A history of fire in the forest and rural landscape in New Zealand - Part 2, post 1830 influences, and implications for future fire management

by Dennys Guild[1] and Murray Dudfield[2]

Introduction

This is Part 2 of a two part history of fire in the forest and rural landscape in New Zealand. The first part covered pre-Maori and Pre-European influences. It is after that background that we now explore the post 1830 influences of fire on our forest and rural landscapes, and look at the implications for future fire management in New Zealand.

Post 1830

1. Fire as a means of quick forest clearance.

With an estimated European population of only 150 people in 1832, early settlement was initially slow, and was concentrated in just a few parts of New Zealand. Northland was one of the earliest areas favoured by Europeans for settlement, probably as a result of the early contact there by missionaries from Australia, which began in 1814. But settlers in other areas such as Bluff in Southland arrived to establish a supply base for whaling ships as early as 1824 (Hall-Jones, 1979), and early European settlements also sprung up at Riverton, Waikouaiti, Akaroa, Nelson, Wellington, Wanganui and Auckland.

With the settlers came a new onslaught on the native forests, which were cleared to make way for pasture and crops. Timber was one commodity that settlers had in over-abundance. However, except for a limited amount required to build the family home or to erect some rudimentary fencing, the rest of the forest on farm allotments could not be used and was an unwanted liability (Halkett, 1991). Life was no Sunday picnic. The hardships suffered by these colonisers have been well portrayed in many great New Zealand novels.

To be sure, there was a thriving timber trade for urban development and export, but the skills required to fell, pit-saw and extract this produce were insufficient to keep up with the farmer's need for grazing land.[3]

During the later half of the nineteenth century forest clearance occurred on a spectacular scale. In today's light these events can be described as extravagantly wasteful.

The effect was to reduce New Zealand's native forest cover from 55% of the land area to about 25% of the land area in the short space of time of just 70 years.

Early accidents. Accidental fires abounded, and the devastation caused by some of these is hard to estimate. One such fire was in the Wakatipu basin near where Kingston now stands. Gilkison (1930) writes: "The first European to see Lake Wakatipu was Mr.Chalmers of Croyden Station, Hokonui. He spied it from the top of a mountain in 1853, but did not follow up his discovery. About 1856, Mr John Chubbin, a pioneer squatter of the Mataura Valley, with three others, having received information as to the great lakes from a Maori chief at Tuturau, pushed up by the Mataura, passed the McKellar's station, and were the first to reach Lake Wakatipu. They nearly lost their lives in this expedition.

> "The weather was hot and sunny, and the vegetation was dry and parched, and one of the party allowed the grass to catch fire. Soon a tremendous conflagration was raging. The explorers were unable to beat it out or to restrict it, and in order to save their lives had to immerse themselves and their horses in the lake. Mr.Chubbin, describing it said *"In fancy I can hear the flames roaring and crackling yet and see the terror-stricken birds trying to escape destruction. The little native quails fared badly, and I should say that hundreds perished. After a most exciting and unpleasant 3 hours in the lake, the fire burnt itself out, and the pioneers, wet but thankful, were enabled to go on their way."*[4]

[1] *Registered Forestry Consultant, Guild Forestry*

[2] *National Rural Fire Officer, National Rural Fire Authority*

[3] *Log export ships, picture from Halkett, top p59*

[4] *Native quail (now extinct) - from Falla et al.*

According to Falla *et al* (1979), the New Zealand quail was last seen in 1875, and is assumed extinct. Did this fire cause the demise of an entire population? Maybe not, and maybe it was doomed anyway (from introduced predators?).

Deliberate and unintentional fires

For forest clearance (and pasture establishment). It would be fair to say that by far the greatest purpose of the fires deliberately lit was for clearing forest to make way for pasture establishment. This agricultural tool was used throughout New Zealand with great success for the intended purpose, which was to clear the land as quickly as possible to allow the over-sowing of pasture grasses. Unfortunately, such was the enthusiasm of the settlers, and such was the lack of skills or resources to control these fires, many thousands of hectares of forest were burnt unintentionally.[5]

The Canterbury landscape, already altered by a history of Maori fires, was further greatly affected by European colonisation. The MP for Christchurch, W.T.L.Travers, spoke in 1869 of the valuable forests being destroyed by fire. In particular he was concerned by a fire that burnt over Banks Peninsula, reducing more than 10,000 hectares of forest to a pile of ashes Halkett (1991).

