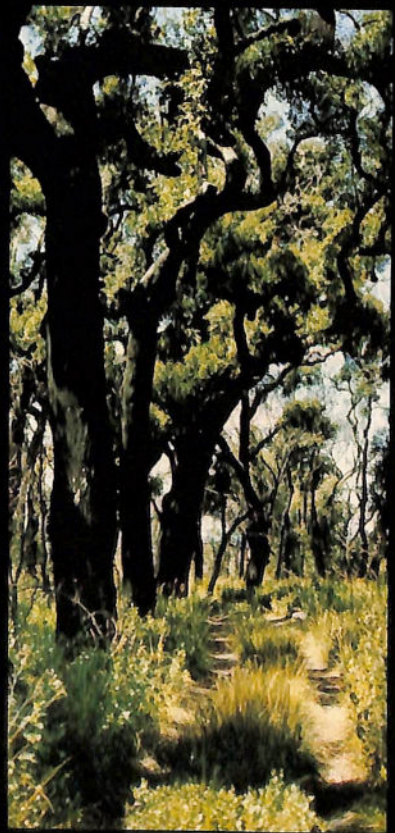
The '72 Fire of Nadgee Nature Reserve



Front Cover:

Fire is a mangement problem. Methods of controlling the severity of a fire, or its escape from a National Park or Nature Reserve with the possibility of destroying property and lives is a constant concern to the Service. In addition the Service is responsible for managing the natural environments. The effect of fire is a subject for continuing research.

Jane Spiers Beach, Nadgee Nature Reserve, was the centre of a fire storm; two months after the fire. (1)
A. Fox

A fire tanker works to control the fire at Nadgee Nature Reserve from engulfing the ranger's quarters. (2)
T. Barratt

Fire in Kosciusko National Park. (3) A. Jelinek

Epicormic shoots developing, 5 months after the fire. (4)
A. Fox

Regeneration 13 months after the fire. (5) A. Fox

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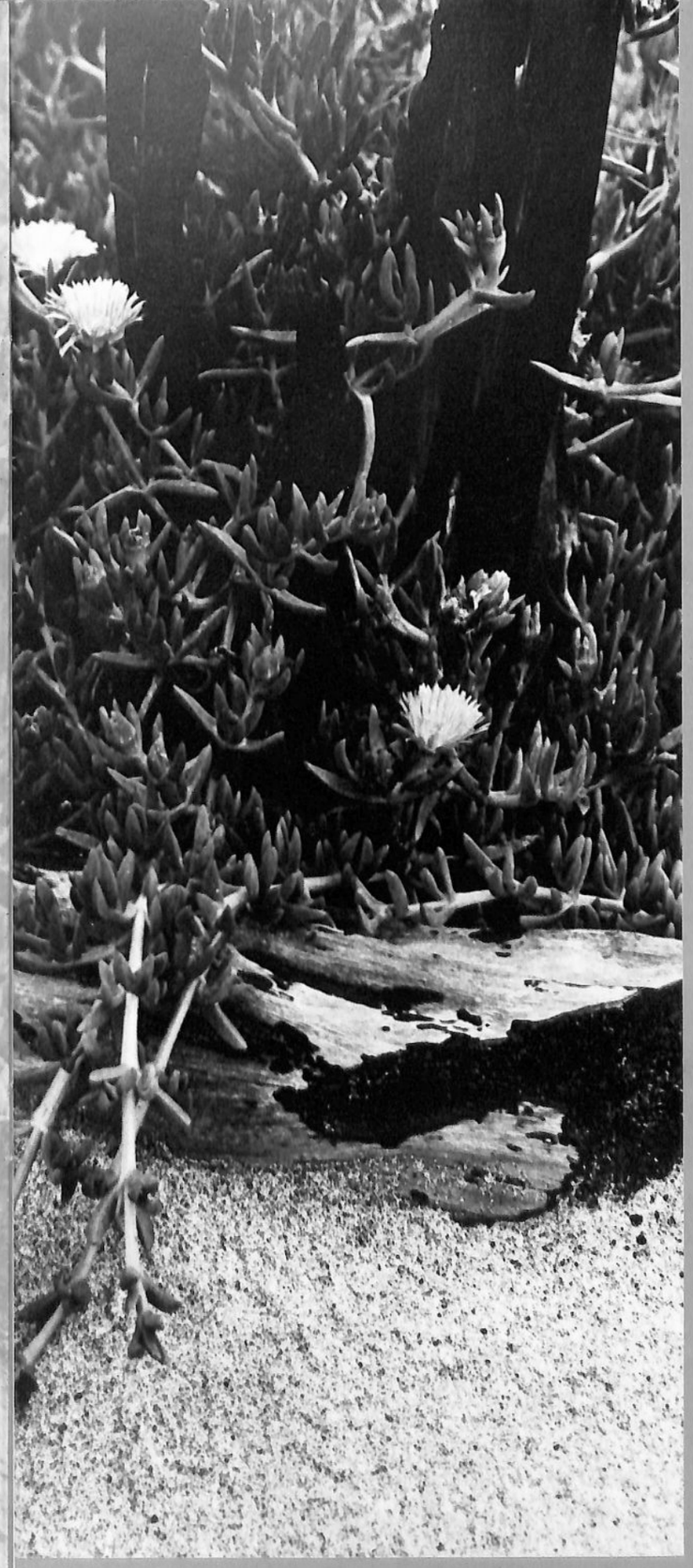

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One of the first plants to reappear in the Jane Spiers firestorm area, the pig face.
A. Fox

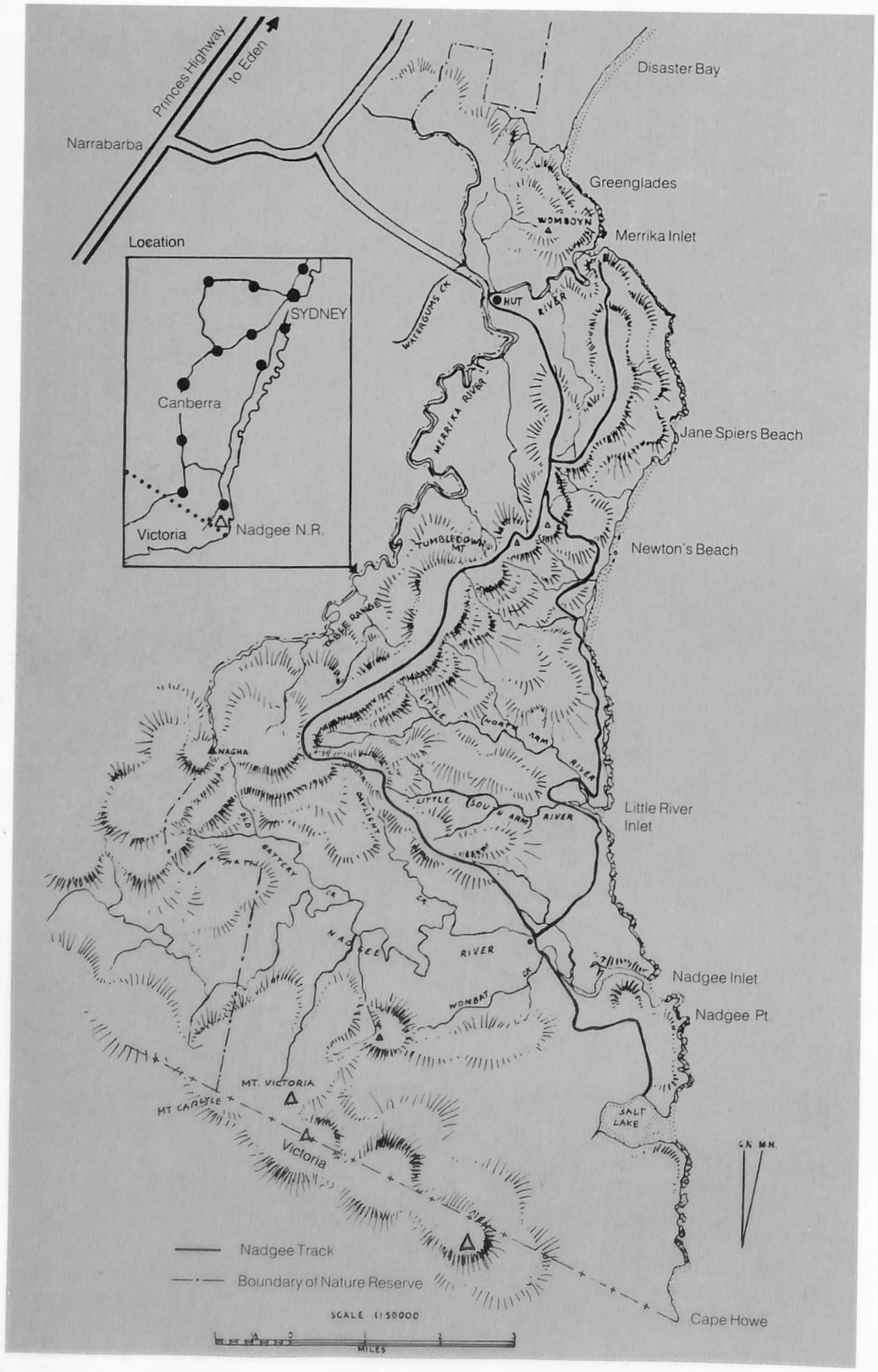
Fire in the Australian bushland draws points of view ranging from a belief that without fire the Australian plants and animals could never have evolved, let alone have existed, to the belief that fire in the bush is the greatest evil. Tied into these views are economic, materialistic, sentimental and at times, scientific considerations. In Australia by far the greatest amount of published research on fire has been for timber resource management. There is very little information concerning the effect of fire on natural systems.

National Park managers are charged with maintaining healthy and diverse ecosystems, which in wilderness and scientific reference areas can only be retained if natural processes, including fire, are protected. Artificial maintenance of ecosystems is at present possible only in very small areas. Apart from there being too little knowledge of how ecosystems function, the artificial maintenance of even the most simple system demands vast and continuous expenditure of energy e.g. the wheat farm or the fish pond.

Do we know what constitutes the natural processes?

The '72 Fire of Nadgee Nature Reserve

Figure 1. Topography of Nadgee Nature Reserve



The forester has been professionally interested in fire for a long time and has evolved quite sophisticated fire management techniques to maximise timber production. However, now he has been placed in the position where the community expects him to provide the answers for the bushfire problem generally. This has resulted in the extrapolation of forestry fire management techniques to that of ecosystem management; an unscientific inference. Conflict is widespread, with the strong polarisation of specialists and laymen alike doing little to shed light on the role of fire in ecosystem management.

Reliable first-hand information of wildfire is a rare resource in the literature as objective assessment is hard to obtain. Firefighters or people threatened by fire take little notice of the pattern of the fire and the student of a running wildfire is generally cursed for being in the way.

Apart from that, the very great complexity of ecosystems causes most observers to shy clear of anything but a very narrow viewpoint while the specialisation of science today makes ecosystem studies a high cost multi-disciplinary work.

