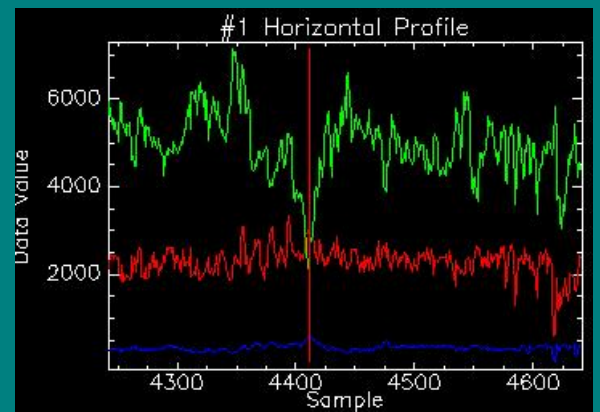


LAND CLEARING IN THE NORTHERN TERRITORY



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Conservation & Natural Resources Group
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Land Clearing in the Northern Territory

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Front Cover. Top : Aerial photograph of clearing on Tipperary Station. Bottom Left: Landsat TM satellite image of clearing on Tipperary Station. Bottom Right: Horizontal profile of clearing in different image bands.

EXECUTIVE SUMMARY

Monitoring land is integral to management and enforcement activities associated with land clearing practices. For the purpose of this report, clearing is defined as all areas where 'native' vegetation has undergone any land cover change that is detectable at a scale 1ha or greater.

503,727 ha or 0.37% of the NT was estimated as having been cleared, based on multiple sources including: Landsat satellite data, historical pastoral reports and estimations of road, rail, and gas pipeline easements.

Specific figures and break-down of clearing by tenure type have been generated using Landsat data for: Darwin, Palmerston, East Arm Region, Coomalie Shire, Litchfield Shire, Mary River Catchment, Daly Basin (biogeographic region), Tiwi Islands, and the Ti-Tree Catchment. In a more comprehensive assessment, historical satellite data has been used to calculate figures for Litchfield Shire since 1977.

Most clearing has occurred in the Daly Basin and Litchfield Shire. A brief summary of the statistics for these two regions are:

The Daly Basin

- 193,655 ha or 9.3% of the region cleared;
- 63% of clearing has occurred on Pastoral Lease Tenures, 29% on Freehold land, with the remaining 8% distributed between all other tenures.
- Majority of Pastoral Lease clearing occurred prior to 1990, on Tipperary Station.

Litchfield Shire

- 44,820 ha or 14.59% of the Shire cleared
- 68% of clearing has occurred on Freehold land, 11% on Vacant Crown Land, and 7% on unclassified tenure that is generally attributed to infrastructure development, 5% on Crown Lease Term Tenure, 5% on Pastoral Lease Tenure, and the remaining 4% distributed between all other tenures.
- Clearing rates of 380-500 ha/year have been calculated. Exceptions are found in the 1990-1995 time period, with a low of 208 ha/year and 1995-2000 time period where the rate peaked at 1144 ha/year.
- Increased clearing between 1995-2000 is directly correlated with horticultural productivity for the same time period where production increased from \$21.4 to \$55.7 million in the Darwin region.

Future directions of clearing assessment will include the finalisation of detailed clearing figures across the Northern Territory. Reporting will be broadly based on biogeographic regions and areas where future agricultural development is most likely to occur.

Further refinement of clearing assessment techniques will include the investigation of rapid assessment technique using MODIS satellite data.

CONTENTS

<i>EXECUTIVE SUMMARY</i>	<i>i</i>
<i>LIST OF FIGURES</i>	<i>ii</i>
<i>LIST OF TABLES</i>	<i>iii</i>
<i>ACRONYMS</i>	<i>iv</i>
1: BACKGROUND	1
1.1 Vegetation Monitoring.....	1
1.2 Historical clearing in the Northern Territory.....	2
1.3 Current Clearing regulations.....	3
2: METHODS	4
2.1 Data Acquisition	4
2.2 Satellite Image Analysis	4
<i>Pre-Processing</i>	4
<i>Change Detection</i>	5
<i>Baseline Assessment</i>	5
<i>Accuracy Assessment</i>	5
3: RESULTS	6
3.1 Land Clearing in the Northern Territory.....	6
3.2 Litchfield Case Study.....	14
4: FUTURE DIRECTIONS	16
REFERENCES	17
<i>APPENDIX I Historical clearing</i>	19
<i>APPENDIX II Land Administration Tenure Types</i>	21
<i>APPENDIX III Interim Biogeographic Regions of the Northern Territory</i>	23

LIST OF FIGURES

Figure 1: Typical spectral reflectances for soil, green vegetation, and water in relation to the red-NIR space Findings	5
Figure 2: Regional distribution of clearing by Land Tenure Type	7
Figure 3: Distribution of Land Tenure Types in the Northern Territory	8
Figure 4: Historical Clearing in Litchfield Shire	14
Figure 5: Distribution of clearing in Litchfield Shire by tenure type between 1977 and 2000	15
Figure 6: Increase of clearing and horticultural production in the Litchfield Shire 1985-2001	15

LIST OF TABLES

Table 1: Clearing in the Northern Territory	6
Table 2: Comparative Clearing by Region for three time periods: Pre 1990, 1990-1995, & 1995-2000	9
Table 3: Clearing in the Litchfield Shire to 2001	9
Table 4: Clearing in the Daly Basin to 2001	10
Table 5: Clearing in Coomalie Shire to 2000	10
Table 6: Clearing in the Mary River Catchment to 2000	11
Table 7: Clearing in the Tiwi Islands to 2000	11
Table 8: Clearing in the Darwin Region to 2000	12
Table 9: Clearing in the Palmerston Region to 2000	12
Table 10: Clearing in the East Arm Port Development Region to 2000	13
Table 11: Clearing in Ti-Tree Catchment to 2000	13
Table 12: Clearing and associated rates in Litchfield Shire 1977-2000	14

ACRONYMS

ADC	Agricultural Development Corporation
ADMA	Agricultural Development and Marketing Authority
AGO	Australian Greenhouse Office
ALCC	Agricultural Land Cover Change
CSIRO	Commonwealth Scientific & Industrial Research Organisation
DCA	Development Consent Authority
DIPE	Department of Infrastructure, planning & Environment
DPI&F	Department of Primary Industry & Fisheries
GPS	Global Positioning System
GGI	Greenhouse Gas Inventory
IBRA	Interim Biogeographic Regionalisation of Australia
ILZ	Intensive Landuse Zone
Landsat ETM	Landsat Enhanced Thematic Mapper
Landsat MSS	Landsat Multi-Spectral Scanner
Landsat TM	Landsat Thematic Mapper
µm	Micro metre
MODIS	Moderate Resolution Imaging Scanner
NIR	Near Infrared
NT	Northern Territory
NTG	Northern Territory Government
QDNR	Queensland Department of Natural Resources
TLC	Tipperary Land Corporation

1. BACKGROUND

1.1 Vegetation Change Monitoring

Monitoring land cover change is increasingly important for natural resource management, biodiversity assessment, and inventory for implementing international agreements on greenhouse gas emissions (Zhan *et al.*, 1999).

