DROUGHT MITIGATION IN AUSTRALIA REDUCING THE LOSSES BUT NOT REMOVING THE HAZARD

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DROUGHT MITIGATION IN AUSTRALIA
REDUCING THE LOSSES BUT NOT REMOVING THE HAZARD

R. L. HEATHCOTE

In Australia technology has reduced but not eliminated the impact of drought and seems set to do the same for the foreseeable CO₂-induced climate change. To document this claim, I wish here to consider first a brief history of drought in Australia—pointing up some parallels and contrasts with the North American experience; second, to outline the various strategies (technological and nontechnological) that have been adopted to try to mitigate drought; third, to review the current thinking on the effect of increasing levels of atmospheric CO₂ on the Australian climate and their relevance to agricultural and pastoral activities through possible modification of the incidence and intensity of drought; and finally to evaluate the history of technological adjustments to drought stresses and to try to forecast the success or failure of such adjustments to foreseeable climate change.

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DROUGHT IN AUSTRALIA: CHRONOLOGIES AND IMPACTS

Periods of unseasonally low rainfall caused considerable distress to the Australian aborigines prior to European settlement, and it is possible to provide a reasonably precise chronology of droughts in Australia from the mid-nineteenth century onward (Foley 1957; Gibbs and Maher 1967). The high variability of the Australian rainfall and the frequency with which annual totals fall below the average has had significant impact upon the pastoral and agricultural activities in Australia.

Droughts retarded land settlement in three periods. After a decade of relatively good rainfalls and settlement expansion in the 1870s, South Australia and to a lesser extent New South Wales and Victoria suffered droughts in the 1880s (Meinig 1962). A further widespread drought at the turn of the century affected the main pastoral areas of New South Wales and Queensland, and the combination of economic depression and drought in the 1930s and early 1940s forced considerable restructuring of the southwestern and southeastern Australia cereal producing areas (Proctor 1940).

[GPQ 6 (Summer 1986): 225-237.]
The worst droughts in Australia have brought about losses to pastoralists and farmers. (Bates 1976; Lovett 1973; Scott 1983; Waring 1976). In fact, the economic losses from drought make it the most expensive natural hazard facing Australia. Although no one has been killed, the economic cost from 1945 to 1975 averaged over $100 million a year, roughly four times the cost of any other hazard (Heathcote 1979, Table 1.3).

The 1982–83 drought shows not only the continuing significance of the economic losses but the variety of ways in which they are made manifest (table 1). Hidden behind this array of national impacts are the regional, community, and personal hardships that no official statistics can adequately measure, but that occasionally come to light through journalistic activity (see, for instance, “Special Report: Australia’s ‘Great Dry,’” Time, 28 March 1983). That droughts in Australia have had and continue to have other significant impacts we shall see later, but it has been toward these economic impacts that the technological defenses have mainly been marshaled.

**TECHNOLOGICAL DEFENSES AGAINST DROUGHT IMPACTS**

In the North American Great Plains and in Australia the patterns and processes of land settlement, along with innovative technologies to reduce the production costs of land clearance, tillage, harvesting and communications, have been remarkably similar since the mid-nineteenth century. Not surprisingly, therefore, the social and technological responses to drought have also been similar.

Whether the Australians have ever fully accepted drought as endemic to the continent is debatable (Heathcote 1969), but there is no doubt that as settlement spread down the rainfall gradient into the interior, settlers evolved pragmatic, often technologically based, strategies to cope with agricultural drought.

**TABLE 1**

<table>
<thead>
<tr>
<th>THE ECONOMIC IMPACT OF THE 1982-83 DROUGHT IN AUSTRALIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. 67% of the national pastoral and agricultural properties were officially recognized to be drought affected (67,000 properties).</td>
</tr>
<tr>
<td>2. Wheat crop failures led to an average 45% decrease in the quantity of wheat sold per farm, and wheat receipts per farm declined 58%.</td>
</tr>
<tr>
<td>3. The 1982-83 wheat harvest (7.8 M tonnes) was 47.6% of the 1981-82 harvest, and average yield (0.76 tonnes per hectare) was down 40% from the previous five year average.</td>
</tr>
<tr>
<td>4. National employment reduced by 2% (100,000 persons).</td>
</tr>
<tr>
<td>5. Overall rural output declined by 18% leading to a 1.1% decline in national output.</td>
</tr>
<tr>
<td>6. 1982-83 decrease in industrial production:</td>
</tr>
<tr>
<td>Chemical fertilizer production</td>
</tr>
<tr>
<td>Flour and cereal production</td>
</tr>
<tr>
<td>Railway transport receipts</td>
</tr>
</tbody>
</table>