The work that follows is a small part of a very broad study made by five workers of the National Parks and Wildlife Service. A great deal of data remains to be interpreted and it is hoped that a much more complete statement will be published elsewhere.

The effect of a fire on an ecosystem must begin with a pre-fire study of the system/s, describe the period of conflagration and follow the post-fire changes which take place until the main characteristics of the pre-fire system have been regained. The knowledge of the pre-fire evolution of the system tells us much about the role of fire in this process and the state of the distribution, abundance and interaction of species which suffer the holocaust — without such knowledge we cannot assess or account for change.

Nadgee Nature Reserve had attracted over 30 scientific projects so that by the time of the wildfire in December 1972, the knowledge of the natural communities of Nadgee was probably more extensive than for any other Nature Reserve in N.S.W.

Nadgee Before the Fire

The Communities of Nadgee Nature Reserve

Nadgee Nature Reserve lies on the south-east corner of the Australian continent (Lat. 37°25'S — Long. 149°52'E). The map, figure 1, defines the topography which is comprised mainly of Upper Devonian sandstones, mudstones, claystones, shales and conglomerates which have been uplifted and deformed in the south and south-west by an intrusion of granite. The highest point, Nagha (540 m) is on the southern edge of a watershed which is the major factor controlling the distribution of the natural communities. Soil moisture, particularly in the sandy soils, is dependent on slope and aspect and provides the limiting factor for vegetation.

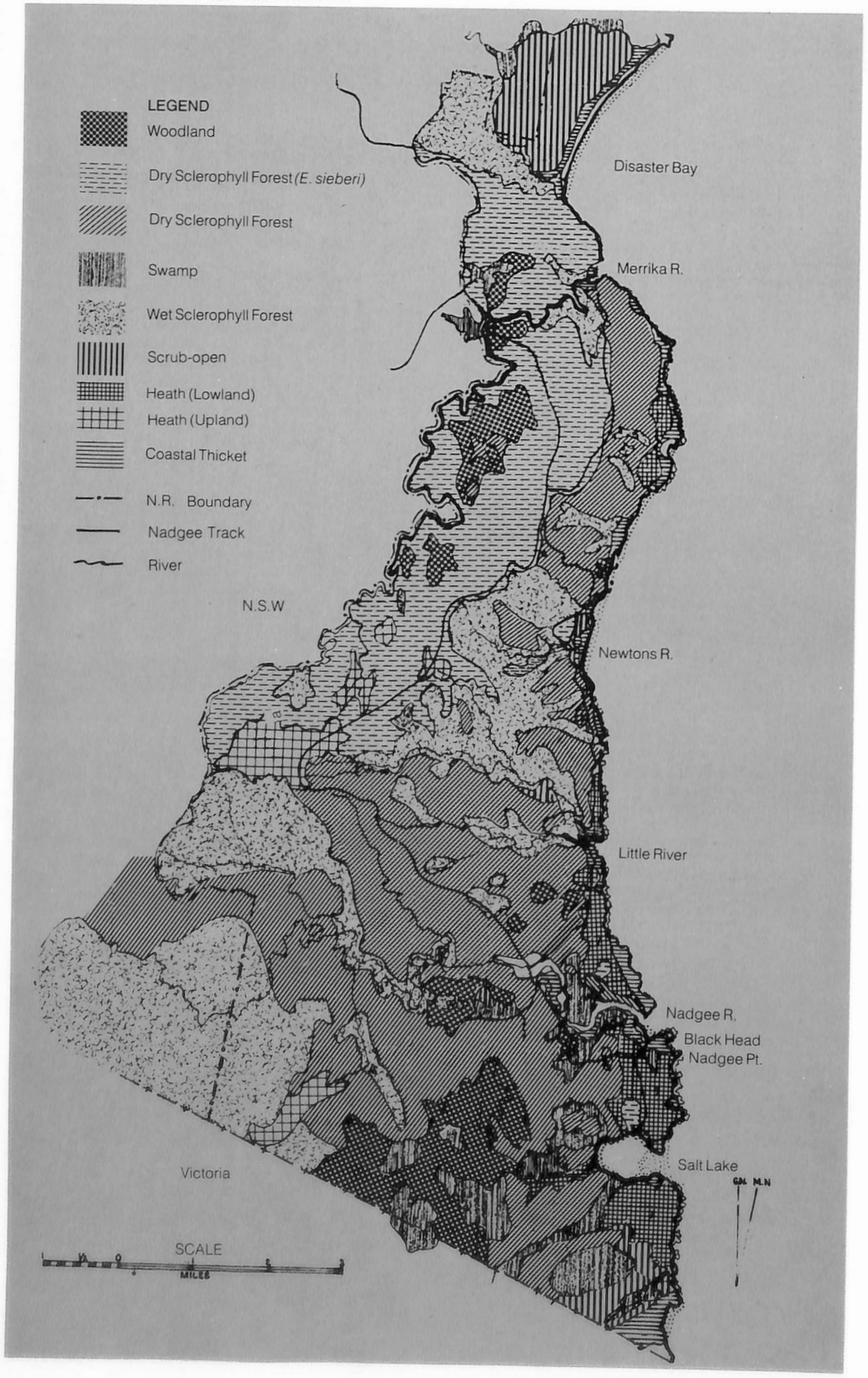
Three major community types predominate — heaths, woodlands and forests. The particular type of community, its structure and species composition is the result of physical conditions, human interference, fire and other natural crises, such as storms and high winds. Figure 2 maps a mosaic of 9 communities, the result of these factors.

Fires lit by graziers have played a significant role in the modification of the heaths for at least a hundred years. Between 1900 and 1954 an attempt was made by the cattle graziers to burn, in a staggered fashion, the heaths and parts of the lower woodlands at least once each five years to provide a source of young protein-rich regrowth for their stock. The last human-lit fires in the Reserve took place in 1965, while in November 1971, two lightning strikes set fires in the Battery Creek area burning 300 hectares of wet sclerophyll forest on very steep land.

Upland heath or sedgeland, Tablehills and Coast Range.
A. Fox

Lowland heath and dry sclerophyll forest, Nadgee Moor.
A. Fox

Figure 2. Vegetation of Nadgee Nature Reserve



Bird Life of Nadgee

Of the 179 species of birds listed for Nadgee, 90 species are long distance (inter-hemisphere) or shorter distance (intra-continental/region) seasonal migrants. If populations of those were removed from the area by natural disaster they would be recharged the following year, providing conditions were suitable for their temporary residence at that time. Eighty-nine bird species make up the resident land species.

The bar graph, figure 3, shows the numbers of bird species resident in each of the habitats while the figures to the right of each bar are the numbers of species restricted only to that habitat. The graphs also give a subjective status ranking— abundant, common, uncommon and rare for that species in the Reserve. This diagram shows the importance of the sclerophyll woodland/forest habitats with the open scrub providing the link between the woodlands and the lowland heath.

Only one species of bird is resident in the open scrub community suggesting that the habitat is a successional stage, particularly as many of the plant species are shared with the lowland heath and woodlands. By contrast, 13 species of birds are totally dependent on the wet sclerophyll habitat suggesting this community is more stable. The coastal thicket has only one resident although 16 species have been recorded in this community. This reflects the unusually rigorous environment (low light, closed canopy, few plant and few food species) and suggests the community suffers considerable modification from time to time.

Wet sclerophyll forest, Battery Creek. A. Fox

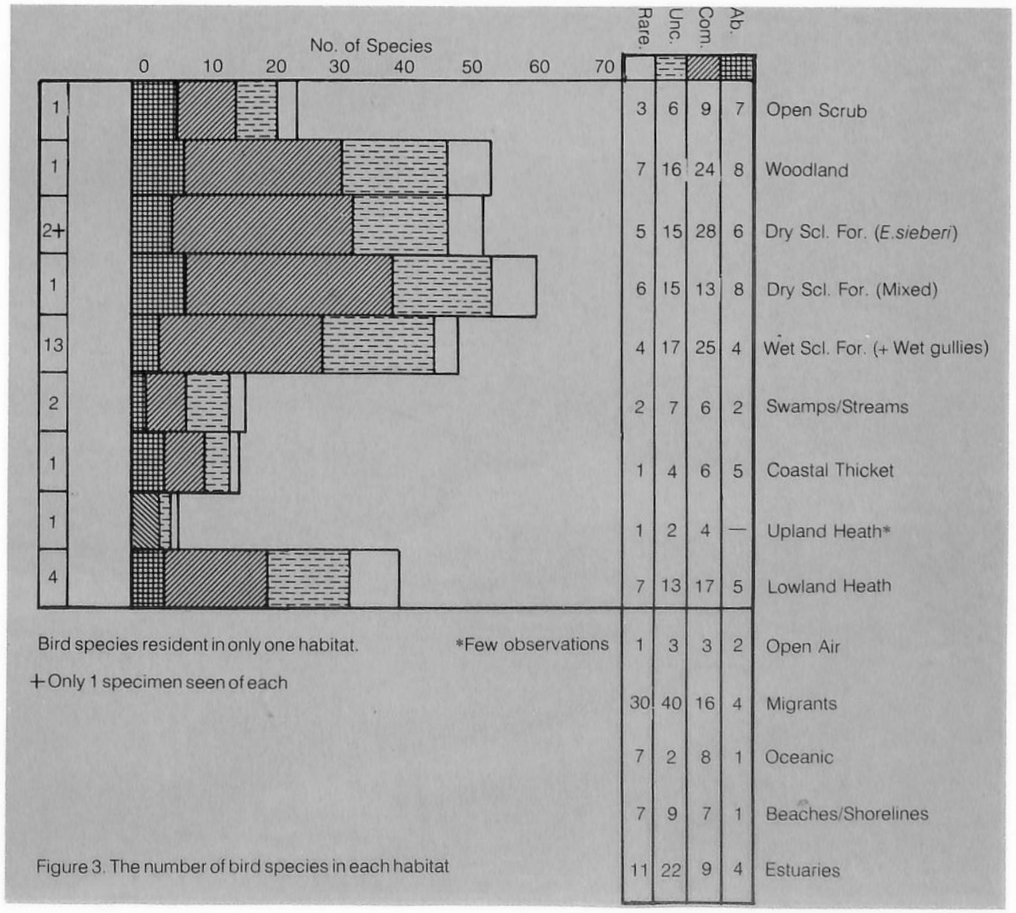


Figure 3. The number of bird species in each habitat

Mixed dry sclerophyll forest, eastern slopes of Mt. Tumbledown.

A. Fox

Coastal thicket and hind dune lagoon, Cape Howe.