Clearing is essentially the mechanical process of changing one vegetative land cover type to another. For the purpose of this report, clearing is defined as all areas where ‘native’ vegetation has undergone any land cover change that is detectable at a scale 1ha or greater. Omission errors will occur in some areas including those cleared prior to 1972 where regrowth has occurred and areas subjected to a high fire frequency. Re-clearing of land including plantation management has not been addressed in this report, but will be incorporated into an ongoing monitoring system.

Early clearing rates for the Northern Territory during the period 1983 to 1993 were estimated to be 16,280 ha/year. These figures were initially compiled for the first National Greenhouse Gas Inventory (GGI), from very diverse sources, and were not considered overly accurate (Barson *et al.*, 2000). The Agricultural Land Cover Change (ALCC) project was subsequently funded to acquire spatially explicit clearing figures using remote sensing between the 1990 - 1995 for the purpose of calculating Australia’s carbon sequestration figures.

For the ALCC reporting period (1990 – 1995) an annual rate of 3,320 ha/year for the Northern Territory was recorded with 58% of this clearing attributed to infrastructure development, 36% attributed to agriculture and horticulture, and 6% attributed to grazing. This data was derived using image differencing and thresholding techniques and was independently verified at 95% confidence level at a scale 1 ha or greater (Lowell, 2000).

The ALCC figures represent a snapshot in time and do not represent all of the clearing that has occurred in the study area. This report documents the change analysis conducted over regions in the NT where cover change due to agricultural expansion is most likely. This includes three time periods; pre 1990, 1990-1995 (ALCC figures), and 1995 – 2000. A clearing figure for the entire Northern Territory has also been calculated from multiple sources, including Landsat satellite data, pastoral clearing records, and road, rail, and gas easement estimates.

A case study of clearing in the Litchfield Shire has also been included to illustrate the rates and types of clearing occurring in this region between 1977 and 2000. Similar studies are planned for each of the priority areas when early Landsat MSS data has been suitably processed.

1.2 Historical clearing in the Northern Territory

The issue of land clearing was considered one of the biggest costs for land cultivation and subsequent agricultural development in the Northern Territory (Dept of Territories, 1960). Early attempts at agriculture in the semi-arid tropics were constrained by failure to adequately assess the implications of climate, topography, and hydrology (Bauer, 1985). Sugar cane was the first agricultural commodity attempted, with options taken out over approximately 40,500 ha along the Daly River, Adelaide River and Cox Peninsula in 1879 (Bauer, 1964). Grand development plans resulted in two small plantations established in 1881-82 along the Daly River and the Cox Peninsula. Only a small nursery crop was ever planted with the Daly River producing nothing and the Cox Peninsula plantation only producing 5 tonnes (Bauer, 1985 1964).

It wasn't until the 1950s that rice was trialed on the Adelaide River floodplains at Humpty Doo and Beatrice Hill by the Commonwealth Scientific & Industries Research Organisation (CSIRO) at Humpty Doo (Mollah, 1982). Early optimism led to the formation of Territory Rice Limited, an American-Australian syndicate that was given the exclusive rights to develop the sub-coastal plains under the Rice Development Agreement Ordinance in 1956 (Mollah, 1982). Although some clearing of woody vegetation was required for these ventures, they led to a significant change in land use. The maximum area ever planted to rice was about 2000 ha in the 1958 and 1959 seasons (Fisher, 1977).

The perceived success of the rice trials and the need for future direction of agricultural industry in the Territory led to the Commonwealth government commissioning a report in 1959, to inquire into the prospects of agriculture in the Northern Territory, commonly known as 'The Forster Report' (Dept of Territories, 1960). Outcomes of this report concluded that rice growing on the sub-coastal plains and the use of improved pasture was 'economic', but for any worthwhile progress, government assistance would be required. Other recommendations included setting up pilot farms and large scale clearing trials in the Katherine, Daly River and Darwin regions (Dept of Territories, 1960) with a strong interest in the expansion of agricultural activities on Tippera soils (Mollah, 1980).

However, commercial rice production had all but died by the early 1960s, with operations of Territory Rice Limited ceasing in 1963 (Fisher, 1977). At the same time expanding beef markets into Japan (Mollah, 1980), and America (Bauer, 1985; Sturtz, 2000) saw a push for improved pastures for stock feed.

In 1967 the first large-scale clearing project occurred in the Northern Territory on Tipperary station by the Tipperary Land Corporation (TLC) and at the time was believed to be the one of the biggest single agricultural projects in the world (NT News, 24/07/1967). The scheme planned for 79,000 ha to be cleared over 5 years, however, poor management, seasons and trying to do too much too soon eventually sent the Texan-based company broke (Mollah, 1980). Not learning from these mistakes, the Agricultural Development Corporation (ADC) undertook a similar feat in the early 1970s on Willeroo Station. An estimated 48,600 ha was recorded as cleared, with only 16,000 ha ever being farmed (Fisher, 1977).

With self Government in 1978, the NT launched the Agricultural Development and Marketing Authority (ADMA) in 1981/82. This Authority assisted private cropping developments (Sturtz, 2000) that helped establish the NT horticultural industry, and resulted in further clearing on Tipperary station in 1988/89 and development of the Douglas Daly research farms.

1.3 Current Clearing Controls

Current clearing controls exist under the *Pastoral Land Act 1992* and the *Planning Act 1999*.

Pastoral land represents 46.4% of the Territory (Fig. 3). Under the *Pastoral Land Act 1992*, a formal written approval is required by the Pastoral Land Board prior to any clearing (not including for infrastructure). Applications to clear land need to outline the reason for clearing, total area to be cleared, location, timing, method, and erosion control measures.

Under the *Litchfield Shire Area Plan 1992*, 50% of any freehold portion can be cleared without any formal approval process. Under this control plan clearing in excess of 50% requires the approval of the Development Consent Authority (DCA), which includes public appeal process.

