RESEARCH PUBLICATION No. 40

Historical Nutrient Usage in Coastal Queensland River Catchments Adjacent to the Great Barrier Reef Marine Park

J.S. Pulsford

Great Barrier Reef Marine Park Authority

Reef

RESEARCH PUBLICATION No. 40

Historical Nutrient Usage in Coastal Queensland River Catchments Adjacent to the Great Barrier Reef Marine Park

J. S. Pulsford

March 1993

A REPORT TO THE GREAT BARRIER REEF MARINE PARK AUTHORITY

ISSN 1037-1508
ISBN 0 642 23011 0
Published July 1996
by the Great Barrier Reef Marine Park Authority

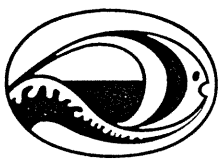
National Library of Australia Cataloguing-in-Publication data:

Pulsford, J. S. (Jim S.).
Historical nutrient usage in coastal Queensland river catchments adjacent to the Great Barrier Reef Marine Park.

Bibliography.
ISBN 0 642 23011 0.

1. Water - Nitrogen content - Queensland - Great Barrier Reef. 2. Water - Queensland - Great Barrier Reef - Phosphorus content. 3. Fertilizers - Environmental aspects. I. Great Barrier Reef Marine Park Authority (Australia). (Series : Research publication (Great Barrier Reef Marine Park Authority (Australia)) ; no. 40).

333.916409943



Great Barrier Reef Marine Park Authority

PO Box 1379
Townsville Qld 4810
Telephone (077) 500 700

TABLE OF CONTENTS

TABLES

FIGURES

APPENDICES

SUMMARY

The land catchments of the North East Coast Drainage Division which is adjacent to the Great Barrier Reef, occupy about 42 million hectares, about 20% larger than the continental shelf which supports the reef.

Land use practices in these catchments depend on landform, climate, availability of irrigation, soil types and the economics of adapting natural conditions to produce various horticultural and agricultural crops.

Most of the soils of the region, the exception being some recent alluvia, are naturally deficient in the major elements, nitrogen, phosphorus and potassium. Addition of these has been necessary for large-scale crop production, particularly sugarcane and fruit and vegetable crops.

Concern has been expressed that the movement of nutrients and eroded sediments from the adjacent land presents a serious threat to the complex ecosystem of the reef. Estimates indicate that the current movement of some nutrients from the terrestrial to the marine environment may be up to four times that which occurred pre-development. There is a need to quantify nutrient transfers at the catchment level, so that management practices can be modified where necessary, to prevent degradation of the reef environment.

The research program of the Great Barrier Reef Marine Park Authority includes investigations on the effects of water quality on the reef ecosystem. As part of the overall studies, it was considered worthwhile to obtain historical data on nutrient applications, particularly nitrogen and phosphorus in fertilizers and stock feed supplements, for each of the river catchments adjacent to the reef. This report covers 28 catchments, for the period from 1910, when the first fertilizer applications were made in north Queensland, to 1990.

The information provided relies heavily on fertilizer industry sources for details of the products supplied at various times to agricultural areas. Data available from the Agricultural Census were used as points of reference, as information at the local authority area level was not published prior to the 1970-71 season. Australian Bureau of Statistics data needed to be modified to allow for changing nutrient content of fertilizer products with time, and for differences in the groups of products for which statistics were obtained. Prior to 1961-62, there was no distinction between various fertilizer types; in that year, superphosphate was first separated from other fertilizers.

Allocation of nutrient applications to catchments presented difficulties, as local authority areas in Queensland rarely relate to boundaries of river catchments. As sugarcane production constitutes the bulk of fertilizer usage (70% of the total nitrogen and 55% of the phosphorus in 1990), and since changes in nutrient use in that crop tend to reflect changes in fertilizer products supplied, a detailed study of changes in the areas and production of sugarcane at the catchment level was essential.

The report provides, for each catchment, a summary of major land uses and some details of fertilizer use practices. The area, mean annual run-off and rainfall data are tabulated for each catchment, as are historical usages of phosphorus and nitrogen. For 1990, tables are provided to show the total quantities of the nutrients applied to the main groupings of crops and pastures, the averages rates for the catchment and ratios of nutrient applications to mean annual run-off volume.

The more significant statistics contained in the report include:

- The total area of the 28 catchments from the Daintree to the Mary River, is 38 million hectares.

- Almost 83 000 tonnes of nitrogen were applied to crops and pastures and in stock feed supplements in 1990. This was about the same as had been applied, cumulatively, up to 1945.

- Cumulative nitrogen applications in the period up to 1990 were about two million tonnes, equivalent to 53 kg N/ha for the whole area adjacent to the reef.

- The intensity of nitrogen use varies considerably between catchments, with higher rates where sugarcane production is the dominant land use, e.g. the Pioneer River catchment averaged 37 kg N/ha in 1990.

- Sugarcane accounted for 71% of nitrogen use in 1990; this share had declined over the survey period as the areas of other crops and improved pastures increased.

- Eleven basins with rain-grown sugarcane production as the major agricultural land use accounted for 57% of the total nitrogen use in 1990 and 7.6% of the total land area.

- The six catchments in north Queensland where average annual run-off exceeds 50% of rainfall occupy 2.6% of the total area and accounted for 20% of 1990 nitrogen use.

- Phosphorus applications to crops and pastures and for livestock supplementation were about 13 500 tonnes of phosphorus in 1990; about the same amount as had been applied, cumulatively up to 1940.

- Cumulative phosphorus applications in the period to 1990 were about 400 000 tonnes of phosphorus, equivalent to about 10 kg P/ha for the whole area.

- The area to which phosphorus fertilizer has been applied represents 1.6% of the total land area adjacent to the reef.

- The intensity of phosphorus use varies considerably between catchments, with the Johnstone, Mossman and Pioneer receiving above 4 kg P/ha in 1990.

- Sugarcane accounted for 55% of phosphorus use in 1990; this share was much larger in earlier years.

- Twelve of the basins, occupying 86% of the total area had average phosphorus application rates of less than 1 kg/ha in 1990.

- The six north Queensland catchments where average annual run-off exceeds 50% of average rainfall, occupying 2.6% of the total area, accounted for 25% of the total phosphorus applied in 1990.

1. INTRODUCTION

The Great Barrier Reef, the world's longest coral reef, covers about 350 000 km^2 off the north-east coast of Australia. It extends for over 2000 kilometres from latitude 10°S, north of Cape York, to latitude 25°S, east of Bundaberg. The reef follows the submerged coastline in the shallow tropical seas of the continental shelf, at distances varying from 30 kilometres from the coast in the northern section to over 200 kilometres at the Swain Reefs off Mackay.

There are over 2600 reefs, varying in size from less than one hectare to more than 100 km^2, 300 coral cays and 60 continental islands. The reef has an abundance of marine species, including over 4000 molluscs, 1500 fish, 400 hard and soft corals, thousands of species of sponges, crustaceans, echinoderms, worms and other invertebrates. Six of the world's seven species of sea turtle breed on the reef, humpback whales calve in reef waters and dugongs graze seagrass beds along the coast. Two hundred and forty-two seabirds frequent the reef area.

The growth of the reef-building corals is affected by the freshness or turbidity of the water, water depth, temperature (> 20°C) and nutrients. The temperature of the water is mediated by the East Australian Current, a surface drift of warmer, less saline, more dilute, less dense tropical water from the equatorial regions of the Pacific, down the east coast of Australia.

The east coast of Queensland spans 2200 kilometres, east of the Great Dividing Range, from latitude 10°30'S at Cape York to 28°15'S at the New South Wales border. The total catchment excluding the islands is 447 655 km^2; of this about 423 725 km^2 are adjacent to the Great Barrier Reef, from the Jacky Jacky basin in the north to the Mary basin in the south. The land area is thus 21% larger than the reef area.

The 42 million hectares of the North East Coast Drainage Division which abuts the Great Barrier Reef are largely used for forestry and extensive pastoral, with 1.3 million hectares of agricultural crops and 3.4 million hectares of improved pastures containing introduced sown species.

Thirty-seven percent of the crop area and 3.3% of the sown pastures are fertilized - overall, fertilizer is applied to 1.4% of the North East Coast Division (595 000 hectares).

The Division's river basins vary considerably in rainfall and topography. These are major factors affecting land use, crops grown and fertilizer applications. There are also large differences in the proportion of the rainfall which runs off the catchment, varying from 7% in the Burnett and Fitzroy basins to 74% in the Tully River system. In each of the basins from the Daintree to the Murray, excluding the Barron, 57% or more of the rainfall runs off, on average.

The actual proportion of the rainfall which runs off in any rainfall event or in any year is very variable and depends on the quantity and intensity of rainfall, the topography and the density and type of ground cover. The average annual volume of run-off is affected by the basin area. The Burdekin basin has the third lowest run-off percentage (12%) but because of its large area, it has the largest annual average run-off volume, over 10 million megalitres.

A combination of high run-off potential and high rates of fertilizer use provides an opportunity for leaching, erosion of topsoil and hence nutrient losses from agricultural areas to streams and rivers and eventually to the reef lagoon. This may impact on the growth of seagrass, algae, coral and other marine organisms, especially if the nutrient balance is disturbed or the concentrations increased.

The possible downstream effects of agricultural practices on Great Barrier Reef ecosystems are of particular concern to primary producers and marine scientists.

No attempt has been made to review the extensive literature relating to fertilizer use efficiency, the mechanisms of nutrient transfer from terrestrial to marine ecosystems or to the impacts of nutrients on reef ecosystems.

This report details historical inputs of nitrogen (N) and phosphorus (P) in fertilizer products into the main basins adjacent to the Great Barrier Reef.

2. METHOD OF ALLOCATION OF NUTRIENTS TO BASINS

The only published information on fertilizer usage is that tabulated by the Bureau of Census and Statistics (to 1972) and the Australian Bureau of Statistics (ABS) since, based on the returns of primary producers.

Under 'The Statistical Returns Acts, 1896 to 1935' farmers and graziers were required to complete Form AP23 entitled 'Agricultural, Dairying, and Pastoral Statistics'. This covered information on land utilisation, employment, area and production of crops, fruit and vegetables, machinery, livestock numbers and production, areas irrigated and areas fertilized and how much fertilizer was applied, for the period ending 31 March each year.

2.1 Queensland Data

A tabulation in the author's possession, for the period 1915-16 to 1950-51, shows total crop area grown, crop area fertilized, tons of artificial fertilizer and loads of natural fertilizer used in Queensland in each year. The origin is unknown and the Bureau is unable to provide any indication where the original data are held. An archival search was not considered by the Australian Bureau of Statistics to be warranted.

2.2 Statistical Divisions

The Australian Bureau of Statistics has records of census data collected at the Shire level from 1938-39. In that year, a change was made from Petty Sessions Districts and Pastoral Districts to Local Authority areas and Statistical Divisions based on them, for all production statistics except Primary Production. The Australian Bureau of Statistics collected figures on fertilizer usage from this period at local authority area level, but these were not published prior to 1970-71 and are not available for inspection. Data at the divisional level have been published since 1951-52 as follows:

(i) 1951-52 to 1955-56: Statistics of the State of Queensland for the year..... Compiled from official records. S. E. Solomon, Government Statistician. Part B - Production Section (i) - Rural Production. Table 36. Fertilization and Irrigation of crops and pastures 19..... The data cover 13 statistical divisions, with areas fertilized and total quantity of artificial fertilizer used on sugarcane, vegetables, fruit, fodder, other crops and pastures.

(ii) 1956-57 to 1960-61: Statistics of the State of Queensland for the year..... Part B - Production. Section (i) - Rural Production. Issued ..... by S. R. Carver, Commonwealth Statistician, compiled by S. E. Solomon, Deputy Commonwealth Statistician and Government Statistician. Table 34/35/36 contained statistics similar to the earlier period, except for 'wheat' being added to the list of crops in 1956-57 and 'other cereals' in 1958-59. K. M. Archer replaced S. R. Carver as Commonwealth Statistician in 1959-60.

(iii) 1961-62 to 1963-64: Statistics of the State of Queensland for the year..... Part B - Production. Section (i) - Rural Production. Archer/Solomon. Table 34. The 1961-62 data included the first published figures for superphosphate usage (21 345 tons), with 'other or mixed fertilizer used' (104 956 tons) shown separately, although this information had been collected on earlier Agricultural, Dairying and Pastoral Statistics forms completed by primary producers.

(iv) 1964-65: As above. Table 39. For the first time, a category 'Straight Nitrogenous Fertilizer Used' was included (50 869 tons).

(v) 1965-66 to 1968-69: As above. Table 39 was headed 'Fertilization of Crops and Pastures, in Statistical Divisions'. The statistical bulletin for 1965-66 refers, for the first time, to the Bureau of Census and Statistics, Queensland office, and introduces decimal currency. The Government Statisticians were S. E. Solomon in 1966 and A. W. Mumme from 1967 to 1969, while J. P. O'Neill, as Acting Commonwealth Statistician, replaced K. M. Archer in 1967-68.

(vi) 1969-70 and 1970-71: As above. Table 39/40 was headed 'Fertilizer used on Crops and Pastures in Statistical Divisions'. F. W. Sayer was Deputy Commonwealth Statistician and Government Statistician.

(vii) 1971-72: As above. Table 41. The Bureau became the Australian Bureau of Statistics, Queensland office. Lucerne was introduced as an additional crop and 'Other Pastures' replaced 'Pastures'. Fodder (not included elsewhere) was excluded.

(viii) 1972-73 and 1973-74: As above. Table 41. In the crop categories, '(including grapes)' was added after 'Fruit' and 'Pasture: Lucerne: Other' was used to subdivide the pasture section. 'Other Crops' was added at the end of the list, having previously been included before pastures. For the first time metric units were used, hectares and tonnes. O. M. May was Acting Government Statistician in 1972-73 and Government Statistician for Queensland in 1973-74. No further publications in this format were issued.

2.3 Local Authority Areas

The first available fertilizer usage statistics in local authority areas were published in January 1972, for the 1970-71 season. Issued by the Bureau of Census and Statistics, Brisbane, as publication Q7/72 and headed 'Artificial Fertilizer used on Rural Holdings, 1970-71 season, Queensland', the bulletin provided the areas fertilized, the total tons of straight nitrogenous, single strength superphosphate, double/triple strength superphosphate and other and mixed fertilizer for each Shire, but not for each crop category (although total tons of fertilizer are shown for each crop group). The superphosphate figure in (vi) above is the sum of the different strength products, with no allowance for the different phosphorus contents in them.

Bulletin Q31/73 for the 1971-72 season provided similar information to the year before, except that the types of fertilizer included superphosphate, urea, sulphate of ammonia, other nitrogenous and other and mixtures. Again, only total tonnage figures were provided for crop groups.

Q62/74 from the Australian Bureau of Statistics issued in May 1974 for the 1972-73 season provided the same kinds of data as for the previous year, using metric units. Statistics for 1973-74 were similarly presented.

From 1974-75 to 1978-79, fertilizer use statistics (areas fertilized and tonnes used) for each local authority were provided for the following crop groupings: wheat, grain sorghum, other cereals, sugarcane, fruit, vegetables, other crops, pasture-lucerne and pasture, other than lucerne, with the fertilizer headings being superphosphate, urea, sulphate of ammonia, other straight nitrogenous and other artificial including mixtures.

In 1979-80 and 1980-81, the Australian Bureau of Statistics collected fertilizer use information only on sugarcane, wheat and pasture (native or sown), without total figures, and only for superphosphate, straight nitrogenous and other artificial including mixtures.

In 1981-82, 1984-85 and 1987-88 the more detailed crop and product statistics as for 1978-79 were again collected, but only for sugarcane, wheat and pasture (as for 1980-81) in 1982-83, 1983-84, 1985-86, 1986-87 and 1988-89. Total areas fertilized and the tonnes of products applied were provided in 1986-87 and 1988-89.

2.4 Using Australian Bureau of Statistics Data to Obtain Nutrient Usages

Assuming no major changes in agricultural practices, it is possible to make estimates of fertilizer usage for 10-20 year periods prior to the publication of more detailed statistics, with a reasonable degree of accuracy. These estimates require consideration of crop areas grown, and the changing proportions of fertilizer on each crop and in each district.

Such estimates have limited value unless information is also available on changes in composition of the various fertilizer groups, i.e. the proportions of the products making up each group. For example, it is necessary to be able to estimate for say, 7-10 years prior to 1971-72 (when the first statistics on forms of nitrogen fertilizers were published/collected), what the proportions of such fertilizers were in the category 'straight nitrogenous fertilizer' which appeared first in the 1964-65 census. Similarly the usage of superphosphate in divisions in the 10 years prior to 1961-62 might be estimated from the figures for that year.

These estimates of the fertilizer products or groups of products might be extended from divisions to local authority areas, using the earliest such data from 1971-72, in the same way.

The value of the results of such estimates and the calculations applied to them depends on the accuracy of the original data. It is highly likely that census figures, in terms of areas fertilized and tonnages used, became less accurate as the complexity of the tables on the form increased.

In more recent times, when direct comparisons can be made with fertilizer industry sales data for the same geographic area, considerable differences are apparent.

Some of the differences can be attributed to the allocation of total fertilizer to the first column of the table (which is for superphosphate). While this may explain why official statistics for superphosphate applications greatly exceed sales in every year, it does not explain differences in total tonnages applied. Because of the inherent difficulties in trying to make sense of the Australian Bureau of Statistics data, an alternative method was sought. This was aimed directly at river basins, rather than at local authorities, few of which have boundaries which contain single basins.

Australian Bureau of Statistics data were considered to be more accurate in relation to the areas fertilized, for each group of crops.

Primary producers have reliable estimates of the area of crops grown and, where these crops are always fertilized, it is simple to record accurately the area fertilized on the census form. Crop producers pay much attention to the calibration of fertilizer application machinery to obtain desired rates of usage, providing a further check on areas and tonnages, but not products.

Assuming that the errors made by farmers completing their census forms are reasonably consistent from year to year, changes in areas fertilized may reflect the major variations in total nutrient usage better than changes in the tonnages applied. If these area changes are combined with changes in the quantities in each of the product groups used, reasonable estimates of usage can be made for each local authority area.

To provide a historical sequence of data on nutrient usage, it is necessary to have several points of reference, over the period being considered, for which accurate information is available and for comparison with calculations made using the Australian Bureau of Statistics data. Such information can only come from within the fertilizer industry. None of this is published.

2.5 Fertilizer Industry Data

In compiling the tables of nitrogen and phosphorus usage in each basin, it was first necessary to calculate or to estimate usage at the regional level. This was done in relation to:

(i) local government authorities and statistical divisions;
(ii) sugar mill areas, which formed the original sales areas of the fertilizer companies; and
(iii) sales districts of fertilizer companies, made up of sales by groups of individual dealers, some of whose sales territory overlapped that of other dealers.

The information utilised included:

(i) 1949. Fertilizer materials required by North Queensland Fertilizers and Chemicals Ltd (NQFC) for the Townsville and Cairns blending plants. Forecast sales of products (superphosphate, ammonium sulphate and blended mixtures) for all suppliers for Mossman, Cairns, Innisfail, Tully, Ingham and Ayr sales districts. Actual deliveries of ammonium sulphate and mixtures to these districts for year ending February 1950.

(ii) 1950-51 to 1958-59. Sales by NQFC and estimates for other suppliers, of ammonium sulphate, superphosphate, mixtures and other products for Mossman, Cairns (Hambledon-Mulgrave), Babinda (from 1954), Innisfail, Tully, Ingham, Burdekin, Townsville and Tablelands.