A. Fox

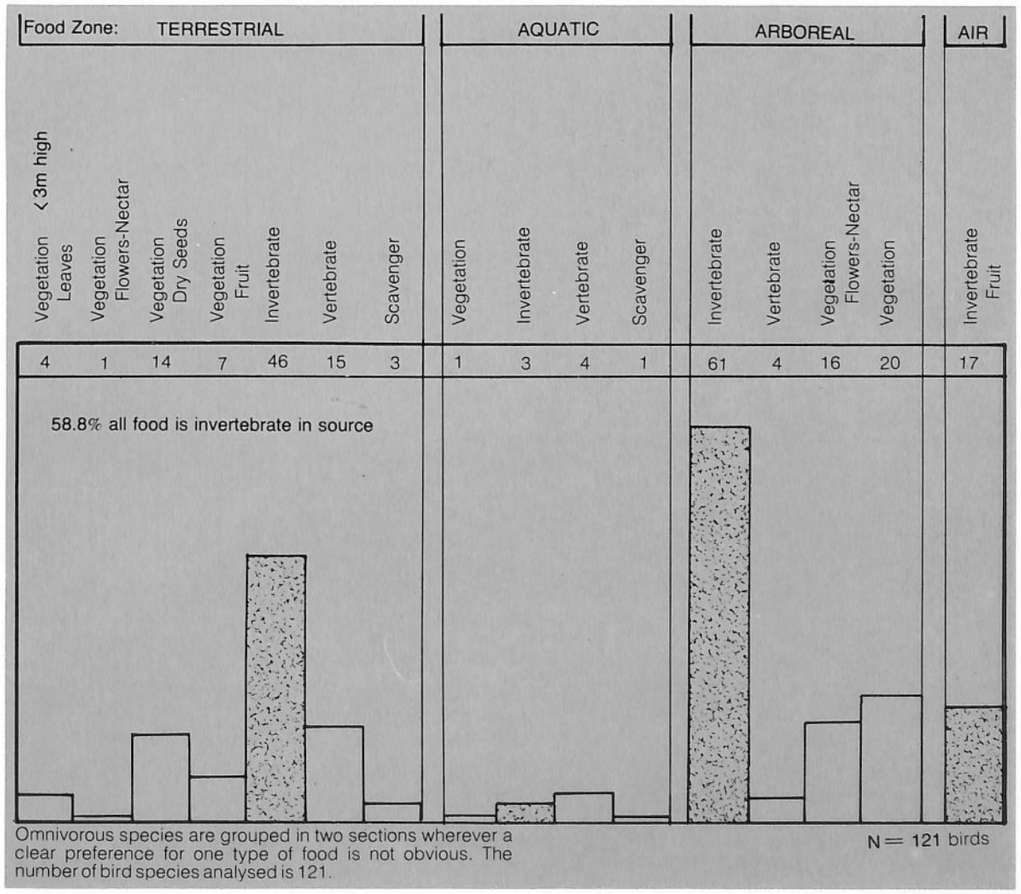


Figure 4. Sources of bird food (excluding solely aquatic birds.)

Fifty-nine percent (59%) of all major food sources for birds are invertebrates (insect, worms, shellfish etc.; Fig. 4). Fifty percent of the bird species studied (i.e. 121) are dependent upon mixed dry sclerophyll forests for food, exploiting different zones of the forests. Of these 60 species 26 chiefly found their food in the canopy, 5 species on the trunks and limbs, 10 in the understorey, 5 in the shrub layer and 14 on the ground.

Figure 5 groups the birds according to the zone in which food is found. The canopy and ground provide food for a large number of species. This gives an indication of the impact on bird populations if the floor, understorey or canopy is destroyed or modified by fire.

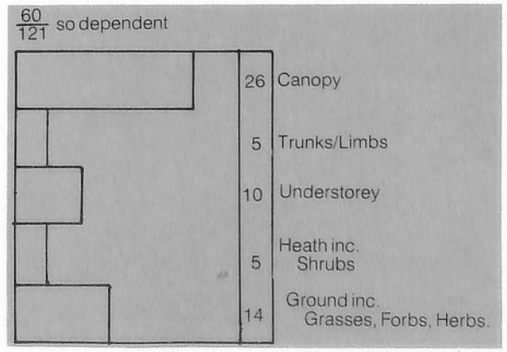


Figure 5. Bird species dependent on one habitat zone for food

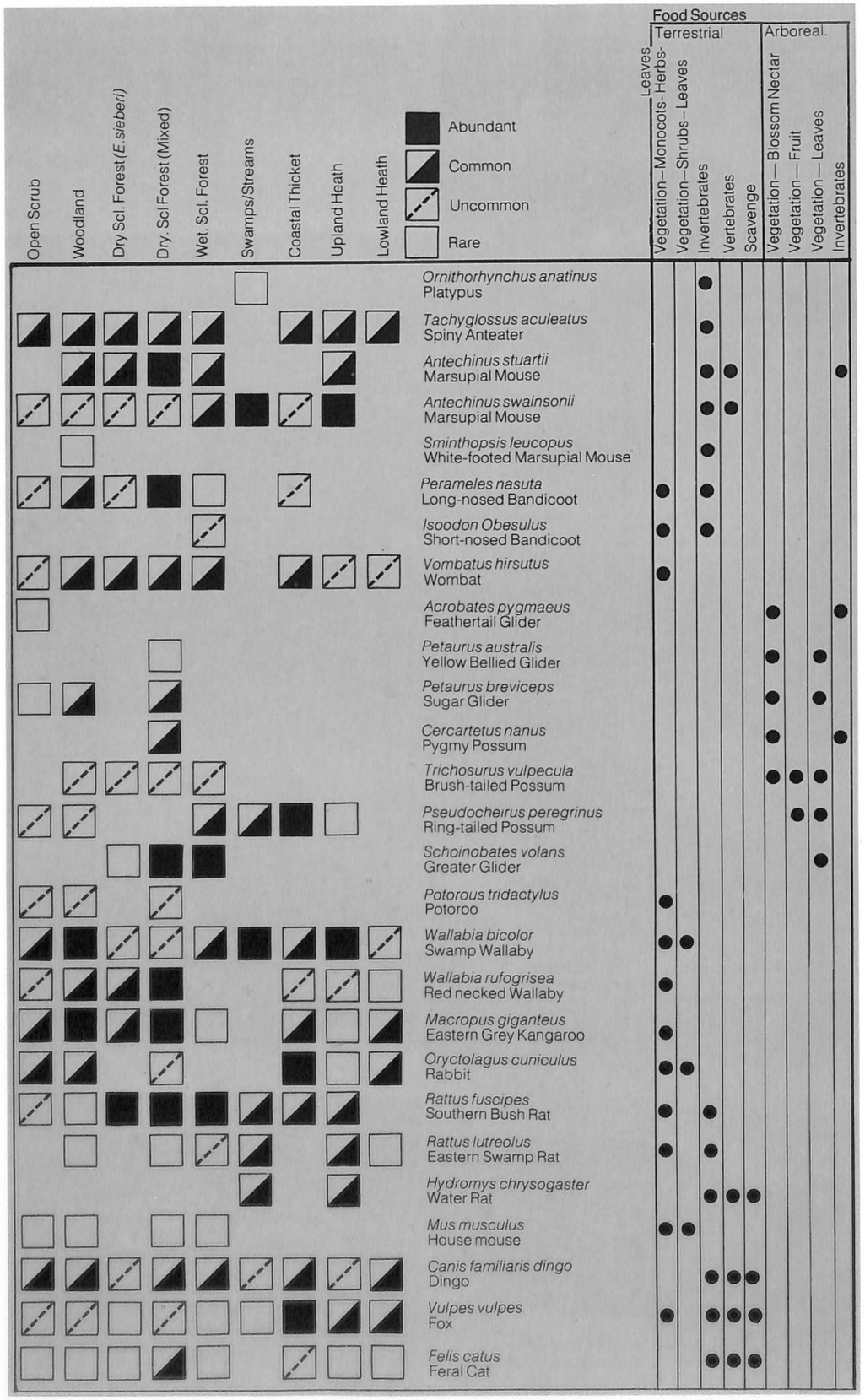


Figure 6. Distribution and abundance of mammal populations.

Mammals of Nadgee

What of the mammals? From many sources I have constructed figure 6 which reviews the status, distribution and food sources of 27 species of mammals within Nadgee. Some of the data were very general so there remains much room for refinement. The work suggests four groups of animals—

1. Small to light mammals which are predominantly invertebrate and omnivorous feeders obtaining most of their food from the litter and top soil horizons. Two of the small mammals (*Antechinus* spp.) also act as predators on smaller vertebrates such as skinks and *Mus* sp. All of these animals either shelter in shallow tunnels, part dirt, part litter, in hollows under dense tussocks or under logs on the floor of the community.

2. Light medium mammals, primarily vegetarian, include the possums and phalangers which are adapted to an arboreal life. These animals have variously developed planing membranes, climbing claws and modified feet and hands and in some, prehensile tails. These animals shelter in limb and trunk hollows and in the case of the ringtail possum build a large nest of dried leaves in the dense canopy of thicket and scrub.

3. Larger herbivores, the wallabies, eastern grey kangaroo and the wombat which according to the species, utilise grasses and herbs, shrubs and plant roots. The wombat is a burrowing animal whose distribution is largely controlled by forest soil types, while the macropods are distributed acccording to their food preferences and shelter in dense thickets near their feeding area. The kangaroo utilises the open heath in the winter, while the forest tends to be the summer habitat. The smallest macropod at Nadgee is the rabbit-sized potoroo, which shelters in long tussocky grasses and is rarely seen, being primarily a night feeder on the grasses and herbs.

4. The mammal predators of the systems are the dingo, fox and feral cat, the last two being exotic. Two marsupial predators, the tiger cat, *Dasyurus maculatus* and the eastern native cat, *Dasyurus viverrinus* probably are in the area in low numbers, though no records of sightings have been made. The dingo is wide ranging (approx. 15 km of coast) and has a population of from 5-8 pairs in the Reserve living off mammals, birds, reptiles, insects, crustaceans and carrion from the tide lines. Foxes are about 80% insectivorous and make up the rest of their diet from reptiles, small mammals and birds while the feral cats are opportunistic feeders on any animal that they can catch. These three predators are usually highly secretive and tend to shelter in the coastal thickets which are usually dark and dry.

From Figure 7 it is once again apparent that the mixed dry sclerophyll forest is the dominant habitat type for mammals. This is the largest and most widespread community east of the Coast Range. The variety of plant species, age classes, heavy litter and log cover of the floor provide a wide range of food and shelter. By contrast, the lowland heath has few resident species and the only native mammals I have noted settling permanently there are the spiny anteater, and a rat, *Rattus fuscipes*. *Rattus* took up residence only after there was sufficient density of vegetation and litter on the ground surface through which it could build its covered runways. These runways usually radiated out from thickets of taller vegetation (mallee-form bloodwoods, *Angophora* and grass trees). On the Nadgee Moor these conditions occurred about 5 years after the 1965 fire. No mammal species appeared abundant on these heaths before 1973, which may be related to the rapid successional changes of the heaths caused by their history of burning. The 9 areas of heaths of Nadgee differed floristically though they appeared to be evolving in the same direction, towards an open scrub.

Along with the bird species, a great deficiency lies in our understanding of the invertebrates of the communities which form such a major food source. Most of the invertebrates which are accessible and chosen for food are in the top few centimetres of soil, in the litter, in and on the bark of plants and on the leaves of the canopy — all highly vulnerable places to damage by fire.