7. Disaster relief paid by Commonwealth and state governments:

<table>
<thead>
<tr>
<th>Year</th>
<th>Description</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980-81</td>
<td>Loans</td>
<td>$60 million</td>
</tr>
<tr>
<td>1982-83</td>
<td>Loans</td>
<td>$120 million</td>
</tr>
<tr>
<td>1982</td>
<td>Freight subsidy</td>
<td>$47 million</td>
</tr>
<tr>
<td>1982</td>
<td>Fodder subsidy</td>
<td>$100 million</td>
</tr>
</tbody>
</table>

**SOURCES:** Campbell, et al. 1983, and estimates by Commonwealth Bureau of Agricultural Economics
Pastoral strategies. Conscious spatial diversification of their properties reduced the drought losses of pastoralists like Sidney Kidman (1857-1935), James Tyson (1819-1898), and others with similar capital and ingenuity. But for the majority—the smaller capitalists—the strategies were limited to increasing surface water storage by dams and tanks and then, when oil-drilling technology became available from the United States in the 1870s and 1880s, to seeking for water deeper down: “If the Lord won't send us water, oh, we'll get it from the devil; Yes, we'll get it from the devil deeper down” (A. B. Paterson, “Song of the Artesian Water,” quoted in Lovett 1973, 193).

Fencing of the range from the 1870s onward helped some to rotate the stock grazing pressure, but droughts always forced stock back upon the few permanent watering points from where the feed had been long gone. Evacuation of stock to rented drought-free pastures or (illegally) to the public traveling stock reserves depended upon their commercial value; often it was cheaper to let animals take their chance in the drought-ridden home paddocks.

Storage of drought fodder has rarely been economically viable except on mixed crop and livestock enterprises and even then only for a small core of breeding stock (Dillon and Lloyd 1962; Powell 1963). Breeding of drought-tolerant livestock has been generally limited to cattle, using Indian Zebu and Texan Santa Gertrudis lines to cross with traditional British beef breeds for the northern tropical ranges. In some cases, as with the “Droughtmaster” line, the goal is obvious.

Dry farming strategies. For the farmers the march out into the droughty plains has been hard-fought. The optimal time for seeding was learned by trial and error; fallowing of land to save moisture from one season to the next began privately in South Australia in the 1880s before the technique received the blessing that followed official contacts with the Campbell system of the Great Plains in 1906. Machinery to harvest drought-stunted crops—notably Ridley’s “Stripper” of 1843—was developed also in South Australia before becoming available in Victoria and New South Wales. South Australian farmers also were experimenting with drought-resistant wheat varieties (Williams 1974) before William J. Farrer began to cross drought-resistant Indian wheats with good quality Canadian baking wheats and with the well-established, high-yielding but vulnerable Purple Straw wheats. The results, especially “Federation,” produced during the last years of the 1895-1902 drought, were to push the wheat fields further down the rainfall gradient over the next 25 years (Wrigley 1981).

The apparent success of highly mechanized broad acre grain farming using scientifically applied fertilizers and legume pastures in the semiarid portions of South Australia from the 1950s onward led to the formation of a specialized agency in the 1970s (SAGRIC International Pty. Ltd.). It has been invited to develop dry farming systems in north Africa and southwest Asia (SAGRIC n.d.). The emphasis is upon adapting successful technologies developed in South Australia to areas of similar climate around the world. Although a water management strategy to conserve all the rainfall on farm and spread it evenly over the land surface had been developed privately in New South Wales in the late 1940s (Yeomans 1954) and had received strong support from the professor of geography at Sydney University (Macdonald Holmes 1960), it appears to have been forgotten in favor of simple contour banks for soil conservation.

On the Australian farms, however, when the crop starts to wilt there is nothing really to be done if irrigation is impossible. And when the crop has died and the soil begins to blow there is only emergency tillage to stave off disaster, and that only as long as the subsoil is moist enough to hold the clods together.

Irrigated farming. Irrigation is not the technological solution to drought stress in Australia. Only about a third of 1 percent of the
pastoral and agricultural properties and only 9 percent of the total cropped area is irrigated, although for some crops irrigation is vital. Canning fruit, dried fruit, and tobacco are entirely dependent on irrigation, while rice, cotton, and some dairy products and vegetables are substantially dependent (Tisdall 1980). Only 23 percent of the irrigated area is devoted to cereal grains, the majority (48 percent) is under pasture (Year Book Australia 1984, 308). However, the total irrigated area in Australia (1.6 M ha) is only 12 percent of the area irrigated on the Great Plains.