On 4 December 2002, the Interim Development Control Order No. 12 was declared and now requires consent for clearing on all freehold land, outside of the existing control plan areas on land 2 hectares or greater in size. Under the new Native Vegetation Clearing Controls landholders can only have a total of 1 hectare of native vegetation cleared without consent. The new controls apply to approximately 620,000km² of land (or about half of the NT). It is envisaged that following a 2-year public consultation period they will be combined within the NT Planning Scheme which will further introduce clearing controls to zoned land throughout the Northern Territory.

2. METHODS

2.1 Data Acquisition

Data was compiled from multiple sources to estimate a figure for total clearing in the Northern Territory. Data sources include Landsat TM and ETM satellite data, historical pastoral reports and estimations of road, rail, and gas pipeline easements. Specific figures and the break down of clearing by Tenure Type (Appendix II) have been generated for using 2000 Landsat ETM data for:

- Darwin
- Palmerston
- East Arm Region
- Coomalie Shire
- Litchfield Shire
- Mary River Catchment
- Daly Basin (biogeographic region)
- Tiwi Islands
- Ti-Tree Catchment

Satellite data has been used to generate the majority of these estimates as it allows an unbiased, cost effective, repeatable method of determining land cover change at a scale of 1 ha or greater. Similar studies include the Statewide Landcover and Tree Study (SLATS) (Danaher, *et al.*, 1998; QDNR, 1999) in Queensland, and national projects such as the ALCC project (Barson *et al.*, 2000), and the Australian Greenhouse Office (AGO) project (Furby, 2001).

A case study giving an historical perspective of clearing in the Litchfield Shire was undertaken using Landsat MSS data for 1977, 1980, 1985 and 1988 and Landsat TM/ETM data for 1990, 1995, 2000 and 2001.

2.2 Satellite Image Analysis

Pre-Processing

To ensure geometric and radiometric accuracy so that historical imagery is comparable, two stages of pre-processing are required: rectification and calibration.

Geometric corrections were used to make sure that clearing identified is spatially accurate and allows for temporal comparison of data. Each image was rectified to a base image using 50 – 70 controls points and resampled using cubic convolution for superior accuracy (Homer, *et al.*, 2002).

Radiometric calibration was used to ensure consistency of ‘like-value’ digital counts through time. This means that areas are comparable over time so if change occurs it is ‘real change’ and not caused by sensor irregularities. This relates to cloud and atmospheric effects along with sensor variation contributing towards attenuation in the value of surface reflection recorded by the sensors (Furby and Campbell, 2001).

Change Detection

Vegetation reflects strongly in the Red (0.63 – 0.69 μm)-Near Infrared (0.769-0.9 μm) (NIR) space of the electromagnetic spectrum (Fig. 1). Changes in the strength of this response vary with different amounts and types of vegetative cover. This means that for a specific region and time of the year, the various cover types have characteristic responses in the red-NIR space (Huete *et al.*, 1999; Zhan *et al.*, 1999). Stratification is used to limit the effects of difference in the spectral reflectance between and within the satellite data to separate patterns of physiographic and phenologic influences (Homer *et al.*, 2002) such as changes in lithology and biogeographic regions.

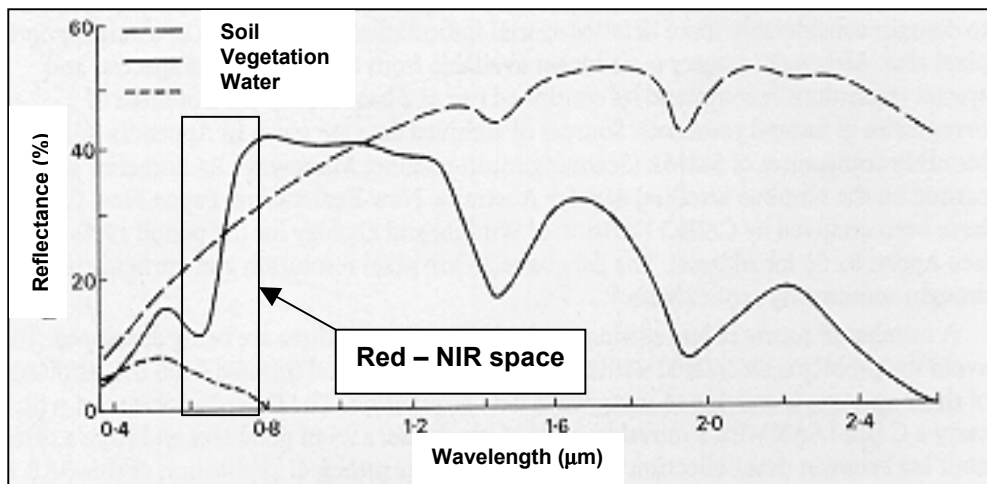


Figure 1: Typical spectral reflectances for soil, green vegetation, and water in relation to the red-NIR space [Adapted from Harrison and Jupp, 1989]

Land cover change due to clearing was identified by isolating where significant changes in the red-NIR space occurred from one year to the next. The change threshold varies between different strata due to types of vegetation present and underlying soil colour and texture. Ideally images from the same time of the year are used to limit seasonal influence, however this is not always possible. In these cases thresholds were adjusted to account for seasonal disparity.

Baseline Assessment

Landsat MSS data is available from 1972 in select areas of Australia, while good coverage across the continent didn't occur until the early 1980s. This means that clearing figures since European settlement can not be obtained by change detection techniques. This baseline figure has been derived by visually assessing and digitising the image data using multiple image datasets.

Accuracy Assessment

The clearing dataset has been field checked by experienced image analysts and field officers using historical photography and global positioning systems (GPS). Accuracy at a scale of 1ha is estimated for these regions. More detailed accuracy estimates will be attached to each region as the temporal clearing assessments have been finalised.

3. RESULTS

3.1 Land Clearing in the Northern Territory

Land clearing estimates for the Northern Territory are presented in Table 1. Adjustments have been made to ensure that no overlap has occurred from multiple data sources.

