REGREENING AUSTRALIA:

THE ENVIRONMENTAL, ECONOMIC AND SOCIAL BENEFITS OF REFORESTATION

Richard Eckersley
Principal issue analyst
Office of the Chief Executive
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SUMMARY

Growing public, political and scientific concern about environmental problems such as land degradation and the greenhouse effect is increasing interest in reforestation as a counter-measure. A preliminary investigation indicates that a large national program to "regreen Australia" — involving the growing of billions of trees and other plants and extending over 10–20 years — would offer a range of environmental, economic and social benefits to Australia.

While aspects of these benefits may be unproven, speculative, conjectural or controversial, their potential, and the seriousness of the problems they address, indicate that the proposal deserves thorough consideration.

Combating land degradation The primary objective of the program would be to halt and reverse land degradation, our most serious environmental problem, and so contribute to the development of sustainable farming systems in Australia. Apart from reducing soil erosion and salinity, and improving soil structure and fertility, "regreening Australia" through large-scale revegetation and reforestation would also provide a public focus for a broader land restoration campaign that embraced a range of other necessary programs, including changes to farm management and land use. A national program based on this concept would also help to promote greater public awareness of the value of the substantial, although fragmented and still inadequate, efforts that are already being made to counter degradation of our land and water.

The necessity to address land degradation provides the main justification for a major national revegetation effort. Given this benefit, however, there are others that further strengthen the case for its adoption. They include:

Countering the greenhouse effect Large-scale reforestation could absorb a substantial amount of the carbon dioxide emitted by the burning of fossil fuels in Australia. While this would be of little global significance, it would, along with other measures such as energy conservation, allow Australia to do its share towards slowing the warming of the earth's surface through the greenhouse effect. More speculatively, it could also help us to manage the possible consequences of the greenhouse effect for the distribution of plants and animals: forests of threatened species could be grown in new areas, or forest corridors created that would allow trees, other plants and animals to "migrate" naturally. While some scientists question the real significance of the "greenhouse" benefit, it is the main reason for the growing public interest in reforestation, and its psychological value could be important to the success of the program.

Increasing agricultural productivity Apart from halting and reversing land and water degradation, 10–25% tree cover on farms can maintain, and even increase, productivity by providing shelter and fodder for stock, reducing water loss from crops, supplying nutrients, and increasing bird life, which reduces insect pests. Trees can also increase the capital value of the land. These benefits will be important in persuading landholders of the value of trees.

Boosting timber production Forests grown to counter land degradation could also be a source of timber, so reducing imports and increasing exports of timber and timber products. While such forests may not be able to pay for themselves entirely through the wood produced, research into hardwood plantations shows promise of substantially increasing their profitability, especially as a source of pulpwood. Growing feature timbers, used for furniture, veneers and other such purposes, could also provide a valuable option for recovering costs.

Enhancing the beauty of the Australian bush Many of Australia's native plants and animals have declined in numbers and distribution. Almost 90 mammal, bird and other vertebrate species and more than 3,300 plant species are listed as rare or threatened. Revegetation would help to conserve and enhance this unique biological heritage. Conservation of flora and fauna has intrinsic merit, but it would also make the Australian environment more attractive to Australians and foreigners alike, so increasing their enjoyment and the economic value of the bush. Trees also enhance the urban environment, providing a buffer against heat, dust, wind and noise.

Job generation While there appears to be considerable scope to improve the effectiveness and efficiency of reforestation and revegetation techniques, they are likely to remain relatively labour-intensive. Thus a large-scale program could generate a large number of jobs that would particularly suit the more mobile young, amongst whom unemployment remains high. In the event of a recession, unemployment will rise, making programs such as this one especially important in terms of creating useful employment.

Creating an export industry Environmental problems are causing increasing concern throughout the world, and environmental conservation and restoration is likely to become a significant industry in the decades ahead. Development funds to Third World countries, for example, are now being tied to environmental, as well as economic, objectives. Australia is well-placed both to offer valuable foreign aid and to earn export income through the natural resources it possesses and the skills and technologies it develops to combat degradation and create sustainable agricultural systems.

Improving national confidence One of the potentially most important benefits of large-scale revegetation is also the least tangible — in being large-scale, conceptually simple, highly

visible, genuinely national in scope, and offering a broad range of environmental, economic and social benefits, the program could become a key to creating a vision of an Australia that is vigorous and enterprising and, at the same time, far-sighted, fair and decent. The program would help to engender among Australians the sense that we are capable of tackling the daunting long-term problems that confront us, and so determine our own national destiny. If it achieved this, it would help to overcome the growing disillusionment and cynicism with which Australians regard politics, and the dismay with which many view the future.

A revegetation program on the scale envisaged would require an investment, private and public, of at least several billion dollars. It seems a huge sum, but has to be set against the costs of the problems. Estimates of the cost of land degradation range as high as $2 billion a year; some of these losses are permanent and cumulative, reflecting irreparable damage and irrecoverable loss. The costs of the greenhouse effect are as yet unknown, but could be immense, especially if its consequences are not anticipated and countered. The direct and indirect costs of unemployment and its social impact probably exceed $10 billion a year. The costs to the country of growing political cynicism and loss of national confidence are beyond any economic assessment, yet could be a significant part of the cost-benefit equation.

In recommending a more detailed examination of whether a massive national revegetation program is both feasible and desirable, five key points must be made to avoid misunderstandings about what is being proposed:

1. While the report deals largely with trees and reforestation, the program would include other forms of revegetation, including with bushes and grasses, which are also important in stopping and reversing land degradation. This revegetation would, in turn, be part of a larger plan for environmental restoration that would incorporate farm management changes and other measures. In relation to the broader social benefits, the program is suggested as *one example* of how these benefits could be achieved. The emphasis on trees reflects both the real benefits they offer, and their value as a symbol of our determination to resolve the serious problems we face. The report does *not* argue that trees are the solution to all our problems.
2. The report is *not* advocating a huge public works program, run by government, that adopts a single system of tree-planting across the continent. To be effective, the program must be tailored to the particular needs of a region, managed at a local level, and carried out using, where necessary, private contractors. The role of government is to provide the necessary policy framework, incentives, funding, coordination, research and education.
3. The program would *not* be a job creation program, undertaken to occupy armies of unskilled unemployed. The problems and opportunities are real. To be economically feasible and to achieve its objectives, the program would have to be made as effective and as efficient as possible. The jobs involved would be as legitimate and as useful as any other, and in many cases would require training and skills.
4. The program is *not* suggested as an alternative to other existing programs, conservation strategies or proposals. It would embrace, and greatly expand, for example, the activities now carried out by State Governments and through programs such as the National Afforestation Program and the National Tree Program. It could be incorporated into, and would again enlarge, the role of the proposed local "land care groups", whose establishment has been recommended by the National Farmers' Federation and the Australian Conservation Foundation, and others.
5. While a lot could be achieved by making better use of the knowledge we already have, Australia still lacks necessary detailed information on both the problems and the treatments. Therefore a component of the program would be a research program that would coordinate and extend current research activities. This is essential, for example, to: understand better the role of trees and other plants in countering degradation problems; know what species to plant where, at both a regional and local level, to maximise the benefit; increase the efficiency and reliability of revegetation techniques; develop restoration practices that lead to sustainable ecological systems — that is, they will not require repeated revegetation; and improve our knowledge of the regional effects of the greenhouse effect and its impact on the Australian environment.

This research would be better focused, and its results put to use more quickly and effectively, if the research were conducted within a broader framework or context of planned national action, such as that considered in this report.

AUTHOR'S NOTE

This report arose from another that I wrote for the Commission for the Future last year. That report, "Casualties of Change: the predicament of youth in Australia", argues that fundamental social, economic and technological changes lie behind the worsening plight of modern youth, expressed in rising suicide, drug abuse, crime and social apathy.

I believe the solutions to our social problems, like those to the environmental problems we face, will have to be as fundamental as their causes, and lie in a much better integration and balance of economic, environmental and social goals and priorities than now exist. One day, I read a newspaper article in which a CSIRO colleague, Denis Saunders, was quoted as saying, as a spokesman for the Ecological Society of Australia, that Australia must embark on a large-scale national revegetation program if it was to avert the ecological disaster threatened by land degradation. About a month later, scientists began talking of the need for massive reforestation as one means of countering the greenhouse effect.

It struck me that a large reforestation and revegetation program might be an excellent example of the sort of national initiative that would both reflect and reinforce the new approach we need to adopt. This report is an examination of that proposition.

The report is primarily intended for the public and those who lead, influence and represent the Australian people. But I also hope that, like my "Casualties of Change" report, it will be useful to those who work in the areas covered. I am sure that of all the people I consulted, none knows everything that is in the report, yet I believe everything in it is relevant and important in deciding whether or not Australia should embark on the course proposed.

The report would not have been possible without the assistance of many people, who readily offered their expert knowledge and advice and, in many cases, their encouragement. They are listed at the back, and I thank them all. Some warrant special acknowledgement. In particular, I am indebted to John Ive, of the CSIRO Division of Wildlife and Ecology and chairman of the Yass River Valley Revegetation Project, for his generous help and tolerance in the face of constant harassment over the past six months. I would also like to thank especially: Roger Gifford, of the CSIRO Division of Plant Industry; Graham Harrington, of the CSIRO Division of Wildlife and Ecology; Barrie Pittock of the CSIRO Division of Atmospheric Research; Bill Rawlins of the CSIRO Division of Forestry and Forest Products; and Lance Woods of the Commonwealth Department of Primary Industries and Energy.

Finally, I would like to express my gratitude to the Chief Executive of CSIRO, Keith Boardman, for his support, without which the report could not have been written.

Richard Eckersley

INTRODUCTION

There will not be another time to address the environmental problems facing Australia and the rest of the world. The crunch has come.

Thomas Lovejoy, a biologist with the Smithsonian Institution in the United States, warned last year:

> 'I am utterly convinced that most of the great environmental struggles will be either won or lost in the 1990s. And that by the next century it will be too late.'[1]

Similarly, the eminent Harvard University biologist, Edward Wilson, told the National Geographic Society recently:

> 'How the human species will treat life on earth, so as to shape this greatest of legacies, good or bad, for all time to come, will be settled during the next 100 years.'[2]

The environmental problems — global, national, regional — are well known: the warming of the earth due to the greenhouse effect; the depletion of the earth's protective ozone layer; the destruction of forests and the expansion of deserts; the pollution of land, rivers and oceans with hazardous chemicals; the extinction of animals and plants; acid rain; the loss and degradation of soil. There are also grave economic and social problems confronting many countries, including Australia.

In an increasingly globalised and competitive world economy, Australia is losing ground. Burdened by growing foreign debt, high interest rates, high inflation and low savings, we are failing to make the long-term investments necessary to assure our economic future. Unemployment, while it has fallen in recent years, remains high and now seems set to rise again. Poverty has grown. The problems of drug abuse and worsening crime and violence seem to defy solution.

This report examines one possible example of how environmental, economic and social objectives can be integrated to help improve our situation. It is a proposal for a massive, long-term effort to "regreen Australia".

LAND RESTORATION

Land degradation

Land degradation is Australia's most serious environmental problem.

Since 1972 there have been 16 inquiries that have called for the development of a national land use policy — on average, one each year [3]. There has been progress, but there is widespread agreement among scientists, governments, government agencies, farmers and conservationists that much more remains to be done. We now have a National Conservation Strategy and a National Soil Conservation Strategy, but their goals and objectives have proved elusive.

The report of one recent inquiry, by the House of Representatives Standing Committee on Environment and Conservation, and issued in November 1986, states:

> 'The seriousness of the land degradation problem facing Australia is so great that it is difficult to comprehend but there should be no doubt that if the trend is not reversed it could have serious consequences for the economy and the environment.'[4]

The impotence of politics in the face of such problems as land degradation is well illustrated in a Time magazine article, published last year, in which the Federal Minister for the Environment (and arts, sport, tourism and territories), Senator Graham Richardson, acknowledges the problem, but says he can do little about it. Land degradation is not 'sexy' enough. It is low profile, a sleeper; there are no votes in it:

> 'Until this dull issue becomes a big public issue, governments won't put big money into it. So far, it has been politically impossible to sell when budget allocations are made.'[5]

Recent developments, including the collaboration between farmers and conservationists on the issue, increased media interest and the Federal Government's plan to make the 1990s a decade of soil conservation, indicate this situation may be changing. But it is still too early to believe the battle to put land degradation on the public and political agenda is over. History shows that issues like land degradation can bubble away for decades, attracting sporadic attention, without ever reaching the "critical temperature" necessary to trigger a sustained public and political reaction. Meanwhile, the problem worsens, and its costs to the nation grow.

Causes and consequences of degradation

Land degradation is the decline in the condition or quality of the land as a consequence of its misuse or overuse. Australia is among the most degraded of developed countries, and in some areas the degradation matches that of the worst developing nations. In degrading the soil, we have also degraded the water. Both are a scarce and precious commodity in Australia; we have poorer soil and less water than any other continent, except Antarctica.

Land degradation began in ignorance and continues through neglect [6,7,8]. We have cleared too much of the native vegetation; we are planting crops where they should not be grown; we are grazing more sheep and cattle than some land can carry. As a result, the land is being laid bare, and precious soil is being blown away, or washed away to clog rivers, lakes and dams with silt.