Not all the forest yielded willingly to this low-cost technique of land clearance. Forests in high rainfall areas often stubornly refused to burn, and there are still remnant pockets of forest on "dark faces" which were by-passed by the infernos. R.D.Dick (1956), of the North Canterbury Catchment Board reports on the difficulty of getting beech forest on the eastern slopes of the Southern Alps to burn due to the high average annual rainfall in the area - 101.93 inches (2,589 mm) average annual rainfall being recorded at the junction of the Bealey and Waimakariri Rivers between 1868 and 1879. This dropped to 62 inches (1,575 mm) per annum between 1890 and 1918, with the very low annual rainfall of only 23.81 inches (605 mm) in 1895 followed by only 37.63 inches (956 mm) in 1896.

Dick reports; "It is considered that extensive mountain beech forest fires take place only during extremely dry seasons, and it is thought that subsequent to settlement, the first big forest fires in the headwaters of the Waimakariri River occurred during 1895 and 1896." Dick also makes an interesting comment: "Prior to 1900 was the period of vast trial and error experiments by the run-holder and before the planned experiments of the scientist". So we can quite rightly assume that scientific method was applied to at least some of the big land clearing fires after 1900.

It also seems that the 'dry' experienced in inland Canterbury in 1895 and 1896 was shared in the Wairarapa over the summer of 1897/98, when over 8,000 ha of forest, 55 dwellings, 39 outbuildings, 1 church, 1 creamery and 1 sawmill were burnt by various fires in the region. And in 1918, probably no fewer than 9 sawmills were burned in the Raetehi fires (Dudfield, unpublished).

It needs to be said that settlers' fires were actively encouraged by some of the authorities of the day, and that there was not always a clear and unequivocal government policy with regard to the preservation of forest for its own sake. Roche (1987) says, after Bell's legislative measures of 1918 and 1919, "no longer did forested land have to be justified as suitable for State Forest reservation. Instead, the onus was on the Lands Department to prove that such lands were viable for settlement"!

According to Cooper (unpublished), another bad period for forest fires was in the summer of the first quarter of 1946, following periods of drought in Hawke's Bay, Rotorua-Taupo, and Northland. State losses totalled 6,665 ha in 62 fires, 50% of which were in native forest. Private forest owners lost a staggering 13,330 ha of exotic forest and 4,460 ha of native forest, and fire ran over a further 216,500 ha of cutover forest, tussock and scrub in a total of 311 fires (State Forest Service Annual Report 1945/46).

For pasture renewal. Halkett (1991) quotes Babrara Harper describing an account of initiatives taken by Canterbury run holders Charles Tripp and John Acland to improve access and induce grass growth for grazing:[6] "The flames needed little encouragement. They blazed, sparked

[5] *Picture of Owaka area where fire was used extensively for clearing heavy forest cover.*

[6] *Picture of remnant beech forest in cold, wetter gullies viewed from tussock-clad Spylaw Hill*

and spread, and in four hours had ravaged 50,000 acres of wilderness. For three days and nights the fire cracked and raged until ten miles of flax, immense snow tussock, speargrass, lawyer bushes and matagouri, and the hapless pigs and rats which dwelt in the shelter, were all shrivelled and burnt to black ashes. The conflagration could be seen over sixty miles away. It was like hell let loose."

For access for kauri gum. The loss of Puhipuhi kauri forest to fire in the 1880's was lamented as one of the greatest forest losses in New Zealand history. Hutchins (1919) describes the loss: "I have been to Puhipuhi and heard the story of its destruction by fire as told by different people, but more especially by Mr.Anderson, the forest official on the spot who has charge of the replanting work now in hand. In 1887 about one third of the area, containing some 300 million superficial feet, was burnt. This fire lasted for several weeks. The forest was filled with gum-diggers, whose interest it was to burn the forest in order to get at the gum in the ground. With the fatal laissez-faire forest policy of those days, no adequate precautions could possibly be taken to stop the gum diggers burning the forest.

