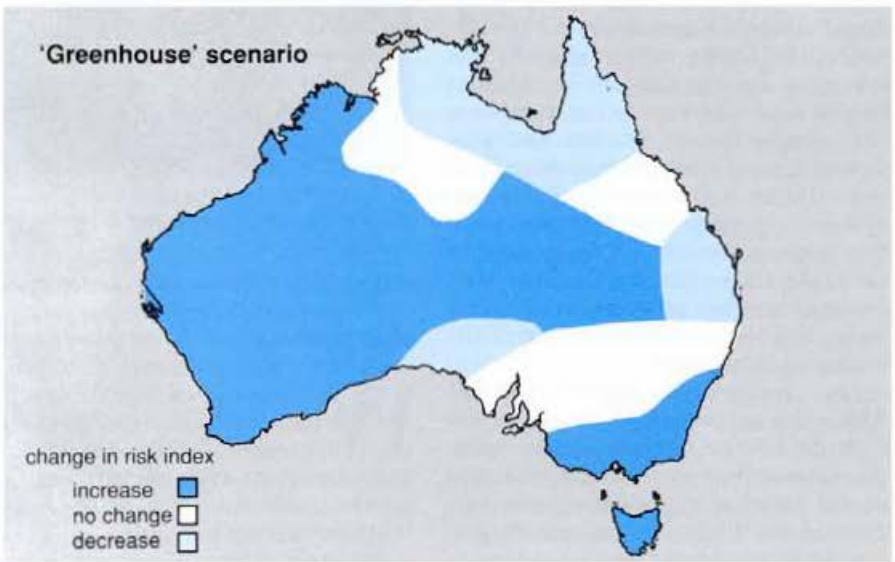
Spectrum

Bushfires in the 'greenhouse'



The model's estimates of how the Forest Fire Danger Index will change with a doubling in atmospheric CO_2 concentration.

Australia's worst bushfires tend to earn macabre epithets. The devastating fires of February 6, 1851, are remembered as Black Thursday. Black Friday followed in January 88 years later and, more recently, Ash Wednesday took more than 75 lives in Victoria and South Australia in 1983.

The prospect of witnessing bushfires of this magnitude most summers is an alarming thought — it would make normal life in much of forested Victoria virtually impossible. Yet the possibility of meteorological conditions similar to those on Ash Wednesday recurring frequently is the worrying conclusion of theoretical research by scientists at CSIRO's Division of Forestry and Monash University.

Fire-fighters grade bushfires and the risk of bushfires starting using a fire-danger meter. The meters combine meteorological data, such as air temperature, relative humidity and wind speed, with a so-called 'drought factor' — a measure of daily rainfall and temperature — to produce a Forest Fire Danger Index (FFDI). The higher the FFDI, the greater is the risk of a fire starting and the more severe it is likely to become.

After examining more than 40 years' meteorological observations, Dr Tom Beer of the Division's Bushfire Research Unit in Melbourne found that relative humidity was the most important factor in estimating fire danger. It is, he says, the amount of moisture in the leaf litter on the forest floor that largely determines the fire's ability to generate high temperatures and spread rapidly — hence the importance of humidity in the estimations.

Armed with this information, the CSIRO and Monash University researchers considered what might happen under the influence of the enhanced greenhouse effect. Using a numerical model of world climate, developed by CSIRO, they generated a map of expected humidity changes throughout Australia following a doubling of the carbon dioxide concentration in the atmosphere.

The model predicted that while some areas, such as the Australian Capital Territory, would experience a moister climate (and thus lower bushfire risk), large areas of Western Australia and Victoria would become drier and therefore more fire-prone. These included the heavily wooded areas of the south-west and, in Victoria, East Gippsland. The latter, the model estimates, would on average experience a 38% rise in the FFDI if the CO_2 level was to double during the next century. Almost every summer that would raise the fire danger in this region to a value as high as those experienced on Ash Wednesday. In Western Australia, the index would rise by between 13 and 17%.

Whether or not the predictions are reliable is a moot point. The computer-based model has proved a poor indicator of expected rainfall and humidity levels. However, Dr Beer says it appears to be broadly correct in simulating observed humidity changes around Australia. Therefore, he says he 'attaches some confidence' to the trends that the model predicts rather than the absolute values it generates. Accordingly, the researchers believe that East Gippsland and south-western Western Australia will become more fire-prone, although at this stage it is hard to say to what extent.

