlot is small it may be skirted but if any wind change occurs, it is highly likely the fire will be lost along sections adjacent to or passing through forested areas. Thus from the grazier's point of view, a forest is an additional hazard which makes fire suppression more difficult, if not impossible.

In NSW, section 54 of the Bushfires Act states: 'A Landholder must take all reasonable precautions to prevent a fire from spreading from his property and causing damage'. The forestry profession has for some time promoted fuel reduction and fuel modification in forest areas as practical ways of reducing fire intensity and rates of spread and assist fire suppression operations. These techniques are also being appreciated by the courts. At the 'Inquiry into the bushfire in the Bundanoon/Morton National Park Kangaroo Valley areas on 8 January 1983 and subsequent days', the Coroner found that 'The carrying out of logistical hazard reduction work would have, in my opinion, reduced the intensity and speed with which this fire spread'. The Coroner found the assertion promoted by witnesses from the National Parks and Wildlife Service of NSW, that prescribed burning as late as 1981 would have no real effect on the rate of spread or intensity of the fire, 'surprising'. (McMahon 1985). In this case, the Coroner considered that the fact that hazard reduction which should have, but did not take place, did not justify recommending that any person be charged with an indictable offence.

In this era of litigation after bushfires (often vigorously promoted by professional hobby farmers), I believe it wont be long before forest owners will be held liable for contributing to fire damage if they dont undertake measures to reduce or modify hazardous fuels. Also because of the complications that forest lots present to the rural firefighter, I believe that the forest owner, both large and small, have a moral obligation to assist the rural community and recognise that treed areas complicate the overall fire fighting effort.

I believe the same conditions must also apply to the State Forest Services and large private companies. After Ash Wednesday in South Australia, it was patently obvious that the Woods and Forests Department has no hope of controlling fires under extreme conditions in plantations with heavy fuel accumulations. It was also patently obvious that where fuel reduction measures had been carried out around Mt. Burr that this reduced the fire intensity and rates of spread. It is incredible and an indictment on our profession that after losing 25% of the State's forests and subjecting their neighbours to immense walls of fire when the fires left the forest that they have not embarked on extensive fuel reduction programs by the many techniques at their disposal. The myth that fuel reduction burning cannot be done because of possible bark beetle attack must be rejected. They apparently dont like the Victorian pines across the border where burning is carried out to remove suspended needles or in private woodlots in the Adelaide Hills where control burning has been carried out almost annually for at least 20 years. I'm sure there are many other large forest owners demonstrating the same irresponsibility.

INSURANCE

Often the only practical advice one can give a small forest owner who suddenly realises he 10 year old woodlot is a tinderbox of rank dry grass, prunings or uncommercial thinnings and weeds is 'Take out insurance'. A businessman with an investment to protect and no clearly defined legal responsibility to take any fire protection measures could well see better value for money in taking out insurance than spending money on fire protection which is likely to fail anyway in the event of a fire.

Insurance companies do have requirements for firebreaks and may take other fire protection arangements into consideration when setting a premium, but the definition of standards is not at all clear. For example, one company requires an external firebreak around the plantation 6 m wide which is 'clear and accessible at all times'. Owners may find that in the event of a fire that their insurance policies may not be valid if there has not been strict compliance with this clause and that in many areas strict compliance with this clause is impossible to achieve (P. Montgomery, personal communication). In some instances, foresters are asked to approve firebreaks for insurance purposes. They may well find themselves personally liable for damages if they have not carefully inspected and measured the firebreaks and established quite clearly the standards that the insurance company requires.

Finally, insurance premiums cover the maximum value the owner can expect to be paid. The actual value paid is assessed after the fire and the forest owner should use a forestry consultant to establish the actual value of his plantations when agreeing to a premium and be prepared to use a consultant again to establish losses after the fire.

MANAGEMENT FOR FIRE PROTECTION

As the small private forest owner is barely capable of suppressing the mildest plantation fire by himself, then he must design and manage his forest so that it is virtually fire-proof or that suppression in the forest can be readily carried out by the existing fire control organisation. This requires planning from the outset and management to maintain fuels at a minimum level throughout the life of the plantation.

Plantation Siting and Design

Plantations should be located on level or undulating terrain where it is possible to work mechanical equipment. Isolated steep and rocky corners of farms can be planted to P. radiata and the fuels maintained at low levels but this siting usually precludes the use of mechanical equipment and requires a large commitment of time and labour by the landholder. In the event of a fire it must be recognised that the fire perimeter will be the forest boundary and it may be better to plant these areas to a more fire resistant species and maintain the area with periodic controlled burning.