…"And so New Zealand lost its most valuable forest, and the most precious forest it can have till, say, a century's forestry has restored the forests to more than their old-time value. The destruction of the Puhipuhi Forest by fire would have been readily preventable…..Then sawmillers, properly enough, were let in to work the burnt timber, but without supervision and without the usual fire-protective measures, so that the advent of the millers brought more fires.[7] Then silver mines were discovered, and the scandalous mining-forest laws operated to hasten the destruction. There was a bad fire in 1881, but the burn that almost finished the forest .. occurred in 1887. In 1913. 11,900 acres of burnt forest was withdrawn from reservation. Old records speak of it as once the finest Kauri forest in New Zealand.

[7] *Working a burnt kauri log at Puhipuhi - picture from Hutchins p57*

…."As will be seen on pages 67 and 68 [Hutchins, 1919] I calculate the net money loss in the destruction of the Puhipuhi forest at (Pounds)3,972,115, taking the value of the virgin-forest timber at present [1919] prices, plus the capitalised value of future kauri crops, less the value of the kauri timber sold and of the present grass lands. (Pounds)3,972,115 / 5,667 acres = (Pounds)701 per acre!"

Author's note: We have converted this to dollars and used CPI to bring it to 2008 values, and the figure is $570 million, or $248,438 per hectare.

Early conservation legislation

A brief mention of this important subject is warranted, if only to alert the reader to some important references on the subject. Out of disaster or public pressure comes legislation. As early as the 1867, many settlers were expressing concern about the rapid and indiscriminate clearing and loss of native forest. Roche (1987) records that the Member of Parliament Thomas Potts remarked in Parliament in 1868 *"the rapidity with which the woods were destroyed would make them disappear in a short time, and work a great change in the prospects of the settlers"*. This led to the first attempts at passing conservation laws. By the late 1860's, most existing systems of timber licensing as a means of regulating the exploitation of Crown forests had proved ineffective.

Julius Vogel pushed for change in the Conservation of Forests Bill of 1873, but this lapsed through lack of support. His later Bill succeeded, and the first New Zealand Forests Act was passed in 1874. This Act was followed by a series of investigations of the state of indigenous forest management in New Zealand, by far the most important being those by Captain Inches Campbell Walker in 1876-1877 as the newly appointed Conservator of Forests, and by David Hutchins, the eminent (aren't they always?) British Forester who was invited to come to New Zealand in 1915. Hutchins work, and Sir Francis Bell (leader of the Legislative Council), who had the ability to persuade Cabinet and overcome the strong lobby from sawmillers and settlers in 1918 and 1919, led eventually to the formation of the State Forest Service and the Forests Act of 1921 (Roche, 1987).

2. Effects of fire

Lost timber value. The losses as calculated by Hutchins (1919) from the fires in Puhipuhi Forest were colossal, and have been covered above. Hutchins observed in the characteristic, phlegmatic writing style of the age: "It will be seen later [in this report] that there is reasonable ground for the opinion that the cost of this war [1914-18] to New Zealand would have been paid for had the original Kauri forests of the Dominion [of New Zealand] been worked and preserved as are the forests now in most

civilised countries, and that this could have been done with considerable gain in the amount of timber available for cutting, and some gain in permanent land-settlement; since all the waste of burnt or deteriorated kauri timber would have been saved, and there would have been permanent employment on the land at the rate of one man per 75 or 100 acres."

We (the authors) are unaware of any attempt to calculate the losses in timber value from other major forest fires, but one would have to assume that the collective loss would be in the billions of dollars. Even the losses from fires in exotic forests have been considerable. The Balmoral Forest fire in 1955 is but one example, where nearly 3000 hectares of mainly Radiata pine and Corsican pine forest was burnt (Ward, 2005).[8] Most of the burnt part of this forest was planted between 1923 and 1931,(Prior, 1958) and if we assume an average yield at age 30 of 400 m3/ha for the Radiata pine, and the same at age 60 for the other species, with an average stumpage value of $20.00 per m3, then the loss of potential timber was $24 million in 2008 terms.