Table 1: Clearing in the Northern Territory

Source/Region	Area Cleared (ha)
PASTORAL RECORDS (1992) *	102394
LANDSAT TM REGIONAL FIGURES**	
Darwin	6841.32
Palmerston	2292.84
Coomalie Shire	17044.29
Port Zone	1096.99
Litchfield Shire	43674.90
Ti-Tree	11175.31
Tiwi Islands	10925.78
Mary River Catchment	19533.29
Daly Basin (Landsat)	190773.16
Daly Basin (estimate since 2000)	600
BRS Data (1990-1995)***	9570
ROADS #	
Federal	10680
Rural	10400
Local	48000
RAILWAY ##	9940
GAS PIPELINE ###	5400
URBAN +	
Alice Springs	2408.43
Tennant Creek	290
Jabiru	286.66
Nhulumbuy ++	400
Total Clearing (ha)	503726.99
% of Total Area (134620000)	0.37

* Based on Pastoral Clearing records prior to the commencement of the *Pastoral Land Act* in 1992.

** Figures based on Landsat TM 2000 imagery. Other dates have been used for verification of historical clearing.

*** Data derived from the ALCC project for 1990-1995.

Road estimates, Federal 2570km x 40m corridor; Rural 2600km x 40m corridor; Local 16000km x 30m corridor.

Rail Corridor estimated at 1420km with an average width of 70m.

Gas Pipeline easement estimated at 1800km with an average width of 30m.

+ Town areas derived from Landsat data not included in the regional figures.

++ Based on DIPE records that 50-60% of the town lease is built on.

Land clearing has been estimated at less than 0.5% of the total area of the Northern Territory, with the Daly Basin and the Litchfield Shire being the areas of most intense activity. These areas are also considered the most likely for future agricultural development. The distribution of clearing in each region by land tenure type (Appendix II) is illustrated in Figure 2 and listed in Tables 2 – 12. The majority of clearing has occurred on freehold land. Exceptions are the Daly Basin, where the clearing at Tipperary Station, a pastoral lease accounts for the single biggest area of clearing; the Mary River, where a large area is under Crown Lease tenure; and the Tiwi Islands and Ti-Tree

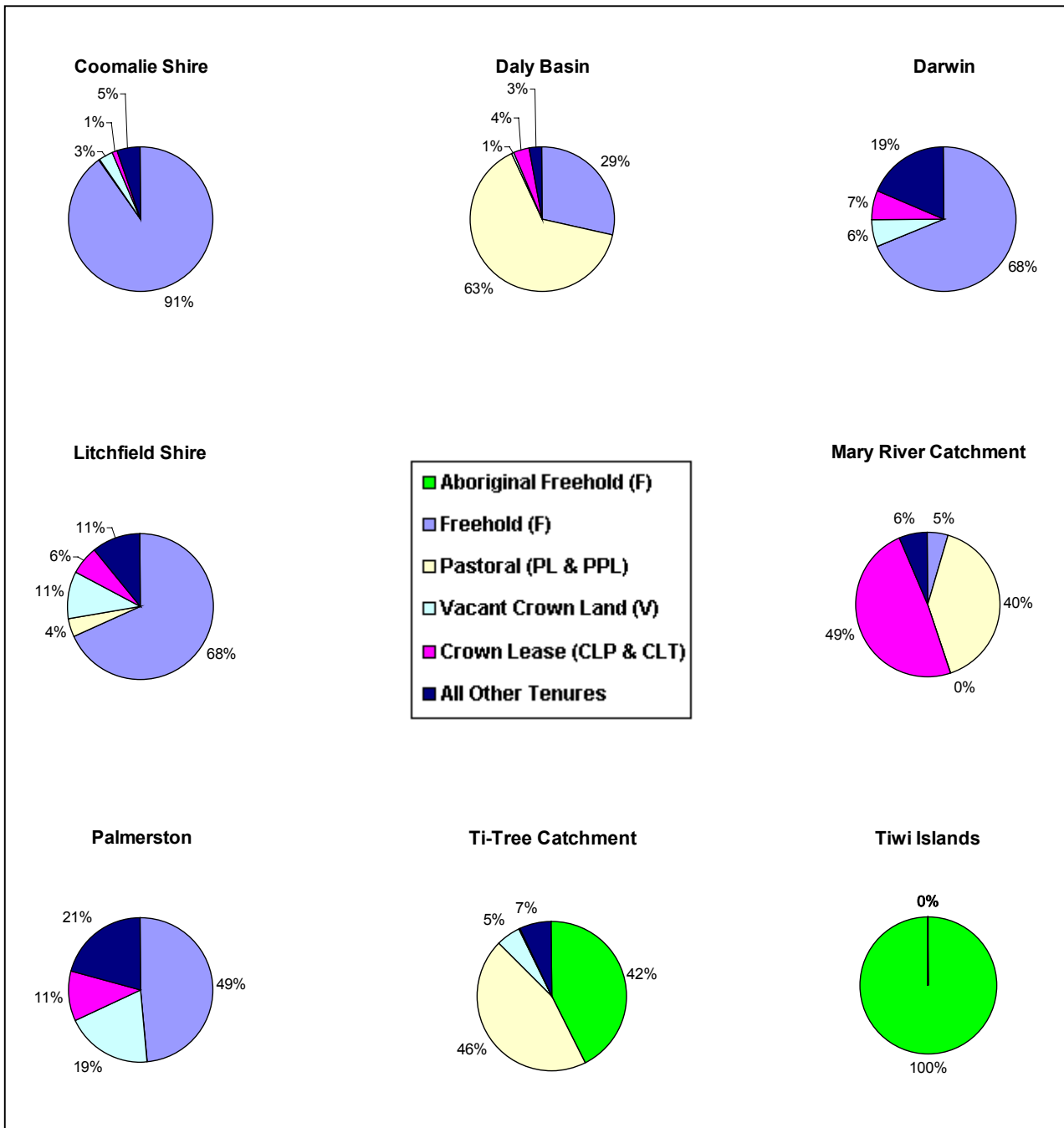


Fig. 2: Regional distribution of clearing by land tenure types.

While the majority of clearing has occurred on general freehold it represents only a fraction of the land mass (Fig 3). The largest tenure type is pastoral (46.4%) followed by Aboriginal Freehold (44.02%).