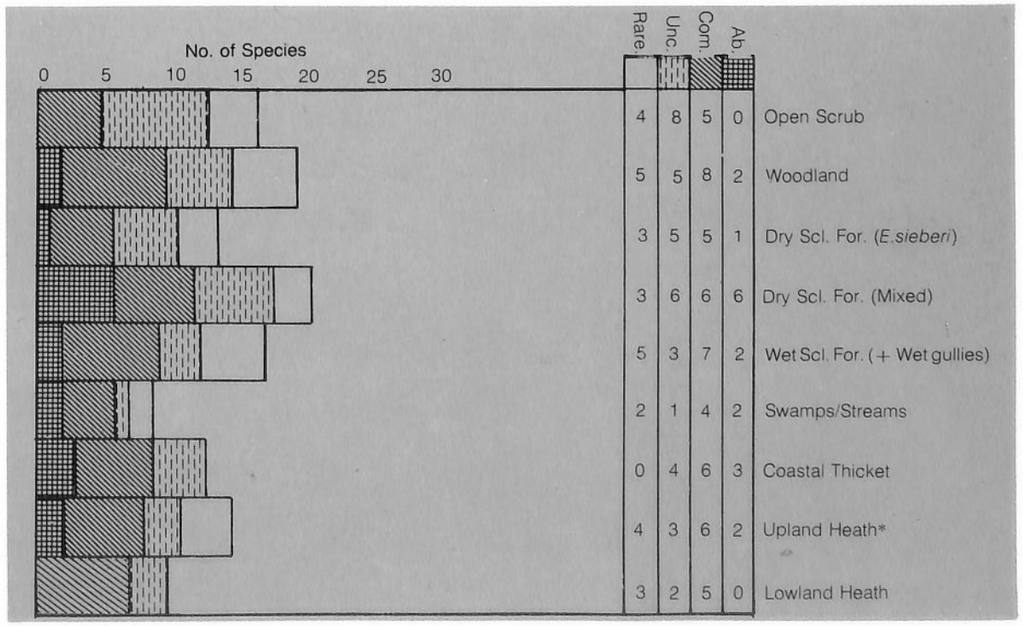


Figure 7. Mammal species present in each community

Environmental Conditions Leading to the Nadgee Fire

From 1967 to 1969 the climate of Nadgee had been dry (Figure 8). The forest litter on the ground in most areas had built up to a steady state condition whereby decomposition equalled litter fall.

In the summer of '70-'71 heavy rain fell (1067mm) and massive vegetation growth occurred. The following winter was cold, restricting growth and drying out the understorey. Figure 9 draws attention to the variation in the rainfall in this small reserve, and indicates the inaccuracies inherent in talking about average rainfall.

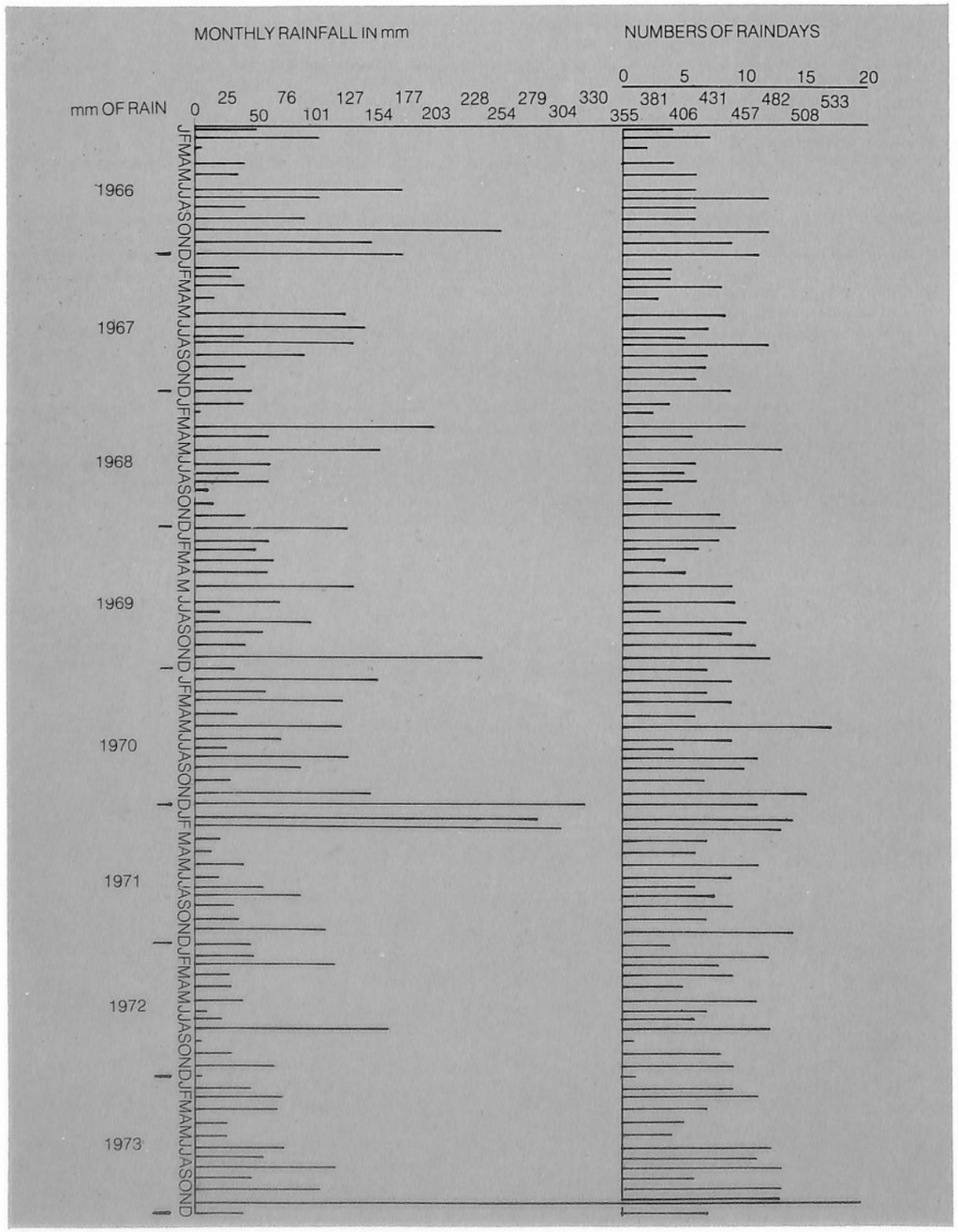


Figure 8. Rainfall at Merrika Station from 1966-1973

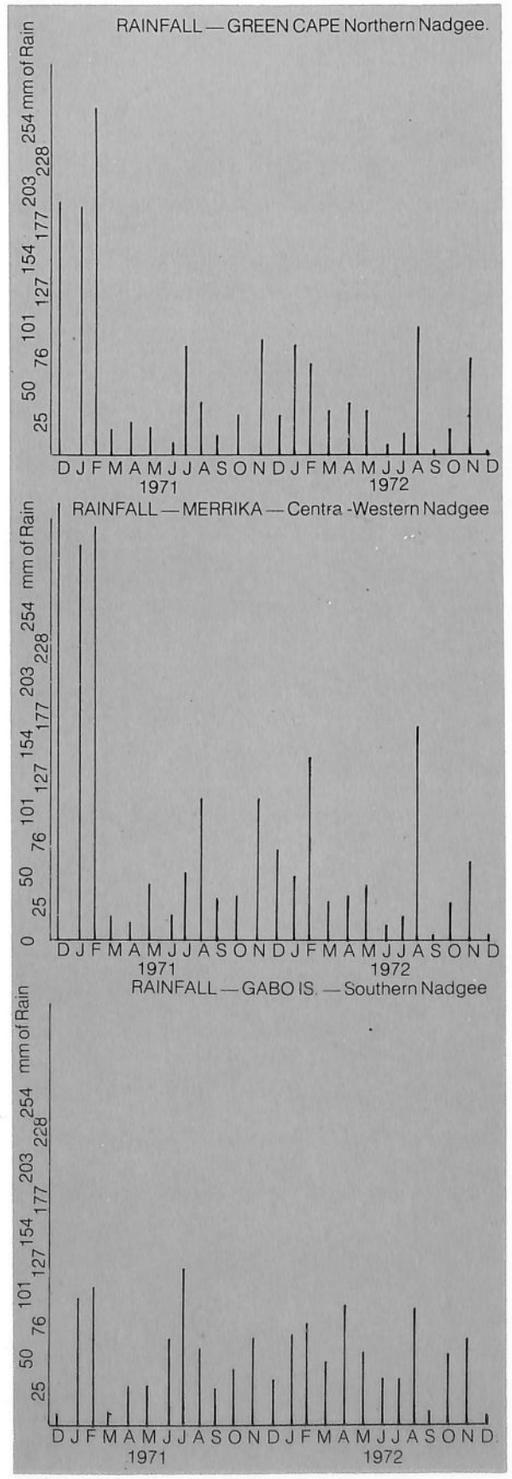


Figure 9. The rainfall in three areas of Nadgee Nature Reserve 1971-72.

In the summer of '71-'72 a rainfall peak occurred, again stimulating growth. Another fall in August 1972 triggered off the spring growth. The last rain before the fire was on 24th November— the drought index * was beginning to rise.

Maximum temperature for 14.12.72 was 35°C and lightning from a local storm sparked severe bushfires near Egan Peaks north-west of Eden. A hot, dry north-westerly change before a cold front in a rapidly approaching trough, further reduced humidity in the area.

At 0900 EST on 15.12.72, a dry front moved across Wilson's Promontory (Figure 10). At 1400 EST it passed over Kosciusko National Park and ignited at least 3 areas reaching the Merrika Station at 2200 EST. No rain fell, but lightning discharge was heavy. It was not until the early afternoon of 16.12.72 that ranger David Hope located two fires in Nadgee after returning from 25 hours fighting the Egan Peaks fire.

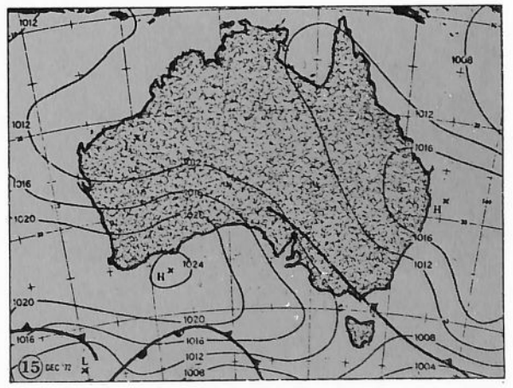


Figure 10. The daily weather map for the 15th December, 1972, showing the front which ignited the fires

Recording the Data

While the fire was still burning we began to muster a team of wildlife staff and to plan a study of the impact of the fire immediately the fire had burned out of the Reserve.