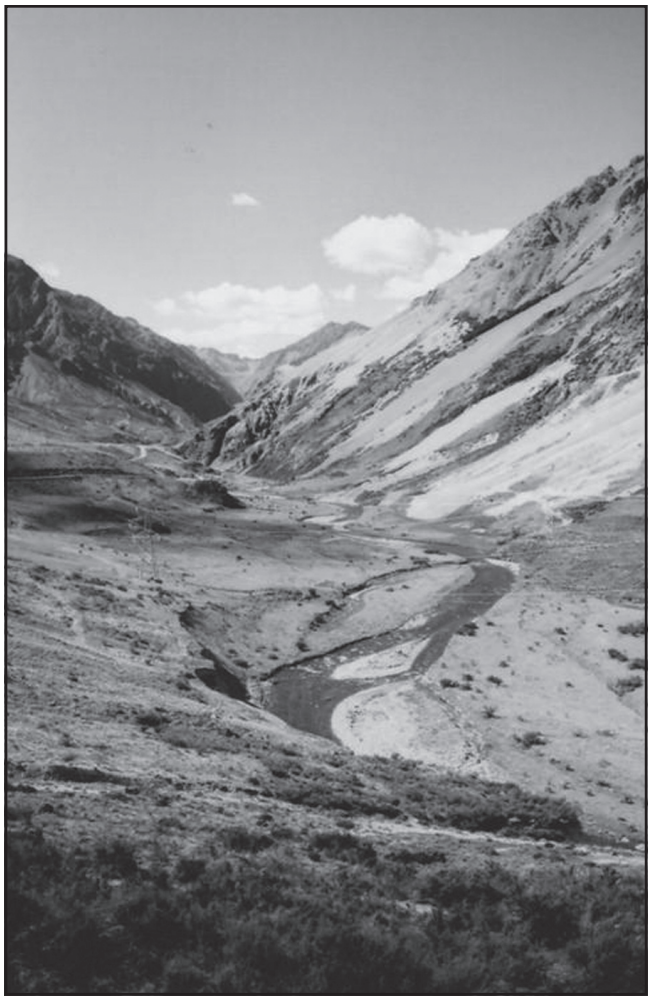
Lost flora, fauna and biodiversity

Depending on their size, intensity, and the way a fire is managed, fires can have anything from a positive to a catastrophic effect on the natural (native) flora, fauna and biodiversity. Obviously, fires lit for the purpose of destroying the resident vegetation for replacement by grass for grazing, are among the most destructive (Sands, 2005). Nevertheless, the period of early Maori deforestation also had a dramatic effect on our biodiversity, with the loss of several species of birds being directly attributed to hunting pressure and the use of fire (Taylor and Smith, 1997, and Halkett, 1991). Other fires, such as those that sweep through wetland communities from time to time, have had a much smaller effect on species and biodiversity (Timmins, 1992), but this is not to say that "small" losses are not important. The cost to society of the loss of a plant species, a bird species, an insect or a lizard, is impossible to value, but it would be a foolhardy person to suggest that it doesn't matter.

This is not to suggest that all fires lead to such losses. Indeed, planned and controlled use of fire for rejuvenating a forest has been well researched and is actively used in some circumstances - Sands (2005) - see also Section 4 below.

Increased erosion

Generally speaking, the loss of surface vegetation from burning is going to expose the topsoil to potential erosion by wind and water.[9] There is suggestion that the fires caused by early Maori had a lesser effect in this regard than the later fires caused by Europeans for the purpose of land clearing for grazing (Taylor and Smith, 1997), and no doubt this would be partly due to the fact that Maori did not have



[8] *Cover picture from Ward, 2005*

[9] *Rainbow Valley, Marlborough, where native forest was destroyed by fires, and severe erosion set in.*

sheep and cattle to exacerbate the situation. Regardless of this, soil loss is soil loss. The authors were once told by an 'eminent' soil scientist that it takes 100 years for a natural environment to recreate one inch (2.5 cm) of topsoil.

The classic saying "the pigeons came home to roost" applied in the Manawatu hill country when, some 50 years after clearing the land for agriculture, the roots of the native vegetation gave way and the land began slipping. The same thing happened much earlier in the Gisborne hill country, where whole hillsides moved downhill to fill streams and rivers, causing immense loss of topsoil and cost for mitigation (but not remedial) action (Allsop, 1973).