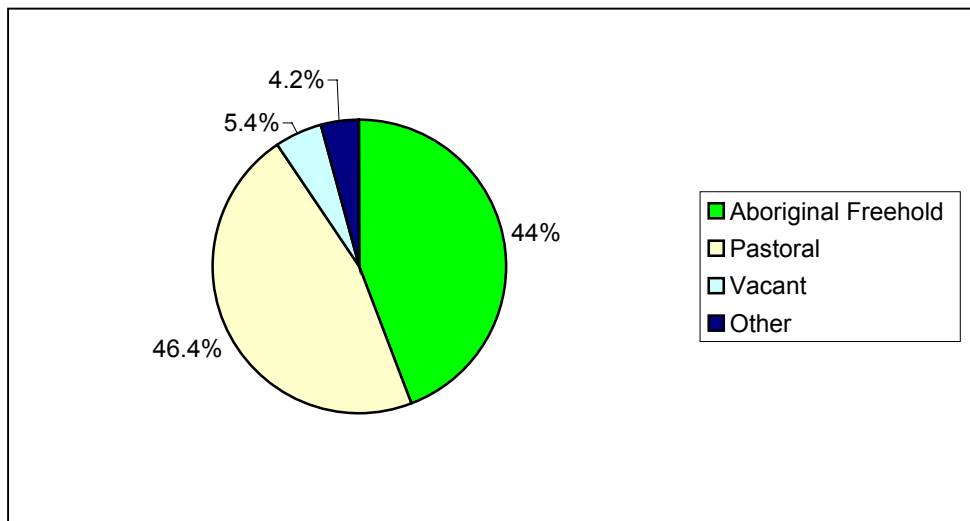


Figure 3: Distribution of land tenure types in the Northern Territory.

Table 2: Comparative Clearing by Region for three time periods: Pre 1990, 1990-1995, 1995-2000

Region	Total Area	CLEARING PRE 90			CLEARING 90-95			CLEARING 95-00			TOTAL CLEARING		
		Area (ha)	% Region	Area (ha)	Area (ha)	% Region	Area (ha)	% Region	Area (ha)	% Region	Area (ha)	% Region	
Litchfield	307255.93	37695.73	12.27	1146.28	0.37	5496.50	1.79	44338.51	14.43				
Darwin	14070.50	6721.65	47.77	18.14	0.13	119.67	0.85	6859.46	48.75				
Palmerston	5620.72	1688.55	30.04	N/A	N/A	604.30	10.75	2292.84	40.79				
Port Region	6885.34	899.77	13.07	55.47	0.81	197.22	2.86	1152.46	16.74				
Tiwi Islands	749851.63	10668.87	1.42	241.50	0.03	256.91	0.03	11167.29	1.49				
Mary River	80852.44	15700.30	1.94	1180.19	0.15	3832.99	0.47	20713.48	2.56				
Coomalie Shire	150819.54	15465.47	10.25	343.17	0.23	1578.82	1.05	17387.46	11.53				
Daly Basin	2256436.25	177031.87	7.85	3771.71	0.17	12851.40	0.57	193654.98	8.58				

Table 3: Clearing in Litchfield Shire to 2001.

Tenure	Area of Shire		Clearing		Total Area Cleared	
	ha	%	ha	%	ha	%
Building Lease (BL)	2.35	0.00	1.149774	0.00		0.00
Crown Lease Perpetual (CLP)	31316.27	10.19	2096.193	4.68		0.68
Crown Lease Term (CLT)	1822.55	0.59	674.612	1.51		0.22
Freehold (F)	105036.37	34.19	30363.08	67.74		9.88
Govt Set Aside (G)	7603.99	2.47	613.1146	1.37		0.20
Misc Lease (ML)	39.77	0.01	39.77041	0.09		0.01
Misc Licence (MLIC)	508.16	0.17	385.1305	0.86		0.13
Not Classified (NC) *	24942.40	8.12	3201.525	7.14		1.04
Occupational Licence (OL)	911.86	0.30	237.4306	0.53		0.08
Perpetual Pastoral Lease (PPL)	75615.57	24.61	2005.85	4.48		0.65
Reserve (RES)	12615.42	4.11	93.79988	0.21		0.03
Special Purpose Lease (SPL)	2264.07	0.74	131.0158	0.29		0.04
Vacant Crown Land (V)	44577.17	14.51	4977.532	11.11		1.62
TOTAL	307255.93	100.00	44820.20	100.00		14.59

Table 4: Clearing in the Daly Basin to 2001

Tenure	Area of Daily Basin ha	%	Clearing ha	Clearing %	Total Area Cleared %
Building Lease (BL)	1.32	0.00	1.47	0.00	0.00
Crown Lease Perpetual (CLP)	260380.15	12.45	4967.01	2.55	0.24
Crown Lease Term (CLT)	98475.82	4.71	2168.67	1.11	0.10
Freehold (F)	498675.60	23.84	55817.65	28.69	2.67
Govt. Set Aside (G)	60.76	0.00	50.73	0.03	0.00
Not Classified (NC) *	9416.90	0.45	4969.89	2.55	0.24
Occupational Licence (OL)	41.35	0.00	11.39	0.01	0.00
Pastoral Lease (PL)	527068.97	25.19	30480.31	15.67	1.46
Perpetual Pastoral Lease (PPL)	555770.28	26.57	94653.13	48.65	4.52
Reserve (RES)	1374.06	0.07	106.21	0.05	0.01
Special Purpose Lease (SPL)	1624.09	0.08	52.95	0.03	0.00
Vacant Crown Land (V)	139221.14	6.65	1265.46	0.65	0.06
TOTAL	2092110.44	100.00	194544.87	100.00	9.30

Table 5: Clearing in Coomalie Shire to 2000.

Tenure	Area of Shire ha	%	Clearing ha	Clearing %	Total Area Cleared %
Building Lease (BL)	0.04	0.00	0.04	0.00	0.00
Crown Lease Perpetual (CLP)	23655.53	15.68	219.22	1.26	0.15
Crown Lease Term (CLT)	282.82	0.19	16.66	0.10	0.01
Freehold (F)	116951.52	77.54	15702.40	90.31	10.41
Govt Set Aside (G)	257.76	0.17	87.54	0.50	0.06
Not Classified (NC) *	2370.84	1.57	795.46	4.57	0.53
Perpetual Pastoral Lease (PPL)	4189.15	2.78	39.61	0.23	0.03
Reserve (RES)	22.03	0.01	0.15	0.00	0.00
Right To Freehold Title (RTFT)	1.36	0.00	1.36	0.01	0.00
Special Purpose Lease (SPL)	19.56	0.01	9.90	0.06	0.01
Vacant Crown Land (V)	3068.92	2.03	515.14	2.96	0.34
TOTAL	150819.54	100.00	17387.46	100.00	11.53

Table 6: Clearing in the Mary River Catchment to 2000.