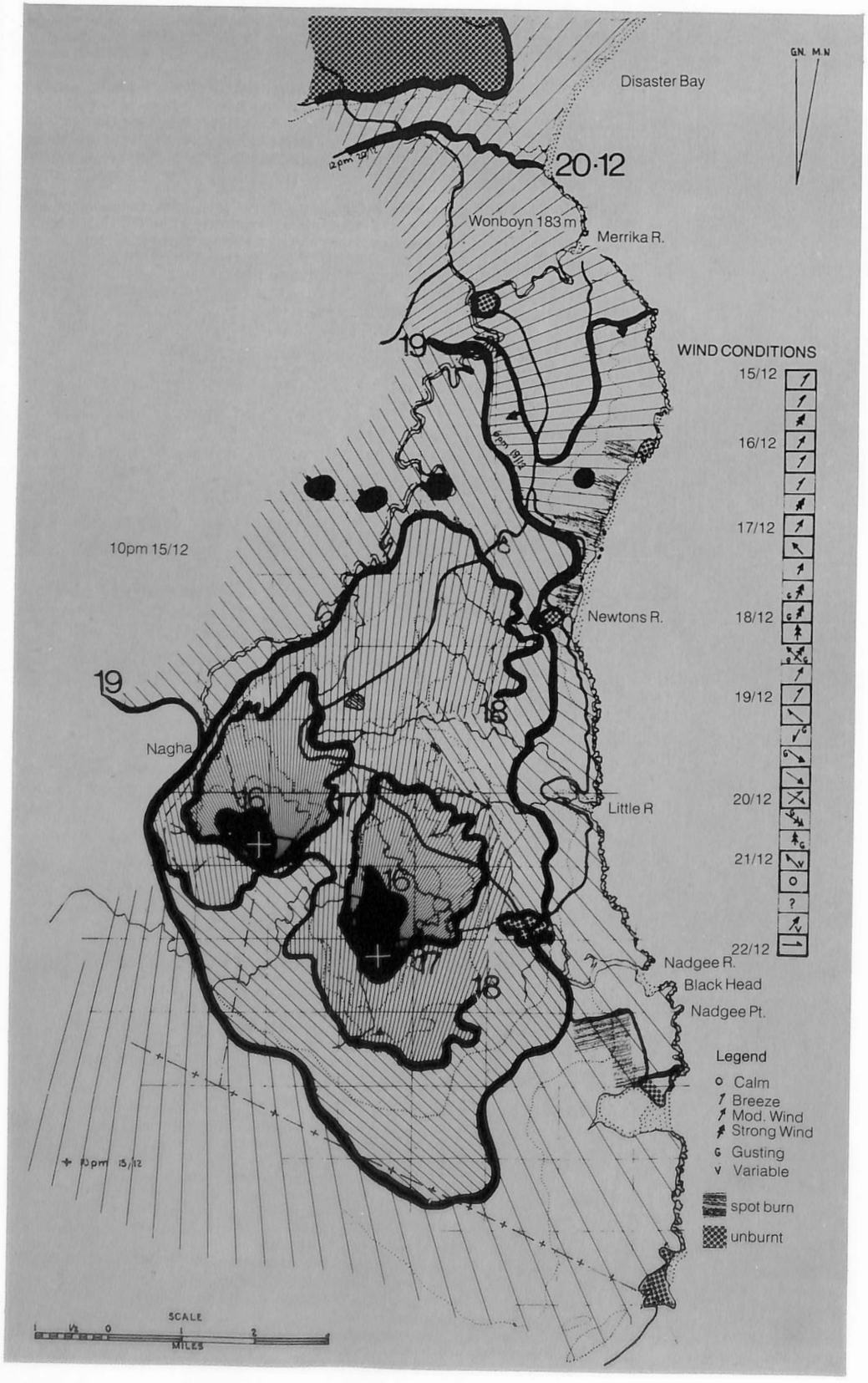
These tasks were given highest priority:

- to map the fire spread and fire intensity
- to photograph the area from the air with large scale oblique colour, black and white and false colour infra-red film
- on the ground to collect, to observe and to record any evidence of impact of the fire upon wildlife
- and to record the experiences of those people involved in the fire.

Following this work we would then lay out study sites to record the longer term changes taking place as the systems re-established themselves.

* Drought index (Macarthur) is a measure of the dryness of dead wood. The higher the index the more susceptible the vegetation is to fire.

Figure 11. Fire development in Nadgee Nature Reserve



The six hourly course of the fire was mapped from the time of ignition by a combination of assembling evidence from the first hand witnesses (using questionnaire and maps), obtaining fire-day weather data (regional and local) and fitting this to the physical geography of the area; field evidence such as scorch heights, crown burns, chimney effects on ant mounds, the directional set of scorched canopies and melted objects (glass, plastic, aluminium). The collection of this data by questionnaire and field observation was begun while the south-western edge of the Reserve was still burning.

On the first day of the study, aerial surveys using a Cessna 182 flying runs between 1245 – 1330 and 1630 – 1750 EST were completed, including the mapping of the "green" canopy onto a base map by a cartographer in the plane. Five long days of walking and note taking followed. The next week a draft map was constructed which was tested against all of the evidence, redrawn and then traced, showing a fire line (where reasonably certain) for each 6 hours, along with a representation of the district wind condition (Figure 11). As well as our own notes we had access to a report by Susan Hope who walked the length of the Reserve and back, two days before our traverses. Our studies tell this story.

Holocaust

Following ignition by lightning at about 2200 EST (15.12.72) at least two centres of fire began moving in a north-easterly direction driven by a south-westerly breeze. The fires crossed the valleys speeding up under a freshening wind and increasing slope. At this time the fires were comparatively cool and rarely crowned in the open forest. After twenty-four hours the fires were still separate and had burned two elliptical areas about 1½ km by 1 km. The air and fuel of the region were rapidly drying under the influence of these fires and a number of other fires to the west of Nadgee which had been burning since 12.12.72.

On the 17.12.72 a moderate wind fanned the fire but it shifted from south-east to south-west and by afternoon was a gusting strong south-westerly. However, the fire had slowed as it had crossed a steep ridge and was moving downhill on the lee side towards Little River. These slopes had a heavy cover of understorey and litter and with the slow burn nearly all of it was consumed. The crowns of the eucalypts scorched and patches of the crown burnt in the convection draughts. The western fire had by this time climbed out of the Nadgee up-slope and reburnt the tall open forest (wet sclerophyll) which had been burned in the 1971 wildfire. By afternoon this fire was travelling steadily through the montane heath and sedgeland. Strong gusting winds blew throughout the night and at about midnight both fires joined after being separated by the Tabletop Road for three kilometres. The strong south-westerly spotted the fire ahead onto the opposite slopes of Little River before dying to a breeze. Those fires burning back downhill cooled considerably passing beneath large areas of canopy without scorching it, while those moving ahead produced a very patchy effect with pockets of intense burns particularly on the drier western slopes in the heads of the creeks. By 2230 EST the fire was passing to the west of Tumbledown but was still east of the Merrika River.

Still the drought index was rising and almost all vegetation was in a wilting condition with fuel in a highly flammable condition.

The 19.12.72 was calmer but the breezes were gusty and constantly shifting. Greatest extension of the fire was across the Merrika and up the slopes into the State Forest areas where fires had been burning since the 15th. Slowly over the period the fire had been wandering southwards and up the slopes of the Howe Hills. By sunset a fireline stretched south from Nagha Trig into Victoria and lay in the forests and woodlands just inland of the coastal heaths right up to the tops above Jane Spiers Beach. At about midnight a backburn was commenced and completed as the wind suddenly gusted to a scorching gale from the north-west. The long line of fire back from the coast swept eastwards and then as it broke onto the heaths the wind backed around to the south. Because the fire had taken four days to develop and was slowly moving, many of the larger macropods had moved ahead of it. An observer from Mallacoota National Park described the behaviour of ground parrots in front of the fire, "they would flush from a metre or two before the flames and fly swiftly, at low level cross the canopy and drop into the vegetation 100-200 metres ahead of the fire." These animals were now trapped between fire and sea. Many were burnt, others jumped the cliffs. At least three fire storms developed, one just north of Salt Lake, another in a basin between the Nadgee Homestead and the southern bank of the estuary while the third, where the southern headland of Jane Spiers beach formed a basin as it ran off the Coast Range. In the latter area the backburn swept in from the north and west as the wind changed and swung the fire up from the south. In this vortex a 20 metre high, extremely dense thicket of *Melaleuca* ½km deep and 2 km long disappeared in a few minutes to become a bed of white sand. At 1400 EST the gusting southerly swept the fire past the Ranger Station and on towards Wonboyn. Nobody clearly remembers the conditions following but in the next twenty-four hours the open forests of the Wonboyn Dunes section of the Reserve lost its complete canopy before the fire was controlled late on the 21st.

One week later (28.12.72) we flew into a thick pall of smoke and exposed a large number of false colour infra-red and colour films over Nadgee from 150 m and 700 m. The infra-red proved extremely valuable in "seeing" through the smoke haze.

Below lay a scene of almost complete desolation, the mile upon mile of heathland edged by the canopy of thicket, woodland and forest was an undulating grey plain only relieved by the gaunt black skeletons of the trees and sooty patches where there were once marshes. The western edge of the Nadgee Moor where previously we had rested under the lush canopy of ancient twisted angophoras was a white plain broken by the surrealistic groping blackened trees. Deeper in the forest of coast ash *E. sieberi*, were the signs of a powerful calamity, trunks half a metre thick had been smashed into so many splinters. Limbs and trunks were scattered about in complete disorder wherever the violent winds created by the fire storm had dropped them. A hundred metres further west the canopy was green. Here was the first surprise. The awesome wildfire which had dominated the headlines for nearly a week, and was still doing so as a "great disaster", had not produced a clean sweep. Instead it had created a most diverse mosaic of intensities from raging inferno, to a burn which did not even get to the soil surface through the litter. But most important, the gullies back in the hills ran like green arteries linking the parts of this mosaic of white, grey, black and green. Apart from the gullies, some 30 ha of unburnt floor was all that remained in the Reserve.

Even from 700 metres above, most of the land below looked as if all wildlife has been extinguished — a feeling which was to depress us in the eerie silence as we padded mile after mile through the Reserve from the third of January to complete a fortnight of ground studies. During that time the drought index was steadily climbing to more than a hundred points above the fire week (from 225 to 360).

The gullies provide refuge for some fauna during and immediately after the fire.

A. Fox

After, the fire there is an eerie silence. It is a fascination of nature that life soon reappears in what looks to be a devastated area.

