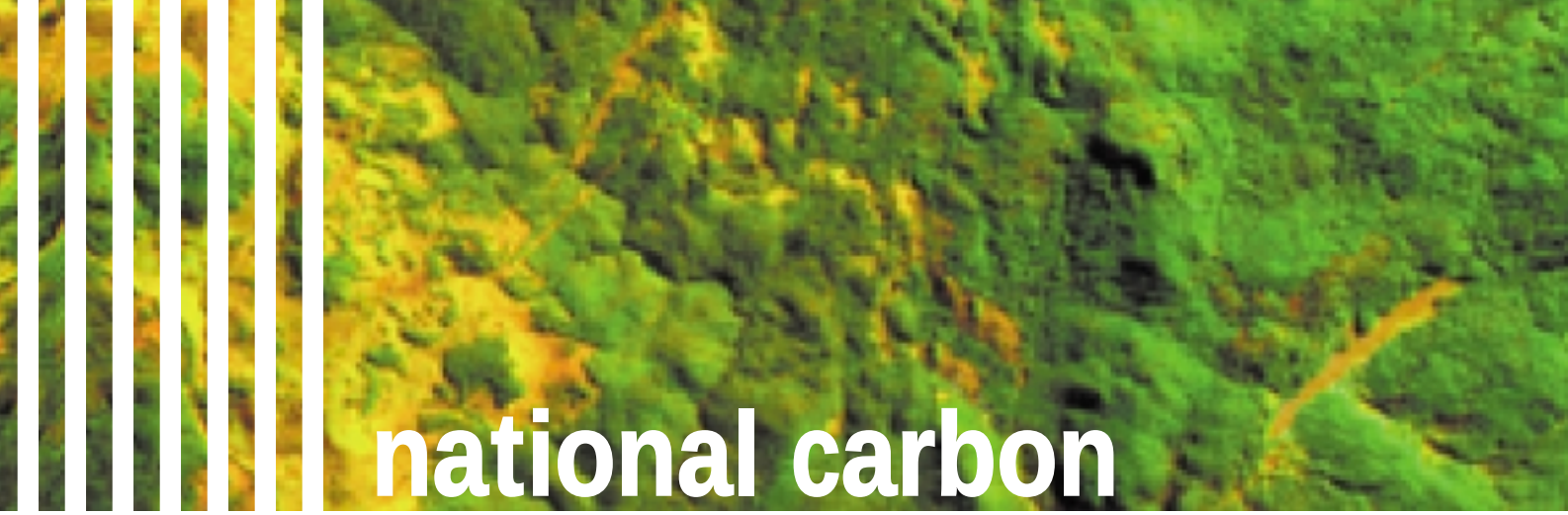

national carbon accounting system

technical report no. 4

Land Clearing: A Social History

Australian Greenhouse Office

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September 2000

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SUMMARY

This social history documents the factors that contributed to the land clearing that occurred since 1970, and provides an overview of where and when it took place. It was commissioned under the National Carbon Accounting System (NCAS), to provide contextual information for a land cover change study for the period since 1970. The information presented here is not intended to be used in either a quantitative or predictive sense. Findings are presented first as a national overview, and then as State and Territory analyses of why clearing occurred, and where and when the major clearing events took place.

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Workshops and reviews by State and Territory Governments led to numerous significant inputs to the report.

ABBREVIATIONS

ACT	Australian Capital Territory
ACTLIC	Australian Capital Territory Land Information Centre
ACTMO	Australian Capital Territory Mapping Office
ADMA	Agriculture Development Marketing Authority
AGO	Australian Greenhouse Office
ALCC	Agricultural Land Cover Change
AMG	Australian Map Grid
ANM	Australian National Mills
API	Aerial Photographic Interpretation
APPM	Australian Pulp and Paper Manufacturers
AUSLIG	Australian Surveying and Land Information Group
CDB	Commonwealth Development Bank
CP	Conditional Purchase (scheme)
CRA	Comprehensive Regional Assessment
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DCDB	Digital Cadastral Data Base
DEHAA	Department of Environment and Heritage (South Australia)
DLWC	Department of Land and Water Conservation (NSW)
EOC	Earth Observation Centre
EPA	Environment Protection Agency
GIS	Geographic Information Systems
IBRA	Interim Biogeographic Regionalisation for Australia
ILZ	Intensive Landuse Zone
IPCC	Inter-governmental Panel on Climate Change
LANDSAT	Land Satellite
MSS	(Landsat) Multi Spectral Scanner
NCAS	National Carbon Accounting System
NGGI	National Greenhouse Gas Inventory
NGGIC	National Greenhouse Gas Inventory Committee
NIR	near infra red
NPWS	National Parks and Wildlife Service (NSW)
NRAC	National Resources Audit Council
NSW	New South Wales
NT	Northern Territory
NVA	Native Vegetation Authority
PALM	Planning and Land Management (ACT)
QDNR	Queensland Department of Natural Resources
Qld	Queensland
R&D	Research and Development
RBG	Royal Botanic Gardens
RCDF	Rural Credits Development Fund
SA	South Australia
SLATS	Statewide Landcover and Trees Study
SoE	State of Environment
Tas	Tasmania
TM	(Landsat) Thematic Mapper
Vic	Victoria
WA	Western Australia

1. INTRODUCTION

Land clearing is a major source of Australia's greenhouse gas emissions, estimated to contribute about 12 per cent of Australia's total emissions in 1998. Land clearing is accounted for under the Land Use Change and Forestry sector of the National Greenhouse Gas Inventory. Estimation methods are guided by the Revised Intergovernmental Panel on Climate Change (IPCC) Guidelines (IPCC 1996). Harvesting for forestry is accounted for separately, using wood harvest statistics. This study, under the National Carbon Accounting System (NCAS), therefore focuses largely upon the clearing of native vegetation for various agricultural purposes.

Under the Kyoto Protocol, as a net emitter in this sector, Australia will be able to include land clearing emissions in its 1990 Baseline. This will require a reduction in the current uncertainties that generally surround estimates of land clearing emissions. A major source of improvement will be gained from better estimates of the rates of land clearing, where it occurred, and what type of vegetation was being cleared. This is critical in the calculation of biomass cleared and resultant carbon emissions. Current methodology assumes a twenty year decay cycle for carbon released by land clearing – this means that an estimation for 1990 will need to include data on the area and location of land clearing from 1970-1990.

Remote sensing will play a key role in improving land clearing estimates for 1970-1990 – indeed it is the only way of providing an accurate map of where clearing occurred, and matching the clearing to the vegetation type. The period 1970-1990 embraces two decades when great advances were made in remote sensing technology, but there are key gaps in the image archive. There are also variations in the quality of the available data, requiring considerable calibration and interpretation.

A number of remote sensing analyses have already been undertaken. These have generally sought to estimate rates of land cover change operating over varying periods. In terms of the 1990 Baseline, the most relevant of these are:

- a study of land cover change across Australia from 1980-1990 (Graetz, Earth Observation Centre (EOC), unpublished data);
- an analysis of forest cover change in Victoria from 1972-1987 (Woodgate & Black 1988); and
- an analysis of tree clearing in Queensland from 1988-1992 (Statewide Landcover and Trees Study (SLATS), Queensland Department of Natural Resources (QDNR) 1997 & 1999).

These studies are described more fully in a later section of this chapter. In general, these studies have selected time periods on the basis of data availability and quality, rather than meeting a specific temporal objective, as required in the 1990 Baseline estimation.

The NCAS will be commissioning a specific multi-temporal remote sensing analysis of land cover change from 1970 onwards. It will be important that this study is focussed on the areas and periods of major change, and that it is able to seek out and integrate a range of data types in those priority places and times. Moreover, an understanding of motivation and process will assist in the explanation of both trends and anomalies in the available data.

1.1 KEY FINDINGS

Agricultural profit is the primary motivator for land clearing. This can be gained in two ways: immediate economic gain from increased production, and future economic gain from increased land values.

During the period 1970-1990 both these forms of economic gain were enhanced by a range of financial and institutional incentives for agricultural

development, which provided cheap land along with venture capital in the forms of loans or tax concessions. These incentives were largely diminished by the late 1980s, although they have left behind a legacy of smaller subdivisions with reduced economic margins, and hence a need to farm more intensively. Also, once land is cleared there is an incentive to maintain the resultant improved land values through re-clearing, particularly in warmer areas where regrowth is significant.

The direct financial incentives were overlain with a range of environmental and socio-economic influences. The availability of suitable land, and associated road rail and water infrastructure was particularly important. In Queensland, New South Wales and Western Australia, large areas of new land were developed for both grazing and cropping. In New South Wales and Western Australia existing grazing land was converted into cropping, requiring more intensive development of the land. The expansion of grazing and the conversion to cropping were supported by a range of agricultural research and development initiatives, providing more productive plant varieties with greater drought tolerance and a capacity to farm on poorer soils through the use of fertilisers.

Land tenure and the introduction of clearing controls have been strong influences, with clearing generally reducing after the introduction of controls, but often reported as increasing beforehand. Clearing is now controlled by legislation in Western Australia, South Australia, Victoria and New South Wales, and to some degree Queensland.
The introduction of legislation, while reflecting changing social attitudes and a growing awareness of the effect and extent of land degradation, has generally been strongly opposed by farmers.

The influence of commodity prices on clearing is varied, and closely tied to the degree of profit to be gained. Increased commodity prices and new markets encouraged agricultural expansion and conversion from grazing to cropping.

Equally though, declining profits either from decreased commodity prices, or from saturated markets, often necessitated clearing, by demanding more production to simply maintain income. Commodity prices therefore do not necessarily affect clearing rates in a direct way, but rather form part of a general framework of available finance to the individual farmer.

Overall the nature and rate of clearing varied throughout the period 1970-1990 on a jurisdictional basis, indicating that government policies have had a profound influence on the economics of clearing at the farm level. During the late 1980s, attitudes towards the land had begun to change, and this is reflected in changed policies. In many areas, the rate of clearing began to decline in the late 1980s, while in other areas, significant clearing continued.

1.2 METHOD OF INVESTIGATION

Data for this project were gathered through personal and telephone interviews, literature reviews and observation. A total of over 105 interviews were conducted throughout Australia with government, non-government, industry and landholder representatives. Interviewees, where possible, were selected in terms of their involvement in past land-clearing data collection and/or their historic understanding of clearing and clearing events on a State, regional or local level. Not all relevant stakeholders could be interviewed for this assessment.

The literature review includes: publications specifically addressing land clearing issues; the results of remote sensing data collection and other mapped information from the internet or written reports and maps.

Information gathered has been sorted into biogeographic regions, where possible, following Thackway and Cresswell (1995). This provides a broadscale break-up of the Australian environment into biogeographical regions, crossing State and Territory boundaries and groupings of interacting ecosystems.

2. THE NATIONAL CONTEXT

2.1 INTRODUCTION

Over many decades Commonwealth and State Governments have directed financial, organisational and human resources to encourage the development and expansion of rural industries in Australia. The rural sector was and continues to be seen as a vital sector of the nation's economic and social fabric.

Land clearing was supported by Commonwealth and State Governments as an essential part of improved productivity, contributing to the enhancement of national economic prosperity. This drive for agricultural development, coupled with technological advances, available finance and a 'pioneering' approach, encouraged both the expansion of agricultural land, and the intensification of agriculture on existing land. During the 1980s attitudes towards the land began to change with a growing awareness of the effect of tree clearing on land degradation.

The 1990s have generally witnessed a major shift at the Commonwealth and State levels, with new legislative, political and economic factors affecting decision-making in relation to land clearing activities.

2.2 MAIN MOTIVATORS FOR LAND CLEARING

Clearing is motivated by the pursuit of agricultural profit, either for immediate returns or future gains through improved land values. The balance between the cost of clearing and the gains to be made is influenced by several inter-related factors. For the purposes of this report, these have been divided into the following topics, although it must be recognised that it is the confluence of these that counts, and not their individual effects: (see Figure 1)

- Environmental and social influences: land capability and suitability, land management practices, attitudes towards the land and clearing controls all form a part of the context in which clearing takes place.
- Financial and institutional incentives: these had the greatest influence, as the cost of clearing is directly alleviated, and often loans or land grants were contingent upon the land being cleared.
- Innovations: new crops and pastures, and the use of fertilisers, made production possible on previously unused lands, and harvesting equipment required cleared swathes. Bulldozers could clear land far more effectively than the previous manual methods.
- Market forces: commodity prices fluctuated, with clearing occurring both in times of boom and bust. Generally farming became less profitable, creating greater pressure on the individual farmer.
- New infrastructure: new dams encouraged more irrigated farming, and road and rail infrastructure was required to support the new industries.
- Urban expansion: urban expansion has occurred mainly in the coastal areas, and while the area of clearing has been small, biomass cleared in high rainfall areas could be significant.

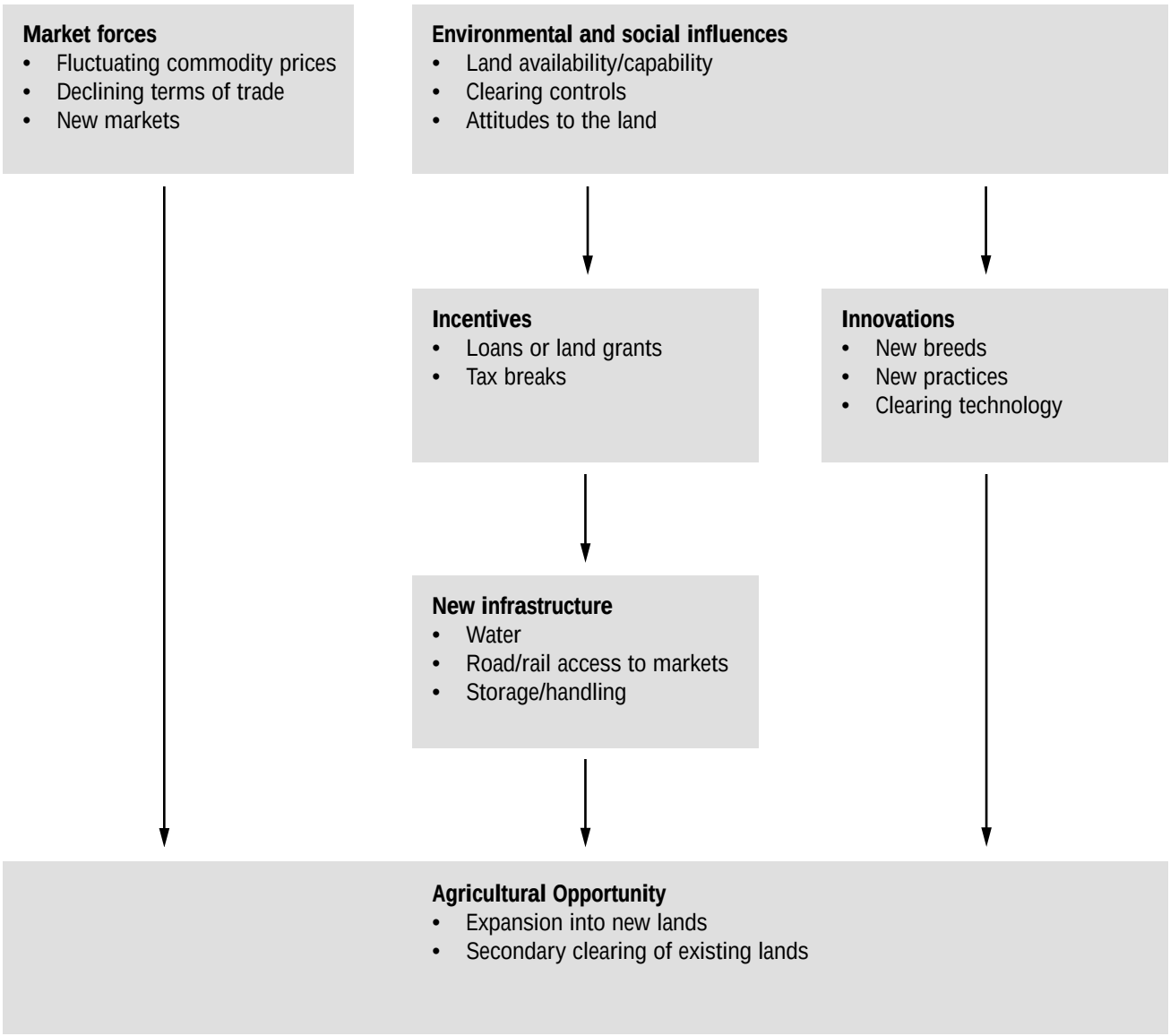

Figure 1: Main motivators for land clearing.

Environmental and Social Influences

At the national level, a range of inter-related environmental and social factors combined to both encourage land clearing for agricultural purposes, and influence its pattern. The influence of climate, and seasonal events such as El Nino, play a strong role in agricultural productivity, and no doubt influence the pattern of clearing. However, the relationship of climatic events to clearing is likely to be complex. On the one hand, good seasons may encourage clearing, as there is a greater confidence in the agricultural economy. On the other hand, clearing may also be a by-product of dry seasons, with more production required at the margins to be profitable. The influence of climate is not further examined in this report, due to the perceived complexity and general lack of understanding of its effect.

Wheat Area and Yield by State 1945-46 to 1980-81: Wheat cultivation shifted substantially to Western Australia with a subsequent drop in overall yield.

State	% of total wheat area 1945-46	% of total wheat area 1980-81	Mean yield 1945-46 to 1980-81 t/ha	Yield variance 1945-46 to 1980-81 t/ha
NSW	33.0	29.6	1.23	0.17
Victoria	28.5	12.7	1.41	0.13
South Australia	18.9	12.8	1.12	0.10
Western Australia	16.1	38.4	0.97	0.04
Queensland	3.4	6.4	1.29	0.19
Australia	100.0	100.0	1.17	0.06

Land Availability

The 1970-1990 period was one where land was seen as plentiful and available for re-vitalised cropping and grazing industries. There were a number of capability assessments, which were often optimistic about the productivity gains that could be made through the application of fertiliser, and the introduction of new plant varieties.

Development opportunities were seen particularly in Queensland, New South Wales, Western Australia and the Northern Territory. In the case of wheat, this generally resulted in a shift from higher yielding States such as Victoria, to lower yielding States such as Western Australia. Ironically, research has shown that although the area planted to wheat shifted between States in response to the push for greater agricultural productivity, national wheat yield rates actually decreased. If the location of production had remained as in 1945-46, the average rate of increase per year would have been 11.9 ± 4.0 kilograms per hectare (ha). Instead, the average rate of increase was 9.0 ± 3.5 kilograms per ha.

Clearing controls

While the primary responsibility for land management lies with the States, the Commonwealth Government's involvement in land management centres on issues of national interest in sustainable management of natural resources, as well as international convention obligations. While the Commonwealth does not have direct powers over land use in the States, provisions relating to the *Australian Heritage Commission Act 1975* and the *Environment Protection (Impact of Proposals) Act 1974* must be met by the States in their decision making processes (Tasmanian Public Land Use Commission 1996, p.168-169).

Clearing controls have generally been seen as successful in reducing vegetation clearance in Australia. Their introduction has been strongly opposed by farmers, and there is a widely held view that fear of impending controls led to greatly increased rates of clearing in those States where clearing controls were proposed but yet to be imposed.

Clearing is now controlled by specific legislation in Victoria, New South Wales, Western Australia, and South Australia, and to some degree Queensland. The introduction of this legislation has generally followed a growing awareness of the effects of clearing on land degradation. Legislation has been introduced at different times, with the nature of control differing between States. It should be noted that, prior to the introduction of specific legislation, there were a number of legislative mechanisms for soil conservation and rural land management in some States to control clearing indirectly. This was particularly the case in South Australia, and also in some parts of New South Wales, and is currently the case for Tasmania.

Clearing controls differ substantially between States both in nature and timing

State	Relevant legislation	Comments
Queensland	*Land Act 1962* and *Land Act 1994*	Permits not required for clearing of regrowth
New South Wales	State Environmental Planning Policy no. 46 (SEPP 46) 1995	
	Native Vegetation Conservation Act 1997	
Australian Capital Territory	*Nature Conservation Act 1980* and *Land (Planning and Environment) Act 1991*	
Victoria	*Planning and Environment Act 1997* and *Planning and Environment Act 1998*	
Tasmania	No direct legislation	Some provisions under the *Forest Practices Act 1985*, the *Land Use Planning and Approvals Act 1993*, the *National Parks and Wildlife Act 1970* and the *Threatened Species Protection Act 1995*
South Australia	*Native Vegetation Act 1985* and *Native Vegetation Act 1991*	
Western Australia	*Soil and Land Conservation Act 1945*	Further enforced since 1995 through the Conservation and *Land Management Act 1984* and *Environment Protection Act 1986*
Northern Territory		

Financial and Institutional Incentives

There were a range of incentives for agricultural land development provided by Commonwealth and State Governments, in the form of low-cost finance, tax concessions or cheap land. These incentives tipped the economic balance in favour of clearing, to both increase production and to improve land values. In many cases this resulted in the subdivision of existing holdings into smaller farming units, which came under increasing financial pressure as terms of trade declined. In some areas, corporate farming was encouraged, and smaller units were combined to provide economies of scale.

The Rural Credits Development Fund

The Rural Credits Development Fund (RCDF) was established by the Commonwealth Government in 1925 under the Rural Credits Bill. The Fund was designed to provide a pool of money to be accessed by a range of rural organisations upon application. Initially, there did not appear to be any consistency about the manner in which funds were allocated. Rather, the monies tended to be sought in times of emergency by both private and public sector organisations. The Fund provided a significant source of investment for the rural sector and, in particular, rural research and development, and worked to supplement Commonwealth, State, and industry contributions.

The RCDF was abolished in 1987 as a result of recommendations made in a report of the Committee of Inquiry into the Australian Financial System. The Committee found that the RCDF was no longer required to provide financial assistance to the rural sector given Commonwealth Government financial constraints and the contribution being made to rural research and development through other avenues.

Commonwealth Development Bank

The Commonwealth Development Bank (CDB) was mentioned by a number of the people interviewed as playing a part in facilitating land clearing.
It was stated that the advent of the CDB marked the time when landholders could obtain loans to

undertake development works, including clearing, from financial institutions. It was also said that other banks soon offered the same loans to preserve business and share in profit from agricultural development.

The CDB was established on 14 January 1960 and was designed to supplement the existing banking system rather than compete with it. Offices were established in each State and Territory capital city. The philosophy underpinning the Development Bank was the:

> *"… opening-up in various parts of Australia of new areas of leasehold land … the new settler … must have greater equity than his counterpart of a few years ago because the costs facing the settler today are greater and yet his returns have not correspondingly increased … the Development Bank by filling in the gap in the sources of finance available, will help to encourage a resurgence of this pioneering spirit and inspire men to undertake bold new schemes which will not only benefit them personally but the nation as a whole. (McDonald 1960)"*

The CDB was only interested in providing rural credit and all fields of primary production were considered (McDonald 1960). Three main purposes for which CDB loans could be accessed were:

- to improve a primary producers standard of living;
- to re-distribute income within the primary producing community; and
- to increase a primary producers income – this included the important field of expenditure on items which improved farm productivity.

The CDB provided loans at low interest rates to primary producers, as well as subsidised financial advisory services to the rural community. Land clearing activities were seen as increasing the value of the land and, hence, improving farm productivity and income.

The Income Tax Assessment Act

A wide variety of tax-based concessions were available to farmers until the mid 1980s. Some of these concessions included five year income averaging, the unlimited carry forward of losses, the provision of machinery investment allowances and special (five year) depreciation rates for items of plant and some structural improvements. Of specific relevance to vegetation clearance, however, was section 75(1)(b) that allowed a full deduction in the year incurred for expenditure on

> *'... the destruction and removal of timber, scrub or undergrowth indigenous to the land.'*

The increasing criticism engendered by Section 75 (1)(b) led to a review by the Bureau of Agricultural Economics and, shortly afterwards, the Commonwealth Government passed an Amending Act (165/1973) that significantly curtailed many of the concessions outlined above. Of special interest was the amendment to Section 75(1)(b) that allowed clearance expenditure (and certain other development costs) to be deducted only over a period of ten years (ten per cent per annum) (Harris 1976, p. 22-23).