Despite the important role of irrigation in official land settlement intensification schemes, which explains the dominance of official schemes in the irrigated areas (table 2), the technical experts, official or otherwise, have been unable to compensate for Australia's relatively poor water resource base. The largest river, the Murray, has only about 3 percent of the flow of the Mississippi and while deeper down the devil has provided water, true to form, much of it has been salty or, even in the Great Artesian Basin, at best brackish and suitable only for livestock.

Even such technological investment as has been put into the Australian irrigation projects has been criticized by some economists as a waste of money. B. R. Davidson suggested that greater economic benefit to the nation would have come from investment in dry land farming technology. He rebutted the standard argument that irrigation provided “drought-proofing” by pointing out that during droughts agricultural production declines more severely in irrigated areas than in surrounding dry farming areas. Furthermore, since irrigated areas are always fully stocked, they cannot provide a refuge for starving animals (Davidson 1969, 241). Of course, he was talking about irrigated lands dependent upon surface water storage rather than underground supplies. Nonetheless, his arguments seem to have been borne out in the 1982-83 drought, when cotton farmers in northern New South Wales received only 10 percent of their predrought allocation of water, water that was 30 percent more expensive. As a result, a 22 percent fall in yield was forecast (Dijk, Mercer, and Peterson 1983, 31). How much drought-proofing does a crop reduced by one-fifth represent?

Those economists arguing for irrigation admit that the irrigated lands do not provide stock agistment in drought (one of the original

<table>
<thead>
<tr>
<th>Source</th>
<th>Area Irrigated (1,000 hectares)</th>
<th>% total area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>State schemes</td>
<td>941.3</td>
<td>57</td>
</tr>
<tr>
<td>Rivers, creeks, lakes</td>
<td>370.6</td>
<td>22</td>
</tr>
<tr>
<td>Farm dams</td>
<td>90.8</td>
<td>5</td>
</tr>
<tr>
<td><strong>Total surface</strong></td>
<td><strong>1402.8</strong></td>
<td><strong>85</strong></td>
</tr>
<tr>
<td>Underground:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Town or country reticulation</td>
<td>236.1</td>
<td>14</td>
</tr>
<tr>
<td>(surface/underground):</td>
<td>15.4</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total all sources</strong></td>
<td><strong>1654</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

SOURCE: Year Book Australia 1984, p. 308.
reasons advanced for their development) but claim that irrigated production has stabilized commodity prices during droughts, for example, in 1967-68 (Tisdall 1980). They claim also that the subsidized price of irrigation water has been too low—leading to inefficiencies in its use (Miller 1980). In addition, the new towns on the irrigation schemes and decentralization of Australian population away from metropolitan centers, together with the recreation and tourist resources generated by the irrigated areas, are seen as further justification for capital investment. The drought-proofing role of Australian irrigation has been submerged beneath other apparent benefits.

**ALTERNATIVE STRATEGIES TO MITIGATE DROUGHT IMPACTS**

Most societies have many ways to face the threats of societal disruptions (White 1974; Burton, Kates, and White 1978). Australia has a history of varied responses—many of which do not have a technological base. Prayers for rain were an early European continuation of aboriginal invocations and the most recent prayers, during the 1983 drought, were led in Queensland by Premier Bjelke-Petersen himself (Time, 28 March 1983: 8). “Business as usual,” if on a reduced scale, has been another common response to the uncertainties of drought. In Australia as in the United States there were similar advocates of the links between forests and rainfall and vocal proponents of “rain follows the plow” ideas (Carr and Carr 1981b; Powell 1976).

The federal and state governments still hold 84 percent of Australia as leaseholds, reserves, or unoccupied land, and through their general welfare roles have been forced to provide drought mitigation strategies. Early in the history of European settlement, official drought relief was provided and, although refined over the years, in general it still operates upon the principle of restoring the status quo before the onset of drought, despite the increasing evidence that some drought losses may result from reckless exposure or high-risk farming practices (Anderson 1979; Freebairn 1978). Nonetheless, the income tax concessions through accelerated depreciation of equipment, investment allowances for new technologies, extension of loan repayment periods, freight subsidies, fodder subsidies, purchase of unsalable livestock, and carry-on loans at concessional rates continue (Lloyd Davies 1982). Even maintenance of overseas monetary reserves needed to cover the fluctuations of Australian rural production is justified in part as a drought security measure (Anon. 1966, 59).