A. Fox

Newton's Valley was a typical example of the effects of the fire. Here the fire had burned in as a slow ring of flames from the ridges which had been suddenly activated by the southerly gale of the 20th which swept fire in from the southern headland and across the thicket-covered dunes and lagoon scrub. In this burst of fire, quantities of burning debris were swept up, and along with scorched and asphyxiated birds, dropped into the sea to be washed up forming a tide line, in places, 30 cm deep. Among these we picked up and identified 609 birds (Tables 1-2). Across and along the upper parts of the beach the fire had smouldered along spinifex runners even burning old strand lines of seaweed. But where green spinifex and *Festuca* tussocks broke the beach, macropod and rabbit tracks abounded. Dingos and goannas had dragged out many carcasses from those washed up. Food for the time being, was abundant for the predator/scavenger In fact on that beach alone seven swamp wallabies, six grey kangaroo and two red-necked wallaby carcasses were collected. Only two showed direct burns— one near the thicket edge had been burned to little more than a skeleton while one swamp wallaby had 10-15 cm blisters on its rump and lay along with nine other macropods at the base of cliffs over which they had leapt.

Table 1 A measure of the impact of the fire on the bird population of the heaths and woodlands.

		Number of Birds of the Heath and Woodland.					
		OCTOBER (pre-fire)		JANUARY (4th & 5th) (post-fire)			
				Alive January		Dead January	
Family	Groups	No.	%	No.	%	No.	%
ACCIPITRIDAE	Eagles & Goshawks	10	.9	1		nil	
FALCONIDAE	Falcons	1		2		nil	
PHASIANIDAE	Pheasants & Quail	nil		nil		2	
COLUMBIDAE	Pigeons & Doves	5		3		4	
PSITTACIDAE	Parrots & Cockatoos	79	9.6%	38	7.3%	14	2.3%
CUCULIDAE	Cuckoos	21		3		1	
STRIGIDAE	Hawk-Owls	2		2		1	
TYTONIDAE	Barn Owls	nil		nil		1	
PODARGIDAE	Frogmouths	nil		nil		1*	
AEGOTHELIDAE	Owlet/Nightjar	nil		nil		2	
APODIDAE	Swifts	nil		10		nil	
ALCEDINIDAE	Kingfishers	4		10		nil	
MENURIDAE	Lyrebirds	8		3		nil	
HIRUNDINIDAE	Swallows & Martins	50	5.3%	58	11.1%	nil	
MOTACILLIDAE	Pipits	8		6		nil	
CAMPEPHAGIDAE	Cuckoo-Shrikes	3		12		nil	
TURDIDAE	Thrushes	4		4		5	
MALURIDAE	Australian Warblers	166	16.6%	183	35.1%	41	6.7%
MUSCICAPIDAE	Old World Flycatchers	40	4.2%	28	5.3%	50	8.2%
RHIPIDURIDAE	Fantails	31		18		nil	
MONARCHIDAE	Monarch Flycatchers	2		4		1	
PACHYCEPHALIDAE	Whistlers	28	2.9%	16	3.0%	24	3.9%
FALCUNCULIDAE	Shrike Tits	12		5		3	
SITTIDAE	Sitellas	nil		nil		2	
CLIMACTERIDAE	Tree-creepers	12		21		10	
DICAEIDAE	Flower-peckers	8		nil		1	
ZOSTEROPIDAE	Silvereyes	24		18		nil	
MELIPHAGIDAE	Honeyeaters	338	34.8%	42	8%	434	71.2%
ESTRILDIDAE	Finches	50		24		6	
ORIOLIDAE	Orioles	1		nil		1	
ARTAMIDAE	Woodswallows	12		nil		nil	
CRACTICIDAE	Australian Magpies	11		8		4	
PTILONORHYNCHIDAE	Bowerbirds	11		1		1	
CORVIDAE		?		?		nil	
		941 (59 species)		520 (57 species)		609	

* only dead bird on the heath, all others on the beach. This figure does not include dead seabirds.

The tea trees, wattles, banksias and melaleucas of the frontal dunes were totally defoliated while the extremely dense melaleuca thicket was just a mass of blackened bars rising from white beach sand. Two fire hardened ringtail possums swung and rattled in the breeze hooked by bone-dry prehensile tails. Already the sedge, *Juncus maritimis* had shot 2-6 cm.

Along the old sea cliffs behind the beach the intense fire had caused flaking of the rock surfaces with the half centimetre thick flakes collecting in screes at the cliff bases.

About half of the clearing with its cover of kikuyu had been burned and of 27 grey kangaroos present on the clearing in August (1972) 19 grey kangaroos and 7 red-necked wallabies were using it immediately after the fire. Three senile unscorched males were dead in unburned grass apparently from shock or asphyxiation or both. The soils of the hillslopes were quite bare, very loose and dusty. Up-valley, where the woodlands became a wet sclerophyll forest, the canopy was green, with king parrots, crimson rosellas, gang gangs and a few bellbirds feeding. Waterholes in the creek were providing harbour for red-bellied black snakes, averaging one snake for each pool (at approximately 20 metre intervals). Scratching for food in the unburned litter of the creek bed were two wonga pigeons. Lyrebirds were also active. Four wombat burrows in the banks of the creek above the campsite were being actively used by wombats, a feature which was borne out at all wombat burrows observed throughout the Reserve. We found no evidence that these animals had been physically injured by the fire.

After dark the marsupial mice, *Antechinus stuartii* and *A. swainsonii* were very active hunting on the unburned flat, making easy trapping targets. A violent shaking of the acacia canopies near the creek led us to two ringtail possums while on a high limb of a mountain gum *E. cypellocarpa*, with black tail streaming in the wind, the star-like eyes of a greater glider gleamed back at the spotlight.

Newton's Flat and the creek were an unburned oasis and as the days of systematic searching went on we realised that there were many small reservoirs of animal life and these were nearly always in the gullies in the hills.

Table 2. Number of Birds found dead on Nadgee beaches in January.

	Howe Beach	Salt Lake	Nadgee	Little River	Spiers	Newtons	Total
Stubble Quail					1	1	2
Brush Bronzewing					2	2	4
Rainbow Lorikeet					1		1
King Parrot						1	1
Crimson Rosella					4	3	7
Ground Parrot					1	4	5
Fan-tailed Cuckoo						1	1
Boobook Owl						1	1
Barn Owl						1	1
Owlet Nightjar					1	1	2
Tawny Frogmouth			1				1
Blackbird						5	5
Blue Wren					3		3
Emu Wren					1		1
Striated Thornbill				1	3	7	11
Brown Thornbill					16	9	25
White-browed Scrub Wren					1		1
Scarlet Robin					1		1
Yellow Robin			10	5	23	11	49
Leaden Flycatcher					1		1
Golden Whistler					10	11	21
Rufous Whistler					1	1	2
Grey Shrike Thrush					1		1
Shrike-Tit						2	2
Whipbird			1				1
Sitella						2	2
W.T. Treecreeper					5	5	10
Spotted Pardalote					1		1
Yellow-faced Honeyeater				5	10	14	29
Brown-headed Honeyeater					4	1	5
White-naped Honeyeater					1		1
New Holland Honeyeater	2	2	1	30	93	138	266
Spinebill				1	5	6	12
Bell Miner				1			1
Little Wattle-bird	1		1	1	35	82	120
Beautiful Firetail					2	1	3
Red-browed Finch					1	2	3
Oriole					1		1
Pied Currawong					2		2
Grey Butcherbird					2		2
Satin Bowerbird						1	1
	3	2	14	44	233	313	609

DIRECTION OF FIRE PATH → ← BACKBURN

The fire-stormed south end of Jane Spiers beach and hinterland however seemed lifeless except for the wombats which remained safe in their burrows having had 50 cm of sand insulating them from the searing heat above, heat which had melted aluminium signs (659°C) and melted beer bottles flat (greater than 1200°C). Here, the creek bottom had been heated to such an extent that all exposed stone boulders were shattered. Even so, small live skinks were present where rock shelter had been deep enough, and the ubiquitous black snake was lying in the single pool above the beach. This beach too had its half-buried macropod and bird carcasses. Another apparent casualty along the sea cliffs behind the beach were many hundreds of rock lily stands *Dendrobium speciosum* which resembled baked bananas on a black rock platter.

On the heaths the ground surface was like brick swept clean of sand and seed by strong south-westerlies on the 22nd. Sand, seed and ash drifted up against any impediment to the wind. On the heaths, which had been dominated by *Banksia serrata* and *Hakea sericea*, the winged seeds had dropped. The fire had dried out and opened the woody fruits and the seeds had been blown into dense masses on the eastern edge of the heath. Fire and wind together have thus probably radically altered the plant distributions on the heath. In most instances all standing wood living or dead, less than 3 cm in diameter had been burned entirely.

Extensive clusters of holes under the woody rootstocks and lignotubers rarely showed signs of life of the expected rat or reptile. As the days of this first post-fire visit went by it became evident that a vast population of small skinks, weevils and millipedes had existed on the heaths. At first, there was little evidence of them but the numbers of carcasses erupted. Lack of shelter and food on the surface appeared to be the cause of their demise. On the 3rd January numbers per square metre ranged from 0-6 but by the sixth, the metre quadrats were showing 6-33 carcasses. At this time ravens and currawongs were very active on the heaths feeding on the small lizards that had no cover. We also observed a very fat and very much alive diamond snake (2.6m) stretched between the skeletons of two banksias out in the centre of the heath and nearly a kilometre from the rocky shore, its normal shelter.

The speed of the fire across Nadgee Moor was such that grey kangaroos had been caught by it out on the open heath, they lay stretched out as if in full flight, their stomachs having exploded. Dingos had searched the dried out corpses for food and found little. Already under the carcasses invertebrates were hard at work breaking down the remains.

In all, 41 macropod carcasses were found after the fire, 29 were swamp wallabies, 9 grey kangaroos and 3 red-necked wallabies. Twenty-four dead ringtail possums near to, or in their thicket habitat with 12 in one discreet area 100 metres by 20 metres were collected.

The whole of Nadgee was now undergoing severe famine following the holocaust.

The Communities Re-Build
Two months after the fire

Throughout this period 102 mm of rain had fallen during twenty rain days, (Figure 8) this light rain caused the drought index to slowly subside from its peak of 430 on January 24th to 310 on 24th February, the first day of our third period of investigation. Because almost the total leaf cover had been removed, the loss of soil moisture by evapo-transpiration was extremely low. Even though most of the light rain was quickly lost from the soil surface by evaporation, there appeared to have been a build up of moisture in the sub-surface (greater than 15 cm) from deeper levels. Rough experiments also demonstrated that the loose sandy surfaces were hydrophobic and shed water into the depressions where wind blown seed and ash had settled.

On the study transect which ran through forest, heath, wet heath, woodland, thicket and littoral grassland twenty species of plants, apart from trees, were producing green leaves. Of these, three were grasses (from seed) and the rest were shooting from underground stems or root stocks, the most notable being oat speargrass *Anisopogon avenaceus* and *Lomandra glauca*. In the damp gullies the lawyer vines *Smilax*, wombat berry, *Eustrephus* and *Tylophora barbata* were growing very vigorously from underground stems. Along with a large white gill fungi which grew among the ashes these vines were being eaten by mammals (rats?) unknown. Within the thicket the only signs of life were a few tenuous *Tylophora* runners snaking out from a rocky break in the slope to the sea cliffs. Down on the edge of these cliffs in a soak, a bed of the sedge, *Scirpus nodosus* had escaped the fire and in it vigorous nest hole digging (14 nests) had taken place since the fire — probably by displaced *Rattus* sp. (Later in the year we planned to live trap and identify the species.)