(iii) 1959. District sales by NQFC of all products from March to September.

(iv) 1959-60 to 1966-67. NQFC sales of urea, ammonium sulphate, aqua ammonia, superphosphate, potash and mixtures in the following districts; Atherton, Mareeba, Mossman-Hambledon-Mulgrave-Babinda-Innisfail, Tully, Ingham, Townsville and Burdekin. Estimates of NQFC market share.

(v) Monthly sales by NQFC of mixtures and various straight products for Burdekin, Tablelands and Ingham to Mossman, from February 1948 to September 1959.

(vi) 1968 to 1973. ACF & Shirleys sales of fertilizers for years ending September.

(vii) Estimates of sales by Austral Pacific Fertilizers Ltd for 1968 to 1971, by sales area.

(viii) October 1973 to June 1974. Nine months sales figures for ACF & Shirleys and ACF-Austral.

(ix) 1969-70. Detailed market study of product and nutrient usage by crop segment in each sales district for Mackay zone and north Queensland zone. All suppliers included in this study.

(x) 1971 to 1992. Monthly sales of products for the Ingham-Mossman and Tablelands area. All suppliers included in annual tabulations, based on imports and local production.

(xi) 1972. Estimates of nitrogen, phosphorus and potassium usage by crop segment for each zone.

(xii) 1976 to 1991. Calendar year allocations of total sales of individual products, by all suppliers, to crop segments, for every sales district in Queensland. Referred to as 'Segmentation data'.

(xiii) 1977 to 1990. Tabulation of quarterly and annual product and nutrient usage, areas fertilized and rates of application of each nutrient for each crop for each sales area.

2.6 Drainage Basins

The drainage divisions of Queensland are depicted in figure 1. Those in Division 1 are east of the Great Dividing Range. Mainland basins 108 to 138, from the Daintree (latitude 16°S) to the Mary River (latitude 27°S) have been investigated for this study of fertilizer usage in catchments adjacent to the Great Barrier Reef. Rainfall and run-off characteristics for each of the 28 basins are shown in table 1. In the northern area, from the Murray to the Daintree, more than half of the average rainfall runs off, as indicated by flow rates from stream gauging stations.

In the central and southern areas, rainfall, run-off and the proportion of rainfall which runs off, are much lower. In the main southern basins, the Burnett and Fitzroy, only 7% of the rainfall on average, runs off.

2.7 Allocation of Nutrients to Basins

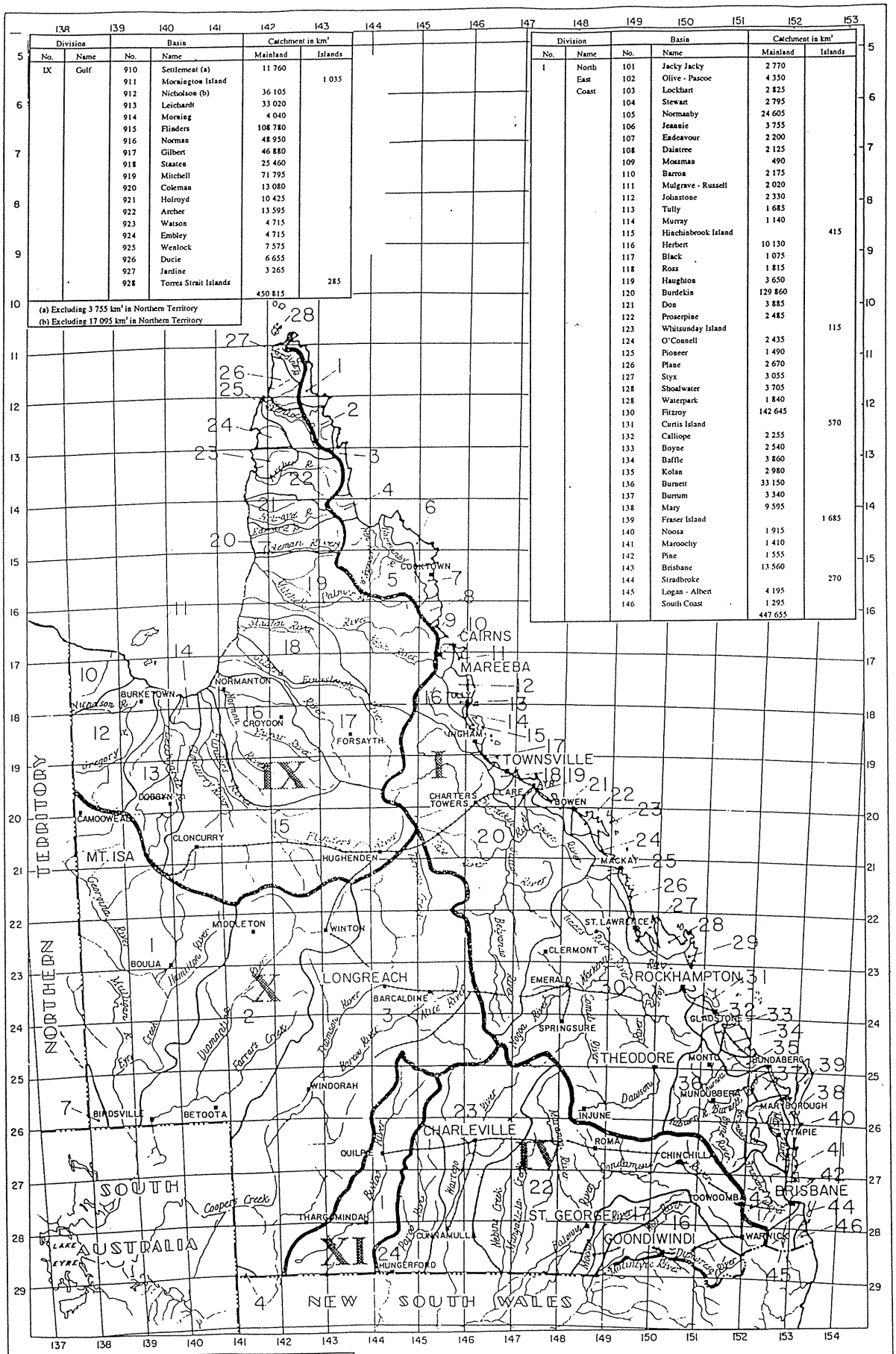
While several other macro- and micro-nutrients which are necessary for plant growth are components of many fertilizer products, only nitrogen and phosphorus are considered in this report. The procedure used to allocate historical usage of nutrients varied from basin to basin, depending on the complexity of the agriculture in each, and on the availability of fertilizer use information for the area. For some areas, e.g. Mulgrave-Russell and Proserpine, the local authority area, sales district and river basins were similar. In others, particularly the smaller basins, it was necessary to allocate proportions of nutrients from two or more sales areas or shires to the basin. In most cases, allocation of nitrogen had to be treated differently to phosphorus and separate calculations and allocations were made.

Most of the allocations were done on a crop basis, and then amalgamated. Unless this procedure was adopted, nutrient figures did not reflect changes in crop area and rates of fertilizer usage adequately. However since sugarcane constituted the bulk of the fertilizer usage in most river basins (the exceptions being Barron, Waterpark, Fitzroy, Calliope, Boyne and Burnett), changes in nutrient usage are highly correlated with changes in sugarcane production methods.

Allocations of sales area data to catchments were confirmed in discussions with industry personnel and by visits to most of the areas.

While the 1990 figures are likely to be the most accurate, it is believed that the earlier years reflect the situation well enough.

The regional totals for nitrogen and phosphorus for the 1950 to 1990 period have high accuracy; in the 1910 to 1950 period there are no statistics available to check against individual areas of usage. The five-year intervals used to 1960 infer average data for the particular period, rather than for the particular year.



Division		Basin		Catchment in km²	
No.	Name	No.	Name	Mainland	Islands
IX	Gulf	910	Settlement (a)	11 760	
		911	Mornington Island		1 035
		912	Nicholson (b)	36 105	
		913	Leichardt	33 020	
		914	Morning	4 040	
		915	Flinders	108 780	
		916	Norman	48 950	
		917	Gilbert	46 880	
		918	Staaten	25 460	
		919	Mitchell	71 795	
		920	Coleman	13 080	
		921	Holroyd	10 425	
		922	Archer	13 595	
		923	Watson	4 715	
		924	Embley	4 715	
		925	Wenlock	7 575	
		926	Ducie	6 655	
		927	Jardine	3 265	
		928	Torres Strait Islands		285
				450 815	

(a) Excluding 3 755 km² in Northern Territory
(b) Excluding 17 095 km² in Northern Territory

Division		Basin		Catchment in km²	
No.	Name	No.	Name	Mainland	Islands
I	North	101	Jacky Jacky	2 770	
	East	102	Olive - Pascoe	4 350	
	Coast	103	Lockhart	2 825	
		104	Stewart	2 795	
		105	Normanby	24 605	
		106	Jeannie	3 755	
		107	Endeavour	2 200	
		108	Daintree	2 125	
		109	Mossman	490	
		110	Barron	2 175	
		111	Mulgrave - Russell	2 020	
		112	Johnstone	2 330	
		113	Tully	1 685	
		114	Murray	1 140	
		115	Hinchinbrook Island		415
		116	Herbert	10 130	
		117	Black	1 075	
		118	Ross	1 815	
		119	Haughton	3 650	
		120	Burdekin	129 860	
		121	Don	3 885	
		122	Proserpine	2 485	
		123	Whitsunday Island		115
		124	O'Connell	2 435	
		125	Pioneer	1 490	
		126	Plane	2 670	
		127	Styx	3 055	
		128	Shoalwater	3 705	
		128	Waterpark	1 840	
		130	Fitzroy	142 645	
		131	Curtis Island		570
		132	Calliope	2 255	
		133	Boyne	2 540	
		134	Baffle	3 860	
		135	Kolan	2 980	
		136	Burnett	33 150	
		137	Burrum	3 340	
		138	Mary	9 595	
		139	Fraser Island		1 685
		140	Noosa	1 915	
		141	Maroochy	1 410	
		142	Pine	1 555	
		143	Brisbane	13 560	
		144	Stradbroke		270
		145	Logan - Albert	4 195	
		146	South Coast	1 295	
				447 655	

Division		Basin		Catchment in km²	
No.	Name	No.	Name	Mainland	Islands
IV	Murray	416	Border Rivers (d)	24 630	
	Darling	417	Moonie	14 165	
		422	Baloone - Condamine	124 500	
		423	Warrego	64 700	
		424	Paroo	31 080	
				259 075	
X	Lake	001	Georgina (c)	142 710	
	Eyre	002	Diamantina	119 400	
		003	Coopers Creek	243 460	
		004	Lake Frome	750	
		007	Hay	4 350	
				510 670	
XI	Bulloo	011	Bulloo	55 035	
				55 035	

(c) Excluding 99 195 km² in Northern Territory
(d) Excluding 16 315 km² in New South Wales

QUEENSLAND
IRRIGATION AND WATER SUPPLY COMMISSION

QUEENSLAND DRAINAGE DIVISIONS

KILOMETRES
100 0 100 200 300

MAINLAND AREA OF QUEENSLAND - 1 723 250 km²

A4-46079

FIG. 1

Table 1. Area, rainfall and run-off statistics of some eastern Queensland basins

Basin	Basins area (km^2)	Mean annual run-off (000 ML)	Mean annual rainfall (mm)	RO/RF (%)	% basin gauged (%)
108 Daintree	2125	3560	2576	65	55
109 Mossman	490	687	2459	57	0
110 Barron	2175	1153	1447	37	89
111 Mulgrave-Russell	2020	4193	3233	64	45
112 Johnstone	2330	4698	3405	59	57
113 Tully	1685	3683	2970	74	87
114 Murray	1140	1628	2485	57	14
116 Herbert	10131	4991	1331	37	87
117 Black	1075	509	1510	31	33
118 Ross	1815	372	1071	19	50
119 Haughton	3650	756	923	22	67
120 Burdekin	129860	10100	640	12	99
121 Don	3885	689	1022	17	33
122 Proserpine	2485	1431	1562	37	14
124 O'Connell	2435	1668	1705	40	30
125 Pioneer	1490	994	1418	47	93
126 Plane	2670	1370	1499	34	16
127 Styx	3055	825	1157	23	0
128 Shoalwater	3705	832	1102	20	0
129 Waterpark	1840	700	1317	29	7
130 Fitzroy	142645	7127	702	7	95
132 Calliope	2255	340	889	17	61
133 Boyne	2540	401	1031	15	99
134 Baffle	3860	750	1173	17	37
135 Kolan	2980	464	1162	13	80
136 Burnett	33150	1743	765	7	98
137 Burrum	3340	718	1104	20	52
138 Mary	9595	2309	1158	21	81

3. NUTRIENT USAGE IN SOME EASTERN QUEENSLAND BASINS

3.1 Nitrogen Usage

Details of nitrogen usage in each basin are included in appendix 1. Table 2 shows the usage at five-year intervals from 1910 to 1955 and annually from 1960 to 1990, for each of the basins.

Table 2. Fertilizer nitrogen usage (tN) in basins 108-114 (continued over)

	Daintree	Mossman	Barron	Mulgrave-Russell	Johnstone	Tully	Murray
	108	109	110	111	112	113	114
1910	-	-	-	-	-	-	-
1915	-	-	-	50	-	-	-
1920	-	10	-	100	10	-	-
1925	-	20	-	250	50	-	-
1930	10	30	10	430	200	50	-
1935	20	60	20	450	600	100	-
1940	30	90	100	675	1100	200	-
1945	40	120	80	1000	900	200	30
1950	55	260	100	1155	1130	345	55
1955	75	350	140	1590	1550	470	75
1960	95	450	180	2040	1990	600	95
1961	110	525	210	2380	2325	700	110
1962	115	550	222	2480	2430	730	115
1963	155	740	260	3010	3230	950	135
1964	155	775	490	3150	3370	1010	160
1965	180	860	605	3525	3790	1140	18
1966	200	870	620	3550	3830	1150	19
1967	210	875	645	3680	3640	1150	200
1968	200	820	650	3600	3760	1140	200
1969	205	825	650	3600	3720	1130	200
1970	210	840	700	3910	4020	900	200
1971	225	860	750	4120	4600	1000	220
1972	240	885	800	3860	4980	1200	240
1973	220	810	760	3850	4840	1140	250
1974	230	840	800	3965	5225	1300	230
1975	240	850	900	4020	5250	1260	240
1976	255	900	1050	4375	5800	1400	260
1977	305	1015	1200	4940	6540	1580	290
1978	245	850	1160	4020	5220	1260	260
1979	300	980	1390	4810	6230	1505	315
1980	365	1195	1690	5850	7580	1830	380
1981	365	1160	1540	5700	7230	1760	370
1982	335	1130	1485	5550	7050	1700	340
1983	337	1140	1480	5665	7000	1710	330
1984	338	1140	1450	5665	7015	1720	340
1985	400	1050	1445	5660	7005	1705	350
1986	400	1050	1440	5050	7000	1860	560
1987	420	1055	1610	4695	7260	2090	700
1988	450	1130	1650	4660	6970	2490	160
1989	440	945	1640	4660	6950	2480	1200
1990	340	820	1680	4720	7300	2660	1290

Table 2. Fertilizer nitrogen usage (tN) in basins 116-122 (continued over)

	Herbert 116	Black 117	Ross 118	Haughton 119	Burdekin 120	Don 121	Proserpine 122
1910	10	-	-	-	-	-	-
1915	50	-	-	10	-	-	-
1920	100	-	-	50	-	-	-
1925	200	-	-	75	-	5	50
1930	350	-	-	150	5	10	100
1935	400	-	-	160	20	20	150
1940	490	-	1	200	50	30	200
1945	500	-	2	220	40	40	260
1950	1100	-	3	600	210	80	310
1955	1500	-	4	650	220	90	360
1960	1930	-	5	785	270	107	680
1961	2255	-	5	1020	350	140	760
1962	2355	-	5	1105	380	140	820
1963	2950	-	6	1715	590	220	1045
1964	3270	-	7	1940	665	250	1205
1965	3580	-	8	2045	705	265	1245
1966	3590	-	9	2360	810	305	1005
1967	3600	-	10	2575	885	335	920
1968	3630	-	10	2725	940	355	1170
1969	3670	-	12	3240	1115	420	1170
1970	4200	-	10	2890	1000	380	1100
1971	4225	-	15	4150	1425	540	1200
1972	4905	-	16	4535	1560	595	1400
1973	4870	-	15	4865	1670	670	1550
1974	5090	-	18	5260	1815	736	1575
1975	5240	-	21	5980	2075	835	1640
1976	5800	-	23	6815	2365	995	1810
1977	6555	-	24	7115	2475	1135	1850
1978	5085	-	18	5450	1905	1030	1750
1979	6100	-	18	5870	2060	1080	1770
1980	7370	-	25	8860	3115	1375	2650
1981	7120	-	22	8015	2840	1280	2390
1982	6745	-	23	8215	2915	1330	2500
1983	6800	-	24	8940	3180	1525	2640
1984	6762	-	19	7400	2640	1390	2120
1985	6800	-	20	7050	2520	1365	1780
1986	7125	-	16	6760	2425	1235	2020
1987	7570	-	16	6875	2475	1285	2015
1988	9190	-	17	7115	2565	1250	2060
1989	9685	-	18	7880	2840	1340	2500
1990	9800	5	21	8805	3180	1445	3040

Table 2. Fertilizer nitrogen usage (tN) in basins 124-130 (continued over)

	O'Connell 124	Pioneer 125	Plane 126	Styx 127	Shoalwater 128	Waterpark 129	Fitzroy 130
1910	-	-	10	-	-	-	-
1915	50	60	90	-	-	-	-
1920	120	180	195	-	-	-	-
1925	170	240	250	-	-	-	-
1930	240	365	390	-	-	5	-
1935	350	450	400	-	-	10	-
1940	400	615	675	-	-	20	5
1945	400	600	650	-	-	25	5
1950	420	655	720	-	-	30	10
1955	510	795	930	-	-	50	15
1960	720	1075	1305	-	-	60	18
1961	930	1390	1685	-	-	70	23
1962	1045	1560	1890	-	-	80	26
1963	1415	2015	2495	-	-	90	52
1964	1330	2120	2490	-	-	100	87
1965	1535	2260	2785	-	-	110	130
1966	1595	2380	2985	-	-	120	140
1967	1665	2450	3015	-	-	125	200
1968	1785	2475	3070	-	-	130	250
1969	2085	2990	3735	-	-	145	320
1970	1990	2805	3555	-	-	160	235
1971	2290	3235	4100	-	-	170	340
1972	2325	3290	4180	-	-	185	340
1973	2535	3580	4545	-	-	200	350
1974	2575	3640	4615	-	-	211	325
1975	2680	3790	4805	-	-	260	425
1976	3405	4435	6160	-	-	306	790
1977	3670	4780	6835	-	-	350	1385
1978	3085	3925	6210	-	-	352	1380
1979	3115	4025	5625	-	-	340	1375
1980	4545	5860	8190	-	-	330	1475
1981	4245	5480	7665	-	-	315	1640
1982	4190	5360	7565	-	-	330	1800
1983	4285	5325	7510	-	-	350	2200
1984	4015	4985	6930	-	-	370	2635
1985	4010	4985	6905	-	-	420	2845
1986	3670	4555	6315	-	-	385	2620
1987	3745	4670	6570	-	-	410	3115
1988	3750	4695	6555	-	-	440	3595
1989	4125	5160	7215	-	-	450	5380
1990	4390	5490	7685	-	-	475	7290

Table 2. Fertilizer nitrogen usage (tN) in basins 132-138

	Calliope 132	Boyne 133	Baffle 134	Kolan 135	Burnett 136	Burrum 137	Mary 138
1910	-	-	-	-	-	-	-
1915	-	-	-	-	-	-	-
1920	-	-	-	-	10	-	-
1925	-	-	-	-	40	-	-
1930	-	-	-	-	60	-	-
1935	-	-	-	-	100	5	10
1940	-	-	-	-	120	20	25
1945	-	-	-	10	160	60	20
1950	-	-	5	35	360	115	110
1955	-	-	13	87	567	217	206
1960	1	-	22	150	715	330	275
1961	3	-	35	220	1000	600	425
1962	6	-	50	300	1250	750	550
1963	8	-	80	450	1600	890	730
1964	10	1	82	450	1590	900	732
1965	17	-	80	455	1590	912	760
1966	18	2	110	680	1970	1180	820
1967	20	2	170	860	2163	1250	950
1968	24	3	160	850	2155	1240	950
1969	30	4	160	780	2020	1300	870
1970	35	4	170	800	1880	1425	1000
1971	33	4	215	1040	2390	1800	1430
1972	28	4	230	1110	2630	1980	1630
1973	26	3	250	1190	2800	2210	1770
1974	25	4	280	1350	3200	2400	1960
1975	26	4	315	1570	3660	2720	2225
1976	27	4	330	1650	4000	3150	2660
1977	27	5	320	1620	3970	2920	2600
1978	28	5	300	1350	3800	2800	2500
1979	28	5	300	1370	3800	2640	2600
1980	28	5	420	1785	4720	3190	2705
1981	35	4	400	1800	4990	3250	3105
1982	40	5	380	1750	4800	3100	3050
1983	45	5	385	1760	4810	3100	3045
1984	53	6	400	1780	5000	3200	3060
1985	62	6	410	1980	5210	3380	3095
1986	70	6	400	1965	5180	3345	3100
1987	72	6	415	1950	5250	3390	3150
1988	70	7	430	1920	5440	3430	3140
1989	63	7	400	1790	5000	3000	2980
1990	62	7	405	1690	4545	2970	2800

Table 3 shows nitrogen usage in groups of basins (this grouping follows Australian Bureau of Statistics statistical divisions to some extent), at five-year intervals from 1910 to 1990.

