Fire Management Branch
Department of Conservation and Natural Resources
ISBN 0 7306 2596 6

A CASE STUDY OF WILDFIRE MANAGEMENT IN THE BYADBO AND TINGARINGY WILDERNESS AREAS

RESEARCH REPORT No. 38

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July 1993

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A Victorian Government Publication.

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SUMMARY

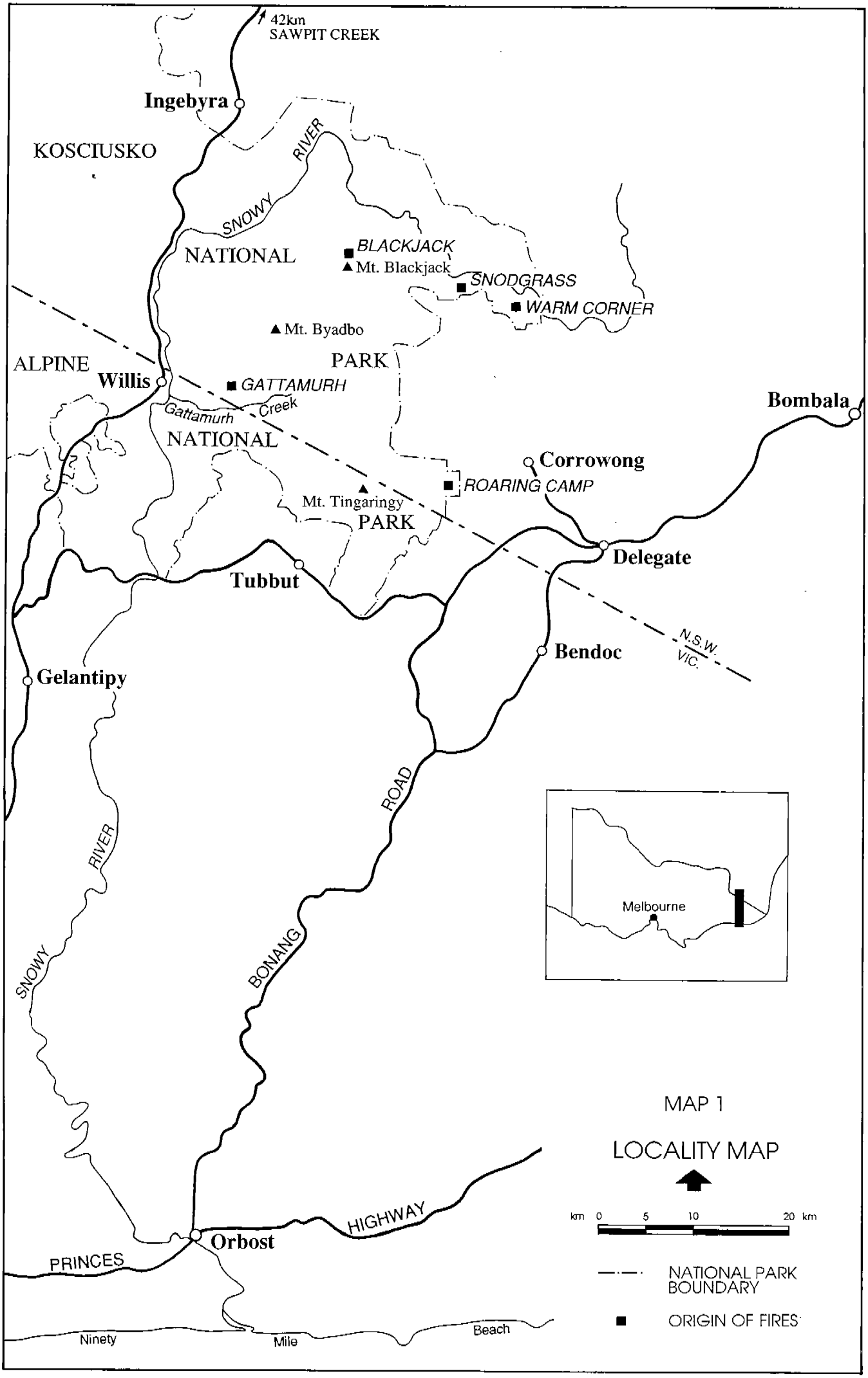
This report describes the suppression and wilderness policy implications of two large wildfires, which originated in January 1988 from a series of lightning strikes seven days apart, in the Byadbo wilderness area of Kosciusko National Park in south-eastern Australia. Victorian and New South Wales fire services co-operated to suppress the fires over a period of 18 days.

After the failure of initial suppression operations, the New South Wales National Parks and Wildlife Service (NPWS) concentrated its resources on those fires which threatened private assets and allowed the remote Blackjack fire to burn for four days within pre-determined control lines. However, the Blackjack fire became a large wildfire, which burnt out into private property, largely because resources were insufficient to implement the necessary fire suppression operations within the time available. The initial suppression operations on the remote Gattamurh fire by the Victorian Department of Conservation and Natural Resources (CNR) failed largely because of a delay of nearly 24 hours in the arrival of ground fire-fighters. These two fires joined together and burnt a total of 63,000ha in New South Wales and Victoria, including more than 50,000ha of the Kosciusko National Park, 9,000ha of the Alpine National Park and 2,750ha of private property. An Emergency Situation was declared which lasted for 9 days.

Both NPWS and CNR used Large Fire Organisations to plan and manage the suppression operations, with each organisation using indirect suppression strategies involving the preparation and defence of more than 40km of control line. NPWS's operations extended over 25 days and involved the use of 90 fire-fighters, 5 aircraft, 3 bulldozers and numerous fire tankers. The Blackjack fire could not be contained within the planned control lines with the result that 2650 ha of private property was burnt. CNR's operations extended over 10 days and involved the use of 300 fire-fighters, 6 aircraft, 13 bulldozers and numerous small tankers. With the exception of a few small spot fires, CNR was able to contain its part of the fire within the planned control lines. Despite the considerable potential for loss of private assets in Victoria only 100ha were burnt. The importance of adequately resourcing large scale suppression operations was clearly demonstrated.

Aircraft were used extensively throughout the suppression operations and greatly assisted fire control. Firebombing operations were most effective on spot fires when deployed rapidly with short turn around times and where ground fire-fighters arrived within two hours of detection. Infra-red imagery was used extensively to obtain information about the development of the fires, the location of unburnt fuel and the condition of recently burnt areas, thereby greatly assisting the development of informed fire control strategy decisions.

The need to maintain a policy of planned control of all summer wildfires which occur in wilderness zones of National Parks in south-eastern Australia was clearly demonstrated. Current wilderness fire management policies however, could be modified to incorporate a range of fire control strategies without compromising fire control objectives. In order not to affect environmental values unduly in these areas, the increased use of aerial fire-fighting techniques should be pursued together with the preference for using existing tracks, or hand-constructed control lines, if direct attack fails. For this policy to be effective, management plans for wilderness areas must provide for the planning and implementation of fire protection works in strategic but less environmentally sensitive areas.


42km
SAWPIT CREEK
Ingebyra
KOSCIUSKO
SNOWY RIVER
NATIONAL
BLACKJACK
Mt. Blackjack
SNODGRASS
WARM CORNER
Mt. Byadbo
PARK
ALPINE
Willis
GATTAMURH
Gattamurh Creek
NATIONAL
Bombala
Corrowong
ROARING CAMP
Mt. Tingaringy
PARK
Delegate
Tubbut
Bendoc
N.S.W.
VIC.
Gelantipy
SNOWY RIVER
BONANG ROAD
Melbourne
HIGHWAY
Orbost
PRINCES
Ninety Mile Beach
MAP 1
LOCALITY MAP
km 0 5 10 20 km
NATIONAL PARK BOUNDARY
ORIGIN OF FIRES

INTRODUCTION

Wildfires occur frequently in south-eastern Australia, with the potential for large wildfires burning under conditions of extreme fire danger to develop almost every third year (Cheney, 1976). This region is characterised by predominantly mountainous, forested country and contains many large National Parks, including Kosciusko (690,000ha), Snowy River (98,700ha), Croajingolong (82,130ha), Coopracambra (36,300ha), and the Cobberas-Tingaringy unit of the Alpine National Park (178,400ha). These National Parks contain 14 designated wilderness areas, ranging from 7,100ha to 92,400ha in size (see Appendix 1), with nearly 225,000ha of Kosciusko and Cobberas-Tingaringy, in proximity of the New South Wales (NSW) - Victoria border, being zoned as wilderness. Land exhibiting wilderness values is a relatively scarce resource in this region.

Fire management (including fire exclusion) can affect wilderness values adversely by changing natural ecological processes or by imposing man-made features. These wilderness areas contain other environmental values, such as some fire sensitive vegetation, threatened species and highly erodible soils, which can be adversely affected by inappropriate fire management.

In eastern Victoria, the Department of Conservation and Natural Resources* (CNR) is responsible for fire suppression on about 800,000ha of public land, which includes National Parks, State Forests, Flora and Fauna Reserves and Reference Areas. During the 10 year period from 1978/79 to 1987/88 the Orbost Region of CNR (essentially comprising the land to the east of the Snwoy River) suppressed 600 wildfires which had burnt a total of 400,000ha, although only 27 of these fires were larger than 500ha. The largest wildfires occurred in 1983 when two wildfires burnt a total of 253,000ha around Cann River. Lightning was the major source of wildfires, causing 46% of ignitions in the Orbost Region as compared with 29% of all ignitions attended by CNR in Victoria (Bartlett, 1990). In southern New South Wales, fire suppression responsibility varies according to land category, with the National Parks and Wildlife Service (NPWS) being responsible for National Parks, the Forestry Commission being responsible for State Forest and the relevant Shire Council being responsible for vacant Crown Land as well as private property.

Fire suppression policy and practice on public lands in Victoria is based on a long history of large and damaging fires and the consequent legal requirement of the Forests Act (1958) that proper and sufficient work be carried out for the prevention and suppression of fire on public land. CNR has an adopted policy on fire management for wilderness areas (CFL, 1988), of which the key elements include:

- the suppression of all wildfires;
- the use of suppression techniques including aerial suppression which least affect wilderness quality;
- the concentration of fire protection works in buffer areas;
- the use of strategies that minimize the possibility of a whole wilderness area being burnt by a single wildfire.

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* In April 1990, the Victorian Government reorganised its Department involved in land use and the environment. At that time the Department of Conservation, Forest and Lands became the Department of Conservation and Environment. In October 1992, a further reorganisation occurred which led to the creation of the Department of Conservation and Natural Resources.

The Land Conservation Council in its final recommendations on wilderness (LCC, 1991) endorsed CNR's policy on fire management for wilderness areas but added an additional recommendation that the "impacts of upgrading and construction of tracks or other facilities, such as helipads or water storages, on the natural condition of the land, be minimized".

NPWS's primary objective relating to fire management is to minimize the undesirable effects of fires on values within and adjoining a park (NPWS, 1988). Its policy is to take all reasonable steps to prevent the spread of fire from the park to adjoining land. During the summer months, suppression operations are conducted on all wildfires to contain the fire to as small an area as possible using suppression strategies which minimize the impact of their use. If initial attack fails, subsequent suppression is to be based on backburning from existing trails with careful use of earth-moving equipment.

During January 1988, lightning ignited a total of five fires in and around the Byadbo wilderness zone of Kosciusko National Park (see Map 1). This area is remote, with few existing tracks. The elevation ranges from 400 - 1450m, although most of the area is below 800m. A significant rain shadow exists with most of the area receiving only 400 - 500mm of rain each year. The vegetation varies considerably, from *Eucalyptus albens - Callitris spp* woodland in the vicinity of the Snowy River, through mixed *Eucalyptus spp* open forests to alpine vegetation on the slopes of Mt Tingaringy.

Prolonged drought conditions had prevailed over the Byadbo area for the two years prior to 1988, with below average winter/spring rains in 1987. Exceptionally hot and dry conditions occurred during December 1987 and January 1988, with temperatures exceeding 30°C on most days during the first half of January 1988. Conditions of high to very high fire danger (see Figure 1) prevailed on all but two days until the fires were controlled.