Since 1983, there have been no income tax deductions for the capital costs of clearing land. Instead, landholders are now able to secure tax deductions by fencing off remnant stands of vegetation and engaging in other landcare type activities.

War settlement scheme

The War Service Land Settlement Scheme was established under the *Lands Settlement Agreement Act 1945 (Cwlth)* and allowed for the Commonwealth Government to finance the development of areas considered suitable for the settlement of ex-servicemen. State Governments were responsible for the local operation and general administration of the scheme.

Operating in the post-war period, the Scheme impacted on land clearing during the 1970 – 1990 period, as it encouraged the subdivision of existing holdings into smaller blocks. These smaller 'soldier settlement blocks' were often economically marginal, leading to land clearing on properties that would not be economically viable without continuous development.

Specific budget allocations for State development

There are many examples where the Commonwealth Government allocated funds to the States and Territories for specific development schemes that either directly or indirectly led to tree clearing. While the majority of these predate the period of review, they still exert an influence on land clearing. For example the allocation of $23 million to Queensland in 1963 towards the Brigalow Land Development Scheme was part of the foundation of a scheme that led to the one of the major and continuing clearing events in the State. Other development schemes funded by the Commonwealth affecting land clearing include the Queensland Beef Roads (funded in the 1960s) and dams such as the Burdekin, Thompson and Fairbairn Dams, also in Queensland.

Commonwealth export licenses

The advent of a market for woodchips in the early 1970s provided an opportunity for forest clearing on private land, with the returns from timber for woodchips assisting in the cost of converting forest to pasture. This was especially important in Tasmania in the early 1970s, and alleviated the full effect of rural recession for many landholders. Although forestry as a land use is generally a state responsibility, the Commonwealth Government must first approve the export licenses for forest products.

Agricultural support programs such as drought relief and rural adjustment

The Commonwealth Government has provided funds for drought relief, distributed via the State and Territory Governments to landholders to compensate for transport costs for fodder and stock. While it is difficult to draw a direct relationship between such subsidies and tree clearing, there is no doubt that Commonwealth funding arrangements such as drought relief and discounted interest rates through the Rural Adjustment Scheme have helped keep landholders on small properties, with more marginal returns. It was reported through interview for this study that Rural Adjustment Scheme loans were still being provided for land clearing in both the Mulga Lands and the Desert Uplands bioregions in Queensland.

Land Taxes and Rating Systems

In high value land areas, rates and land taxes are likely to be high. These are generally areas where development pressures are high, for either urban development or high value agricultural commodities such as vineyards or sugar cane. This provides an incentive to convert land into production, to offset the cost of high rates and taxes.

Agricultural Research and Development:

Government support for research aimed at improving the productivity of Australia's rural industries began in 1918 with the establishment of the Council for Scientific and Industrial Research, later to become the Commonwealth Scientific and Industrial Research Organisation (CSIRO). Other organisations funded by the Commonwealth to conduct research in this area were universities, State Government departments of agriculture and a mixture of statutory and non-statutory industry schemes. For example, Rural Industry Research Funds were established in the 1950s, derived from the sale of commodities.

Early research and development focussed on immediate short-term benefits. There was an abundance of land and international markets were

buoyant. Within such a climate, farmers and government preferred research that provided quick financial returns rather than investing in less-certain long-term research investigations.

Research gradually became fragmented and the relationship between industry and researcher tenuous. The passage of the *Rural Industries Research Act 1985 (Cwlth)* resulted in change, with the numerous research committees that existed to manage the rural industry development funds, merged into fourteen industry research councils. The research councils were commodity based, with the National Farmers Federation giving support to the new structures and arguing that it improved the prospects for the conduct of research beneficial to farmers.

When the *Primary Industries and Energy Research and Development Act 1989 (Cwlth)* was passed, the research councils were converted into the network of commodity based Rural Research and Development Corporations that exist today. The basis for the change to a corporate structure was that Government wanted to work in partnership with industry to create profitable and sustainable agricultural enterprises (Lovett 1997, p. 1-3).

The establishment of rural research and development institutions specifically focusing on increasing agricultural productivity led to the introduction of new agricultural management practices. Some of the research undertaken to improve agricultural productivity presented new opportunities in regions previously not considered viable for grazing or cropping enterprises. In so doing, this research facilitated land clearing activities. For example, research into soil deficiencies and the ways in which soil could be improved through the use of trace elements and fertilisers has been a major driver for further land clearing and conversion to agricultural production. Closely associated with this research was detailed experimentation with pasture cultivars believed to be suitable for application on trace element deficient lands.

This type of investigation led to the selection of a number of suitable strains and the sowing down of newly cleared trace deficient areas to mixed leguminous and grass pastures. As the research into trace elements and fertilisers improved so did the development of specifications for farmers to use in particular locations, with each State investing in research to develop sets of local specifications.

In combination with this research were the technical improvements of machinery available for clearance and cultivation. World War II proved productive in this respect, stimulating rapid development and refinement of such heavy machinery as the crawler-tracked bulldozers, a machine well suited for cheap and rapid scrub clearance. At the same time heavy disc ploughs became widely available, combining with the bulldozers to provide a land utilisation technology suited to cheap and rapid vegetation clearance (Harris 1976, p. 20-21).

Rural research and development has been a significant contributor to agricultural productivity in Australia over the twentieth century. The relationship between research and its impact on land clearing activities, particularly in the post World War II era, has been noted with more recent developments such as the introduction of new wheat varieties and more tolerant and robust crops continuing to influence land use. In general, however, the past decade has recognised the importance of sustainable agricultural production, with research more focused on efficient and effective land use, rather than the opening up of new land for agricultural enterprises.

Market Forces

The profitability of Australian agriculture, with its orientation towards export trade, remains closely linked to price fluctuations in international markets. During the 1970s new markets developed for beef, wheat and cotton, and associated periods of high prices for many rural commodities. The influence of commodity prices on clearing varies. Clearing can take place in times of boom, taking advantage of

new markets, while in times of bust, clearing also can take place to maintain income by increasing volume of product. Perhaps more significant than commodity prices have been the declining terms of trade which place more pressure on the individual farmer. This has been balanced by greater productivity, gained through new varieties and fertilisers which have enabled previously unproductive land to be utilised.

In general, market forces have contributed to an expansion and intensification of farming, resulting in substantial clearing of trees on grazing properties in order to develop sown pastures or crops. In some wheat-growing regions, such as south-west Western Australia; the mallee wheat lands of South Australia; and the wheatbelt of central New South Wales, expansion and intensification of cropping activities resulted in major changes to land cover.

Figure 2 shows the decline in the value of farm production following post World War II agricultural expansion.

2.3 DISTRIBUTION OF LAND CLEARING

A number of studies have used satellite imagery to map land cover change, and to provide estimates of rates of land clearing, both nationally or on an individual State basis. These studies have generally increased our understanding of where clearing has taken place, providing rates over very broad periods. Generally different techniques have been used and it is therefore difficult to compare results. However these studies provide a context for further study of land clearing, and give an overview of the rates and location of major land clearing events.

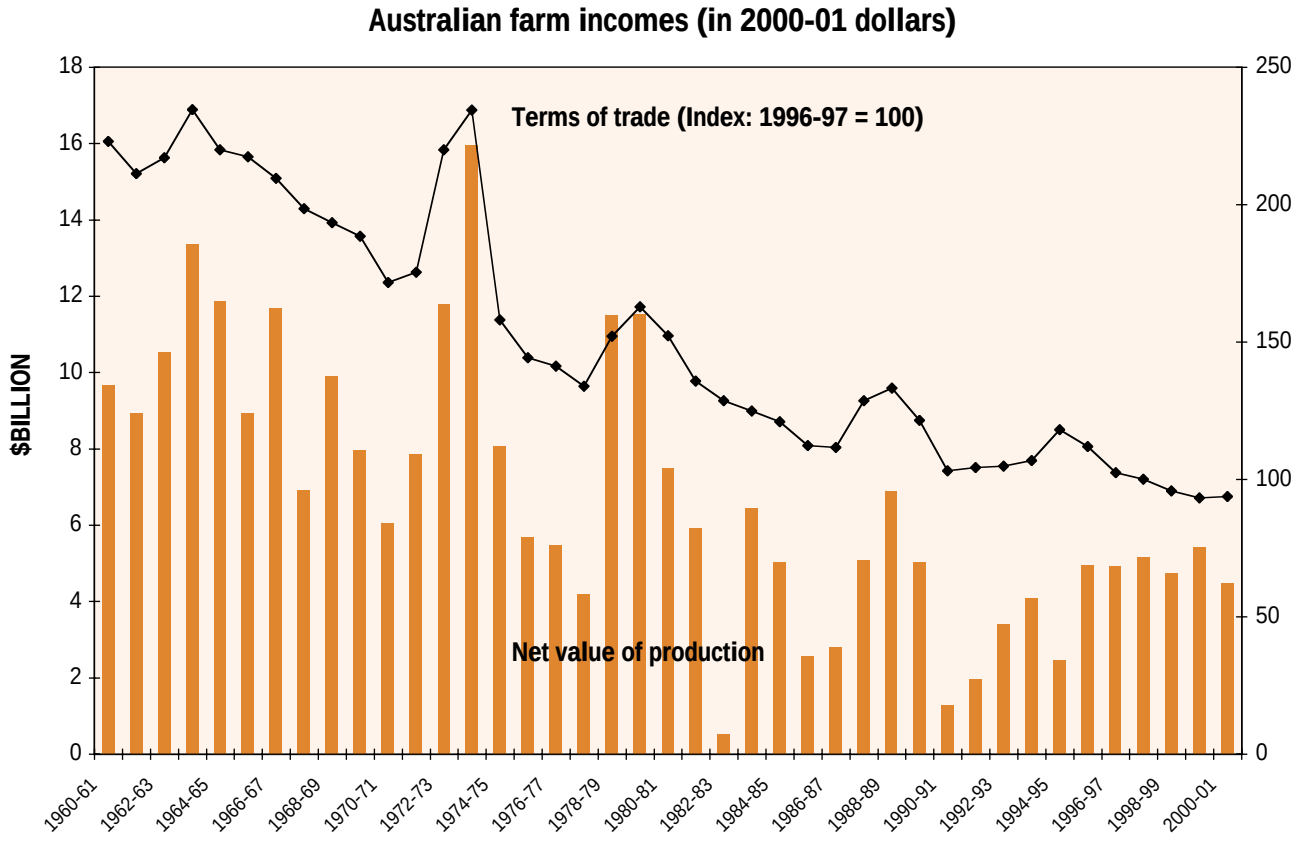

Figure 2: Net value of Farm Production (ABARE 2000)

The major studies undertaken to date are:

- Land Cover Change Analysis 1980-1990 (Graetz, EOC, unpublished data). Change was mapped nationally using Landsat MSS at 80 metre resolution. All clearing is included.
- Forest cover change in Victoria 1972-1987. Change was mapped for Victoria, using Landsat MSS at 80 metre resolution. Cover loss due to fire and clearing for forestry purposes are identified (Woodgate & Black 1988).
- Land cover change in Queensland 1988-1992 (SLATS, QDNR 1997 & 1999). Change was mapped using Landsat TM at 30 metre resolution.
- Vegetation change in the NSW Wheatbelt (Sivertson, unpublished data). Change was mapped in detail using aerial photographs.
- Agricultural Land Cover Change (ALCC) 1991-1995 (Barson 1999). Change was mapped nationally using Landsat TM at 30 metre resolution.

Results of major land cover change analyses, providing clearing rates for each state and territory are shown below. Results have been obtained using different techniques, and are therefore not directly comparable.

Jurisdiction	Time period	Clearing rate (ha/yr)	Data Source
Queensland	1980 – 1990	297,560	Graetz, EOC, unpub data
	1991 – 1995	263,450	SLATS (QDNR 1997 & 1999)
New South Wales	1980 – 1990	52,230	Graetz, EOC, unpub data
	1991 – 1995	16,400	ALCC (Barson 1999)
Australian Capital Territory	1980 – 1990	163	Graetz, EOC, unpub data
	1991 – 1995	0	ALCC (Barson 1999)
Victoria	1972 – 1987	10,000	Woodgate & Black 1988
	1980 – 1990	21,770	Graetz, EOC, unpub data
	1990 – 1993	3,000	Gilbee unpub data
	1991 – 1995	2,450	ALCC (Barson 1999)
Tasmania	1980 – 1990	2,410	Graetz, EOC, unpub data
	1991 – 1995	940	ALCC (Barson 1999)
South Australia	1980 – 1990	28,800	Graetz, EOC, unpub data
	1991 – 1995	1,370	ALCC (Barson 1999)
Western Australia		92,560	Graetz, EOC, unpub data
		21,150	ALCC (Barson 1999)
Northern Territory	1980 – 1990	12,840	Graetz, EOC, unpub data
	1991 – 1995	3,320	ALCC (Barson 1999)

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3: QUEENSLAND

3.1 INTRODUCTION

Queensland (Qld) contains the largest remaining area of forest and woodland in Australia. The tropical climate is favourable to intensive cropping and improved pastures and the State's economy is firmly embedded in primary production. Significant clearing took place between 1970 and 1990, and continues to the present day. The great majority of this is undertaken either to expand areas under pasture or crops, through the removal of virgin forest and woodland, or to maintain previously cleared areas through the removal of vigorous regrowth.

Tree clearing is monitored by the Statewide Landcover and Trees Study (SLATS)(e.g. QDNR 1997 & 1999), which analyses satellite data for vegetation cover and cover change for management planning and greenhouse gas inventory purposes. The latest analysis indicates that the clearing rate for the period 1995-1997 was some 340 000 ha / year accounting for approximately 80% of all clearing in Australia.

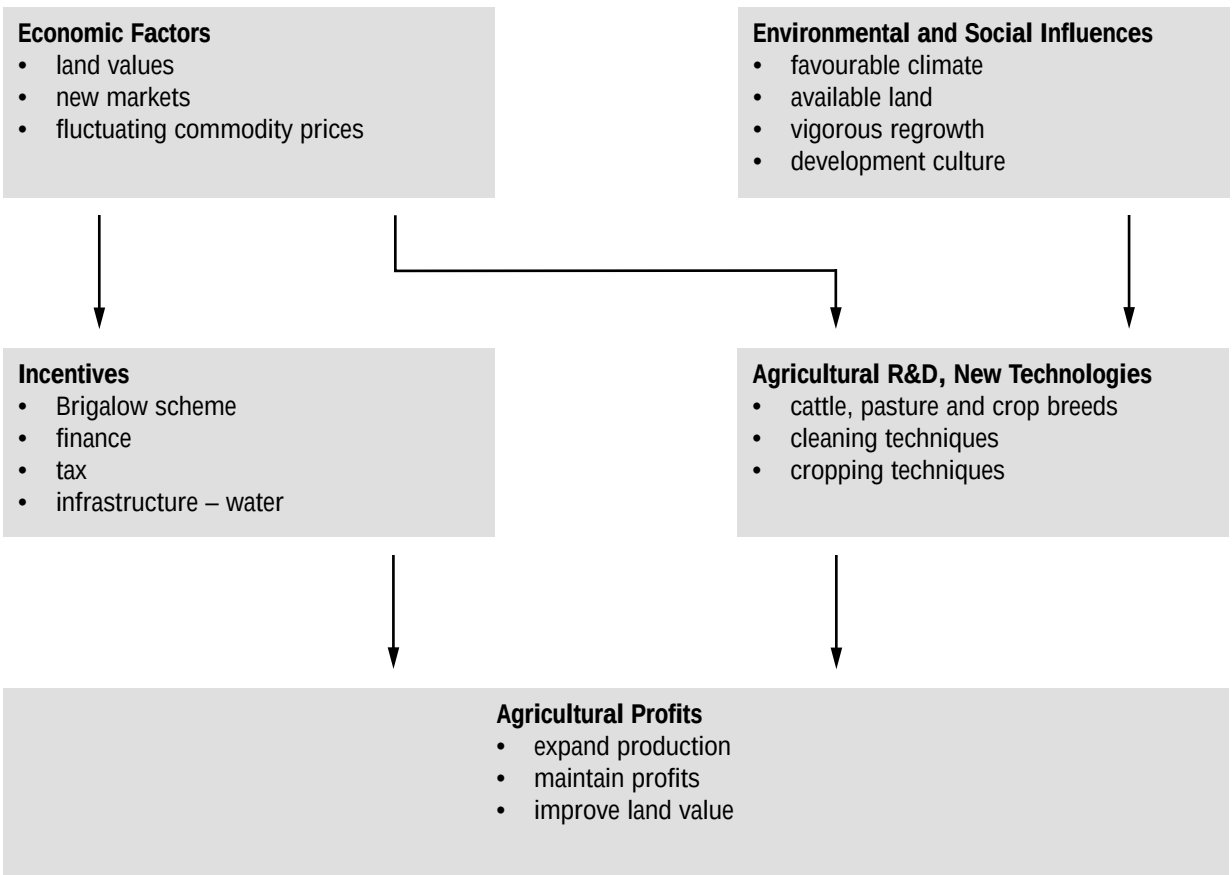

Figure 3: Clearing in Queensland has been motivated by agricultural profits, assisted by a combination of environmental influences, incentive schemes and agricultural R&D.

Clearing has resulted from a range of interrelated factors, each motivated by the pursuit of economic profit. The availability of cheap, undeveloped land was a major driver for agricultural expansion, particularly in the beef industry. This was coupled with new clearing techniques, and agricultural research and development that both enhanced productivity on existing holdings and enabled profitable production on lands previously considered unsuitable. As new markets opened up, commodity prices rose and provided incentive to clear to expand the agricultural enterprise and increase profits. Equally, when prices of existing commodities fell, there was a further incentive to expand the area of productive land simply to maintain income.

The era has been marked by a culture of development, and additional impetus came from the availability of finance from banks and a number of government incentive programs, particularly the land development schemes. These schemes often led to the subdivision of large, undeveloped properties into smaller units with proven economic viability once developed by clearing existing vegetation for production. Cleared land became an asset in itself, and clearing of regrowth was important to maintaining that asset.

The most extensively cleared regions are the Brigalow Belt, Desert Uplands, Mulga Lands and the Gidgee Lands. These have been developed largely for cattle, with some sheep and cotton production. The clearing occurred as a succession of waves that began in the best of the brigalow country in the last half of the 1950s and later moved into the less productive land. As new opportunities in the brigalow diminished, interest turned to the comparatively undeveloped Desert Uplands and surrounding regions. By the 1980s and 1990s land clearing had extended to the Gidgee and Blackwood regions adjacent to the Mitchell Grass Downs.

On the coast, land was cleared for sugar cane, horticulture and urban expansion. Clearing for irrigated cropping occurred around the Burdekin, St. George and Fairbairn Dams.

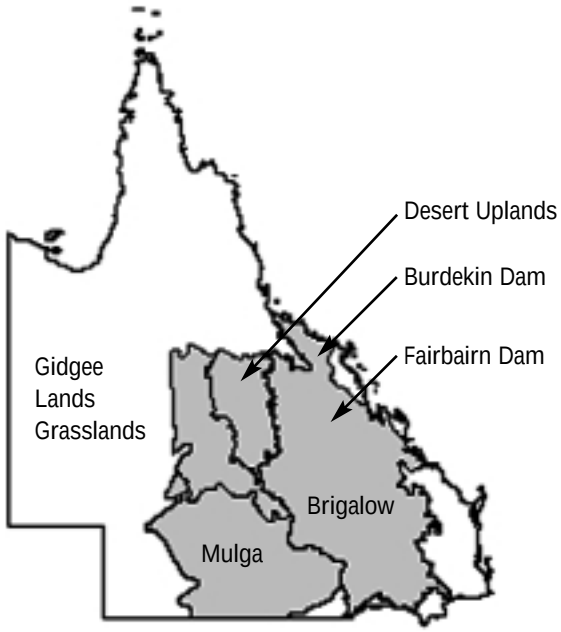

Figure 4: Areas of major clearing in Queensland.

3.2 MOTIVATORS FOR LAND CLEARANCE

Environmental and social influences

Qld contains large areas of woodland and forest with further potential for development. It could be said that the State is still in an expanding phase of development. This is particularly so in lush coastal areas. The climate in many areas is also favourable to plant growth, making it well suited to high value crops. This has created increasing demand for development of the State for rural use and triggered large-scale clearing.

To some, land is viewed as wasted unless it is developed and, in this sense, clearing is often seen as progressive. For example, in the mid-1960s to 70s there was a major effort to clear and make productive the light sandy soils of the coastal wallum lands of the southeast. The use of tropical pastures, fertilizer and trace elements resulted in some initial success, although the project later failed due to the high cost of inputs and the beef recession.

In some areas of open forest and woodland, such as those in the Desert Uplands and associated eucalypt lands, there has been evidence of an increase in density of woody plants, often referred to as 'thickening'. This is thought to be a result of either or both livestock grazing and reduction in fire frequency (since Aboriginals used the land). This both reduces plant competition and allows regeneration of unpalatable woody plants to occur. This regrowth reduces stocking rates and this becomes a motivation for re-clearing.

Other environmental effects also have a bearing on the rate of clearing. Because of the vigour of regrowth, clearing of regeneration is estimated to make up about 40% of the total clearing in Qld annually. For instance, in the 'soft mulga' areas of southwestern Qld, dense regeneration occurs and must be felled to maintain stocking rates. The felling of mulga for fodder during drought is also a well-accepted practice.

Availability of land

The large amount of 'undeveloped' land with agricultural potential led to significantly cheaper property purchase in Qld than in the southern States. This provided opportunities to both start a farming business and create a demand from successful landholders in New South Wales, Victoria and South Australia. The main reasons for the demand were that the availability of land offered:

- new challenges;
- opportunities for extension of farm area; and
- accommodation of expanding family enterprises.

A further incentive was the potential value of the land. The value of a cleared property is substantially higher than that of an undeveloped block. Clearing permits attached to a block also increase value, in advance of actual clearing. This was particularly so for blocks acquired through government programs such as the Brigalow Land Development Scheme which are discussed later.

Clearing controls

Between 1970 and 1990, no comprehensive legislation controlled native vegetation management on all tenures in Qld. *The Land Act 1994* and the Broadscale Tree Clearing Policy regulated tree clearing on leasehold tenures, and a range of legislation applied to vegetation management in specific situations on freehold tenures. Permits were required for clearing of native vegetation, but not for previously cleared vegetation. While clearing permits were generally available, there were isolated cases where impending controls may have increased clearing. Early in 1999 the Qld Government endorsed the development of a native vegetation management framework to apply consistently across all tenures.

Financial and institutional incentives

In the period 1970-1990, a variety of State and Commonwealth incentives and increased availability of finance facilitated land clearing. Other encouragements included initiatives such as the superphosphate bounty and drought assistance.

Land development schemes

To encourage land development, a number of major agriculture infrastructure projects, jointly funded by the State and Commonwealth Governments, were introduced. Of these, the Brigalow Land Development Scheme had the greatest impact. The Scheme commenced in 1962, continued until 1985, and covered some 11.1 million ha. A significant part of the area remained in the control of the existing settlers, who were granted better land titles as compensation for having some land resumed from their existing leases. The Scheme provided about 250 properties with successful applicants required to prove that they had the capacity to undertake development. To ensure that the land was brought into full production as soon as possible, the lease required that a proportion of each holding be cleared within a given time frame. Government planners encouraged landowners to clear in large blocks to

make it easier to meet the clearing requirements. The Scheme was a notable success in developing the brigalow lands for improved pastures and beef production and, later, for intensive cropping.