Table 3. Fertilizer nitrogen usage, (tN) at five-year intervals from 1910 to 1990, in groups of basins.

	Daintree-Murray	Herbert-Don	Proserpine-Plane	Styx-Boyne	Baffle-Mary	Total
1910	0	10	10	0	0	20
1915	50	60	200	0	0	310
1920	120	150	595	0	10	875
1925	320	280	710	0	40	1350
1930	730	515	1095	5	60	2405
1935	1250	600	1350	10	115	3325
1940	2195	771	1890	25	165	5046
1945	2370	802	1910	30	250	5362
1950	3100	1992	2105	40	625	7862
1955	4250	2464	2595	65	1090	10464
1960	5450	3097	3780	78	1492	13897
1965	10280	6603	7825	257	3797	28762
1970	10780	8480	9450	434	5275	34419
1975	12760	14151	12915	715	10490	51031
1980	18890	20745	21245	1838	12820	75538
1985	17615	17755	17680	3333	14075	70458
1990	18810	23256	20605	7834	12410	82915

Table 4 shows nitrogen usage in 1990, for each of the basins, by major crop groupings.

In the area under investigation, the nitrogen content of fertilizers applied to crops and pastures and in stock feed supplements, approached 83 000 tonnes of nitrogen in 1990. This was about the same quantity as had been applied, cumulatively, in the period to 1945.

Nitrogen usage increased substantially in the post-war period, due to increasing areas of production of sugarcane, to a reduction in the area of legume green manure crops (planted to supply some of the sugarcane's nitrogen requirements) and to a lesser quantity of nitrogen being available from organic matter mineralisation, as poorer soils were utilised for cane growing.

The 1990 usage of nitrogen, in decreasing order, for the eight major nitrogen-using basins (accounting for 67% of the total) was as follows:

	tonnes (t)	
Herbert	9800	
Haughton	8805	(8940 t in 1983)
Plane	7685	(8190 t in 1980)
Johnstone	7300	(7580 t in 1980)
Fitzroy	7290	(has increased since 1990)
Pioneer	5490	(5860 t in 1980)
Mulgrave-Russell	4720	(5850 t in 1980)
O'Connell	4390	(4545 t in 1980)

(Other basins are included in table 8).

As indicated above, there has been a reduction in the use of nitrogen, particularly in sugarcane areas, since the peak of 1980. This has been largely due to reduced rates of application

following lower sugar prices and increasing adoption of green cane harvesting in the higher rainfall areas of north Queensland.

Over the 1980 to 1990 period, nitrogen usage has increased on irrigated crops, especially cotton, but including sugarcane in the Plane Creek and Bundaberg districts, as the areas with irrigation water supplies have been expanded.

Currently, sugarcane accounts for about 71% of the total nitrogen usage, field crops over 13%, pastures 8% and all fruit and vegetable crops 8%.

Table 4. Fertilizer nitrogen usage (tN) in some eastern Queensland basins in 1990

Basin	No.	Sugarcane	Fruit	Vegetables	Field Crops	Pastures	Total
Daintree	108	320	3	0	0	17	340
Mossman	109	812	5	0	0	3	820
Barron	110	25	106	489	693	367	1680
Mulgrave-Russell	111	4453	110	7	0	150	4720
Johnstone	112	4867	593	0	0	1840	7300
Tully	113	1890	522	4	0	244	2660
Murray	114	640	530	12	0	108	1290
Herbert	116	8848	44	85	29	794	9800
Black	117	0	1	1	1	2	5
Ross	118	0	3	2	3	13	21
Haughton	119	7783	30	480	500	12	8805
Burdekin	120	2654	20	246	200	60	3180
Don	121	851	6	584	0	4	1445
Proserpine	122	2786	2	1	18	233	3040
O'Connell	124	4146	1	1	2	240	4390
Pioneer	125	4626	1	1	2	860	5490
Plane	126	7468	4	1	2	210	7685
Styx	127	0	0	0	0	0	0
Shoalwater	128	0	0	0	0	0	0
Waterpark	129	0	430	15	5	25	475
Fitzroy	130	0	30	160	6950	150	7290
Calliope	132	0	26	12	16	8	62
Boyne	133	0	0	1	5	1	7
Baffle	134	360	15	10	20	0	405
Kolan	135	1500	50	120	20	0	1690
Burnett	136	844	350	506	2310	535	4545
Burrum	137	2655	15	130	20	150	2970
Mary	138	1250	380	90	460	620	2800
Total		58778	3277	2958	11256	6646	82915

3.2 Phosphorus Usage

Details of phosphorus usage in each basin are included in appendix 1. Table 5 shows the usage at five-year intervals from 1910 to 1955 and annually from 1960 to 1990, for each of the basins.

Table 5. Fertilizer phosphorus usage (tP) in basins 108-114 (continued over)

	Daintree	Mossman	Barron	Mulgrave-Russell	Johnstone	Tully	Murray
	108	109	110	111	112	113	114
1910	-	-	-	-	-	-	-
1915	-	-	-	-	-	-	-
1920	-	-	-	10	10	-	-
1925	-	10	-	30	30	10	-
1930	-	15	-	75	70	25	-
1935	-	30	10	120	108	40	-
1940	5	45	30	185	175	60	-
1945	10	50	30	220	225	80	5
1950	15	65	25	300	290	90	15
1955	15	65	25	315	310	90	15
1960	17	82	34	375	360	110	17
1961	22	105	40	480	470	140	35
1962	20	100	38	460	450	133	33
1963	30	160	60	740	735	210	55
1964	30	167	160	740	730	200	58
1965	35	175	180	780	800	226	60
1966	35	175	190	780	770	220	70
1967	40	180	230	800	800	226	80
1968	45	190	240	810	780	300	90
1969	60	215	300	840	1048	360	100
1970	70	236	330	870	1296	430	135
1971	72	240	403	880	1300	650	140
1972	80	250	436	880	1400	760	150
1973	80	245	445	880	1300	650	140
1974	85	250	490	870	1400	640	140
1975	80	260	485	865	1300	460	150
1976	85	280	460	900	1450	470	155
1977	85	300	465	920	1400	480	160
1978	80	280	455	900	1300	470	155
1979	90	300	563	950	1650	500	150
1980	100	350	600	1220	1950	1600	180
1981	120	245	660	1215	1890	515	160
1982	100	200	660	865	1700	485	150
1983	110	225	670	865	1650	520	150
1984	120	220	630	820	1600	500	160
1985	110	220	580	770	1550	520	170
1986	100	220	540	700	1500	510	160
1987	115	220	510	625	1450	527	200
1988	110	210	546	600	1400	520	210
1989	100	220	580	600	1600	520	215
1990	100	240	625	605	1700	530	220

Table 5. Fertilizer phosphorus usage (tP) in basins 116-122 (continued over)

	Herbert 116	Black 117	Ross 118	Haughton 119	Burdekin 120	Don 121	Proserpine 122
1910	-	-	-	-	-	-	-
1915	-	-	-	-	-	-	-
1920	10	-	-	-	-	-	-
1925	20	-	-	10	-	-	-
1930	44	-	-	30	10	-	10
1935	78	-	-	55	10	-	20
1940	136	-	-	100	20	10	35
1945	150	-	-	120	35	30	50
1950	200	-	-	160	50	55	70
1955	265	-	-	175	53	61	107
1960	350	-	-	200	56	60	130
1961	446	-	-	245	72	79	145
1962	424	-	-	284	83	92	170
1963	680	-	-	307	87	113	240
1964	705	-	-	348	100	127	300
1965	710	-	-	387	111	155	285
1966	700	-	-	317	86	113	258
1967	720	-	-	370	105	148	235
1968	720	-	-	350	101	127	220
1969	720	-	-	304	86	108	267
1970	720	-	-	339	92	123	290
1971	565	-	-	236	65	96	196
1972	646	-	-	256	72	127	308
1973	600	-	-	333	80	164	290
1974	525	-	-	271	73	134	282
1975	600	-	-	254	73	141	290
1976	700	-	-	266	73	129	330
1977	750	-	-	303	83	166	320
1978	700	-	-	259	76	197	229
1979	720	-	-	341	101	212	240
1980	1000	-	-	484	147	233	360
1981	950	-	-	532	164	266	377
1982	970	-	-	679	217	271	350
1983	950	-	-	485	157	264	360
1984	1020	-	-	450	146	269	267
1985	980	-	-	432	136	231	205
1986	1000	-	-	404	136	206	270
1987	1070	-	-	342	143	246	307
1988	1100	-	-	434	181	245	300
1989	1200	-	-	529	221	327	330
1990	1330	-	-	613	256	380	459

Table 5. Fertilizer phosphorus usage (tP) in basins 124-130 (continued over)

	O'Connell 124	Pioneer 125	Plane 126	Styx 127	Shoalwater 128	Waterpark 129	Fitzroy 130
1910	-	-	-	-	-	-	-
1915	-	-	-	-	-	-	-
1920	-	5	10	-	-	-	-
1925	-	10	20	-	-	-	-
1930	10	17	30	-	-	-	-
1935	20	35	60	-	-	-	-
1940	50	70	120	-	-	1	-
1945	70	100	160	-	-	5	-
1950	100	125	215	-	-	10	1
1955	148	180	315	-	-	19	7
1960	180	220	370	-	-	33	20
1961	208	253	426	-	-	36	9
1962	250	305	511	-	-	37	7
1963	366	445	749	-	-	41	14
1964	459	557	936	-	1	42	35
1965	435	527	888	3	5	43	69
1966	397	482	811	17	20	46	79
1967	365	444	746	35	40	42	100
1968	343	417	700	50	60	38	73
1969	410	496	837	45	50	38	98
1970	484	576	953	45	45	40	102
1971	449	533	882	50	40	45	81
1972	447	530	878	55	50	40	80
1973	446	530	877	60	80	38	90
1974	492	584	965	35	45	36	67
1975	512	609	1007	7	8	38	73
1976	546	648	1071	8	10	40	120
1977	524	622	1028	8	13	35	126
1978	477	566	936	15	35	37	127
1979	500	593	982	10	38	40	163
1980	576	684	1130	8	44	44	194
1981	609	732	1125	5	50	40	241
1982	578	695	1046	6	40	50	254
1983	593	713	1094	-	35	60	286
1984	524	632	965	5	30	77	311
1985	443	533	819	4	30	75	361
1986	428	518	789	3	28	70	288
1987	433	524	798	2	25	75	388
1988	458	550	846	2	22	70	389
1989	494	594	912	3	25	72	658
1990	539	648	995	3	27	73	786

Table 5. Fertilizer phosphorus usage (tP) in basins 132-138

	Calliope 132	Boyne 133	Baffle 134	Kolan 135	Burnett 136	Burrum 137	Mary 138
1910	-	-	-	-	-	-	-
1915	-	-	-	-	-	-	-
1920	-	-	-	-	10	-	5
1925	-	-	-	-	25	5	10
1930	-	-	-	-	45	10	15
1935	-	-	-	5	100	20	30
1940	-	-	-	10	150	30	45
1945	-	-	5	10	150	30	40
1950	-	-	10	35	200	80	100
1955	-	-	14	66	420	140	197
1960	1	-	18	80	448	160	220
1961	1	-	21	103	640	152	240
1962	1	1	22	110	690	160	260
1963	2	2	24	140	917	200	300
1964	2	2	26	150	924	230	330
1965	3	3	28	169	958	294	405
1966	28	3	30	203	1150	321	562
1967	56	4	33	210	1220	400	720
1968	100	5	37	215	1215	410	860
1969	95	5	40	220	1150	428	905
1970	90	6	46	232	1250	660	1101
1971	90	7	62	250	1282	690	1243
1972	100	7	69	280	1410	730	1350
1973	110	7	155	290	1467	740	1340
1974	131	8	95	300	1512	720	1300
1975	32	3	100	366	1636	680	738
1976	40	2	41	380	1718	710	1050
1977	26	2	46	370	1500	660	950
1978	30	2	99	350	1267	650	1020
1979	30	2	91	360	1212	660	1100
1980	28	2	62	378	1206	684	1260
1981	17	2	55	390	1426	730	1180
1982	18	2	49	360	1255	750	1150
1983	17	2	50	340	1070	650	1260
1984	17	2	64	330	1100	678	1210
1985	20	2	66	330	1007	610	1270
1986	15	2	66	300	980	580	1010
1987	14	2	102	350	1200	660	1100
1988	20	2	108	345	1100	582	950
1989	20	2	106	350	1160	600	1000
1990	20	2	105	360	1160	650	1050

Table 6 shows phosphorus usage, in groups of basins, at five-year intervals from 1910 to 1990.

Table 7 shows phosphorus usage in 1990, for each of the basins, by major crop groupings.

In the area under investigation, the phosphorus content of fertilizers applied to all crops and pastures, together with phosphorus in stock feed supplements, approached 13 500 tonnes of phosphorus in 1990. This was about the same quantity as had been applied, cumulatively, in the period to 1940.

Table 6. Fertilizer phosphorus usage (tP), at five-year intervals, from 1910 to 1990 in groups of basins

	Daintree-Murray	Herbert-Don	Proserpine-Plane	Styx-Boyne	Baffle-Mary	Total
1910	0	0	0	0	0	0
1915	0	0	0	0	0	0
1920	20	10	15	0	15	60
1925	80	30	30	0	40	180
1930	185	84	57	0	70	396
1935	308	143	135	0	155	741
1940	500	266	270	1	235	1272
1945	620	335	380	5	235	1575
1950	800	465	510	11	425	2211
1955	835	554	750	26	837	3002
1960	995	666	900	54	926	3541
1965	2256	1363	2135	126	1854	7734
1970	3367	1274	2303	328	3289	10561
1975	3600	1068	2418	161	3520	10767
1980	6000	1864	2750	320	3590	14524
1985	3920	1779	2000	492	3283	11474
1990	4020	2579	2641	911	3325	13476

Table 7. Fertilizer phosphorus usage (tP) in some eastern Queensland basins in 1990

Basin	No.	Sugarcane	Fruit	Vegetables	Field Crops	Pastures	Total
Daintree	108	85	0	0	0	15	100
Mossman	109	230	2	1	0	7	240
Barron	110	6	14	254	236	115	625
Mulgrave-Russell	111	597	3	0	0	5	605
Johnstone	112	895	141	20	4	640	1700
Tully	113	409	96	5	0	20	530
Murray	114	130	75	10	0	5	220
Herbert	116	1025	6	29	30	240	1330
Black	117	0	0	0	0	0	0
Ross	118	0	0	0	0	0	0
Haughton	119	300	40	116	33	124	613
Burdekin	120	112	10	64	40	30	256
Don	121	41	8	296	0	35	380
Proserpine	122	376	0	0	0	83	459
O'Connell	124	475	0	0	1	63	539
Pioneer	125	421	0	0	1	226	648
Plane	126	937	0	0	2	56	995
Styx	127	0	0	0	0	3	3
Shoalwater	128	0	0	0	0	27	27
Waterpark	129	0	70	1	0	2	73
Fitzroy	130	0	3	3	665	115	786
Calliope	132	0	8	0	2	10	20
Boyne	133	0	0	0	1	1	2
Baffle	134	85	2	1	2	15	105
Kolan	135	320	8	20	0	12	360
Burnett	136	240	85	110	600	125	1160
Burrum	137	580	1	25	4	40	650
Mary	138	175	80	65	180	550	1050
Total		7439	652	1020	1801	2564	13476

Phosphorus usage increased substantially between 1963 and 1980, largely due to the expansion of sugarcane production and to a lesser extent, to pasture improvement. In more recent years there has been a reduction in usage on sugarcane in those areas where ratoon cane is not fertilized with the nutrient on an annual basis.

The 1990 usage of phosphorus in decreasing order, for the eight major phosphorus-using basins (accounting for 62% of the total), was as follows:

	tonnes (t)	
Johnston	1700	(1950 t in 1980)
Herbert	1330	(1000 t in 1980)
Burnett	1160	(1718 t in 1976)
Mary	1050	(1350 t in 1972)
Plane	995	(1130 t in 1980)
Fitzroy	786	(has increased since 1990)
Burrum	650	(750 t in 1982)
Pioneer	648	(732 t in 1981)

(Other basins are included in table 8).

Table 8. Fertilizer nitrogen and phosphorus usage in 1990

Nitrogen	tN	Phosphorus	tP
Herbert	9800	Johnstone	1700
Haughton	8805	Herbert	1330
Plane	7685	Burnett	1160
Johnstone	7300	Mary	1050
Fitzroy	7290	Plane	995
Pioneer	5490	Fitzroy	786
Mulgrave-Russell	4720	Burrum	650
Burnett	4545	Pioneer	648
O'Connell	4390	Barron	625
Burdekin	3180	Haughton	613
Proserpine	3040	Mulgrave-Russell	605
Burrum	2970	O'Connell	539
Mary	2800	Tully	530
Tully	2660	Proserpine	459
Kolan	1690	Don	380
Barron	1680	Kolan	360
Don	1445	Burdekin	256
Murray	1290	Mossman	240
Mossman	820	Murray	220
Waterpark	475	Baffle	105
Baffle	405	Daintree	100
Daintree	340	Waterpark	73
Calliope	62	Shoalwater	27
Ross	21	Calliope	20
Boyne	7	Styx	3
Black	5	Boyne	2
Styx	0	Black	0
Shoalwater	0	Ross	0

As indicated above, there has been a reduction in the use of phosphorus since the peak of 14 524 tonnes in 1980. It will be noted that, of the top eight nitrogen and phosphorus usage basins, five (Johnstone, Herbert, Pioneer, Plane and Fitzroy) have both high nitrogen and phosphorus consumption.