Increased atmospheric CO_2

Sands (2005) goes to some length to discuss the current obsession with Carbon dioxide. Burning wood converts sequestered carbon to Carbon dioxide, end of story.

Fire legislation

Historically, important forest fire legislation was enacted after devastating fires such as the Puhipuhi Forest fires of the 1880's. Initially this legislation was contained within the Forests Acts (1874 and 1921) for the protection of State forest, and elsewhere such as the Counties Amendment Acts of 1903 and 1908 to help private forest owners. However, the Forest and Rural Fires Act of 1947, the initial rapid response to the disastrous 1946 fire season, was the first Act dedicated specifically to rural fire control, and the first aimed directly at protecting areas other than State forest. The passing of the Forest and Rural Fires Act in 1955 brought all forest and rural fire legislation under one Act for the first time (Cooper, unpublished).

The 1946 legislation did much to reduce the indiscriminate use of fire to destroy forest and scrubland, though Cooper also attributes the decline in forest fires to the conversion of inflammable scrub and fern on forest boundaries to "fire-safe" farmland. In other words, as agriculture improved, so the losses of forest from fires reduced.

Cooper also reported that NZ Forest Service unpublished records for the 1970 decade showed that the numbers of fires reported by all fire authorities "is high" at an average of 280 per annum burning a total of 4,100 ha. "The bulk of this loss is scrub, fern and tussock. Exotic forest loss averages 330 ha per year, and indigenous forest loss is negligible. The major cause of fire in exotic forests is still burning off for land clearance, but many fires are started from equipment and vehicles used in the forests. Scrub fires on the edge of and within indigenous forest are often deliberately lit for deer browse".

But comparing these losses with those reported in 1.2.1 above, a vast improvement is obvious.

4. Fire as a tool

This section explores the use of fire as a tool which is beneficial to nature, as opposed to its use to clear native vegetation for conversion to pasture land or exotic forest, both of which have been the main uses of fire in New Zealand in the past.

Internationally, fire has been an effective tool in the management of some forest ecosystems, though the examples are few and relatively recent. Sands (2005) argues reasonably strongly against the use of fire as a tool to clear sites between rotations of plantation grown species, but promotes the use of fire in the management of *Eucalyptus regnans* in Australia. Burrows (1999), in his report for the Department of Conservation (DOC) says "Some ecosystems, such as native forests, are destroyed by fire. Others, such as tussock grasslands and some wetlands, are fire-induced and depend on fire, if only very occasionally, for their maintenance".

The New Zealand experience is limited mainly to the burning of crop stubble after grain harvesting, burning cutover exotic forest between rotations, and the burning of tussock grasslands to rejuvenate tussock growth.[10]

The Dept of Statistics has recently released some interesting provisional data from its 2007 census which throw some light on current use of fire as a tool by landowners. Controlled burning of crop residues totalled nearly 60,000 ha, 95% of this being in the South Island. Burning of tussock totalled 23,000 ha, 99% being in the South Island. And burning of other standing vegetation totalled 13,000 ha, 75% of this being in the South Island. The dominance of the South Island in these data is interesting, and it would be interesting to obtain more details on the make-up of 'crop residues' (which we assume refers to grain stubble and the like) and 'other standing vegetation' (which could include the now diminishing practice of burning cutover exotic forest prior to replanting by commercial forest owners).

The use of fire as a tool for re-juvenating tussock grassland has been a topic of hot debate between high

[10] *Picture of stubble fire in South Canterbury, September 2008*

country farmers, regional councils and DOC for at least two decades. In the on-going evolution of their role of managing the national conservation estate, now covering some 30% of the land area of New Zealand (Official New Zealand Yearbook 2006) (excluding Marine reserves), DOC has had a major change in focus with regard to fire. An internal audit report of DOC's fire management was published in 2005, and since then, through the preparation of two national policy documents, the emphasis is now on 'fire management' rather than 'fire suppression' (Hunt, 2007).

Implications for Future Fire Management

"If we forget about our history, we are in danger of repeating it" Anon.

The objective of the preceding narrative was to provide a comprehensive background for looking forward with respect to the future needs of effective and efficient forest and rural fire management in New Zealand.