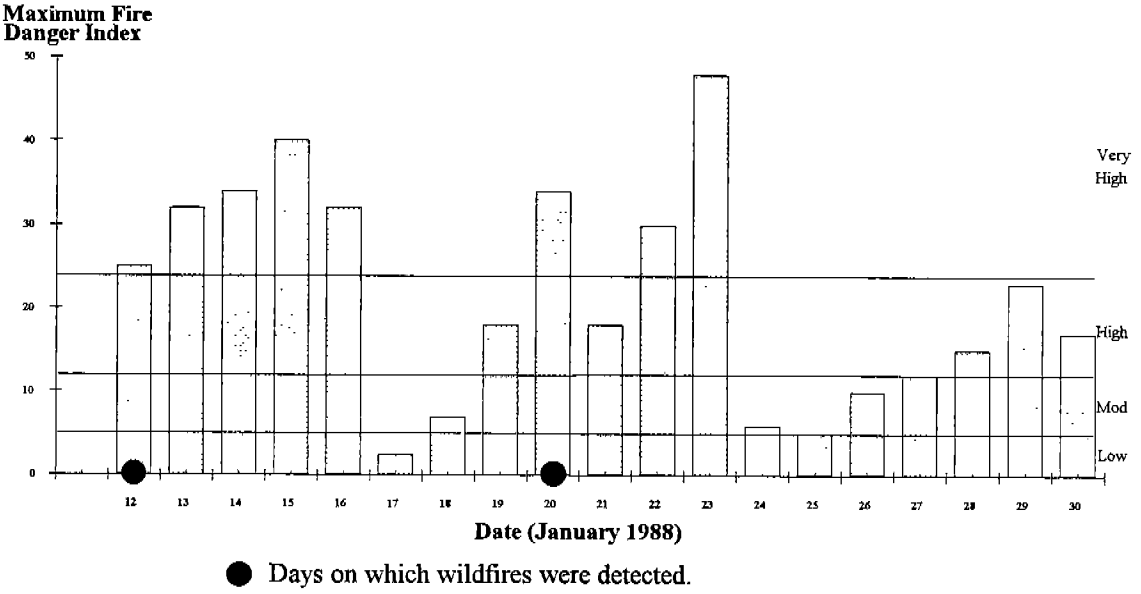


Figure 1. Forest Fire Danger Index (daily maximum) during the Blackjack and Gattamurh wildfires.

The purpose of this report is to describe the suppression of the 1988 Byadbo wildfires and hence to evaluate the appropriateness of wilderness fire management policies for mainland south-eastern Australia. The report concentrates on the suppression of the two larger Blackjack and Gattamurh fires, each of which is described for a number of periods in terms of: the situation; the suppression strategy which was adopted; and the outcome. References to Fire Danger Index (FDI) are as calculated using the McArthur Mark 5 Forest Fire Danger Meter (McArthur, 1973).

FIRE SUPPRESSION OPERATIONS

(A) Blackjack Wildfire

Day 1 12 January

Situation:

In the early afternoon of 12 January, 1988, a violent electrical storm passed over the Byadbo wilderness zone, igniting four fires dispersed over an area of 400km^2. Three of these, known as Roaring Camp, Warm Corner and Snodgrass fires, were within 1km of private property, while the fourth, known as Blackjack fire, was 6km from the nearest non-forested private property.

The actual weather conditions experienced between 13-22 January in the Byadbo area are shown in Table 1 and the resources utilised by NPWS during the suppression of the Blackjack, Snodgrass and Warm Corner fires are shown in Table 2.

Table 1: Actual weather conditions for the Byadbo area between 13 and 22 January 1988. Source: Robson (1988).

Date	Maximum temperature (^{0}C)	Minimum RH (%)	Wind direction	Wind speed (km/h)	Fire Danger Index
12 Jan*	34	17	NW	5	26
13 Jan	36	16	SW	5	32
14 Jan	36.5	18	S	25	34
15 Jan	37	15	N/SW	20	40
16 Jan	36	21	S	20	32
17 Jan	19	74	SE	15	2
18 Jan	24.5	46	SE	10	7
19 Jan	31	30	NW/SE	15	18
20 Jan	29	18	NW	30	34
21 Jan	29	24	NW	10	18
22 Jan	30	16	NE	20	30

* Source: Forestry Commission, Bombala

Table 2: Resources utilised by NPWS fire suppression operations between 12 and 23 January 1988. Source: Robson (1988)

Table 2: Resources utilised by NPWS fire suppression operations between 12 and 23 January 1988. Source: Robson (1988)

Date	Fire-fighters	Support personnel	Bulldozers	Helicopters light/medium
12 Jan	15	8	1	0/1
13 Jan	29	13	1	1/1
14 Jan	29	15	1	1/2
15 Jan	33	14	1	1/2
16 Jan	30	14	3	1/1
17 Jan	30	13	3	1/2
18 Jan	44	16	3	1/2
19 Jan	55	15	3	1/2
20 Jan	70	21	3	1/4
21 Jan	50	24	3	1/4
22 Jan	55	22	3	1/3
23 Jan	43	25	4	1/3

Strategy:

NPWS decided to establish its fire control structure and to commence initial suppression operations on the fires, with support from the Bombala Shire and volunteer brigades on the Warm Corner and Snodgrass fires. NPWS gave approval for the use of fire retardant on the Roaring Camp fire, which was located close to a track 2km north of the State border. Because the Blackjack fire was located in rugged country more than 4km from the nearest track, the fire controller decided to use direct attack tactics and to transport fire-fighters by helicopter to the fire.

Outcome:

A CNR fixed-wing firebomber based at Delegate dropped one load (900L) of retardant on the Roaring Camp fire. Volunteer brigades from the NSW Bushfire Council and Victorian Country Fire Authority (CFA) quickly suppressed that fire. NPWS obtained a medium-sized helicopter from Wollongong and winched two four-person crews into the Blackjack fire area at 1630 and 1800 respectively. Even though the fire-fighters were experienced, the fire spread too quickly to be contained by night fall. Work during the night was too dangerous because of steep terrain.

Days 2-5 13-16 January

Situation:

The Blackjack fire had increased in size to 144ha. Neither the Warm Corner or Snodgrass fires had been controlled on the first day. The forecasted weather was for hot and dry conditions with light to moderate winds. The expected fire danger for the next four days was therefore very high. After the failure of direct attack, control options for the Blackjack fire were limited because of the steep terrain and the sparse track network. The logical existing control lines were the Biddi, Byadbo and Byadbo Gap fire trails, as well as the Snowy River and Byadbo Creek (see Map 2).

Strategy:

Because of the potential threats to life and property from the Warm Corner and Snodgrass fires, NPWS decided to concentrate its limited resources on the suppression of those fires and to withdraw the fire-fighters from the Blackjack fire on the morning of 13 January. The fire controller used the NPWS's PREPLAN geographic information system, incorporating the McArthur fire behaviour model, to predict that the Blackjack fire would not threaten the existing control lines for at least four days. For those reasons, NPWS decided not to carry out active suppression operations on the Blackjack fire during that four day period but to carry out daily aerial reconnaissance and mapping of the fires.

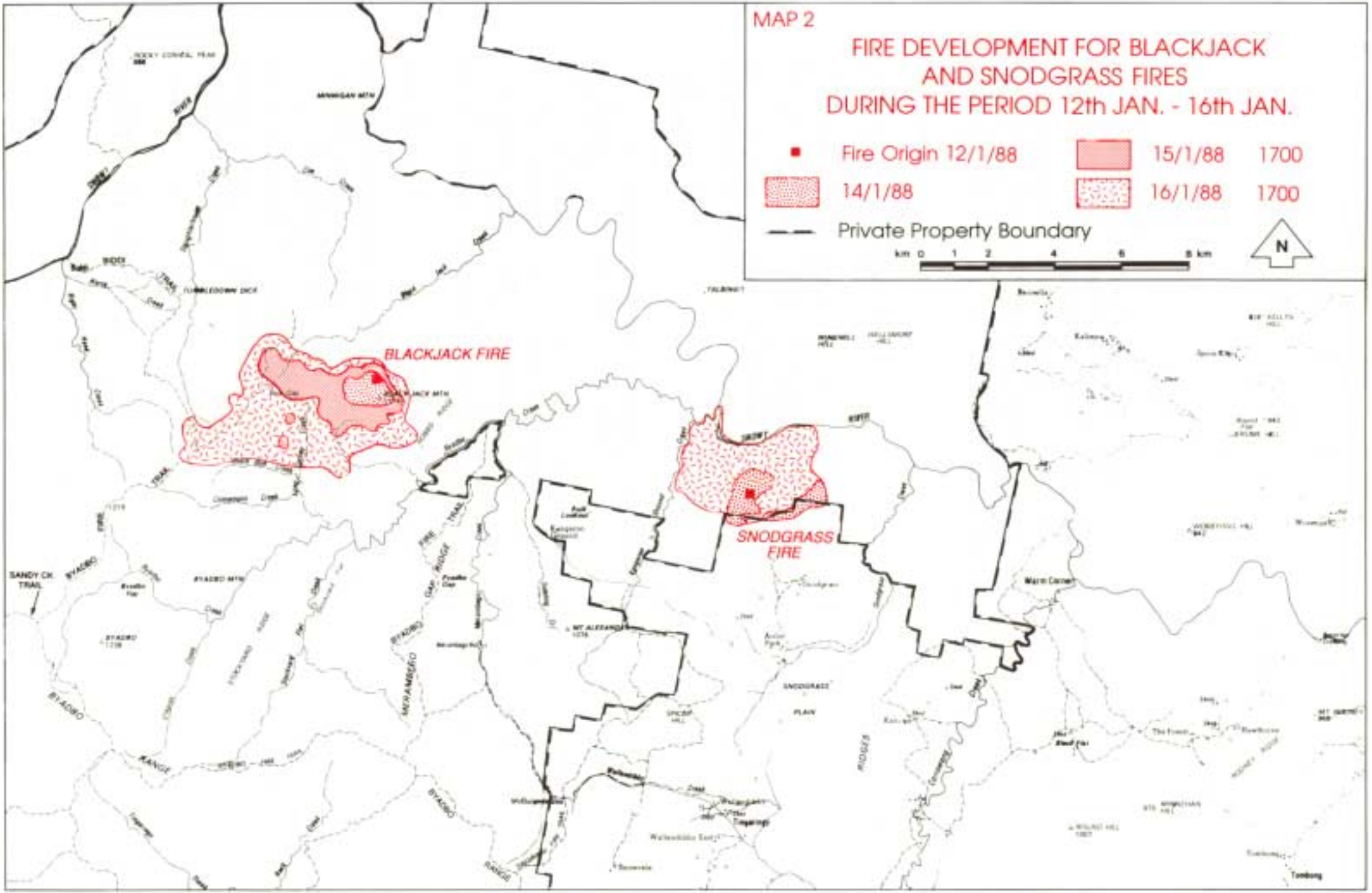
Outcome:

NPWS controlled the Warm Corner fire on 14 January at a size of 15ha and the Snodgrass fire on 16 January at 1500ha. The Blackjack fire behaved much as predicted: it increased in size to 1740ha and spread mainly in a south-westerly direction (see Map 2). On 16 January it crossed the Biddi Trail, which had been one of the planned control lines. Some very light rain fell on the evening of the 16 January.

Days 6-8 17-19 January.

Situation:

The weather had moderated considerably, with daily temperatures between 19-29^{O}C, minimum relative humidities between 74-30% and generally light south-westerly winds. The perimeter of the Blackjack fire was still located to the north of the Byadbo Creek, between 0 and 9 km from the existing fire trails, and its eastern development was being limited by an area on Hobbs Ridge which had been fuel reduced in 1985. The NPWS resources that had been used on the Warm Corner and Snodgrass fires were now available for deployment on the Blackjack fire and in addition three bulldozers were available for track preparation work.


MAP 2
FIRE DEVELOPMENT FOR BLACKJACK AND SNODGRASS FIRES DURING THE PERIOD 12th JAN. - 16th JAN.
Fire Origin 12/1/88
14/1/88
15/1/88 1700
16/1/88 1700
Private Property Boundary
km 0 1 2 4 6 8 km
N
BLACKJACK FIRE
SNODGRASS FIRE
BYADBO RANGE
SANDY CK TRAIL
OAK RIDGE
MT ALEXANDER
SNODGRASS PLAIN
Tambong

Strategy:

NPWS made the following strategic decisions:
- to establish a base camp at Byadbo Gap, 5km south-east of the fire, but to maintain its fire control organisation at Sawpit Creek Park Headquarters, 50km to the north;
- to engage three bulldozers to clean up the fire trail, giving priority to containing the fire that had crossed the Biddi trail, as well as to cleaning the tracks around the Kangaroo Ground private property;
- to mount intensive operations involving ground fire-fighters and water bombing helicopters on Hobbs Ridge in the hope that the fire could be contained north of Byadbo Creek;
- to schedule back burning for the Biddi trail and Byadbo trail north of its junction with the Sandy Creek trail;
- to conduct aerial ignition of unburnt areas, in the vicinity of Biddi trail and north of Byadbo Creek, in an attempt to keep the fire from crossing the natural control line of the Byadbo Creek; and
- to arrange additional fire-fighters to implement its suppression operations.