Sugarcane accounted for 55% of the total 1990 phosphorus usage, pastures 19%, field crops nearly 14%, and all fruit and vegetable crops over 12%.

3.3 1990 Nitrogen and Phosphorus Usage Relative to Basin Areas

The intensity of nutrient usage varies considerably between basins. While rates of nitrogen and phosphorus on the major crop, sugarcane, are not very different from area to area, the proportion of the basin occupied by sugarcane varies.

As a consequence, average nitrogen rates in 1990 varied from about 37 kg/ha of basin area in Pioneer to less than 1 kg/ha over a considerable area of central coastal Queensland (tables 9 and 10). Average phosphorus rates were highest in Johnstone (over 7 kg P/ha of basin area) but less than 1 kg/ha in 12 of the basins (occupying 86% of the total basin area of 38 million hectares).

Table 9. Basin areas, total nitrogen and phosphorus usage and average rates applied in 1990

Basin	No.	Area	Total Usage		Average Rates	
		(000 ha)	tN	tP	kg N/ha	kg P/ha
Daintree	108	212.50	340	100	1.60	0.47
Mossman	109	49.00	820	240	16.73	4.90
Barron	110	217.50	1680	625	7.72	2.87
Mulgrave-Russell	111	202.00	4720	605	23.37	3.00
Johnstone	112	233.00	7300	1700	31.33	7.30
Tully	113	168.50	2660	530	15.79	3.15
Murray	114	114.00	1290	220	11.32	1.93
Herbert	116	1013.10	9800	1330	9.67	1.31
Black	117	107.50	5	0	0.05	0.00
Ross	118	181.50	21	0	0.11	0.00
Haughton	119	365.00	8805	613	24.12	1.68
Burdekin	120	12986.00	3180	256	0.24	0.02
Don	121	388.50	1445	380	3.72	0.98
Proserpine	122	248.50	3040	459	12.23	1.85
O'Connell	124	243.50	4390	539	18.03	2.21
Pioneer	125	149.00	5490	648	36.85	4.35
Plane	126	267.00	7685	995	28.78	3.73
Styx	127	305.50	0	3	0.00	0.01
Shoalwater	128	370.50	0	27	0.00	0.07
Waterpark	129	184.00	475	73	2.58	0.40
Fitzroy	130	14264.50	7290	786	0.51	0.06
Calliope	132	225.50	62	20	0.27	0.09
Boyne	133	254.00	7	2	0.03	0.01
Baffle	134	386.00	405	105	1.05	0.27
Kolan	135	298.00	1690	360	5.67	1.21
Burnett	136	3315.00	4545	1160	1.37	0.35
Burrum	137	334.00	2970	650	8.89	1.95
Mary	138	959.50	2800	1050	2.92	1.09
Total		38042.60	82915	13476	2.18	0.35

Table 10. Average nitrogen and phosphorus rates applied in some eastern Queensland basins in 1990

	kg N/ha		kg P/ha
Pioneer	36.85	Johnstone	7.30
Johnstone	31.33	Mossman	4.90
Plane	28.78	Pioneer	4.40
Haughton	24.12	Plane	3.70
Mulgrave-Russell	23.37	Tully	3.15
O'Connell	18.03	Mulgrave-Russell	3.00
Mossman	16.73	Barron	2.87
Tully	15.79	O'Connell	2.21
Proserpine	12.23	Burrum	1.95
Murray	11.32	Murray	1.93
Herbert	9.67	Proserpine	1.85
Burrum	8.89	Haughton	1.68
Barron	7.72	Herbert	1.31
Kolan	5.67	Kolan	1.21
Don	3.72	Mary	1.09
Mary	2.92	Don	0.98
Waterpark	2.58	Daintree	0.47
Daintree	1.60	Waterpark	0.40
Burnett	1.37	Burnett	0.35
Baffle	1.05	Baffle	0.27
Fitzroy	0.05	Calliope	0.09
Calliope	0.27	Shoalwater	0.07
Burdekin	0.24	Fitzroy	0.06
Ross	0.11	Burdekin	0.02
Black	0.05	Styx	0.01
Boyne	0.03	Boyne	0.01
Styx	0.00	Black	0.00
Shoalwater	0.00	Ross	0.00

3.4 1990 Nitrogen and Phosphorus Usage Relative to Basin Run-off

There are large differences in the ratio of 1990 nutrient nitrogen and phosphorus usage to the average run-off volume for the different basins (tables 11 and 12).

The Haughton Basin, with high nitrogen use and low average run-off, has the highest nitrogen run-off ratio of 11.6 kg N/1000 ML. The Herbert Basin, with the highest total nitrogen use in 1990, has a ratio of less than two.

The Johnstone River Basin, with the highest phosphorus usage, and highest average phosphorus rate over the total basin area, has a lower ratio of phosphorus applied to run-off volume than the Burrum and eight other basins. The ratio of phosphorus application in 1990 to average run-off was 0.9 kg P/1000 ML for Burrum, to less than 0.01 for Boyne, Styx, Black and Ross, with an overall average of 0.23.

The significance of these ratios is not known. The actual sites of fertilizer use are not necessarily the origins of the run-off from the various river basins. Nevertheless the ordering of the basins might provide a relative measure of the potential importance of each basin in contributing to nutrient contents of rivers adjacent to the Great Barrier Reef.

Table 11. Nitrogen and phosphorus application in 1990 relative to mean annual run-off volume

	No.	Run-off (000 ML)	tN	tP	Ratio of Nutrient Use to Run-off Volume	
					kg N/1000 ML	kg P/1000 ML
Daintree	108	3560	340	100	0.096	0.028
Mossman	109	687	820	240	1.194	0.349
Barron	110	1153	1680	625	1.457	0.542
Mulgrave-Russell	111	4193	4720	605	1.126	0.144
Johnstone	112	4698	7300	1700	1.554	0.362
Tully	113	3683	2660	530	0.722	0.144
Murray	114	1628	1290	220	0.792	0.135
Herbert	116	4991	9800	1330	1.964	0.266
Black	117	509	5	0	0.010	0.000
Ross	118	372	21	0	0.056	0.000
Haughton	119	756	8805	613	11.647	0.811
Burdekin	120	10100	3180	256	0.308	0.025
Don	121	689	1445	380	2.097	0.552
Proserpine	122	1431	3040	459	2.124	0.321
O'Connell	124	1668	4390	539	2.632	0.323
Pioneer	125	994	5490	648	5.523	0.652
Plane	126	1370	7685	995	5.609	0.726
Styx	127	825	0	3	0.000	0.004
Shoalwater	128	832	0	27	0.000	0.032
Waterpark	129	700	475	73	0.679	0.104
Fitzroy	130	7127	7290	786	1.023	0.110
Calliope	132	340	62	20	0.182	0.059
Boyne	133	401	7	2	0.017	0.005
Baffle	134	750	405	105	0.540	0.140
Kolan	135	464	1690	360	3.642	0.776
Burnett	136	1743	4545	1160	2.608	0.666
Burrum	137	718	2970	650	4.136	0.905
Mary	138	2309	2800	1050	1.213	0.455
Total		58691	82915	13476	1.413	0.230

Table 12. Ratios of nitrogen and phosphorus usage in 1990 to mean annual run-off volume

	kg N/1000 ML		kg P/1000 ML
Haughton	11.65	Burrum	0.91
Plane	5.61	Haughton	0.81
Pioneer	5.52	Kolan	0.78
Burrum	4.14	Plane	0.73
Kolan	3.64	Burnett	0.67
O'Connell	2.63	Pioneer	0.65
Burnett	2.61	Don	0.55
Proserpine	2.12	Barron	0.54
Don	2.10	Mary	0.46
Herbert	1.96	Johnstone	0.36
Johnstone	1.55	Mossman	0.35
Barron	1.46	Proserpine	0.32
Mary	1.21	O'Connell	0.32
Mossman	1.19	Herbert	0.27
Mulgrave-Russell	1.13	Mulgrave-Russell	0.14
Fitzroy	1.02	Baffle	0.14
Murray	0.79	Tully	0.14
Tully	0.72	Murray	0.14
Waterpark	0.68	Fitzroy	0.11
Baffle	0.54	Waterpark	0.10
Burdekin	0.31	Calliope	0.06
Calliope	0.18	Shoalwater	0.03
Daintree	0.10	Daintree	0.03
Ross	0.06	Burdekin	0.03
Boyne	0.02	Boyne	0.01
Black	0.01	Styx	0.00
Shoalwater	0.00	Black	0.00
Styx	0.00	Ross	0.00
Average	1.41		0.23

4. DISCUSSION

It is likely that less than one half of the nitrogen fertilizer applied for crop and pasture production is recovered in crop products in the year of application. The remainder is lost to the atmosphere, organically fixed in crop residues or lost in run-off or to drainage below the usual level of root growth. The proportions vary considerably from area to area, crop to crop and year to year. Any residual nitrogen which is not transferred from the crop production site in marketed produce has a potential to enter the water cycle, via run-off of soluble fertilizer products such as urea, or as dissolved ammonium and nitrate, in sediment and organic matter to streams and rivers, and by percolation to underground water resources, which may enter streams subsequently.

Of the 80-85 000 tonnes of nitrogen being applied annually in fertilizer, 20-30 000 tonnes are contained in products sold off-farm. While there is some evidence of organic nitrogen accretion in soils under green cane, trash blanket systems and under some pastures, most of the 50-65 000 tonnes not utilised by crop growth is eventually lost to the atmosphere, and to run-off and leaching from the site of application.

Annual nitrogen losses to streams are likely to be quite variable, depending mainly on rainfall amount and intensity, on density of ground cover and on fertilizer application methods and timing. Losses are likely to be more considerable in the high rainfall areas where run-off, as a proportion of rainfall, is high.

The greatest transfer of nitrogen is likely to be from the basins with the highest ratios of nitrogen use: run-off volume, listed in table 11.

Recovery of applied phosphorus by crop and pasture plants is considerably lower than for nitrogen, in the year of application. Any phosphorus not utilised is fixed in the soil in organic and inorganic forms, some of which become available for uptake in following years. Major system losses depend on soil loss by erosion, as soluble phosphates tend not to stay long in the soil solution, unless the soil has a low clay percentage and low organic matter status.

Of the 13 000 tonnes of phosphorus being applied annually in fertilizer, 1-2000 tonnes are contained in products sold off-farm. Most of the remainder, together with similar proportions of phosphorus applied previously, accumulates in the soil in forms which are of low availability to plants - hence the need for re-application for each crop or crop cycle.

As with nitrogen, there is a high potential in some areas for loss of phosphorus from agricultural systems to associated streams and rivers (and eventually to the marine ecosystem) and to aquifers. Such losses are likely to be higher where rainfall and run-off are highest and where residual phosphorus levels are also high. The actual losses will depend on phosphorus application methods and rates, as well as soil characteristics, for each cropping system.

The greatest contribution of phosphorus to water systems is likely to be from the basins listed towards the top of table 11, i.e. those with a high ratio of phosphorus use to run-off volume. This contribution will be mediated by the structure of the basin, in so far as potential sources of phosphorus loss may not coincide with run-off sources.

Total phosphorus applications to the eastern catchments adjacent to the Great Barrier Reef since 1920 probably exceed 400 000 tonnes (as against about two million tonnes of nitrogen). It is likely that a high proportion of this phosphorus is still contained in the topsoils of the 600 000 hectares of land to which it has been applied over the last 70 years.

As such, the phosphorus represents both a valuable resource and a major source of potential loss into aquatic systems. On both counts, it necessitates the use of farming practices which ensure losses are minimised, so as to protect the long-term nutritional fertility status of the land and to reduce any potential adverse impacts on Great Barrier Reef ecosystems.

ACKNOWLEDGMENTS

The provision by Queensland Department of Primary Industries Water Resources of detailed maps of Queensland drainage basins and the data presented in table 1 is greatly appreciated.

Incitec Limited and its earlier associated companies provided the information which enabled nutrient usage to be calculated for various east coastal Queensland marketing areas.

Statistics of fertilizer usage tabulated by the Australian Bureau of Statistics, from Agricultural Census returns, were utilised in the analysis. Access to statistics prior to the 1952 publications was not provided.

Some of the allocations to river basins were based on estimates provided during discussions with sugar industry and fertilizer industry personnel. Their assistance is gratefully acknowledged.

APPENDIX 1. FERTILIZER USAGE IN BASINS ADJACENT TO THE GREAT BARRIER REEF MARINE PARK

Basins are listed by place and number in order from north (Daintree-108) to south (Mary-138).

Details are provided for each basin, as follows:

- latitude and longitude
- area
- mean annual rainfall and run-off (see table 1; page 11)
- description of the catchment
- land use
- fertilizer usage, including comments on trends in nutrient applications (see tables 2, 3, 5 and 6 for details).

Some fertilizer products such as urea, ammonium phosphates, superphosphate and rock phosphate are used as nitrogen and/or phosphorus supplements for livestock. These uses have been included in the tables 2, 3, 5 and 6 covering individual basins and groups of basins. In tables 4 and 7, nitrogen and phosphorus utilised as fertilizer products for livestock supplementation are included in the pastures column.

DAINTREE — Basin 108

Latitude 16°10'S **Longitude** 145°20'E

Area 2125 km^2 - 212 500 ha
820 sq ml - 524 875 acres

Mean Annual Rainfall - 2576 mm
Mean Annual Run-off - 1675 mm (3 560 000 ML)

Run-off - 65% of rainfall

Fifty-five percent of the basin is gauged, with one gauging station on the Bloomfield River, two on the Daintree River and two on Saltwater Creek in the south-east corner.

Description The Daintree (100 kilometres long) and Bloomfield Rivers comprise the bulk of the catchment, which extends about 60 kilometres north-south from Bloomfield to Newell and about 35 kilometres from west to east, from the Dividing Range to the sea. The highest peaks are about 1500 metres in the Range in the headwaters of the Daintree River. A coastal peak near Cape Tribulation reaches 880 metres.

Land Use The catchment includes a high proportion of the World Heritage Area which is present in the Douglas Shire (182 739 hectares). Most of the south-western area is national park, with rainforest dominating the steeper slopes and the Dividing Range as well as the coastal Bloomfield area.

The Upper Daintree, Stewart Creek and Douglas Creek have been cleared for beef cattle grazing, most being planted to introduced grasses. Setaria and green couch are present on the river terraces, guinea grass and blady grass on the slopes. Spring burning is practised before the onset of the wet season to control blady grass and ingress of woody weeds.

The coastal lowlands between Saltwater Creek and Daintree Village are mainly utilised for sugarcane. These cane areas are drained by small creeks. Barrett Creek flows north from near the Pinnacle under the Dagmar Range and into the Daintree estuary.

Bamboo Creek flows south on the western edge of the Dagmar Range and joins Whyabee Creek which meets Saltwater Creek from the west at Miallo. Small areas of tropical fruits are grown. About 6800 hectares of land are used for crops and livestock, about 30% of the total catchment.

Fertilizer Usage No separate figures are available for this catchment as distinct from the Douglas Shire, of which it forms the northern part. The early history of the Shire was associated with dairying as well as sugarcane growing, there being 87 dairy farms in the Shire in 1939, with a butter factory at Mossman. The dairy industry had disappeared by 1963.

The northern Daintree has the bulk of the cattle and improved pastures in the Shire, and for the more recent years, the Shire data for improved pastures have been ascribed to the Daintree catchment.

Precise information on the proportion of sugarcane in the northern part of the Shire is not readily available. It has been assumed that about one-third of the cane is now being grown in the Daintree - Newell area, this being a higher proportion than in the earlier years, when dairying was more popular.

Less than 1% of the catchment is used for cultivation, so that fertilizer usage has been concentrated on a small proportion of the catchment.

Pre-1963, nitrogen usage was at a low level, increasing at a linear trend rate of three tonnes per year, largely due to small increases in the area of sugarcane receiving fertilizer as the total area expanded in the Douglas Shire. In 1963 there was a 22% expansion in cane area, which led to further increases in nitrogen usage from the 110 tonnes in 1962 to 150 tonnes in 1963. Continuing increases in area grown and, up to 1980, increases in the rate of application, have increased nitrogen usage to 420 tonnes nitrogen in 1988, a linear trend of 12 tonnes per year. Recent usage has declined, due largely to low sugar prices.

Nitrogen rates on cane were below 100 kg N/ha until the mid-1950s. Rates increased during the 1960s and 1970s, with application of about 170 kg N/ha on plant cane and 180 kg N/ha on ratoons. About 85% of the area is ratoon cane.

Usage of nitrogen on bananas and perennial tree crops is at a higher rate than on sugarcane but contributes less than 2% of the total use.

Most of the 5000 hectares of sown pastures in Douglas Shire is in the northern part of the Daintree catchment. New plantings and a small proportion of the Brachiaria planted since the 1970s is fertilized with nitrogen to maintain beef cattle, using rates of 50-100 kg N/ha on about 200 hectares.

Usage of phosphorus was at a low level, less than 10 tonnes annually, prior to 1950. During the 1960s and 1970s there has been an increase, generally in line with the area of sugarcane, reaching about 120 tonnes of phosphorus in 1981, with stability or a slight decrease in recent years. Usage in plant cane is about 60 kg P/ha, about three times the rate used on ratoons. Some ratoons may not be fertilized with phosphorus every year, so that the average rate for the whole cane area grown is 18 kg P/ha.

Ten to fifteen tonnes of phosphorus are applied to pastures, with year to year variations depending on seasons and the size of areas planted. Rates are in the 20-30 kg/ha range, being

highest on new plantings. Most of the pasture is not fertilized - the overall average rate is about 0.3 kg P/ha of sown pasture available. A considerable quantity of ammonium phosphate (58 tonnes of phosphorus in 1987) may be provided as a stock feed supplement in the area in some years. Usage is variable, with little being fed at all in years of good pasture availability.

MOSSMAN **Basin 109**

Latitude 16°30'S **Longitude** 145°20'E

Area 490 km^2 - 49 000 ha
820 sq ml - 121 000 acres

Mean Annual Rainfall - 2494 mm
Mean Annual Run-off - 1400 mm (687 000 ML)

Run-off - 57% of rainfall

There is one gauging station on the Mossman River and another on the South Mossman River, both located near Mossman.

Description The Mossman River rises in the Great Divide near Mt Spurgeon (1450 metres) and flows about 15 kilometres to the Bay south of Newell. The South Mossman River (20 kilometres) drains the area south of the town, forming the Mossman River on the coast. These two rivers form the bulk of the catchment, generally to the north of Port Douglas.

A narrow strip of land astride the Cook Highway from Cairns to Mossman in the southern section has short streams such as the Mowbray River and Hartley Creek between Port Douglas and Yorkeys Knob.

Land Use The lowlands around Mossman and south to Port Douglas are almost entirely utilised for sugarcane production, about two-thirds of the cane in the Douglas Shire. Other crops such as tropical fruits occupy a very small area.

Over 40 000 hectares of the catchment is World Heritage Area, comprising State Forests and National Parks in the Dividing Range and headwaters of the Mossman River.

Fertilizer Usage No separate Australian Bureau of Statistics figures are available for the catchment, it being included in the Douglas Shire. It is estimated that about two-thirds of the fertilizer used in the Mossman sugar mill area is applied to sugarcane in this catchment; i.e. to about 4350 hectares.

Total current use on cane is about 780 tonnes of nitrogen (180 kg N/ha fertilized) and 140 tonnes of phosphorus (32 kg P/ha grown).