In the forests and woodlands the species of trees were reacting differently. The black ash, *E. sieberi* had rapidly produced reddish clumps of epicormic shoots but already these were in trouble from the first of a series of insect plagues to develop on this vast new resource of food. A green caterpillar (about 150 mm long) had hatched by the million and was feeding and engulfing each clump of early shoots in a web. These clumps were dying and as the epicormic shoots were lost, the trees too were dying. However even at this early time the herbivores were being attacked by growing populations of small ants (three species) which were carrying endless processions of the caterpillars to underground nests.

Red bloodwoods *E. gummifera* were the first eucalypt to shoot, in the forest, from both lignotubers and epicormic buds, and on the heath the stunted forms grew prolifically from lignotubers and from the lateral roots. One patch south of Little River measured 50 x 75 metres. Here there was considerable evidence of grazing by both wallabies and grey kangaroos. The woolly butt *E. longifolia* while showing signs of splitting and shedding its 1 cm thick "leathery" bark showed no shoots.

The most remarkable growth was with the rough barked apple *Angophora floribunda* which was enclosed from its lower butt to the branch tips with a sheath of bright green epicormic growth. The effectiveness of the protection of the vascular systems in the apple was clearly shown on the edge of the southern fire storm area where ash stems 40-50 cm in diameter had been killed while in among these trees apple stems 4-10 cm diameter were shooting. At the same time there were many areas of mixed forest where all the ash crowns had been scorched while among them the woolly butts and apples were green. Does the ash canopy burn with such intensity that it kills itself, particularly when it is in almost monospecific stands? From a biogeographic point of view the reason for the purer stands of apples on the western edges of the

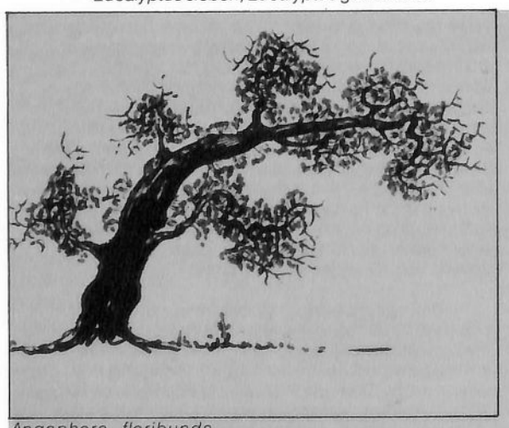
heaths becomes clearer—the hotter higher ground fires caused by the understorey of heath favours the more fire resistant apple. The importance of the apples to wildlife for shelter and food in the famine phase which follows fire is remarkable. Forest enrichment practices for commercial purposes which eliminate the unproductive apples must severely reduce the wildlife values of the forest which is susceptible to wildfire (Figure 12).

Behind Jane Spiers Beach the scene had changed little over the two months— the wombat was foraging widely in its quest for roots and beach grasses, while macropods were concentrating on *Spinifex* and bloodwood shoots. The small stream at the south end had a higher water level probably due to the complete absence of evapo-transpiration losses from the catchment, but it was becoming highly eutrophic. No doubt ground water seepage was carrying a higher nutrient load and any dust settling in the pools would be charged with fire-freed nutrient.

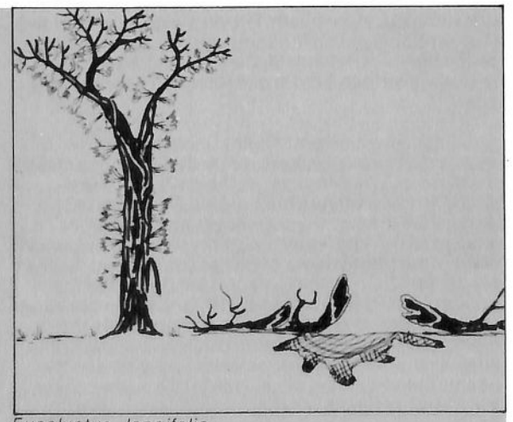
At two months, vertebrates found almost no shelter and little food on the heaths and almost no change in the thickets. Ground fauna in the woodlands and forests fared little better. For animals such as Swainson's marsupial mouse, *Antechinus swainsonii* which hunt invertebrates and small vertebrates on the floor of woodland and forest, conditions generally were unsuitable and from the Australian Museum's study area they had disappeared. In the habitat for *Antechnius stuartii* which is both arboreal and ground dwelling, conditions overall were not so rugged. However the survival of both species depended upon small patches of unburned habitat and to those arteries of life, the gullies.

Spotlighting at night gave us an idea of how the arboreal species were faring. Because ringtail possums live in low dense canopies and frequently spend the day in leafy nests we did not expect to see many because almost all of this kind of habitat had been incinerated. We were surprised therefore to find thirteen just north of Newton's Campsite in apple regrowth and in some unburned *Banksia serrata* crowns. Eleven were in one patch where a cool fire had burned only the understorey. On assessments we had made of possum carcasses to area of habitat we would think that these eleven were probably original residents of the area that remained unburned. The next night we sighted the yellow eyes of two ringtails high up in green woolly butts (greater than 25 m) while the silvery star-like eyes of seven greater gliders were also in woolly butts on a steep slope of Tumbledown. One other glider was seen about 40 m up a woolly butt in a gully. The kind of habitat these animals were favouring, high trees in wet gullies or on steep slopes, was not one which had been severely burned. In these same areas the bellbird remained, and the flocks of rainbow lorikeets were feeding on the buds.

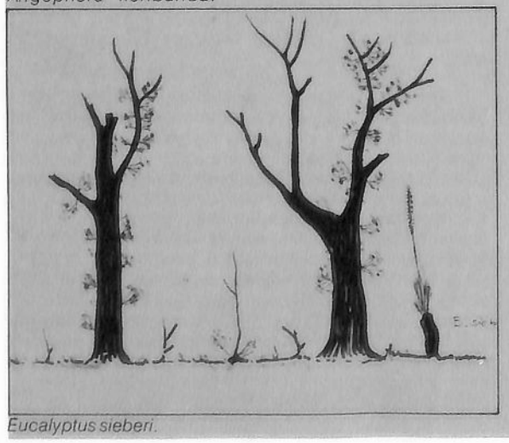
Figure 12. The responses of four tree species to fire, *Angophora floribunda, Eucalyptus longifolia, Eucalyptus sieberi, Eucalyptus gummifera.*



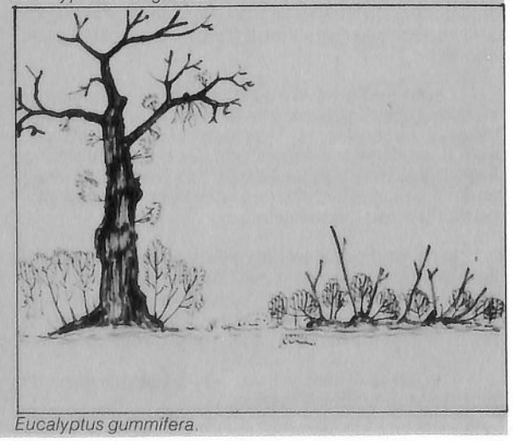
Angophora floribunda.



Eucalyptus longifolia.



Eucalyptus sieberi.



Eucalyptus gummifera.

Work on the heaths was always accompanied by the grating croaks and continuous crackling as the powerful bills of the yellow-tailed black cockatoos split open what remained of the fruits of the needlebush *Hakea sericea*. There was little growth yet to give cause for an influx of birds.

After the feasts of cooked herbivores, later starved herbivores and small omnivores, food shortage had caught up with the carnivores. Newsome's studies showed that the macropods were down by about 50% and that they were becoming the main source of food for the dingo whereas before the fire they were only a very minor source. Small vertebrates (reptile and mammal) were at a very low level and large insects too were in low numbers. Together these animals make most of the food for the fox and feral cat. Again Newsome showed a major drop in the populations of foxes and cats. With winter coming on further shortages could be expected.

Four months after the fire

Another 91.44 mm of rain had fallen over 12 rain days (Figure 8) and the temperature remained mild. Little change had occurred except that the trends observed earlier had become clearer. Three plants were sharing dominance of the heath, *Lomandra glauca*, a hard bluish-leaved tussock 5-10 cm long, *Scirpus antarcticus*, a fine-leaved bright green tussock and the heath she oak *Casuarina distyla* which was throwing out masses of short stems and leaves from its heavy rootstock. There was still no sign of shoots from the crown burnt woolly butts and the ashes which had been attacked by insects were now apparently dead. (No shoots have subsequently developed). The insect attack had subsided and those trees with healthy shoots remained unaffected.

The first plant to flower after the fire, from new growth, was the fringed violet *Thysanotus tuberosus* which had been in flower for a few days. All new plant species appearing on the transect were from old root stocks.

Traplines were set with small mammal traps with no success except to attract dogs.

Seven months after the fire (9.7.73/20.7.73)

The winter was abnormally mild with three recorded frosts and in the three months only 152 mm of rain had fallen on twenty seven rain days (i.e. a total of 345 mm over 59 rain days since the fire, Figure 8). So light were the falls that in one area of severely burned coastal woodland no ground vegetation had appeared and the soil was still hydrophobic, loose and dusty to about ten centimetres.

However, the most obvious change was in the behaviour of the macropods, nearly all females were carrying advanced pouch young and many young-at-heel were hopping with parents. All were more wary and flighty than I had ever seen them in twenty years. Small family groups of kangaroos were distributed very widely throughout. Together with the masses of rabbit fur about the warrens and the tracks of desperate chases on roads and beaches, one gained the impression that the dingos were under severe food stress.

Stands of succulent "ink plants" in heavy fruit were growing where the tea tree scrub had grown behind and on the beach dunes. Crimson rosellas and currawongs were in numbers feeding on the berries. It was perhaps the attraction for the birds and the berries that drew the foxes and feral cats to the beaches.

Four species of plants which were to become increasingly dominant in future months were seedlings of the ash, the red bean *Kennedia rubicunda*, kangaroo apple *Solanum aviculare* and Sydney golden wattle, *Acacia longifolia*. The ash had germinated in vast numbers from 350-4,800 per metre. Other plants germinating from seed which were to become important were *Melaleuca armillaris* with tiny 1mm cotyledon leaves and the needlebush *Hakea sericea* (about 2 weeks old). We saw no survival of this needlebush from burnt plants though the other common heath needlebush *Hakea teretifolia*, very effectively sprouted from root stock. The necklace fern was also becoming common. July was the month when seed germination began in earnest. *Banksia asplenifolia, Hibbertia stricta, Epacris impressa, Isopogon* sp. and *Scaevola ramosissima*, common heath plants, were beginning to grow strongly from both root stocks and seed.