A private forest owner should design firebreaks and internal roads from the outset. In flat topography the road density should be around 45mha^{-1} giving an average compartment size of 20 ha. On smaller units or on steep topography the road density will be higher; in New South Wales Forest Commission plantations on steep topography have a road density of around 70 mha^{-1} (Cheney and Richmond 1980). As the fire threat is most likely from outside, the external roads should be located where the firefighting is easiest and the roads are easy to maintain. Short steep sections should be avoided. These roads should be maintained as non-flammable firebreaks 3-5 m wide and be capable of stopping a surface fire under low to

moderate fire danger conditions. Wide firebreaks are costly to maintain and are only of value when the plantations are young.

Clearly, the external break cannot stop a high intensity fire. Its prime purpose is to provide access for firefighting vehicles and to control any fuel reduction burning within the plantations. Whether or not it will be useful under wildfire conditions often depends on the orientation relative to the prevailing wind but if it is not maintained there is little opportunity for agressive firefighting.

Establishment

Site preparation and establishment practices should aim to achieve the maximum growth rates and early dominance of the site. Particular attention should be paid to removal of clearing debris and control of grasses and woody weeds. The past practice of leaving windrows within plantation areas means that effective firelines cannot be established without using heavy machinery and complicates all later management. The following procedures are recommended.

- Complete removal of all clearing debris by burning and repeated stoking if necessary
- Complete cultivation for control of woody species and reduction of tussock grasses
- Use of herbicides for grass control around individual trees.
- Pasture control by discing in the first 3 years or until stock can be introduced to the area.
- Planting unsuitable areas with an alternative but suitable species (e.g. wet areas with poplars or smooth barked eucalypts).
- Selection of top quality planting stock from a known seed source.
- Singling (removal of unwanted multiple stems) in the first 2 to 3 years before the operation contributes a large fuel accumulation.
- Partial pruning of trees from an early age.

A regular plantation layout which allows access and cultivation both along and across the rows will enable mechanisation of a number of operations which previously have only been possible by hand or on foot.

Pruning

The value of pruning for fire control operations has been debated for many years. Benefits from improved access and removal of aerial fuels are in some cases countered by increased wind speeds within the stand and additional surface fuels around the base of the tree. Under very high fire danger conditions there is probably little difference in fire behaviour between pruned and unpruned stands if the fuel associated with the pruning operation is not removed from the stand. Pruning should be conducted as a multistage operation which in the early stages (3-6 years) aims at keeping the lower branches small and green and preventing large accumulation of debris that results from a single operation. Mechanised hedging of the lower branches will keep them small and green and can be carried out rapidly.

When pruning adjacent to the trunk is necessary, it will be easier on the smaller branches and cause less nodal distortion. Some experimentation is probably required with the following:

- Removal of large branches when singling (age 2-3).
- Hedging of lower branches say 1 ft from the stem with rotary slashers or powered saws.
- Remove pruning debris from the base of the tree, place between rows and disc into the soil.

Pruning with a vertically oriented rotary slasher works fine on windbreaks in New Zealand. Leaving the external row unpruned may have a slight advantage in reducing wind speeds in the stand but the disadvantages are reduced access into the stand and huge branches in the final crop trees which are costly to dispose.

Prescribed Burning

Because of the resin in dead pine needles they can be burnt at higher moisture contents (about 30%) than eucalypt litter (18-20%). This means that light surface fires to remove needles can be carried out under very mild conditions. Also suspended needles can be burnt when surface fuels will not. In Victoria, needles are burned from standing trees in unpruned plantations. Piles of thinning slash can be partially burned if the operation is carried out when only the suspended needles are dry enough to burn.

Burning heavy accumulations of thinning slash is a delicate operation and difficult to carry out without causing damage. Once the surface litter dries out, the burning operation will most often consume large banches and stems in the slash and although the flames may not be high, the persistance of the fire can cause damage to the tree bole or tree height scorch. The difference in moisture content between having a successful or damaging burn is small and may be only one day of drying after rain. Reliable prescriptions have not ben written and in undulating topography small changes in aspect can cause a big change in fire behaviour and subsequent tree damage.

However, a farmer who is not constrained by AWU hours, is continually awareof the burning conditions and is prepared to burn small units when appropriate, can carry out fuel reduction burning with a considerable degree of finesse in P. radiata from 5-6 years of age. After age 18-20, prescribed burning P. radiata is easy provided there are no large accumulations of thinning debris.