The clearing of the Brigalow would have taken place without the settlement scheme, but it would have taken much longer. In addition, without the Scheme, it is likely that properties would have been fewer, larger and significantly more wealthy, and less of the land would have been cleared.

Developments such as the Brigalow Scheme and an earlier Soldier Settlement Scheme grew from the subdivision of larger properties into smaller holdings. During the 1970s, declining terms of trade on smaller properties meant that greater productivity was required from the same land area. This often led to further clearing as a way of maintaining or expanding production.

Finance

Between 1925 and 1987, loans for rural development were available from the Rural Credits Development Fund. The Commonwealth Development Bank was established in 1960 and had great success with its loans for development that included clearing. This encouraged other financial institutions to follow suit. Consequently, from the mid-1970s a wide range of finance for property expansion and development became available. This was further enabled by the deregulation of the financial market around the same time. Tax concessions through depreciation were also available for land development. Until 1973 the full cost of clearing was deductible in the year that it was incurred.

Land rating systems

Land rates may also be an incentive to clear land in some instances. For example, Hinchinbrook Shire has a system that rates highly land designated as growing sugar cane. If a landholder who runs cattle decides to grow sugar cane on part of the property, then the higher rate is applied to the entire holding. This becomes a disincentive to running cattle and an incentive to allocate more of the property to the higher value sugar cane, which usually entails clearing.

Innovations: new breeds, equipment and practice

During the 1970s, a range of innovations were introduced to agriculture and actively promoted in the rural community by a skilled and dedicated group of extension officers employed by the State Government. The application of trace elements and fertilisers and the development of new breeds and varieties of livestock and crops allowed previously unproductive land to be developed. The availability of heavy machinery facilitated clearing of the land.

New cattle breeds

Although Brahman cattle had been in Australia since early this century, it was not until the 1960s that Brahman derived breeds such as Santa Gertrudis, Braford and Brangus largely replaced the traditional British breeds of mainly shorthorn and Hereford. The widespread introduction of these heat-tolerant and tick-resistant cattle contributed to the success and expansion of the cattle industry, and the increased profitability provided both funds and incentive for clearing.

New pasture and crop varieties

In the late 1970's, two new pasture varieties, buffel grass and stylo, were introduced and considerably enhanced productivity. For example, with the use of buffel grass, grazing capacity in the Brigalow area increased up to six-fold. In addition, expansion of buffel grass was aided by aerial sowing, allowing much easier pasture establishment and enabling farmers to reach higher stocking rates faster than with older sowing methods. New crop varieties enabled the expansion of wheat, sugar and cotton farming enterprises. This was accompanied by increased clearing, funded by the increased profitability.

New machinery and techniques

Improved technology was developed for large-scale clearing. This included innovations such as injection with poison (herbicide) and the use of a blade plough for clearing regrowth. At the same time, large machinery (bulldozers) became available through specialised contractors, who often took advantage of the high-quality second-hand machinery available at attractive prices from the mining industry.

If several landholders shared in the cost of bringing a bulldozer contractor to the area, costs to the individual were reduced and this prompted some farmers to clear in advance of need. In some areas, the introduction of large harvesters and other large equipment necessitated extra clearing to allow access.

Market forces: new markets, changing commodity prices

Invariably, the decision of a private landholder to clear can be explained in economic terms and is motivated by the potential for increased profits. Thus, market forces have an impact on rates of clearance: increasing demand creates opportunities for expansion of production, whereas falling demand causes shifts in land-use, both of which can increase clearing. For example, the 'beef crisis' in the early 1970s was presumed to decrease the need for land clearing. However, to support the transition from beef to more profitable grain cropping, clearing may have continued during this period.

In the 1970s and 1980s, new markets for Australian beef were found in Japan and Korea. The Qld beef industry was quick to respond by clearing more land for production. Similarly, from the mid-80s, both the sugar and cotton markets expanded, leading to tree removal in particular areas, for example, near Cunnamulla in the Mulga Lands.

High prices for wool often encouraged the subdivision of large properties into smaller holdings for closer development. After the 'wool boom' of the mid-70s to mid-80s, declining terms of trade and low commodity prices made it difficult for these small holdings to remain viable. Consequently, further land clearing was seen as one way to maintain and / or expand production.

Terms of trade for pastoralists declined between 1970 and 1990, but they increased for landholders growing wheat and other grains and, in particular, cottons and horticultural crops, all enterprises entailing clearing.

New infrastructure

The provision of infrastructure has opened up new areas to development and allowed improved access to markets. For example, the government built 'Beef Roads' to transport cattle from isolated areas to abattoirs closer to the coast. This made clearing possible and profitable in remote parts of the State.

Increasing urban development has supplied infrastructure such as markets, goods and services. This has supported rural development and associated clearing of the wider surrounding area.

Large-scale mining developments, such as on the open cut coalfields, have led to the establishment of roads and services and this has often supported other land development. In western Qld, there has been some clearing associated new mining operations on private grazing properties. However, the major impact has been on the surrounding landscape, through the access provided by infrastructure associated with the mines to new land for development by clearing.

Extension of the cane rails that transport sugar cane from the farm to the mill often leads to increased clearing in the Wet Tropics. If a mill has a profitable year and decides to reinvest in the local industry it may expand the rail system into an entirely new area. Access to the mill encourages landowners to take up cane quotas and increase clearing to plant cane. An increase in capacity of the mill has a similar effect.

The supply of cheap, plentiful water for irrigation, offering a viable alternative to the irrigation areas of NSW, has been a major drawcard to the development and clearing of rural Qld. It has also led to a shift from low-intensity grazing to high-intensity cotton growing in areas such as the Mulga Lands. Closer to the coast, construction of the Fairbairn and Burdekin Dams provided the infrastructure to support the development of large cotton and horticultural production areas, which have necessitated some clearing. In some drier parts of the State, water provided by the sinking of bores may have encouraged clearing for grazing.

Urban expansion

Over the last few decades, the entire South East Bioregion has been viewed as an area that could accommodate major urban expansion and provide a source of revenue for both local and State Government. Regional planning encouraged development. The Sunshine Coast was promoted as a major retirement area and attracted people and capital from the southern States of New South Wales and Victoria.

Thus, since the 1960s, the area has experienced a development boom. The mainland coastal belt has become increasingly urbanised and land use in and around Brisbane and the Gold Coast has shifted from primary production to residential settlement. Considerable clearing has accommodated this urbanisation. For example, in the 15-year period from 1974 a total of 33% of the remaining bushland on the coastal southeast Qld mainland was cleared.

During the same period, on the fringes of the major cities, rural residential developments proliferated. These small holdings often required clearing, usually on a small scale.

3.3 DISTRIBUTION OF LAND CLEARING

Significant clearing occurred during the period 1970–1995 and varied widely in scale between regions. Most clearing occurred in four central bioregions – the Desert Uplands, Mulga Lands, Brigalow Belt North and Brigalow Belt South. There, leasehold land, which requires a permit for clearing native vegetation, predominates. Clearing was broadscale and permits for areas less than 400 ha were rare. By contrast, land in the coastal bioregions is predominantly freehold, which is not subject to clearing controls. The different title, smaller holdings and pressures such as urban development result in more small area clearing events on the coast.

Central Brigalow woodlands

This region has a semi arid climate with variable, summer-dominant rainfall, ranging from about 480–700 mm. Droughts are frequent: the region is too far north to receive reliable winter rain and too far south for the monsoonal wet periods typical of northern Australia. The eastern section of the region is known as the Brigalow Belt, which supports open forest and woodland communities dominated by Brigalow *Acacia harpophylla*. This is characterised by cracking clay soils and flat alluvial plains that are ideal for cultivation and irrigation (e.g. McCosker & Cox 1996, p. 1; Johnson 1984, p. 41; Lloyd 1984a, p. 37). In the far west, Gidgee, Blackwood and open grasslands predominate.

The predominant land use for the region is sheep and cattle grazing, interspersed with cropping of cereal and cotton in the Brigalow Belt. The grazing carrying capacity has been increased mainly through land clearing and the introduction of non-native grass species. Nevertheless, with the exception of the Brigalow Belt, low fertility soils are a limiting factor. Throughout the western region, tenure is mostly leasehold. Settlement schemes have resulted in small land holdings, which required clearing to increase area and offset declining profits from grazing.

Summary of land clearing rates and causes in the major zones of activity, Qld, 1970-1990.

Zone	Biogeographic regions (IBRA)*	Rate of clearing 1980-1990 (ha/yr)	Primary drivers	Clearing pattern
Central Brigalow woodlands 	Brigalow Belt (North and South), Darling Riverine Plains, Desert Uplands, Mitchell Grass Downs, Mulga Lands, Nandewar	200,000–300,000	Mainly beef, with some wool and cotton production Brigalow Land Development Scheme provided cheap land	Expansion into new lands Patch size: large Vegetation cleared: woodland and open forest
Coastal 	Central Mackay Coast, NSW North Coast, Wet Tropics, South Eastern	100,000–200,000	Sugar cane production, urban expansion, and horticulture	Expansion, particularly around Burdekin, Thompson and Fairbairn Dams, and urban fringe development. Also secondary clearing of existing cane growing areas Patch size: small Vegetation cleared: mainly open forest, some closed forest and woodland
Northern 	Cape York Peninsula, Einasleigh Uplands	<10,000		Patch size: Vegetation cleared: mainly woodland

* following Thackway and Cresswell (1995)

Both the North and South Brigalow Belt bioregions have undergone extensive clearing since the early 1960's, greatly assisted by the Brigalow Land Development Scheme (see earlier). The Brigalow Belt was cleared from west of Emerald through to Pine Hill between 1965 and 1975, and to the edge of the Desert Uplands region from 1975 to 1985. As available land in the better-soiled areas of the Brigalow diminished, the focus shifted to the comparatively undeveloped Desert Uplands, which were extensively cleared from 1985. From there the clearing extended into the north-east corner of the Mitchell Grass Downs, where the predominantly Gidgee and Boree *A. tephrina* slopes were heavily cleared between the 1980s and 1990s.

Steady clearing of the Mulga Lands, to manage regrowth and encourage native grasses, continued throughout the period. Felling of Mulga foliage for drought fodder was also common practice.

The Brigalow and Desert Uplands are characterised by large clearing events. Small area clearing is not a feature of the Mulga Lands either, however, some permanent loss of small areas may have resulted from the cutting of Mulga for fodder.

Coastal zone

The Wet Tropics bioregion comprises wet coastal ranges, lowland coastal rainforest and other forests dominated by *Melaleuca spp*. On 9 December 1988, the Wet Tropics of Qld World Heritage Area was inscribed by the World Heritage Committee on the list of World Heritage properties and described as a site of exceptional beauty and scientific significance (Trott 1996, p. 2). Following the listing, industries such as logging and mining ceased with the World Heritage area. However, clearing associated with agriculture, particularly sugar cane, and urban development has continued in parts of the Atherton Tableland and the coastal lowlands.

The South Eastern Qld bioregion is humid with *Eucalyptus-Lophostemon-Syncarpia* tall, open forests, eucalyptus open forests and woodlands, rainforests often with *Araucarua cunninghamii* emergents, *M. quinquenervia* wetlands and Banksia low woodlands and heaths.

There is a wide variety of land use, comprising urban development for residential and tourism purposes, horticulture, sugar cane farming, grazing and some plantation forests. In the southern part of the coastal strip, land uses include service industries and manufacturing. In the 1960s, approximately one million people lived in the Moreton and Brisbane areas. Since then, along the mainland coastal belt around Brisbane and the Gold Coast, land use has shifted from primary production to residential settlement.

Because of the interest in biodiversity conservation in the Wet Tropics there have been a number of studies examining vegetation change in different areas. This data shows that in some areas within the Wet Tropics there has been revegetation, but in the agricultural areas and the coastal strip there has been a steady decline in the remaining forest cover.

The removal of forest cover in the Wet Tropics appears to be a gradual process rather than episodic. Johnson *et al.* (2000a & b) estimates that 40 to 60% of lowland rainforest communities have been lost since 1940 and that the clearing rate has fallen only recently, due to the slowdown in the expansion of sugar cane farming.

In the South East bioregion, Catterall *et al.* (1996) reports that, during the 15 year period from 1974-1989, 39% of freehold bushland was cleared. This represents a rate of 3,312 ha per year.

Overall, individual clearing events in the coastal zone are small scale, but their cumulative impact is significant.

Northern zone

The North West bioregion is in the dry tropics. Since 1980, Gidgee scrubs in the southern areas of the Gulf Plains bioregion have been cleared for grazing at a rate of about 1,000-3,000 ha per year.

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Summary of data on clearing in Qld, 1970-1990, and their source.

Region	Description of data	Source
All	Baseline vegetation change assessment based on differences in Landsat Thematic Mapper (TM) images mostly between 1991 and 1995.	QDNR 1997
Desert Uplands	Map at 1:500,000 (p. 20, fig 3.1) for the Desert Uplands showing extent of tree clearing, July 1995. Mapping based on July 1995 TM satellite image, and mapped at 1:100,000 with a stated accuracy ± 20%.	Morgan *et al.* 1997
	In the Augathella area quite extensive clearing began after 1975 and much heavier clearing from 1985 to the present. Additionally, west of St George and Roma, there has been a heavy period of clearing over the past fifteen years. Within the triangle described by Mitchell, Injune and Roma, heavy clearing has occurred stimulated by cropping and grazing activity. In the Cunnamulla area there has been a shift to cotton that has resulted in clearing. This shift has been facilitated by a demand for water and Qld offering a viable alternative to the irrigation areas of NSW.	Fensham *et al.*, in McCosker & Cox 1996
	Of the 4,108,674 ha McCosker & Cox study area, 3,131,930 was cleared by 1991-1992. A further 198,690 ha area was cleared between 1991-1992 and 1994-1995. Between 1965 (a nominal date for the CSIRO air photo mosaics) and 1991, 3,070,934 ha were cleared – a rate of about 192,000 ha per year. Between 1991-1992 and 1994-1995, 180,012 ha were cleared.	
Mulga Lands	Two satellite images, from December 1972 and 1988, show some vegetation cover loss in the drainage lines of part of south-western Qld, which Graetz *et al.* (p. 100) interpret 'as the consequence of grazing, and extensive clearing of woodlands cleared by mechanical methods to encourage the regrowth of grass.'	Graetz *et al.* 1992
Brigalow Belt	The extent of clearing from 'original' extant to 1992 extant is provided by province and land system, which are not directly comparable with IBRA bioregions.	McCosker & Cox 1996
	The main industry in the area is grazing, with about 1,292 individual establishments of an average size of 9,287 ha and an average stocking rate of 1 beast per 7.7 ha. Other industries of high economic significance are coal mining in the Bowen Basin, irrigated and dryland cotton, and various cereal grain crops, both irrigated and dryland. Since World War II the Brigalow Belt has become a major agricultural and grazing area. The entire Brigalow Belt Biogeographic Region has been subject to extensive broadscale clearing since the Brigalow Land Development Scheme that began in the 1960s and required landholders to develop land at a certain rate per annum in order to retain their leases.	
	A review and assessment of the distribution of clearing of vegetation by land types, utilising digital satellite imagery and field validation to aid regional conservation planning for seven shires within the Brigalow Belt.	
	Tables provide a Shire by Shire breakdown of the area cleared from 'the original,' to the 1991-1992 and 1994-1995 native vegetation coverages.	

Region	Description of data	Source
Brigalow Belt cont.	Collated tree clearing permit data attests that since 1986, 846,109 ha of native vegetation and 586,542 ha of regrowth have been approved for clearing. Permits issued for 1994 identify 178,795 ha of native vegetation and 239,131 ha of regrowth. 'Eight 1991-1992 landsat images were rectified to the AMG zone they covered (either 55 or 56) using control points taken from 1:100,000 topographic maps. ARC/INFO was used to digitise the coverage. The images were displayed in standard NIR false colour composites (bands 3, 4 and 7). Using both digital and hardcopy satellite imagery; the whole study area was digitised into six disturbance categories…' (p. 1). The percentage of remaining natural vegetation occurring in each Shire in the Brigalow belt by 1995 is given as: Emerald– 52.8% with 4.5% (41,860 ha) cleared between 1991-1992 and 1994-95; Peak Downs – 52.8% with 2.5% (21,940 ha) cleared between 1991-92 and 1994-95; Broadsound – 36% with 3.9% (50,345 ha) cleared between 1991-92 and 1994-9; Belyando – 49% with 4% (117,494 ha) cleared between 1991-92 and 1994-95; Jericho – 63% with 7% (134,886 ha) cleared between 1991-92 and 1994-95; Bauhinia – 57% with 3% (27,366 ha) cleared between 1991-92 and 1994-95 [this data is identified as incomplete]; Duaringa – 41% with 2% (10,951 ha) cleared between 1991-92 and 1994-95 [this data is identified as incomplete]. It is also noted that recent clearing has been most extensive in Belyando and Jericho Shires.	
	A comparison of two images of the Clermont area, in August 1972 and August 1991. The images show clearing from mining activities, and although not large in area, they are discernable. An estimated '15% of the scene has lost landcover. By eyeballing the early and late images, you can interpret these landcover changes as resulting from clearing of woodland. Some of this clearing has been on land of substantial slope' (p. 154).	Graetz *et al.* 1992
Mitchell Grass Downs	The north-east corner of this bioregion experienced heavy clearing of the slopes between the 1980s and 1990s, predominantly Gidgee and Boree. This clearing is believed to be associated with an extension of clearing from the Desert Uplands.	Interviews

Region	Description of data	Source
Coastal Region	Staff of the EPA (Townsville) hold data showing that in Hinchinbrook Shire 40-50,000 ha has been cleared since 1970. In Cardwell Shire, 50,000 ha has been cleared since 1970. In some parts of the Shire, such as along Davidson Creek, over 80% of vegetation present prior to 1970 has been cleared in small lots.	Interviews
	Table of clearing amounts and rates in the wet tropical lowlands of north Qld. Lowland sections include: Bloomfield; Thornton; Mossman; Macalister; Innisfail; and Ingham. No frequency data provided.	Unpublished material provided by Dr S. Goosem, WTMA, Cairns
	For the period 1975-1983, rainforest vegetation (closed forest) amounted to 956 ha per year and all vegetation types over this eight year period amounted to 2,632.5 ha per year. This increased to 9,127 ha per year in the 14-year period from 1983 to 1997.	
	Vegetation mapping of the Herbert River Catchment, which includes all of Hinchinbrook Shire and Herberton Shire and part of Cardwell, Johnston, Atherton and Thuringowa. Land cover mapped for every decade interval, at 1940, 1950, 1960, twice in the 70s, twice in the 80s, and every year for 1992 to 1996. Both in GIS form and map form.	Johnson 2000a & b
Coastal Region	The following is a summary of the area of vegetation and the broad vegetation types cleared in the immediate Mission Beach district between early 1992/late 1991 and end 1998. Bingil Bay/Maria Creek – 6.25 ha rainforest with sclerophyll associates (primarily *Lophostemon* and *Eucalyptus pellita*); 6.36 ha sclerophyll forest with rainforest associates; 2.5 ha various rainforest types – Total 15.11 ha. Wongaling/Mission Beach –15.625 ha mixed beach swale community – *Acacia, Melaleuca, Lophostemon, Eucalyptus/Corymbia* mixed with rainforest associates; 2.4 ha of rainforest with sclerophyll associates; 4.375 ha of rainforest (much on impeded or poor drainage); 6.875 ha of *Melaleuca* dominated foreshore/swale vegetation – Total 29.275 ha. South Mission Beach –37.7 ha of sclerophyll forest with rainforest associates; 13.75 ha of *Acacia/Corymbia* dominated vegetation; 13.1 ha of early successional forest dominated by Acacia; 15.0 ha of rainforest with sclerophyll associates; 14.375 ha of rainforest – Total 93.925 ha. Sugarcane Creek Area –11.25 ha *Eucalyptus pellita* dominated woodland/mixed forest; 25.625 ha of mixed *Melaleuca/Eucalyptus/Allocasuarina* open woodland; 11.875 ha of rainforest (primarily of impeded nature) – Total 48.75 ha. Clearing by broad vegetation type – Sclerophyll forest with rainforest associates 84.685 ha; Rainforest (of mixed types) 33.125 ha; Mixed sclerophylls dominated by *Melaleucas* 32.5 ha; Rainforest with mixed sclerophylls 23.65 ha; Early successional *Acacia* dominated forest 13.1 ha –Total 187.06 ha.	Areas of clearing were cross-referenced and calculated from the aerial photography of the area in that time period. Aerial photography included 1992 & 1997 runs at a scale of 1:25 000 (Innisfail 8162) by Department of Lands, Beach Protection Authority 1996, at 1:12 000, QDNR 1998 (Innisfail/Tully) and at 1:25 000. Areas are approximate, to the nearest 1000 square metres.
Central Mackay Coast	Three LANDSAT scenes south from Mackay (extending into the Brigalow Belt Bioregion) for the period between August 1972 and August 1991. 'There is change everywhere within this area' (pp.82-83).	Graetz *et al.* 1992

Region	Description of data	Source
South-east Qld	Results of a study of the effects of habitat loss and fragmentation on native wildlife of south east Qld. Landsat Thematic Mapper was used and a set of 1:100,000 bushland maps of south-east Qld were produced. Remnant maps were converted to GIS format. The maps are included with the report, reproduced at 1:200,000. The nine map sheets covering the report region are: Gympie, Laguna Bay, Nambour, Caloundra, Caboolture, Brisbane, Ipswich, Beenleigh and Murwillumbah. The sheets cover approximately 19,000 sq. km. These maps are based on aerial photography.	Catterall & Kingston 1993
	Bushland was interpreted visually using a hardcopy print based on satellite. Two satellite images (1:100,000 LANDSAT-5 TM photographic print; Bands 3, 4, 5; Precision Georeferenced) were used, the first taken on 16 Sept. 1989 covering the study area from the Qld-NSW border to Nambour, the second taken on 30 July 1989 covering the remaining part of the study area. Identified remnant boundaries were cross-referenced using recent colour aerial photography (1:25,000) (although unavailable for the Caloundra map sheet). The dates of all aerial photography ranged from Sept. 1987 to June 1990. Four main land cover categories (Integral Bushland, Thinned Bushland, Littoral Vegetation, Non Bushland Matrix) and two mosaic categories (Bushland/Clearance Mosaic, Integral/Thinned Bushland Mosaic) were applied. 'Where the mixture of bushland and cleared areas occurs at a scale too detailed for the scale mapped, mosaic categories were used' (p. 25). A number of map sheets at various scales (1:200,000; 1:300,000, 1:400,000) were also used for botanical mapping.	
	Clearing rates of 2,284 ha per year for the two-year period 1987-1989 increasing to 3,458 ha per year in the five-year period between 1989 to 1994. For the seven-year period from 1987 to 1994 the clearing rate was 3,432 ha per year. During the 15-year period 1974 to 1989 39% of freehold bushland was cleared. On freehold land, bushland was cleared at the rate of 0.9% of the land area (1,254 of 3,680 square km) per year (0.9% of 368,000 represents 3,312 ha per year over the fifteen year period from 1974 to 1989).	Catterall *et al.* 1996
	Two scenes of an area of 3,368 km2 of the Maryborough/Fraser Island region one in August 1972 and the other August 1991. An interpretation of the images shows the 'various methods by which the native landcover [eucalypt woodland] was removed and replaced by exotic plantations' (p. 122). Additionally, images of Fraser Island (pp. 126-127) shows, amongst other things, the expansion of agriculture and plantation forests.	Graetz *et al.* 1992

4: NEW SOUTH WALES

4.1 INTRODUCTION

As the first colony and the centre of colonial expansion, New South Wales (NSW) experienced a major impetus of land clearing about 200 years ago. Benson (1991) reports that by the 1920s woodland and forest across more than 40% of the State had been ringbarked and partially removed for agriculture. Today, much of the former forest and woodland has been totally cleared or converted to open woodland. Clearing has been most extensive in parts of the State that contain better soils on flat or undulating land, such as the major river valleys and coastal plains. Other centres of clearing are the tablelands and the wheatbelt.