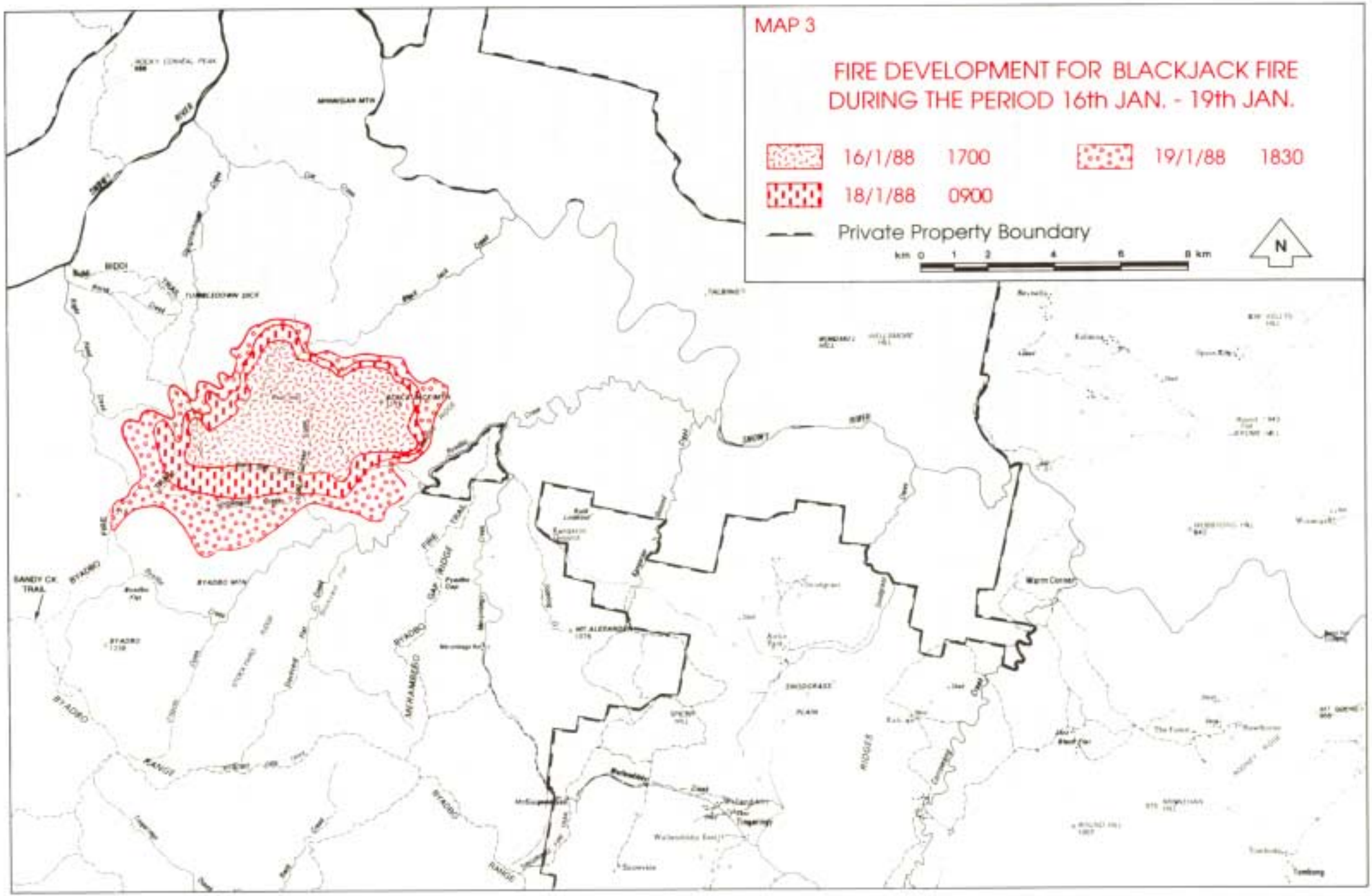
Outcome:

NPWS controlled the spot-over in the vicinity of Biddi trail on 18 January and held the eastern edge of the fire at Hobbs Ridge. A flare up of the Snodgrass fire on the eastern side of Byadbo Creek near its junction with the Snowy River occurred late on the afternoon of 19th January. NPWS attacked it using ground fire-fighters and water bombing helicopters, but the diversion of resources prevented the implementation of the aerial ignition north of Byadbo Creek. Back burning operations were undertaken on the western perimeter along Biddi and Byadbo trails on 19 January. The fire increased in size to 3380ha, spread mainly in a south-westerly direction and was uncontrolled on both its northern and southern perimeters (see Map 3).

Days 9-10 20-21 January

Situation:

Extreme fire weather was forecast for 20 January with strong north-westerly winds prevailing during the afternoon. NPWS had detected the Gattamurh fire at 0930 during aerial reconnaissance of the Blackjack fire. NPWS had not completed control lines to the south and east of the Blackjack fire. The 45 km of existing trails had been cleaned up but backburning had not been undertaken along most of the Byadbo and Byadbo Gap trails. Because aerial ignition of unburnt country north of Byadbo Creek had not been undertaken it was likely, given the forecast weather, that the fire would cross Byadbo Creek during the day.


MAP 3
FIRE DEVELOPMENT FOR BLACKJACK FIRE
DURING THE PERIOD 16th JAN. - 19th JAN.
16/1/88 1700
19/1/88 1830
18/1/88 0900
Private Property Boundary
km 0 1 2 4 6 8 km
N
BIDDI
MIMINGAH MTN
BYADBO
BYADBO MTN
BYADBO RANGE
SANDY CK TRAIL
FIRE TRAIL
GAP RIDGE
MYRAMBEEBO
MT ALEXANDER
SWIDDRASS PLAIN
RIDGES
Warm Corner
Tenterfield

Strategy:

NPWS recognised the need to contain the wildfire within the Byadbo fire trail system. It planned to undertake further back burning as conditions allowed, giving priority to controlling the eastern flank of the fire, as that was the area which could threaten private property. It also decided to obtain two additional medium helicopters and to hand over the initial suppression of the Gattamurh fire to CNR, under the arrangements contained in the previously determined Border Fire Agreement.

Outcome:

At 1500 on 20 January the fire, fanned by strong north-westerly winds, breached control lines near Byadbo Gap and threatened the NPWS base camp, which had to be shifted to private property at Corrawong. NPWS personnel and volunteer brigades conducted a backburn at Wollondibby Station which was in the path of the escaped wildfire. They contained that escape during the evening and conducted further back burning along Byadbo and Biddi trails.

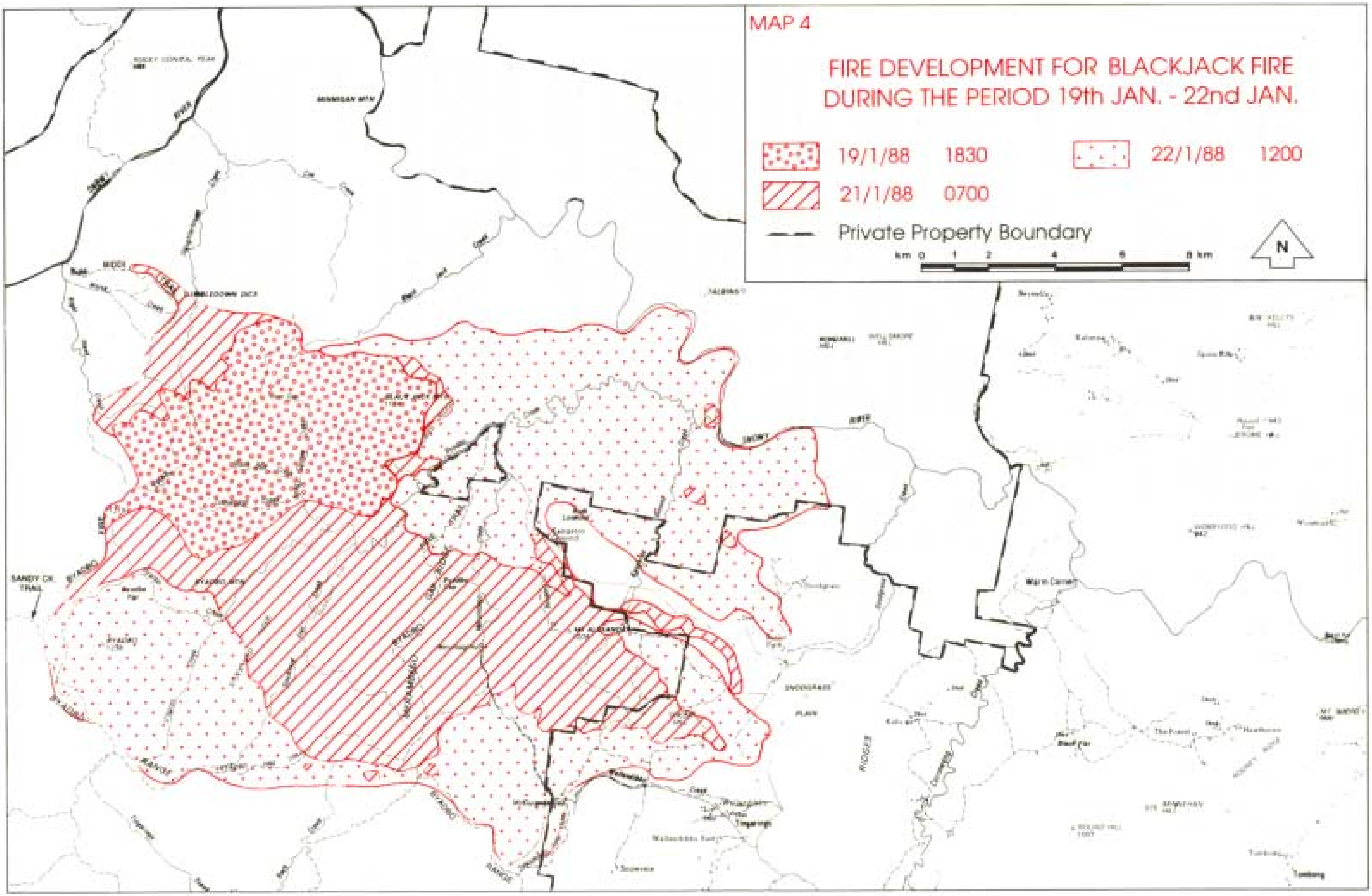
By the morning of 21 January, the Blackjack fire had crossed 6 km of the Byadbo trail, had burnt about 10,000ha, was within 8km of the Gattamurh fire and was burning out of control across its 25km wide southern flank (see Map 4). During that day a spot fire occurred on the north side of the Snowy River below Windmill Hill. NPWS quickly suppressed it using water bombing helicopters. As a result of the north-westerly winds, the wildfire spread in a south-easterly direction and burnt out into private property in the Kangaroo Ground and Wollondibby areas. Strong winds reactivated the southern edge of the previously controlled Snodgrass fire which then also burnt out into private property.

At 1400 on 21 January, the Chief Co-ordinator of the NSW Bush Fire Council declared a Section 41F Emergency under the NSW Bushfires Act for the fires in Kosciusko National Park, and appointed a Co-ordinator for the overall fire suppression operations. Later in the afternoon the Co-ordinator convened a meeting of representatives from the fire services working on the fires to determine a combined fire strategy. That meeting allocated sectors to each of the three NSW fire services and the southern sector, which was mostly in Victoria, to CNR. Each fire service maintained its own command structure, with the three NSW services reporting to the Co-ordinator. CNR was legally and financially responsible for its own operations but maintained close liaison with both the Co-ordinator and the NPWS.

Days 11-12 22-23 January

Situation:

The NPWS was responsible for the western and northern sectors of the combined fire suppression effort, stretching from Willis on the Victoria - NSW border to the Snowy River in the vicinity of the previously controlled Snodgrass fire. Responsibility for control along the eastern sector of the fire adjacent to private property lay with the NSW Bushfire Brigades and NSW Forestry Commission. Given the forecasted north-westerly winds, the anticipated fire control problems were on the eastern and southern sectors rather than on the NPWS sector.



MAP 4
FIRE DEVELOPMENT FOR BLACKJACK FIRE
DURING THE PERIOD 19th JAN. - 22nd JAN.
19/1/88 1830
21/1/88 0700
22/1/88 1200
Private Property Boundary
km 0 1 2 4 6 8 km
N
MINNEGAN MTN
SANDY CK. TRAIL
SNOWGRASS PLAIN
RIDGES
Warm Corner
Tongaroo

Strategy:

NPWS decided to establish a control line between the Snowy River and the Biddi Trail implementing the following tactics: backburn along the Sandy Creek trail; aerially ignite unburnt country between that line and the Gattamurh wildfire; and aerially patrol the Snowy River with water bombing helicopters.

On the eastern sector, the Bushfire Brigades decided to establish control lines in pasture land, with the aim of minimizing loss of private property.

Outcome:

NPWS completed backburning operations along all but the lower 2km of the Sandy Creek trail. Control lines on the private property were established and then held during the extreme fire weather of 23 January. Up to 200 volunteer fire-fighters were involved in those operations in any one day.

Days 13-18 24-29 January

Situation:

Light rain had fallen across the fire area during the previous afternoon and night. The fire was contained within control lines but several large areas of unburnt country existed within those lines. Cool mild weather was forecast for the next few days.