Further research is planned using more sophisticated numerical models recently developed by CSIRO and the Bureau of Meteorology.

Brett Wright

BT resistance emerges

The ingenuity and flexibility of insects continues to confound us. More than 500 insect species are known today to be resistant to one or more chemical pesticides, and evidence is rapidly emerging to indicate that one of our most environmentally friendly weapons against insect pests — bacterial toxin — may have a limited future.

Scientists at a recent entomological conference in Taiwan reported cases of insect populations developing high levels of resistance to toxins derived from the soil bacterium *Bacillus thuringiensis*, or BT for short. Horticulturists use BT-type sprays widely to protect vegetable crops against caterpillar pests, and use of these microbial sprays is growing quickly due to concern about the environmental impact of agricultural chemicals. Genetic engineers have also incorporated genes from the BT bacterium into crops such as cotton to make them resistant to certain insect pests. (See *Ecos* No.70, pp. 6–11.)

The evidence suggests that so far resistance has appeared only in two serious pests, the diamondback moth (*Plutella* spp.) and the Indian mealmoth (*Plodia* spp.), in isolated insect populations in Hawaii, mainland United States,

Thailand and the Philippines. Some scientists fear, however, that resistance to BT toxins will spread and render genetically engineered crops vulnerable within 3–10 years.

Some genetic engineers originally thought the development of transgenic plants that could express BT toxins might be a panacea for pest control, believing that, as the bacteria and the insect pests had co-existed for millions of years, any potential for resistance would have already emerged. What they overlooked was that the insect populations had faced relatively rare bacterial epidemics, with a consequently low evolutionary pressure to adapt naturally. The heavy use of BT sprays has changed that, and resistance is growing.

Scientists at the CSIRO Division of Plant Industry expected resistance to the BT toxins would eventually emerge, and are currently working on ways to combat the potential threat before it arrives here. In 1991, the Division developed the first commercial variety of cotton with an extra gene to make it toxic to budworms. The toxin (known as *Cry*1A) produced by the plant is derived from a single BT strain. However, other useful toxins (predictably called *Cry*1B and *Cry*1C) occur in different strains, and these are being investigated as possible alternatives. The researchers are also looking at toxins produced by other plants such as the giant taro, a tropical plant that tolerates a wide range of insect pests. If the work is successful, a single plant may be able to express a range of toxins — therefore making it harder for insects to adapt. Alternatively, plants expressing different toxins may be rotated in the field in successive years, giving the insects too little time in which to develop any resistance.

Dr Danny Llewellyn, a plant scientist in the Division's Canberra laboratories, suggests another avenue of attack: developing transgenic plants that produce a toxin just in those parts of the plant most susceptible to pests. This would keep the insects' exposure to the toxin to the bare minimum and therefore extend the life of the gene as a pest-control measure. The laboratory has already isolated a piece of DNA from tobacco, which may do the job. The DNA segment, when spliced with other genes, acts as a gene-promoter, causing them to be highly expressed in the flower buds of the plant. If it can be successfully incorporated in transgenic cotton, it would replace the existing promoter (derived from a plant virus) that causes the BT toxin to be expressed through the entire plant.

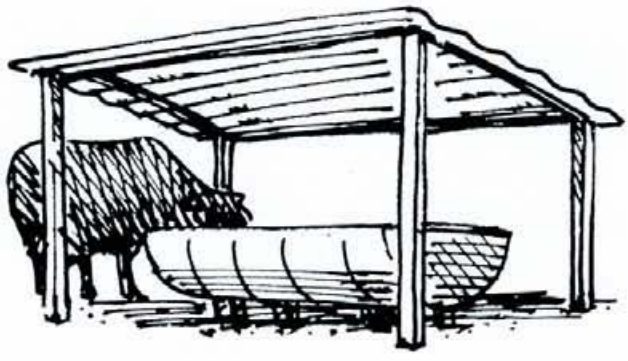
Brett Wright

The evolutionary potential of crop plants. F. Gould. *American Scientist*, 1991, **79**, 496–507.