The urban bases of political power established early on the humid southern rim of Australia have maintained their control over the whole range of Australian environments. However, two droughts forced the nation to move toward regional as opposed to state resource management, while a third brought on a national restructuring of the cereal grain industry.

In 1865, with the South Australian government under pressure from drought-stricken pastoralists, Surveyor General George W. Goyder was ordered to map the southern edge of the drought area so that relief measures could be administered. As a result of his experience, together with his subsequent influence in the colonial bureaucracy and the recurrence of droughts in the 1880s and 1930s, his Line has remained on the official maps and in the legislation as an effective division between the purely pastoral areas to the arid north and the mixed farming and cereal growing areas to the south (Meinig 1962; Heathcote 1981).

The major drought of 1895-1902 resulted in official inquiries into land settlement in Queensland in 1897 and New South Wales in 1901. In New South Wales massive stock losses (approximately half the sheep and a third of the cattle) and land degradation led to proposals for a regional administration for the western third of the state. The resultant Western Lands Commission, set up in 1902, has remained active, although its role is currently being reassessed—in part due to the

The depression and droughts of the 1930s and early 1940s brought bankruptcy to many wheat farmers, especially on the semiarid margins. A series of official inquiries by the separate states culminated in a Commonwealth-financed restructuring scheme costing $4 million to repurchase abandoned wheat farms and combine the areas into mixed crop and livestock properties (Proctor 1940). The scheme, covering land from Western Australia to New South Wales was, arguably, the first evidence of a national resource management policy and was, in part, drought induced.

**CLIMATIC CHANGE IN AUSTRALIA: CO\textsubscript{2} OR ENSO?**

Australian climatologists seem to agree that atmospheric CO\textsubscript{2} will produce a warming effect, although somewhat modified in range. Idso (1984), however, challenges the belief in the overall warming effect of increased atmospheric CO\textsubscript{2}. He postulates a cooling, from an inverse CO\textsubscript{2} greenhouse effect, that is generally offset by vegetation expansion into arid areas, leading to decreased albedo (reflectivity) and consequent warming—the end result being neither significant global warming nor cooling! As yet no Australian climatologist has responded to this interesting variation on the theme.

The evidence for recent climatic changes in Australia predated the CO\textsubscript{2} debate, for Gentilli (1971) demonstrated the advance of the boundary of arid and semiarid climates in eastern Australia over the period between 1911 and 1940, following a more humid period from 1881 to 1910. During the period 1946 to 1974 eastern Australia, including the area studied earlier by Gentilli, experienced increases in annual rainfall, mainly during the summer, of 75-150 mm as seen in Fig. 1 (Pittock 1981). Separate attempts to test the influence of increased CO\textsubscript{2} as postulated in rainfall trends have had limited success. Tucker and Stokes (1980) found it impossible to separate any “signal” of trends from the “noise” of seasonal variations.

The effects of a CO\textsubscript{2}-induced warming on Australia have been forecast to include wetter conditions north of latitude 25° S and possibly north of 37° S, but with drier conditions to the south (Pittock 1980; Tucker 1981). In his most recent paper, however, Pittock (1983) has argued that these changes have in fact already taken place. Comparing the period 1946-78 with 1913-45, he noted changes that were closely analogous to the changes predicted from a 50 percent increase in atmospheric CO\textsubscript{2} over the next 30 years. If Pittock is right, the CO\textsubscript{2}-induced changes to the year 2000 would bring nothing new and would pose no chal-

**FIG. 1. Climatic Changes in eastern Australia 1881-1974.**

Key: 1 Eastern boundary of climatic zones 1881-1910 (perarid, arid, etc.).
2 Eastward boundary expansion 1911-1940.
3 Eastern boundary of climatic zones 1911-1940.
4 Increase in mean annual rainfall (mm) between 1913-1945 period and 1946-1974.
Sources: Gentilli 1971, Pittock 1981.
Challenge beyond the scope of existing technology, assuming technology has been able to cope so far.