Because of over-clearing and irrigation, water tables are rising, carrying to the surface dissolved salts that poison the soil and contaminate the waterways. Improving pastures with fertilisers and legumes is now making the soil in many areas acidic, toxic, less productive, and more prone to erosion. Pesticide use has contaminated the soil with toxic residues; these have also polluted streams and rivers, as have chemical fertilisers and defoliants. Introduced animals and plants have run rampant, adding to the degradation.

Over huge areas, farming is pulverising and compacting the soil, destroying its fertility. In other regions, thick scrub is taking over once productive countryside (*Box 1*).

Behind the despoliation of the continent lies a combination of natural and social circumstances. Australia is very different from Europe. Our soils are generally infertile, thin, weathered, and erosion-prone; our climate is characterised by low or variable rainfall — droughts and flooding rains are normal features of our climate, not aberrations. Our native plants and animals evolved in isolation, making them vulnerable to damage, both from farming and the ravages of introduced species.

Compounding the problem has been a range of social influences: the "pioneer" ethic that regards the land as something that must be tamed, subdued; economic pressures that push farmers to overuse the land; extensive farming systems, making care of the land difficult; low land values, making conservation and restoration uneconomical; government policies that have encouraged degradation; and lack of political will, in part due to fragmented government responsibilities.

The result: more than half the land used for grazing or growing crops in Australia — over 2.6 million square kilometres — has been assessed as needing treatment for degradation (*Figure 1, Table 1*).

This assessment is based on the only national study of degradation in Australia, the Commonwealth and State Government Collaborative Soil Conservation Study, undertaken in 1975–77 [8,9]. While governments have stepped up soil conservation programs since then, the situation is unlikely to have improved, and has probably deteriorated, because of the severe drought of 1979–83, the worsening of both dryland and irrigation salinity, and the extension of cropping into marginal land.

One study estimated that by 1983 two-thirds of Australia's farmland needed soil conservation treatment [10]. According to another estimate, of

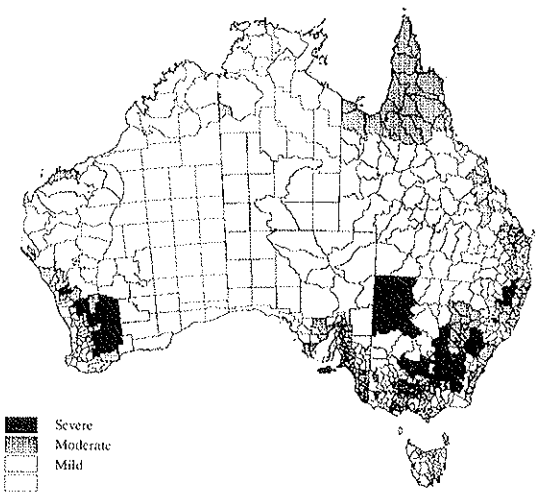
BOX 1

The dimensions of land degradation in Australia

- In Western Australia, 250 square kilometres of agricultural land are going out of production each year because of soil salinisation caused by the over-clearing of native vegetation. Over large areas of the West Australian wheat belt, less than 10% of the native vegetation remains, scattered in small patches, most of which are degraded by grazing, invasion of weed and rabbits and lack of regeneration [6].
- In some irrigation areas of the Murray-Darling Basin, groundwater levels are rising at a rate of more than 20 cm a year. The rising water table, which has already reached the surface in some areas, brings with it dissolved salts that are present in amounts of 3000 tonnes per hectare, or more. Some of this salt gets into the river system; every minute, 2.5 tonnes of salt flows over the South Australian border in the waters of the Murray [20].
- In western NSW and south-western Queensland, the semi-arid woodlands that stretch in a belt covering 500,000 square kilometres are severely degraded by the invasion of woody shrubs and soil erosion, resulting from lack of fire (which controls the shrubs) and over-grazing. Already, some land can no longer sustain grazing. At a rough estimate, one half of the entire area could become unproductive within 30 years if the problem is not corrected [6,21].
- Wheat yield per hectare in the Darling Downs in southern Queensland is almost five times the national average. Each year, however, it loses 4 to 8 millimetres, or about 8 million tonnes, of its rich black topsoil through erosion; at this rate the soil will be gone in 30 to 50 years. The value of nutrients in soil washed from the Downs in drought-breaking rains in 1983 has been estimated at $2 billion [14].
- The Burdekin catchment covers 15 million hectares, an area twice the size of Tasmania, and supports a quarter of Queensland's export beef cattle industry, earning over $250 million last year. Soil erosion caused by grazing has risen to 5–50 times the geological rate. Each year, 20 million tonnes of topsoil, containing nitrogen and phosphorus worth $100 million, is deposited in the Burdekin Falls Dam, or out to sea. The resource is irreplacable [19].

FIGURE 1

Land degradation in Australia



Source: John Ive, Doug Cocks, CSIRO Division of Wildlife and Ecology.

TABLE 1

The extent and nature of land degradation in Australia (1975)

Form of degradation	*Area* '000 sq km	Percent
Non-arid areas		
area in use	1804	
area not requiring treatment	987	55
water erosion	577	32
wind erosion	57	3
combined wind and water erosion	55	3
vegetation degradation	92	5
dryland salinity	10	<1
irrigation salinity	9	<1
other	14	<1
total area requiring treatment	815	45
Arid areas		
area in use	3356	
area not requiring treatment	1506	45
vegetation degradation and		
little erosion	950	29
some erosion	467	14
substantial erosion	284	8
severe erosion	148	4
dryland salinity	1	<1
total area requiring treatment	1850	55

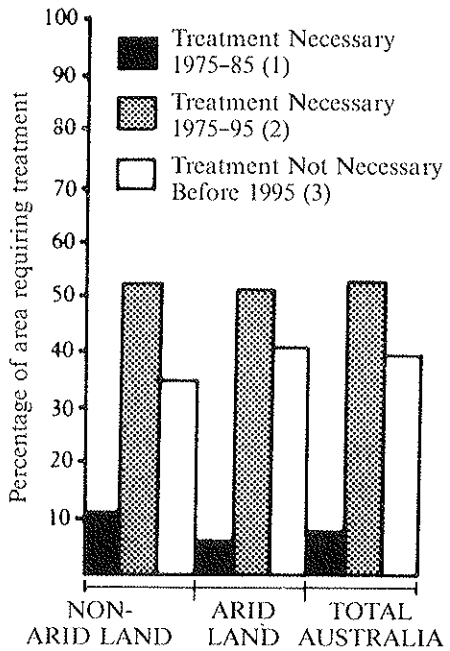
Source: Colin Chartres, *Australia's land resources at risk*. In *Land degradation: problems and policies*, edited by Anthony Chisholm and Robert Dumsday. Cambridge University Press, 1987. Adapted from L E Woods, *Land Degradation in Australia*, AGPS, Canberra, 1983.

the land assessed by the Collaborative Study as needing treatment before 1995 if irreversible damage and further loss of productivity were to be avoided, only about 5% has been treated (*Figure 2*).

The Collaborative Study concentrated on soil erosion and salinity and vegetation degradation. Other forms of degradation such as soil acidity, waterlogging, and declining soil fertility and structure, are still to be fully assessed. A comprehensive study of land degradation in NSW by the State's Soil Conservation Service, issued in March, indicates that these problems occur over large areas. For example, 10% of the state, or 8 million hectares, is moderately or severely affected by induced soil acidity, while moderate to severe decline of soil structure is found over 17%, or 14 million hectares, of the State (*Table 2*) [11].

FIGURE 2

Urgency of treatment of degraded land in Australia, 1975



1. *If no action taken, irreversible damage, or serious off-site effects likely*
2. *Remedial action required to prevent further loss of productive potential or undesirable off-site effects*
3. *Land degraded but no worsening*

**Data not available for non-arid S.A.*

Note: according to one estimate, only about 5% of the land in categories 1 and 2 has so far been treated.

Source: State of the environment in Australia 1985, Department of Arts, Heritage and Environment, AGPS, Canberra 1985, p28. Prepared from data in L E Woods, *Land degradation in Australia*, AGPS, Canberra, 1983.

Also, the Collaborative Study focused on degradation of farm land, which extends over two-thirds of Australia. While the areas of land devoted to other purposes such as urban development, forestry and transport are comparatively small, degradation is also occurring in these areas.

The total economic, environmental and social costs of land degradation are impossible to evaluate. Nevertheless, some figures are indicative of the scale of the problem. The Federal Department of Primary Industries and Energy estimates that land degradation is already costing Australia $600 million a year in lost agricultural production; this cost will continue to escalate until the problem is adequately addressed. The total cost of land degradation — including treatment of degraded land, nutrient loss, research, and off-site costs such as those associated with silting and pollution of rivers, dams, lakes and harbours —would be much higher, perhaps $2 billion a year [12].

Contrary to public perceptions, which tend to see land degradation in terms of erosion and salinity, the greatest costs result from other changes. The general view emerging in scientific circles, according to the Institute of Foresters of Australia, is that for every dollar dryland salinity costs us, water and wind erosion costs $5, soil acidification $25, soil structural decline $125, and soil nutrient degradation $625 [13].

Some of the damage caused by degradation is permanent, the loss irrecoverable. For example, the value of the nutrients in the soil washed from the rich Darling Downs by drought-breaking rains in 1983 has been estimated at $2 billion [14]. Doing what can be done to arrest and repair the damage was estimated by the Collaborative Study to require an immediate investment of $675 million, plus a continuing expenditure of $50 million a year [8,9,14]. In today's dollars, that is about $2.5 billion, plus $180 million a year.

These figures underestimate the total cost of combating degradation because they were based mainly on the need for engineering treatment for erosion and salinity, and did not include the costs of other remedies, such as large-scale reforesting and changed management. And, as already noted, the study did not assess all forms of degradation.

Of the total of $675 million, the Collaborative Study estimated that an expenditure, by landholders and government, of $200–300 million (about $700–1,000 million in today's dollars) would achieve a reasonable cost-benefit ratio [9]. The level of investment in land restoration has been nowhere near even this amount.

The Federal Government has allocated $20.7 million in 1988–89 for land degradation, through the National Soil Conservation Program, the Federal Water Resources Assistance Program and the National Afforestation Program [15]. This is considerably more than in earlier years — the previous Federal Government abolished the Federal soil conservation program to save $3 million a year [16]. The Government announced in April that funding for the National Soil Conservation Program over the next three years will total $45 million [17]. Total government

TABLE 2

Land degradation in NSW

Type	*Severity*	*Percent of State affected*	*Area ('000 ha)*
Water erosion			
sheet and rill	moderate	1.81	1451
	severe	0.53	425
	very severe	0.31	252
gully	moderate	5.68	4550
	severe	4.80	3849
	very severe	0.67	540
	extreme	0.07	57
Mass movement	present	2.69	
Wind erosion	moderate	14.06	11270
	severe	9.04	7246
	very severe	1.57	1255
Saline seepage	moderate	0.54	
	severe	0.66	
Irrigation salinity	moderate	0.52	
	severe	0.25	
Scalding*	moderate	9.18	7357
	severe	0.88	706
Soil acidity (induced)	moderate	6.65	5330
	severe	3.38	2712
Soil structure decline	moderate	6.48	5191
	severe	10.86	8701
Woody shrub infestation	moderate	12.75	10216
	severe	4.41	3533
Tree regrowth #	no regrowth	50.91	40800

*Scalds are bare unproductive areas where surface soil has been eroded away, exposing a clayey subsoil.

#Land that shows no tree regeneration is not necessarily degraded. However, many kinds of degradation are either caused or aggravated by tree loss or lack of regrowth. The figure should be interpreted with caution because it includes naturally treeless areas.

Note: figures cannot be added to derive the total area of NSW affected by land degradation, as any particular location may suffer more than one form of degradation.

Source: Land Degradation Survey — NSW 1987–88. Draft report by the Soil Conservation Service of NSW, March 1989.

(State and Federal) expenditure on soil conservation is currently estimated at about $100 million a year [18].

Land restoration

Halting the degradation of the land requires a revolution in community attitudes to the land and its use. It means making land use sustainable, and to do this involves social, political, and economic considerations as well as environmental.

The task will involve substantial changes to both current land use patterns and farming practices. On some grazing land, livestock numbers will have to be reduced — at least temporarily. Some erosion-prone cropland will have to be returned to pasture. Some land now used for grazing or cropping will have to be replanted with trees, and land that continues to be used for crops will have to be managed more conservatively.

The Collaborative Study estimated that about half the degraded land in Australia could be treated just by changing management practices. The other half will require additional measures, including reforesting and mechanical treatment such as contour banks and relocation of fences (which encourage erosion if badly placed). On 5–10% of the land, the use needs to be changed [9].

To offset the production losses from these changes, production could be increased in "safe" areas without degrading the land. While Australian agriculture is considered efficient in terms of the labour and energy required, it tends to be inefficient in terms of the potential yield based on rainfall. In the better regions, for example, wheat production rarely exceeds 20–30% of the potential yield on this basis because of poor soil, pests, weeds and disease [19].