AGRO-FORESTRY

Grazing should be introduced into all pine forests as soon as it is practical. Grazing not only removes grassy fuels but also the effects of trampling and removal of unwanted regeneration compacts the fuel bed and makes fires much easier to control.

In climates where grass remains green throughout most years, agroforestry may practically eliminate fire problems. However, in climates where grasses cure annually the agro-forest may be more difficult to protect than a conventional forest, managed primarily for timber production alone. Bad grassfires occur in those years when there is abundant grass everywhere following good spring rains. Graziers often have difficulty in stocking heavily enough to eat out the home paddocks.

From a fire control point of view, the ideal grass is one which forms a fine continuous low sward which is palatable to stock. In the event of a fire, the pasture burns with low flames and short residence times. Tall coarse grasses which can withstand droughts will produce high flames and high scorch heights even under relatively mild conditions.

The agro-forester is in a real bind. Hardy perennial pastures capable of withstanding summer droughts such as Phalaris require heavy grazing pressure to keep the fuel loads down. Native pastures will degenerate with moderate stockings. With the added competition from trees, they will develop unpalatable grasses, thistles and other weeds and it will be difficult to reduce fuel loads by grazing. Perhaps the only solution is to face up to the cost of maintaining biennial improved pastures such as rye-gras and clover and use minimum tillage techniques such as sod seeding to replace the pasture.

EQUIPMENT

If the forest owner wishes to undertake prescribed burning within his stand or participate in fire suppression operations, he needs a minimum amount of equipment suitable for forest fire suppression. The list is not extensive but includes a number of McLeod tools, knapsack sprays, drip torches, a chainsaw, a portable floating filling pump and a small fire tanker equipped with a 500 litre tank and pump capable of delivering water at 1000 k Pa through at least 60 m of 20 mm diameter hose. A tractor with blade capable of cutting a narrow fire break in a grassy sward is very useful for fighting small fires or constructing temporary fire breaks for prescribed burning operations.

Wherever possible, the small forest owner should join the local volunteer bushfire brigade and like other rural landholders, be prepared to learn about and participate in fire suppression. This means being on his property on days when extreme fire weather warnings are issued or total fire bans are enforced.

CONCLUSION

Most small private forests in Australia are unprotectable. The risk of being burnt out at least cnce in the rotation is high and if burnt, substantial losses are likely.

Fire suppression in forests is beyond the capability of most rural fire brigades unless extensive fuel modification has been carried out. Fire protection will remain difficult unless it is taken into consideration at the inception of the plantation and fuel reduction and fuel modification are carried out from establishment and maintained almost annually throughout the life of the plantation. In many cases these measures can be combined with good silvicultural practices. The agro-forest may be just as vulnerable as conventional forest stands unless grass fuel loads in summer are reduced to low levels.

Professional advice to intending forest growers should point out all the risks involved and explain the function, organisation and capability of rural fire brigades. Forest owners should be aware of the hazards that excessive fuel accumulations pose to the surrounding rural community and be informed of possible legal consequences which may arise if they have not taken reasonable precautions to reduce these hazards.

REFERENCES

Borough, C.J. 1980. Agro-forestry in Australia. Paper presented to the ANZIF Conference, Rotorua 12-16 May, 8 p.

Cheney, N.P. 1976. Bushfire Disasters in Australia. Aust. For. 39, 245-68.

Cheney, N.P. and Richmond, R.R. 1980. The Impact of Intensive Forest Management on Fire Protection with Special Regard to Plantations of Eucalypts. Paper presented to Eleventh Comm. For. Conf. Sept. 1980, 22 p.

McArthur, A.G. 1978. Rural Fire Protection. In Growing Trees on Australian Farms. Ed. A. Brown, N. Hall. Comm. For. Timb. Bur. Canberra, 271-304.

McMahon, J.L. 1984. Finding of the Coronial Inquiry into the Bushfire in the Bundanoon/Morton National Park/Kangaroo Valley areas on 8 January 1983 and subsequent days.

Morrison, G.L. and Langley, P.A. 1980. The development of farm forestry in Victoria. Paper to the ANZIF Conference, Rotorua, 12-16 May. 8 p.

Oates, N.M. 1980. The small woodlotter - who is he and why does he plant? Paper to the ANZIF Conference, Rotorua, 12-16 May. 8 p.

Smail, P. 1980. Trees relative to farm production. Paper to the ANZIF Conference, Rotorua, 12-16 May. 5 p.