Tenure	Area of Catchment ha	%	Clearing ha	Clearing %	Total Area Cleared %
Crown Lease Perpetual (CLP)	241644.02	29.89	10070.62	48.62	1.25
Crown Lease Term (CLT)	436.78	0.05	56.46	0.27	0.01
Freehold (F)	29024.44	3.59	1005.08	4.85	0.12
Govt Set Aside (G)	1.86	0.00	0.00	0.00	0.00
Not Classified (NC) *	3776.33	0.47	1240.17	5.99	0.15
Pastoral Lease (PL)	103279.40	12.77	1747.47	8.44	0.22
Perpetual Pastoral Lease (PPL)	313783.08	38.81	6511.17	31.43	0.81
Right To Freehold Title (RTFT)	116514.93	14.41	77.79	0.38	0.01
Vacant Crown Land (V)	61.59	0.01	4.72	0.02	0.00
TOTAL	808522.44	100.00	20713.48	100.00	2.56

Table 7: Clearing in the Tiwi Islands to 2000.

Tenure	Area of Islands ha	%	Clearing ha	Clearing %	Total Area Cleared %
Freehold (F)	746789.15	99.59	11154.82	99.89	1.49
Not Classified (NC) *	2480.53	0.33	11.84	0.11	0.00
Special Lease (SPL)	0.52	0.00	0.52	0.00	0.00
Vacant Crown Land (V)	581.43	0.08	0.11	0.00	0.00
TOTAL	749851.63	100.00	11167.29	100.00	1.49

Table 8: Clearing in the Darwin Region to 2000.

Tenure	Area of Region ha	%	Clearing ha	Clearing %	Total Area Cleared %
Building Lease (BL)	1.89	0.01	1.89	0.03	0.01
Crown Lease Perpetual (CLP)	651.67	4.63	396.28	5.78	2.82
Crown Lease Term (CLT)	68.21	0.48	67.44	0.98	0.48
Darwin Town Area Lease (DTAL)	0.68	0.00	0.51	0.01	0.00
Freehold (F)	7996.19	56.83	4706.69	68.62	33.45
Govt Set Aside (G)	179.63	1.28	140.38	2.05	1.00
Not Classified (NC) *	2888.83	20.53	1025.76	14.95	7.29
Occupational Licence (OL)	7.19	0.05	6.44	0.09	0.05
Reserve (RES)	1173.30	8.34	96.52	1.41	0.69
Special Lease (SPL)	9.80	0.07	7.09	0.10	0.05
Vacant Crown Land (V)	1093.10	7.77	410.47	5.98	2.92
TOTAL	14070.50	100.00	6859.46	100.00	48.75

Table 9: Clearing in the Palmerston Region to 2000.

Tenure	Area of Region ha	%	Clearing ha	Clearing %	Total Area Cleared %
Crown Lease Perpetual (CLP)	29.01	0.52	29.02	1.27	0.52
Crown Lease Term (CLT)	340.64	6.06	231.88	10.11	4.13
Freehold (F)	1328.42	23.63	1107.79	48.31	19.71
Govt Set Aside (G)	56.44	1.00	56.10	2.45	1.00
Not Classified (NC) *	1677.68	29.85	411.30	17.94	7.32
Occupational Licence (OL)	2.50	0.04	1.59	0.07	0.03
Reserve (RES)	2.91	0.05	2.91	0.13	0.05
Special Lease (SPL)	8.49	0.15	8.23	0.36	0.15
Vacant Crown Land (V)	2174.64	38.69	444.04	19.37	7.90
TOTAL	5620.72	100.00	2292.84	100.00	40.79

Table 10: Clearing in the East Arm Port Development Region to 2000.

Tenure	Area of Region ha	%	Clearing ha	Clearing %	Total Area Cleared %
Crown Lease Perpetual (CLP)	90.34	1.31	38.46	3.34	0.56
Crown Lease Term (CLT)	159.11	2.31	57.46	4.99	0.83
Freehold (F)	1010.39	14.67	248.38	21.55	3.61
Govt Set Aside (G)	346.77	5.04	319.08	27.69	4.63
Licence to Occupy (LOC)	3.04	0.04	2.70	0.23	0.04
Not Classified (NC) *	4509.89	65.50	144.79	12.56	2.10
Reserve (RES)	172.65	2.51	69.55	6.04	1.01
Vacant Crown Land (V)	593.15	8.61	272.04	23.61	3.95
TOTAL	6885.34	100.00	1152.46	100.00	16.74

Tenure 11: Clearing in the Ti-Tree Catchment to 2000

Tenure	Area of Catchment ha	%	Clearing ha	Clearing %	Total Area Cleared %
Crown Lease Perpetual (CLP)	16.38	0.00	7.98	0.07	0.00
Crown Lease Term (CLT)	675.14	0.07	3.17	0.03	0.00
Freehold (F)	274245.17	27.47	4734.44	42.37	0.47
Govt Set Aside (G)	22.02	0.00	16.45	0.15	0.00
Not Classified (NC) *	2711.60	0.27	770.40	6.89	0.08
Pastoral Lease (PL)	16913.65	1.69	0.00	0.00	0.00
Perpetual Pastoral Lease (PPL)	689075.93	69.02	5039.07	45.09	0.50
Reserve (RES)	0.33	0.00	0.33	0.00	0.00
Vacant Crown Land (V)	14688.61	1.47	603.47	5.40	0.06
TOTAL	998348.83	100.00	11175.31	100.00	1.12

3.2 Litchfield Shire Case Study

The Litchfield Shire is one of the most intensely developed rural areas in the Northern Territory. Clearing figures (Table 12) based on satellite imagery indicate that 14.6% of the Shire has undergone land cover change.

Since 1977, 12,989 ha of land has been cleared, which represents 4.37% of the Shire (Table 12). These historical figures have been graphically summarised in Fig. 4.

Table 12: Clearing and associated rates in Litchfield Shire between 1977-2001.