Nitrogen application rates have increased substantially as growers utilise more of their assigned areas for sugarcane production. In the early pre-1960 period, less fertilizer nitrogen was needed because of the high natural fertility of the alluvial soils, the use of fallows between last ratoons and replanting, the growth of green manure crops to provide some nitrogen and the generally lower yield potential.

Phosphorus application rates have increased also, as new land of lower fertility was brought into production and yields per hectare were increased. In more recent years, usage has remained

static or declined, as growers make use of the residual supplies from previous applications which were well in excess of removal in cane stalks.

Usage on sugarcane constitutes 98% of the nitrogen and 96% of the phosphorus in the Mossman River basin, with the remainder largely applied to tropical tree fruits and papaws.

BARRON

Basin 110

Latitude 16°45' to 17°30'S **Longitude** 145°15' to 145°45'E

Area 2175 km^2 - 217 500 ha
839.4 sq ml - 537 225 acres

Mean Annual Rainfall - 14 447 mm
Mean Annual Run-off - 530 mm (1 153 000 ML)

Run-off - 37% of rainfall

89% of the basin is gauged.

Description The Barron River (160 kilometres long) rises in the Herberton Range and receives many small tributaries as it flows north-east to Lake Tinaroo, the dam being 100 kilometres from the river mouth and 25 kilometres long. The dam also receives water from the Lamb Range to the east. The Barron flows 30 kilometres north through Mareeba and then arches to the east from about 50 kilometres at Bilwon through Koah and Kuranda to Barron Falls (20 kilometres) from where it flows down to the 10 kilometres long tidal estuary beginning at Kamerunga. Tributaries in the north of the catchment from the Great Dividing Range separate waters flowing north-west into the Mitchell River. Water from Tinaroo Dam is diverted by channels and pipelines for a large irrigation area south and west of Mareeba, the Walsh River scheme being outside the catchment.

Land Use The catchment includes all of Atherton Shire (the Barron River near Tinaroo forming its northern boundary) and most of the crop land in the Mareeba Shire (excluding an area of tobacco and some crops west and north of Mareeba). The eastern portions of Atherton and Mareeba Shires have over 80 000 hectares as World Heritage Area in the Lamb Range, Whitfield Range and Macalister Range.

The agricultural crop land comprises about 15 000 hectares of maize, peanuts, tobacco and more recently, sugarcane which is replacing rice north of Mareeba. East of Atherton around Yungaburra and towards Malanda and Upper Barron, improved pastures have replaced rain forest, supporting a dairy industry supplying milk to coastal and north-west Queensland.

Most of the dairy production occurs in Eacham Shire around Millaa Millaa and in Herberton Shire on the Evelyn Tableland. These areas are in the Johnstone and Herbert River catchments.

Fertilizer Usage Current fertilizer usage on the Atherton Tablelands approximates 4000 tonnes of nitrogen and 1600 tonnes of phosphorus, however less than 45% of this is applied in the Barron River catchment. Of this only that portion used in the Atherton Shire (about half of the nitrogen and two-thirds of the phosphorus) is applied above the Tinaroo Dam. Part of this water is used for irrigation outside the catchment, west of the Divide.

Prior to 1963, when a bounty on superphosphate manufacture was introduced, fertilizer application was largely restricted to tobacco in the Mareeba area. The price reduction on

superphosphate was followed by a 25% nitrogen subsidy in 1966. In the same year a 50% State Government subsidy for dairy pasture development was introduced. While these factors had the greatest effect on the higher rainfall dairying areas, the reduced fertilizer prices resulted in increases in nitrogen and phosphorus use for maize and peanuts on the red soils around Atherton.

Between 1970 and 1990, the total area of crops fertilized in the Barron River catchment increased from about 6500 hectares to 10 000 hectares, over 50%. The area of pastures fertilized increased from 4000 hectares to 10 000 hectares over the same period (much of the pasture which has been fertilized in Mareeba Shire is in the Walsh-Mitchell catchment).

As a consequence of declining soil fertility, average rates of fertilizer applications have increased, as well as there being larger areas fertilized. Average rates of nitrogen currently applied to crops range from 100-150 kg N/ha on rice, maize, fruit trees and vegetables, 170 kg N/ha on tobacco and 200-300 kg N/ha on irrigated pastures for dairy cattle. Phosphate rates vary considerably, with most of the peanuts not being fertilized, grain crops receiving 20-40 kg P/ha, tobacco, fruit and vegetables 70-100 kg P/ha and pastures 10-40 kg P/ha depending on pasture type and on rainfall or irrigation availability.

In 1970 an average of 57 kg N and 14 kg P/ha was applied to the fertilized area of crops and pastures. By 1980 with a 40% increase in the area being fertilized, average rates had increased to over 100 kg N and 45 kg P/ha.

Over the last decade, nitrogen and phosphorus usage has stabilised at about the same quantities as in the early 1980s. While the total area fertilized has increased by another 40%, average rates of usage have declined to about 80 kg of nitrogen and 30 kg of phosphorus per fertilized hectare.

MULGRAVE-RUSSELL — Basin 111

Latitude 16°50' to 17°30'S **Longitude** 145°35' to 146°5'E

Area 2020 km^2 - 202 000 ha
780 sq ml - 498 940 acres

Mean Annual Rainfall - 3233 mm
Mean Annual Run-off - 2079 mm (4 193 000 ML)

Run-off - 64% of rainfall

45% of the basin is gauged.

Description There are two distinct catchments which have a common estuary at Woolanmaroo-Russell Heads. The Mulgrave River (75 kilometres long) rises in Gadgarra Forest Reserve north and west of Bartle Frere and flows northwards. The Little Mulgrave River from the Bisley Hills of the Lamb Range in the north of the catchment joins at 42 kilometres. From here the river flows east, mainly through canelands between Gordonvale and Aloomba, around the north side of Walsh's Pyramid to the foot of the coastal Malbon Thompson Range. Here the river, 20 kilometres upstream, flows south, about two kilometres east of the Bruce Highway through lowlands draining the Bellenden Ker Range.

The Russell River, 65 kilometres long, rises opposite the Mulgrave River west of Bartle Frere and flows eastwards, draining the south side of the Bellenden Ker Range. Thirty kilometres

upstream it flows generally northwards, draining low-lying country at Waugh Pocket. Babinda Creek (25 kilometres) from the eastern side of Bartle Frere joins at Palma, 15 kilometres from the junction with the Mulgrave. Much of the Babinda-Woolanmaroo area is low-lying. The Bruce Highway crosses the Russell River south of Mirriwinni, 32 kilometres from the mouth.

Many streams flow north from Gordonvale and north-west from the Murray and Malbon Thompson Ranges into Trinity Inlet north of Cairns. Another system draining the east side of Bisley Hills and Mount Sheridan (600 metres) drains the Hambledon Mill area.

Most of the catchment is in Mulgrave Shire; the southern boundary of the Shire is also the basin boundary.

The Lamb Range in the northern half of the catchment is also the Shire boundary. The western section of the Mulgrave River and the upper reaches of the Russell River are in Eacham Shire; about one-third of Eacham Shire is in this basin.

Land Use The World Heritage Areas of Mulgrave and Eacham Shires, totalling almost 117 000 hectares, are in the Mulgrave-Russell basin; i.e. about 58% of the basin is reserved as forests.

The agricultural area is a north-south strip along the Bruce Highway about eight kilometres wide in the south around Mirriwinni, only two kilometres wide from Bellenden Ker to Aloomba, but widening again to 10 kilometres around Gordonvale. The total area of holdings is about 75 000 hectares of which 30 000 hectares are cropped, mainly with sugarcane. Pasture areas support 5000 head of beef cattle.

Fertilizer Usage The agricultural area is entirely within the Mulgrave Shire so agricultural census data are relevant to the basin. Prior to 1938-39, statistics were compiled in Petty Sessions districts, the basin including Cairns and Innisfail in the Rockingham Division. The area became Cairns Shire in 1938-39 statistics, with boundaries similar to those of the current Mulgrave Shire. From 1951-52, data are for Mulgrave Shire.

The early history of the shire was associated with production of sugarcane, although about a third of the landholders had some dairy and beef cattle. Almost all of the farm land is now sugarcane, with less than 100 hectares of fruit crops. Small areas of pasture are found in the lower country unsuitable for cane and higher up the Little Mulgrave, Mulgrave and Russell Rivers and along Babinda Creek.

About one-third of the basin is occupied as agricultural holdings and about half of the farm area is under sugarcane crop. The area regularly fertilized, about 24 000 hectares annually, represents 13% of the basin area.

Current nitrogen use is in the range of 4000 to 5000 tonnes each year, almost totally applied to sugarcane which is fertilized at planting with about 150 kg N/ha. Sugarcane ratoons receive from 160 to 200 kg N/ha, depending on sugar prices. Total nitrogen usage increased until 1980, stabilised until 1985, and declined over the last five years, in response to low prices for sugar and the loss of cane lands to urban development.

Phosphorus usage is restricted almost entirely to sugarcane. Application rates are usually about 45 kg P/ha at planting, (more on new land) and 25-30 kg/ha on ratoons. Some ratoons may not receive a phosphorus fertilizer, so that the average phosphorus rate on all cane is slightly below 20 kg P/ha. Total phosphorus usage is about 600 tonnes per year, having declined from the 800 tonnes used annually from 1963 (after the introduction of a price subsidy) until 1984. The

decline in usage is attributed to a reduction in area of sugarcane and to the higher levels of soil phosphorus built up over many years, so that ratoon cane gives little response to applied phosphorus fertilizer.

JOHNSTONE — Basin 112

Latitude 17°20' to 17°50'S **Longitude** 145°30' to 146°15'E

Area 2330 km^2 - 233 000 ha
899 sq ml - 575 510 acres

Mean Annual Rainfall - 3405 mm
Mean Annual Run-off - 2017 mm (4 698 000 ML)

Run-off - 59% of rainfall

57% of the basin is gauged.

Description This basin is formed by the catchments of the two Johnstone Rivers and Liverpool Creek. The Johnstone River (125 kilometres) rises in the Evelyn Tableland, circling Malanda and then flowing south-east to near Crawford's Lookout on the Palmerston Highway, about 50 kilometres from its mouth. The river meanders in an easterly direction through canelands and the Goondi area north of Innisfail, six kilometres up the estuary from the Port of Innisfail at Flying Fish Point.

The Ithaca River, Dirran Creek and the Beatrice River, which all rise in the Cardwell Range are the major tributaries in the north-west, draining the pasture lands of the Eacham Shire in the area of Tarzali, Jaggan, Minbun and Millaa Millaa.

The South Johnstone River (90 kilometres) rises east of Ravenshoe. It drains the mountainous land south of the Palmerston and then the cane lands of the Mena Creek-South Johnstone-Mourilyan area. It joins the Johnstone River five kilometres from the Port.

The Liverpool Creek (50 kilometres) drains the southern portion of the catchment north of the Walter Hill Range through Warrakin Road cane fields, Japoonvale and Warrubullen, entering the sea at Cowley Beach.

Several small creeks in the south-east drain the Silkwood, El Arish area, flowing into the sea between Bingil Bay and Kurrimine. The Moresby River drains the country east of the Basilisk Range, entering the sea at the Port of Mourilyan.

The basin comprises all of the Johnstone Shire and the southern 80% or more of Eacham Shire.

Land Use A coastal area and the middle portion of the basin are World Heritage Areas, comprising 94 000 hectares or 40% of the area.

The agricultural area, about 45% of the basin, comprises the dairy-beef pasture country of the upper Atherton Tableland (Malanda-Millaa Millaa) and the predominantly sugarcane areas of the Johnstone Rivers from 45 kilometres from the mouth, and in the south-east.

Much of the land near the coast is poorly drained, especially south of Innisfail to Mourilyan and in the vicinity of the Moresby River.

The total cropping area in the basin is about 32 000 hectares, dominated by sugarcane, with 1800 hectares of bananas and 1000 hectares of tea and other horticultural crops. The 35 000 hectares Tableland section which is in rural holdings, is largely grass pasture having varying degrees of productivity, less than one-third being fertilized in any year.

Fertilizer Usage Fertilizer usage in the Johnstone Shire has been, until recently, associated with sugarcane production; lately bananas have become of some importance. Nitrogen rates on plant cane are about 140 kg/ha, 160-180 kg/ha on ratoons. Bananas are fertilized eight to ten times a year, most receiving 600 kg N/ha overall. Current annual nitrogen usage on sugarcane is about 4900 tonnes, with 500 tonnes on pastures and 1000 tonnes on bananas - some of the bananas in the Mission Beach area are in the Tully Basin.

In the Eacham Shire portion of the basin, fertilizer use is restricted almost entirely to improved pastures. Usage was of minor proportions until the mid-1960s when a Dairy Pasture Subsidy scheme was introduced, with a State Government subsidy for pasture development.

For a short period about 2000 hectares were being planted annually, largely replacing grassland areas of lower productivity. Nearly 12 000 hectares were fertilized in 1972-73, but declined with the reduction in meat prices and large increases in fertilizer costs in 1975.

The pasture area fertilized gradually increased to peak at 15 000 hectares in 1985-86, declining to 12 000 hectares annually in recent years. Within the Johnstone basin, nitrogen usage on grassland is estimated at 1300 tonnes, consisting of a range of rates varying from nil, over much of the area, to as much as 300 kg/ha on some irrigated rye grass pastures on the Tablelands.

The combined Johnstone Shire and the portion of Eacham Shire in the basin have a total nitrogen use of 7300 tonnes.

Phosphorus application rates for sugarcane depend on soil test values. Most plant cane receives 45-60 kg P/ha; many growers may not re-apply phosphorus until the third ratoon crop.

Bananas are fertilized with 50-60 kg P/ha at the beginning of the plant crop and yearly thereafter. Some growers prefer more frequent applications, using nitrogen, phosphorus and potassium mixtures at monthly intervals throughout the year, except during the cooler months, and during the summer when the ground is too wet to be able to apply fertilizer.

Pastures on the Atherton Tableland in the Eacham Shire are fertilized annually with about 3000 tonnes of superphosphate and 1500-2000 tonnes of ammonium phosphates, containing about 600 tonnes of phosphorus in all.

Total phosphorus usage increased gradually from 1950 to 1980, with periods of stable usage from 1963 to 1968 and from 1970 to 1978. Following the major expansion in 1980, when consumption reached nearly 2000 tonnes of phosphorus, there has been a gradual decline in total annual applications, largely due to a reducing demand for use in sugarcane production and to a lesser extent, a decline in usage of the pastures on the Tableland. Current usage approximates 1700 tonnes of phosphorus.

The average rates of fertilizer application over the whole catchment are 31 kg N and 7 kg P/ha annually. The area which actually receives fertilizer on a fairly regular basis represents nearly 18% of the total catchment size.

TULLY **Basin 113**

Latitude 17°40' to 18°5'S **Longitude** 145°30' to 146°5'E

Area 1685 km^2 - 168 500 ha
650 sq ml - 416 195 acres

Mean Annual Rainfall - 2970 mm
Mean Annual Run-off - 2185 mm (3 673 000 ML)

Run-off - 74% of rainfall

87% of the basin is gauged.

Description Tributaries of the Tully River (130 kilometres long) rise north of the Cardwell Range near Ravenshoe. The river itself rises and flows north-west of the range. It is dammed (100 kilometres) to form the Koombooloomba Reservoir south of Tully Falls. The river arches through the Range at Cardstone and flows south-east, receiving the Davidson Creek at Munro Plains (40 kilometres). Jarra Creek, draining the Table Top Range and the southern side of the Walter Hill Range, enters 30 kilometres upstream. The river then meanders near the edge of the basin with the Murray River, before entering the sea in Rockingham Bay.

Land Use The northern and western portions of the basin are World Heritage Areas, essentially mountainous with peaks to 1185 metres in the north-west. The lower country in the Echo and Davidson Creek area is used for pasture (Tully River Station) while the alluvial flats and gentle rises around Tully are utilised for sugarcane and bananas. Coastal country in the area from Kenny to Googarra is low-lying, draining into the Hull River and Kennedy Bay. Three hundred and sixty-four hectares of bananas are grown near Mission Beach which is in the Johnstone Shire.

The Tully basin forms part of Cardwell Shire, the Cardwell Range forming the north-western boundary. The upper Tully, including the reservoir and the hydro-electricity operation at Kareeya power station, is in Herberton Shire.

Fertilizer Usage Cardwell Shire forms the major proportion of the Tully and Murray River basins. Agricultural census data for the Shire provide some estimates of crop production and fertilizer usage. There are major differences between Australian Bureau of Statistics figures and sales figures of the fertilizer suppliers. Census data for superphosphate are almost three times actual sales, probably due to some growers allocating their fertilizer usage to the first column of the table.

Duchess rock phosphate dust, which first became available in Townsville from the dust-suppression operation at the port outloading facility in 1977, and a later product from the sludge pits at Duchess, has been used on sugarcane and to a much greater extent, on pastures by Tully River Station. These products are included in Australian Bureau of Statistics data as 'other fertilizers'. The greater use of potassium fertilizers as straights in Cardwell Shire (and also at Innisfail) necessitates careful attention to the changing nitrogen and phosphorus percentages in fertilizer mixtures over time. This is further complicated by the increasing adoption of urea-based fertilizer blends for sugarcane, resulting in a reducing phosphorus percentage and an increasing nitrogen content, of the 'other fertilizers' component of the fertilizer statistics.

Sugarcane is the main crop of the area, accounting for over 70% of the nitrogen currently being used. The Tully sugar mill was built by the Queensland Government in 1925, and sold to

growers in 1931. It is supplied from 16 000 hectares of cane grown between El Arish and the Murray River, i.e. three river basins. Fertilizer nitrogen rates are higher than in other sugarcane production areas largely because of the higher rainfall - 220 kg N/ha on plant cane and 280 kg N/ha on ratoons. Phosphorus rates are also generally higher, with some plant cane areas receiving heavy applications of superphosphate, with the intention of building soil phosphorus status to more than 40 mg/kg acid-extractable phosphorus as soon as economically possible. Ratoon cane in high phosphorus soils is often not fertilized with this nutrient - about 70% of the ratooned area receives an average of about 38 kg P/ha. About 77% of the phosphorus is applied to sugarcane.

Bananas around Tully (1735 hectares) and at Mission Beach (364 hectares) constitute 44% of the north Queensland area and 30% of the north Queensland growers. Average annual nutrient use on bananas is in excess of 600 kg N/ha and 50 kg P/ha, applied in up to ten applications over the year. Bananas account for about 20% of the nitrogen and phosphorus used in the Tully catchment.

Pastures for beef cattle are a minor user of nitrogen (less than 10%) and phosphorus (about 4%). Occasional large applications of rock phosphate, e.g. in 1980, distort an otherwise fairly static usage of phosphorus in the catchment since 1975.

Overall, nitrogen usage has increased at over 5.5% annually since 1950, largely due to the expansion of sugarcane production and more recently, bananas. Phosphorus usage increased significantly between 1960 and 1972 (more than 18% annual trend), declined in the mid-1970s with higher prices, and has changed little since.

MURRAY **Basin 114**

Latitude 18° to 18°30'S **Longitude** 145°45' to 146°15'E

Area 1140 km^2 - 114 000 ha
440 sq ml - 281 580 acres

Mean Annual Rainfall - 2485 mm
Mean Annual Run-off - 1428 mm (1 628 000 ML)

Run-off - 57% of rainfall

14% of the basin is gauged.

Description The Murray River (75 kilometres long) drains the northern and western half of the catchment, through the cane areas of Euramo and Bilyana, entering low-lying country 15 kilometres upstream of the mouth into Rockingham Bay.