Strategy:

The Fire Co-ordinator decided that all unburnt country within the control lines would be ignited aerially to reduce the possibility of the fire escaping from control lines under future hot weather. The major task for the fire-fighters was to achieve an extinguished or blacked out edge around the fire's perimeter. Helicopters were to be used to transport crews to troublesome reignition sources (hot spots) within the burnt area.

Outcome:

NPWS carried out aerial ignition in the Sandy and Blackjack Creek watersheds. One spot fire, of undetermined cause, occurred on 29 January north of the Snowy River, but NPWS quickly contained it using a water bombing helicopter. The Section 4IF emergency was terminated at 1800 on 29 January. On 4 February, because of continued reactivation of previously extinguished edge in the area north of Bear Gap, NPWS decided to ignite aerially the remaining 6000ha of unburnt country in the area bounded by the Snowy River and Blackjack Creek. NPWS continued to patrol the fire edge and to conduct operations within the burnt area until 13 February (Day 33).

(B) Gattamurh Wildfire

Days 9-10 20-21 January

Situation:

The Gattamurh fire originated from lightning late in the afternoon of 19 January, at a position 1km north of the State border and 12km south-east of the Blackjack fire in the headwaters of the Gattamurh Creek (see Map 5). On that day the fire had remained undetected. It was burning in a box-type eucalypt woodland with a grassy understorey and was located on a ridge in an area which was very steep and rocky and where the creeks were rocky and dry.

Upon aerial detection at 0930 on 20 January, the NPWS reported the fire to the CNR Bendoc office (see Map 1) located 45km south-east of the fire. Initial assessment by CNR indicated that the fire would be difficult to control under conditions of high fire danger (see Table 3) and would threaten Victorian assets, particularly the Alpine National Park. The 0.5ha fire was remote, the nearest track was overgrown and 2km away, and ground crews were not expected to reach the fire for at least five hours.

The forecasted and actual weather conditions for each of the first four days of the Gattamurh fire are given in Table 3 and the resources utilised by CNR are shown in Table 4.

Table 3: Forecast and actual weather for the first four days of the Guttamurh wildfire.

DATE	FORCASTED WEATHER					ACTUAL WEATHER				
	Maximum temp (°C)	Minimum RH (%)	Wind direction	Wind speed (km/h)	Fire Danger Index	Maximum temp (°C)	Minimum RH (%)	Wind direction	Wind speed (km/h)	Fire Danger Index
20 Jan	21/25	40/15	SW/NW	20/40	10-40	29	18	N/SW	30	33
21 Jan	23	30	WSW	30	18	32	32	W	20	20
22 Jan	26	35	NW	20	14	34	21	WNW	20	30
23 Jan	27	50	NW	25-35	11	28	48	WNW	60-90	48

Table 4: Resources utilised by CNR fire suppression operations on the first four days of the Gattamurh wildfire.

DATE	SUPPRESSION RESOURCES				
	Fire-fighters (day/night)	Support personnel	Bulldozers	Fixed-wing firebombers	Helicopters (light/medium)
20 Jan	29/29	20	2	2	1/0
21 Jan	68/60	45	2	2	1/1
22 Jan	67/100	46	13	2	1/2
23 Jan	119/129	70	12	2	2/2

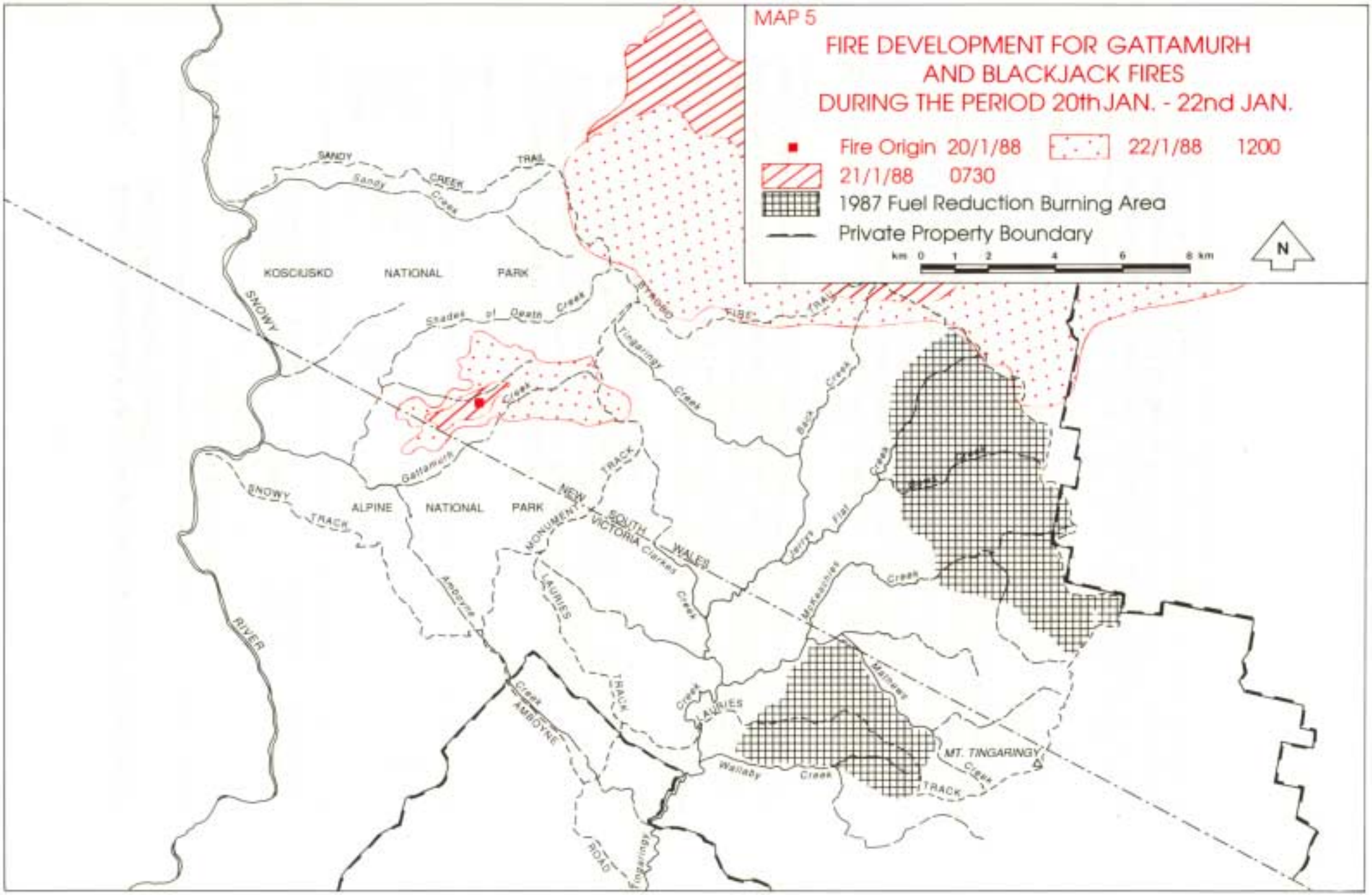
Strategy:

CNR made the following initial strategic decisions:
- to despatch an initial ground crew of nine fire-fighters by road from Bendoc;
- to engage two bulldozers to clear overgrown tracks and to construct an access trail;
- to utilise two fixed-wing firebombing aircraft and a light helicopter; and
- to request a medium helicopter with rappel crew.

Because of the potential for the fire to become large, CNR decided to initiate its fire control structure (known as the Large Fire Organisation or LFO) and to establish a forward headquarters and base camp at the small settlement of Tubbut, located about 15km south-east of the fire. CNR also decided to place a liaison officer in the NPWS headquarters at Sawpit Creek to ensure that effective communication was maintained between CNR and NPWS.

The CNR Fire Team decided to adopt a Fire Control Plan which had the objective of minimizing the area burnt. That plan contained the following strategic decisions:
- to confine the Gattamurh fire to the area between the nearby dry and rocky tributaries of Gattamurh Creek to the south and Shades-of-Death Creek to the north (see Map 5);
- to use direct attack tactics, with ground fire-fighters constructing control lines with hand tools and firebombing aircraft providing support where the flame heights made direct attack difficult; and
- to transport many of the fire-fighters on to the fireline by helicopter, to maximise their productivity.

The Fire Team gave this control strategy a 20-30% chance of success but rejected the alternative of backburning from the nearest existing tracks, such as the Sandy Creek Trail, Monument Trail, Snowy Track and the Snowy River, because it would have increased the fire area to 12,000ha. The strategy was developed on the assumption that the NPWS fire-fighters would contain the Blackjack fire at the Byadbo Fire Trail.


MAP 5
FIRE DEVELOPMENT FOR GATTAMURH
AND BLACKJACK FIRES
DURING THE PERIOD 20th JAN. - 22nd JAN.
Fire Origin 20/1/88
22/1/88 1200
21/1/88 0730
1987 Fuel Reduction Burning Area
Private Property Boundary
km 0 1 2 4 6 8 km
N
KOSCIUSKO NATIONAL PARK
ALPINE NATIONAL PARK
SNOWY RIVER
SANDY CREEK TRAIL
Sandy Creek
Shades of Death Creek
Tingaringy Creek
Gattamurh Creek
SNOWY TRACK
NEW SOUTH WALES
VICTORIA
MONUMENT
Clarkes Creek
Ferris Flat
McKeahnies Creek
Mathews Creek
LAURIES CREEK
AMBOYNE CREEK
TRACK
ROAD
MT. TINGARINGY
Wallaby Creek
TRACK

Outcome:

At about 1100 on 20 January, two firebombing aircraft each with 900 litre capacity commenced operating from the Delegate airstrip, some 43km from the fire. During the afternoon, each firebomber dropped seven loads of fire retardant. The initial aerial attack failed to contain the fire in the absence of ground fire-fighters and the fire spread along the ridge under the influence of a northerly wind. CNR used the light helicopter for reconnaissance and to direct aerial attack. The medium helicopter with a rappel crew and a 1,500 litre belly tank for firebombing, which was stationed at Benalla 230km west of the fire, did not arrive until 1800 due to pilot unavailability.

The first ground crew arrived at 1630. It found the fire to be 25ha in size, with a perimeter in excess of 2km, and to be spreading rapidly along the ridge and down the northern side of the ridge, under the influence of a south-westerly wind. The fire-fighters worked in conjunction with the fixed-wing aircraft to attack the head fire. However, with flame heights of up to 2m that tactic was unsuccessful and the Fireline Boss redeployed the crews to conduct direct attack on the flank fires. The first bulldozer arrived at about 1900 but, because of the terrain, was able only to construct a track along the ridge through the burnt area and to construct a helipad at the western end of the fire. By sunset a total of 29 fire-fighters were working on the fire.

During the night the winds changed from south-westerly to north-easterly. The construction of control lines with hand tools during the night was extremely dangerous, and was ineffective because rolling debris (such as burning logs) breached all control lines.

By early morning on 21 January the Gattamurh fire had extended into Victoria and was approximately 170ha in size with about 6km of perimeter. The base for the fixed-wing aircraft was moved from Delegate to Gelantipy airstrip to reduce turn-around times to 30 minutes. By midday the CNR fire-fighters had established control lines around more than 5km of fire perimeter, with 1km remaining uncontrolled in six separate tongues. This broken edge, combined with steep cliffs and rock screes, made the construction of control lines difficult. Flame heights were generally 0.4m while the fire was burning downhill but up to 2m where uphill runs occurred. Short distance spotting into the grass fuels of the eucalypt woodland continually breached some sections of control line. The firebombers were effective during the morning, but once the FDI rose above 12 in the afternoon they were unable to keep up with the numerous spot fires.

Situation at 1500, 21 January:

At 1500 the eastern edge of the fire had crossed the tributary of Gattamurh Creek and then, fanned by a westerly wind, had begun to run quickly up a spur towards Monument Trail. The Fireline Boss therefore had abandoned the direct attack strategy and had withdrawn the crews to Monument Trail, pending the development of a new fire control strategy.

The Blackjack and Gattamurh fires were then less than 4km apart and had a combined uncontrolled fire front of more than 30km (see Map 5). They were burning in an area where the nearest existing tracks which could be used as fire control lines were generally more than 10km away. Given the failure of direct attack, the size of the fires, the general lack of suitable tracks from which to establish control lines and the forecast of hot windy weather during the next 48 hours, control options were limited.