Evidence suggests that Australia could reasonably expect to increase wheat production to 50% of the potential yield on 50% of farms — adding about $1 billion to gross export earnings — by improving management in areas such as soil structure and water use, crop residues and root disease, land degradation, nutrient deficiency and toxicity, chemical residues and pollutants, and weed control. However, we have yet to develop the coordinated and integrated systems necessary to achieve this goal.

Deforestation

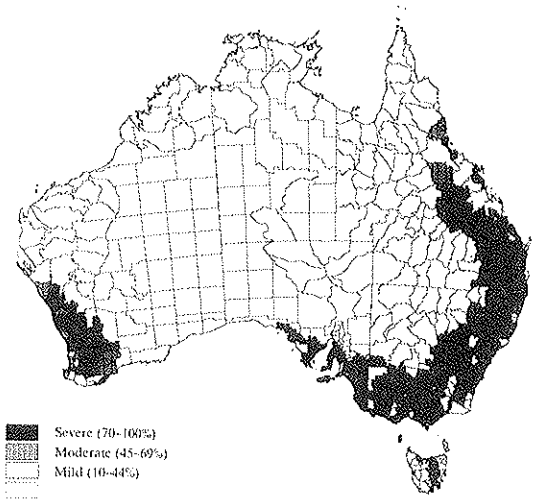
The extent of tree-clearing in Australia is one of the most striking features of the country's development. Before European settlement, forests covered 10% of the country and woodlands, where trees are often smaller or more widely spaced, covered 23% [14]. CSIRO has estimated that 50% of the original tall and medium forest and 35% of the woodlands have now been cleared or severely modified (*Figure 3*).

Three-quarters of our rainforest is gone. Large areas of what was once rainforest, cleared for agriculture in the 1800s and early 1900s, are now unproductive, infested with weeds, heavily eroded, and swept by fire. This land has the potential to grow some of our finest timber, but it is not being reforested because this is usually considered "uneconomical", an assessment that rarely takes account of the multiple benefits of reforestation [22].

The loss of trees is continuing through both continued clearing and, increasingly, "dieback" resulting from disease, attack by pests, and old age (in many farming areas, the only trees left

FIGURE 3

Extent of tree clearing in Australia since European settlement



Source: John Ive, Doug Cocks, CSIRO Division of Wildlife and Ecology.

are scattered mature trees, and these are now dying). The extent of this continuing loss is evident from the estimation that Victoria needs to plant 5 million trees a year on farm land just to maintain the present level of tree cover on this land [4].

While the total area of forest in Australia may have remained relatively unchanged in recent years because of increased reforestation for commercial and other reasons, there is a risk of a further huge loss of tree cover if the potential for massive clearing of poplar box woodlands in central Queensland becomes a reality (*Box 2*).

While tree-clearing is not in itself necessarily degrading, it is a major cause of degradation (*Figure 4*). Conversely, while reforestation (and more carefully controlled clearing of existing forest and woodland) is only part of what is needed to reverse degradation in Australia, it is an important component of the remedy.

BOX 2

The poplar box woodlands are one of the largest uncleared areas of woodland in Australia, extending over a vast area of central Queensland and into northern NSW.

There is now the potential to clear 30–50% of the 100 million hectares (1 million square kilometres) of poplar box woodland in Queensland through the aerial application of an arboricide, Graslan. It would be a $2–4 billion operation, justified by its proponents by the promise of huge gains in productivity.

The woodlands are already used for grazing beef cattle. Clearing the land is expected to double or triple its carrying capacity. At a conservative estimate, this would allow an additional 1–2 million head of cattle to be grazed in the region.

Queensland authorities are confident that the clearing can be carried out responsibly, leaving enough trees — about 20% — to avoid the problems of soil loss and dryland salinity that have resulted from large-scale clearing in the south. However some scientists remain deeply concerned about the risk of widespread land degradation and massive loss of wildlife. The region represents the heartland of Australia's remaining koala population, which would be hard hit by the clearing.

The scientists say the woodlands are ecologically fragile, drought-prone and, if cleared, would be vulnerable to salinisation and over-grazing. If the clearing goes ahead, it could mean the loss of about 5 billion trees, or more.*

*Based on clearing 80% of 30–50 million hectares, with about 150–200 trees per hectare.

BOX 3

Trees and soil

The generally beneficial effects of trees on soil result from a range of processes. Some are well proven, others reasonable supposition and widely accepted, except where otherwise indicated.

Processes which augment additions to the soil

1. Photosynthesis: fixation of atmospheric carbon and its transfer to the soil
2. Nitrogen fixation, both symbiotic and non-symbiotic
3. Nutrient retrieval: the taking up of nutrients released by rock weathering in deeper layers of the soil, and their release by litter decay on the surface (not specifically demonstrated)
4. Provision of favourable conditions for input of nutrients by rainfall and dust (not demonstrated)

Processes which reduce losses from the soil

5. Protecting the soil from erosion (water and wind), thereby from loss of carbon and nutrients
6. Trapping and recycling nutrients which would otherwise be lost by leaching (not demonstrated)

Improvement of soil physical fertility

7. Soils under trees generally have better physical conditions, including a higher water-holding capacity combined with good permeability and drainage, and greater erosion resistance, than non-forest soils.

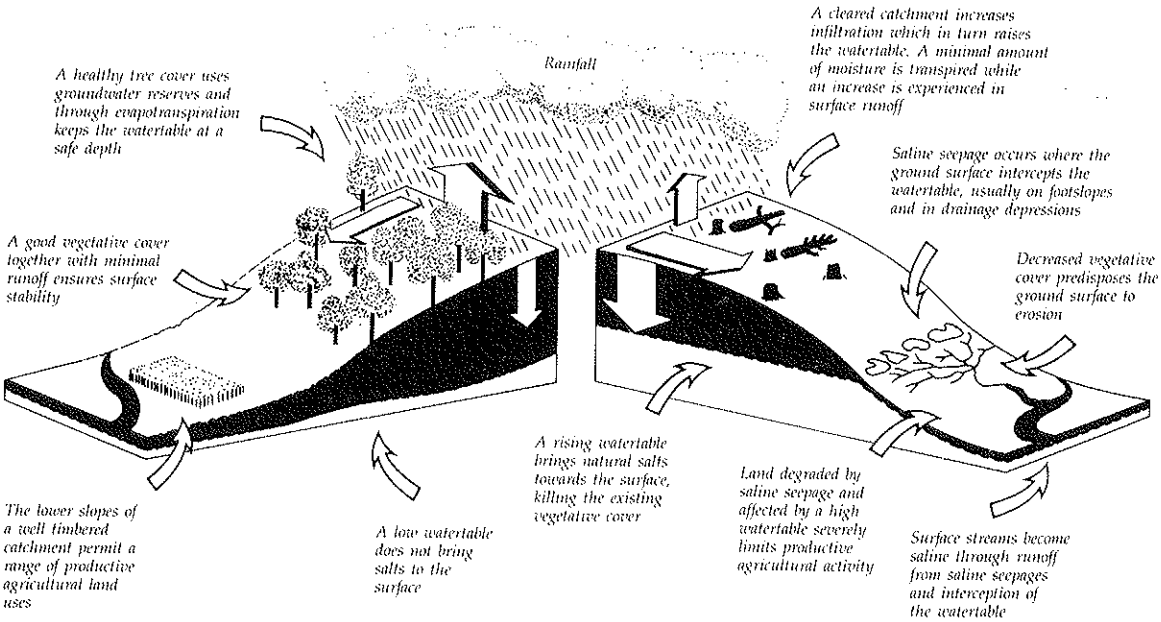
Processes that affect the quality of plant residues and their transfer to the soil

8. Promotion of a range of different qualities of plant litter, through supplying a mixture of wood and herbaceous litter (hypothesis)
9. Favourable effects of roots: growth-promoting substances in the rhizosphere — the region in the soil around the root system of a plant (demonstrated in some cases); possibly also provision of a range of root-litter quality (hypothesis)
10. Timing of nutrient release: Under natural conditions, the provision of a steadily-decaying nutrient store in the form of soil organic matter; under management, the potential to control timing further, for example, through decision on when to prune (hypothesis)
11. Effects of shading on microclimate, thereby on soil climate and rate of mineralisation (demonstrated in some cases; hypothesis)

Source: Anthony Young, *Effects of trees on soils.* In *Amelioration of soil by trees — a review of current concepts and practices,* edited by R T Prinsley and M J Swift. Commonwealth Science Council, July 1986.

FIGURE 4

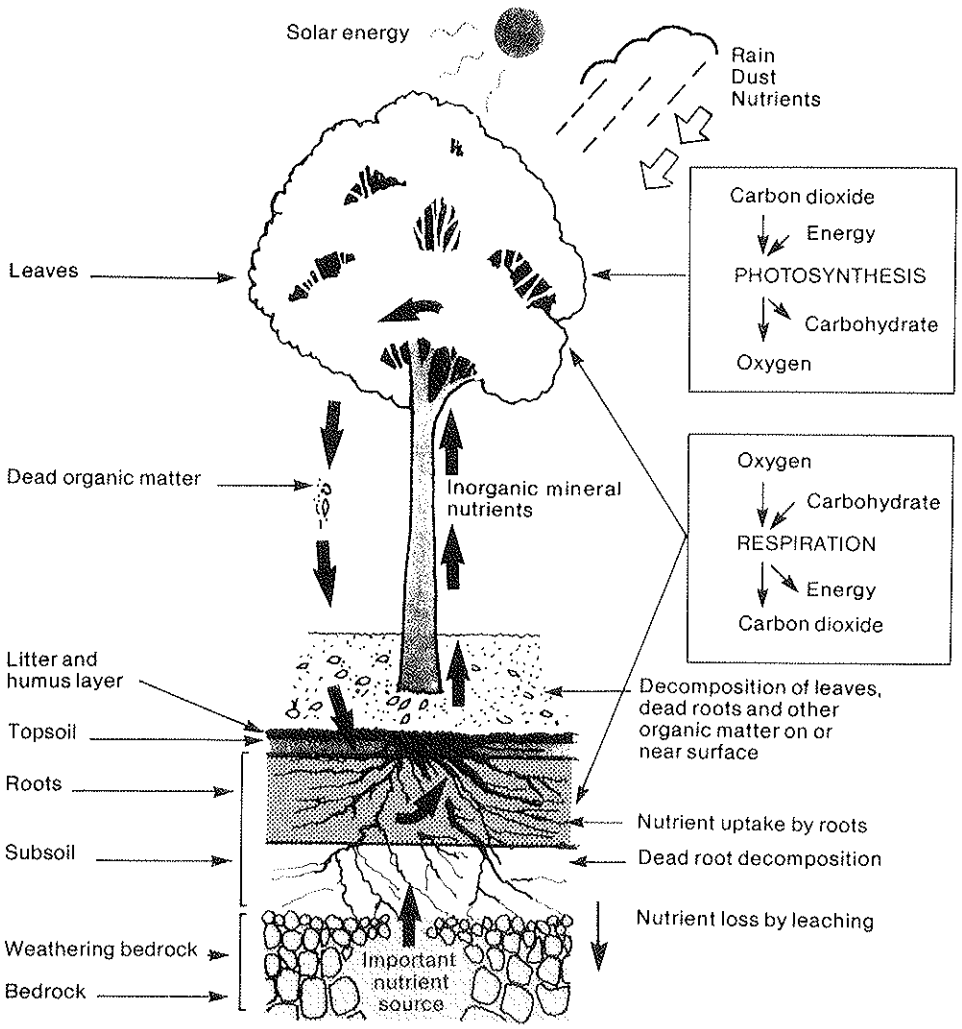
Trees and land degradation



Source: Soil Conservation Service of NSW. *Yass Valley Soil Conservation Project.* NSW Government Printers, 1988.

FIGURE 5

The mineral nutrient cycle



Source: Think trees grow trees. Department of Arts, Heritage and Environment. AGPS, Canberra, 1985.

According to the Institute of Foresters of Australia:

> 'Tree loss has been at the core of almost every aspect of land degradation in Australia. Tree replacement will be essential if we are to redevelop the fertility of many of our degraded soils and maintain sustainable systems of agriculture.'[13]

However, the nature of the relationship between trees and soils remains clouded by controversy and touched with mysticism. Our understanding of the basic processes involved in the interaction between trees and soil and groundwater is still limited. The potential of trees to reduce soil erosion and salinity is generally recognised; they also improve water flow — reducing run-off, for example — and water quality. In some cases, they can reduce soil acidity. Trees may also contribute to soil fertility and structure, and, over centuries, to soil formation (*Box 3, Figure 5*) [13,19,23].

Trees can also have adverse effects if there are too many or they are badly managed. For example, pines can increase soil acidity; some eucalypts have been blamed for desiccating the soil; harvesting of trees will, like any crop, lead to loss of soil nutrients; and poorly-managed forests can accelerate erosion [23].

The extent of revegetation

The scale of revegetation facing us can be gauged from a comparison of current activities with estimates of what is required if we are really to come to grips with degradation. Between its inception in 1982 and 1987, the National Tree Program achieved, directly and indirectly, the planting and nurturing of about 5 million trees and the establishment of several million more trees by direct seeding and natural regeneration [24]. A major component of this activity was paid for with $43 million from the now-abandoned Community Employment Program, which provided jobs for more than 4,200 people in 600 projects.