The Kennedy Creek - Meunga Creek system flows east of the Range through Ellerbeck between Kennedy and Cardwell to the southern part of Rockingham Bay, opposite the northern tip of Hinchinbrook Island.

The narrow southern portion, south from Cardwell to the Cardwell Gap, is low-lying adjacent to Hinchinbrook Channel, east of the Bruce Highway - Northern Railway. The western section forms part of the Cardwell Range with peaks to 1100 metres in the vicinity of Macalister Mountains.

Land Use About 25% of the 10 500 hectares of sugarcane grown in the Cardwell Shire is in the Murray River Basin, mostly located from west of Euramo to Tully Heads, south of the Tully River. Pastures and small crops are grown around Murray River, including 460 hectares of bananas. Bananas are also grown near Kennedy (380 hectares) together with mangoes, lychees and papaws.

The Edmund Kennedy National Park extends along the coast north-east of Kennedy. The southern and western mountainous regions of the Cardwell Range are World Heritage Areas.

Fertilizer As in the Tully River system, fertilizer usage in the Murray River basin is dominated by sugarcane and, more recently, bananas. Nitrogen usage increased from about 100 tonnes in 1960 to nearly 400 tonnes in 1980 (7.5% annual increase). Since 1985, with the rapid increase in the production of bananas (where rates in excess of 600 kg N/ha are applied each year), tropical tree crops and cucurbit crops, particularly melons, nitrogen usage has trebled.

Phosphorus usage has increased linearly since 1960 to reach 200 tonnes per year, about 60% on sugarcane and 30% on bananas.

As in other sugarcane production areas, and particularly since the advent of green cane trash blanket harvesting methods, the rate of phosphorus application to ratoon cane has decreased.

HERBERT — Basin 116

Latitude 17°30' to 19°S **Longitude** 145° to 146°15'E

Area 10 131 km^2 - 1 013 100 ha
3910 sq ml - 250 236 acres

Mean Annual Rainfall - 1331 mm
Mean Annual Run-off - 493 mm (4 991 000 ML)

Run-off - 37% of rainfall

87% of the basin is gauged.

Description The Herbert River rises as the Wild River, 335 kilometres from its mouth, at about 1260 metres above sea level near Herberton on the Evelyn Tableland in Herberton Shire, flowing south. Tributaries enter from the Mt Garnet area in the Great Dividing Range to the west and from Ravenshoe to the east. At the Herberton Falls (160 kilometres) the river's direction changes to the east, flowing through the Yamanie Falls National Park (leaving the Herberton Shire) adjoining the Gorge Range, which is the watershed of the Burdekin River to the south. Stony Creek with the 305 metre high Wallaman Falls, enters west of Abergowrie (85 kilometres), draining the Seaview Range to the south. Tributaries from the Cardwell Range and Rockingham Bay Range to the north in Cardwell Shire enter below Abergowrie while the Stone River (50 kilometres) drains the southern area west of the highway. From Ingham, 35 kilometres upstream, the Herbert River flows north-east through the Macknade and Halifax cane areas entering the sea through several channels north of Lucinda in the Hinchinbrook Channel.

The south-east, adjoining Halifax Bay, is low-lying swampy land, with extensive mangroves south of Allingham.

Land Use The lower part of the Herbert Valley was first settled in 1865, west of Abergowrie, for pastoral use. The alluvial soils of the Herbert and Stone Rivers were ideally suited to sugarcane and the first cane produced north of Mackay was crushed at the Girlock Mill in 1872.

The Macknade Mill, the longest operating sugar mill, crushes about 1 million tonnes of cane, while the largest, Victoria Mill, crushes up to 2.5 million tonnes annually.

Eighty percent of the Hinchinbrook Shire is in rural holdings, and less than 10% is under crops. The 38 000 hectares used for sugarcane represent less than 4% of the Herbert River basin. The Shire has 51 819 hectares, or 18% of the Shire, designated as World Heritage Area.

The Upper Herbert River, in the Herberton Shire, is largely pastoral. The beef cattle area is served by the Kennedy Highway from the Forty Mile Scrub to Mt Garnet and Ravenshoe; this is the watershed with the Lynd River flowing north-west to the Mitchell River. The higher and wetter Evelyn Tableland (above 950 metres) between Ravenshoe, Kaban and Herberton is used for dairying, with some vegetable production.

Eighty-two percent of the Herberton Shire is in rural holdings. Slightly less than 10% (90 691 hectares) is designated as World Heritage Area. Less than 1400 hectares are utilised for summer grain crops.

As indicated above, the Herbert River basin consists of most of the Herberton and Hinchinbrook Shires. It also includes a small part of the Cardwell Shire (the river forming the southern boundary in one section) and Dalrymple Shire near the headwaters of the Burdekin River. Since the Upper Tully River is also in Herberton Shire, the combined areas of the two shires exceeds the catchment area by 20%. Taking this into account, the basin includes about 0.9 million hectares of rural holdings, less than 42 000 hectares (less than 5%) being cropped and fertilized.

Fertilizer Usage In common with other northern sugar areas, there is a discrepancy between Australian Bureau of Statistics fertilizer data and industry sales. In the case of the Hinchinbrook Shire (where the shire boundaries coincide with the fertilizer industry sales region), actual superphosphate applications to sugarcane are about 20% of the Census figure, and ammonium sulphate about half as much.

Some fertilizer products, e.g. urea and ammonium phosphate are used also for stockfeeding and are not recorded by primary producers. Forestry uses, although small, are not recorded. Overall there is good agreement on total product tonnes between Australian Bureau of Statistics and fertilizer industry data for sugarcane. The total fertilized area is 4% of the catchment area.

In the Hinchinbrook Shire, sugarcane accounted for 95% of the 9260 tonnes of nitrogen applied as fertilizer in 1990, with less than 350 tonnes of nitrogen used on all other crops and pastures. Depending on the season, up to 600 tonnes of nitrogen is fed to cattle as a supplement.

In the Herberton Shire, about 540 tonnes of nitrogen are applied annually to about 2000 hectares of pasture, largely to Kikuyu grass and to a lesser extent, rye grass and oats for dairy cattle on the Evelyn Tableland.

In the Herbert River basin, sugarcane accounts for 90% of the 9800 tonnes of nitrogen used as fertilizer (about 20% of this being applied to the plant crop) and pastures 8%.

Nitrogen usage increased annually by nearly 6% from 1950 to 1980. During the early 1980s there was little change in usage, about 7000 tonnes per year, as sugarcane farmers adjusted to lower sugar prices and green cane harvesting methods.

Recent expansions in sugarcane areas and developments in other market sectors have pushed usage above 9000 tonnes per year.

Phosphorus usage closely followed nitrogen usage at about 20% of the quantity until 1970. Over this period, nitrogen rates for sugarcane were five times those of phosphorus. Phosphorus usage was virtually static between 1965 and 1970, with a fall during the mid-1970s in response to higher prices for phosphatic fertilizers and lower prices for cattle. Since the 1974 low in usage (about 500 tonnes of phosphorus), growth in demand has increased at a trend rate of 6% per year, to above 1300 tonnes in 1990.

BLACK **Basin 117**

Latitude 19°S **Longitude** 146°50'E

Area 1075 km^2 - 107 500 ha
415 sq ml - 265 525 acres

Mean Annual Rainfall - 1510 mm
Mean Annual Run-off - 474 mm (509 000 ML)

Run-off - 31% of rainfall

33% of the basin is gauged.

Description The western boundary is the Paluma Range with Mt Spec (990 metres), Mt Halifax (1062 metres) and Mt Cataract (720 metres), the highest peaks. Several creeks flow seasonally from the range to Halifax Bay, the longest (45 kilometres) being the Black River with its tributary, the Alice River. Others are Saltwater Creek and Bluewater Creek. The major villages are Paluma and Muntarnee in the north, with Rollingstone on the Bruce Highway and Northern Railway the main centre.

The catchment forms part of Thuringowa Shire, which also includes the catchment of the Ross River and the northern side of the Haughton River from Giru north. The Paluma Dam, west of Mt Spec, is in the Burdekin basin.

Land Use Most of the area is dry savannah woodland, the higher rainfall Ingham cane land extending to the northern boundary of the basin. A considerable area has been cleared for small farms, few of which are of economic significance.

Fertilizer Usage No fertilizer is used on a regular basis. Small quantities are applied to irrigated crops at Bluewater, totalling less than 10 tonnes of nitrogen and phosphorus per year.

ROSS **Basin 118**

Latitude 19°30'S **Longitude** 146°45'E

Area 1815 km^2 - 181 500 ha
700 sq ml - 448 000 acres

Mean Annual Rainfall - 1071 mm
Mean Annual Run-off - 204 mm (372 000 ML)

Run-off - 19% of rainfall

50% of the basin is gauged.

Description This basin includes Townsville City and the bulk of Thuringowa Shire. The Bohle River in the northern third, above 25 kilometres long drains from the northern side of Round Mountain (375 metres) through low-lying country to the sea north of Pallarenda.

Lansdowne Creek (50 kilometres) rises near Mt Flagstone (640 metres) and becomes the Ross River near Toonpan. The Ross River reservoir, 30 kilometres from the river mouth at Cleveland Bay, supplies water to Townsville and suburbs.

Land Use Most of the area is dry savannah, used for grazing by beef cattle, with timber treatment the only improvement to feed supply, apart from some naturalised areas of Townsville stylo. Small farms are common.

Fertilizer Usage Apart from the applications on home gardens, parks and the CSIRO Lansdown Research Station, there is no fertilizer usage of significance.

HAUGHTON **Basin 119**

Latitude 19°20' to 20°S **Longitude** 146°30' to 147°30'E

Area 3650 km^2 - 365 000 ha
1409 sq ml - 901 550 acres

Mean Annual Rainfall - 923 mm
Mean Annual Run-off - 207 mm (756 000 ML)

Run-off - 22% of rainfall

67% of the basin is gauged.

Description The Haughton River (100 kilometres long) with its north western tributary, the Reid River, forms the major catchment. The southern third is drained by the Barratta Creeks (90 kilometres) which also enter the sea in mangroves on the north-facing Bowling Green Bay. Mt Elliot (1717 metres) National Park forms part of the northern boundary of the basin; other peaks in the Hervey Range to the north-west and west rise to 750 metres, with The Bluff in the Haughton Valley at 546 metres.

The main centres are Ayr and Brandon, with smaller centres at Pioneer, Barratta and Giru on the Bruce Highway. Reid River is on the Flinders Highway to Charters Towers from Townsville, with Mingela at the top of the range on the basin boundary, 100 kilometres from the Bay.

The basin comprises parts of Thuringowa and Burdekin Shires, the Haughton River forming the Shire boundary.

Land Use The basin is mostly dry savannah woodland and used for grazing by beef cattle. The agricultural areas of the south-eastern section include the Pioneer Mill area at Brandon and Invicta Mill at Giru. These mills crush nearly two million tonnes of cane each year, from 19 000 hectares of assigned area. Rice, mangoes and vegetable crops are of most recent significance.

Fertilizer Usage Sugarcane is the principal crop and user of fertilizer. The first cane was grown in the Burdekin Delta in 1879 and the first mill was erected in 1884, two years after the town of Ayr was surveyed.

All of the cane is irrigated; the generally drier environment and ability to control soil moisture over most of the growing season results in high potential sugar yields. In turn, application rates of nitrogen are high, as are the trends towards increasing nitrate concentrations in the groundwaters.

Rates of nitrogen fertilizer applications to sugarcane in the Burdekin area exceed those of cane grown in the wet tropics to the north by 25% or more.

In times of high prices for sugarcane in more recent past years, rates reached 300 kg N/ha; from 200 to 250 kg N/ha are normal rates at current sugar prices, even less for plant cane on fallow land. The trend towards green cane harvesting which retains the nitrogen present in the green tops in the cane field instead of losing it to atmosphere by burning before harvest, is much less advanced in the Burdekin, with less than 10% of the cane harvested green (as against virtually 100% at Ingham).

The nitrogen applied in the Burdekin region is split between three catchments. The area north of the Burdekin River drains to the Haughton, part of the south side is in the Don Basin, while the Clare, Dalbeg and Millaroo irrigation areas are in the Burdekin River basin, together with Rita Island in the Delta. The position with regard to nitrate accumulations in river systems and aquifers is complicated by the water diversion schemes from the Burdekin River (which recharge aquifers north of the river) and also by weirs on the Haughton River.

Nitrogen usage in the Haughton basin is dominated by cane, with about 88% of total applications in 1990, vegetables and rice using most of the remainder. The tonnage applied increased from 1000 tonnes annually in the early 1960s to 3000 tonnes in 1970, partly in response to expansions in area but largely due to a significant increase in the rate of nitrogen applied per hectare.

Further expansions in 1974, 1978, 1989 and 1990 have increased the area available for cane growing.

This change and a higher proportion of ratoon cane, together with high rates of N/ha, resulted in nitrogen usage increasing, reaching nearly 9000 tonnes in 1980. Annual usage declined to 7000 tonnes in the mid-1980s and has since increased to 9000 tonnes. Rates of application are very sensitive to relative prices of sugar and fertilizer.

Phosphorus usage is evenly shared between sugarcane and all of the other field and horticultural crops and pastures. While 90% of the plant cane receives phosphorus, only 22% of the ratoon cane is currently fertilized with phosphorus. Rates of use are usually between 15 and 30 kg/ha. diammonium phosphate is the main phosphorus source.

Total phosphorus usage increased gradually over the period to 1960 and reached a peak in 1965 of nearly 400 tonnes. Usage declined slightly over the next 15 years, but the introduction of

new, lower fertility land for cane, rice and other crops, and the expansion of irrigation in the early 1980s, resulted in a major increase in use to nearly 700 tonnes in 1983.

Usage declined again almost to the levels of the 1970s by 1987, but has increased more recently following further irrigated farming development with the completion of the Burdekin Falls dam. There is no apparent relationship between the rates of usage of nitrogen and phosphorus over time, other than the general increase of both during area expansions.

The quarterly distribution of nitrogen (N) and phosphorus (P) applications in 1990 were as follows:

	N (%)	P (%)
January - March	4.4	13.0
April - June	5.4	24.2
July - September	46.6	44.5
October - December	43.6	18.3

BURDEKIN **Basin 120**

Latitude 18°10' to 24°30'S **Longitude** 144°15' to 148°35'E

Area 129 860 km^2 - 12 986 000 ha
50 000 sq ml - 32 026 000 acres

Mean Annual Rainfall - 640 mm
Mean Annual Run-off - 78 mm (10 100 000 ML)

Run-off - 12% of rainfall

99% of the basin is gauged.

Description This basin is second only to the Fitzroy Basin in size in Queensland. The 720 kilometres long Burdekin River rises in the Seaview Range north-west of Ingham. It arches to the west and south through Greenvale to Clarke River (490 kilometres) where the Clarke River (180 kilometres) enters from the western Divide.

Further south-east, through Charters Towers to the Upper Burdekin Falls (180 kilometres), the Burdekin is separated from the Suttor River sub-basin comprising the Cape (260 kilometres), Belyando (400 kilometres), and Suttor (320 kilometres) Rivers (this latter confluence comprising about half the basin area). At the Dam (160 kilometres upstream) the Burdekin turns northward flowing through Dalbeg, Millaroo, Clare, Ayr and Home Hill into the Delta around Rita Island. The Bowen River sub-basin through Collinsville from Eungella drains into the Burdekin south of Dalbeg, 120 kilometres upstream. The Bogie River (120 kilometres) joins near Millaroo. The Burdekin basin is very narrow for 30 kilometres upstream. The north bank of the river is the boundary with the Haughton Basin. The boundary with the Don Basin passes between Mt Inkerman and Home Hill.

The Burdekin Basin comprises the Dalrymple and Belyando Shires, most of Burdekin and Bowen Shires and parts of Etheridge, Herberton and Nebo Shires.

Land Use This large area is mainly savannah woodland utilised for intensive grazing with little improvement other than fencing, water and some timber treatment.

Much of this country is seasonally overgrazed. The feeding of nitrogen and phosphorus supplements to cattle during the dry season has been considered to have allowed the maintenance of higher cattle numbers and contributed to land degradation, including soil loss.

The alluvial terraces from Dalbeg to Clare were originally developed as soldier settlement farms with tobacco and small crops as the main interest. These have largely been replaced by sugarcane, although cucumbers, melons, pumpkins, beans and other horticultural crops are still important to some growers.

The narrowness of the Basin in the Ayr-Home Hill area determines that only parts of the Inkerman and Pioneer Mill supply areas of sugarcane production, including Rita Island, are included.

Fertilizer Usage As in other sugarcane areas, nitrogen usage has expanded rapidly since the early 1960s. A ten-fold increase in the 16 years to 1976 (a 16% annual increase) resulted from the introduction of cheaper forms of nitrogen fertilizers (urea in 1958 and aqua ammonia in 1962), high sugar prices in 1963 (partly due to cyclone damage to the Cuban crop), the introduction of a 25% nitrogen price subsidy in 1966 and improving returns from sugar from 1969 to 1976.

Since 1976, usage has peaked at about 3000 tonnes of nitrogen in each of the 1980 to 1983 and 1990 seasons, with about 2500 tonnes of nitrogen being applied between 1984 and 1989. Within the Burdekin Basin, an increasing proportion of the total nitrogen has been applied to sugarcane, as vegetable and other crops assume less importance up-river.

Phosphorus usage has been of little importance (100 tonnes per year in the early 1960s declining gradually to 75 tonnes by 1978) for agriculture in the Burdekin Basin. The expansion of cane production to new areas resulted in peaks of usage in 1982 and 1990, with about 250 tonnes per year being used currently.

Some superphosphate has been applied at various times to Townsville stylo pastures in the upper Burdekin, e.g. at Dottswood, Fanning River (CSIRO) and Swan's Lagoon (QDPI) and on Pangola Grass and fodder crops at Havilah and Birralee on the Bowen River south of Collinsville (Pioneer Stations).

DON **Basin 121**

Latitude 19°40' to 20°35'S **Longitude** 147°20' to 148°15'E

Area 3885 km^2 - 388 500 ha
1499 sq ml - 959 595 acres

Mean Annual Rainfall - 1022 mm
Mean Annual Run-off - 177 mm (689 000 ML)

Run-off - 17% of rainfall

33% of the basin is gauged.

Description The Don River rises in the Clarke Range, 80 kilometres from its mouth, flowing north to Bowen. Euri Creek flows from the Mount Aberdeen National Park, parallel to the Don River over most of its 45 kilometres length. Further north, the 45 kilometre Elliot River flows

north through Guthalungra into Abbott Bay. Many small creeks flow into Upstart Bay crossed by the Bruce Highway between Kyburra and Inkerman.

The coastal land east of the Bruce Highway - Northern Railway line (side by side from Bowen to Home Hill) is mostly low-lying with fringing mangroves on the tidal flats. The western areas are broken country.

Land Use Mostly grazing lands, relatively unimproved apart from the provision of stock water, fencing and some ringbarking or other timber treatment. At Bowen, about 5500 hectares of vegetable crops and 150 hectares of mangoes utilise irrigation from the Delta aquifer and the bed of the Don River. Smaller areas of horticultural crops are grown at Euri. A proportion of the sugarcane supplying the Inkerman Mill is produced near Home Hill.

Fertilizer Usage The Don basin forms part of the Bowen and Burdekin Shires. The Bowen Shire includes the south-eastern portion of the Burdekin basin. The south-eastern boundary of the Bowen Shire with Whitsunday Shire is in the Proserpine basin.