Strategy:

The NSW Fire Co-ordinator allocated CNR the southern sector which extended from Willis on the Snowy River 26km south-east wards to Mt Tingaringy and from there 5km north into NSW (see Map 6). The CNR Fire Team decided to prepare a new Fire Control Plan (see Appendix 2), which identified the fire control objectives, the constraints, the control strategies which would be adopted, and some tentative fallback control lines. The control objectives were to establish achievable control lines while minimizing both losses of private property assets and adverse environmental impacts in the Tingaringy National Park. The strategy adopted by CNR was as follows:

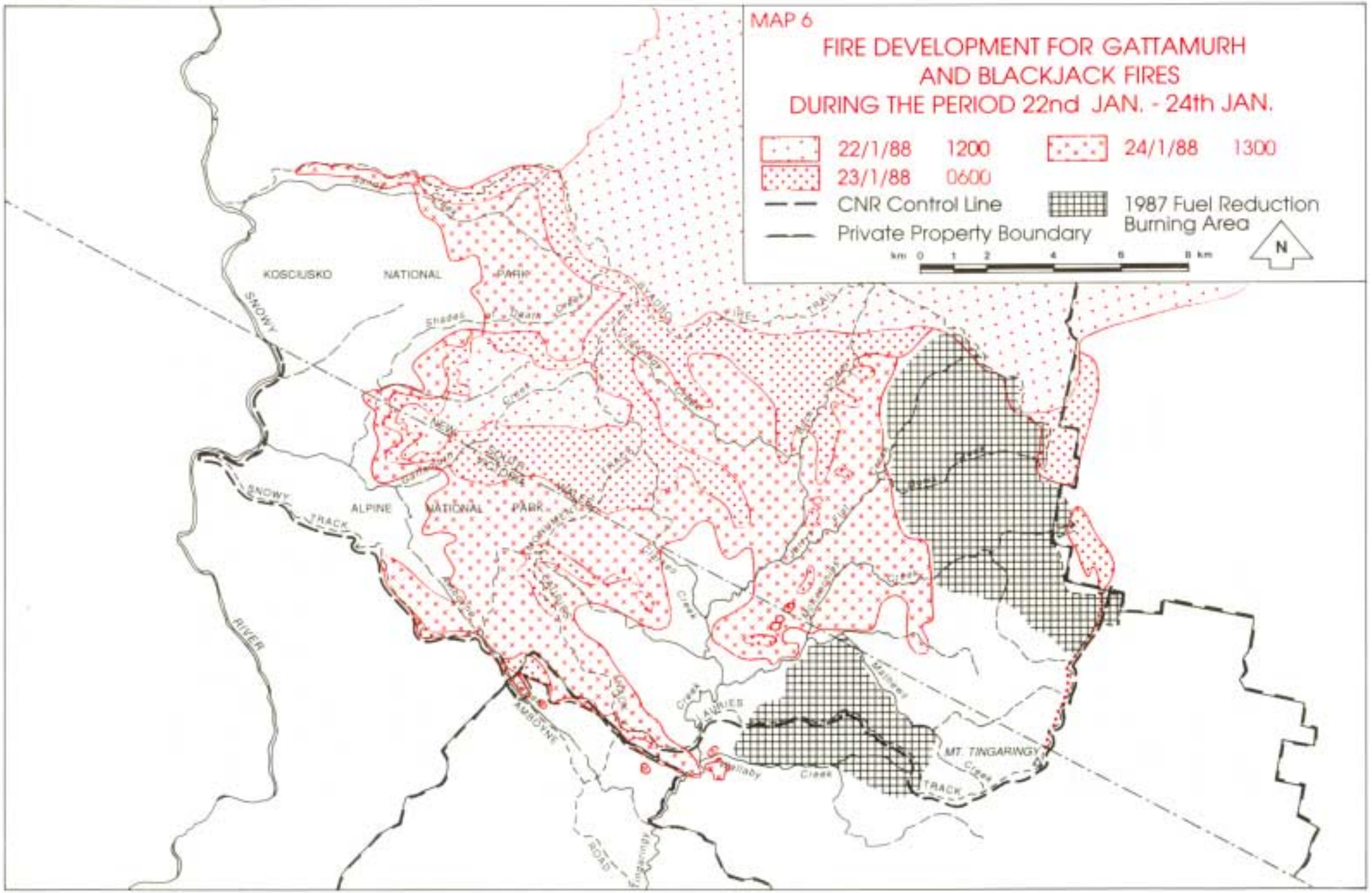
- to use indirect attack tactics, where 34 km of existing tracks (including 5km in NSW), located between 2.5 and 12km from the fire front, were to be cleaned, widened when necessary and used as control lines from which to backburn;
- to construct about 7km of new control line along the forest-pasture boundary on private property at Amboyne Creek, as a substitute for the western end of Lauries Track which traversed difficult terrain; and
- to utilise natural control features such as the Snowy River, and a 2,700 ha area along Lauries Track that had been fuel reduced ten months earlier and which carried fine fuel loads of less than 3t/ha on 90% of the area.

The option of constructing a new control line along Gattamurh Creek closer to the fire was rejected by the Fire Team because it may have compromised wilderness and soil conservation values and would have been difficult to construct in the steep terrain in a short time period.

The Fire Team recognised the magnitude of the task and the potential threat to private property assets, if the control strategy was not completed before the onset of the forecast severe fire weather. It decided to adopt an immediate objective of completing the preparation of the control lines within 24 hours to enable backburning operations to commence on the following evening. To achieve this, the Fire Team decided to engage an additional 11 bulldozers as well as an additional 120 fire-fighters to conduct the backburning operations. The extensive CNR fireline operations, which were divided into five fireline sectors, were to be managed by the Fireline Boss using a light helicopter.

Outcome:

The fire reached Monument Trail in four hours, crossing it at 1900 as a crown fire with flame heights of 20m. During the afternoon the FDI peaked at 20. By late that evening CNR had six bulldozers preparing new control lines.


MAP 6
FIRE DEVELOPMENT FOR GATTAMURH
AND BLACKJACK FIRES
DURING THE PERIOD 22nd JAN. - 24th JAN.
22/1/88 1200
23/1/88 0600
24/1/88 1300
CNR Control Line
Private Property Boundary
1987 Fuel Reduction Burning Area
km 0 1 2 4 6 8 km
N
KOSCIUSKO NATIONAL PARK
SNOWY
ALPINE NATIONAL PARK
SNOWY TRACK
RIVER
AMBOYNE
ROAD
TRACK
MT. TINGARINGY
Creek

Days 11-12 22-23 January

Situation:

Overnight, CNR had prepared more than 10km of control lines but progress on the remaining 23km had been slow in some steep sections. Thirteen bulldozers were available and additional fire-fighters had arrived to assist with back burning operations. High fire danger was forecast for the next three days.

Strategy:

CNR's objectives were to complete the preparation of control lines by late afternoon on 22 January, to undertake and complete backburning operations during the following night and then to hold those control lines.

To assist with the implementation of the Fire Control Plan the Fire Team made the following strategic decisions:

- to clear seven helipads to assist in the transport of fire-fighters and fuel for the bulldozers;
- to obtain an additional light helicopter to assist with reconnaissance operations;
- to commence backburning operations only after the FDI fell below 10, in order to reduce the risk of escapes; and
- to use an infra-red line scan to determine the success of the backburning operations, prior to the onset of the extreme fire weather.

Outcome:

By mid afternoon on 22 January, some 24km of control lines were ready for backburning and a further 8km of control lines passed through the fuel reduced area. The fire weather was worse than forecasted, culminating in a maximum FDI of 30 at 1735; and the FDI did not fall to 10 until 1830.

Backburning operations commenced at 1845 and continued throughout the night. Until sunset CNR carried out aerial ignition operations adjacent to the backburns as well as along major ridges between the control lines and the wildfires, to reduce the possibility of the wildfire developing substantial uphill runs and hence spotting over the control lines.

By daybreak on 23 January, the fire-fighters had backburnt along 32 km of the control lines, leaving about 9km uncompleted. However, the Fire Team expected only 3km of the uncompleted control line in the vicinity of Tingaringy Creek to be threatened by wildfire during the day. An infra-red line scan showed that the two wildfires had joined, that the leading edges of the combined fire were about 8km from the CNR control lines and that the backburn at Mt Tingaringy and further to the north had not penetrated to a very great depth, because of steep cliffs. The Fire Team used that information to identify control weaknesses, to develop strategy and to plan crew deployments.

At about 1130, as the temperature inversion began to break up, the wind increased dramatically to 60kph from the west-north-west, with gusts to 90 kph. The FDI quickly climbed from 8 to 48 and crown fires and fire storms developed. At 1140 a spot fire occurred outside the control lines in grassland on the private property at Amboyne. During the next two hours a further six spot fires occurred in the vicinity of Amboyne Creek and Wallaby Creek. The four spot fires on private property had probably originated from sections of backburn, which included burning windrows. These spot fires were suppressed relatively quickly by the water bombing helicopters, which filled from a nearby farm dam, and with the assistance of three tankers which the CFA had redeployed from NSW. However, the Fire Team was concerned about the three inaccessible spot fires in the forested Wallaby Creek area, which had probably originated from the uncontrolled wildfire some 4.5km to the north-west.

During this period of extreme fire behaviour the wildfire fronts advanced actively towards the control lines, covering a distance of 5.5km in four hours. The prepared control lines contained the wildfire except along small distances in the Amboyne-Tingaringy Creek area. The Fireline Boss observed crown fires revert to surface fires, as they reached the areas which had been ignited aerially on the previous evening, and as well as the progress of the wildfire to be halted by the two fuel reduced areas (see Map 6.)

CNR used the two light helicopters to undertake the difficult task of patrolling the whole length of the control lines, checking reports of spot fires and advising the ground crews on safety and control options. The medium helicopters and fixed-wing aircraft dropped water and retardant on the remote spot fires with considerable success.

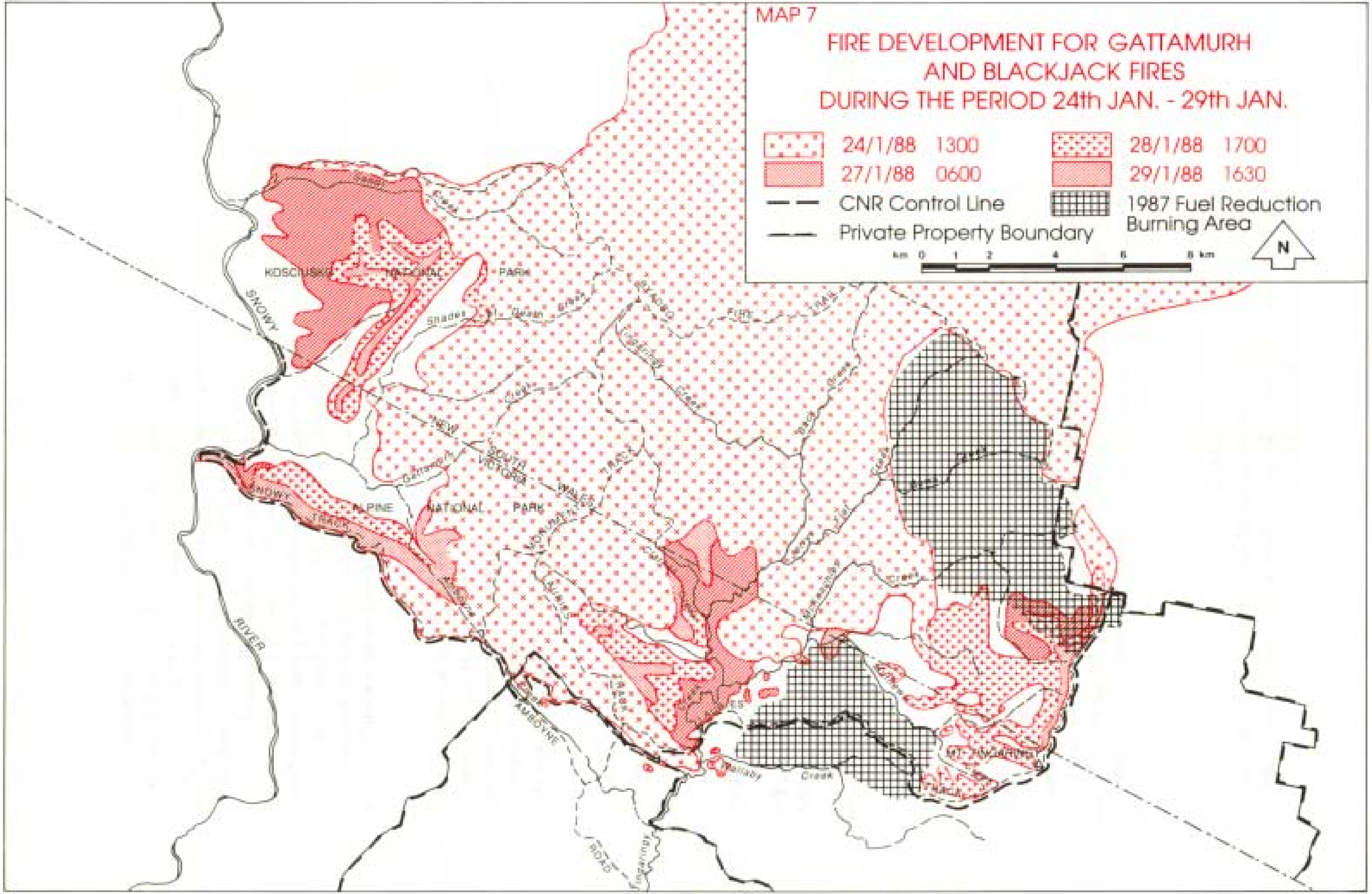
By 1430 the wind had moderated and had begun to swing to the west-south-west, bringing the FDI down to 19. The Fireline Boss initiated a direct attack strategy on the three uncontrolled spot fires, using the rappel crew and other ground crews supported by the fire bombing aircraft. The fixed-wing aircraft in conjunction with the rappel crew extinguished the running edge of the most remote spotfire near Mt Whittakers, restricting it to 15ha. At 1515, some light rain fell at Tubbut and the FDI fell to 6. During the night, CNR continued work on re-establishing control lines around all of the spot fires.