Two years into its three-year $15 million program, the National Afforestation Program has spent $13.8 million, usually matched dollar-for-dollar by recipients, in planting 13,000 hectares of hardwood plantations and rehabilitating another 5,000 hectares of land [25]. This represents about 10–18 million trees.

Perhaps the best estimate of national activity, although still incomplete, comes from a Queensland-based tree group that sought in 1985 to record the planting of 200 million trees nationally by 1988 as a Bicentenary project [26]. On the basis of figures provided by forestry services, local councils, private companies and other bodies, it registered 201 million trees planted in the three years 1985–88.

TABLE 3

Restoring the Murray-Darling basin

Area	1,000,000 sq kms
Value of agricultural production	$10 billion pa
Share of national agricultural production	30–40%
Cost of land degradation	$250 million pa
Proportion of land needed to be reforested to limit degradation*	15%
Area of reforestation required*	150,000 sq kms
No. of trees required, based on 30% foliage cover, 800 trees/hactare*	12 billion

Source: Andrew Bell. *Hope for the Murray-Darling.* Ecos (CSIRO's magazine on science and the environment), no 53, spring 1987, pp3–7. *John Ive, Doug Cocks and Chris Parvey. CSIRO Division of Wildlife and Ecology.

On the other hand, CSIRO researchers, using a computer model to predict dryland salinity hazard, estimate that to keep salinity of the Murray-Darling Basin at a level of moderate or better, 15% of it — 150,000 square kilometres or 15 million hectares — will have to be reforested (*Table 3*) [27]. That would require about 12 billion trees.

According to experts, roughly 40% of Australia's degraded land would be best treated by revegetation and conserving existing areas of natural vegetation. About 10–20% (included in the 40%) needs to be treated with reforestation — more in the wetter regions, less in drier areas [9]. This represents a total of some 260,000–520,000 square kilometres, although this does not necessarily mean this entire area would have to be covered in forest.

CSIRO's computer modelling of tree loss and associated degradation in Australia indicates that about 10% of the model's 'basic mapping units' (which, in those regions most affected by degradation, correspond to local government areas) are categorised as 'priority 1' for reforesting: they have 90-100% tree loss with high tree-related soil degradation. Over half of the units are ranked as priority 1,2, or 3 (out of a total of 7), meaning that they have lost at least 45% of their tree cover and in most instances suffer at least some tree-related degradation (*Figure 6*) [27].

Costs, techniques and strategies

The cost of large-scale revegetation would be much less per tree or hectare than indicated by the figures given above for smaller ventures. Many of the CEP-funded projects, for example, were inefficient, achieving very low planting rates.

Cost estimates vary considerably, ranging from several hundred to thousands of dollars per hectare, depending on the technique, terrain, soil type, species and other factors. The main techniques are direct-seeding, tree-planting and natural regeneration (*Box 4*).

Allowing for some differences of emphasis and some contradictions among the people with whom the issue was discussed, the position appears to be this: large-scale revegetation would involve "a horses for courses" approach, with direct seeding, tree-planting and natural regeneration each being used in the appropriate places.

While the costs of revegetation are high, they have to be set against the growing and cumulative costs of neglecting the problem. There are also other benefits of revegetation that would further justify its cost. Nevertheless, it is clear that a

BOX 4

Costs and techniques

It is hard to get a consistent picture of the costs and effectiveness of different techniques for growing trees and other woody plants — no doubt a reflection of people's personal experiences, where the reforestation has been carried out, and how up-to-date the information is.

In direct seeding, seeds are sown directly on the land being reforested, supplemented with fertiliser and ant-repellent. With "tube stock", seedlings are grown in nurseries, and then planted out. Both direct seeding and tree-planting can be mechanised.

Where land has not been cleared for a long time and seeds are still present in the ground, another possible method is natural regeneration, where an area is set aside to allow plants to grow back naturally. All techniques usually involve fencing off an area to protect new plants from stock, kangaroos and rabbits, and soil preparation such as cultivation and spraying to control weeds.

Large-scale reforestation would most likely involve the use of all techniques, with direct seeding, tree-planting and natural regeneration each being used in the appropriate places.

Direct seeding would have to play a big part because it is cheaper and faster. The problem is that the result can be highly variable: the outcome might be no trees per hectare, or 30,000. This problem could, however, be overcome through research into improving the technology.

Generally speaking, costs per hectare are $300–$2,000 for direct seeding and $1,500–$10,000 for tube stock, based on growing 500–2,000 trees per hectare. Under good conditions, one person can plant about 500 trees a day, or, with a planting machine, about 5,000 a day; one person using a seeding machine can sow up to 20,000 trees in a day.

The costs of large-scale reforesting would be at the lower end of the ranges, primarily because of the economies of scale that apply. Apart from the number of trees grown and the scale of the project, factors which affect costs include the species used, rainfall, soil type, terrain, and degree of exposure. The cost advantage of direct seeding tends to disappear in low-rainfall country because repeated applications are often required before trees become established.

These costs do not include fencing, which costs about $2,000 per kilometre for conventional fencing, and rather less for electrical fencing. Again, relative costs for fencing decline as the area being reforested increases.

The development of improved techniques and practices for revegetation in recent years is reducing costs. According to one estimate, the cost of supplying and establishing tube stock has dropped from about $2 a tree in 1977 ($5.50 in today's dollars) to about $1.20. A western Victorian farmer, who has been using and developing direct-seeding technology over the past six years, said he believed large-scale revegetation could be achieved for as little as 10 cents a tree, including preparation and fencing, and without risk of failure.

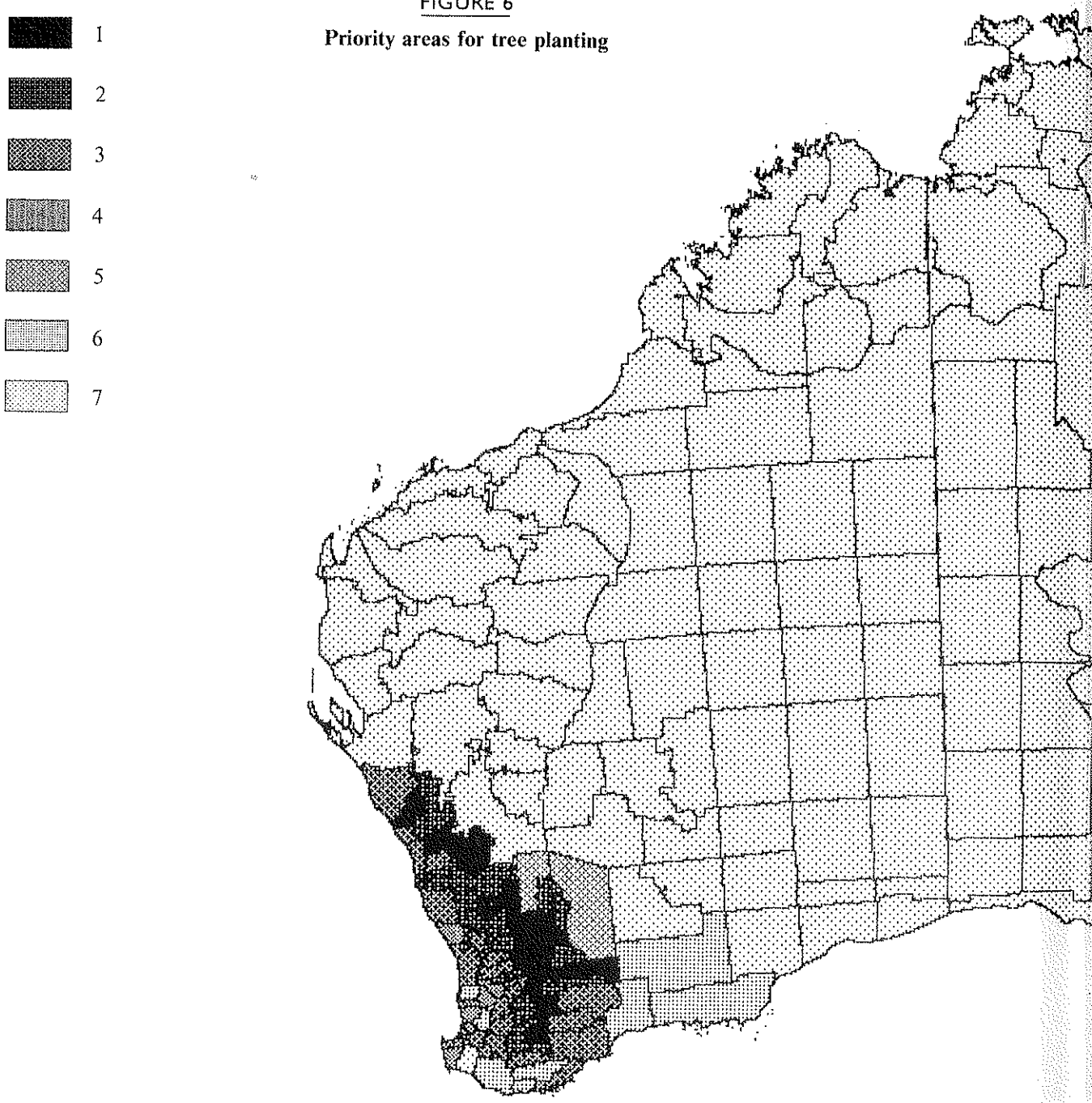
Even at this price, the costs associated with reforestation on the scale required are large. For example, the cost of establishing trees over 15% of the Murray Darling Basin would be about $1.2 billion — even assuming the whole Basin could be treated for this price, which it couldn't be; costs would be higher in the drier areas.

However, there is probably considerable scope to reduce further the costs of revegetation. Fencing is the single biggest cost associated with tree-growing on farms, representing 40–80% of the cost per hectare, depending on the type of fence and the shape of the block of land being revegetated. Melbourne University researchers have shown that electrical fencing, if properly designed, constructed and maintained, can cost a third the price of conventional fencing. Some research is also being undertaken into other protection technologies such as "sap charging", where the sap of the tree is electrified, and chemical repellents. Also, while research has already led to improvements in direct-seeding techniques and their cost, it is likely that substantial further gains in reliability and effectiveness could be achieved.

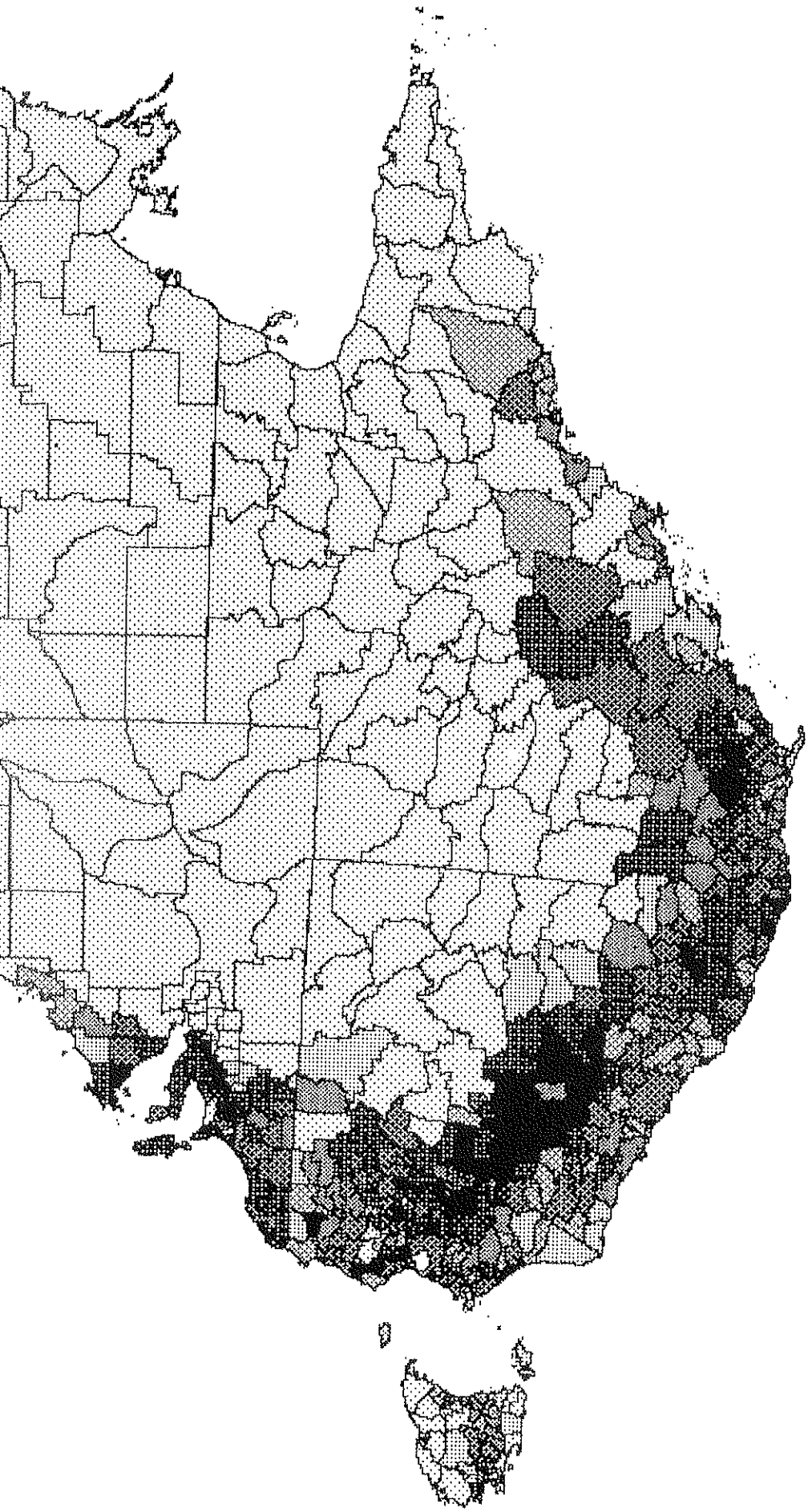
Source: Pete Bulman, SA Department of Woods and Forests; Andrew Campbell, Melbourne University; Wilf Crane, John Ive, CSIRO; Richard Weatherly, Mortlake, Victoria.