Insecticide resistance of diamondback moth (Lepidoptera: Plutellidae) in North America. A.M. Shelton and J.A. Wyman. *Proceedings of the Second International Diamondback Moth Workshop Taiwan, 1991).*

Cool troughs

Farmers and scientists have long known that the quality of the water in stock troughs is crucial to animals' well-being, and that in summer months heat stress caused by insufficient water, or low-quality water, can lead to dehydration, weight loss or illness. Water temperature is just as important: the hotter the water becomes, the greater the rate of evaporation; the more evaporation occurs, the greater the concentration of salt in the water. Sunlight also encourages the growth of algae, which make water unpalatable.



Now, CSIRO Centre for Environmental Mechanics research scientist Dr Ian Webster and University of Melbourne student Mr Charles Day, working at the Centre on a summer research project, have demonstrated the effectiveness of shading water troughs in improving and maintaining water quality. Theirs is a cheap solution; it has no moving parts, it can be constructed using everyday farm materials... and it is astonishingly effective. Simply placing a corrugated-iron 'sun-hat' over water troughs reduces evaporation during the hottest period of a summer day by 40%, and keeps the water in the trough up to 10° cooler than in an unprotected trough.

The 'sun-hat' can be built for around $40 with all new materials, but Dr Webster points out that the vast majority of farmers, used to keeping serviceable materials for future use, will have some sheets of corrugated iron, some fencing wire and star posts available. A few minutes' work, and a few days' wait while stock become accustomed to their 'new' water trough, will quickly pay dividends in healthier water... and healthier stock.

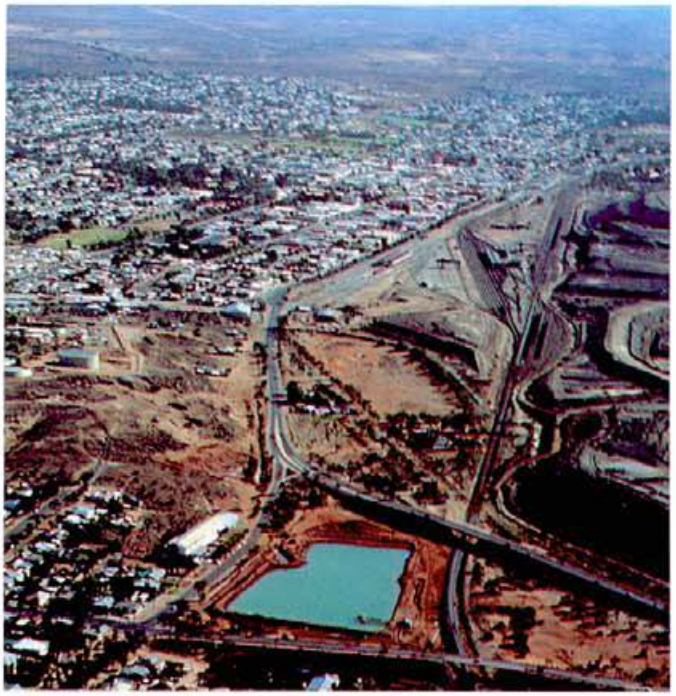
Carson Creagh

Tracing lead contamination at Broken Hill

Lead dust from mines and dumps in the western New South Wales city of Broken Hill is apparently jeopardising the health of many of the city's young children. A State Health Department survey has found that about one-fifth of Broken Hill's children under the age of 4 years have potentially unsafe levels of lead in their blood. A follow-up study by CSIRO indicates that much of the contamination has probably come from the city's mining operations.

The public health unit of the Department's Orana and Far West Region recently completed its survey of blood-lead concentrations in 899 Broken Hill children under four. Almost 20% of those tested had lead levels above the Australian 'level of concern' of 25 micrograms (µg) per 100mL, set by the National Health and Medical Research Council (NHMRC). The mean value was 18·1 µg per 100mL.

The survey found strong links between the level of lead in the children's blood and their place of residence, and between blood-lead levels and the occupation of their fathers. Children living with a current or former mine-worker had a mean lead level of 18·8 µg per 100mL, compared with 17·5 µg per 100mL for others, raising the possibility that mine-workers were carrying lead dust into the home on their footwear and clothing. Those children living in South Broken Hill — nearest the city's open-cut mines and tailings dumps — were found most likely to



Australian Overseas Information Service

Broken Hill — city and mine.

have high blood-lead levels. Children in this area recorded a mean lead concentration of 22·8 µg per 100mL, with almost 37% above the NHMRC safety limit. In addition, a small cluster of children with high lead levels lived close to a former lead smelter site.