During July, while we were spotlighting for possums and gliders another natural disaster was building up. Huge seas were throwing spray and at times green water 15 metres above the end of our transect. By morning the small colony of rats we had been avoiding disturbing had been swept out to sea or drowned in their burrows.

The arboreal species of fauna which had been strongly dependent on the apple and the woolly butt in the early months were now widely distributed, the ringtails wherever the cover was dense. The greater gliders which were almost exclusively seen in woolly butts were now in mountain gums, stringybarks *E. muellerana* and the apple but favouring the taller mountain gum which earlier had suffered more leaf scorch than woolly butts.

Ten months after the fire (10.10.73)

Two hundred and three millimetres of rain over 24 raindays (549 mm/83 days for 10 months, Figure 8) in the increasing warmth of spring caused a surge of growth.

In the thicket the growth was almost bewildering. The kangaroo apple plants were now over our heads completely overtopping all else and becoming bound together with lawyer vine and the saw-edge *Ghania*. Most of the young *Melaleuca* died but a few (1 in 1,000) in less dense places grew rapidly long and spindly supported by neighbouring plants. Of the old *Melaleuca* plants only 4% re-sprouted from shoots near the base. At about 2 metre intervals Sydney golden wattle which we had never recorded pre-fire in the thickets, was growing into robust shrubs. The red bean, *Kennedia rubicunda* likewise was establishing itself and climbing into the canopy of the dead melaleucas. In the thicket there was food and shelter enough to hide any animal and this was probably the reason why no macropods were seen in the Reserve for the five days and why the roads and beaches were showing evidence of extensive dingo movement.

Out on the heaths the *Anisopogon* grass was standing like an oats crop, while the large number of other monocotyledons were showing signs that there would be a bumper season of hard seed. Later we were to see an eruption of the house mouse *Mus musculus* which undoutedly benefited from this crop.

However, most notable was the great variety and number of ground orchids which blossomed during this spring. Some 23 species were common and 14 of these had not been recorded in the area before. Spotted and veined sun orchids *Thelymitra* with as many as twenty flowers a stem were growing throughout the woodland while an exquisite pink *Thelymitra*, 1½ cm across the flower and 15 cm high was growing among at least

three species of leek orchids, one species about 80 cm high, on the heaths. The weird duck orchids and bearded orchids were common. The yellow double tails, *Diuris*, were in broad waving stands, obviously succulent to macropods as many of the heads had been lopped off and 'roo footprints were throughout these stands. The impact of selective feeding by native animals in successional vegetation is an interesting problem.

12 months after the fire (22.12.73)

The drought was broken—in November 559 mm of rain fell, (Figure 8) more than for the preceding eleven months—and this on thirteen rain days. Anything loose had been moved by the running water, from one small slope approximately 200 cubic metres of soil had been washed onto Newton's Beach where it became a veneer across the sand. Such deluges are not uncommon on the far south coast and one might wonder what the effect of the fire would have been if it had been immediately followed by such rain. So apart from the variable local weather conditions and the years of natural community build-up to the point of ignition, the unique weather circumstances which followed the fire largely determined the effect of the fire. One might ask, what is predictable when there is such an interplay of unpredictable dominating conditions? We might also speculate that this very unpredictability is the environment to which our wildlife is adapted. What happens to that wildlife when we eliminate the unpredictable by prescribing the fire conditions of the natural environment in management programmes?

The rains of November on top of the warm damp spring released the fire-freed nutrients for plant use and particularly in the gullies and valley bottoms, thistles grew like small trees with stems 8 cm across and 2½ metres high, while one *Smilax australis* runner grew a measured 26 cm in 24 hours. At last the Jane Spiers fire storm area came to life with *Goodenia ovata* running wild on the hill slopes and *Acacia longifolia, Melaleuca armillaris, Patersonia sp., Leptospermum laevigatum, Correa reflexa* and the pig face growing vigorously on the sandy hind dune area. The wombat had shelter and food too.

What we had written off as grilled rock lilies *Dendrobium speciosum* were building up new bulbs of food store with fresh young leaves which were immediately being nibbled by swamp wallabies. Flowering was occurring in the least burned stands. Throughout the whole Reserve lyrebirds had become highly vocal, usual for December, making this species more apparent, although it at no time appeared to have been seriously affected by the fire.

All of this surging life. Some stringybark lignotuber shoots had grown 2½m. The clumps of epicormic shoots had given rise to more eruptions, masses of saw-fly larvae were denuding stringybark saplings, while millions of a fawn ladybird beetle were attacking what the saw-flies left.

As with the reduction of *Melaleuca* seedlings the prolific ash seedling production noted earlier was quickly reduced by competition and insect attack from 350-4,800 (July) to 0-29 (December) per metre square. With green feed, flowers, masses of insects and the mild conditions, bird populations too were undergoing an abnormal explosion of numbers. In fact unseasonal multiple nesting of fantails, warblers and wrens was observed; in one fantail nest three batches of young were produced. With the vast production of high protein plant regrowth for food, the grey kangaroos also appeared to lose their essentially seasonal breeding characteristics, the females having pouch young of all ages.

However, amid all of this surging life recorded on the monitor photos, we began to realise that the parasite mistletoe had been considerably checked. On a random walk to test this in the woodlands, 260 infested stringybarks were counted—92% of the mistletoe clumps were apparently dead even though the host branches beyond the parasite were still alive. Should we consider that crown fire in the past has controlled this parasite in the woodlands?

The main characteristics of the effects of the Nadgee wildfire had become apparent by the end of the first year. There appeared to have been five major phases in the anatomy of these fired communities:

- the preparation of the communities for the kind of fire that ensued
- the holocaust
- the famine period immediately following fire
- the period of plague development
- the establishment of a dynamic balance in the system and diversity of life.

The '72 fire of Nadgee Nature Reserve occurred as it did because of the interplay of the natural systems:

- the topography
- the previous fire history
- the vegetation communities
- the previous years' weather that created dry conditions following a high fuel build-up
- the pattern of weather that ignited and maintained the fire
- the presence of many fires in the district at the same time
- and the backburn that was lit to contain the fire.

Recovery of the organic communities was a result of:—

- the extent of the fire
- the intensity of burn
- the regenerative capabilities of the species
- the sources for colonisation of fauna
- the survival mechanisms of some animals e.g. burrowing animals
- the weather conditions following the fire.

So, the Nadgee fire which we have been observing will provide a story unique to itself—it has been the result of a very mild, very dry (in a total sense) and yet humid year immediately following the holocaust.

If any of these factors had varied, so would the story of the effect on Nadgee. We are thus presented with a major problem in predicting the individual effects of fire on natural communities and their components. The effect of fire on particular components of a community is perhaps the most difficult problem in prediction.

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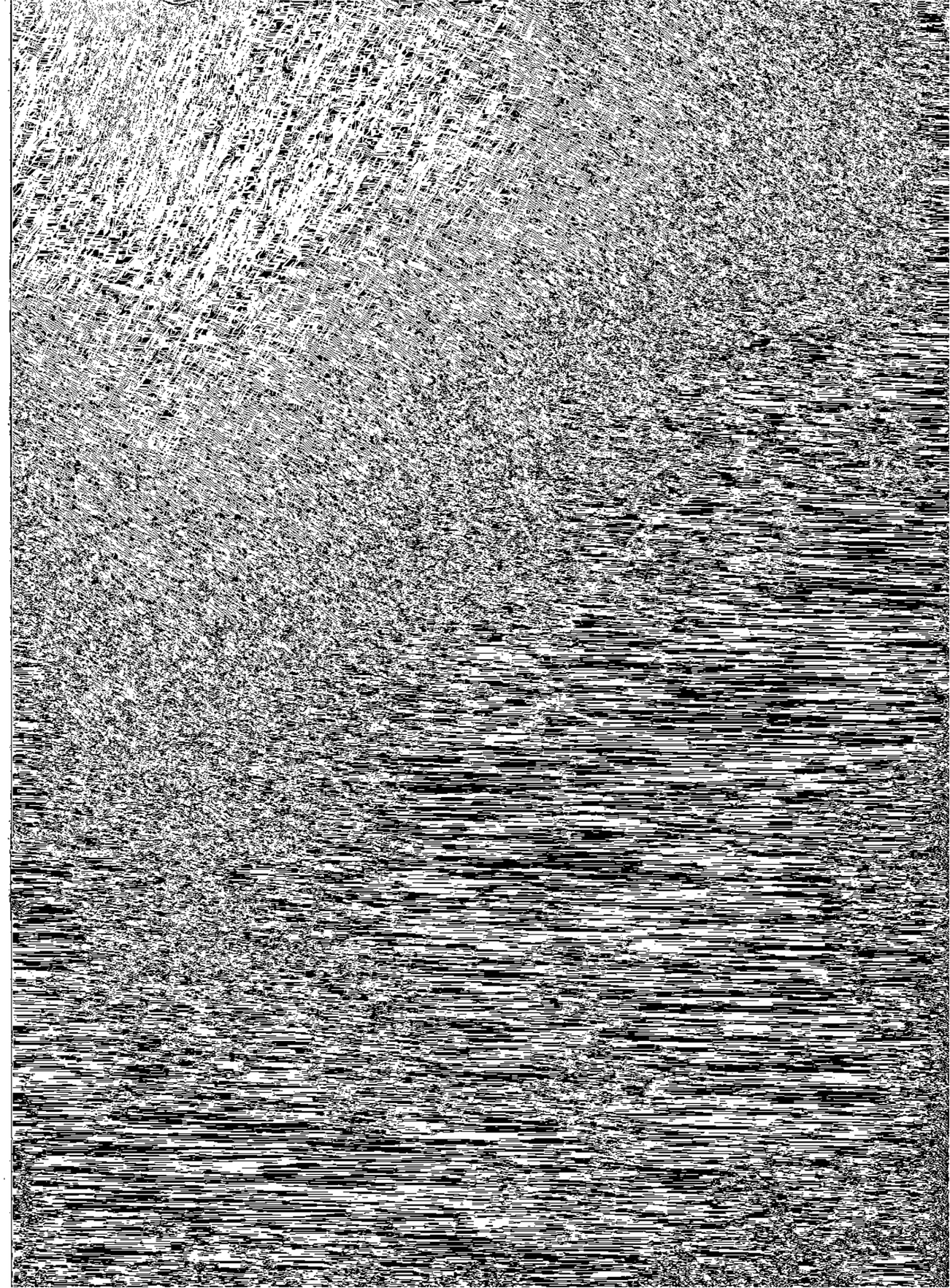
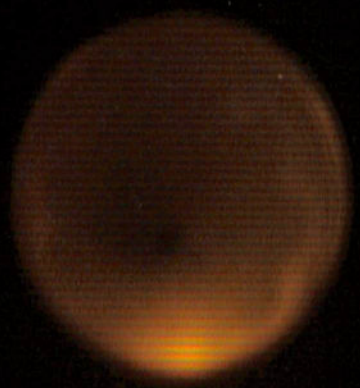
This work was carried out while Mr Fox was working for the N.S.W. National Parks & Wildlife Service.





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