	Area Cleared (ha)	Clearing Rate (ha/year)	% Shire Cleared
Pre 1977	31832	-	10.36
1977 – 1980	1142	380	10.73
1980 – 1985	2494	400	11.54
1985 – 1988	1257	436	11.95
1988 – 1990	971	501	12.27
1990 – 1995	1146	208	12.64
1995 – 2000	5497	1144	14.43
2000 – 2001	482	480	14.59

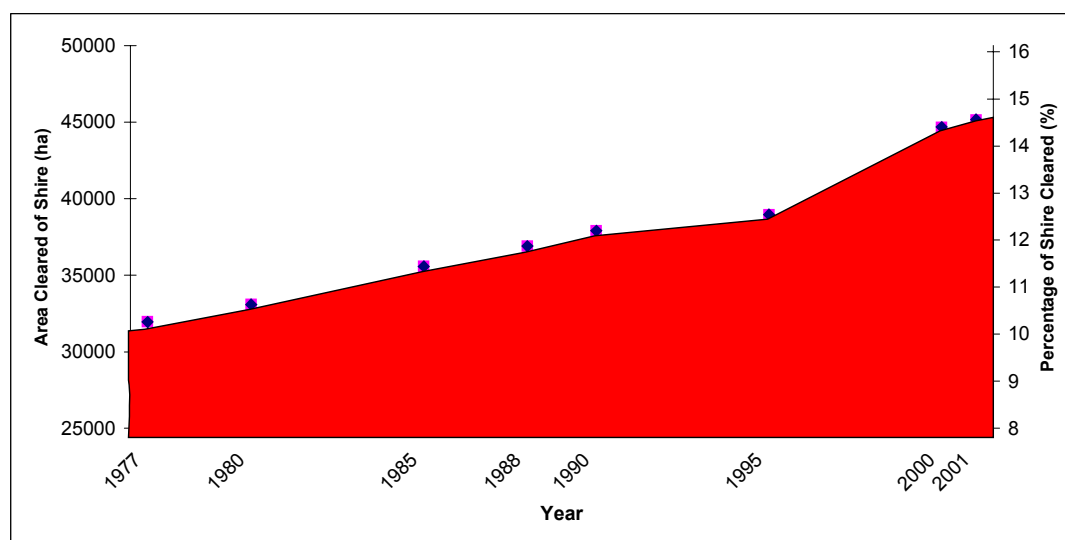


Figure 4: Historical Clearing in the Litchfield Shire.

Based on these clearing rates approximately 32,000 ha of land was cleared before 1977, and 45,000 ha cleared by 2001. Clearing rates were steady between 1977 – 1990 with a rate of 457 ha/year. The rate actually decreased in the 1990-1995 period to 208 ha/year and increased to 1144 ha/year in the 1995-2000 time period, supporting observations by Brock (2001) that more concentrated clearing occurred largely after the mid 1990s. Figures for the 2000-2001 period suggest that clearing rates have decreased to levels observed pre-1990.

The distribution of clearing against tenure types is shown in Figure 5. Freehold land is consistently the tenure type under the greatest clearing pressure. The rise in the 95-00 period coincides with increased horticultural development, particularly mangoes.

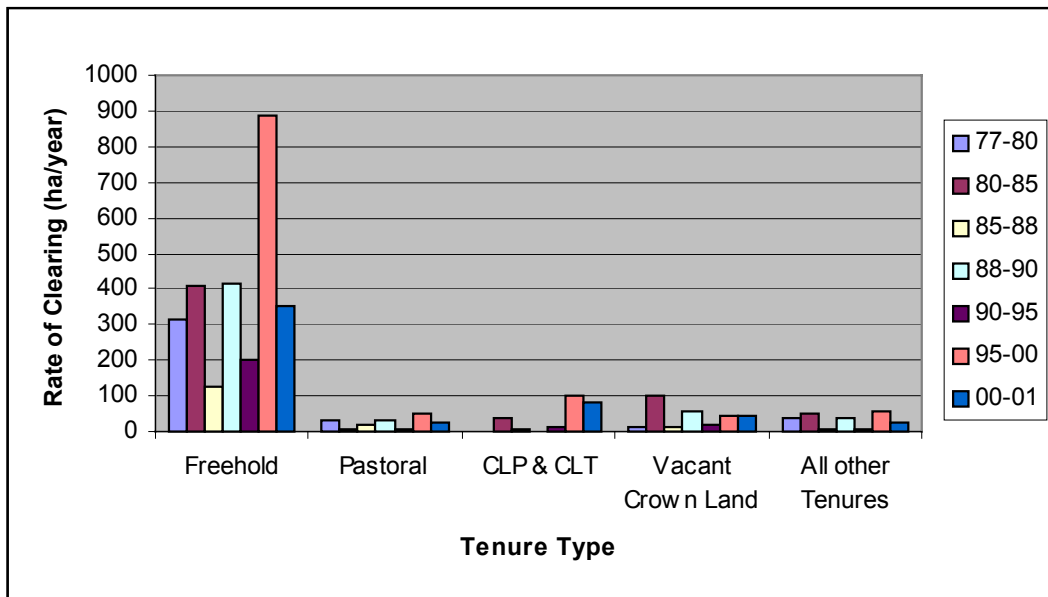


Figure 5: Distribution of clearing in Litchfield Shire between 1977-2000.

A strong correlation exists between land clearing since 1985 and horticultural production (Fig. 6). For every 1% (307 ha) cleared productivity has increased by \$28,000,000. A clearing increase of 5,728 in the 1995-2000 time period corresponds to horticultural production doubling from \$21.4 M to \$55.7 M (DPI&F, 1985 –2000).

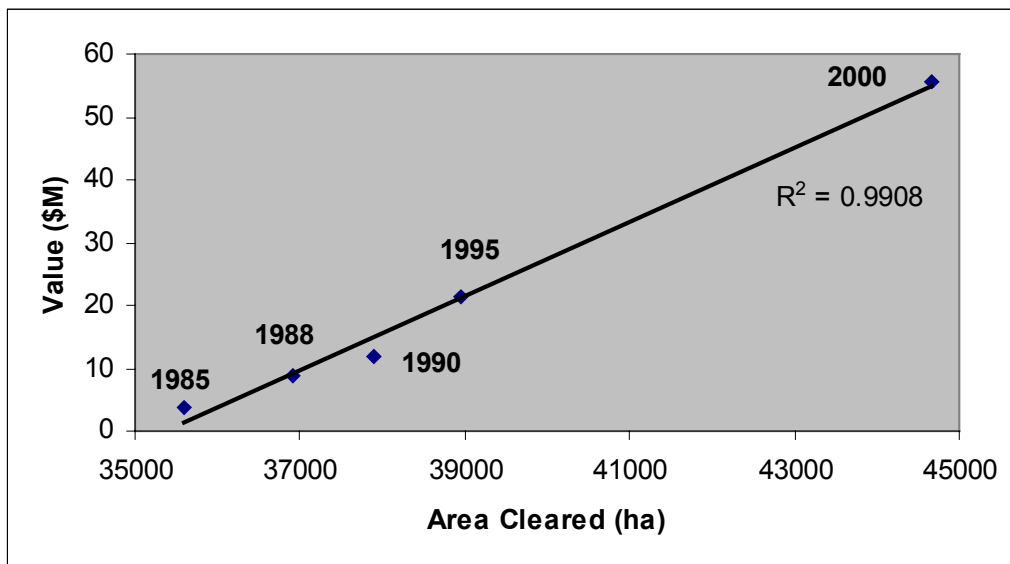


Figure 6: Increase of clearing and horticultural production in the Litchfield Shire, 1985-2000.