Days 13-18 24-29 January

Situation:

During 23-24 January a total of 13.4 mm of rain fell at Tubbut with heavier falls at higher elevations such as Mt Tingaringy. The rain extinguished the fire in the fuel reduced areas and elsewhere it extinguished much of the active fire edge, but left numerous hot spots in the form of smouldering logs and stumps and burning hollow trees. Although the fire posed little immediate danger, further hot and windy weather which could reactivate the wildfire was forecasted to occur within four days.

The Fire Team identified three control problems:
- about 9km of control lines had not been backburnt;
- the narrow control lines north of Mt Tingaringy would not stop a running wildfire; and
- large areas of unburnt fuel existed within the control lines, which could cause control problems if burnt while the fire danger was high.



MAP 7
FIRE DEVELOPMENT FOR GATTAMURH
AND BLACKJACK FIRES
DURING THE PERIOD 24th JAN. - 29th JAN.
24/1/88 1300
27/1/88 0600
28/1/88 1700
29/1/88 1630
CNR Control Line
Private Property Boundary
1987 Fuel Reduction Burning Area
N
km 0 1 2 4 6 8 km
KOSCIUSKO NATIONAL PARK
SNOWY
RIVER
NEW SOUTH WALES
VICTORIA
ALPINE NATIONAL PARK
SNOWY TRACK
AMBOYNE
ROAD
Shades
Creek
Wallaby Creek

These factors had to be balanced against environmental values, particularly the need to protect rare plants around Mt Tingaringy and the undesirability of burning alpine vegetation.

Strategy:

To address the control problems the Fire Team made the following strategic decisions:
- to backburn along the unburnt control lines as a matter of urgency;
- to conduct further aerial ignition operations to widen the control lines north of Mt Tingaringy; and
- to use infra-red imagery to determine the likelihood of reignition of the rain-checked edge adjacent to the unburnt areas.

Because of the forecast weather, the Fire Team decided to release most resources on 25 January then to use local fire-fighters from 26 January to undertake backburning and blackout operations;

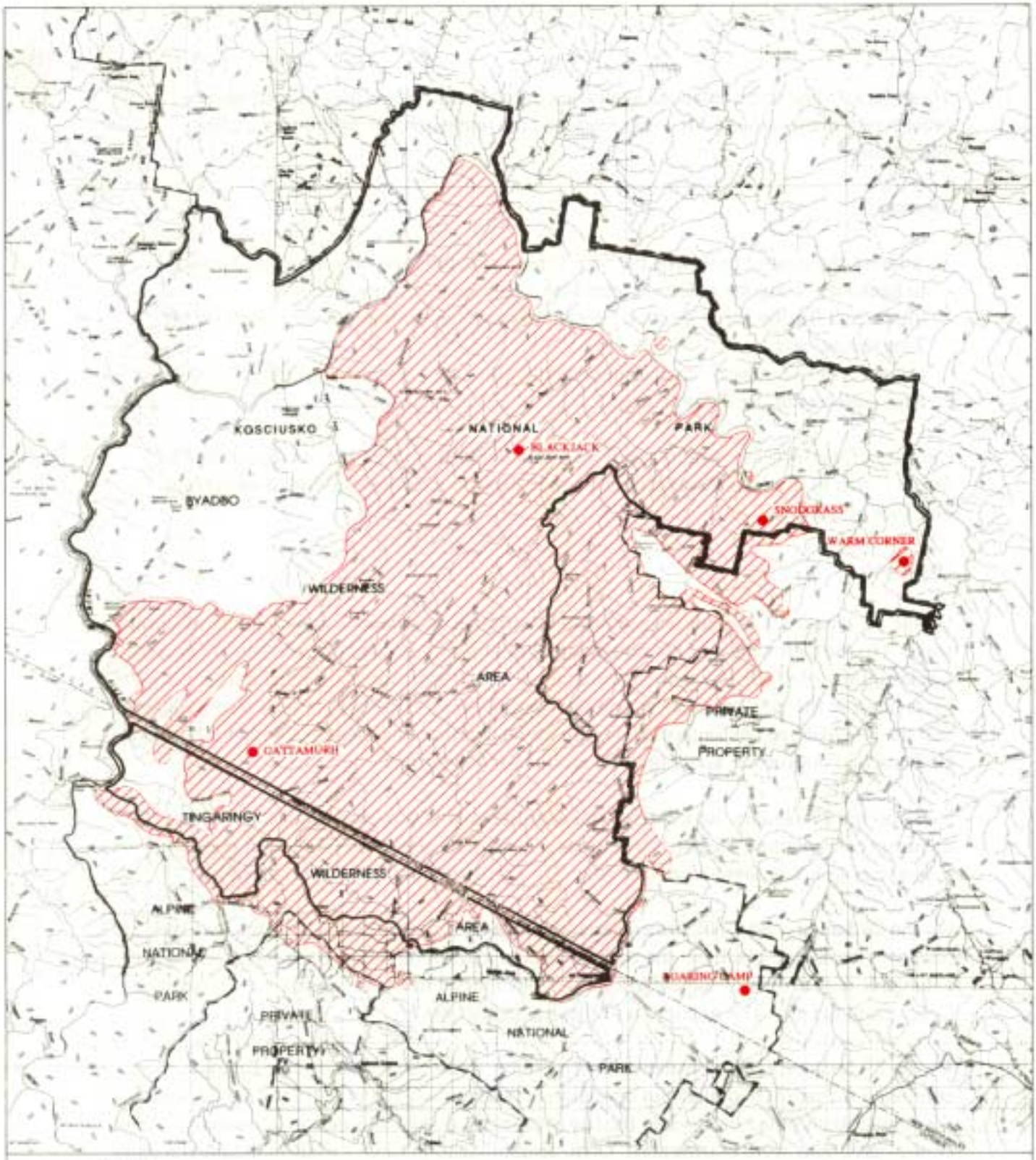
Outcome:

On the 25 January, CNR carried out detailed aerial reconnaissance and mapping of burnt areas. On the following day the remaining 9km of backburn was completed. A Forward Looking Infra-Red (FLIR) camera, mounted in a light helicopter, detected numerous hot spots close to the unburnt areas within the control lines. The FLIR camera also indicated that the fire had been extinguished by rain in the *Callitris* woodlands. On that afternoon, CNR carried out further aerial ignition around Mt Tingaringy.

Early on the 27 January, an infra-red line scan showed that several thousand hectares of unburnt fuel remained, in three large areas. During the afternoon CNR used two light helicopters to ignite these areas (see Map 7). The maximum FDI experienced was 11.

On the 28 January, 84 CNR fire-fighters and four CFA tanker crews, assisted by FLIR imagery, worked to black out the control lines to a depth on 40m. Because of active fire behaviour within 1km of the control lines, CNR ignited unburnt ridges around Gattamurh Creek from the air. The maximum FDI experienced was 15.

By the 29 January, CNR considered the fire to be "controlled", but 46 fire-fighters continued the patrol and blackout operations. During the day the FDI reached 23, which was higher than it had been when the fire escaped from control lines on 21 January. As no control problems were experienced, CNR demobilized the LFO . CNR maintained a daily patrol of the control lines until 16 February (Day 36) when, after receiving 25mm of rain, the fire was declared "safe".



MAP 8

AREA BURNT BY 1988 BYADBO WILDFIRES

- FIRE ORIGINS
- FINAL FIRE AREA
- WILDERNESS AREA BOUNDARIES
- PRIVATE PROPERTY BOUNDARY

N

FINAL STATISTICS

The combined fires in two States burnt 63,000ha (see Map 8), including more than 51000ha of Kosciusko National Park, 9,000ha of Alpine National Park, 2,650ha of private property and 51km of fencing in NSW, and 100ha of private property in Victoria. About 68% of the combined Byadbo-Tingaringy wilderness area was burnt either by wildfire or planned ignition. The cost of the combined suppression operations was about $1.2 million in Victoria and about $1 million in NSW, excluding the opportunity costs of the volunteer fire-fighters.

During CNR's suppression operations the two fixed-wing fire-bombers had delivered 17 loads of retardant from the Delegate base, with turn-around times of 28-51 minutes, and 26 loads from the Gelantipy base, with a turn-around times of 24-34 minutes. The two medium-sized helicopters, filling directly from the Snowy River and from dams on private property, dropped 98 loads of water with turn-around times of 3-15 minutes. The medium helicopters also delivered 10 loads of water to portable tanks located along steep sections of control lines. NPWS also had made extensive use of four medium helicopters in its suppression operations, with a total of 210 hours of flight time and 383 loads of water dropped.

Subsequent site rehabilitation of the Alpine National Park by CNR was extensive. Two bulldozers breached and barred more than 30km of control line over a six week period; and locally-collected seed was used to revegetate the cleared areas where the width was greater than that needed for ongoing management. Weed control operations have been conducted each subsequent year.

DISCUSSION

The 1988 Byadbo fires provide an opportunity to examine wilderness fire management policies on the basis of actual wildfire experience. There are some important lessons regarding fire development, initial suppression operations, large-scale indirect suppression operations as well as fire protection planning and works.

Fire Development

Fire behaviour and fire development at these wildfires were in accordance with what can reasonably be expected during summer months in south-eastern Australia. The Blackjack fire was ignited on a day of very high fire danger (FDI 26) and the fire behaviour at the time was such that eight fire-fighters were unable to control the fire with hand tools. The fire burnt in a predictable manner over the first four days, under conditions of very high fire danger (FDI 32-40) but low winds, with an average forward rate of spread of 0.13 km/h. It developed major runs of 12km on the ninth day and of 6km on the twelfth day, with estimated maximum forward rates of spread of 1.5km/h on each of those days. The wildfire displayed crown fire and fire storm characteristics during periods of extreme fire weather.

The Gattamurh fire was detected on a day of very high fire danger (FDI 33) and over the first seven hours following detection the rate of spread averaged 0.12km/h for the head fire and 0.015km/h for the flanks. The following day under milder conditions (FDI 20) the fire developed an average forward rate of spread of 0.75km/h while burning up a slope. This fire developed its maximum forward rate of spread of 1.4km/h on the fourth day, under conditions of very high to extreme fire danger (FDI 48), during which a maximum spotting distance of 4.5km was recorded.

These patterns of fire development are common in south-eastern Australia, especially during summers when the forest fuels are very dry because of below average rainfall during the preceding winter and spring, as occurred in 1982/83 and 1987/88. Rawson *et al.* (1983) reported spread rates of up to 10km/h during the 1983 wildfires; and most major wildfires have made extensive runs during periods of severe fire weather lasting less than 12 hours (Cheney, 1976). Damaging wildfires have occurred in eastern Victoria during any of the months between September and April (Bartlett, 1990). Clearly, in the absence of intervention, wildfires in south-eastern Australia have the potential to develop major runs during periods of extreme fire weather. All the wilderness areas on the mainland of eastern Australia are too small for unmanaged fire not to be able to emerge and cause loss of life and adjacent assets.

Initial Fire Suppression

The initial fire suppressions operations for remote wildfires usually will be difficult due to the lack of access for fire-fighters. At both of these fires the initial suppression operations failed for a variety of reasons. The initial suppression of the Blackjack fire, on a day of very high fire danger (FDI 26), was delayed by several hours because a helicopter had to be obtained from Wollongong, 350km away. Under hot dry conditions the experienced fire-fighters were unable to control the fire in the steep topography around Mt Blackjack. Fire retardant was not used to assist fire-fighters because of concerns about its effect on native vegetation, a position which was criticized by the subsequent coroner's inquiry (Jordan, 1990).

The Gattamurh fire remained undetected for about 14 hours and the rappel crew was delayed for a further eight hours. By the time the first ground fire-fighters arrived the fire was more than 20ha in size. Under conditions of high fire danger the fire-bombers, operating with a turn-around time of nearly 50 minutes and in the absence of ground fire-fighters, were ineffective. The steep and rocky terrain made the construction of control lines impossible by bulldozers and very difficult by hand.

The major reasons for the failure of initial suppression operations at the two wildfires related to delays in the arrival of fire-fighters and either the absence or ineffectiveness of firebombing operations. Because there are risks and large costs involved in allowing fires to burn out to predetermined control lines it is important that extra effort be put into the initial suppression operations for remote fires. To ensure effective initial suppression of summer wildfires in wilderness areas, firebombers and a rappel crew must be dispatched quickly and in most cases direct attack tactics should be utilised.