Some vegetation clearance to expand agricultural land continues in NSW, mainly along the relatively uncleared margins of the wheatbelt. Elsewhere, tree removal is less extensive but widespread, mainly affecting remnant vegetation on existing holdings in the wheatbelt, irrigation areas, northern tablelands and along the coastal fringe.

The major driver for land clearing between 1970 and 1990 was a change in agricultural focus from grazing to cropping. Profits from grazing were declining, while markets for cotton, wheat and rice were increasing. The development of new crop varieties and availability of irrigation water allowed these crops to be grown on land that was previously unproductive. Clearing occurred on two fronts: firstly, to expand the agricultural zone into new areas and, secondly, to make more intensive use of existing areas.

Venture capital was available for the conversion of grazing land to cropping, often encouraging corporate farming to achieve economies of scale. The use of harvesting machinery required areas to be cleared uniformly, and expensive clearing machinery became available through the corporate enterprise. The availability of processing facilities, such as wheat silos and cotton gins, and associated road and rail links provided the necessary supporting infrastructure. The NSW Government further encouraged development through an active policy of releasing uncleared Crown Land for agricultural purposes, and also for urban expansion on the eastern seaboard.

From 1970-1990, the majority of clearing occurred in the wheatbelt, for wheat and cotton cropping, and in the Murray irrigation area, for rice cultivation.

4.2 MOTIVATORS FOR LAND CLEARANCE

Environmental and social influences

NSW contains much of the Murray-Darling Basin network of rivers, some of the most productive land in Australia. The alluvial soils of the coastal valleys and plains are also highly productive. Situated just west of the Great Dividing Range, the tableland country, with temperate climate and relatively fertile soil, is ideal for both grazing and cropping. The tableland also contains a major water harvesting catchment, which directs water to the west through black soil plains country that is ideally suited to irrigation for a variety of new and traditional crops.

The conversion of grazing land to cropping was greatly facilitated by the development of irrigation schemes that were in place well before the 1970s. Agricultural areas in NSW also have close access to the highest population density in Australia, in the Newcastle, Sydney and Wollongong urban areas. These cities provide excellent port facilities, bulk grain handling facilities and access to export markets.

In the coastal zone, particularly in the north of the State, the temperate climate and relatively easy access to the larger metropolitan areas has attracted an increasing demand for rural residential developments, which entail clearing.

During the 1980s, general attitudes towards land management began to change. New land became scarce and farmers, faced with declining terms of trade, needed to clear land to either expand or maintain production. At the same time, there was a

growing movement to conserve the land, which focussed on the dwindling remnants of native woodland and forest. This polarisation of attitudes either encouraged or discouraged clearing, depending on the prevailing point of view.

Clearing controls

Specific clearing controls were introduced in NSW in 1995, using the State Environment Protection Policy, and further cemented in 1996, with the *Native Vegetation Management Act*. Other new legislation, such as the *Threatened Species Act*, introduced in 1995, require conservation assessments before clearing can take place. Before these specific controls were introduced, there were a number of legislative instruments, such as the *Soils Conservation Act*, the *Pasture Protection Act* and the *Rural Lands Protection Act*, which could have been used to control clearing.

It is likely that fear of government intervention resulted in clearing action, particularly during the late 80s. Arising from his work in the NSW wheatbelt, Sivertsen (1995b) reports significantly increased clearing in the wheatbelt subsequent to the 1985-86 Moree Plains Regional Environmental Study. The Study suggested that clearing regulations might be imposed, with the increased rates of clearing observed being a direct response to fear of impending controls.

Availability of land

During the 1970s the availability of cheap cropland in western NSW attracted a large number of wheat farmers, including many from the Eyre Peninsula in South Australia. For a variety of reasons, including land degradation and insufficient property size, cropping had become unprofitable on the Peninsula and this triggered the migration.

Financial and institutional incentives

Between 1970 and 1990, the main government action leading to clearing was a deliberate policy to release Crown Land and to facilitate conversion of leasehold land, which was subject to a degree of environmental control, to freehold land, where clearing could occur at the discretion of the landholder. The release of land was motivated by a need to reduce government responsibility for the land, and was administered through the NSW Land Commission.

In addition, economies of scale meant that smaller holdings were amalgamated into larger corporate farms, encouraging further development of existing cleared land.

Finance

From 1960, venture capital was available through the Commonwealth Development Bank, which began providing low interest loans for land development to primary producers. Other banks soon offered similar rural credit. Under these arrangements clearing was seen as improving land value, farm productivity and income.

A variety of tax concessions were also available to farmers. Until 1983 these included full deductibility of the costs of removal of timber, scrub and undergrowth in the year incurred.

Land tenure

Land development was actively encouraged by the State Government's Land Commission, which had a policy of releasing Crown Land for both agricultural and urban purposes. Vacant Crown Lands were a repository of natural vegetation, isolated by the clearing of freehold land around them. There was a limited capacity within government to manage these lands. Consequently, they were often leased out and either treated as freehold or converted to freehold. Between 1965 and 1980 in the Western Division, the area devoted to dryland cropping increased tenfold, mainly through the release of Crown Land.

Zoning controls also facilitated development of the land, particularly for the purpose of urban expansion in coastal areas. Existing tenures were often subdivided into smaller blocks, leading to clearing of small areas.

Clearing for timber products

Landowners wishing to clear their land, were sometimes able to gain forestry concessions, particularly in coastal areas where freehold land often carried high quality forest. While they received a low royalty for pulpwood, it provided an offset to the costs of any clearing. This practice mainly operated in the south-eastern part of the State, adjacent to general forestry activity associated with the Eden woodchip mill.

Elsewhere, demand for other timber products, such as sleepers and landscape materials, resulted in the logging, and localised clearing, of many remnant stands of mature River Red Gum *Eucalyptus camaldulensis.*

Innovations: new breeds, techniques and practices

New crops and pastures

The development of new wheat varieties in the 1960s led to the clearing of land previously considered too dry for use as cropland. The new dwarf wheat varieties required less moisture than conventional strains and enabled the expansion of the wheatbelt westwards, into drier country.

Research into new varieties of cotton, coupled with the development of pest management and water harvesting techniques, led to a substantial expansion of the industry. This resulted in the clearing of remnant vegetation on land that was previously cleared for grazing, or on new marginal land. The clearing of land for dryland cotton farming continues to the present day.

New machinery and techniques

Crop farming and new practices such as minimum tillage and the exploitation of heavy clay soils, required the use of large machinery. Equally, heavy equipment such as bulldozers, was required to clear remnants and other marginal lands. The rise of corporate farming increased the availability of such equipment.

Improved off-river water distribution techniques facilitated the expansion of cotton enterprises.

Market forces: new markets, changing commodity prices

The great majority of clearing in the period 1970-1990 took place with the expansion of cropping, particularly wheat and cotton. Markets for wool declined during the period from 1970-1990, whereas crop markets, particularly for wheat and cotton, expanded. Nevertheless, overall agricultural profits were declining, leading to a consolidation of resources, including corporate farming. Grazing land was converted into more intensively cleared cropland, resulting in the clearing of remnants. Both cropping and grazing expanded into new marginal land, resulting in further clearing of natural vegetation.

The development of water harvesting techniques, off-river water storage, and modern pumps and irrigation equipment further facilitated the expansion of dryland cotton farming, which continues today.

New infrastructure

The existing road, rail and water infrastructure was an ideal basis for the development of further specific infrastructure to support the cotton and wheat industries. Necessary handling facilities, such as wheat silos and cotton gins, were established, with easy access to markets through road and rail. The existing water infrastructure was further utilised to support cotton and rice production.

Urban expansion

Between 1970 and 1990, there was continuing clearing of remnant native vegetation for further development in metropolitan areas. A major driver for clearing of the coast was the rapid urban expansion in the Newcastle-Sydney-Wollongong area. However, in the past 20 years, population shifted from these centres to the warmer northern coastal areas, either for retirement purposes or for an alternative lifestyle in new land developments. Hence, most coastal clearing accommodated the rapid development of non-metropolitan areas. This was particularly intense on the north coast, with high demand from people wishing to move from Sydney and Melbourne. Former small towns, such as Tweed Heads and Port Macquarie, are now major urban centres. The trend towards urbanisation is extending to other towns such as Ballina, Coffs Harbour and Forster-Tuncurry.

There was an active policy of releasing Crown Land for urban development, particularly on the coast. The process slowed in the 1990s because of a stricter assessment process that includes meeting the requirements of the *Threatened Species Conservation Act 1995*. Continuing expansion of rural residential developments around the larger cities often results in clearing, usually of remnant vegetation. On the Northern Tablelands, many parcels of low fertility land, such as granites and sandstones, are now being cleared for hobby farms.

4.3 DISTRIBUTION OF LAND CLEARING

Although a number of vegetation mapping projects have been undertaken, few data on vegetation clearance rates are available for NSW, either at a State or bioregional scale. Sivertsen and Benson collated a series of case studies and personal observations, which have been used previously to provide indicative rates of clearing.

There are four major zones of clearing which together comprise quite a large proportion of the State (see table over page). In the north-west corner, the vegetation varies from sand dune vegetation containing spinifex grassland and sparse *Acacia* and chenopod shrublands to *Acacia* dominated woodlands known as Mulga. Although heavily grazed, the region is largely uncleared.

Coastal Zone

The Coastal Region comprises a major escarpment, undulating foothills and coastal plains. Tall open forests, open forests and woodlands dominate the vegetation. Closed forests occur in the wet valleys and freshwater swamps in the extensive coastal floodplains. Other vegetation types include smaller areas of warm temperate and subtropical closed forests, and coastal heath communities.

Land use in the coastal region is a complex mixture of intensive grazing, horticulture, dairy farming, conservation and urban development. The grassy woodlands of the coastal foothills valleys and floodplains, and some northern rainforests have been extensively cleared for grazing for wool, beef and milk production. Littoral rainforest was cleared for sandmining and urban development from the 1950s to 1980s. Rapid urbanisation throughout the 1970s and 1980s has resulted in clearing of bushland and wetlands on the coast.

The vegetation of this region has been well sampled although little information is available on rates of clearing. Small area clearing dominates in the coastal valleys, peri-urban and hobby farm areas adjacent to coastal towns.

Summary of land clearing rates and causes in the major zones of activity, NSW, 1970-1990.

Zone	Biogeographic regions (IBRA)*	Rate of clearing 1980-1990 (ha/yr)	Primary drivers	Clearing pattern
Coastal 	NSW North Coast, South East Corner, Sydney Basin	<10,000	Wool, beef, milk production, urban expansion, rural residential development, hobby farming	Secondary clearing of remnants Patch size: small Vegetation cleared: mainly open forest and woodland, some closed forest
Mountains 	Australian Alps, New England Tableland, NSW South Western and South Eastern Highlands	10,000–100,000	Wool, beef and wheat production, some horticulture	Secondary clearing of remnants Patch size: Vegetation cleared: open forest and woodland
South-west 	Murray-Darling Depression, Riverina	<10,000	Wool, wheat, rice and orchard fruit production	Secondary clearing of remnants Patch size: Vegetation cleared: woodland
Wheatbelt 	Cobar Peneplain, Darling Riverine Plains, Nandewar, South Brigalow	10,000–100,000	Wool, wheat and cotton production	Expansion into new lands, and secondary clearing of remnants Patch size: range Vegetation cleared: woodland with some open forest

* following Thackway and Cresswell (1995)

Mountains and slopes

The tablelands consist of elevated hills, steep mountain ranges, dissected gorges and elevated plains. Tall open forests and open forests, woodlands and some cool temperate closed forests predominate.

The region comprises some of the longest established agricultural lands in Australia. It is used largely for grazing for wool and beef production, and cropping, with some horticulture. On the rugged escarpments and mountain ranges, conservation and forestry are important land uses.

Most alpine areas are conserved, either within Kosciusko National Park or other reserves. The tablelands and slopes were cleared prior to 1970. During the 1980s, many isolated remnant trees were affected by dieback. Goldney and Bowie (1986) report that the remaining vegetation in the 'central west' is divided among some 3,500 individual remnant stands, 90% of which are less than 500 ha in area.

Clearing of small remnants was likely to be significant in the southern part of the region, whereas large scale (>50 ha) clearing events predominated in the north.

South-west zone

In the south-west of the State chenopod and *Acacia* shrublands largely dominate the vegetation. River Red Gums line major watercourses that form extensive floodplains. Black box woodlands occur on the floodplains and along drainage lines. White Cypress Pine, Belah and Rosewood are found on sandier soils associated with former stream channels.

Land use is dominated by grazing and cropping. In the Riverina, large irrigation developments support rice and horticultural crops. The extensive floodplain forests along the Murray River have been cut for timber over the last 150 years. Clearing has also occurred along the Darling River.

Between 1970 and 1990, land clearing occurred mainly around the Murray River, for irrigated cropping of rice and other horticultural crops. Anecdotal information regarding the Riverina bioregion indicates large scale clearing events (>50 ha) predominated.

Wheatbelt

This region has areas of sedimentary derived soils, high nutrient basalt soils, rocky outcrops and floodplains. Woodland is the main vegetation type. The major land uses are sheep grazing and cropping of both wheat and cotton.

A large proportion of this region was cleared for grazing and cropping during the 1970s and 1980s, although the far western section had not been cleared. Much of the region has been heavily grazed and parts, such as the Cobar Peneplain bioregion, are now affected by an increased abundance of woody unpalatable native shrubs.

NSW National Parks (Sivertsen, 1995b) undertook a detailed mapping and land clearance project of the north-west plains wheatbelt. The recorded clearing rates vary for the different map sheets although a consistent trend is apparent. Clearing rates in the 1980s and 1990s were greatly reduced from those recorded for the 1970s. It is likely that large scale (>50 ha) clearing events predominate in the wheatbelt.

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Summary of data on clearing in NSW, 1970-1990, and their source.

Region	Description of data	Source
North coast	Data covers private land in the Richmond and Clarence catchments located in the northern part of the bioregion. For the 867,700 ha of vegetated privately owned land in the study area in 1972, the following clearance rates were recorded:1972 to 1982 – 2,700 ha per annum; and 1982 to 1994 – 1,755 ha per annum.	Flemons 1995 (unpublished)
	This project on the upper north east of NSW produced a regional estimate for the entire Natural Resources Audit Council (NRAC) area with maps of clearing that occurred between 1972-1982, 1982-1994, and 1972-1994.	Final Report on Mapping of Clearing in the NRAC area
	The NRAC study area includes the Richmond and Clarence River catchments and comprises the northern sector of the NSW North Coast bioregion and small areas of the New England Tableland bioregion. The scale of the resultant map, based on a 100m grid cell, was 1:250,000. Area estimates are provided of the amount of clearing that has occurred on private lands between 1972-1994.	
Sydney basin	The vegetation of the Sydney, Gosford and Lake Macquarie, Penrith Wallerawang, Katoomba, Burragorang, Merriwa and St Albans areas has been mapped (1: 100 000) by the Royal Botanic Gardens (RBG), Sydney. The Wollongong, Mittagong and Mount Pomany map sheets are currently being prepared.	Benson & Howell 1994; Benson 1986, 1992; Benson & Keith 1990; Keith & Benson 1988; Fisher *et al.* 1995; McRae & Cooper 1985; Ryan, Fisher & Shaeper 1996; Benson 1999
	During 1996-1997 the National Parks and Wildlife Service (NPWS) surveyed the flora and mapped, at a fine scale, the vegetation remnants on the Cumberland Plain in western Sydney.	NPWS 1997
	A range of studies cover the Illawarra rainforest and dry woodlands.	Benson 1999
Coastal: south-eastern corner	The southern section of the NSW portion of the bioregion, covering the Eden and Bega areas, has been comprehensively surveyed and ecologically mapped at 1:25,000 scale on GIS to be published at 1:100,000 in a hard copy form.	Keith and Bedward 1999; NPWS
	The current and pre-1750 vegetation of the northern section of the Bioregion in NSW is being mapped and modelled by NPWS as part of the CRA for forests. In part, this mapping is using two decades of modelling data from the CSIRO Division of Wildlife and Ecology (using over 9,000 mainly canopy tree species plots), along with a range of full floristic plot data and API from Benson (1999).	
Northern tablelands: tablelands, mountains & foothills	The RBG has sampled and mapped the vegetation of the Guyra 1:100,000 map sheet area at scales of 1:25,000 in a digital format and at 1:100,000 in a hard copy format for publication.	Benson & Ashby in prep.
	The conservation of land systems and major vegetation types is addressed.	Morgan & Terrey 1990
	Many of the state forests and conservation reserves have been surveyed and mapped at a fine scale, for example Torrington State Recreation Area.	Clarke *et al.* 1997

Region	Description of data	Source
South-eastern highlands	Vegetation survey and mapping cover parts of the bioregion at different scales and quality. Most of the private land has not been mapped or sampled to the same degree as public land. However, the NPWS (Southern Zone) has mapped the native vegetation of the Yass Shire using aerial photographs.	
	As part of the CRA for forests, some of the vegetation is being sampled and subject to air photo interpretation and computer modelling in order to produce a vegetation map at a scale of 1:100,000.	Benson 1999
North-west slopes	The vegetation of the Ashford 1:100,000 map sheet has been sampled and is being mapped by the RBG, while DLWC have obtained National Heritage Trust funds for mapping woody vegetation in the bioregion through aerial photographic interpretation.	Benson 1999
South-west slopes	The remnant vegetation in the northern section of the South Western Slopes bioregion in the vicinity of Forbes is described and partly mapped at 1:250,000 scale. However, there are no published clearance rate data for the Forbes sheet. More detailed vegetation maps at 1:100,000 scale have been produced on a GIS for the Mid-Lachlan Regional Vegetation Management Plan in central-western NSW.	Howling 1997; Sivertsen & Metcalfe 1995
	The southern section of the bioregion (east of the Hume Highway), centred on Tumut, has been mapped and classified by the NPWS for the CRA for forests.	
	NPWS has also used air photo interpretation to map vegetation in the Shires of Cootamundra and Young (R. Good, pers. comm.). West of the Hume Highway, around Wagga Wagga, several local studies have taken place.	Benson 1999
Wheatbelt: Brigalow Belt South	Rates of clearing for that part of the Goondiwindi 1:250,000 sheet occurring in NSW (representing a small part of the northern NSW section of the Brigalow Belt South bioregion) and western section of the Inverell 1:250,000 sheet. Note: Sivertsen (unpublished) and (Sivertsen 1995a) have differing rates of clearing for the Goondiwindi map sheets.	Sivertsen unpublished & 1995a
	For that part of the Goondiwindi 1:250,000 sheet occurring in NSW, native vegetation clearing rates were:	
	1973 to 1985 – 11,500 ha per annum;	
	1984 to 1994 – 2,000 ha per annum; and	
	1994 to 1998 – 250 ha per annum.	
	For the Inverell 1:250,000 sheet, native vegetation clearing rates vary from:	
	1970 to 1984 – 8,000 ha per annum	
	1984 to 1994 – 200 ha per annum; and	
	1994 to 1998 -130 ha per annum. (NB data tables are inconsistent between references).	
	For the whole bioregion the following rate of clearing has been recorded: 1995 to 1997 – 1,500 ha per annum.	

Region	Description of data	Source
Cobar Peneplain	A detailed mapping project of the Forbes and Cargellico 1:250,000 map sheets.	Sivertsen & Metcalfe 1995
	For part of the Condoblin 1:100,000 sheet the following clearance rates are reported: 1973 to 1991 -1,170 ha per annum; and 1991 to 1995 – 5,000 ha per annum. Based on only part of the Condoblin 1:100,000 sheet, rates of 1,170 ha per annum from 1973 to 1991 and 5,000 per annum in the period 1991-1995 are reported.	Sivertsen unpublished
	An assessment of this bioregion, that includes vegetation mapping, was undertaken by the NPWS.	Creaser & Knight 1996
	Land systems mapping by Department of Land and Water Conservation (DLWC) covers the section of this bioregion in the Western Division.	Benson 1999
Darling Riverine Plains	For the Moree 1:250,000 sheet map the following native vegetation clearance rates are documented: 1977 to 1985 – 52,200 ha per annum; 1985 to 1994 – 4,800 ha per annum; 1994 to 1996 – 6,200 ha per annum; and 1996 to 1998 – 2,500 ha per annum. For the Inverell 1:250,000 sheet map the following native vegetation clearing rates are documented: 1970 to 1984 – 8,000 ha per annum; 1984 to 1994 – 200 ha per annum; and 1994 to 1998 130 ha per annum.	Sivertsen 1995a & unpublished
South-west region: Riverina	For the period 1970-1995, no vegetation clearance data is currently known for this bioregion within NSW.	
	The vegetation has been described and mapped at 1:250,000 scale by the RBG.	Fox 1991; Scott 1992; Porteners *et al.* 1997
	Land systems mapping by DLWC cover the area. The mallee of Nombinee and Round Hill Nature Reserves in the northern part of the Bioregion has been documented and mapped at 1:100 000 scale.	Cohn 1995
	To assist with regional vegetation assessments, DLWC has combined the RBG mapping with the BASINCARE M305 data to produce a 1:100 000 vegetation map for the southern mallee planning region section of the Bioregion.	Val 1997

5: AUSTRALIAN CAPITAL TERRITORY

5.1 INTRODUCTION

The Australian Capital Territory (ACT) is totally surrounded by New South Wales. Although the smallest jurisdiction in terms of area of land within Australia, covering only 2,358 km^2 or 0.03% of the landmass, it has the largest inland city, Canberra. Most land was cleared well before the 1970s, and extensive areas of remaining bushland have been set aside as Public Land with statutory management objectives for conservation of the natural environment (ACT Parks and Conservation Service 1998, p. 13). These areas include a major part of the southern portion of the Territory, as well as reserved land throughout the Canberra cityscape.

The city of Canberra was developed as the National Capital, with the public service and other urban-related developments and employment opportunities providing the basis for urban expansion. Much of the urban expansion has been on previously cleared rural land. Rural residential developments associated with the city continue to expand into former farmland, but these are situated largely in surrounding New South Wales.

5.2 MOTIVATORS FOR LAND CLEARANCE

Urban expansion

Although Canberra is a small city by world standards, within the context of the South Eastern Highlands region and the jurisdiction of the ACT, it is significant in terms of land use change. For example, for the period 1971 to 1986, the population grew from 141,000 to 259,000, an increase of over 80% in the fifteen-year period. This growth resulted in the development of thirty-one new suburbs, which has resulted in the removal of some small areas of remnant vegetation, but the city has been planned so that much of the remaining woodland is retained.

The ACT does not have its own distinctive biogeographical region. Instead, it is predominantly within the South Eastern Highlands IBRA region, and a smaller land area is within the Australian Alps region.

Summary of land clearing rates and causes in the major zones of activity, ACT, 1970-1990.

Zone	Biogeographic regions (IBRA)*	Rate of clearing 1980-1990 (ha/yr)	Primary drivers	Clearing pattern
ACT 	South Eastern Highlands	<1000	Urban expansion, some wool production	Secondary clearing of remnants. Patch size: small Vegetation cleared: open forest and woodland

* following Thackway and Cresswell (1995)

5.3 DISTRIBUTION OF LAND CLEARING

The ACT is highly urbanised, with the vast majority of people within the Territory living in Canberra. Additionally, the majority of the ACT has been set aside as Public Land for conservation of the natural environment. During 1990, agricultural activities in the ACT utilised only 61,000 ha of land.

Urban development has had the greatest impact on land clearing within the ACT. This impact is reasonably insignificant for the period 1970 to 1995 as the development has been, in the main, on areas that had previously been cleared for primary production purposes.

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Summary of data on clearing in the ACT, 1970-1990, and their source.