FIGURE 6

Priority areas for tree planting



Priority category	Description
1	Tree loss 90–100% with high tree-related soil degradation.
2	Tree loss 90–100% with low tree-related soil degradation, *or* tree loss 70–89% with high tree-related soil degradation.
3	Tree loss 90–100% with no tree-related soil degradation, *or* tree loss 70–89% with low tree-related soil degradation, *or* tree loss 45–69% with high tree-related soil degradation.
4	Tree loss 70–89% with no tree-related soil degradation, *or* tree loss 45–69% with low tree-related soil degradation.
5	Tree loss 45–69% with no tree-related soil degradation, *or* tree loss 10–44% with high tree-related soil degradation.
6	Tree loss 10–44% with low or no tree-related soil degradation.
7	No tree loss, *or* original tree cover less than 10% of mapping unit area.



Source: John Ive and Doug Cocks.
CSIRO Division of Wildlife and Ecology.

national program would only be economically feasible if techniques were made as efficient as possible, and tree-growing undertaken in those areas where it would have the maximum impact on land degradation. In some parts of the Murray-Darling Basin, for example, not even extensive tree-planting would fix the problem; in others, a 10% cover of trees probably would [27].

A considerable amount of research into land degradation has already been carried out by CSIRO, universities and state agencies. A lot could be achieved to reduce degradation by drawing together and applying what we already know. A major component of the first phase of the program would, then, be this task of integration and extension. But we also need to know much more about the problem and its management if we are to tackle it in the most effective and efficient manner. Therefore an expanded, integrated research effort would also be an important component of the program. This needs to be a multi-disciplinary exercise, exploring the social, economic and political dimensions of the problem, as well as the physical.

We lack adequate knowledge of the extent of degradation in Australia, its impact and the processes involved. While clearing of the land is recognised as a major cause of degradation, and revegetation as an important means of combating it, we have little detailed knowledge of how trees and shrubs interact with the soil and groundwater. We need to know more about what regions would benefit most from revegetation, and what species should be planted, and where, for both individual farms and districts. We need to develop better techniques for revegetating land, and to ensure that the revegetation is self-sustaining.

The strategy and structure of the program would also have to maximise efficiency and effectiveness. It would not involve the indiscriminate application of a single system of tree-growing by armies of unskilled workers scattered across the country, but would be tailored to the needs of different regions and districts, and embrace existing projects such as those funded through Federal and State initiatives.

Landholders must be convinced of the value of trees. To work, revegetation would have to involve local communities persuaded of its benefits, be managed locally and be integrated with other changes in land management. An integrated approach to the problem is essential, but so far has been lacking. The main functions at the national and state level would be setting

BOX 5

A National Land Management Program

In February this year, the National Farmers' Federation and the Australian Conservation Foundation submitted to the Federal Government a proposal aimed at ensuring that "Australia's agricultural and pastoral lands are used within their capability by the year 2000 and that land is used sustainably thereafter". The proposal calls for an integrated program of major national initiatives, incorporating a local, cooperative, self-help approach, and requiring Commonwealth expenditure of $340 million between 1990 and 2000.

The NFF-ACF proposal includes 13 elements:

- establishment of some 1,600 local land care groups, representing all land users and conservation interests
- development of individual property plans consistent with catchment or district guidelines
- technical support and advice supplied by government and private consultants
- a taxation rebate or credit of 30% for the cost of works undertaken by landholders as part of approved district plans
- incentives to encourage conservation farming techniques such as minimum tillage cropping
- direct government funding for major district projects
- State support and administrative services for farm plans, district plans and technical infrastructure
- urgent national assessment of land degradation
- provision of primary data on land capability
- provision of economic data on land use
- development of model State legislation and a review of Commonwealth legislation
- incentives to encourage conservation of native vegetation
- development of education and awareness programs for farmers and the general public

Source: A national land management program. A joint submission by the Australian Conservation Foundation and the National Farmers' Federation. February 1989.

the appropriate policy framework, funding, research, coordination, education and training.

The program could, for example, be incorporated into the national land management program proposed to the Federal Goverment by the National Farmers' Federation and the Australian Conservation Foundation (*Box 5*) [3]. The proposal includes the establishment of local land care groups to develop and implement district plans; individual property plans integrated into district plans; technological and research support networks; and incentives, including tax credits and rebates, to encourage landholder participation.

Meeting the cost

It is likely that reforestation can be increased considerably for purely commercial reasons such as timber production and improved agricultural productivity. Private investment could, therefore, meet a large part of the cost of a "regreening Australia" program.

The program might attract Japanese interest, both because of Japan's place as a major consumer of timber, and because environmental "greening" projects are part of its immensely ambitious "Global Infrastructure Project" [28]. This project embraces a range of visionary international projects, of which the proposed building of a futuristic Multifunction Polis in Australia is one.

Nevertheless, while private funding needs to be exploited to the utmost, it alone will not be sufficient to achieve the rate and extent of revegetation required. Government involvement will be required, including increases in government spending, to accelerate the process. This support could include incentives to the private sector such as a greater range of tax rebates and deductions. Funds could also be required for revegetation projects where there is no prospect of commercial timber production, and to provide adequate infrastructural support in the form of coordination, research, promotion and extension.

It is, in any case, appropriate that a major part of the cost of revegetation be borne by the whole community. The primary objective of the program is to combat land degradation, which has been occurring over the 200 years of European settlement, and is in large part the result of land-use policies of government. The benefits and costs of treating land degradation cannot be assessed in terms of individual farms. For example, the cause of one farm's salinity problem may be overclearing on another property; whole districts and regions would benefit from improvements in water quality. Also, benefits from the program would extend to the entire community through the protection of the national heritage.

The notion of large public expenditure on a program such as this runs counter to current economic wisdom, and this will be a powerful obstacle to its adoption. The Federal Government continues to be under strong pressure, especially from the business sector and economic analysts, to cut further government expenditure, primarily to reduce our current account deficit. While it is beyond the scope of this report to examine this issue in detail, there appears to be growing doubt about the validity of this view: the relationship between government spending and the current account deficit is not as clear as those who are applying this pressure seem to assume.

Countries that have achieved budget surpluses, including the UK and Australia, continue to face high current account deficits; other countries with sizeable budget deficits have strong current account surpluses [29,30]. In fact, the OECD country with the largest current account deficit as a percentage of GDP, Norway, has the biggest general government surplus, while Italy, which has the largest general government deficit, has a negligible current account deficit. A recent Australian study of the issue supports the view that there is not a close relationship between budget and current account deficits, stating that "attempting to solve the balance of payments problem by cutting the fiscal deficit is an inappropriate and inefficient way to proceed" [31].

Where cuts to government expenditure result in inadequate funds for maintaining and improving a country's infrastructure, then this could, in the long term, contribute to a deterioration in the balance of payments. In fact, our neglect of land degradation is already having this effect through lost agricultural production. Furthermore, government spending on environmental restoration would make little, if any, direct contribution to the level of imports because the materials used and the technology required are available locally.

Community attitudes to degradation

Would the community be prepared to pay for a national program to "regreen Australia"? Several surveys of community attitudes conducted over the past few years indicate people would be. For example, a 1985–86 study of NSW households found strong support for soil conservation, with people rating it as more important than preserving rainforests or rare species of kangaroos; more were in favour of extra government spending to stop soil erosion than getting that money back as a tax rebate [10]. A more recent national survey also found Australians ranked control of soil erosion as more important than rainforest preservation and protecting rare plant and animal species [32].

A 1986 national survey by the Australian Bureau of Statistics found that almost half of Australians were concerned about environmental problems, with those causing most concern being, in order, pollution, conservation of flora and fauna, and deforestation. Soil erosion ranked sixth, and water salinity eighth [33].

TABLE 4

Australian perceptions of threat to environment

	Total	Percent Men	Women
How serious is the threat?			
Too much fuss made	11	14	8
Must be treated seriously	87	84	90
Don't know	3	2	2
Which is the most serious issue?			
Chemicals in the atmosphere	40	35	45
Pollution of rivers, oceans, bays	27	29	26
Soil erosion	14	19	10
Destruction of forests	13	12	14
Don't know	6	5	6

Source: Saulwick Herald/Age Poll, conducted by Irving Saulwick and Associates, and published in The Sydney Morning Herald and The Age, 16 May 1989.

A recent Saulwick Poll for The Sydney Morning Herald and The Age found that two-thirds of Australians would be willing to pay higher taxes to prevent pollution of beaches, rivers and lakes, noting that rarely had the poll found "such strong and widespread public opinion on any issue" [34].

The latest survey on environmental issues, again a Saulwick Poll, found that almost nine out of ten Australians said the threat to the environment was real and must be treated seriously [35]. Of four issues, people were most concerned about chemicals in the atmosphere (reflecting concern about the depletion of the ozone layer and the greenhouse effect), followed by pollution of rivers, oceans and bays, soil erosion, and destruction of forests (*Table 4*).

These and other findings suggest widespread public approval for greater national efforts to combat environmental problems, and support the value, in terms of mobilising public opinion, of measures that address several problems rather than just one. A "regreening Australia" program would, for example, help to address virtually all the environmental issues mentioned above.

While revegetation provides very real benefits in improving the condition of the land, it also offers something more that could be just as important: the public appeal of trees, which would make it a key to persuading the Australian public of the value of a comprehensive approach to land restoration that would also incorporate the other measures noted earlier.

In other words, more trees would not be the sum total of our efforts to rehabilitate the land, but they would be the evidence — the most obvious, visible, appealing dimension of a wider campaign. Many reports and experts stress the need to change community attitudes towards the land, and the importance of mobilising public support and increasing community involvement if land degradation is to be beaten.

Reforestation could be the key to achieving these objectives, encouraging in all Australians a sense of belonging to the land and an involvement in its care. Metropolitan Australians may have trouble relating to stocking and cropping capacities, contour banks and fence lines, but trees are a different matter: if saving forests is a "sexy" political issue, growing forests could be too.

The issue of land degradation is a sleeper because the problem is a creeper. However aware metropolitan Australians may be of land degradation, probably the only time a significant proportion were directly affected by it, briefly, was on 8 February 1983 when billowing clouds of western Victorian topsoil — 250,000 tonnes of it — rolled over Melbourne on its way out to sea [36]. That event aside, land degradation's big failure as an issue is that it lacks dramatic impact — no gaping, gushing wounds or pools of gore, just the slow, unhealing haemorrhaging of the nation's lifeblood.

Perhaps, then, the public impact has to be in the remedy. The adoption and promotion of the concept of "regreening Australia" through the growing of billions of trees — a concept which also embraces a range of other environmental restoration programs — could give land degradation the public and political status it deserves.

OTHER BENEFITS

Were it not for the seriousness of land degradation in Australia, a reforestation and revegetation effort on the scale envisaged probably could not be justified. Given the impact of the effort on this problem, however, other benefits would flow from a "regreening Australia" program that strengthen the rationale for its adoption, and would contribute to meeting or offsetting its cost.

These additional benefits — environmental, commercial and social — include: helping to counter the greenhouse effect; improving both urban and rural landscapes and increasing wildlife, so enhancing the value of leisure and tourist activities; other improvements in farm productivity; increasing timber production; generating worthwhile work, especially for young people; and encouraging greater national self-confidence.

Countering the greenhouse effect

While land degradation is the most urgent environmental problem facing Australia, it could

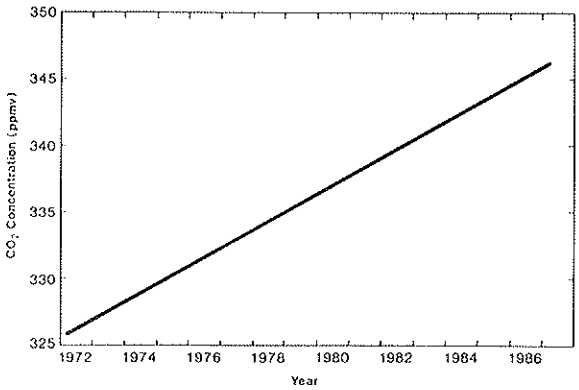
well be matched next century by the greenhouse effect. Furthermore, the changes associated with the greenhouse effect could, in some areas, aggravate the problem of degradation, especially through their impact on vegetation (although there could also be positive outcomes in the short term).