Policies

Fire management covers a wide range of land ownerships, commercial and non-commercial organisations, and wider public interest groups with no direct affiliation, investment or involvement other than simply being New Zealanders. In order that New Zealand forest managers can cope with such a range of interest (vested and otherwise) strong government leadership needs to be demonstrated through a framework of well prepared national forest and land management strategies which bring together the diverse interests of various government departments for the wider good of the New Zealand public.

This strategy guideline then needs to be used to develop agreed objectives and specify agreed policies for future fire management of New Zealand's forest and rural hazardscape. This process will require full co-operation and assistance from all organisations (central government, local government, commercial and non-governmental) currently involved in or impacted by the effects of forest and rural fires. Such policies will need to be underpinned by appropriate fire research.

To ensure effective and efficient forest and rural fire management in New Zealand, the above policies will need to be implemented in the most practical and cost effective way.

Risk

Generally risk has to do with something unwanted that could happen in the future. It involves uncertainty, and an adverse consequence of something happening or going wrong.

In 1987 the New Zealand Government approved a new set of guidelines for its assistance for major emergencies based on outcomes ie., the recovery end of the process. The intention was to force people/agencies to think more broadly than just responding to events and away from insurance. The focus was to bring forward issues like loss prevention, public safety, business continuity, and minimizing social and economic input. The guidelines set out detailed principles and conditions, and got people thinking about consequences and cost.

In the years since the guidelines were issued, government has become convinced of the plan's practicality. It is risk based; it puts prime responsibility where it is best managed. It is an important principle of risk management that the owner of the risk should analyse, evaluate and take full responsibility of their risks.

This example also brings out a further point; that one of the overriding considerations for government is to ensure that the fairest balance is achieved of sharing the risk optimally between people as individuals, people as tax payers, and people as rate payers. These are not simply questions of finance ie., who should pay. Instead they are about determining the best level at which to manage the various risks.

There will still be risk. Risk is not something that can be eliminated from our rural and forest lands. Jerry Williams suggested in 2004 that somewhere between the freedoms of human judgement (where lapses have terrible consequences) and rule books, in the form of precise manual direction (where we can never write manuals thick enough to cover every contingency); somewhere between these two, lies good policy. Policies guide our decisions and actions. In broad terms, policies should help us deal with pervasive, complex problems.

Research

'Fire management' implies a potentially positive use for fire, or at least an understanding of both the positive and negative aspects of fire with respect to conservation management. In 2007 DOC released a report prepared by D.Hunt strongly advocating a proactive role for DOC in fire research in New Zealand. "Information gathered in preparing this report supports the view that understanding fire ecology (i.e. fire's impact on ecosystems and species) is fundamental to nature conservation and will enable DOC to make better conservation management decisions".[11] The report also emphasises the need to close the gap between research findings (including results from on-going research) and management practice.

Several bodies have been involved in fire research, and a number of government departments and research authorities are still active in this field.