Indirect Fire Suppression

If the initial suppression operations fail to control a fire in a wilderness area the main tactics available are those of indirect attack. Strategy decisions must reflect the expected fire development, the threats to assets and wilderness values, the available resources and the practicality of defending the proposed control lines.

At both the Blackjack and Gattamurh fires the use of indirect tactics, mainly the preparation of and backburning from existing tracks, was constrained by the scarcity of existing tracks and lead to a considerable escalation in the total area burnt by the fire. Other options, those of constructing new trails by hand or with bulldozers, would at both fires have been ineffective, because of difficult terrain and either the lack of resources (Blackjack fire) or insufficient time to construct the trails (Gattamurh fire). The use of bulldozers to construct new tracks in order to minimize the area burnt, as advocated by Jordon (1990), would also have caused lasting damage to wilderness values. Indirect tactics using existing tracks can be the best option both for maintaining wilderness values and for achieving fire control.

Using indirect tactics does not guarantee success in the fire control. A consequence of the NPWS decision (which was quite justifiable) to concentrate the scarce NPWS resources on the Snodgrass and Warm Corner fires which threatened private assets was that, after a delay of four days, NPWS faced the formidable task of preparing and backburning 45km of control lines with 3 bulldozers and 70 personnel within three days. In comparison, for the 48 km of control lines at the Gattamurh fire, CNR needed 13 bulldozers and 318 personnel to complete all but 3km (7%) of the critical control lines within two days. If indirect attack is to be successful, then resources must be provided early enough and in sufficient numbers to ensure that control lines are prepared before the fire threatens them.

A key factor in the ability of the CNR resources to complete adequate control lines was the existence of a well maintained track network in the Alpine National Park. In addition, the one-year-old fuel reduction burn reduced the need to prepare control lines and to backburn over a distance of 8km, thereby facilitating the achievement of the fire control strategy. The success of indirect attack depends not only on resourcing suppression operations, but also on the existence of adequate protection works prior to fire occurrence.

Both CNR and NPWS used aircraft extensively to support many aspects of the indirect control operations, including firebombing, transport and both visual and infra-red reconnaissance. In firebombing roles CNR used aircraft to the greatest advantage during the extreme fire weather on Day 12. The fixed-wing fire bombers were extremely effective on the forest spot fires despite the absence of ground support for at least three hours. This was because they were ready for immediate deployment and were working with a turn-around time of 30 minutes. The waterbombing helicopters were extremely effective on the grassland spot fires because of their load-dropping precision and quick turn-around. In forest conditions the helicopters were most effective when the turn-around time was less than eight-minutes. NPWS also found water-bombing helicopters to be effective in controlling two spot fires north of the Snowy River which would otherwise have caused a major expansion of the area burnt. Without fire-bombing aircraft there is little doubt that both the damage to private assets and the fire size would have been greater.

In transport roles both CNR and NPWS used medium helicopters extensively. By airlifting fire-fighters to the fireline, especially where the return trip on the ground was greater than three hours, the helicopters helped to avoid excessive fire-fighter fatigue, by keeping shift lengths below 16 hours, and to minimize the penalty wage payments associated with shifts longer than 16 hours. The cost of using helicopters for transporting fire-fighters ($74 per person per day) was marginally more expensive than the cost of ground transport ($62 per person per day), unless a shift penalty ($250 per person) was incurred. By transporting fuel and water to sections of the fireline where access was difficult, CNR ensured that the urgent task of preparing control lines was not delayed and that water was available to support backburning and blacking out operations. The use of medium helicopters in transport roles contributed in a number of ways to the timely completion of important control tasks.

The light helicopters were used mainly for reconnaissance of fire development, management of suppression operations and the implementation of prescribed aerial ignition. At such a large wildfire these activities were essential for: efficient planning and implementation of fire control operations, rapid detection of spot fires, and widening backburns and achieving a planned burn-out within the control lines.

CNR used Forward Looking Infra Red (FLIR) imagery on many occasions. The technique was effective for analysing the general condition of large sections of fire edge and for identifying specific hot-spots requiring treatment, especially when the fire edge was more than two days old and had been subject to blackout operations. This capability assisted tactical decisions about resource deployment, so that blackout was completed sooner and more reliably. On two occasions the FLIR also provided strategic information about the need for further aerial ignition in environmentally sensitive areas. It demonstrated that further ignition in the alpine vegetation near Mt Tingaringy was necessary, because the wildfire edge had not been sufficiently extinguished by rain, and that further ignition in the fire-sensitive *Callitris* woodlands near the Snowy River was unnecessary, because the backburning had been sufficiently extensive and effective. The availability of FLIR imagery reduced the chances of fire escape and gave the Fire Team the ability both to save money by the having the confidence to release resources early and to avoid unnecessary burning of fire-sensitive woodlands.

Infra-red line scans that were flown during the night were used by both CNR and NPWS to provide broad-scale information about current fire development. At such a large wildfire they were found to be an extremely efficient means of obtaining a complete up-to-date picture of the fire's development. The alternative of visual reconnaissance can only provide this information several hours after the day shift has already commenced. Because of their timely availability the line scans greatly assisted strategic planning to ensure the most efficient use of the available resources.

Overall, the experience from these wildfires clearly demonstrated the once direct attack fails, indirect strategies can be effective in controlling the fire and sensitive in relation to wilderness values. The success of such strategies requires adequate and timely resourcing, the provision of adequate protection works such as tracks, and helipads and fuel reduced areas and the extensive use of aircraft.

Wilderness Fire Policies

Current fire management policies for wilderness areas (CFL, 1988; NPWS, 1988) from the mainland of south-eastern Australia attempt to balance the need to suppress wildfires with the desire to protect the remaining wilderness areas from those fire control activities which have a lasting impact on wilderness values. Improvements could be achieved by reference to the Blackjack and Gattamurh fires, and to wilderness fire policies in the United States of America.

The USDA Forest Service's fire management policy for wilderness areas (Lunsford, 1988), which has been debated since fires in 1988 affected more than 450,000ha in Greater Yellowstone and cost $120 million to suppress (Varley and Schullery, 1991), had two objectives:

- to permit lightning-caused fires to play as nearly as possible their ecological role within wilderness.
- to reduce to an acceptable level the risk and consequences of wildfire within wilderness or escaping from wilderness.

Under that policy, there are a number of defined suppression strategies that may be adopted, with the actual choice depending on the condition of the wilderness compared to presumed natural conditions, the forecast weather and the risk of unacceptable damage to property or resource values, and the costs and impacts of alternative suppression strategies. The choice of suppression strategies includes: *control* where the fire within the control line is suppressed until the line can reasonably be expected to hold under the foreseeable conditions; *containment*, where the fire is surrounded by control line which can reasonably be expected to check the fire's spread under the prevailing conditions; and *confinement*, where fire spread is limited by natural or preconstructed barriers or environmental conditions.

The U.S policy applies to wilderness areas which are generally larger and less fire prone than those occurring on the mainland of south-eastern Australia. However, the U.S. approach of clearly stating objectives and indicating alternative suppression strategies could be useful in south-eastern Australia.

For the mainland in south-eastern Australia, a fire management policy for wilderness areas needs to recognise the inevitability with which wildfires will occur within wilderness areas, the potential for wildfires to escape from wilderness areas and cause damage to assets, the role of fire in the maintenance of ecosystems and the need to minimize lasting effects of fire management programs. These needs should be encompassed in policy objectives such as:

- to minimise the risk of a wildfire escaping from a wilderness area.
- to minimise the impacts of fire management programs on wilderness values.
- to manage fire within wilderness areas to maintain ecological processes.

Under these policy objectives there must be strategies that cover pre-suppression, suppression and post-suppression activities.

The strategies that relate to pre-suppression need to cover the proper planning and implementation of fire protection works, including prescribed burning and a strategic network of tracks, helipads and water points. By adopting a planning procedure which seeks to balance fire protection and environmental requirements, it should be possible to ensure that the necessary pre-suppression works are located in areas which have strategic fire protection values but which have less sensitive wilderness and environmental values. It is desirable to identify ecologically sensitive areas and the preferred location of any new fire control lines as part of the planning process rather than risk haphazard development of fire control lines during supression operations. Good pre-planning and implementation of pre-suppression works should minimize undesirable impacts on wilderness values during fire suppression.

Minimizing both fire escapes from wilderness areas and the impacts of fire management programs requires a compromise between naturalness and fire protection works. Given the absence of a dense network of tracks in wilderness areas and the undesirability of constructing new tracks, permanent helipads and water points may be needed within wilderness areas. A strategic network of well maintained tracks within and surrounding wilderness areas will also be necessary, so that when wildfires occur indirect attack from an existing tracks is a viable control option.

Another aspect of pre-suppression strategy relates to the use of prescibed fire for both fire protection and ecological purposes as advocated by Good (1981). The experience from these fires demonstrated that fuel reduction burns can provide real assistance to fire control, particularly where large scale indirect suppression strategies are used. Prescribed burns, if carefully planned, also may help avoid the disturbances induced by absence of fire in plant and animal communities which have evolved under the influence of recurrent wildfires (Gill, 1981). Managing fire regimes, not just wildfires, is an important aspect of the management of wilderness ares.

The strategies that relate to suppression need to cover a range of control options that may be used, similiar to those contained in the U.S policy. In south-eastern Australia wildfire is not usually detrimental to the ecosystems or wilderness values. Values such as aesthetics, endangered and fire sensitive species, wilderness and soil conservation however may be adversely affected by either a wildfire or the suppression operations. By having a range of control options and tactics available to the fire manager there would be greater flexibility to balance fire control and wilderness management objectives. The actual choice of control option would depend on the time of year, the site factors and the prevailing weather conditions. The choice of control options may include:

- *suppression*, where control operations extinguish the fire to a degree where the risk of escape from the control lines would be minimal irrespective of the fire danger.
- *containment*, where control operations keep the fire within defined control lines under the prevailing conditions, but otherwise do not hinder fire spread within these boundaries.
- *restriction*, where weather or fuel conditions, or natural or other existing barriers limit the development of the fire under the prevailing weather conditions.

All three of these control options insist that fires are controlled, in that the risk of fire escape and threat to life and private assets is minimal - just as they are under the current policy of "suppressing all fires". Further, as supported by the Blackjack-Gattamurh experience, suppression or containment will still be the most appropriate choice for most fires during the fire danger season, which will include summer and substantial parts of spring and autumn. The option of restriction simply provides a policy basis for a practise of not being required to downgrade wilderness values to suppress a fire that poses no threat.

The process of choosing the appropriate control option may be assisted by reference to a decision support diagram such as the one shown in Figure 2. Further, as the Blackjack-Gattamurh experience showed, the fire manager will need to be able to predict fire behaviour reliably and to implement the chosen strategy within the necessary time frame.

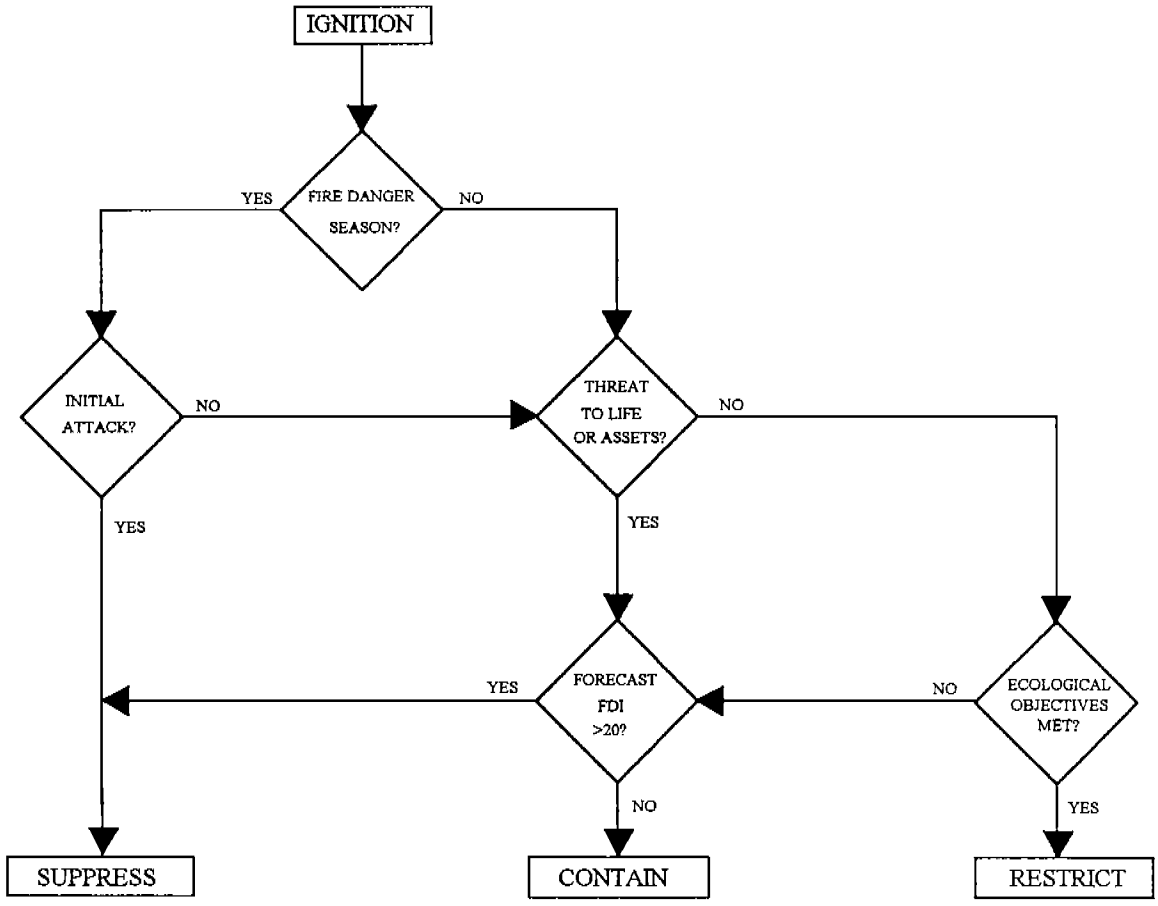


Figure 2. A possible decision support diagram for the control of fires in wilderness areas. The diagram would need to be used repeatedly as the fire and the conditions develop.