Region	Description of data	Source
All	1990-1992 MSS satellite image data were used to map the type, severity and extent of landcover disturbance across Australia, analysed at a scale of 500x500m. The ACT falls entirely into the ILZ category, with 48.7% of area uncleared, 13.9% thinned, 37.4%, and 51.3% both thinned and cleared (p. 34).	Graetz *et al.* 1995
	The ACT Mapping Office (ACTMO) is responsible for the programming, flight planning, acquisition and reproduction of aerial photography over Canberra and the surrounding region. A collection of colour aerial photography from the past twenty-five years, and a limited black and white coverage dating back to the early 1950s is available. The collection comprises high level vertical colour photography at a scale of 1:25,000, with overlapped scenes to provide stereoscopic coverage. Adjacent runs also overlap. Coverage generally extends from Lake George to Bredbo and from Wee Jasper to Bungendore. Development records are also available in the form of vertical colour photography at a scale of 1:10,000, stereoscopic coverage and overlapping adjacent images. Coverage generally extends from north of the ACT border to Tharwa, and from the Murrumbidgee River in the west to Sutton Road in the east and including Queanbeyan. In some years, coverage was extended past these areas. Oblique photo images are also available, covering developing areas and sites of special interest.	ACT Land Information Centre (ACTLIC) Aerial photography stored at: Planning and Land Management (PALM), 16 Challis Street, DICKSON, ACT, 2605
	A Digital Cadastral Data Base (DCDB) of the ACT began in 1972. The system currently exists under the name of ACTMAP with all cadastral data utilising survey calculations to ensure accuracy. All blocks of land created since 1992 have been captured from digital data provided by surveyors. ACTMAP is linked to a textual database and is used for land administration purposes. It includes data sets such as: urban and rural blocks with identifiers; unit title boundaries; topographic information and images including LANDSAT/SPOT satellite imagery; selected 1:10,000 aerial photography; and selected deposited plans.	
	Compares vegetation cover for the periods 30 June 1980 and 1990. Demonstrates that there has been no clearing of forest or woodland cover within the ACT and that there is a slight increase in plantation forestry (up from 14,000 ha to 15,000 ha, a rise from 5.8% of plantation forestry in 1980 to 6.3% in 1990 (p. 45).	Castles 1992
	According to this report, 'broadscale clearance of woody native vegetation has ceased…no woody native vegetation was cleared between 1983 and 1993' (p. 36, quoting Rob Corey, ACT Dept. of Environment, Land and Planning, as cited in the NGGIC 1994, p. 129b).	Biodiversity Unit 1995
	Includes LANDSAT FCC images of Canberra from August 1972 and January 1988. Also includes growth statistics for all Australian capital cities during the period 1971 and 1989. Canberra (including Queanbeyan) has the highest relative growth of 91%. A second considers the proportion of the total state population residing in each capital city for the period 1971 and 1989. Canberra was the capital with the greater percentage of state population residing in the city: 99% of people in 1971 and 100% in 1989 (p. 38).	Graetz *et al.* 1995

6: VICTORIA

6.1 INTRODUCTION

Victoria (Vic) is the smallest and most densely populated and urbanised of the mainland States. Much of the land is suited to agriculture, with intensive farming in the southeast and extensive grazing in the southwest. The far northwest is largely mallee desert, but there are irrigated vineyards along the Murray River, and the northeast is mountainous and unsuited to agriculture except along the valleys.

According to a report based on 1990-1992 satellite image data, in terms of relative area, Vic has experienced the largest level of clearing since European settlement of all States and Territories (Graetz *et al.* 1995, p. 34). Victoria's forests and woodlands were estimated to have covered some 88% of the State. Since European settlement in the 1830s, over 53% of the State has been cleared (Biodiversity Unit 1995, p. 32).

The pattern of clearing closely followed land types, which reflected the capability of land for agriculture. Most clearance occurred on the plains of northern and northwestern Vic and coastal Gippsland, extending into the highlands along the relatively flat and fertile valley floors.

Using satellite image analysis, Woodgate and Black (1988) estimated an annual gross clearing rate (excluding re-forestation) of 15,392 ha per year for the period 1972 to 1987. This mostly took place on private land around Mildura and Horsham, and mainly during the 1980s. Clearing in the Mildura area was largely for irrigated farming, while in Horsham the activity centred around a shift from wool to wheat production. In the late 1980s, with a shift in attitude towards conservation, and removal of government incentives, the rate of clearing began to decline.

The main driver for land clearing during the 1970s and 1980s was the switch in importance from grazing to cropping. Declining terms of trade meant farmers had to clear remnants to expand the area of their properties available for cropping.

6.2 MOTIVATORS FOR LAND CLEARANCE

Environmental and social influences

The pattern of clearing in Vic was well established prior to 1970-1990. Land clearing followed the economic development of the pastoral industry (Woodgate & Black 1988, p. 3) that began in the 1860s and was fostered by land development schemes. The establishment of irrigation areas, closer settlement initiatives, and the development of transport infrastructure further facilitated agricultural development and, thus, land clearance. This pioneering spirit of developing the land prevailed until the 1970s, supported by government incentives. In the early 1980s, with little land left to develop, and a growing awareness of the effects of land degradation, there was a swing towards conservation of remaining woodland and forest.

Clearing controls

Native vegetation clearing controls on private land were introduced in 1989 as an amendment to the *Planning and Environment Act 1987*. Fear of impending controls may have lead to some clearing but, overall, Gilbee (1999) reports that the Act resulted in a significant reduction in clearing.

Financial and institutional incentives

Land development schemes

By 1970, the era of government-backed rural development schemes was ending. Early in 1968 a proposal to develop approximately 200,000 ha of mallee vegetation in the Little Desert area was put forward. The Little Desert Settlement Scheme was among the last of many proposals for agricultural settlement of Australia's semi-arid areas (Robin 1998, p. 28-29). It was to be a small-holding settlement scheme aimed at decentralisation and

agricultural development of unused land. By mid-1969, the proposal was scaled down in response to a lobby for the area to be set aside as a National Park. This lobby was significant in Australia's history, and in terms of land clearing, as it was one of the early signs of changing community attitudes towards the environment.

Another significant result of the Little Desert controversy was the establishment of the Land Conservation Council by the Victorian Government. The allocation of Crown Land would be subsequently subject to public hearings, expert advice and a transparent decision-making process.

Finance

For about twenty years, beginning in the mid 1960s, and initiated by the Commonwealth Development Bank, banks offered easily obtained loans for rural development including clearing. During the same period the Government encouraged development by providing taxation concessions for developmental costs. These incentives and concessions ceased in the early 1980s.

Market forces: new markets, changing commodity prices

During the period 1970-1990, declining terms of trade for grazing industries resulted in an expansion of wheat cropping. Much of this expansion took place on land that was already cleared and involved clearing of remnant stands of vegetation. In western Vic, land was also cleared for lupin cropping, from 1970 until the introduction of clearing controls in 1989.

New infrastructure

In the 1970s, construction of the Dartmouth Dam, northeastern Vic, and Thompson Dam, Central Gippsland, resulted in clearing. Although the dams were mainly to produce hydroelectricity, they released some water for irrigation, which allowed more intensive farming and further clearing of remnant vegetation.

The Millewa Stock and Domestic Pipeline was opened in 1975. It provided water to 227,000 ha of sheep and wheat properties in the Millewa area west of Mildura and may have contributed to land clearing in the region (Eastburn 1990, p. 49).

Urban expansion

Urban expansion and associated small rural residential developments have caused clearing in Vic. However, clearing for suburbs did not occur on the same scale as on the north coast of NSW and in parts of Qld.

6.3 DISTRIBUTION OF LAND CLEARING

A comprehensive statewide study, undertaken by Woodgate and Black (1988), compared satellite imagery from 1972–1982 and estimated the average annual clearing rate to be 15,392 ha per year. Most clearing occurred on freehold land in the western regions of Mildura, Horsham and Portland. Clearing on public land between 1972 and 1987 totalled 36,498 ha while re-forestation totalled 31,568 ha, which included tree removal to establish the Dartmouth and Thompson Dams (5,914 and 1,900 ha, respectively).

A study in eastern Vic, to determine whether permits for clearing matched the areas that were being cleared, found that permits for the period 1989 to 1993 indicated that 15,136 ha were cleared, but there were inconsistencies with actual clearing.

Summary of land clearing rates and causes in the major zones of activity, Vic, 1970-1990.

Zone	Biogeographic regions (IBRA)*	Rate of clearing 1980-1990 (ha/yr)	Primary drivers	Clearing pattern
Central Northern 	NSW South Western Slopes, Riverina, South Eastern Highlands, Australian Alps	<10,000	Wool, beef, milk and wheat production, orchards in irrigated areas.	Patch size: 50-100 ha Vegetation cleared: Open forest
Western Coastal 	Victorian Volcanic Plain, Naracoorte Coastal Plain	<1,000	Wool, beef and wheat production, urban/industrial expansion.	Patch size: 50-100 ha Vegetation cleared: Open forest and woodland
South-eastern and Midlands 	Victorian Midlands, South East Coastal Plain, South East Corner	<10,000	Wool, beef, milk, and wheat production, viticulture, and urban/industrial expansion.	Patch size: 50-100 ha Vegetation cleared: Open forest and woodland
Western 	Murray-Darling Depression	<100,000	Wool, wheat and milk production, horticulture in irrigated areas.	Major period was 1985-1989 Patch size: >100 ha Vegetation cleared: Mallee and open Woodland

* following Thackway and Cresswell (1995)

Central north

The central northern zone comprises the NSW South Western Slopes, Riverina, South Eastern Highlands and Australian Alps. The NSW South Western Slopes and the Riverina bioregions were settled in the nineteenth century and remain major farming areas. By contrast, the Victorian Highlands area is generally sparsely settled, despite the efforts of early pioneers to develop agricultural and mining pursuits.

Agriculture and forestry make up the major land uses within the NSW South West Slope bioregion, with sheep and cattle grazing, and some dairy farming, in the more fertile valleys. Much of the Riverina bioregion's land is used for cereal cropping and sheep grazing, and some irrigated areas produce dairy products and fruit.

The flatter and lower areas of the South East Highland bioregion have also been used for beef cattle and sheep grazing, and in more heavily settled areas, dairy farming. Tourism and recreation are also major industries. In catchment areas, water production is an important use of public land, some of which is also used for grazing and apiculture. The majority of the Otway Ranges is covered in forest and heath vegetation. In the ranges, timber harvesting, dairying, potato production and beef cattle grazing are major industries.

Generally, clearing has been extensive throughout the central north, although some remnants of native vegetation remain.

In the 1970s, land was cleared for the creation of the Dartmouth Dam, in the north-east, and the Thompson Dam, in central Gippsland.

Western coastal zone

The Victorian Volcanic and Naracoorte Coastal Plains are situated in Victoria's western coastal zone. The Victorian Volcanic Plain was formed from volcanic activity in south-western Vic. The climate is mild to temperate with annual rainfall ranging from 500 to 700 mm. The Victorian section of the Naracoorte Coastal Plain is located in the south-western corner of the State, extending for about 230 kilometres along the coast. This bioregion is mainly flat with parallel dune limestone ridges, swampy areas and limestone depressions.

The major land use in the Victorian Volcanic region is sheep and cattle grazing, as well as cropping in the north. Settlement includes areas on the outskirts of Melbourne, parts of Geelong and Ballarat. Urban and industrial developments continue to expand from these cities. The region was one of the first areas of agricultural settlement in Vic. Hence, large areas have been cleared, most prior to the 1970-1995 period. However, remote sensing data and interviews indicate that clearing was ongoing in the Portland area for the period 1972 to 1987 and, to a lesser extent, 1990 to 1993. This recent clearing appears to be predominantly associated with the establishment of plantations.

On the Naracoorte Coastal Plain, hardwood forestry within State Forests makes up almost 30% of the bioregion. About half of the bioregion has been cleared for agricultural or plantation purposes and, of the remaining 50% of natural vegetation, 40% is made up of National Parks and Conservation Reserves.

South-east and midlands

The South East Corner bioregion includes the East Gippsland Uplands and the East Gippsland Lowlands bioregions. Only a small part of the bioregion has been cleared and the area supports extensive forests and other native vegetation. The Victorian Midlands bioregion includes patches of woodland and forest, with agricultural pastures and some crops.

The exception is the South Eastern Highlands bioregion, where over 75% of the vegetation cover remains. In the Highlands, the river valleys of the Dandenong and Strezeleki Ranges, on the edge of the region, are the main centres of clearing.

The major primary industries within the south-east and midlands are sheep and cattle grazing, cropping and viticulture, mining and timber production and some dairy farming. In the South East Corner bioregion, nature conservation is the major land use, although timber harvesting, fisheries and tourism are also important.

Urban land use is associated with Geelong and other centres in the south-east such as Colac. Brown coal is mined near Anglesea, west of Geelong.

Land use in the Gippsland Plain bioregion includes urban development associated with Melbourne's central business district, Mornington Peninsula and the La Trobe Valley. Dairy farming, sheep, beef, potato production, hardwood and softwood plantations and brown coal mining are also important industries. The fertile, flatter land has been largely cleared, for agricultural, urban or other development uses.

Western zone

This region is part of the Murray-Darling Depression bioregion and lies in the corner of Vic between the Murray River and the Avoca River in the east. It includes the major regional centres of Horsham, Mildura and Swan Hill.

Within Vic, the Murray-Darling Depression has few surface water areas and its soils are highly permeable. Annual rainfall ranges from 500 mm in the south to less than 250 mm in the north. The region includes two Victorian catchments: the Mallee and the Wimmera. In the Murray Mallee and the Wimmera vegetation, communities associated with the better agricultural soils have been cleared. These communities include Grassland, Plains Grassy Woodland, Wimmera Mallee Woodland, Slender Cypress-pine and Buloke and Belah woodlands.

The area was settled early and has been heavily cleared and farmed. Cereal and coarse grain cropping, and livestock industries are dominant in the dryland areas. Irrigated horticulture occurs along the Murray and Wimmera Rivers.

Approximately 70% of Victoria's mallee vegetation has been cleared. Gilbee (1999) reports that, for the 1990-1993 period, the Mildura area has the greatest loss of permanent tree cover on freehold land in Australia.

Woodgate and Black (1988) report that the Mildura and Horsham areas contributed a large proportion of clearing for the period 1972 to 1987. In both regions, clearing was predominantly on privately owned land for agricultural purposes – for irrigated farming in the case of Mildura, and wheat cropping in the case of Horsham. The peak of this activity is thought to be in the mid-1980s, up until the introduction of controls in 1989. Over the same period, no decrease in permanent tree cover was recorded on public land.

Gilbee (1999) demonstrates that controls were effective – between 1990 and 1993, tree cover loss on freehold land due to agricultural clearing was recorded as 1,773 ha in the Mildura region and 746 ha around Horsham, which were substantially reduced rates.

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Summary of data on clearing in Vic, 1970-1990, and their source.

Region	Description of data	Source
All	State forest type map at a scale of 1:1,000,000, the result of an examination of all forest type maps, with gaps filled with mapping from aerial photographs and hardcopy LANDSAT imagery.	Edwards 1983 cited in Gilbee (1999, p. 11)
	In 1988 the Remote Sensing Group undertook the first comprehensive tree cover study, designed to give a strategic picture of woody vegetation across the State. The study used LANDSAT MSS hardcopy transparencies (1:1,000,000), which were visually interpreted to provide information about the extent of tree cover in 1972 and 1987 and to document the change between these two years. The mapping was at a scale of 1:500,000 with a minimum mapping unit of about 15 ha. The report provides a comprehensive review of its method, a map, and a historic account of clearing.	Woodgate & Black 1988
	Tree Vic commissioned a study in 1993 to compare the changes in woody vegetation in 1990 and 1993 across the State. A finding of the study was the majority of changes tended to be dynamic changes within the native forest, such as those resulting from fire and seasonal change. It utilised digital LANDSAT TM data allowing the whole State to be mapped at the scale of 1:100,000 with a minimum mapping unit of one ha. Computer-based classifications were used to interpret images, which reduced reliance on manual interpretation. This study also provides an excellent critique of problems associated with the collection, comparison and interpretation of remote sensing data.	Gilbee (1999)
Western Division and entire State	A second study was commissioned by the Victorian Greenhouse Unit to identify tree cover change in 1987 and 1990, in the western division of Vic. This area was selected because of the land clearing that had taken place in recent times and because of the small amount of tree cover available on freehold land and the rate at which it was being cleared. LANDSAT TM data were used, allowing for a minimum mapped area of about 6 ha and an output scale of 1:250,000. The study also went back over the entire State and quantified forest loss by type between 1972 and 1987 using existing sources such as Edwards (1983) as cited in Gilbee (1999).	Frisina *et al.* 1991 cited in Gilbee (1999)

7: TASMANIA

7.1 INTRODUCTION

Tasmania (Tas) has plentiful water, rich soil and extensive forests. Minerals, forestry and hydroelectricity for industry are the State's main resources. Since European settlement about one-quarter of the native vegetation cover in Tas has been cleared, mainly for grazing. Much of Tas is mountainous, and plains suitable for agriculture are found only in the northeast, midlands, central highlands and far northwest.

In Tas 39% of the land is private land and of the remaining 60% public land. Some 40% of the land mass is in reserves and 20% managed by the State for multiple use forestry. The public areas managed by the State for multiple use forestry are required by law to be regenerated following harvest.

In the 1970s and 1980s, significant clearance of native vegetation occurred for agricultural purposes. Nevertheless, the rate of clearing declined by more than 40% over the period. Most conversion of forest to pasture occurred along the margins of already cleared land or in remnant patches of native vegetation. Clearing was undertaken almost totally in dry eucalypt forests in the east and north east of the State. There was also some clearing for hydroelectric impoundments.

7.2 MOTIVATORS FOR LAND CLEARANCE

Environmental and social influences

Until the mid-70s land clearing was seen as progressing the State's economic interests. Very few rural councils had planning schemes and there was a marked reluctance to enforce stricter control on land clearance. This philosophy permeated government policies and programs up to the mid-1980s. In the mid-1980s it was recognised that the potential for the private forest estate to continue to supply wood was being compromised by the level of harvest, the conversion of forests to other uses and the failure to properly manage the private forested estate.

The Everett Gentle (1977) report recommended the introduction of a Forest Practices Act to regulate operations in the forest and a quota system to regulate the total pulpwood yield from private land. *The Forest Practices Act* was introduced in 1985 and the pulpwood yield regulated by export licenses.

During the 1980s, with the removal of many economic incentives to clear and a scarcity of potential farmland, a shift in attitude occurred. Many landholders viewed the presence of native vegetation on their property as a benefit rather than a disadvantage. Only occasionally was it seen as a refuge for pests and a potential fire hazard, that would be better cleared.

The rate of clearance decreased by about 40% between the periods 1972-80 and 1980-88. This decline could possibly reflect the reduced availability of natural vegetation and deep soils on relatively flat private land.

Financial and institutional incentives

Finance

In the early 1970s land owners were able to sell wood to a woodchip export company. Prior to this only land owners close to the two domestic paper mills were able to sell pulpwood. In many cases, especially along the east coast, owners received payments for the sale of their wood under contracts that allowed the buyer to harvest the wood decades into the future. This cash income was very important during a period of exceptional economic stress.

Various taxation concessions provided under the *Commonwealth Income Tax Assessment Act* provided economic drivers for clearing. These were reduced over a number of years, finally being removed in 1983.

The establishment of the Commonwealth Development Bank in 1965 made finance readily available to farmers for land development, including clearing. Other financial institutions soon began to offer similar support for rural development and this continued until the early 1980s.

Land tenure

The advent of the woodchip industry in the 1970s presented those landholders, with native forest, an opportunity to sell timber and use the funds to finance the conversion of harvested areas to agricultural and pastoral uses.

The export woodchip operators were required under their export license to regenerate forests harvested. Under the first license issued in the 1970s to Northern Woodchips, a company relying wholly on the private forest estate for supply, regenerated a set area each year. By 1986 all export licenses required that for each 1,000 tonnes of conventional pulpwood harvested, 1 ha of plantation was to be established anywhere in the State and 4 ha regenerated in the Forwood zone or region where the wood was harvested.

The license holders were required to report on the areas regenerated and planted. Both the regenerated and plantation areas had to be surveyed to ensure they were adequately regenerated or established as plantation.

To encourage land owners to regenerate their land, an extra regeneration payment was made in addition to the base payment, for the wood harvested from areas that were to be reforested. The export license holder also undertook the necessary operations to regenerate the forest. Similar incentive schemes were also available if the land owner wished to establish a plantation on an area harvested. During this period the State Government also funded incentive schemes to encourage land owners to establish plantations or actively manage their native forest.

Innovations: new breeds, techniques and practices

Agriculture in Tas underwent significant change in the two decades before 1970, when extra revenue from increasing commodity prices enabled farmers to reinvest in their land. Fertilisers and other trace elements were used to boost productivity and make poorer land productive for grazing. In the midlands area, for example, most farmers used molybdenum phosphate to improve pasture production. In coastal areas, cattle failed to thrive until the trace element cobalt was applied.

New crops and pastures

In the 1970s apples ceased to be an important crop when Tas lost its British markets, but new varieties were developed for the mainland market. This entailed only a small increase in the clearing.

Market forces: new markets, changing commodity prices

The grassy woodlands of the State are ideal for producing fine wool. In the late 1960s to early 1970s a rise in commodity prices for fine wool became a driver for clearing to expand pasture and for the use of woodlands and dry forest areas for grazing. Fire was used to modify the woodland and forest understorey to favour the grasses and herbs. Once the land had been cleared, the conditions that favoured the production of fine wool were lost.

By 1973/74 there was an oversupply of agricultural land, so only limited conversion of native vegetation areas to improved pasture or cropping was occurring. The only district where this was not the case was the north west area, where conversion from broadscale sheep and beef enterprises to more intensive dairy farming took place in the mid 1970s and late 1980s and involved some clearing to expand existing pasture.

Urban expansion

The coastal fringe of Tasmania's north and some areas around the major population centres of Hobart and Launceston were developed for small-scale settlements such as hobby farms. Land was cleared for houses and associated buildings and paddocks. For example, in the north east region of the State, heath and dry sclerophyll were cleared for urban and hobby farming activities. Around the urban fringes north of Hobart, forest was cleared for large housing developments in the 1980s.

7.3 DISTRIBUTION OF LAND CLEARING

The most comprehensive data for Tas as a whole is Kirkpatrick's and colleague's work, which records native vegetation removal from 1972-1980 (Kirkpatrick & Dickenson 1982), from 1980-1988 (Kirkpatrick 1991) and from 1988-1994 (Kirkpatrick & Jenkin 1996). However, concern has been raised by Private Forests Tas regarding the accuracy of the data, especially the efficacy of the techniques used to distinguish between clearing for agriculture as opposed to clearing for forest plantation or areas harvested and being regenerated.

The following clearing rates reported for Tas show that clearing declined significantly during the 1980s:

- 1972-1980: 14,000 ha per annum (excluding clearing for forestry purposes and hydro-electric impoundments) (Kirkpatrick & Dickenson 1982);
- 1980-1988: 6,000 ha per annum (native vegetation clearance rates for each of Tasmania's vegetation types) with the higher rates (greater than 1,000 ha per annum) in the lower biomass open forests and woodlands (Kirkpatrick 1991); and,
- 1988-1994: 3,525 ha through dam impoundment and 5,000 ha from clearing for agriculture (Kirkpatrick & Jenkin 1996).

Useful data sets in relation to size distribution of patches cleared, especially in the smaller size categories, are not available at a State or bioregional level. Any data sets that include information about size distributions tend to be based on techniques which mask small area clearing event sizes. A data set for private forest land is available, but the native vegetation cover changes are based on widely disparate time frames.