The greenhouse effect refers to the expected warming of the earth's surface because of rising atmospheric concentrations of several gases as a result of increasing industrial and agricultural activities. These gases are transparent to sunlight, but absorb, and reflect back, some of the infra-red or heat energy which the earth radiates into space.

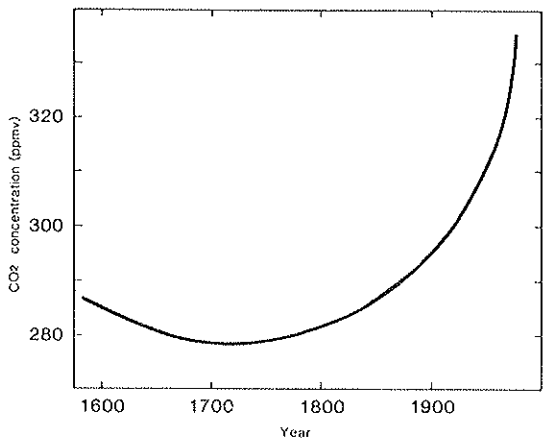
The most important of the "greenhouse" gases is carbon dioxide, the concentration of which is

FIGURE 7

Trends in atmospheric carbon dioxide



Recent changes in atmospheric carbon dioxide levels over south-eastern Australia (in parts per million by volume).

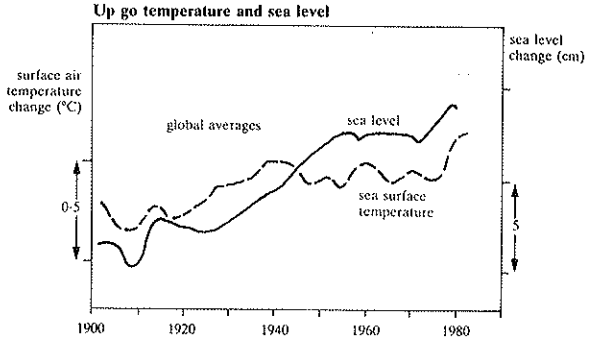


Changes in atmospheric carbon dioxide concentration over the past few centuries, as revealed in air extracted from Antarctic ice (in parts per million by volume).

Souce: Graeme Pearman. *Greenhouse gases: evidence for atmospheric changes and anthropogenic causes.* In *Greenhouse — planning for climate change.* Graeme Pearman (ed). CSIRO Division of Atmospheric Research. EJ Brill, 1988, pp3-21.

FIGURE 8

Global changes in sea level and temperature



Source: Andrew Bell. *Prepare now for climate change, scientists warn.* Ecos (CSIRO's magazine on science and the environment), no 53, spring 1987, pp18-21.

rising because of the burning of fossil fuels and the clearing and burning of tropical rainforests (*Figure 7*). Scientists now expect that this increase, together with that of other gases such as nitrous oxide, methane and chlorofluorocarbons, or CFCs, will result in an average warming of the earth's surface of between 1.5 and 4.5 degrees Celsius by about 2030. Sea levels will rise by 20–140 centimetres because of thermal expansion of the oceans (*Figure 8*)[37,38,39]. Over a longer period, greater changes can be expected.

While the regional effects of this global warming are not yet clear, temperature changes at high latitudes may be twice the global average, and there are likely to be significant changes in rainfall patterns. The frequency and intensity of tropical cyclones will change, and they may occur over a wider area. These climatic changes will affect agriculture and the distribution of flora and fauna. The extinction of whole communities of plants and animals is possible. Other changes could be more positive, at least in the shorter term: for example, warmer temperatures, higher rainfall, the fertiliser effect of carbon dioxide and more efficient water use by plants as a result of the higher carbon dixoide levels, could improve agricultural production in some regions [40,41,42].

The dramatic increase in public and political awareness of the greenhouse effect, fuelled by the seemingly unusual weather patterns experienced in many parts of the world during the past year or so, has generated growing interest in a proposal that at first glance sounds absurd — massive reforestation as a means of soaking up some of the excess carbon dioxide and so slowing or arresting the effect.

While some remain sceptical of the remedy because of large areas of new forest that would be required, there is growing recognition that reforestation, while not *the* solution, is *one* of an

array of counter-measures that should be taken. Also, this benefit will be important in winning community support for a "regreening Australia" program: the greenhouse effect has been able to capture the public imagination in a way that land degradation has not, and it is this role of trees that is most responsible for the increased public interest in reforestation.

An American power company received international publicity last year when it announced it would plant 52 million trees to offset the carbon dioxide emissions from a new power station it is building — for a cost that is less than 1% of the total cost of the station [43]. The American Forestry Association has launched a campaign called Global ReLeaf to encourage Americans to plant 100 million trees over the next four years [44]. At least two US congressional committees have held hearings that touched on the possibility of massive reforestation to counter the greenhouse effect [45]. The United States Environmental Protection Agency, in a just-released draft report on "policy options for stabilising global climate", lists reversing the destruction of forests and encouraging tree-planting amongst the most effective short-term actions to stop the build-up of greenhouse gases [46].

In Australia, proposed actions to come out of the Greenhouse 88 conferences, organised by the Commission for the Future, include the implementation "as a matter of urgency" of programs to reduce deforestation and increase afforestation [37]. The Greening Australia organisation is seeking $50 million in Commonwealth funds over three years for a major tree-planting program, the theme of which is lessening the greenhouse effect's impact [47]. A growing number of business and community groups and organisations have become interested in promoting tree-planting. Again, the reason is the greenhouse effect.

The burning of Australian-produced fossil fuels produces about 150 million tonnes of carbon a year. To absorb this amount of carbon by growing trees would require converting to forest about 30 million hectares, or 300,000 square kilometres, of good land, which represents about 60% of our crop and improved pasture lands. This estimate assumes a capacity of new forests to absorb 5 tonnes of carbon — the equivalent of producing 10 tonnes of dry wood — per hectare per year while the trees are growing. Trees could also be planted on poorer land, but their capacity to take up carbon dioxide would be correspondingly lower [48].

Once forests reach maturity — after about 40 years — they cease to be net absorbers of carbon dioxide. If the trees are then cut down and the timber used for building, for example, the carbon can remain fixed for up to 100 years or more. If the wood is burned or rots, then the carbon will be released into the atmosphere (in terms of the greenhouse effect, however, burning wood is still preferable to burning fossil fuel if the trees that are cut down are replaced).

Australia exports much of its fossil fuel, notably coal. The carbon output from fossil fuel consumption in Australia is about half that of fossil fuel production. Furthermore, only 50–60% of the extra carbon dioxide remains in the atmosphere, the rest being absorbed by the oceans and plant life. Taking these factors into account, Australia would have to forest rather less than 15 million hectares, or 30%, of its arable and improved pasture land (or its equivalent), to soak up its share of the world's excess carbon dioxide.

This is not to suggest that this amount of prime land should be set aside for the purpose of countering the greenhouse effect. However, these estimates, while only a crude guide, do indicate that a significant proportion of the excess carbon could be taken up through the revegetation required to arrest land degradation and other purposes. Complementary measures such as increased energy conservation and efficiency, greater use of alternative, renewable energy sources (including wood), and less clearing of land would also reduce Australia's contribution to rising carbon dioxide levels.

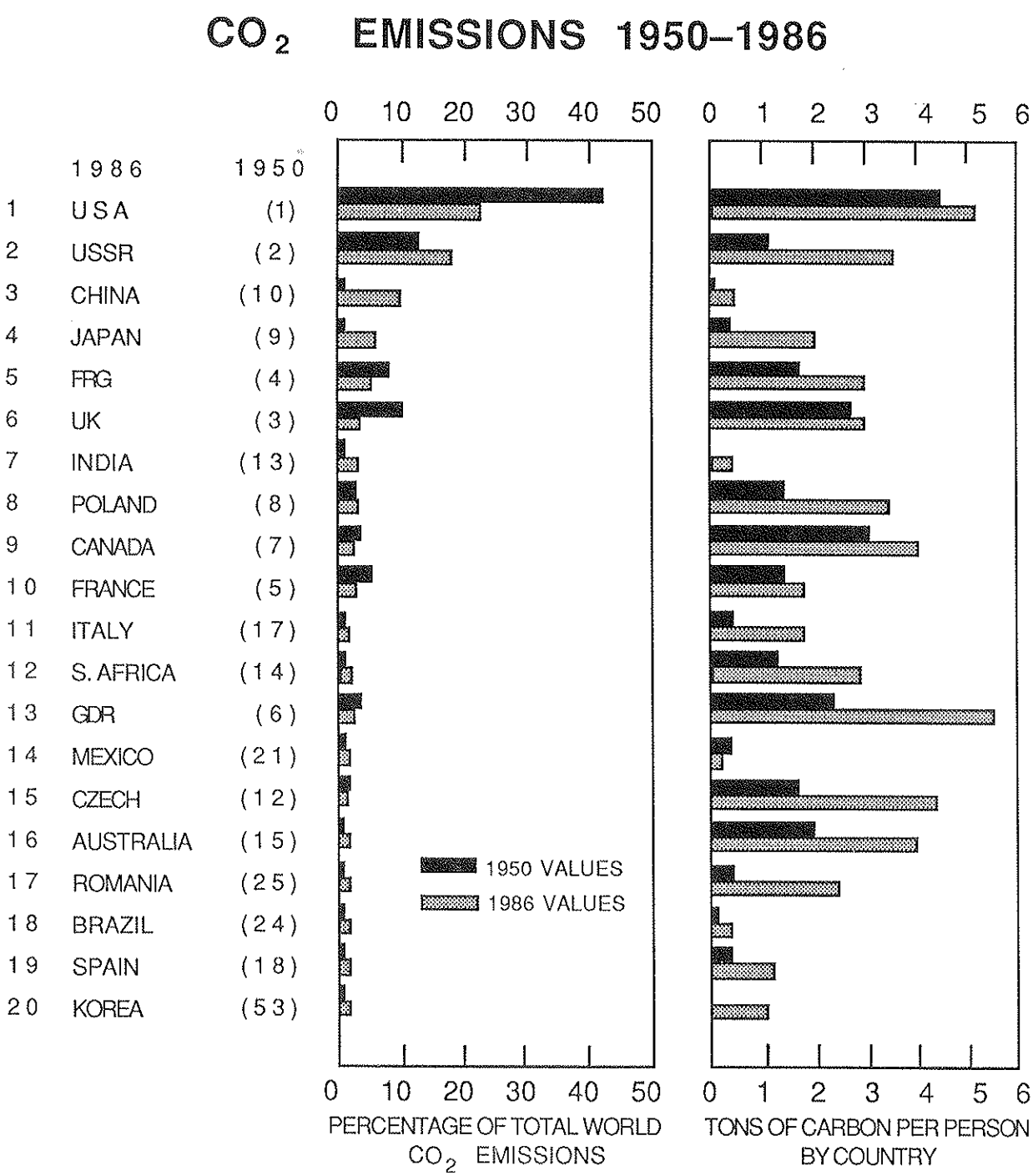
Of course, Australia produces only a small share of the world's fossil fuel carbon dioxide emissions — about 1–2% (*Figure 9*) [49]. The slowing and halting of the greenhouse effect would only be achieved if other countries — the top three emitters are the US, USSR and China, who account for more than half the total — also took action to reduce or absorb their carbon dioxide emissions. But Australia ranks fifth in per capita emissions, as well as being a major coal exporter, so it could be argued that there is a strong case for Australia to set an international example in "accounting for" its share of global carbon dioxide.

In the longer term, and still speculative, is the possibility that reforestation could help us to adapt to greenhouse changes, which are expected to alter substantially the habitats of many plants and animals. Many tree species may not be able to re-establish in new areas naturally, either because of the rapid rate of change; because they may be locked in small reserves surrounded by cleared farmland and so unable to "migrate"; or because suitable climatic conditions might disappear from Australia altogether. This problem would also bear on the survival of other plant and animal species that depend on the trees.

Preliminary results of research at the Australian National University, based on current predictions of temperature changes, suggest the greenhouse effect could have a serious impact on some forests in Australia, both natural and planted, by reducing their productivity and capacity to regenerate [50]. For example, what is called the

FIGURE 9

Fossil fuel carbon dioxide emissions



Source: CDIAC Communications, Winter 1989. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory.

"preferred climatic envelope" for mountain ash, *Eucalyptus regnans*, the tallest hardwood tree in the world and widely used for construction and paper pulp, could shift into the Southern Ocean. Similarly, that for *Pinus radiata*, the most widely grown softwood in Australia, could almost disappear from the mainland. On the other hand, another economically important eucalypt, *E. nitens*, would be little affected.

Tentative though such findings about the impact of the greenhouse effect on forests may be, some US scientists are already warning of the possible need for afforestation to assist plants and animals in adapting to the changes ahead [51,52]. Ways of doing this include growing threatened species in new areas, and creating a network of forest corridors that would allow plants and animals to redistribute naturally as the climate changes.

The other side of the greenhouse coin is that reforestation for other purposes, whether com-

mercial or environmental, will have to take into account the consequences of the greenhouse effect [53,54,55]. And whatever these consequences turn out to be, research into the role of climatic factors in the growth of different tree species will be important in developing the most effective regimes for reforestation. CSIRO's work in introducing Australian trees overseas is providing a valuable "preview" of their ability to cope with different climatic conditions.