The chosen suppression strategy would be implemented through specific tactics. For direct attack, suitable tactics may include the following, used either alone or more typically in combination with each other:

- The use of an existing network of helipads. This options permits the use of less costly light helicopters, and provides increased flexibility in situations when medium-sized helicopters are unavailable. This tactic is particularly important because lightning frequently causes simultaneous and widely dispersed ignitions. Ideally a network of helipads should allow fire-fighters to reach all fires within two hours.
- The use of hover-exit techniques, whereby fire-fighters are able to alight from a helicopter hovering 1.3m above the ground. This option can reduce the need for helipads in wilderness areas which contain rocky or heathland areas.
- the use of rotary or fixed-wing aircraft for dropping water, fire retardant or foam. In the absence of nearby water sources the use of fire retardant is likely to be the most efficient because of long turn-around times for fixed-wing aircraft. The use of helicopters to drop water or foam may be appropriate in situations where the fire is small, there is a nearby water source and ground fire-fighters are present.

For indirect attack suitable tactics may include:

- the use of the existing track network. Provided that sufficient resources are available to implement the large-scale backburning operations, this tactic is generally the most appropriate manner to suppress wilderness wildfires for which direct attack has failed.
- the use of appropriately located hand-constructed fire trails. The success of this tactic depends on the availability of a large contingent of fire-fighters supported by firebombers, the construction of a series of helipads to facilitate fire-fighter transport and the existence of moderate weather conditions.
- the construction of new tracks for use as temporary fire control lines. This may be the only realistic option in situations where there are no suitable existing tracks or when the predited weather or available resources preclude the implementation of large-scale indirect tactics. Where these new tracks are necessary , they must be carefully planned, properly supervised and subsequently adequately restored.
- the use of aerial ignition techniques to facilitate planned burning at control lines. This tactic also offers the potential to implement high intensity prescribed burns to meet ecological objectives, which otherwise would not be possible.

The choice of suppression strategy and tactics should be made by the Incident Control Team after an evaluation of the likely environmental effects and the likelihood of achieving fire control under each strategy and should be set out in a fire control plan. The experience from the Blackjack and Gattamurh wildfires highlights the importance of the early development and continual revision of an overall fire control plan to ensure that the fire control operations are logically planned, adequately resourced and conducted in an environmentally sensitive manner.

In addition to strategies for pre-suppression and suppression, strategies for post-fire suppression activities are also important for minimizing the long term impacts of fire control activities in wilderness areas. Helipads and tracks that have been constructed during the fire control operations and which are not required as part of the strategic network should be rehabilitated. Weed control operations may also be necessary in subsequent years.

The adoption of the objectives, strategies and tactics discussed in this section would provide fire managers with clearer guidance on how to balance wilderness and fire management objectives. Some compromise of wilderness ideals is inevitable, but if wildfires are managed in a planned holistic manner then undesirable impacts can be minimised.

CONCLUSION

The failure of initial attack suppression operations on two lightning ignitions in a wilderness area of Kosciusko National Park subsequently led to the development of a large wildfire which burnt more than 60,000ha of National Park and 2,750ha of adjoining private property. A co-ordinated inter-state operation suppressed the fires, over a period of 18 days.

The initial attack of both fires failed because the fires were in steep remote forested country and under the prevailing weather the suppression resources arrived too late and in too few numbers. The initial attack of summer wildfires such as these must be fast, well planned and resourced, and in wilderness areas will normally require the use of aircraft, for firebombing and rappelling or crew transport, supported by ground fire-fighters. To be most effective firebombing operations should commence within one hour of fire detection and turn around times need to be less than 8 minutes for water bombing and 30 minutes for retardant bombing operations.

In wilderness areas, if initial attack fails, fire suppression strategies need to balance wilderness and fire control objectives. The Blackjack-Guttamurh experience showed that falling back to an existing track network can be an appropriate suppression strategy for wilderness fires, but that in doing so the suppression operations must be adequately resourced. Depending on the forecast weather it could well be appropriate to allow the wildfire to burn within planned control lines, provided that fire development can be confidently predicted and is regularly monitored and that the control lines can be confidently held.

With large wildfires aircraft can greatly assist the efficient conduct of the suppression operations, and at the Blackjack-Guttamurh fires aircraft undoubtedly contributed to the wildfire being controlled within the final planned control lines. Helicopters and fixed-wing aircraft were used for the transport of fire-fighters and supplies, rappelling, infra-red scanning, FLIR and visual reconnaissance, aerial ignition, fireline management and especially for firebombing. Infra-red FLIR and line scan technology was invaluable in providing strategic, tactical and timely information on fire activity and location, for the planning and conduct of fire suppression. At large wildfires line-scans in particular provide quick and accurate information of the fire environment, where uncertainty about the current fire condition is a notorious limitation of achieving fire control.

Fire protection, wilderness and other environmental values are likely to be served best by a sensible combination of suppression capability and the careful planning, proper implementation and maintenance of pre-suppression works. Given that wildfires will continue to occur in wilderness areas, wilderness managers must recognize that a planned approach to fire management will ultimately result in fewer undesirable effects than simply reacting to wildfires when they occur. Depending on circumstances and specific policy, pre-suppression works within wilderness areas will include: a network of tracks, helipads and fire dams, as well as prescribed burning for strategic fuel reduction and the important maintenance of ecological balance.

Fire management in wilderness areas can be sensitive to environmental and wilderness values by incorporating the following principles:

- allow for alternative fire control options, including suppression, containment and restriction, depending on the circumstances which exist at the time of the fire;
- suppress wildfires within the fire danger season quickly and decisively by direct attack with a clear preference for using minimal impact techniques;
- prefer the use of aerial techniques, especially firebombing and fire-fighter transport by helicopter;
- use indirect attack tactics which give preference to the use of existing tracks or hand constructed control lines, if initial attack fails, even if this causes some increase in the area burnt;
- incorporate the planned ignition of areas within the control lines according to fire control and ecological needs;
- minimize the construction of temporary fire control tracks, and carefully plan, properly supervise and adequately rehabilitate any constructions that are necessary.
- consider allowing lightning fires which occur outside the main fire danger period to burn within planned limits when the threat is minimal.
- permit the implementation of necessary fire protection works including prescribed burning, track maintenance and aerial suppression facilities in a planned manner which balances fire protection and wilderness values.

These principles should apply to all wilderness areas on the mainland of south-eastern Australia, because of the certainty that summer wildfires will continue to occur and have the potential to become large in most years. By adopting these principles fire control can be assured while at the same time wilderness values can be substantually maintained.

ACKNOWLEDGEMENTS

I wish to acknowledge the support and constructive comments given by Andrew Wilson, Senior Fire Research Officer, CNR and Phil Cheney, Bushfire Section CSIRO. I thank various NPWS staff, in particular Russell Knutson, Chief Ranger Kosciusko National Park for allowing me access to NPWS records and Ian Pulsford, Tony Baxter and Dave Darlington for providing information. I thank Bryan Rees (CNR Fire Management Branch) for providing me with records of helicopter use. Grateful thanks are extended to the staff at CNR Orbost, especially Sue Watson for the word processing and Melissa Ellis for the draughting in this report.

REFERENCES

Bartlett, AG (1990) Orbost Regional Fire Protection Plan - Department of Conservation, Forests and Lands Victoria. 79pp.

Cheney, NP (1976) Bushfire disasters in Australia, 1945-1975. *Australian Forestry* 39(4) 245-268

CFL (1988) Fire management for wilderness areas. Policy No 2.5.1.P National Parks and Wildlife Policy & Procedure Manual. Dept of Conservation, Forests and Lands. 3pp.

Gill, AM (1981) Adaptive responses of Australian vascular plant species to fire. In Gill AM, Groves RH and Nobel IE (Eds), *Fire and the Australian Biota*. Australian Academy of Science, Canberra. pp243-272.

Good, RB (1981) The role of fire in conservation reserves. In Gill AM, Groves RH and Noble IR (Eds), *Fire and the Australian Biota*. Australia Academy of Science, Canberra. pp529-549.

Jordan, AJ, (1990) Findings of the Coroners Inquiry into the Byadbo Wilderness Bush Fires, Coroner's Court, Bombala NSW, 17 December 1990. 11pp.

LCC (1991) Wilderness special investigations. Final Recommendations. Land Conservation Council, Victoria.

Lunsford, J. (1988) Wilderness fire management in Region 8. *USDA Fire Management Notes*. 49(1) 3-7.

McArthur, AG, (1973) Forest fire danger meter, Mk5. Forest Research Institute, For. & Timb. Bureau, Canberra.

NPWS (1988) Kosciusko National Park Plan of Management 2nd Edition National Parks and Wildlife Service, New South Wales.

Rawson, RP, Billing PR and Duncan SF (1983) The 1982-83 forest fires in Victoria. *Aust For* 46(3): 163-172.

Robson, J (1988) Deputy 41F Fire Controllers Report, Byadbo bushfires, Kosciusko National Park, NSW National Parks and Wildlife Service. (Unpubl. report).

Varley, JD and Schullery P (1991) The Yellowstone Fires. Encyclopaedia Brittanica Science Year Book 1991. pp 130-143.

APPENDIX 1 Wilderness areas of mainland south-eastern Australia

National Park	Wilderness Area	Area (ha)
Kosciusko	Jagungal	66,300
	Pilot	92,400
	Byadbo	69,700
	Bogong Peaks	25,600
	Bimberi	18,200
Alpine	Indi[1]	13,800
	Cobberas[1]	10,000
	Buchan Headwaters	30,000
	Tingaringy[2]	7,900
Snowy River	Snowy River	27,000
	Bowen	17,500
Coopracambra	Genoa	19,400
Croajingolong	Sandpatch	15,600
	Cape Howe	7,100

1 - These areas adjoin Pilot
2 - This area adjoins Byadbo

APPENDIX 2 CNR Fire Control Plan for Gattamurh Fire

FIRE 88 ORBOST REGION
LOCATION: ALPINE NATIONAL PARK (COBBERAS-TINGARINGY UNIT)

Objectives

1 Stop the run of the wildfires which originated at Blackjack Mountain and Gattamurh Creek NSW.
2 Minimize the area of land burnt in Victoria consistent with establishing realistic control lines.
3 Minimize the loss of private property assets along the Deddick Valley and Dellicknora-Cabanandra areas.
4 Minimize adverse environmental effects due to wildfire suppression activities in the Snowy-Tingaringy National park.

Constraints

1 Steep, rocky, inaccessible terrain.
2 Absence of established tracks.
3 Wilderness values of Gattamurh creek.
4 Restricted access to water.

Strategy

1 CFL to control southern sector of combined fire suppression effort, specifically the area from the Snowy River at the Victorian/New South Wales border east across to Mt Tingaringy and north into NSW to the junction of Tingaringy track and the private property at Avondale.
2 Indirect attack using existing tracks where possible and backburning from these prepared lines.
3 Control lines to become Snowy River, Snowy Track, Armstrong Track, Laurie Track, Tingaringy Track.
4 1987 Fuel Reduction burn south of Mathew and Mountain creeks and Laurie Track to form part of control lines
5 Burn out unburnt country between wildfire and backburn using aerial incendiaries.

Fallbacks

1	South West	Jam Creek track, Jam Creek (may not be possible). Otherwise Snowy River - Mackillop bridge cleared private property boundaries north of Deddick River.
2	South	Amboyne Road, Deddick River.
3	South East	Tubbut - Ingram Track, Fire 48, Forlorn Hope Ridge.
4	East	Tingaringy Track, Karachi Track.

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