4. FUTURE DIRECTIONS

While the main objective of this document is to outline the amount of clearing that has occurred across the Northern Territory, the future direction is to develop a comprehensive semi-automated monitoring system.

Future aims are to:

- Finalise detailed baseline clearing assessment across the Northern Territory.
- Analyse time trend data across the Northern Territory.
- Develop annual reporting processes based on the Interim Biogeographic Regionalisation of Australia (IBRA) (Appendx III).
- Investigate the use of the Moderate Resolution Imaging Scanner (MODIS), a new generation satellite sensor for rapid, inter-annual assessment of land cover change.

Historical Landsat Satellite Data is currently being acquired for 1972, 1977, 1980, 1985, 1988, 1989, 1991, 1992, 1995 and 1998, where it is available. This data will be used to analyse regional land clearing trends and confirm total clearing figures.

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APPENDIX I

Historical Clearing

- 1879** First interest in sugar cane (Bauer, 1964).
First station at Katherine stocked (Dept of Territories, 1960).
- 1881** April 1881 approximately 100000 acres selected by southern interests. By June work had commenced on the Daly River and the Cox Peninsula (Bauer, 1964).
- 1884** Both major sugar efforts completely abandoned, with Daly River venture producing nothing and the Cox Peninsula effort producing 5 tonnes (Bauer, 1964).
- 1952/53** Rice trials commenced with 48 acres planted at Humpty Doo (Dept of Territories, 1960).
- 1955** December 1955 - Agreement signed by the Commonwealth Government and Territory Rice Limited (Mollah, 1982; Dept of Territories, 1960).
- 1956** 1. Northern Territory Administration established a research centre at Beatrice Hill, on sub coastal plains near Humpty Doo, (Mollah, 1982).
2. Rice Development Agreement Ordinance – giving Territory Rice Limited exclusive rights to develop the sub-coastal plains effective from January 1. (Mollah, 1982).
- 1958/59** First major seeding of about 2000 acres by Territory Rice (Fisher, 1977).
- 1959** CSIRO coastal plains research centre established at Middle Point
- 1959/60** Land clearing trials on 200 acres adjacent to the Northern Territory Administration form at Katherine, 150 acres on the Daly River Road (both on Tipperary Land System), 150 acres on the Daly River, and 130 acres at the Berrimah Experiment Farms (Koolpinyah land type) (Dept of Territories, 1960).
- 1967** Clearing on Tipperary started in April 1967 (Fisher *et al.*, 1977).
- 1969** Commonwealth Soil Conservation Land Utilization and Control Ordinance
- 1971** Northern Agricultural Development Corporation (NADC) formed. Clearing of Willeroo Station commenced 1970-71 (Fisher *et al.*, 1977).
- 1978** 1. The Northern Territory gains self government.
2. Soil Conservation and Land Utilization Act Legislated based on the Soil Conservation and Control Ordinance 1969.
- 1981/82** Agricultural Development Marketing Authority (ADMA) launched to assist private cropping development (Sturtz, 2000).
- 1988** Soil conservation order revoked on Willeroo Station (Pastoral Records).

- 1992**
1. Pastoral Land Act commenced 26 June 1992. Lessees are required to submit a formal application to clear to the Pastoral Land Board, outlining the reason why they wish to clear including the total area, and where the clearing is to occur.
 2. Litchfield Shire Area Plan released.
- 2001**
1. Clearing for railway corridor commenced.
 2. Soil Conservation Land Utilization Act updated.
- 2002**
- Land Clearing Guidelines released.

APPENDIX II

Land Administration and Information System (LAIS) Tenure Types

Code	Tenure Type	Purpose
BL	Building Lease	Temporary Occupation of Govt buildings
CLP	*Crown Lease Perpetual	Perpetual Lease for specific purposes such as horticulture etc.
CLT	*Crown Lease Term	Two to Five year lease for development purposes convertible to Freehold / CLP on completion of development covenants
F	* Freehold	Fee Simple (Torrens) registered title
FCL	* Fish Culture Lease	Term Lease for specified purpose
FFL	* Fish Farming Lease	Similar to above
G	Government	NT Government usage - no registered tenure
LOC	Licence to occupy	Short term occupation of Crown land
ML	Miscellaneous Lease	Term Lease up to 30 yrs for miscellaneous purposes
MLIC	Miscellaneous Licence	Temporary use of Crown land for timber gathering
MIN	Mineral Lease	Some 'registered' historical tenements only
OL	Occupation Licence	Occupation of Crown Land under yearly renewable licence for Grazing / Horticulture / water bores etc.
PCL	* Pearl Culture Lease	Term Lease for Pearl Farming
PL	* Pastoral Lease	Term Lease (generally 50 years) for Pastoral Purposes
PPL	* Perpetual Pastoral Lease	Perpetual Lease for Pastoral Purposes
RES	Reserve	Proclaimed Reserve (Cemetery, Historic, Recreation etc.)

RTFT	Right to Freehold Title	Land subject to acquisition of Fee Simple (Freehold) interest by the Commonwealth of Australia under the NT Self Govt Act but for which no freehold title has been issued
SPL	* Special Purpose Lease	Term Lease (generally 10 to 30 years) issued to Sporting Clubs, Scout Groups etc.
V	Vacant Crown Land	Un-alienated Crown Land with no registered title

NOTES: Tenure Types prefixed * infer exclusive permanent land ownership (in the case of Freehold) or exclusive occupation (under the terms of the Lease) for Leasehold land.

‘Freehold’ land includes titles issued by the Northern Territory Government (‘NT Freehold’) limited to a maximum of 150 km² per holding, and titles issued by the Commonwealth Government under the Aboriginal Land Rights (NT) Act (‘Commonwealth’ or ‘Aboriginal Freehold’) unlimited in size.

Freehold titles issued by the NT Government as a result of negotiated Land Claim settlement are issued in the name of Aboriginal Corporations, and for large tracts of land contain blocks of titles not exceeding 150 km² per title.

Tenure for Freehold or Leasehold land is referred to as ‘registered’ tenure, ie. formally registered with the Land Titles Office.

MINING tenures such as Exploration Licence, Mineral Lease, Extractive Mineral Lease, Mineral Claim etc. are issued and recorded by the Department of Mines & Energy and apart from some historical tenements do not appear in LAIS.