Although no accurate bioregional assessment is possible with Kirkpatrick and Dickenson's (1982) data, a generalised distribution map in Kirkpatrick and Dickenson (1982) shows the areas converted to pasture are predominantly in the Woolnorth, Ben Lomond, and Tasmanian Midlands bioregions.

Summary of land clearing rates and causes in the major zones of activity, Tas, 1970-1990.

Zone	Biogeographic regions (IBRA)*	Rate of clearing 1980-1990 (ha/yr)	Primary drivers	Clearing pattern
Northern 	Woolnorth	<10,000	Wool production	Patch size: Vegetation cleared: open forest
Western 	West and South West	<10,000	Wool production, dam impoundment	Patch size: Vegetation cleared: open forest and some closed forest

* following Thackway and Cresswell (1995)

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Summary of data on clearing in Tas, 1970-1990, and their source.

Region	Description of data	Source
	In the 1970s the rate of logging on private land expanded to supply the new export pulpwood market. Between 1973 and 1975 the Silvicultural Branch of the Forestry Commission carried out sample surveys to determine the post harvest land use. In 1979 the Private Forestry Division surveyed land logged between 1975 and 1978. A third survey was undertaken in 1983 of the areas logged between July 1978 and June 1983. In all cases the area sampled were visited and the landowner interviewed. The surveys were only conducted on areas logged by the export woodchip operators. No surveys were undertaken of areas where logging supplied wood to domestic paper producers (ANM at Boyer and APPM at Burnie).	Forestry Commission Tas 1993 & 1994
	On 45,120 ha logged to the end of 1974, 18,630ha (some 40 %) was converted to agricultural and pastoral development. In the period mid 1975 to mid 1978, 31,730 ha were logged with 11,740 ha (37 %) being converted to agricultural and pastoral development. In the period mid 1978 to mid 1982, 51,680 ha were logged with 21,754 ha (42%) was converted to agricultural and pastoral development.	
	Almost half of the logging by area occurring between 1978 and 1982 has occurred in the South East with most of the remainder in the North East. Of the logged area, about 40% is being converted to pasture, split almost evenly between the North East and the South East. No information was available for unlogged private forest being converted to pasture.	
	LANDSAT images at 1:250,000 were visually inspected and differences between the 1972 and 1980 images traced onto acetate overlays. Areas under 25 ha were considered difficult to distinguish. Areas of clearance on both private and public land for Pinus radiata plantations were calculated using Tasmanian Forest Commission data.	Kirkpatrick & Dickenson 1982
	Analysis of the satellite imagery, revealed that in the period 1972-1980 74,000 ha of native vegetation was converted to improved pasture. Of this, 69,500 ha was previously dry eucalypt forest with the remainder being heath country. 24,000 ha were cleared for forestry purposes and 51,800 ha inundated by hydro-electric impoundments. Based on these figures and excluding clearing for forestry purposes and hydro-electric impoundments, the annual clearing rate between 1972-1980 was approximately 14,000 ha per annum.	
	No accurate bioregional assessment is possible with this data. However, a generalised distribution map shows the areas converted to pasture as predominantly in the Woolnorth, Ben Lomond, and Tasmanian Midlands bioregions.	
	A Statewide value for loss of each of the vegetation types since 1802.	Kirkpatrick *et al.* 1995
	Native vegetation clearance rates for each of Tasmania's vegetation types – an average of 6,000 ha per annum with the higher rates (greater than 1,000 ha per annum) in the lower biomass open forests and woodlands. A small scale map showing areas of vegetation clearance and the generalised size distribution of the clearing is provided.	Kirkpatrick 1991

Region	Description of data	Source
	Vegetation clearance for agriculture, forest establishment and inundation in the period 1988-1994; 30,560 ha were cleared for agriculture and 3,525 ha through dam impoundment – a rate of clearing for agriculture of approximately 5,000 ha per annum. Highest rates of clearing were in the higher biomass forests but these were predominantly for forest plantation establishment. Predominantly, dry forest types were cleared for agriculture during this period.	Kirkpatrick & Jenkin 1996
	Although inundation of native vegetation from dam impoundment has been included as vegetation clearance in the literature, its impact on greenhouse gas production is equivocal.	Kirkpatrick & Jenkin 1996; Kirkpatrick & Dickenson 1982
	From analysis of satellite imagery, in the period 1972-1980, 51,800 ha were inundated by hydro-electric impoundments in West South West bioregion. From 1988-1994, 3,525 ha inundated.	
	1:500,000 black and white map of agricultural clearance and vegetation loss 1988-1994 accompanies.	Kirkpatrick & Jenkin 1996
	Aerial photography was used to delineate areas where the land cover had changed.	Taylor 1996
	Photography used for the 1989 review (Private Forest Council 1989) of the private forest resource was compared with more recent photography. The number of years between the air photographs used varied considerably across Tas.	
	Field visits were undertaken to verify boundaries, to determine the new land cover and owner intentions. In total 5,740 individual areas had changed forest cover. A database of the changes was complied from the field data. This database records actual changes in land cover and the reason for that change. It is not possible to link the change in land cover with actual area changed. The database records individual incidents of change only and not the area changed.	
	The holdings owned by North Forest Products were not included in the field survey. The survey records that 35% of changes resulted in the development for pasture/agriculture.	
	Detailed information on the previous land cover was not available for all 5740 changes. Of the 5740 changes: • in 1,285 incidents, forest was changed to plantation (57 incidents), or converted to agriculture (1,108) or residential or similar uses (120); and. • in 636 incidents, areas fire damaged, bracken, pine plantation, scrub or secondary species were converted to plantation (15 incidents), agricultural (433), selectively harvested (162), or residential or similar uses (26).	

Region	Description of data	Source
	In addition, a database of the actual area changed was established as part of the process to prepare the report. On 162 1:25,000 scale map sheets the area changed from one type of forest cover to another type of cover was measured. On the 162 map sheets forest changes had occurred on 115,253 ha: • of the 115,253 ha, 30,756 ha of forest was removed and replaced by agricultural cover. • on 29,263 ha the forest cover was replaced by plantation. • approximately 7,000 ha of forest cover was changed but the intended use was not recorded; and, • in total, areas converted to agriculture plus the areas partly converted, there were 31,735 ha of forest affected. The database records individual patches of forest cleared for use as agriculture on a map sheet by map sheet basis. These patches may span many landowners and could also be contiguous with cleared areas of adjoining map sheets. The largest patches of clearing for agriculture occurred on the map sheets with the longest gap between base year and update year photography. The largest 43 patches, all greater than 101 ha in total covered 8,812 ha. There were 117 patches, 50 ha or more in size covering in total 13,896 ha. Only 13,434 ha of the area converted were recorded as having pasture or crops on the land. The rest was either rough grazing with and without some minor cover retained (Peter Taylor Private Forest Tas, June 1999 pers. comm.).	

8: SOUTH AUSTRALIA

8.1 INTRODUCTION

South Australia (SA) is the State with the least area of woodland and forest. Since European settlement, it has been extensively cleared for agricultural production. Most of the clearing has been in the agricultural zone, about one-fifth of the State that has higher rainfall and is generally suitable for pasture and crops. In 1975, about 75% of the zone had long been cleared. Over the next decade or so this rose to 80%, mainly through clearing of remnants.

During the 1970s and early 1980s, the major areas of clearance, and the main areas where pressure continued for clearing approval, were Eyre Peninsula, especially the far west and north, the Upper and Lower Southeast and Kangaroo Island.

By the 1970s, the pioneering era of extensive land clearing for agricultural development had waned, in part because of a severe scarcity of undeveloped arable land for expansion. Nevertheless, many leases still had a requirement to clear and there were taxation incentives to do so. Other powerful incentives to clear included a desire to expand the area of productive land to accommodate the family or simply to remain profitable. In addition, research and development identified trace elements that, in small amounts, could make poor soils on marginal lands suitable for crops and pasture.

The period of rapid urban expansion had also ended. Although there was a greater demand for rural residential developments, these were often on land previously developed for agriculture and the need for further clearing was minimal.

In the early 1980s Commonwealth taxation incentives were removed. About the same time, pressure increased from a public concerned at the massive scale of destruction of native vegetation and loss of its associated fauna. This resulted in the introduction of State Government controls, which greatly slowed the rate of clearing. Under the *Native Vegetation Management Act of 1985*, the Government began offering financial assistance to landholders prepared to protect remnant native vegetation. More recently, in 1991, the *Native Vegetation Act* was passed. These measures were aimed at retaining native vegetation and have effectively put an end to broadscale clearing in SA.

Applications for clearing are now largely confined to scattered remnant trees on land being developed for vineyards, crops such as potatoes with pivot irrigation, and some olive orchards. The area approved for this type of clearing between April 1991 and June 1995 was 147 ha.

8.2 MOTIVATORS FOR LAND CLEARANCE

Environmental and social influences

The 1950s and 1960s were a period of agricultural expansion by clearing in SA. A fairly common belief was that the bush harboured native and introduced pests, increased fire risk and was useful only as firewood and rough farm timber, and this also favoured clearing.

This expansive period, when commodity prices were high, continued into the 1970s. The need to expand the family farm to accommodate children leaving school, but staying in the district to marry and establish families, was an important social motivator to clear. Such social patterns may not have contributed as dramatically to the amount of vegetation cleared as legal, economic and technological drivers, but they were general and significant.

Availability of land

Most arable land had been cleared and developed prior to the period 1970-1990, which was consequently marked by a general scarcity of arable land for development.

Clearing controls

In the early 1980s, removal of some of the economic concessions reduced the incentive to clear. However, legislative controls introduced as a result of widespread concern by the urban community at the loss of wildlife habitat and plant and animal species were the main reasons for a dramatic reduction in vegetation clearance.

The introduction of these controls was not greeted warmly by many of the rural community and many in the bureaucracy responsible for primary industry. This resulted in numerous meetings, negotiations, a High Court challenge and considerable stress for many farmers and their families.

Nevertheless, in 1983 the *Crown Lands Act* was amended to remove the requirement in existing lease conditions to clear vegetation. Regulations to control vegetation clearance were introduced under the *Planning Act 1982*. The *Native Vegetation Management Act 1985* offered financial assistance to landholders prepared to enter a Heritage Agreement to protect remnant native vegetation.

The *Native Vegetation Act 1991* addressed the issues of incentives and assistance to landholders to manage native vegetation on their properties and to limit clearing to circumstances that would facilitate the efficient use of land for primary production. From April 1991 to June 1995 approval was given to general clearance for property management on only 204 ha.

Re-vegetation is now generally a requirement of any clearance approvals and there are financial incentives through Heritage Agreements and Natural Heritage Trust funding to encourage tree planting.

Financial and institutional incentives

Land development schemes

War Service Land Settlement schemes were in place long before 1970. However, some of these were small holdings which, beginning in the 1980s, may have suffered from declining terms of trade, necessitating more extensive clearing and or amalgamation with neighbouring properties to expand the farming enterprise.

Finance

Various taxation concessions and incentives provided under the *Commonwealth Income Tax Assessment Act* provided economic drivers for clearing. Concessions under the *Income Tax Assessment Act* were reduced over a number of years, finally being removed in the August Budget in 1983.

The establishment of the Commonwealth Development Bank in 1965 made finance readily available to farmers for land development, including clearing. The success of this initiative saw other financial institutions offer similar support of rural development until the early 1980s.

Land tenure

Perpetual leases and agreements with covenant to purchase, which applied to almost 55% of the agricultural lands of the State, included a requirement to clear and maintain for cultivation or grazing a specified area (generally the bulk of the lease) within ten years of allotment. The requirement was repealed in 1983.

Local government rates were also levied and varied from district to district; the highest were generally for land adjacent to urban or suburban areas. The increased capital value of farmlands adjacent to suburbs did not benefit landowners wishing to remain on the land. Indeed, the high rates often forced premature subdivision and / or clearance.

Land Tax was collected by the State Government and was based on an assessment of the unimproved value of land. The value placed on land reflected its development potential rather than its existing uses. For example, land used for primary production received a statutory exemption of $40 000, but land held for conservation purposes received no relief.

Succession and gift duty were also based on the valuation of a property according to its development potential, and in some instances the amount owing was sufficiently large to force sale of all or part of a property. Subsequent pressures for land clearance to met this potential were often inevitable.

Innovations: new breeds, techniques and practices

New crops and pastures

Large parts of the agricultural regions of SA are deficient in trace elements. The discovery that application of small amounts of trace elements could increase productivity substantially was a major breakthrough for agriculture and contributed to much of the land clearance and development of the period 1970-1990. Experimentation with pasture cultivars led to the selection of new strains, which enabled pastures to be established in areas unsuitable for existing strains.

New machinery and techniques

Technological improvements in machinery for broad scale clearance and cultivation on stony soils improved the economics of land clearance and led to an increase in the rate of clearing.

Market forces: new markets, changing commodity prices

The 1950s and 1960s were decades of high prices for many rural commodities, and general national growth led to an expansion and intensification of farming. In some wheat-growing regions, such as the mallee lands of SA, expansion and intensification of cropping activities resulted in major clearing. After the 'wool boom' of the mid-70s to mid-80s, declining terms of trade and low commodity prices made it difficult for small holdings to remain viable. Consequently, further land clearing was seen as one way to maintain and/or expand production.

Terms of trade for pastoralists declined between 1970 and 1990, but they increased for landholders growing wheat, other grains and horticultural crops, all enterprises entailing clearing for the conversion of grazing land.

New infrastructure

Most of the infrastructural support systems for agriculture were in place before the 1970s. These include access to major ports, storage and loading facilities, and irrigation systems on the Murray River.

Urban expansion

The main period of urbanisation occurred before the 1970s, but the demand for hobby farms has grown, for example, on Kangaroo Island. This has entailed some clearing for housing and associated fire hazard reduction, which is controlled by local government regulation rather than the *Native Vegetation Act 1991*.

8.3 DISTRIBUTION OF LAND CLEARING

By comparison with other States and Territories, data on vegetation clearance in SA is substantial. Since the 1970s the State has collected remnant vegetation data to support vegetation management policy initiatives. However, only rarely is there quantitative data available to make temporally and spatially accurate comparisons. It is not until the advent of rigorous vegetation mapping from large scale (less than 1:60,000) air photography in the mid to late 1980s and 1990s that quantitative information became available. This mapping program however, has not been repeated to make a temporally comparable analysis possible.

Information on the size distribution of clearing events is also lacking. Early (1970s) information tended to not include small (less than 25–100 ha) blocks in original or derived mapping exercises. More recent mapping programs have not been repeated. Size distribution of existing remnants is available from the more recent intensive mapping programs, but is of little value in describing past clearing event size distributions.

Digital data sets covering the woody vegetation in SA are available for:

- 1976, based on air photo mosaics from 1967-1974;
- 1980, based on air photos (possibly included air photo mosaics) from 1967-1978;
- 1989, based on visual interpretation of 1988 1:250,000 LANDSAT images; and
- 1998, based on air photos from 1984-1997/98

As all the data sets, except for 1998, did not include small areas (less than 100 ha), the distribution and frequency of small area clearing events remain equivocal.

A detailed metadata of environmental data sets held in South Australian Government agencies is available.

Summary of land clearing rates and causes in the major zones of activity, SA, 1970-1990.

Zone	Biogeographic regions (IBRA)*	Rate of clearing 1980-1990 (ha/yr)	Primary drivers	Clearing pattern
South-west 	Eyre and Yorke Blocks	<10,000	Wheat and wool production	Expansion of agricultural area, and some secondary clearing of remnants Patch size: large Vegetation cleared: mainly woodland
Eastern Ranges 	Flinders and Olary Ranges, Murray Darling Depression	10,000–100,000	Wool and wheat production; horticulture in the southern part around the Murray River	Secondary clearing of remnants Patch size: mainly large patch size Vegetation cleared: woodland
Western 	Great Victoria Desert, Nullabor	<10,000	Wool production	Patch size: large Vegetation cleared: mainly woodland
South-east 	Lofty Block, Naracoorte Coastal Plain	<10,000	Wool, beef and wheat production, some intensive horticulture, urban expansion	Secondary clearing of remnants. Patch size: mainly large, but small patch size associated with urban expansion Vegetation cleared: mainly woodland

* following Thackway and Cresswell (1995)

South-west zone

The south-west zone is an area of 6,066,100 ha encompassing the Yorke Peninsula and Eyre Peninsula. It is typified by undulating to occasionally hilly calcarenite and calcrete plains and areas of aeolian sands, with low open woodlands, mallee woodlands, shrublands and heaths.

Cereal cultivation and livestock grazing dominate rural land use in the Eyre and Yorke Block bioregion. Rotational cereal cultivation and livestock grazing is more intensive in Yorke Peninsula than in Eyre. There is a small but important area of market gardening on the northern plains adjacent Adelaide.

By the turn of the century, the upper part of the Yorke Peninsula was all but cleared for cereal growing and grazing. The foot of the Yorke Peninsula had been only patchily cleared by 1945 and post-war developments for livestock and some cereal growing greatly extended the clearance. Similarly, the Eyre Peninsula underwent extensive post-war clearance and development. Technological changes brought clearance to the edges of the stony sheet calcrete country to open it for grazing. Much of the clearance represented intensification of agriculture in established farming districts on better soils.

For the Yorke Peninsula, native vegetation clearance rates varied from 750 ha to 2,000 ha per annum, from the early-mid 1970s to mid 1980s, to 600 ha per annum, from the early-mid 1970s to late 1980s. For the mid 1980s to late 1980s, a rate of 100 ha per annum was reported.

For the Eyre Peninsula, native vegetation clearing rates varied from 23,000 to 38,000 ha per annum from the mid-late 1960s and mid 1970s to the mid 1980s, to 20,000 ha per annum from the mid-late 1960s and mid 1970s to the late 1980s. A rate of 1,000 ha per annum was recorded for the mid 1980s to late 1980s.

Quantitative information on the size distribution of clearing events in the Eyre and Yorke Blocks bioregion is not available in the pre-1980s data sets because information tended to not be collected for small (less than 25-100 ha) blocks. From anecdotal information, however, it is apparent that large scale (>50 ha) clearing events predominated up to the mid 1980s for the Eyre Peninsula. Some minor, small scale clearing took place in the 1970s and 1980s on Yorke Peninsula, predominantly towards the south.

Eastern ranges

Murray-Darling Depression

Of the 197,480 ha of the Murray-Darling Depression IBRA bioregion, 47,103 ha are located within SA. The Murray-Darling Depression is a gently undulating, sand and clay plain frequently overlain by aeolian dunes and vegetated with semi arid woodlands, mallee shrublands and heath.

Much of the zone is marginal for cereal growing, the Murray-Darling Depression bioregion is mainly used for sheep grazing and cereal growing. Irrigated horticulture and grazing dominate the alluvial flats of the Murray River.

Large areas of the Murray-Darling Depression bioregion, generally south of the River Murray, were extensively cleared immediately before and after the Second World War, for livestock, mainly sheep grazing and more recently cereal cultivation. Stony ground south of Waikerie and east of Eudunda was cleared in the 1950s and 1960s, as were the deep infertile sands north of Lameroo and Pinnaroo. North of the River Murray, irrigated horticulture and viticulture and some cereal cropping in favourable years have extended clearance to the north.

For the Murray-Darling, native vegetation clearance rates varied from 7,000 ha per annum from the early 1970s to mid 1980s, and 3,000 ha per annum

from the early 1970s to late 1980s, to 3,500 ha per annum from early 1970s to mid 1980s. For the mid 1980s to late 1980s a rate of 1,500 ha per annum has been documented.

Quantitative information on the size distribution of clearing events in the Murray-Darling bioregion is not available because few records were kept on blocks less than 25-100 ha in area. From anecdotal information, however, it is apparent that large scale (>50 ha) clearing events predominated in all areas up to the mid 1980s.

Western zone

The western zone comprises the Great Victoria Desert and Nullabor Plain, where the climate is arid and the sparse woodland vegetation has been lightly cleared for sheep grazing, mainly to produce wool.

South-eastern zone

Lofty Block

The Lofty Block is a bioregion comprising 2,375,200 ha of temperate uplands which include the Adelaide Hills, Fleurieu Peninsula, Kangaroo Island and Mid and Upper North (Thackway & Cresswell 1995). Once dominated by eucalypt open forests, woodlands and heaths, it is now largely cleared for agriculture and urban settlement. The Lofty Block bioregion includes areas referred to in the literature as the Mount Lofty Ranges, Kangaroo Island and Mid North. Although considered to be part of the south-western zone, Eyre and Yorke Blocks bioregion, the Adelaide Plains have usually been included as part of the Lofty Ranges bioregion data sets.

The Lofty Block includes some of the most productive and intensively used agricultural lands in SA. Major land uses range from intensive horticulture, conservation and cropping to extensive livestock grazing. Urban, recreation, water storage and introduced pine plantation forestry are minor uses within the bioregion.

The Adelaide Plains were largely cleared by the early twentieth century. The Mt Lofty Ranges and Fleurieu Peninsula were cleared extensively, for sheep, cattle grazing and some improved pasture, after the Second World War. Clearance of Kangaroo Island for improved sheep pasture also accelerated dramatically after the Second World War with War Service Land Settlement, and in the 1960s and 1970s through private development. In the Mid and Upper North, with the exception of the crests and upper slopes of ridges, good-soiled land was cleared for cereal growing and grazing.

For the Mt Lofty Ranges, native vegetation clearing rates varied from 2,500 ha per annum in the 1940s to late 1960s, to 1,800 ha per annum in the late 1960s to mid 1970s, 1,400 ha per annum in the mid 1970s to mid 1980s, 250 ha per annum in the mid 1970s to late 1980s, and 10 ha per annum in the mid 1980s to late 1980s. Consents to clear broadacre native vegetation amounted 107 ha in the period 1983 to 1995, with 67 ha of this approved to be cleared in 1983.

Native vegetation clearance rates on Kangaroo Island varied from 2,250 ha per annum in the mid 1970s to mid 1980s, to 4,200 ha per annum in the mid 1970s to mid 1980s, 3,500 ha per annum from the mid 1970s to late 1980s, and 500 ha per annum from the mid 1980s to late 1980s.

Native vegetation clearing rates in the mid-north of the Lofty Block bioregion varied from 5,500 ha per annum in the mid 1960s to mid 1970s, to 1,000 ha per annum in the mid 1960s to mid 1970s and 500 ha per annum in the mid to late 1980s.

Quantitative information on the size distribution of clearing events in the Lofty Block bioregion is not available for the pre-1980s because collated information tended to not include small blocks. From anecdotal information, however, it is apparent that up to the late 1970s, large scale (>50 ha) clearing events predominated in all areas except the Adelaide Hills. Small scale clearing predominated in the small cadastral-sized blocks close to Adelaide, and where remnant patch size was already small. Since the mid 1980s, there has only been small area clearing.

Naracoorte coastal plain

Of the 2,890,500 ha Naracoorte Coastal Plain bioregion, 2,368,800 ha lie within the south-east of SA. South Australian data normally refers to this bioregion as the Lower and Upper South East. The Naracoorte Coastal Plain is a broad coastal plain of Tertiary and Quaternary sediments with a regular series of calcareous sand ridges separated by inter dune swales. Vegetation is dominated by woodlands with healthy understoreys and mallee shrublands with wet heaths in the inter-dune swales (Thackway & Cresswell 1995).

Land use is dominated by livestock grazing, with dairying in the higher rainfall areas of the south, sheep grazing over much of the bioregion, especially the north, and beef cattle over the remainder. Horticulture is centred around Mt Gambier and increasing areas are turned to viticulture in the Coonawarra and Padthaway districts. Plantation forestry occurs in the higher rainfall areas of the south.

By the late 1940s, clearance in the South Australian part of the Naracoorte Coastal Plain was of limited extent, the majority being used for low intensity pastoralism on unimproved lands. Post-war this changed dramatically. The combined State and Commonwealth War Service Land Settlement Schemes and AMP schemes, along with private development for grazing, led to clearance of over 350,000 ha.