Fertilizer data for the Bowen Shire cover the irrigated horticulture production in the Delta area. Comparisons with fertilizer industry sales figures for this area show considerably lower usage of nitrogen and phosphorus, as calculated from the Australian Bureau of Statistics (ABS) census figures, than actual. Figures for 1987 were as follows:

	ABS (tonnes)	Industry (tonnes)	Actual v. ABS
Superphosphates	469	734	+ 56%
Urea	382	851	+123%
Other nitrogen	273	49	- 82%
Mixtures	1291	1700	+ 32%
Nitrogen	380	620	+ 63%
Phosphorus	172	223	+ 30%

Australian Bureau of Statistics data show some of the annual trends in the usage of various products, e.g. the increase in use of superphosphate and urea and the more recent reductions in the use of 'other N' (ammonium nitrate) and mixtures (due to increasing adoption of higher nitrogen, phosphorus and potassium concentration products). These changes defy reasonable calculations of nutrient applications from the Australian Bureau of Statistics information, unless the changes in analysis of the products are known.

From 1960 to 1986, nitrogen usage in the Don basin increased ten-fold, peaking at 1500 tonnes of nitrogen. These changes reflect the growth of horticulture at Bowen and the expanding sugarcane production around Inkerman. Between 1980 and 1990, nitrogen use varied between 1250 and 1500 tonnes annually. Less than 60% of current usage is on sugarcane, compared with 75% in the early 1970s. The Bowen area has expanded production from a predominantly one crop (tomatoes) per year system to a multicrop system, including capsicums, sweetcorn, beans and various cucurbit crops such as melons and cucumbers.

Phosphorus usage was about 150 tonnes each year from 1964 to 1976. With the sugar expansion, usage increased to 260 tonnes through to 1988. Over the last few years, further increases have occurred reflecting mainly higher annual usage for horticulture as two crops are planted each year.

PROSERPINE **Basin 122**

Latitude 20° to 20°30'S **Longitude** 148°15' to 148°50'E

Area 2485 km^2 - 248 500 ha
959 sq ml - 613 795 acres

Mean Annual Rainfall - 1562 mm
Mean Annual Run-off - 576 mm (1 431 000 ML)

Run-off - 37% of rainfall

Only 14% of the basin is gauged.

Description The basin consists of three systems; eastern streams flowing into the Whitsunday area, northern streams flowing into Edgecumbe Bay and southern streams entering Repulse Bay. The Whitsunday system (13% of the basin) is dominated by the Conway Range (National Park), the watershed of streams flowing into Pioneer Bay and the Whitsunday Passage.

The Edgecumbe Bay system (30% of the basin) is dominated by the Gregory River (40 kilometres long) which rises near Mt Dryander, flows west to North Gregory (25 kilometres) and then north to Edgecumbe Bay in mangroves. Smaller creeks including Eden Lassie Creek (crossed at Longford Creek on the Bruce Highway) drain low country east of Bodes Range and Double Peak Range in the north of the basin.

The Proserpine River (55% of the basin) rises in Mt Quandong State Forest, 85 kilometres from the sea and flows north for 25 kilometres before turning to the east, passing through the town of Proserpine (30 kilometres upstream). The Peter Faust dam with a catchment of 270 km^2 and a capacity of 50 000 ML was completed in 1991. To the south of the river are Lethe Brook and Goorganga Creek, which join 10 kilometres from the mouth of the river. The Thompson Creek enters Repulse Bay at the Brook.

Land Use Most of the basin, the exception being the Edgecumbe Bay section, is in the Whitsunday Shire. All of the north western section was included in the Bowen statistical area until 1954.

The Andromache Creek and its tributaries from the Normanby Range are in the O'Connell basin, this river forming the southern boundary of the Shire with Pioneer Shire.

The Edgecumbe system is used for grazing by beef cattle, except for a small area of sugarcane along the Gregory River near the Bruce Highway at North Gregory.

The eastern and western parts of the basin are State Forests or National Park.

Sugarcane is grown within 15 kilometres around Proserpine, also along Kelsey Creek and Lethe Brook, between Crofton Creek and the Gregory River and along the Proserpine River from 25 to 55 kilometres upstream - a total of 15 000 hectares of a gross assigned area of 16 000 hectares, producing one million tonnes of harvested cane. Most cane is irrigated, some from a substantial aquifer.

Extending around the cane lands are extensive grazing properties supporting 40-50 000 beef cattle. Higher carrying capacity is available in the lower reaches of the Proserpine River, in areas known as Pocket Paddock, Campbell's Plains and the Proserpine Plain. In this area, the

bed and banks of the river are higher than the surrounding flood plain, with little exchange of water from the river bed sands to underlying sediments. A small area of orchards and plantation fruit occurs in the eastern section near Cannon Valley.

Fertilizer Usage Australian Bureau of Statistics data are complete for sugarcane since the 1972 season indicating a 42% increase from 8950 hectares fertilized in 1972 to 12759 hectares in 1988. The tonnage applied increased by 27% to 8338 tonnes. This reflects a change from aqua ammonia (20% nitrogen) to urea (46% nitrogen) as the preferred nitrogen source and adoption of urea - nitrogen, phosphorus and potassium (NPK) blends for application to ratoon cane in preference to NPK mixtures plus sidedressing of urea. Over the 1972 to 1988 period, NPK mixtures changed from 37% of the total tonnage of fertilizers applied, to 64%.

While there is closer agreement between the Australian Bureau of Statistics data and industry sales figures for the Proserpine area than for most other sugarcane areas, additional information, particularly the changing nitrogen and phosphorus contents of the mixtures is required to calculate nutrient applications.

Nitrogen usage has increased from 700 tonnes in 1961 to 3000 tonnes in 1990, over four-fold or about 5.5% annually. Increases between 1955 and 1965 were followed by a period of static usage, of about 1000 tonnes annually for several years until 1972 when usage again increased at a much faster rate that the area fertilized, reaching 2500 tonnes of nitrogen in 1980.

Almost all of the nitrogen (96%) is applied to sugarcane, a small quantity being used on pastures and for stock supplements. Of the sugarcane, which is all fertilized in most years, 20-25% is plant cane and 75-80% ratoons. Nitrogen rates on plant cane average 175 kg N/ha, and 190 kg/ha on ratoons.

Phosphorus usage showed a linear trend to 1962 when the introduction of a phosphorus bounty reduced costs and led to an increase in rate of application. Annual usage has been about 300 tonnes of phosphorus since 1964 with a small upward trend, consistent with the increase in sugarcane area and the decrease in average rate applied on older country.

Plant cane is fertilized with 50-60 kg P/ha while ratoon cane may not be fertilized with phosphorus in some situations. Average rates for all ratoon cane vary from 10-15 kg/ha.

Superphosphate has been applied to pastures at various times in the past - in recent years, too little for the Australian Bureau of Statistics to publish. The topdressing of Townsville stylo was practised on some properties in the 1968-74 period - nearly 6000 hectares (using 600 tonnes of superphosphate) in the peak year of 1972. Low cattle prices, a trebling of superphosphate price and disease in the stylo resulted in the demise of this practice in 1975 for several years. Current usage of 40-60 tonnes of phosphorus annually represents less than 15% of total phosphorus, the remainder being applied about equally to plant and ratoon sugarcane.

Basin 124

O'CONNELL

Latitude	20°30' to 21°8'S	**Longitude**	148°15' to 149°15'E
Area	2435 km^2	-	243 500 ha
	1558 sq ml	-	601 445 acres
Mean Annual Rainfall		-	1705 mm
Mean Annual Run-off		-	685 mm (1 668 000 ML)

Run-off - 40% of rainfall

30% of the basin is gauged.

Description The southern section of the basin consists of many small catchments along the east coast between the Clarke Range and the sea. St Helens Creek (40 kilometres) flowing through Calen to St Helens Bay, rises in the Eungella National Park near Mt Omega. Blackrock Creek flows through Pindi Pindi to St Helen's Bay.

The dominant catchment is the Andromache River - O'Connell River system. Andromache Creek (45 kilometres) rises in the Normanby Range and flows east, joining the O'Connell 12 kilometres from its mouth. The O'Connell River, (55 kilometres) flows north from near Mt Dalrymple in the Eungella National Park, through Bloomsbury, to enter Repulse Bay.

The Bruce Highway and Northern Railway from Mackay to Proserpine bisect the basin. The basin comprises about 80% of Pioneer Shire.

Land Use Most of the basin is forested especially in the southern and western sections. Clearings for sugarcane supply Farleigh Mill. Areas around Calen, Kolijo, Seaforth, Mt Jukes and Mt Ossa (St Helens and Murray Creeks) occupy very low-lying areas affected by salinity and by flooding in wet seasons unless drained. Mid-slopes along the O'Connell River at Bloomsbury and east of the Highway are utilised for beef cattle grazing.

Fertilizer Usage Sugarcane is the major user of fertilizer. Nitrogen usage reached 1000 tonnes in 1962, after the Cuban sugar crisis. During the 1960 to 1980 period, usage increased 3.5-fold (6.5% annual growth rate) to 4500 tonnes. This was due to higher rates of application and to a lesser extent, increases in the area being grown. During the 1980s, rates of application declined, in response to lower sugar prices. Fifteen to twenty percent of the cane is harvested green - nitrogen rates will increase as green cane harvesting is more widely adopted. Annual rates are 150-175 kg N/ha on plant cane and 175-220 kg/ha on ratoons.

Most ratoon cane is fertilized with a one-shot urea-blend containing diammonium phosphate and potassium chloride as well, while plant cane has a low rate of nitrogen (35 kg/ha) at planting, followed by a topdressing of urea at 50% canopy closure.

Phosphorus usage prior to 1975 was closely related to nitrogen, being applied at about 20% of the rate of nitrogen to all sugarcane. Usage reached 600 tonnes in the early 1980s, the increase being due to the need to apply higher rates of phosphorus to new cane areas. Plant cane crops are fertilized with 40-50 kg P/ha. In most areas, three or four ratoon crops are grown before replanting and about 60% of these crops are fertilized with phosphorus, at rates of 15-20 kg/ha.

Usage of nitrogen or phosphorus on crops other than sugarcane is minimal. Superphosphate has been used in small quantities on improved pastures for beef production, particularly when establishing legumes.

PIONEER **Basin 125**

Latitude	21° to 21°30'S	**Longitude**	148°30' to 149°15'E
Area	1490 km^2	-	149 000 ha
	575 sq ml	-	368 030 acres

Mean Annual Rainfall - 1418 mm
Mean Annual Run-off - 668 mm (994 000 ML)

Run-off - 47% of rainfall

93% of the basin is gauged.

Description The Pioneer River (115 kilometres) rises as Black's Creek in the Clarke Range and flows south-east through State Forest west of the Pinnacle Range. 60 kilometres upstream, Stockyard Creek enters from the south and the river flows north to Mia Mia (45 kilometres) where Cattle Creek (40 kilometres) enters from the west. Cattle Creek also rises in the Clarke Range, in the Eungella National Park and drains the cane lands of Finch Hatton and Gargett. The Pioneer River flows through a very narrow catchment (five kilometres wide) from Mirani to Mackay entering Sandringham Bay. Weirs are at Mirani and Dumbleton Rocks.

The basin comprises Mirani Shire and that part of the southern 20% of Pioneer Shire to the top of the Pioneer River bank, less than one kilometre to the south of the river. This watershed passes through the villages of Mirani, Marian, Walkerston and Te Kowai, with the Marian, Pleystowe and Racecourse sugar mills located along it.

Land Use Most of the basin is state forest or national park, apart from the sugarcane lands along Cattle Creek and Pioneer River from Mirani to West Mackay.

Fertilizer Usage Sugarcane is the only crop of importance in the basin. Nitrogen usage increased from 1000 tonnes in 1960 to 5750 tonnes in 1980, an annual growth rate of 9%. Usage declined during the 1980s to 4500 tonnes but reached 5500 tonnes in 1990.

Rates and methods of application of nitrogen fertilizer to sugarcane are similar to those elsewhere in the Mackay area.

Phosphorus usage reached 200 tonnes of phosphorus in 1960 and exceeded 400 tonnes of phosphorus in 1963, in response to the phosphorus bounty and expanded cane areas. Usage has since grown to over 600 tonnes, with periods of growth and decline largely related to sugar prices and to the area expansions of 1964, 1974, 1978 and 1989-90.

Rates of application on plant cane are higher than on ratoons, with applications at planting being applied below and beside the cane set 10 centimetres below the soil surface, at 40-50 kg P/ha.

Applications to ratoons, where practised, are at lower rates and usually broadcast on the soil surface and cultivated in later. Green cane harvesting is increasing; fertilizer applications following harvestings are often applied on the top of the trash, awaiting rain to take the nutrients into the soil.

Usage of nitrogen and phosphorus on pastures is small and restricted to dairy farms on the Eungella Plateau, most of which are in the Burdekin Basin.

PLANE **Basin 126**

Latitude 21°10' to 22°10'S **Longitude** 148°50' to 149°30'E

Area 2670 km^2 - 267 000 ha
1030 sq ml - 659 490 acres

Mean Annual Rainfall - 1500 mm
Mean Annual Run-off - 513 mm (1 370 000 ML)

Run-off - 34% of rainfall

16% of the basin is gauged.

Description With the exception of the northern section between Mirani, Sarina and Mackay, this basin extending along the coast south to Kalarka is less than 20 kilometres wide. Marion Creek and Carmila Creek drain the southern part of the Connors Range south of Koumala. Plane Creek, Alligator Creek, Sandy Creek and Bakers Creek drain cane lands of Sarina, Homebush and Eton. The Bruce Highway from St Lawrence to Mackay traverses the basin, midway between the Range and the coast.

Land Use Streamflows are diverted from Mirani Weir on the Pioneer River to Sandy Creek to the Kinchant Dam, providing water for the Eton Irrigation Area to allow irrigation of 11 000 hectares of sugarcane (dam capacity - 6280 ML). South of the Pioneer River, water for irrigation is available from an aquifer, recharged by rainfall percolation to the ground water storage.

The area of land assigned for sugarcane exceeds 65 000 hectares, from which over 4.5 million tonnes of cane are harvested. This cane area represents 24% of the basin area.

The basin includes the southern part of Pioneer Shire, which extends to Alligator Creek, part of Sarina Shire which extends over the Connors Range to Funnel Creek in the Fitzroy basin and down to Rocky Dam Creek at Mt Christian, and the north-eastern portion of Broad Sound. As a consequence, statistical data of the Australian Bureau of Statistics for these shires are of no use for determining areas of crops or pastures, livestock information or fertilizer figures for the basin area.

Fertilizer Usage The Plane basin includes all of the sugarcane grown in Sarina and Broad Sound Shires, about 45% of Pioneer Shire and 7% of Mirani Shire. Rates of fertilizer usage are similar for all areas, except on new land and where irrigation is practised as a routine rather than on a supplementary basis.

Nitrogen usage exceeded 1000 tonnes soon after 1955 and grew rapidly from 1960 to 1980 to exceed 8000 tonnes - an annual rate of nearly 9%.

As in other basins dominated by sugarcane, the same factors influenced year to year changes over the period and the same reductions and recovery in usage in the 1980s were experienced.

Phosphorus usage in the 1980s has been closely correlated with nitrogen, except for a period between 1968 and 1974 when considerable areas of improved pastures were established in the Sarina area. In the Mackay Division, 25 000 hectares were fertilized in 1974; the area had declined to 5700 hectares in 1977 following large increases in the cost of superphosphate and low prices for beef (superphosphate usage, according to Australian Bureau of Statistics data, fell from 5330 tonnes in 1972 to 915 tonnes in 1977). The total area of pasture topdressed has stabilised at around 11 000 hectares each year since 1980.

Total phosphorus usage in the basin increased rapidly in the 1950 to 1965 period - from 200 tonnes to 900 tonnes or about 10-11% annually. Usage increased, with peaks at times of sugarcane area expansions, to 1100 tonnes in 1980 and then declined to 800 tonnes in the mid-1980s. It has since recovered to 1000 tonnes with recent increases in sugarcane areas.

STYX

Basin 127

Latitude 22° to 22°50'S **Longitude** 149°20' to 149°50'E

Area 3055 km^2 - 305 500 ha
1179 sq ml - 754 585 acres

Mean Annual Rainfall - 1157 mm
Mean Annual Run-off - 270 mm (825 000 ML)

Run-off - 23% of rainfall

The basin is not gauged.

Description The basin includes several intermittently-flowing creeks entering Broad Sound. Clairview Creek enters south of Kalarka, Freshwater Creek into the Port of St Lawrence and Amity Creek further south, passing through Wumalgi. The southern section is drained by the Styx River, formed from Granite Creek, Tooloomba Creek (80 kilometres) passing through Ogmore, and Deep Creek. Wellington Creek flows into the river estuary at the lower end of the Sound. The land adjoining the coast is low-lying, poorly drained and seasonally wet.

The Bruce Highway from Marlborough to Carmila passes through the basin west of the Northern Railway from Kooltandra to St Lawrence and Kalarka.

The basin includes the coastal section of the Broad Sound Shire and the northern section of Livingstone Shire, the Shire boundary being the Styx River.

Land Use The higher country of the Broad Sound Range is lightly timbered. Land other than the tea tree flats and mangrove swamps of the coast has been selectively cleared for beef cattle grazing, the main properties being Rosedale, Wumalgi, Granite Creek, Angleside, Mamelon and Glenprairie.

Fertilizer Usage Pasture improvement involving the planting of Townsville stylo and superphosphate applications took place in the late 1960s. An outbreak of anthracnose in the stylo killed most stands by the mid-1970s.

Low cattle prices and poor returns from superphosphate on depleted pastures resulted in a decline in fertilizer use. Ammonium phosphate and urea are fed as supplements for beef cattle; overall quantities are small.

SHOALWATER

Basin 128

Latitude 22° to 23°S **Longitude** 149°45' to 150°35'E

Area 3705 km^2 - 370 500 ha
1430 sq ml - 915 135 acres

Mean Annual Rainfall - 1102 mm
Mean Annual Run-off - 224 mm (832 000 ML)

Run-off - 20% of rainfall

The basin is not gauged.

Description This basin is a low-lying area bounded by Broad Sound to the north and Shoalwater Bay to the east. Herbert Creek drains the southern section, north and east of the Bruce Highway between Glen Geddes and Marlborough, into a broad, mangrove-lined estuary into Broad Sound. Wadallah Creek discharges run-off into low-lying tea tree country in the north. Louisa Creek drains the south-east lowlands into Shoalwater Bay, rising along a low coastal range.

The basin forms the north-eastern third of Livingstone Shire.

Land Use Freehold and grazing selections occupy most of the area apart from Army training grounds in the east. The country is of low fertility and supports beef cattle at low stocking rates. Much of the land is seasonally inundated, supporting Para grass swamps. Saline areas affect the Broad Sound section.

Fertilizer Usage A number of grazing properties, e.g. Tilpal, Couti Uti, Torilla, Banksia and Raspberry Creek had brief periods of pasture development with Townsville stylo in the early 1970s, using some aerially applied superphosphate. Current usage is negligible. Urea and ammonium phosphate are fed as supplements on some properties.

WATERPARK — Basin 129

Latitude 22°15' to 23°30'S **Longitude** 150°30' to 150°50'E

Area 1840 km^2 - 184 000 ha
710 sq ml - 454 480 acres

Mean Annual Rainfall - 1317 mm
Mean Annual Run-off - 381 mm (700 000 ML)

Run-off - 29% of rainfall

70% of the basin is gauged.