Other environmental and agricultural benefits

Quite apart from the issue of degradation, research indicates that tree cover on farming land can yield other benefits that will be crucial in persuading farmers to forest part of their land. Trees can increase productivity by sheltering stock, reducing water loss from crops, providing soil nutrients, fodder, timber and firewood, and increasing the numbers of birds that feed on insect pests. Because of all these benefits, trees can also substantially increase the capital value of the land.

The optimal level of tree cover will vary from region to region, and from site to site. For sheep farms in southern Australia research suggests that shelterbelts covering 10% of the property — and possibly up to 20% — can be economically justified just in terms of the shelter and shade they provide, without taking into account other benefits such as salinity and erosion control and timber production [56]. For the New England area, the ideal level of tree cover, in terms of present farm income, seems to be somewhat less than 15%. Rural dieback is reducing tree cover to about this level now, and further tree loss is likely to result in a fall in farm income [57]. The Institute of Foresters of Australia states that, overall, farmers will benefit from placing 10–25% of their land under trees [13].

A possible alternative to conventional cropping in Australia, currently being assessed by CSIRO and University of Queensland researchers, is "alley cropping", where crops are grown between wide rows of trees [58]. The trees are pruned regularly (usually to a height of less than one metre to reduce shading) and the prunings used as a mulch and nutrient source for the crop. The benefits include: nutrient recycling; improved soil structure; good erosion control; reducing or eliminating the use of chemical fertilisers; more efficient use of water and reduced run-off; weed control; and provision of forage, firewood or timber if multi-purpose tree species are used. While alley cropping will be most easily applied to small-scale crops such as vegetables and maize, the technique may also be adaptable to larger, broadacre farming.

Loss of trees has a huge impact on wildlife. Eucalypt woodland suffering severe dieback has only 10% of the birds found in healthy woodland, and open pasture less than 5%. In healthy woodland, birds may take about half the insects produced — about 30 kg per hectare per year. Small mammals such as sugar gliders and predatory insects and spiders take a sizeable proportion of the remainder [59].

Clearing of the land is probably the most important factor behind a decline in Australia's native animals and plants. Seventeen species of mammal and one species of bird are already presumed to be extinct, with a further 28 species of mammals, birds, reptiles, amphibians and freshwater fish listed as endangered — that is, they are likely to become extinct unless action is taken to save them. Another 40 species are considered to be vulnerable — that is, they may soon become endangered [14].

In 1981, 2,206 species of native plants, or 10% of the total, were categorised as rare or threatened, including 78 species presumed to be extinct, 200 species considered to be endangered, and 612 regarded as vulnerable. The remainder of the 2,206 species were listed as rare or thought to be threatened. As many as a quarter of the eucalypt species are regarded as rare or threatened [14].

Knowledge gained since then indicates the situation is worse than these figures suggest. A 1988 assessment of rare or threatened plants, just published, shows that 97 species are now presumed extinct, and about 17%, or 3,329 species, of Australia's native plants are considered to be rare or threatened. Of these, 209 species are now listed as endangered, and 784 as vulnerable [60].

The conservation of Australia's unique biological heritage is of intrinsic importance and value. But by increasing wildlife and generally conserving and even enhancing the beauty of the Australian environment, revegetation will also increase Australians' enjoyment of the bush and increase its appeal to overseas tourists, further boosting its economic value. Some of the rare or threatened plants could also have considerable commercial potential — for example, as food crops, flowers, or as a source of new medical drugs.

Trees planted in and around cities and towns will make them pleasanter places to live by providing a buffer against noise, dust, heat and wind [14]. Shade trees can have an economic and environmental benefit by reducing energy demand for air-conditioning. (According to the American Forestry Association, the potential savings of its tree-planting campaign in air-conditioning costs in the US could amount to US$4 billion a year [44]. On this basis, one US researcher calculated that trees shading air-conditioned buildings would, through cutting fossil fuel use, have four times as much impact on atmospheric levels of carbon dioxide as trees that were only taking up the gas as they grew [61].)

Timber production

Australia currently imports each year about $1.5 billion of timber and pulp and paper products. This accounts for about 10% of our current account deficit, making it one of the biggest contributors to the deficit. Large-scale reforestation could help to improve the balance of payments by cutting the level of imports and increasing exports.

Australia has about 1 million hectares of plantations, representing about 2.2 percent of its total area of forest. Most of the plantations are softwood — 860,000 hectares in 1987, and increasing at a rate of about 30,000 hectares a year. Hardwood plantations covered about 50,000 hectares in 1987, and are increasing by about 7,000 hectares a year; the rate is rising [62,63].

Growing hardwood plantations is a relatively new activity in Australia and while they are attracting increasing interest as a source of timber and pulp, the economics remain uncertain because of the long timescale involved (10–40 years). The Australian Conservation Foundation has published a strategy for the forest industry which involves establishing sufficient eucalypt plantations on previously cleared land to meet nearly all of the industry's expected hardwood needs in the future, and phasing out most logging of native forests over the next 15–30 years [62].

The industry argues, however, that while it strongly supports the development of eucalypt plantations, the current state of scientific and economic knowledge indicates that they are best seen as supplementing the native forests [63,64]. Thus the current commercial emphasis is on planting on good land that will yield high productivity and bring existing resources to a size that will support "world-scale" processing plants.

There are, therefore, important differences between the priorities of commercial forestry operations and forestry for environmental restoration. Nevertheless, while trees grown on farm or Crown land to combat degradation are unlikely to be optimal for wood production alone, the value of the timber could help to offset their cost, or even make the venture profitable.

For example, Victorian Department of Agriculture research suggests that shelterbelts on farms may be an economical source of timber, quite apart from their other benefits, especially if farmers were to form cooperatives to operate their own small sawmills [65]. To take another, quite different example: the pine forests around Canberra were grown initially to restore and enhance degraded land and protect the quality of Canberra's water supply (and later extended for commercial purposes). Apart from also being a popular recreation area, the forests now essentially pay for themselves, and even return a small "profit", through gross earnings of $8–9 million a year from logging. In this way, once degraded, unproductive land has been converted to sustainable, productive use, providing employment for 450 people [66].

The prospects of multiple benefits from reforestation projects have prompted State governments to offer a range of incentives to encourage private eucalypt plantations. Schemes attractive to farmers and other rural landholders, such as plantation sharefarming, agroforestry, leaseback and direct grants have been developed, while some governments are establishing their own eucalypt plantation and agroforestry programs [62].

The most ambitious of these State schemes is the West Australian Government's "Tree Trust" project, launched this year with the aim of planting 105 million trees on 105,000 hectares of cleared farmland in the State's south-west by the year 2000 [67]. The project will be paid for entirely through private investment, and create a new pulpwood resource as well as alleviating the region's serious land degradation problems (*Box 6*).

Research promises to improve considerably the economics of hardwood plantations. Over the long term, plantations are generally expected to achieve double the yield of unmanaged native forests on the same site, with some results suggesting even bigger gains. For example, recent CSIRO research in Tasmania with intensively managed plantations of mountain ash has achieved stemwood production rates by the age of 5 years of 31 cubic metres per hectare per year, compared with about 6 cubic metres for unmanaged plantations or regrowth forests on similar sites. With another eucalypt, *E. nitens*, intensive management produced an even higher level of stemwood production at age 5 years — 46 cubic metres [68].

This research, and most commercial interest, focuses on hardwood plantations as a source of pulpwood, because the trees can be grown quickly and harvested young. However there are other commercial products that could be derived from trees grown on farms or elsewhere. For example, specialty or feature timber could be particularly suited to multi-purpose woodlots or plantations [69]. These timbers are used for furniture, flooring, wall lining and other special purposes. Top-grade furniture timber can command prices 5–20 times those of sawn green wood, with single trees worth anything up to $20,000 or more.

In the past, Australia had an abundance of feature timbers, including blackwood, silver ash, rosewood, Queensland maple, myrtle beech, silky oak, blackbean, mountain ash, jarrah, cypress pine, tulip oak, blue gum, and brush box. Today, we import feature timbers.

Trees used for feature timbers have to be allowed to grow until they are big enough to provide high-quality sawlogs and veneer logs. This means they represent a 50-year investment, or longer. We also need to know a lot more about how best to select, grow and process feature timbers. However, by serving other purposes while they grow, and assisted by government incentives and research support, feature timbers could become a significant Australian industry once again.

They would also offer opportunities for export. Relatively few high-quality feature timbers, which are mainly hardwoods, grow in the northern hemisphere and for centuries these timbers have been imported from tropical countries. The availability of these timbers is decreasing because of population pressures, exhaustion of supplies and campaigns by conservationists to protect remaining areas of tropical forest.

Over the long term, global demand for timber, or the need for new timber resources, could be influenced by a number of developments [48,53, 54,55,70]. Warmer temperatures and the fertiliser effect of higher carbon dioxide levels could increase the productivity of existing forests, thus reducing the need for new ones. Much greater conservation or replacement of paper — through, for example, more recycling or the more extensive use of electronic information systems — could affect demand for pulpwood.

On the other hand, the adverse effects on existing forests of greenhouse changes, acid rain, and ozone pollution in the lower atmosphere and ozone depletion in the upper, as well as community pressure to preserve larger areas of natural forests, could greatly increase the need for new, plantation forests. Technological improvements, the depletion of fossil fuels, and/or growing concern about the greenhouse effect and other environmental issues, could also see timber and wood-based products become economically competitive with, or socially preferable to, products that are derived from fossil fuels, such as plastics, or require large amounts of fossil fuel energy for processing, such as steel and aluminium. For example, CSIRO is currently researching a new process for manufacturing rayon, a wood-derived synthetic fibre, which failed to compete against nylons largely because of technological difficulties.

While these are long-term considerations, they deserve examination in the context of a large-scale reforestation program.

Job creation

While some aspects of revegetation, such as planting or direct seeding, can be mechanised, it remains a comparatively labour-intensive activity. While this is often seen as a major drawback of any large-scale revegetation program, it becomes

BOX 6

The West Australian 'Tree Trust' Project

This year the West Australian Government launched what it claims is the largest reforestation program ever undertaken in Australia — "Tree Trust". The project aims to plant 105 million trees on 105,000 hectares of cleared farmland in the State's south-west by the year 2000.

The project will rely completely on private investment. By 2000, the Government expects the plantations will generate a gross revenue of $350 million a year from pulpwood. Over 4,000 jobs will be generated, directly and indirectly, in planting and managing the plantations, returns to the farmers, harvesting and transport and chipmilling.

Central to the project, and the key to persuading farmers to volunteer land, is the "sharefarming" arrangement whereby farmers will lease land to the trust for two ten-year rotations, and are paid an annual return plus a proportion of the final value of the tree crop once it is harvested.

The project's viability is based on a projected shortfall in the supply of high-quality short-fibred eucalypt required for the production of high-quality paper, and the region's suitability for establishing hardwood plantations. The species to be used, the Tasmanian bluegum, *Eucalyptus globulus*, is one of the fastest-growing trees that produce high-quality wood.

Apart from the commercial yields and the jobs generated, the project will: offer new opportunities to farmers whose land is affected by salinity, waterlogging, erosion or pesticide residues; improve water quality, resulting in tax savings of $40 million a year; absorb 3.4 million tonnes, or 13%, of the carbon dioxide now emitted in Western Australia; have a lasting impact on algal problems in waterways and estuaries, caused by phosphorus pollution, by lessening fertiliser use and lowering the water table; and contribute a 4% reduction in Australia's trade deficit.

In its policy statement for the last election, the West Australian Government said it would also help farmers to plant at least 100 million trees in rural regions by the year 2000, as one of several new measures to arrest and reverse salinisation and soil erosion. This planting will be in addition to the Tree Trust project and will be funded through the National Soil Conservation Program.

Source: Tree Trust — restoring nature's balance. A proposal for a private enterprise funded hardwood afforestation program for south-western Australia. WA Government booklet, 1989. Syd Shea and John Bartle. *Restoring nature's balance — the potential for major reforestation of south-western Australia.* WA Department of Conservation and Land Management, 1988. WA Labor Party Policy Statement, 1989.

less so if the program is viewed in a broad social context: it could generate a large number of jobs. Over the long term, land restoration would have a permanent impact on jobs and rural life in Australia through maintaining and even improving Australia's agricultural industries.

Tree-planting has been used before to create jobs for those out of work, most recently under the Commonwealth Community Employment Program. The exercises have not been an unqualified success. They have been seen by the unemployed as exploiting a cheap and vulnerable source of labour, and offering little in the way of skill development and career prospects, while the public has tended to regard them as make-work programs that waste public money on schemes of dubious value.

These perceptions, whether valid or not in the context of the CEP programs, would not apply to a large-scale national program. The necessity for revegetation is clear. To be feasible, it would have to be done in the most cost-effective way possible. There is no question of "making work" for people.

The jobs involved would be every bit as "real" as, say, a job in a factory making products for export. Also, if the program operates on a large, national scale, it would require a sizeable, multi-disciplinary research and education effort, and a suitable organisational structure. Thus it would involve much more than a large unskilled workforce; it would need skills, and so offer opportunities for training, in a range of fields — science, technology, administration, management, education and communications.