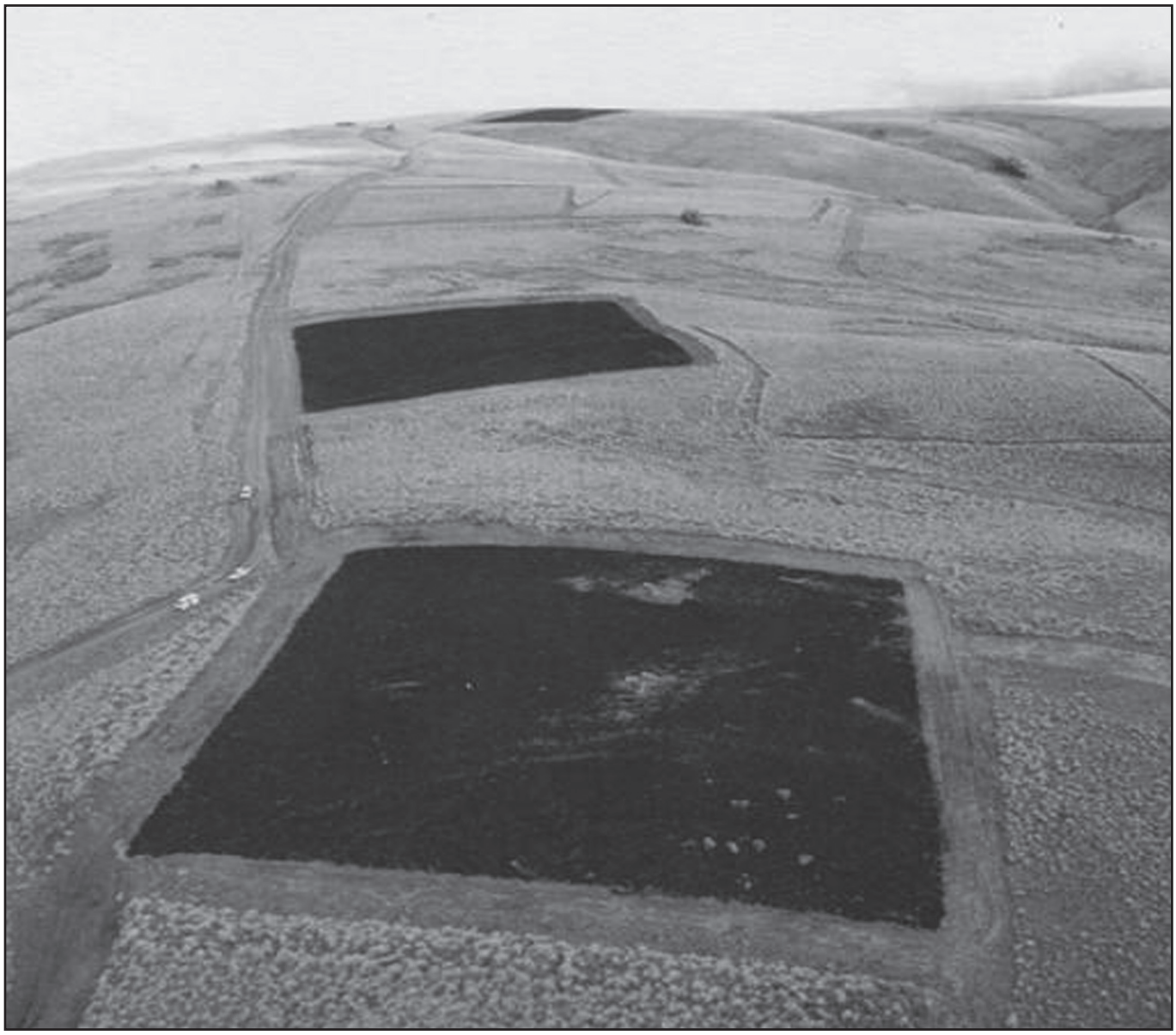
[11] *View of Mt Benger research burn, Otago 2006 - picture on cover of Hunt 2007 - see picture next page.*

Conclusion

From the perspective of a twenty-first century Kiwi, what lessons emerge from our past with respect to forest and rural fires? The truisms which can be seen are:

1. Uncontrolled forest and rural fires can, and usually do cause financial loss from the unsalvageable timber contained within burnt forests, and from the loss of the growing "capital" (live trees and other vegetation) in a burnt forest or other rural environment. These losses are quantifiable, and can be significant. Examples: Puhi Puhi Forest fire of 1880's; Balmoral Forest fire of 1950's
2. Forest fires can result in significant loss of sequestered carbon, and unwanted addition to atmospheric carbon (in the form of CO2) which is a "greenhouse" gas. These losses are becoming quantifiable as methods for measuring carbon stored in plant material are developed for the government's climate change initiative.
3. Forest and rural fires can cause damage to and loss of threatened species of plants and animals, and lead to soil erosion. These losses are hard to value. Examples: loss of native quail in the Wakatipu fire of 1850's; erosion of Gisborne and Manawatu unstable hill country since removal of forest (largely by burning) and conversion to grass.
4. Forest and rural fires can cause severe injuries and loss of life both to those involved in fighting a fire, and those victims caught in its path. Such losses are hard to value.
5. There is no such thing as "fire risk". Rather there is a risk in which fire may be the agent of fortuity.
6. Increasing importance of cross-sectoral issues in forest policy, demands coherence and co-ordination with other policies and instruments, which may have direct or collateral impacts on fuel accumulations and fire ignition patterns.