Many studies have linked lead with intellectual impairment in young children, even at levels commonly found in mining towns and industrial areas (see *Ecos* 71).

Before the completion of the Departmental survey in late 1991, CSIRO's Division of Exploration Geoscience offered its sophisticated lead-isotope 'fingerprinting' techniques to help trace the source of lead exposure among the children.

Any sample of lead has four atomic isotopes (with atomic weights of 204, 206, 207 and 208) that vary in proportion depending on the geological or industrial source of the metal. Particular isotopic ratios — such as that of ^{206}Pb to ^{204}Pb — can be used like a fingerprint, identifying a known source. The lead ore mined at Broken Hill has a ^{206}Pb:^{204}Pb ratio (known in the trade as a 'six-to-four') of 16·0, meaning that ^{206}Pb is 16 times more abundant than the ^{204}Pb. By comparison, the lead ore from the Rosebery deposit in western Tasmania, richer in ^{206}Pb, has a 'six-to-four' of 18·3. The lead used to make the petrol additive tetra-ethyl lead has a variable 'six-to-four', but tests in Broken Hill currently show it to be about 16·6.

In their investigation, CSIRO researchers collected venous blood samples from 41 Broken Hill residents — 16 children and 25 adults (mainly women) — as well as dust and water samples from 11 homes. Isotopic analysis revealed that the dust collected from home ceilings and vacuum cleaners had a ^{206}Pb:^{204}Pb ratio of about 16·0–16·1, similar to the Broken Hill ore, and therefore probably came from the mines.

The isotopic profiles of the adult and child groups differed from that of the ore, and from each other. For the women, the ratios fell between 16·5 and 16·9, while the range for the children was 16·2 to 16·5. (None of the women had more than 10 µg of lead per 100mL in her blood, while none of the children tested above 25 µg per 100mL.) The figures suggest that, although both groups are being contaminated by lead from sources other than the mines, a larger proportion of the lead in the children's blood originated from Broken Hill ore. Interpreting the results, Dr Brian Gulson of the Division of Exploration Geoscience said sources of lead other than the mines (such as petrol or water) apparently accounted for a major component of the blood-lead in the women, but only a minor component in the children. Furthermore, he said, the tests show that the children with the highest blood-lead levels had the lowest ratio of ^{206}Pb to ^{204}Pb, indicating that these children were apparently receiving a greater proportion of their lead burden from the mines.

Preliminary tests on the tap-water samples indicate that Broken Hill's water has a low lead content and is comparable to a control sample collected at a CSIRO laboratory in Sydney.

The findings point strongly to Broken Hill's mining operations as an important source of the lead in the blood of the city's child population. It appears that young children receive extra doses of lead due to ingestion of soil outdoors or from dust in the home. The lead in two of the ceiling-dust samples tested by CSIRO was found to have 'a very high degree of bio-availability', indicating that it would be readily absorbed if ingested.

Dr Gulson has recommended a more extensive testing program to confirm the findings and to ascertain whether elevated blood-lead levels in the children have resulted from chronic, long-term exposure to environmental lead or from a short-term 'burst' of exposure due to ingestion of dust with an unusually high concentration of bio-available lead.

The Division is currently involved in a research project with the University of Adelaide's Department of Community Medicine, investigating the sources and mobilisation of lead during human pregnancy, largely funded by the United States National Institute of Environmental Health Sciences.