But are the demonstrated climatic changes associated with rising CO₂ levels or with something else? Australian climatologists have become particularly interested in the apparent linkages between weather in southeastern Australia and atmospheric conditions in the Indonesian region (Pittock et al. 1978). A 1983 conference on El Nino and the Southern Oscillation (ENSO) reported that there seemed to be significant correlations between the occurrences in Australia of relatively dry and wet periods and variations in the Southern Oscillation (Anon. 1983, 335). The teleconnection between sea surface air pressures and the Australian monsoon systems has been established (Allan 1983) and lagged linkages between Darwin air pressures and rainfalls in eastern and northern Australia suggested (Coughlan 1983; Nicholls 1983a). Scientists may be able to warn of future droughts simply by noting when Darwin's air pressure remains above the long-term mean for a month or two (Nicholls 1983b).

**TECHNOLOGICAL ADJUSTMENTS TO DROUGHT IN AUSTRALIA**

Human occupation of the Australian continent is substantially buffered against the impact of agricultural droughts. Livestock are grazed successfully on ranges with average rainfall of 100 mm or less and with severe drought incidence; wheat is grown without irrigation in areas with an average rainfall of 200–300 mm. Of these achievements we can be and are justly proud. But we must also recognize that these achievements have not been made without significant economic, environmental, social, and psychological costs.

Technological solutions to resource management problems depend upon the extent to which the innovations are accepted and practiced. Innovations are accepted or rejected according to a complex interplay of the characteristics of the overall economy, the cultural and social attitudes of the community, and the personality of the individual. In Australia while some farmers in the semiarid areas experiment with minimum or zero tillage, others still burn their stubbles and disk their paddocks, apparently oblivious to the consequences in terms of soil erosion; while some accept the most recent wheat varieties, others cling to older, supposedly less efficient but tried varieties (Heathcote 1980). Irrigation in South Australia, at least, is still dominated by the furrow system (44 percent of the area in 1980), and although center-pivot systems are known and in use, they still are a minority technology (Menzies and Gray 1984).

Given that technology has diffused over time, however unevenly, have the innovations controlled drought in Australia? Wheat yields and unrealized sowing intentions in Australia are directly compatible with those of the United States (see Great Plains Quarterly 6:203, above) and show a more unstable and, if anything, horizontal trend in yields (fig. 2). Detailed studies of trends in regional wheat yields in South Australia from 1896 to 1964 showed that “over 75 percent in the variation in yield is explained by the rainfall and time variates” (Cornish et al. 1980, 12). Further, the yield required to make a profit from wheat farming had gone up from 0.2 tonnes per hectare in the 1880s to 0.4 tonnes in the 1930s and by 1980 was approximately 0.8 tonnes! Technology faces a considerable challenge in attempting to provide such continually increasing yields in the face of significant rainfall variability.

For the pastoral industry the drought impacts and current leveling off of stock numbers have been documented elsewhere (Heathcote 1977). A recent study by Dury (1983) has suggested that the fluctuations of livestock numbers and economic returns comprise step-functions. The steplike increase or decrease of the trends through time is, in his view, associated with drought onset and termination and is not impressive evidence of any technological buffers against drought impact.
One of the most obvious technological responses to the challenge of unfavorable weather has been to try to modify it. Successful rainmaking in Australia is first documented for 1947, after which there was an increasing official commitment to experiments—usually triggered by the onset of droughts as seen in Fig. 3 (McBoyle 1980). In 1980 cloud seeding seemed to have a future as an environmental management strategy, but the cancellation of the final experiments by Commonwealth Scientific and Industrial Research Organisation (CSIRO) in Victoria a year later marked the end of attempts to use this particular technology. As a CSIRO spokesman commented, “We know how to make rain but the right clouds haven’t been there” (Financial Review, 4 November 1981).

Innovations in tillage methods, mechanization of labor, and use of fossil fuel energy helped push the Australian wheat frontiers down the rainfall gradients into the riskier droughty country of the interior. Over time this expansion has been impressive and is still going on (fig. 4). The costs to the industry and to the nation, however, have been sufficient to cause concern.

To what extent technology alone has encouraged the expansion of grain farming into more risky climatic areas is debatable, but there seems little doubt that successful technological innovations in the face of local environmental challenges or high production costs have supported speculative expansion into more risky areas. Set against the undoubted increased grain production from such areas is
the local evidence of some soil modification (plow pan formation at 8–15 cm depth), which in fact increases the drought risk since the pan prevents moisture or root penetration beyond the shallow surface soil zone (Harte 1984). Associated with this tillage of semiarid areas have come increases in soil salinity, loss of yield, and, locally, abandonment of land (WPDSA 1982; Mulcahy 1978).