The degree to which the program, or other similar initiatives, can alleviate Australia's social problems will depend on the extent to which they can generate jobs and offer an alternative way of life to those society excludes. This aspect of the proposal cannot yet be assessed. If the extent of job creation is large, then the social benefits of the program could be substantial.

The WA Government estimates its 100,000-hectare Tree Trust project will create 4,000 new jobs [67]. Greening Australia says its request for $50 million over three years for a major tree-planting program would provide up to 3,000 new jobs [47]. Even if one assumes the number of jobs created by a program on the scale proposed is only a fraction of these per unit of area or expenditure — because of economies of scale, greater use of direct seeding and natural regeneration, technological improvements, less commercial harvesting and processing etc — the estimates suggest that many tens of thousands of jobs could be generated.

The social problems facing Australia are as serious and as deep-seated as the environmental problems. The Federal Minister for Social Security, Mr Howe, recently warned of the possibility of "massive deprivation" in Australia that would exceed government's capacity to provide the infrastructure necessary to support those affected [71].

Since 1970, Australia has seen the proportion of its population dependent on social welfare grow from 10% to over 25% because of factors such as higher unemployment rates and the big jump in the number of single parent families [72]. (The rise in unemployment is not due to a decline in the proportion of the population in work, but to an increase in the proportion seeking work as more married women have joined the workforce.)

While unemployment rates have dropped over the past six years, a period of sustained economic growth, they remain considerably higher than those that existed up to the mid-1970s. In the absence of new ways of dealing with the problem, high levels of unemployment may become a permanent feature of our society.

There is a growing recognition in the welfare sector that, in the long term, the only effective way to deal with the burgeoning cost of welfare and, at the same time, create a more equitable society is to guarantee people an adequate income in return for doing socially useful work. Reversing land degradation would be eminently socially useful.

Land restoration might have particular relevance to youth problems. High youth unemployment is just one component of a much wider alienation among young Australians that is reflected in high rates of suicide, drug abuse and crime. Another dimension of this alienation is an often bleak expectation of the future, a common feature of which is the continuing destruction of Earth's environment (for this reason, schools should be part of the community involvement in the program) [73].

A revegetation program could provide work that would suit the more mobile young and addresses an issue that concerns them. In doing that, it would give them a stake in the future of the country and so provide the meaning and purpose that many lack in their lives. It would get them out of the cities, which often seem to reinforce their social exclusion, and give them an opportunity to belong to communities of people working together for something they believe in. And out of the cities, housing will be more affordable.

In achieving this, the program would reduce the economic and social costs, often overlooked, of the physical and mental ill-health, deprivation, family conflict and breakdown, drug abuse and crime associated with unemployment, poverty and alienation, not to mention the direct cost of welfare payments. These broad social benefits could be important in convincing all Australians, urban and rural, of the value of the program.

This is not to say that the program alone would

provide the means to rehabilitate problem youth (although it could be a component of a rehabilitation project, if combined with counselling and other services). Rather, its main social benefit would be preventive, providing the opportunity to live a worthwhile and useful life to people who might otherwise be denied it.

According to a recent report from the Brotherhood of St Laurence, the total direct cost to government of unemployment in Australia is an estimated $5–6 billion a year (based on 1987 figures of 600,000 unemployed and 500,000 beneficiaries) [74]. This estimate covers only those direct costs such as unemployment benefits, foregone tax revenue, and government services for the unemployed. It does not include the indirect costs mentioned above, which are difficult if not impossible to quantify.

The report cites a US study that links, although not necessarily causally, a 1.4% increase in unemployment levels with a 5.8% increase in prison admissions, and notes that criminal behaviour could contribute a major component of the total cost of unemployment — as would health problems. A study of national health in Britain identifies unemployment as an area where significant improvements in health could be most readily achieved, stating that "a reduction in unemployment is likely to have a major benefit on wide-ranging aspects of health" [75].

Similarly, a recent report to Australian Health Ministers states that "poverty is the single greatest denominator underlying and probably indeed causing much avoidable ill-health" [76]. The report includes the following estimates of the annual costs of preventable premature death, illness and injury in Australia through: poor nutrition, $6.0 billion; motor vehicle accidents, $3.5 billion; cardiovascular disease, $2.0 billion; alcohol abuse, $1.5 billion. The total cost of mental illness is estimated at $10 billion a year.

Export earnings and foreign aid

The expertise and technologies developed through the revegetation program, and the broader effort to improve land management and use, could provide the basis of an export industry, and a form of foreign aid, that would be of great value to other parts of the world such as Africa, where countries face similar, but even worse, degradation problems. Australia is already well-placed in this area because of its expertise in forestry, and dryland agricultural systems that combine cropping and grazing; the qualities of its native plants; and its position as the only developed nation with tropical land.

The increasing emphasis being placed on the environment by the World Bank and others in providing development funds to Third World countries could boost the demand for expertise in environmental restoration. The onset of the greenhouse effect could further increase the need for this expertise as many developing countries lack the scientific resources needed to adapt their agriculture to the changes. Unless they are able to do this, the effects on food supplies could be dire [77].

Trees, and Australian trees in particular, have a major role to play in global environmental rehabilitation, especially in the tropics, in both wet and dry regions [78]. About 40% of trees currently planted in the tropics are Australian species. The Australian Centre for International Agricultural Research and CSIRO's Australian Tree Seed Centre are already making an important international contribution in this area.

Deforestation in arid and semi-arid regions around the world has caused widespread environmental damage and social hardship, and reforestation has become a priority in these regions, to provide fuel, building material and to combat degradation.

Australia has many trees and shrubs with characteristics useful for this community forestry. Casuarinas and acacias are nitrogen-fixing species that can tolerate infertile soil and produce firewood, charcoal, building poles, tannins, fodder and honey. Eucalypts are fast-growing and can be coppiced — that is, regrown from a cut stump — thus helping to avoid costly replanting.

In respect to this international role, a "regreening Australia" program could be linked to the Multifunction Polis, a multinational "City of the Future", proposed by Japan in 1987 as a means of presenting "new ideas for industry and for living in the 21st century while serving as a centre for cultural and technological exchange in the Pacific". A pilot concept paper for the proposal has identified the "biosphere" as one of three core themes for the MFP — a theme aimed at establishing a "world position in environmental management" [79].

The paper estimates that over the next 5–10 years the potential annual world market for products, processes and services related to environmental management will be US$240 billion for land management and US$550 billion for water treatment and purification. The biosphere concept, the paper states:

> '... provides both Australia and Japan with an opportunity to obtain commercial advantage and to assist in solving global environmental problems. It also provides opportunities for international investment and has the potential for broad international acceptance.'

Restoring national self-confidence

Apart from reducing degradation, tackling the greenhouse effect, conserving wildlife, making farming sustainable, and providing timber and jobs, a national "regreening Australia" program could have another benefit that is less tangible, but equally important: it could provide a focus

for the far-reaching political and social changes that are necessary if we are to succeed in integrating economic, environmental and social objectives, and so overcome the problems of environmental despoliation and social dispossession.

The necessity to develop this longer term, integrated national strategy has not yet penetrated far into the political consciousness of Australia, or most other countries. Australians' disillusionment with the major political parties, and politics generally — probably greatest among the young — is now well recognised, and at least one respected political analyst and commentator, Richard Farmer, has suggested that this disillusionment and cynicism threaten to make Australia ungovernable because of its impact at the polling booth [80]. But political analysts generally attribute the current mood of the electorate to the continuing squeeze on wages and living standards, a reflection of their belief that the "hip-pocket nerve" is all-important in politics.

Yet a range of social research indicates that the condition afflicting us is much more serious than a pinched hip-pocket nerve. A survey by the Commission for the Future of Australian attitudes to change and the future shows that most Australians feel that, in many respects, life has become worse over the past 20 years, and more expect the quality of life in Australia to be worse early next century (40%) than believe it will be better (30%) [81].

Surprisingly, it seems that economic factors, which dominate serious political debate, are not a major reason for this perception; social and environmental factors are. (This may reflect public perceptions of which issues are being addressed by government and which are not, or the extent to which economic factors are now seen as divorced from the quality of life. However, the survey was conducted in the first two weeks of August 1988, when our economic prospects seemed brighter; on the other hand, environmental issues are also now attracting much more public attention.)

The survey shows that roughly two-thirds of Australians believe the standard of living has improved or remained the same over the past 20 years and that it will do the same over the next 20, with the majority of these opting for improvement. In contrast, nine out of ten Australians believe crime and violence has become worse over the past 20 years, and three- quarters believe it will continue to get worse over the next 20 years. Eight out of ten believe pollution and the quality of the environment has become worse and more than half that it will continue to get worse in the future. In terms of a perception of deterioration, crime and violence ranks first out of 16 issues for both past and future changes, while the environment ranks second. Poverty and unemployment are among the other issues to rank high on this basis, for both the past and the future.

The Commission for the Future survey, like a number of other recent studies, suggests that Australians, as a nation, lack a sense of identity, purpose and direction [82,83,84,85]. We are troubled by our apparent inability to solve the problems facing us. We are confused by a multitude of disparate policy issues that appear unrelated to any coherent vision of where the country is going, and are, in many cases, made incomprehensible by the jargon in which they are framed. As a result, we are losing faith in our leadership, in ourselves and in the future.

A "regreening Australia" program could, then, be one example of the sort of national initiative that all Australians would see as addressing these serious and fundamental concerns. In doing that, the program would encourage a new sense of national unity and purpose, and a new optimism about the future.

If it achieved this, the overall value of the program would be immense, transcending any mere economic assessment.

CONCLUSION

A program to "regreen Australia" through massive revegetation and reforestation is an example of a national initiative that integrates and reconciles major environmental, economic and social objectives — objectives which are often, and perhaps increasingly, seen as incompatible and irreconcilable. Unless we can achieve this sort of integration and balance, it seems likely that the wealth generated through economic growth and development will increasingly be squandered in paying for the environmental and social problems created by the processes of growth.

The primary justification for a government-driven program on this scale is environmental: the program offers an important means of addressing land degradation, the threatened extinction of many native plants and animals, and the greenhouse effect. They are issues of growing concern to Australians, issues that will have a major influence in shaping the future of the Australian continent and Australian society.

But both by addressing these environmental problems and in other ways, the proposed program would also have significant economic effects: it would help to sustain our agricultural productivity, allow us to expand our timber industries, enable us to develop an export industry based on environmental management skills and technologies, and benefit tourism. Given these environmental and economic impacts, social benefits would also flow from the program: it could generate many useful and worthwhile jobs, and so help to reduce the high personal, social and economic costs of unemployment.

These are all tangible, physical achievements. Also important is the conceptual strength of the proposed program — its capacity to symbolise a new approach to national affairs, and so encourage among all Australians the belief that we can overcome the serious problems we face.

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PERSONAL COMMUNICATION

Information for this report was sought from, and aspects of it discussed with, a wide range of people, both inside and outside CSIRO. Some commented on drafts of the report, or specific sections of drafts. They are listed below, and I gratefully acknowledge their assistance. Their mention should not be read as an endorsement of the overall thrust of the report, and the responsibility for any errors, misrepresentation or oversights is mine alone.

CSIRO

Division of Wildlife and Ecology: Doug Cocks, Rhondda Dickson, Graham Harrington, Ken Hodgkinson, John Ive, Joe Landsberg, Denis Saunders, Geoff Tracey, Brian Walker, Allan Wilson.

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Government agencies

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SA Department of Environment and Planning: Julianne Venning.

Universities

John Burton, *University of New England.*
Andrew Campbell, *University of Melbourne.*
John Dargavel, *Australian National University.*
John Freeland, *University of Sydney.*
Ross Gutteridge, *University of Queensland.*
David Ingle Smith, *Australian National University.*
Colm Kearney, *University of NSW.*
Henry Nix, *Australian National University.*
Roy Rickson, *Griffith University.*
Jack Sinden, *University of New England.*

Others

Bob Beale, *The Sydney Morning Herald*
John Cameron, *Australian Conservation Foundation.*
Malcolm Campbell, *Greening Australia,* Adelaide.
Daryl Dixon, Canberra.
Claire Ekas, *"Tree Millions"*, QLD.
Peter Fray, *The Sydney Morning Herald*
Ian Gorrie, *Greening Australia,* Canberra.
John Gray, *Institute of Foresters of Australia.*
Richard Weatherly, *"Connewarran"*, Mortlake, VIC.

Mr Richard Eckersley

Principal issue analyst, Office of the Chief Executive, CSIRO

Richard Eckersley joined CSIRO in 1983 as its senior media liaison officer, and before that was The Sydney Morning Herald's science reporter. He holds a Bachelor of Science from the Australian National University and a Master of Science and Society from the University of NSW.

In 1987 he went on part-time secondment to the Commission for the Future, during which time he wrote two reports for the Commission: a review of 'Australian attitudes to science and technology and the future'; and an analysis of the social and psychological problems experienced by young Australians, 'Casualties of Change: the predicament of youth in Australia'.

He now works for the Chief Executive of CSIRO, Dr Keith Boardman, researching and analysing science and technology-related issues. He is also preparing a third report for the Commission for the Future based on a survey of Australian views on change and the future.

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