- Justice policies and landowners legal aspects
- Financial and fiscal policies towards rural property



- Land use planning and development policies
- Economic and energy policies
- Agricultural and rural development policies
- Conservation and natural resources management policies

etc...

But what has happened to turn us towards a more responsible nation with respect to forest and rural fire?

1. The legislation had to change. The earliest conservation laws of the 1870's were a brave attempt to establish some discipline into what had become a laissez faire attitude to the natural environment. But it was to take many decades of legislation before the Conservation Act 1987 and Resource Management Act 1991 set the country on its current environmentally responsible course. These laws will continue to evolve.
2. The land managers' practices had to change. The apt term "match-stick farming" didn't come from nowhere. New Zealand is able to punch well above its weight with respect to scientific research and development of sound and sustainable land management principles - our thriving land-based industries of farming, forestry and viticulture are testament to that. But progress toward this was slow, and can still be unnecessarily slow, when the facilities for efficient and effective technology transfer are lacking.
3. The public's attitude had to change. People had to become educated about the benefits of sustainable management, and the dangers of uncontrolled and unsustainable activity. In other words, there had to be a paradigm shift in the way the ordinary person felt about the environment in which they were living. The outrageous and outspoken environmental movement of the 1970's and 1980's had a lot to do with bringing about this awareness.
4. The processes for dealing with rural fire control had to change. Good fire control requires education of the public, fire research, and a structure that responds to the individual needs of each region but which is in sync with the over-arching framework. This cannot be done by centralising everything. At the end of the day, fire control is just another aspect of land management, along with pest control, weed control, or soil and water control. The local managers need to be property and appropriately resourced, and need to be accountable for achieving the desired outcomes. Part of this process requires the development of a Statement of agreed objectives and policies for future forest and rural fire management in New Zealand.

Acknowledgements

The authors wish to acknowledge the helpful comments on the draft manuscript provided by John Purey-Cust. They also wish to acknowledge permission to use statistics provided by the Dept of Statistics and information provided by the Department of Conservation.

References

1. Allsop, F. (1973); *The story of Mangatu, the forest which healed the land*. AR Shearer, Government Printer. 100 pp
2. Burrows, N.D. (1999); *Fire ecology and management information transfer from Western Australia to New Zealand*. Department of Conservation science and research internal report No. 166. 30 pp
3. Cooper, A.N. (Unpublished) *Forest fires in New Zealand - history and status 1880-1980*. 11 pp
4. Dick, R.D. (1956); Sixty years after a mountain beech forest fire. *NZ Journal of Forestry*, Vol. VII No.3. p104-108.
5. Dudfield, M. (Unpublished); *Fire management for forest and rangelands in New Zealand*. 3 pp
6. Falla, R.A., Sibson, R.B., and Turbott, E.G. (1979); T*he new guide to the birds of New Zealand*. Collins 247 pp
7. Gilkison, R. (1930); *Early days in Central Otago*.
8. Halkett, J. (1991); T*he native forests of New Zealand*. GP Publications Ltd. 149 pp
9. Hunt, D. (2007); Department of Conservation fire research needs analysis. Report on a project to implement Recommendation 7 of DOC's Fire Management Systems audit. DOC 95 pp
10. Hutchins, D.E. (1919); *New Zealand forestry, part I, kauri forests and forests of the north and forest management*. Department of Forestry, New Zealand. 200 pp
11. *New Zealand official yearbook 2006*. Statistics New Zealand. 536 pp
12. Prior, K.W. (1958); *NZ Journal of Forestry*, Vol. VII No.5. p35-50.
13. Roche, M.M. (1987); *Forest policy in New Zealand - an historical geography 1840-1919.* The Dunmore Press Ltd 143 pp
14. Sands, R. (2005); *Forestry in a global context*. CABI Publishing. 262 pp
15. Taylor, R., and Smith, I. (1997); *The state of New Zealand's environment 1997*. Ministry for the Environment. 633 pp
16. Timmins, S.M. (1992); Wetland vegetation recovery after fire: Eweburn Bog, Te Anau, New Zealand. *NZ Journal of Botany*, Vol30, pp 383-399
17. Ward, J. (2005); *The Balmoral forest fire*. National Rural Fire Authority. 35 pp