Wind erosion from droughty fallow land was responsible for Australian soil finding its way to the New Zealand snowfields in 1944, and dust clouds enveloped Melbourne (Victoria) on 8 February 1983 at the height of the 1982–83 drought, just as they had in a similar drought on 21 November 1902. Indeed, the Commonwealth's Bureau of Meteorology annual publication on the climate of Australia featured a photograph of the February dust storm over Melbourne on the cover of its 1983 edition.

Water management as a drought mitigation strategy also has had its problems in Australia. Initial reservoirs on the plains were much too large. The several thousand sheep or cattle they served soon destroyed the feed within effective traveling distance from the water and, as a result, stock continued to die in the droughts—but from starvation, not thirst (Heathcote 1977). Similar problems faced the developers of the artesian bores. As the bores were often at least 1000 meters deep, they were too expensive to be scattered over the property, and again they were too few to enable optimal management of available feed. As a result, the devastated “sacrifice” areas around the watering points became the core of the overgrazed areas, visible even now on satellite imagery, across the Australian rangelands (Douglas 1980).

Australia has a fair share of the environmental problems associated with irrigation (Pels 1978). The main irrigated areas, along the River Murray, are threatened by increasing levels of salinity not only in the soil but in the water supplied for irrigation. Some of the salts

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**FIG. 3. Rainmaking experiments in Australia 1947-1980.**

Key: 
- Rainmaking experiments undertaken in state indicated.
- Major drought period.

N New South Wales  
Q Queensland  
S South Australia  
T Tasmania  
V Victoria  
W Western Australia

are natural but approximately half are derived from poor management of the irrigation systems (Menzies and Gray 1983). In South Australia, which gets the river water last in line, a series of expensive remedial measures were suggested and the cheapest is currently being carried out (SAEWS 1978, 120–21).

A week after Melbourne’s dust storm on 9 February 1983, the city was menaced by bushfires that covered over 500,000 hectares in South Australia and Victoria, killed 72 people and over 300,000 domestic livestock, and caused approximately $400 million property damage (Bardsley et al. 1983; Oliver et al. 1984). Each drought in Australia is accompanied by an increase in the incidence of bushfires, and scientists acknowledge the logical linkage in fire danger indices (Gill 1983). Again, despite the application of modern firefighting technology, the losses in 1983 were ranked as a national disaster. Less newsworthy but nonetheless important were the erosion losses (up to 48 tonnes of soil per hectare or over 30 times the total normal annual loss) from some of the burnt areas in the drought-breaking rains of March 1983 (Atkinson 1984).

FIG. 4. The spread of wheat growing in New South Wales 1871-1980s.
Key: 1 Wheat growing areas.
2 General wheat growing areas.
3 Westward limits of wheat growing for years indicated.
4 Isohynets of average rainfall for wheat growing period April to October.
CONCLUSION

Technology has, in part, successfully buffered Australian society against the impact of droughts, not least by allowing the economy to diversify away from agricultural and pastoral sectors. Droughts no longer make the economic or social impact they did in the nineteenth century or even the 1930s and 1940s because of the increased diversity of the components of the gross domestic product.

Yet droughts were endemic to the continent and technology has really only reduced and not removed their impacts. Indeed it can be argued that technology in some ways has made society more vulnerable, for all technologies have their own negative as well as positive impacts upon the environment, as the general public is slowly becoming aware. Recent media coverage of the soil erosion problem in Australia pointed out that it was not drought alone that caused the problem but mismanagement of the available technology (ABC-TV 1984).

I see the technological solutions to environmental problems as only part of an optimal strategy. As K. W. Butzer points out, “Complex societies, both traditional and industrialized, are to some extent buffered from environmental vicissitudes by multiple layers of technology, social organization and exchange networks” (Butzer 1983, 290). Technologies are tools in the hands of managers, but they are also constraints to management options and they have their own costs. Further, as Butzer notes, the more complex or sophisticated the technology the greater the chance for Murphy’s Law to take effect.

In Australia the current general high standard of living reflects the successful application of a variety of technologies to reduce the impact of environmental hazards, including drought and possible man-induced climatic change. The negative legacy of those technologies, however, is only now being seriously considered and the cost-benefits are now being assessed on grounds that are no longer purely short term and economic. I can admire the ingenuity and skills with which technology has provided defenses against drought and climatic change, but we must forget neither the defenses that failed nor the high cost, both environmental and societal, of the apparent successes.

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