For the Lower South East, native vegetation clearing rates varied from 1,700 to 3,000 ha per annum in the early-mid 1970s to mid 1980s, to 1,500 ha per annum from the early-mid 1970s to late 1980s. A rate of 200 ha per annum was recorded for the mid 1980s to late 1980s.

In the Upper South East, native vegetation clearance rates varied from 9,500 to 10,500 ha per annum in the late 1960s and early 1970s to mid 1980s, to 9,000 ha per annum from the late 1960s and early 1970s to late 1980s. From the mid 1980s to late 1980s a rate of 700 ha per annum was recorded.

Quantitative information on the size distribution of clearing events in the Naracoorte Coastal Plain bioregion is not available in the pre-1990s data sets because information was not often collected on small blocks. However, from anecdotal information, it is apparent that large scale clearing events predominated up to the mid 1980s.

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Summary of data on clearing in SA, 1970-1990, and their source.

Region	Description of data	Source
All	Table 2 provides a summary from 1945-1983 of the annual soil conservation works under the *Soil Conservation Act*, sourced from *Soil Conservation Act* Annual Reports. Information is provided on areas inspected, based on areas for which an application had been made to clear under the *Soil Conservation Act*. No details are currently available on areas given permission to clear.	Matheson 1983
	Records remaining vegetation based on air photo mosaics, 1967-1974, for all Hundreds in southern agricultural regions of SA, arranged by County and region. Harris holds original detailed cadastral plans showing remaining vegetation.	Harris 1976
	Map at 1:1,000,000 scale based on air photos mosaics from 1967-1974, showing cleared and uncleared agricultural land. Exact distribution of dates of air photo mosaics used difficult to determine.	Harris 1976
	Digital data set based on Harris (1976) and 1967-1978 aerial photography and updated in some areas with more recent 1978 aerial photography for the South East, Kangaroo Island, Lower Eyre Peninsula and with 1975 aerial photography for northern Murray Mallee, Northern Yorke Peninsula and Northern agricultural. Map does not show remnant areas less than approximately 100 ha.	SA Government 1980
	Digital data set based on visual interpretation of February and March 1988 LANDSAT 1:250,000 images, and map produced at 1,000,000 scale. Remnant areas less than approximately 25 ha not captured. Map does not show remnant areas less than approximately 100 ha. The 1989 map has additional information showing degraded vegetation and areas cleared.	SA Government 1989
	Compiled vegetation map from a range of datasets ranging from 1985 onwards, based on detailed air photo analysis at 1:25,000 to 1;40,000 scales.	Flavel 1998
	Detailed spatial and temporal data set on Access database of areas for which permission has been granted to clear with and without conditions. Data classified into broadacre, wood collecting, brush collecting and scattered trees. Data for broadacre consent with and without conditions represents most appropriate data for Greenhouse gas inventory analysis. Broadacre consents with or without conditions from Native Vegetation Authority Annual Reports are: 127,500 ha/annum from May 1983 to Nov 1985, 21,000ha/annum from November 1985-1990 and 5,000 ha/annum for 1991-1995. Spatial analysis of the data are somewhat difficult due to changes in the digital cadastral data base. Many sections of native vegetation for which a clearance application has been granted have been subdivided and are no longer recorded in the DCDB. A trial (Craig Whisson DEHAA, pers. comm.) indicated that approx 40% of the Lower South-East clearance permit data could not be mapped accurately. However, all data could be placed into IBRA bioregions based on Hundreds rather than Section numbers.	Vegetation clearance in SA (DEHAA data base)

Region	Description of data	Source
All	Table 7.5 in SoE Report provides regional data for native vegetation remaining in Agricultural districts of SA for 1975, and that remaining outside NPWS Reserves January 1988. Information is probably based on digital data sets for 1978 and 1988. The 1978 digital data is based on 1967–1978 air photographs and air photo mosaics. Records approximately 651,600 ha (54,000 ha per annum) of native vegetation cleared over this 12 year period or approximately 65,000 ha per annum if a ten year interval is used. The SoE also reports (page 106) that 478,000 ha was cleared between 1975 and introduction of clearance controls in November 1983; a maximum rate of approximately 60,000 ha per annum over this 8 year period. The SoE data is sourced and updated from Vegetation Clearance in SA in 1985-86 – Native Vegetation Authority's Annual Report (Table 3) covering the years 1976-1985. The clearing rate of 651,000 ha over this 9 year period is approximately 72,400 ha per annum. Table 3 in Vegetation Clearance in SA in 1985-86 – Native Vegetation Authority's Annual Report is likely to be generally comparable with 1988 data in SoE 1993 to provide an indicative rate from 1985 to 1988 the first three years after the introduction of clearance controls.	State of Environment Report 1993
	Table 3 records a reduction from 3,767,000 ha of native vegetation outside NPWS reserves in 1976 (based on Harris air photo mosaics from 1967–1974) to 3,126,400 ha in 1985.	Native Vegetation Authority's Annual Report 1986
	Table 3 NVA Annual Report records a reduction from 3,126,400 ha in 1985 to 3,115,373 ha in 1988 (SOE Report 1993) – a rate of approximately 4,500 ha over this 2.5 year period.	Native Vegetation Authority's Annual Report 1985-1986; State of Environment Report 1993
	Provides regional data for native vegetation remaining in Agricultural districts of SA for 1974 and 1984, based on data sets from Harris 1976 (who used 1967-1974 air photo mosaics) and an extrapolated figure of 33% clearing for all regions from Nature Conservation Society's 1981 vegetation surveys in Lower South East. On these assumptions an annual clearance rate for Agricultural Districts of SA would be approximately 100,000 ha per annum for the 10 year period 1974–1984.	Dendy 1984
Lofty Block – Mt Lofty Ranges part of Lofty Block	Chronoflex maps of Mt Lofty Ranges in 1945 and 1968 showing native vegetation transposed from 1:63,360 Military Ordnance maps, 'all but two of the twelve maps were produced immediately prior to or during the last war' (green layer interpretation; about late 1930s to early 1940s), and 1965-1968 air photos of unknown scale for 1968 maps transposed from air photos on to 1:63,360 scale maps and then reduced to 1:250,000 scale.	Andrew Lothian Submission to House of Representatives Select Committee on Wildlife Conservation April 1971.
	Very detailed 1:250,000 maps held by Andrew Lothian (DEHAA). Used as basis for updated work by Caldicott 1980.	
	Approximately 1,800 ha per annum clearance of native vegetation in Mt Lofty region in the 6 year period from 1968-1974, a reduction from 2,500 ha in the 23 year period from 1945-1968. Information based on Lothian submission above and resurveyed by Caldicott in 1974.	Caldicott 1980
	Digital data set: derived information for which may be available on request from SA Planning. Based on this 1985 data set, 379 patches (larger than 0.5 ha) of native vegetation 10 ha or under and 280 patches 5 ha or under were recorded on the Fleurieu Peninsula (southern part of Lofty Block IBRA Bioregion).	Williams & Goodwin 1989

Region	Description of data	Source
Lofty Block – Mt Lofty Ranges part of Lofty Block	Records a reduction from 41,000 ha in 1974 to 27,000 in 1984 for Mt Lofty Ranges; a rate of approximately 1,400 ha per year, though the date of the air photos sources is not given. The 1974 data is based on Harris data (1976), although the air photo mosaics for this area are likely to be 1972 and 1973.	Dendy 1984
	Table 7.5 records a reduction from 39,700 ha to 36,787 ha in the period 1975 (Harris, 1976) to January 1988; a rate of approximately 250 ha per year. These data do not include areas less than approximately 100 ha.	State of Environment Report 1993
	Table 3 NVA Annual Report records a reduction from 36,800 ha in 1985 to 36,787 ha in 1988 (SOE Report 1993) – a rate of less than 10 ha per annum over this 2.5 year period.	Native Vegetation Authority's Annual Report 1985-1986; State of Environment Report 1993
	For Mt Lofty Ranges: Table 3 records a reduction from 39,700 ha of native vegetation outside NPWS reserves in 1976 (based on Harris air photo mosaics of c. 1974) to 36,800 ha in 1985 – a rate of approximately 250 ha per annum over this 11 year period.	Native Vegetation Authority's Annual Report 1985-1986
	Consents for broadacre clearance of native vegetation from 1983 – 1995 in the Mt Lofty Ranges amount to a total of 107 ha, with 67 ha of this approved to be cleared in 1983.	Vegetation clearance in SA (DEHAA data base)
	Graetz's 1980-1990 clearance rate data supplied by AGO for Lofty Block bioregion (a larger area than the Mt Lofty Ranges region as used in this table) is an order of magnitude greater than that provided by SA interviewees and published information for 1945 through to 1995. Graetz records (as supplied by AGO) an annual average rate of clearing in the Lofty Block bioregion of 23,400 ha per annum.	Graetz, EOC, unpublished data
Lofty Block – Kangaroo Island part	Reports a reduction from 68,203 ha (outside NPWS Reserves) to 45,969 ha in the years 1974 (Harris data based on c. 1974 air photo mosaics) to 1984 – a rate of 2,250 ha per annum over this 10 year period.	Dendy 1984
	Table 7.5 records a reduction from 95,000 ha in 1975 (Harris data based on 1974 air photo mosaics) to 47,730 ha in 1988 – a rate of approximately 3,500 ha per annum over this 14 year period.	State of Environment Report 1993
	For Kangaroo Island: Table 3 records a reduction from 95,000 ha of native vegetation outside NPWS reserves in 1976 (based on Harris air photo mosaics of 1974) to 48,800 ha in 1985 – a rate of approximately 4,200 ha per annum over this 11 year period.	Native Vegetation Authority's Annual Report 1985-1986
	Table 3 NVA Annual Report records a reduction from 48,800 ha in 1985 to 47,730 ha in 1988 (SOE Report 1993) – a rate of approximately 500 ha over this 2.5 year period	Native Vegetation Authority's Annual Report 1985-1986; State of Environment Report 1993
Lofty Block – Mid North	Mid and Upper North: a reduction from 483,168 ha (outside NPWS Reserves) in 1974 (Harris data based on 1967 air photo mosaics) to 390,723 ha in 1984 – a rate of approximately 5,500 ha per annum over this 17 year period.	Dendy 1984
	Table 7.5 records a reduction for the Mid-North from 987,200 ha in 1975 (Harris data based on 1967 air photo mosaics) to 968,009 ha in 1988 – a rate of approximately 1,000 ha per annum over this 21 year period.	State of Environment Report 1993

Region	Description of data	Source
Lofty Block – Mid North	For Mid North, Table 3 records a reduction from 987,200 ha of native vegetation outside NPWS reserves in 1976 (based on Harris air photo mosaics of 1967) to 969,200 ha in 1985 – a rate of approximately 1,000 ha per annum over this 18 year period.	Native Vegetation Authority's Annual Report 1985-1986
	Table 3 NVA Annual Report records a reduction from 969,200 ha in 1985 to 968,009 ha in 1988 (SOE Report 1993) – a rate of approximately 500 ha over this 2.5 year period.	Native Vegetation Authority's Annual Report 1985-1986; State of Environment Report 1993
Murray-Darling Depression	Murray Mallee: a reduction from 245,011 ha (outside NPWS Reserves) in 1974 (Harris data based on early 1970s air photo mosaics) to 164,157 ha in 1984 – a rate of approximately 7,000 ha per annum over this approximately 12 year period.	Dendy 1984
	Table 7.5 records a reduction for the Murray Mallee from 529,000 ha in 1975 (Harris data based on early 1970s air photo mosaics) to 481,256 ha in 1988 – a rate of approximately 3,000 ha per annum over this 16 year period.	State of Environment Report 1993
	For Murray Mallee Table 3 records a reduction from 529,000 ha of native vegetation outside NPWS reserves in 1976 (based on Harris air photo mosaics of early 1970s) to 485,300 ha in 1985 – a rate of approximately 3,500 ha per annum over this 13 year period.	Native Vegetation Authority's Annual Report 1985-1986
	Table 3 NVA Annual Report records a reduction from 485,300 ha in 1985 to 481,256 ha in 1988 (SOE Report 1993) – a rate of approximately 1,500 ha over this 2.5 year period.	Native Vegetation Authority's Annual Report 1985-1986; State of Environment Report 1993
Naracoorte Coastal Plain	Records for Lower South-East: reduction from 53,447 ha (outside NPWS Reserves) in 1974 (Harris, based on 1973 air photo mosaics) to 29,100 ha in 1984 (based on Nature Conservation Society of SA figures, 1981, from on air photos of unknown age) – a rate of approx. 3,000 ha per annum over an approximate 8 year period.	Dendy 1984
	Upper South-East: a reduction from 408,225 ha (outside NPWS Reserves) in 1974 (Harris data based on 1967 and 1973 air photo mosaics) to 273,531 ha in 1984 – a rate of approx. 9,500 ha per annum over this 14 year period.	Dendy 1984
	Table 7.5 records a reduction for the Lower South east from 69,400 ha in 1975 (Harris data based on 1973 air photo mosaics) to 48,540 ha in 1988 – a rate of approximately 1,500 ha per annum over the 15 year period.	State of Environment Report 1993
	Table 7.5 records a reduction for the Upper South East from 256,900 ha in 1975 (Harris data based on 1967 and 1973 air photo mosaics) to 98,015 ha in 1988 – a rate of approximately 9,000 ha per annum over this 18 year period.	State of Environment Report 1993
	For Lower South East, Table 3 records a reduction from 69,400 ha of native vegetation outside NPWS reserves in 1976 (based on Harris air photo mosaics of 1973) to 48,900 ha in 1985 – a rate of approximately 1,700 ha per annum over the 12 year period.	Native Vegetation Authority's Annual Report 1985-1986
	For Upper South East, Table 3 records a reduction from 256,900 ha of native vegetation outside NPWS reserves in 1976 (based on Harris air photo mosaics of 1967 and 1973) to 99,700 ha in 1985 – a rate of approximately 10,500 ha per annum over this 15 year period.	Native Vegetation Authority's Annual Report 1985-1986

Region	Description of data	Source
Naracoorte Coastal Plain	Table 3 NVA Annual Report records a reduction for Lower South East from 48,900 ha in 1985 to 48,540 ha in 1988 (SOE Report 1993) – a rate of approximately 200 ha over this 2.5 year period.	Native Vegetation Authority's Annual Report 1985-1986; State of Environment Report 1993
	Table 3 NVA Annual Report records a reduction for Upper South East from 99,700 ha in 1985 to 98,015 ha in 1988 (SOE Report 1993) – a rate of approximately 700 ha over this 2.5 year period.	Native Vegetation Authority's Annual Report 1985-1986; State of Environment Report 1993
Eyre and Yorke Blocks	Dendy records for Yorke Peninsula a reduction from 57,878 ha (outside NPWS Reserves) in 1974 (Harris data based on 1974 air photo mosaics) to 38,778 ha in 1984 – a rate of approximately 2,000 ha per annum over this 10 year period.	Dendy 1984
	For the Eyre Peninsula: a reduction from 1,590,584 ha (outside NPWS Reserves) in 1974 (Harris data based on 1967 to 1974 air photo mosaics) to 1,065,691 ha in 1984 – a rate of approximately 38,000 ha per annum over a c. 14 year period.	Dendy 1984
	Table 7.5 records a reduction for the Yorke Peninsula from 67,400 ha in 1975 (Harris data based on 1974 air photo mosaics) to 59,140 ha in 1988 – a rate of approximately 600 ha per annum over this 14 year period.	State of Environment Report 1993
	Table 7.5 records a reduction for Eyre Peninsula from 1,722,400 ha in 1975 (Harris data based on 1967 to 1974 air photo mosaics) to 1,375,596 ha in 1988 – a rate of approximately 20,000 ha per annum over a c. 18 year period.	State of Environment Report 1993
	For Yorke Peninsula, Table 3 records a reduction from 67,400 ha of native vegetation outside NPWS reserves in 1976 (based on Harris air photo mosaics of 1974?) to 59,300 ha in 1985 – a rate of approximately 750 ha per annum over this 11 year period.	Native Vegetation Authority's Annual Report 1985-1986
	For Eyre Peninsula, Table 3 records a reduction from 1,722,400 ha of native vegetation outside NPWS reserves in 1976 (based on Harris air photo mosaics of 1967 to 1974) to 1,378,400 ha in 1985 – a rate of approximately 23,000 ha per annum over a c. 15 year period.	Native Vegetation Authority's Annual Report 1985-1986
	Table 3 NVA Annual Report records a reduction for Yorke Peninsula from 59,300 ha in 1985 to 59,140 ha in 1988 (SOE Report 1993) – a rate of approximately 100 ha over this approximately 2.5 year period.	Native Vegetation Authority's Annual Report 1985-1986; State of Environment Report 1993
	Table 3 NVA Annual Report records a reduction for Eyre Peninsula from 1,378,400 ha in 1985 to 1,375,596 ha in 1988 (SOE Report 1993) – a rate of approximately 1,000 ha over this 2.5 year period.	Native Vegetation Authority's Annual Report 1985-1986; State of Environment Report 1993

9: WESTERN AUSTRALIA

9.1 INTRODUCTION

Western Australia (WA) has a distinctive history of agricultural development characterised by large-scale releases of Crown Land in relatively recent times. There have been numerous incentives for people to take up the new land and commence land clearing. In the early 1960's the Government of WA had a stated policy of developing and releasing 'a million acres a year', and a buoyant culture of development prevailed until the 1980s.

Private economic gain was the primary driver for clearing at the farm level, but in many areas clearing may not have occurred at all, and certainly not at the same rate, without the support of a constellation of substantial government incentives. Nevertheless, land development was fundamentally driven by agricultural research and development, which identified trace elements, fertilisers and new crop varieties that enabled poorer lands to be released and cleared for production. Agricultural expansion was further aided by increased availability of reticulated water, through water supply schemes.

Almost all native vegetation clearance in the state has been in the wheatbelt, woolbelt and coastal agricultural zones of the southwest. Nevertheless, significant clearance has also occurred in the Perth Metropolitan Region.

By contrast, clearing for cropping or grazing is generally not allowed in the Pastoral Zone, which more-or-less comprises all but the southwest corner of the State. There are small areas of clearing associated with horticulture in the Ord River Irrigation Scheme and on the Fitzroy River but these are insignificant in terms of the total area of the Pastoral Zone. The Zone also supports a number of mining enterprises but these do not involve significant clearing.

A substantial portion of the southwest was cleared quite recently, between 1945 and 1982. From the late 1960s, the scale of land clearing in the Agricultural Zone – centred around the Avon Wheatbelt, the Mallee and the Esperance Plain – was vast. Profits from cropping were lucrative and there were also more sources of finance through sources such as the newly-established Commonwealth Development Bank. Incentives to clear included the availability of cheap land, large machinery and a water infrastructure, combined with the development of soil science enabling the cultivation of poorer lands.

Declining profit margins in the 1980s led to new larger holdings, with 'industrial-scale' farming that favoured broadacre clearing of new land, or consolidation and rationalisation of existing holdings. In the late 1980s, with a dramatic decline in availability of arable land and much of the remaining vegetation fragmented, the rate of clearing began to decrease.

The development of the southwest has left an indelible legacy of change to the native vegetation of WA. Associated with the change are a plethora of problems, such as salinity and soil loss, that threaten both the production and conservation values of the fragile land. As a result, the 1980s saw the introduction of clearing controls, which reflected altered attitudes to land management, bringing an end to the era of expansion. The focus shifted from clearing to expand productive land, to protection for both production and conservation.

9.2 MOTIVATORS FOR LAND CLEARANCE

Environmental and social influences

Until the emergence of the minerals boom in the 1960s, agriculture was the only major primary industry that could produce significant wealth for WA. After World War I, agriculture was seen as the only way of decreasing dependence on the Commonwealth Government, perceived by Western Australians to favour the eastern states. Thus, a culture of independence grew up, based on a pioneering attitude toward development of the land

for agricultural production. There was a perception that crops and livestock could thrive even on the light sandy soils and a widespread feeling of invincibility.

Successful landholders stood for election to local government and became a dominant voice on rural councils that would then lobby State Governments for more development in their area. Local government decision making, ranging from road maintenance to the issuing of fire permits to burn large areas of pulled native vegetation, also reflected a favourable attitude to agricultural development.

The ready availability of land often meant that it was bought by inexperienced farmers. There was little appreciation of natural resource management or property planning, so farmers cleared entire paddocks without fencing out any remnant vegetation. The failure rate of farming enterprises was high, resulting in amalgamation of neighbouring properties, which sometimes led to further clearing to recover the costs of the takeover.

From the time of establishment of the livestock industry, in many parts of southern WA there have been heavy stock losses through the ingestion of poisonous plants. Among other toxins, there are high amounts of naturally occurring toxin 1080 in the native vegetation of this part of the State. Shepherding of sheep through native vegetation proved impossible, so extensive clearing and fencing became the only way to keep livestock alive. In the earlier settled regions, such as the Avon Wheatbelt and Western Coolgardie, some areas of poisonous plants were left uncleared because they were fenced off or otherwise avoided. These areas have remained uncleared, and many have now been reserved. On properties developed during the era of expansion, when it became easy and economically feasible to clear large tracts, wholesale clearing was used to remove areas of poisonous plants. This was the case in the Mallee and Esperance Plains bioregions, where poisonous plants were a major disincentive for maintaining windbreaks and other patches of remnant vegetation as part of the landscape.

Availability of land

The availability of large areas of uncleared land for totally new development was a major driver for clearing, eventually attracting farmers from the eastern States. Land development schemes, taxation incentives and ready finance all facilitated the process. By the 1980s the scarcity of unused arable land and degradation of existing farmland, led to the imposition of clearing controls and a dramatic decrease in the rate of clearing.

Clearing controls

Between 1980 and 1983 there were severe dust storms in many parts of the wheatbelt. These storms and the very evident soil erosion they caused received a great deal of media attention. Public concern led to a change in attitude to land clearing and natural resource management.

The government began to actively promote soil conservation and land care activities allowing far greater community involvement in land management policies. Clearing controls were gradually introduced firstly to protect water catchments from salinity, and later to halt the processes of land degradation more broadly.

As early as the 1960s, clearing controls were introduced to protect water supplies against salinity in some major water catchments. These early bans on alienation of Crown Land were followed by the gradual introduction, beginning in 1976, of clearing controls to prevent further land degradation, imposed on private lands. In some cases, it was reported that impending clearing controls had a perverse effect, leading to a temporarily increased rate of clearing. For example, in the Jarrah-Forest bioregion (Thackway & Cresswell 1995), anecdotal evidence suggests that the more stringent controls applied in 1976 were preceded by increased clearing as landholders were aware that a license to clear would become difficult to obtain.

Financial and institutional incentives

Land development schemes

The Conditional Purchase scheme (CP) was a major incentive for land development. First introduced in the early period of settlement to encourage agriculture, the scheme was reinvigorated in 1961 and continued until 1982. Under the CP scheme, large areas of land were released in the Agricultural Zone. In the early years, it was possible for nearly all applicants to be granted a farming property. Sir David Brand, premier of WA in the 1960s, proudly claimed that, under the CP scheme, 'a million acres a year' were released.

Properties in the scheme came at an extremely low cost, the equivalent of twenty-five cents per ha in 1999 currency. Each block was also heavily supported by State Government funds in that:

- it had been fully surveyed and all legal work completed;
- it had road access provided by Government; and
- a telephone service was extended to all new development blocks.

Towards the end of the 1960s demand increased as landholders and others in the east became aware of the CP scheme and saw it as a golden opportunity to establish themselves or their children on the land. Ballots were introduced to deal with the increase in applicants.

A condition of taking up a property was that a certain proportion had to be cleared within a given period. This requirement often led to over-clearing. The presence of plants that were poisonous to stock meant that remaining native vegetation had to be fenced off and such extra expenditure was not seen as necessary. Thus, some farmers cleared entire paddocks.