Description This basin consists of a narrow coastal section from Keppel Bay north to the Warginburra Peninsula and Shoalwater Bay, including Emu Park and Yeppoon. Waterpark Creek drains south from Shoalwater Bay to Corio Bay at the Byfield National Park. The basin forms the eastern portion of Livingstone Shire.

Land Use The northern section is used for extensive grazing. The main agricultural industry is 1000 hectares of pineapples at Emu Park and south of Yeppoon.

Fertilizer Usage Nitrogen usage has grown from 50 tonnes in 1960 to 470 tonnes in 1990, mostly on pineapples, at a fairly consistent annual increase of 8%.

Phosphorus usage is of minor significance, restricted to horticultural crops, especially pineapples. Usage has doubled from 35 tonnes to 70 tonnes since 1960.

FITZROY — Basin 130

Latitude 21°15' to 26°25'S **Longitude** 146°33' to 151°E

Area 142 645 km^2 - 14 264 500 ha
55 052 sq ml - 35 233 315 acres

Mean Annual Rainfall - 702 mm
Mean Annual Run-off - 50 mm (7 127 000 ML)

Run-off - 7% of rainfall

95% of the basin is gauged.

Description The largest coastal basin in Queensland, the Fitzroy includes the catchments of the Connors, Isaacs, Nogoa, Comet, Mackenzie, Don and Dawson Rivers. The western watershed is formed by the Drummond and Denham Ranges, which are also the south-eastern boundaries of the Burdekin basin. This western watershed stretches from Injune, north-west to the Carnarvon Range through Bogantungan to west of Clermont, Moranbah and Nebo in the north. Here, the Connors Range forms the boundary with the Pioneer basin. The southern boundary from near Injune to the edge of the southern Burnett basin north of Miles, is the Great Dividing Range. The eastern section adjoins the Burnett basin, the Boyne basin east of Biloela, and the Calliope basin to the south of the Fitzroy River entrance into Keppel Bay and the Waterpark, Styx and Plane basins to the north.

Land Use The Fitzroy basin comprises a range of country types from brigalow scrubs, now mostly cleared, to black soil grasslands of the Central Highlands, now mostly under crops, to savannah woodland and saline areas around Port Alma. The basin's entry to the sea through the Fitzroy River is about 10 kilometres wide, the north-south length is 570 kilometres and east-west is 420 kilometres.

The Fitzroy basin includes the Shires of Livingstone, Fitzroy, Mt Morgan, Banana, Taroom, Bungil, Bauhinia, Emerald, Duaringa, Peak Downs, Broad Sound and Nebo, and the eastern part of Belyando. It supports over three million beef cattle and has three million hectares of sown pastures, largely established after the clearing of brigalow scrub.

A wide range of grain and legume crops is grown. The construction of the Fairbairn Dam near Emerald, on the Nogoa River, has allowed extensive irrigation, particularly of cotton on the Central Highlands. Cotton is also grown intensively at Biloela, irrigated from aquifers and the Callide River.

Fertilizer Usage Nitrogen applications prior to 1975 were at a low level, restricted to irrigated cotton in the Emerald area. During the 1980s, nitrogen usage increased from 1500 tonnes to over 7000 tonnes, over 16% annually, largely due to cotton and wheat in the Central Highlands (4700 tonnes of nitrogen) and Biloela (2100 tonnes). Nitrogen fertilizers are also applied to sorghum, sunflowers, barley and oats.

Rates applied to winter cereals are 30 kg/ha under dryland conditions, 70-85 kg/ha where irrigated. Summer grains and oilseed crops are fertilized with 15-45 kg N/ha, depending on soil type, soil moisture available at planting and cropping history. Irrigated crops receive 75-115 kg N/ha.

Cotton has been grown on up to 25 000 hectares in recent times. Crops receive 125-175 kg N/ha, as anhydrous ammonia, aqua ammonia or urea, and diammonium phosphate or monoammonium phosphate.

Phosphorus applications reached 100 tonnes per year during the 1967 to 1975 period, applied mainly to wheat and barley in the Emerald area. Expansion in usage since 1975 has been similar to nitrogen, with nitrogen being used at 10 times the quantity overall. Current usage is

800 tonnes of phosphorus per year, mainly as monoammonium phosphate for winter cereals. Cotton in the Emerald Irrigation Area has become a substantial user of phosphorus, but not at Biloela.

Rates of phosphorus application are 8-10 kg P/ha on dryland grain crops, 18-20 if irrigated. About two-thirds of the cotton at Emerald receives phosphorus, at up to 25 kg P/ha. Twenty percent of the Biloela area cotton is planted with monoammonium phosphate, at low rates, supplying about 2 kg P/ha.

CALLIOPE — Basin 132

Latitude 23°30' to 24°15'S **Longitude** 150°40' to 151°15'E

Area 2255 km^2 - 225 500 ha
870 sq ml - 556 985 acres

Mean Annual Rainfall - 889 mm
Mean Annual Run-off - 151 mm (340 000 ML)

Run-off - 17% of rainfall

61% of the basin is gauged.

Description The Calliope River (90 kilometres) rises in the Callide Range west of Gladstone and flows east and then north through Beecher to the estuary in Port Curtis, south of Curtis Island. Mundanan Creek drains the northern section, east of Mt Larcom.

Land Use The western section is state forest and the eastern coastal lowland is poorly drained. The middle section is used for beef cattle grazing, most of the land being partially cleared. Spear grass is dominant. A small horticultural area, mainly papaws, is at Yarwun. Some fodder crops are grown. The Calliope basin comprises the middle half of the Calliope Shire.

Fertilizer Usage Nitrogen usage is of minor importance largely for horticultural crops at Yarwun and on fodder crops for beef breeders around Calliope.

Phosphorus fertilizers were applied during the 1965-1975 period on improved pastures containing Townsville stylo, Rhodes grass and Siratro in the Calliope area. Usage since then has declined to about 200 tonnes of superphosphate a year.

BOYNE — Basin 133

Latitude 23°45' to 24°40'S **Longitude** 150°55' to 151°30'E

Area 2540 km^2 - 254 000 ha
980 sq ml - 627 380 acres

Mean Annual Rainfall - 1031 mm
Mean Annual Run-off - 158 mm (401 000 ML)

Run-off - 15% of rainfall

99% of the basin is gauged.

Description The Boyne River (128 kilometres) rises in the Bobby Range and flows north towards Gladstone through Many Peaks, Ubobo and Benaraby. Degalgil, Glassford, Diglum and Futter Creeks from the Dawes and Calliope Ranges enter along the valley from the west, while the Eastern Boyne River and Iveragh Creek drain the Many Peaks Range in the east. The Awoonga Dam north of Benaraby provides water for Gladstone and the Boyne smelter.

Land Use The basin forms the eastern third of the Calliope Shire. The land is used for beef cattle grazing. Small areas of fodder crops are grown. Pasture development is limited to timber treatment.

Fertilizer Usage Virtually no fertilizer is used for cropping on a routine basis. Small areas of pasture were top dressed with superphosphate in the early 1970s; the practice has ceased in recent years in favour of direct supplementation of cattle.

BAFFLE

Basin 134

Latitude 24° to 24°45'S **Longitude** 151°25' to 152°15'S

Area 3860 km^2 - 386 000 ha
1490 sq ml - 953 420 acres

Mean Annual Rainfall - 1173 mm
Mean Annual Run-off - 194 mm (750 000 ML)

Run-off - 16% of rainfall

37% of the basin is gauged.

Description Baffle Creek (120 kilometres) is the main catchment, draining to the south from Bororen to Miriam Vale (100 kilometres). Colosseum Creek enters from the west at Colosseum (75 kilometres) and Granite Creek north of Lowmead (60 kilometres). Small creeks enter from the Dawes Range at Berajondo (40 kilometres) and the Creek flows eastwards to the Port of Baffle Creek. Oyster Creek from the northern subcoastal part of the basin, enters 20 kilometres from the estuary; Bottle Creek from the south at Rosedale enters near the mouth. Small creeks in the northern part of the basin flow into Rodds Bay.

Land Use The eastern section of the basin is Wallum Country and includes Deepwater and Eurimbula National Parks and Forestry reserves near Agnes Waters and Town of 1770. Grazing country extends from Iveragh to Miriam Vale and Rosedale; areas of the Grevillea, Dawes and Watalgan Ranges are State Forest.

Miriam Vale Shire (370 000 hectares) occupies most of the basin; the Kolan River section in the south-west is excluded. The south-eastern section of the catchment is in Gooburrum Shire, with some areas of sugarcane between the Kolan River and Baffle Creek.

Fertilizer Usage Small quantities of fertilizer are applied to the sugarcane grown in the Baffle Creek area, being part of the Fairymead Mill area.

Increased usage occurred throughout the 1960-1980 period, reaching 400 tonnes of nitrogen. Little change occurred during the 1980s.

Phosphorus usage reached 150 tonnes in 1973, following a period of adoption of superphosphate usage on Townsville stylo pastures in the Bororen - Miriam Vale area. Usage declined with low beef prices, high superphosphate costs and loss of stylo stands due to anthracnose. Small amounts of phosphorus are applied to grazing areas, although more phosphorus is now supplied to cattle as supplements. Most of the phosphorus currently used is for sugarcane, some was used on tobacco grown in the Miriam Vale area in the 1960s.

KOLAN **Basin 135**

Latitude 24°30' to 25°10'S **Longitude** 151°20' to 152°25'E

Area 2980 km^2 - 298 000 ha
1150 sq ml - 736 060 acres

Mean Annual Rainfall - 1162 mm
Mean Annual Run-off - 156 mm (464 000 ML)

Run-off - 13% of rainfall

80% of the basin is gauged.

Description The Kolan River (180 kilometres) rises in the Dawes Range in State Forest and over the next 70 kilometres receives small tributaries from the Burnett Range to the West and the Dawes Range to the east. Lake Monduran (Fred Haigh Dam) 80 kilometres upstream, backs up to 110 kilometres, where the Bruce Highway crosses north of Gin Gin. The final 80 kilometres to the sea, north of Moore Park is through grazing land initially, then through sugarcane land at Avondale. Weirs are located five and ten kilometres from the sea to prevent entry of saltwater upstream. Gin Gin Creek from the south-west enters about 50 kilometres from the mouth of Kolan River.

Land Use Most of the catchment is located in the Shires of Kolan and Gooburrum. The Kolan River forms the north-eastern boundary of the Kolan Shire and the southern boundary of Miriam Vale. Part of Kolan Shire, south of Gin Gin, is in the Burnett basin. The Gooburrum Shire, to the east, includes parts of Baffle, Kolan and Burnett basins.

Beef cattle grazing is the main activity, with usually low stocking rates on partially cleared savannah woodland. Sugarcane is grown for the Bingera and Fairymead Mills although both these mills also obtain cane from the Burnett basin. Less than 6% of the Kolan basin is cropped, largely with sugarcane.

Fertilizer Usage The changes in fertilizer usage are similar to those of the other sugarcane production areas. Over the 1960-1985 period, nitrogen usage increased from 130 tonnes to 2000 tonnes, with more rapid growth to 1976 and a slow increase over the next decade.

Due to lower sugar prices and the completion of the irrigation project from Lake Monduran, usage of nitrogen has decreased since 1985.

Rates of nitrogen on sugarcane are higher where irrigation is available (up to 200 kg N/ha) and lower on ratoon cane (110-120 kg N/ha). Overall, rates average 150 kg N/ha.

Phosphorus usage increased to 350 tonnes in 1976, from below 100 tonnes in 1960. There has been a downward trend in total usage since 1982, partially due to a replacement of small

cropping activities with sugarcane. Plant cane is usually fertilized with 30 kg P/ha, ratoon cane with 15 kg P/ha. About 15% of ratoon cane areas are not fertilized with phosphorus.

BURNETT **Basin 136**

Latitude 24°30' to 27°S **Longitude** 150°20' to 152°30'E

Area 33 150 km^2 - 3 315 000 ha
12 794 sq ml - 8 188 050 acres

Mean Annual Rainfall - 765 mm
Mean Annual Run-off - 53 mm (1 743 000 ML)

Run-off - 7% of rainfall

98% of the basin is gauged.

Description The Burnett basin is the third largest on the east coast, being less than a quarter the size of the Burdekin and Fitzroy catchments. It adjoins the Kolan and Calliope basins to the north, Fitzroy to the west, Brisbane to the south and Mary and Burrum to the east.

The basin is formed by the Burnett River (420 kilometres) in the northern half, the Auburn River (240 kilometres) and the Nogoa (120 kilometres) in the west, and the Boyne River (220 kilometres), Stuart River (160 kilometres), Barker Creek (140 kilometres) and Barambah Creek (250 kilometres) from the south. The section between Gin Gin and Bundaberg Harbour narrows from 20 kilometres to five kilometres. Here, the river banks are higher than the surrounding land in the Kolan basin to the north and the Burrum basin to the south. The main agricultural centres are Monto, Eidsvold, Mundubbera and Gayndah in the North Burnett and Nanango, Kingaroy, Murgon and Proston in the South Burnett.

Land Use This basin has a wide diversity of soil and vegetation types and of agricultural production systems. Away from the alluvial flats of the major creek and river systems, extensive grazing of spear grass is the major rural activity. Areas of brigalow occur in the north along Three Moon Creek; these have been cleared for cultivation. The krasnozem soils of the Kingaroy area are cropped to maize and peanuts. Citrus are extensively grown along the Burnett River at Mundubbera and Gayndah. Sugarcane is the major crop from Wallaville to Gin Gin and Gooburrum, over the last 100 kilometres of the river's length.

Fertilizer Usage Because of the narrowness of the basin along the lower reaches, only one-third of the 48 000 hectares of sugarcane around Bundaberg is in the Burnett basin. Considerable areas of crops and pastures are fertilized in the Upper and South Burnett, totalling 70 000 hectares in recent years.

Nitrogen usage has increased consistently from 1000 tonnes in 1961 to 5900 tonnes in 1988, with only occasional periods without market growth.

This has been due to the diversity of crops grown, increasing irrigation availability and higher rates of nitrogen application to sugarcane crops, as well as to the larger areas of crops being grown.

Phosphorus usage was closely related to nitrogen up to 1975, about half as much phosphorus being applied annually. This was largely due to the increasing use of phosphorus for pastures in

the Upper Burnett, and on maize and other crops in the South Burnett, at the time when the rate of nitrogen was increasing on sugarcane.

Phosphorus applications declined from 1976 to 1986, affected to some extent by drought and low cattle prices and by changing use of phosphorus on sugarcane. Rates of phosphorus on plant cane are usually 30 kg P/ha, as against 15 kg on ratoons, with about 85% of the ratoon cane being fertilized with phosphorus.

BURRUM **Basin 137**

Latitude 24°45' to 25°35'S **Longitude** 152°5' to 153°E

Area 3340 km^2 - 334 000 ha
1289 sq ml - 824 980 acres

Mean Annual Rainfall - 1104 mm
Mean Annual Run-off - 215 mm (718 000 ML)

Run-off - 20% of rainfall

52% of the basin is gauged.

Description This basin comprises four small river systems. The Elliott River (50 kilometres) drains cane land south of the Burnett River, entering Hervey Bay at Elliott Heads. The Gregory River (90 kilometres) flows north from the Woowoonga Range through Childers (80 kilometres) and then south-east through Goodwood, entering the Bay at Burrum Heads. The Isis River (105 kilometres) starts as Oakey Creek, near Booyal, receives Sandy Creek from the south-west of the catchment and becomes the Isis River after the entry of Agnes Vale Creek about 25 kilometres from the mouth into the estuary at Burrum Heads. The Burrum River rises in the Seaview Range in the north of the basin as the Doongul and Duckinwilla Creeks, which merge about 10 kilometres upstream of Howard at the Lenthall Dam. The Burrum River also enters the estuary with the Gregory and Isis, discharging into Hervey Bay.

Land Use Much of the coastal section of the basin is infertile, low-lying country apart from areas around Childers and Isis Central. Sugarcane is the main crop, supplying the Isis and Maryborough Mills (25 000 hectares of assigned land) in the south and Millaquin, from Elliott River cane areas, in the north. The estuary is designated as Woodgate and Burrum River National Parks.

The basin contains parts of the Shires of Woongarra, Isis, Biggenden, Woocoo and Hervey Bay (previously Burrum to 1976).

Fertilizer Usage Sugarcane in the Isis and Woongarra Shires accounts for the bulk of the fertilizer used.

In recent years, tomatoes and other vegetables have become important crops in the Bundaberg area. Some of the expansion of sugarcane production in the Elliott River catchment has been necessary to make up for the loss of cane land to residential and industrial development between Bundaberg and Bargara. The development of this poorer land has required high rates of fertilizer than used on older cane areas where fertility had been built up.

Nitrogen usage increased from 250 tonnes of nitrogen in 1960 to over 3000 tonnes in 1976, a growth rate of 17% over the 16 years. Over the 1976-1990 period, usage of nitrogen has been

3000-3400 tonnes annually, varying with sugar prices and seasonal conditions. Sugar accounts for more than 85% of the nitrogen.

Rates of application on sugarcane average 160 kg/ha on plant crops and 112 kg N/ha on ratoons.

Phosphorus usage increased to 700 tonnes in the early 1970s and declined slightly to 600 tonnes in recent years. Sugarcane crops account for 80% of the phosphorus usage, with vegetables, fruit and beef pastures using the rest.

MARY **Basin 138**

Latitude 25°35' to 26°50'S **Longitude** 152° to 153°E

Area 9595 km^2 - 959 500 ha
3708 sq ml - 2 373 150 acres

Mean Annual Rainfall - 1158 mm
Mean Annual Run-off - 241 mm (2 309 000 ML)

Run-off - 21% of rainfall

81% of the basin is gauged.

Description The Mary River (260 kilometres) flows north from the Conondale Range and Blackall Range through Gympie and Maryborough to enter the Great Sandy Strait at River Heads, south of Hervey Bay. Widgee Creek from the coastal range at Manumbar and Munna Creek from near Broowena drain the western and northern sections, entering the Mary River between Gunalda and Gundiah. Tinana Creek flows parallel to the River in the eastern section, joining the Mary at Maryborough. The estuary from Maryborough to Fraser Island is mangrove-lined, the basin narrowing to the width of the river mouth. The Susan River drains the north side of the river east of Maryborough.

Land Use The basin comprises Widgee and Tiaro Shires and parts of Caboolture, Caloundra, Maroochy, Noosa, Kilkivan, Woocoo and Hervey Bay Shires.

The bulk of the catchment is forest land, with considerable clearing for grazing, beef and dairy, closer to the river and along the major creeks. There are 10 000 hectares of cane land supplying the Maryborough sugar mill. Horticultural crops are of economic significance around Gympie; there are some grain crops in the Kilkivan area. Fodder crops and irrigated pastures for dairy cattle are widely grown.

Fertilizer Usage Nitrogen usage shows close similarity in growth to other areas where sugarcane is significant. Usage increased from 250 tonnes in 1960 to 3000 tonnes in 1981 - a 12-fold increase or 18% annually.

No change occurred over the 1980s, largely due to the increase in usage on dairy pastures compensating for slight reductions on sugarcane.

Phosphorus usage was restricted to sugarcane and fruit crops until the late 1960s. The introduction of the Dairy Pasture Subsidy Scheme in 1966, whereby the State Government provided half of the cost of pasture development, had a major impact on superphosphate use, with many new plantings receiving 50 kg P/ha. Pasture establishment expanded to beef

properties in the Mary Valley, but fertilizer use virtually ceased with the collapse of beef prices and increases in the cost of superphosphate in 1975. The overall trend in phosphorus use from 1972 to 1990 has been downwards, with total usage currently about 1000 tonnes per year.