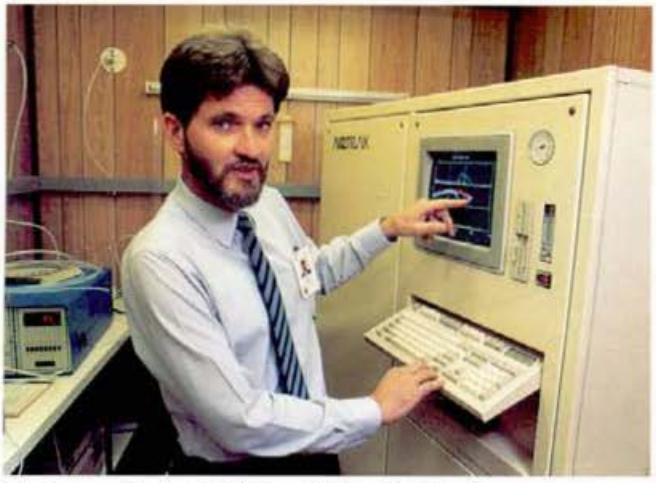
Brett Wright

'CSIRO Research into Sources of Lead in Humans at Broken Hill.' B.L. Gulson. (CSIRO: Sydney 1991.)
Measuring the impact of lead. B. Wright. *Ecos* No.71, Autumn 1992, 25–7.

Tracking smog in Perth

Air pollution researchers in Western Australia have begun an extensive study of air quality in Perth using the Airtrak monitoring system in an effort to better understand the city's growing smog problem.

The State Energy Commission of Western Australia (SECWA) has purchased an Airtrak monitor at a cost of about $72 000, and plans to buy further units for the establishment of a comprehensive air-monitoring network in Perth. The purchase is the first sale of the instrument in Australia, although units have been used in Sydney, Melbourne and the United States. Invented by scientists at CSIRO's Division of Coal and Energy Technology, and manufactured by MCI, Airtrak samples the air, measures photochemical smog and predicts pollutant levels downwind. It can also locate the source of emissions that fuel the formation of smog.



Study co-ordinator Mr Pelham Weir with Airtrak.

The Airtrak unit is being used as part of a $3 million 3-year environmental study by SECWA and the State's Environment Protection Authority. Now installed at an existing EPA monitoring station at Caversham, on Perth's north-eastern outskirts, the instrument measures levels of ozone and nitrogen oxides and the photochemical activity of hydrocarbons that are carried from the central business district on the prevailing sea breeze. It will also evaluate the environmental impact of nitrogen oxide emissions from new gas-turbines under construction at the Pinjar power station, 40 km north of the city.

People generally perceive Perth as having no serious air pollution problem — it is a windy city with a relatively small population (1·2 million compared with Sydney's 3·6 million). During most months of the year, it does indeed have little air pollution. In summer, however, when solar radiation is high and wind patterns favour smog formation, occasional breaches of the national goal for photochemical smog (measured as ozone) have occurred. The city also has increasing problems with associated haze.

In the summer of 1990/91, the EPA's air-monitoring station at Caversham recorded one breach of the acceptable ozone concentration (for a 1-hour average) of 12 parts per hundred million (p.p.h.m.), set down by the National Health and Medical Research Council (NHMRC), and seven cases exceeding the World Health Organisation (WHO) goal of 8 p.p.m.. By comparison, Melbourne — with a network of nine monitoring stations — recorded during 1990/91 no breaches of the NHMRC standard and about 10 cases exceeding the WHO goal. The WHO's ozone goal (for an 8-hour average) of 5 p.p.h.m. was exceeded four times in Perth and 16 times in Melbourne.

Recent theoretical analyses by CSIRO's Environmental Consulting and Research Unit in Melbourne have indicated Perth's smog levels can build up over a period of 3-4 days as pollutants are carried out to sea by morning easterlies and returned on the afternoon sea breeze. The Unit's report will help State authorities decide where best to locate the city's proposed air monitors. Vehicle emissions in the CBD are thought to be the main contributor to Perth's air problems, although — at this stage — inadequate information about the wind flows and photochemistry in the region makes it hard for researchers to draw any firm conclusion. That's where Airtrak may make a big difference.

According to the study manager, Mr Pelham Weir, SECWA's co-ordinator of atmospheric studies, Airtrak will not only measure smog levels and the pollutants that lead to smog formation, but also interpret data on the possible origins of particular 'air parcels' and help with the development of a mathematical model of the dynamics of the air mass above Perth.

Mr Weir says the model will be used for planning purposes and to assess the environmental impact of major development projects.

Brett Wright

'Perth Airshed Study: Predicted Windfields on Possible Ozone Days — Final Report.' P.C. Manins, P.J. Hurley, G.M. Johnson and M. Azzi. (CSIRO: Melbourne 1992.)

Smog moves west as Sydney grows. B. Wright. *Ecos* No. 70, 1991/92, 17–22.

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