Initially, some lands of poorer quality were excluded from the CP. However, the demand for more agricultural land and successful clearing of the better country encouraged eventual expansion into marginal land. There was also an emerging awareness that some lands should be set aside and this was done. However, it meant that landholders could clear all of the larger holdings they obtained without any expectations of leaving marginal land under native vegetation.

It is said that during the height of the CP scheme there was more land being released and farms created than there were skilled farmers to manage them. Consequently, there was a high failure rate and many of the initial landholders sold their properties to successful neighbours. Frequently, these neighbours had borrowed heavily and had to clear rapidly and plant crops to pay their debts.

The CP scheme continued until 1982 when the last land was released. A realisation that land degradation was a real issue and the concern to conserve the last remnants of the large tract of land initially involved for biodiversity conservation brought the CP scheme to a relatively recent close.

Throughout the 1970s, major agricultural expansion occurred in the Mallee and Esperance Plain regions. Corporate farming was actively encouraged by the State Government, and particularly aided in the Esperance Plain by the passing of the Esperance *Land Development Act 1968*. This granted special privileges to a private United States consortium including the Chase Manhattan Bank, allowing it to develop large areas and then sell holdings to individuals.

Development of Avon Wheatbelt and Western Coolgardie area occurred largely prior to the 1970s, aided by many of the earlier War Service and Group Settlement schemes. In these areas land clearing was a slower process because the area was settled earlier when clearing was more difficult and the holdings were smaller. Third class land was classified as marginal and it was expected that landholders would not clear it. Invariably, they did clear to increase the area of productive land on their small holdings.

Finance

Loans for land clearing and other property development work could be obtained through the Commonwealth Development Bank, established in 1960. In addition, tax concessions for clearing and other development were available until the late 1980s.

Innovations: new breeds, techniques and practices

The infertile, sandy soils of much of WA, combined with the lower rainfall in the eastern part of the Agricultural Zone, proved a challenge to agriculture. This was met with a concerted effort to develop new cropping and pasture systems and machinery that dealt with both clearing and subsequent cultivation.

New crops and pastures

State funded research showed that fertiliser combined with trace elements and the use of clovers provided the basis of a cropping-ley system that was highly productive for wheat and wool enterprises. This led to the view that any environmental limitation could be overcome with the fertiliser, trace element and clover triad and, as a result, land with lighter poorer soils was released for development. In this way, agriculture expanded out from better land into poor country, which required clearing.

New wheat varieties were developed that, together with trace elements and fertilisers, allowed cropping of previously marginal areas for agriculture. In the mallee and Esperance Plain region the availability of new wheat varieties promoted rapid clearing. These new varieties were also important along the eastern margins of the Avon Wheatbelt and Western Coolgardie region.

New machinery and techniques

The minerals boom that began in WA in the 1970s allowed many earthmoving and machinery suppliers to establish in the State. Contractors involved in land clearing could purchase good equipment direct from the suppliers or obtain excellent second hand items from mining companies. This resulted in more rapid, broad-scale land clearing.

With the new equipment one person could clear thousands of acres rather than the hundred or so of a decade before. Large four-wheel drive tractors became available and innovations such as new ploughs that could be pulled by the more efficient tractors were developed. For example, a plough that could pull out mallee roots and stack them in windrows ready for burning was developed specially for Western Australian conditions.

Thus, the new machinery and equipment made clearing of large new properties, for example, in the mallee and Esperance plain region, a realistic and achievable goal. Large tracts were cleared without leaving windbreaks and shelterbelts.

On the older holdings in the Avon Wheatbelt and Western Coolgardie, much of the clearing during the 1970-1990s was second-phase clearing, which became more economical with the ready availability of new equipment and machinery.

Market forces: new markets, changing commodity prices

The beef crisis in the first half of the 1970s, and the availability of new wheat varieties and cultivation techniques, led some farmers to clear more extensively for a switch to cropping. In the Geraldton Sandplain region, there has been clearing for the tree crop tagasaste.

New infrastructure

Development of major metropolitan areas provided larger markets and improved services and facilities to support agricultural expansion and associated clearing.

The Ord River Irrigation Scheme and water reticulation infrastructures on the Fitzroy River and elsewhere have opened up new areas to intensive agriculture, such as cotton and horticultural crops.

Summary of land clearing rates and causes in the major zones of activity, WA, 1970-1990.

Zone	Biogeographic regions (IBRA)*	Rate of clearing 1980-1990 (ha/yr)	Primary drivers	Clearing pattern
Wheatbelt 	Avon Wheatbelt, Coolgardie, Yalgoo	10,000 – 20,000	Wheat and wool production. Conditional Purchase Scheme provided cheap land until 1982.	Secondary clearing of remnants Patch size: Vegetation cleared: woodland
South-eastern 	Mallee, Esperance Plains	50,000–100,000	Wheat production. Esperance Land Development Act (1968) encouraged corporate farming.	Expansion into new lands. Patch size: Vegetation cleared: woodland and scrub heathlands
Coastal 	Geraldton Sandplains, Carnarvon	10,000 – 20,000	Wheat production, and tagasaste (a tree fodder crop).	Expansion into new lands. Patch size: Vegetation cleared: woodland and scrub heathlands
South-western 	Jarrah Forest, Swan Coastal Plain, Warren	10,000 – 20,000	Wool, wheat and milk production and viticulture. Urban expansion is a major feature.	Patch size: Vegetation cleared: open forest, woodland and scrub

* following Thackway and Cresswell (1995)

Urban expansion

Around ninety per cent of the population of WA resides on the Swan Coastal Plain. It has been extensively cleared since the establishment of the colony in 1829.

Between 1970 and 1990, significant urban expansion and rural residential development occurred in the southwestern coastal areas of the State. This is likely to have involved substantial clearing of small areas of land. There are a variety of continuing reasons for clearing, including intensive agriculture, particularly horticulture and viticulture.

With the introduction of clearing controls and the end of the expansion era of the 1960s and 70s, the rate of clearing for agriculture has declined. Hence, clearing for urban expansion and rural residential development may now exceed that for agriculture.

9.3 DISTRIBUTION OF LAND CLEARING

Almost all native vegetation clearing has occurred in the south-west region of WA, particularly in the Avon Wheatbelt, Jarrah Forest, Esperance Plains, Warren, Mallee, Swan Coastal Plain and Gascoyne biogeographic regions. These regions include the wheatbelt, woolbelt and coastal agricultural zones.

According to Beeston (1996), since the introduction of regulations under the *Soil and Land Conservation Act 1986*, clearing has decreased and is 'becoming a marginal activity in the context of remnant vegetation decline … since 1986 clearing has totalled about 213,000 ha and added only 1.25% to the agricultural resource base'.

Wheatbelt

Development of this area occurred largely prior to the 1970s, aided by many of the earlier War Service and Group Settlement schemes. Land clearing was a slower process because the area was settled earlier and in smaller holdings.

This region contains the major sheep and wheat producing area of the Agricultural Zone. Much of the clearing was second phase clearing because most of the land had been cleared earlier in the history of the State. However, there were undoubtedly larger remnants that were cleared in the period 1970-95 and the cumulative impact would have been significant.

South-east

Major agricultural expansion occurred in these bioregions between 1970 and 1990. Larger land holdings and new equipment became available and, together with the new wheat varieties and R&D into trace elements and fertilizers, promoted rapid clearing. These bioregions contained the major expansion of the wheat industry as it moved east. They are almost exclusively agricultural bioregions that experienced major clearing events.

Coastal Zone

This region displays a similar pattern to the Mallee and Esperance Plain regions, with an additional recent clearing for the tree crop tagasaste.

South-west

Because many of the urban water catchments are located in the Jarrah Forest bioregion there has been a gradual imposition of clearing controls. Anecdotal evidence provided from interviews suggested that the more stringent controls applied in 1976 were preceded by increased clearing, as landholders were aware that a license to clear would become difficult to obtain.

These Swan Coastal Plain contains nearly all of the population of WA and includes all the major urban centres, including Perth. There is some intensive agriculture. All clearing now requires a permit, and the area being cleared for agriculture has declined because of the introduction of clearing controls.

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Summary of data on clearing in WA, 1970-1990, and their source.

Region	Description of data	Source
All	Two maps, the first of the shires in WA that have less than 20% of their total area as public or private vegetation (see p. 39), and the second of the location and spread of land development in WA to 1870; 1871 to 1900; 1901 to 1930; 1931 to 1984; and also reserves and Crown Land (see p. 40). Also includes a summary of cases dealt with under Notices of Intention to Clear Regulations from 1986/87 to 1993/94 and a summary of Remnant Vegetation Protection Scheme grants from 1989 to 1995 (see p. 38). Since the introduction of regulations under the *Soil and Land Conservation Act 1986*, clearing has decreased and is 'becoming a marginal activity in the context of remnant vegetation decline … since 1986 clearing has totalled about 213,000 ha and added only 1.25% to the agricultural resource base' (pp. 33-34).	Beeston 1996
	Map (from Arnold 1988), which describes the possible changes in the wheatbelt of the south-west of WA (no scale provided).	Castles 1992
	Includes maps describing the spread of farming from 1850, 1890, 1919 and 1939 at a scale of 1:10,000,000 (p. 76) and growth of the timber industry from 1899 to 1984, including: total log production figures for 1984; and extent and additions to the State Forest in the periods 1924 to 1930, 1930 to 1954, 1954 to 1959, 1959 to 1969, and 1969 to 1984. The map is at a scale of 1:2,000,000 (p. 68). The publication also includes a breakdown of rural establishments in the State for 1984/85 in terms of activity (nurseries, vineyards, sheep, cereal grain etc.) and the number of production units (p. 83).	Jarvis 1986
	Debate on woodchip licenses began in 1986, with reference to private land, stimulating the presentation of the first mapping of remnants on private land.	Beeston 1996
	In 1991 the majority of aerial photographs were interpreted and mapped, marking the establishment of a database and data analysis.	Beeston 1996
	A report on private remnants.	Beeston *et al.* 1994
	Includes a table of land permitted to be cleared by district for 1986-1987 to 1989-1990 (p. 34). Also states that 'Of an estimated total cover of over 24.693 million ha, about 20.124 million ha have been cleared … A substantial portion was cleared between 1945 and 1982 … Significant clearance has also occurred in the Perth Metropolitan Region where some 270,000 ha of the total estimated area of 530,000 ha have been lost …It has been calculated that from 1986-87 to May 1992, about 194,800 ha of native vegetation were permitted to be cleared' (p. 34).	Biodiversity Unit 1995
Esperance Plain	Two scenes of agricultural areas near Esperance during the period October 1978 and January 1991. The images show a 'pattern of expansion at the margins as well as the loss of native vegetation remnants within the established croplands' (p. 68). The CD ROM supporting this publication features a full Esperance scene.	Graetz *et al.* 1992

Region	Description of data	Source
	Presents a map of vegetation clearance across the continent for the periods 1860, 1920 and 1980 (see p. 54), adapted from maps in Australians: a Historical Atlas 1987, and 1:5 million 'Present Vegetation'. The map describes considerable clearing for the south-west region, particularly for the areas mostly cleared by 1980. Additionally, a continent map of 'Major Vegetation Changes' (p. 55) describes the clearance of predominantly woodland and scrubland within these bioregions (scale of 1:20,000,000; source: 1:5 million maps 'Natural Vegetation'.	AUSLIG 1990
	Includes a table of land permitted to be cleared by district for 1986-1987 to 1989-1990 (p. 34). 'Of an estimated total cover of over 24.693 million ha, about 20.124 million ha have been cleared … A substantial portion was cleared between 1945 and 1982 … Significant clearance has also occurred in the Perth Metropolitan Region where some 270,000 ha of the total estimated area of 530,000 ha have been lost … It has been calculated that from 1986-87 to May 1992, about 194,800 ha of native vegetation were permitted to be cleared'(p. 34).	Biodiversity Unit 1995

10: NORTHERN TERRITORY

10.1 INTRODUCTION

The Northern Territory (NT) has a large beef cattle industry and differs from the States in that so much of its agriculture is based on rangeland pastoralism. The rangelands are suitable for grazing in their natural state. Thus, pastoralism in the NT is based mostly on ecosystems that need little or no clearing to be productive.

Vacant Crown Land that could be taken up as pastoral lease has not been available in the NT since the early 1960s. Since then, the only way to take up a new agricultural enterprise has been to make more intensive use of land that has already been allocated.

Nevertheless, it has been estimated less than two per cent of the woody vegetation of the NT has been cleared. This clearance took place mostly between about 1975 and 1995, to make way for localised urban development and creation of fruit blocks around Darwin, the establishment of some pine plantations on Melville Island, and more intensive use of pastoral leases in the Daly and Finniss River Basins. Significant land clearing occurred in only three bioregions: Top End Coastal; Daly Basin; and Pine-Creek Arnhem.

As part of the Territory Government funded agricultural development scheme, there were several episodes of clearing in the Daly Basin. There was broadscale clearing in the late 1960s and early 1970s on the Scott Creek and Willeroo leases in the south and again, between 1967 and 1973, on Tipperary Station in the north, and selective clearing of the Douglas Daly farms in the 1980s.

Several relatively small-scale clearing events during the 1970s and 1980s were associated with large intensive cropping schemes, such as the sorghum development at Tipperary. These schemes largely failed, and had a profound impact on development aspirations in the NT. Much of the land was subsequently converted to improved pasture for grazing purposes. In other cases, bush was allowed to regenerate.

A more cautious approach was taken to the Agriculture Development Marketing Authority (ADMA) scheme, which was developed during the 1980s and involved broadscale clearing. This differed from the earlier land development schemes in that it was based on dryland farming, and not horticulture, and was subject to detailed resource assessment and property planning. Successful development of agriculture was achieved in some areas, through the evolution from a cropping based exercise to mixed farming and subsequently to grazing of improved pasture.

The development boom that accompanied reconstruction following Cyclone Tracy in the 1974 gave an added boost to the area. Small areas were cleared around Katherine and Darwin, where horticultural crops, such as mangos and bananas, were successfully established, usually on a scale of twenty hectares or less. The success of these smaller scale horticultural developments has pointed the way for more carefully planned larger developments. These smaller projects also drew attention to some of the locational advantages enjoyed by Darwin and its proximity to Asia.

10.2 MOTIVATORS FOR LAND CLEARANCE

Environmental and social influences

The dry-tropical climate and vegetation of the NT are mainly suitable for cattle grazing, although there has been some development of horticultural crops around population centres.

The pioneering era came to an abrupt end with the failure of the large-scale intensive-farming initiatives of the 1970s and early 1980s. Some of these schemes suffered from a lack of financial analysis and land use planning before they were implemented. Notwithstanding, the failed schemes had a profound impact. Subsequent development was based on more critical assessment of resource and economic constraints.

It is the continuing policy of the NT Government to develop and intensify its agricultural industries. Development has been facilitated by the provision of strategic assistance such as infrastructure (roads) and advice on property planning and development. Property management planning is a voluntary process, supported by training modules organised by various government agencies.

Some sectors of the community now hope that Darwin might become the export capital for a wide range of products specially designed for the Asian market, and a major food producer for Australia. Efficient air, road and rail transport to other parts of Australia is also included in this vision.

Availability of land

The days of finding vacant Crown Land that could be taken up as pastoral lease came to an end in the late 1950s and early 1960s. After this, the only way that budding agricultural entrepreneurs could make profits in the NT was to use land that had already been allocated in more intensive ways, which may have involved some small-scale clearing. Nevertheless, land was relatively cheap compared to other areas of Australia.

Landowners continue to subdivide and develop on the basis of commercial decisions. Land continues to be subdivided and cleared for agricultural purposes, indicating that there is a market for such enterprises.

Financial and institutional incentives

Land development schemes

The large land development schemes of the 1970s and 1980s, such as the Humpty Doo rice project and the Tipperary sorghum development, offered cheap land supported by irrigation and other Territory funded infrastructure. The failure of these schemes resulted in the land reverting to grazing so that a certain amount of regrowth occurred.

A more cautious approach was taken to The Agriculture Development Marketing Authority scheme, which was developed during the 1980s and involved broadscale clearing. The scheme was based on dryland farming and subject to detailed resource assessment and property planning. The original objective to develop agricultural enterprises based on intensive cropping were not met, but the area evolved first into mixed farming and then into grazing on improved pasture to supply the live cattle to Asia.

In the Daly Basin, starting in the late 1960s and ending in the 1980s, there were several waves of Territory Government assisted clearing to bring the area into agricultural production.

Finance

Between the late 1960s and early 1980s the banks, led by the newly formed Commonwealth Development Bank, made finance readily available for agricultural development, including clearing. During this period, the Commonwealth Government also allowed the costs of clearing to be fully tax deductable in the year they were incurred. These were strong incentives to clear during a period when land development for agriculture was encouraged.

Innovations: new breeds, techniques and practices

New cattle breeds

The widespread introduction of heat-tolerant and tick-resistant Brahman derived breeds of cattle in the late 1960s contributed to the success and expansion of the cattle industry.

Market forces: new markets, changing commodity prices

The development of the Asian live cattle trade has bestowed significant profits to those sectors of the northern Australian cattle industry able to take advantage of it. Since the 1980s some pastoralists have cleared areas on the Sturt Plateau because of increased profitability from this demand from Asia for live cattle.

This development of the beef live export trade has led to some pastoralists purchasing smaller properties in the Darwin area for use as short term holding paddocks for cattle awaiting shipment. This has led to some local small-scale clearing.

New infrastructure

Territory funded infrastructure to attract farmers to the various land development schemes led to some relatively small-scale clearing for crops. Many roads have been built to bring cattle to the major centres, but this has not led to significant clearing.

Urban expansion

There is a strong hobby farm movement in the Darwin region, particularly in nearby local government areas such as Litchfield Shire. A wide range of uses are permitted on rural residential land and there is a strong and idealistic motivation for many owners to pursue efforts to make an income from their land. The native vegetation is often cleared and replaced with pasture, garden or crops.

10.3 DISTRIBUTION OF LAND CLEARING

The area of land cleared for crops and sown pastures in the NT is insignificant compared to the amount of land used for extensive pastoral and non-rural uses such as National Parks and equivalent reserves and Indigenous lands. Thus, in most of the Territory's bioregions the rate of clearing is low or clearing is absent. Indeed, it is estimated that less than 2% of the woody vegetation of the NT has been cleared. Significant land clearing has occurred in only three bioregions: Top End Coastal; Daly Basin; and Pine-Creek Arnhem. Development of the northern live export cattle trade to Asia has resulted in some clearing in the Sturt Plateau bioregion in recent years.

Summary of land clearing rates and causes in the major zones of activity, SA, 1970-1990.

Zone	Biogeographic regions (IBRA)*	Rate of clearing 1980-1990 (ha/yr)	Primary drivers	Clearing pattern
Top End 	Pine-Creek Arnhem, Top end coast, Daly Basin	10,000–100,00	Beef and rice production, horticulture and other cropping activity.	Expansion into new lands Patch size: Vegetation cleared: mainly woodland, some open forest

* following Thackway and Cresswell (1995)

Top End

The Top End Coastal bioregion is centred on the undulating plains that surround Darwin. It comprises open forest with sorghum grass understorey on loamy red and yellow earths and sandy alluvial soils. The region has a marked, monsoonal climate with distinctive wet and dry seasons.

Around the urban Darwin, rural residential developments dedicated to horticulture are a feature. However, larger commercial horticultural enterprises, mainly mangoes and bananas, have become more significant in recent times. Small properties with intensive cropping provide short term holding facilities for cattle destined for live export to Asia.

Land clearing in this bioregion has been predominantly associated with urban development and horticultural establishments.

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Summary of data on clearing in the NT, 1970-1990, and their source.

Region	Description of data	Source
All	A comparison of census figures for the populations of all capital cities in Australia, 1971-1989. Darwin's population of 39,000 in 1971 grew to 73,000 in 1989 (p. 38 & p. 54). This represents a growth of 87% for the period (slightly behind Canberra, which has the highest relative growth of 91%) and an annual growth rate of 4.8%.	Graetz *et al.* 1992
	LANDSAT FCC images of Darwin for the period May 1976 and June 1988, and a 1976-1988 FCC Difference image (size is 47 km by 32 km). The images demonstrate that landcover change due to urban expansion is reasonably small. The development of Palmerston and other suburbs around Casuarina are prominent, as well as smaller areas of urban infill (p. 54).	Graetz *et al.* 1992
Pine-Creek Arnhem	The NT University carried out a regional study of native vegetation clearance using LANDSAT MSS data. The boundaries of the study area cross into the Top End Coastal bioregion, extending from the coastline in the north-west down to Pine Creek. The study includes the northern part of the Tipperary development. Between 1984 and 1994 at least 40,806 ha of native vegetation (0.88% of the study area) was cleared (p. 37).	Ahmad, cited in Biodiversity Unit 1995
Daly Basin	A map of major vegetation change for the continent (scale 1:20,000,000, from 1:5 million maps) shows tree thinning occurred near the Daly River between the period 1780s-1980s (p. 55). Clearing was associated with the Tipperary development scheme that began in 1967 and was abandoned in 1973. The amount of clearing was approx. 10,000 ha.	AUSLIG 1990 Woinarski & Darson (in press)

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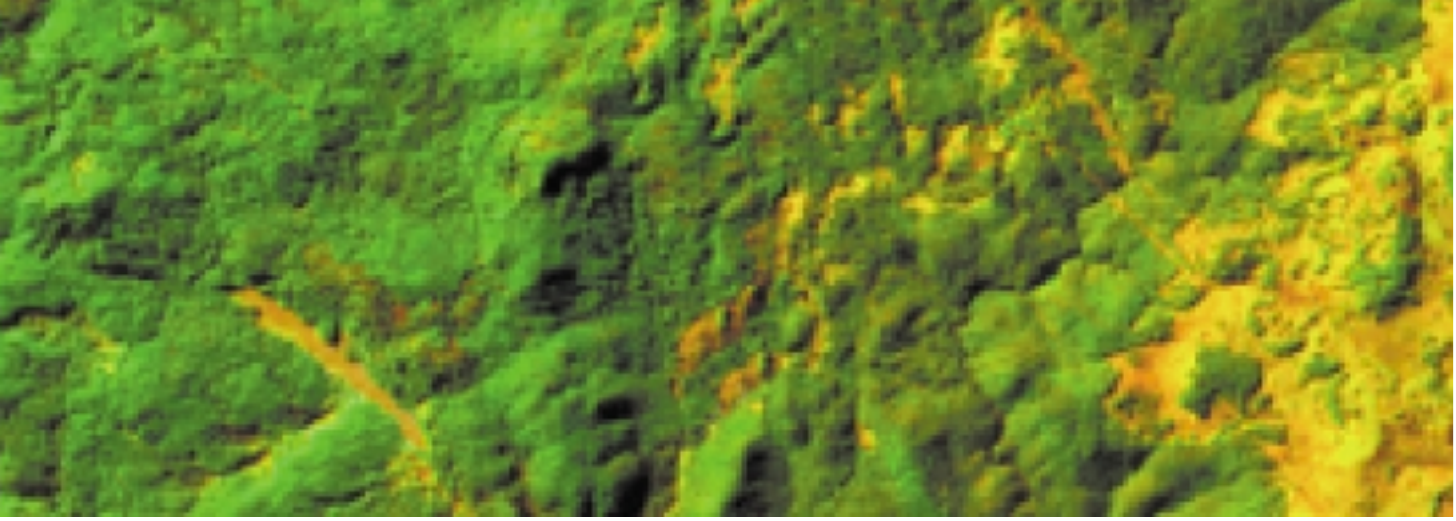

The National Carbon Accounting System provides a complete accounting and forecasting capability for human-induced sources and sinks of greenhouse gas emissions from Australian land based systems. It will provide a basis for assessing Australia's progress towards meeting its international emissions commitments.

technical report no. 4

Land Clearing: A Social History