A LAND USE STUDY TO INVESTIGATE POTENTIAL AGRICULTURAL CHEMICAL INPUTS TO MARINE ENVIRONMENTS IN THE NORTHERN GREAT BARRIER REEF REGION.

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GREAT BARRIER REEF MARINE PARK AUTHORITY

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PROJECT TITLE: "A LAND USE STUDY TO ASCERTAIN POTENTIAL AGRICULTURAL CHEMICAL INPUTS TO MARINE ENVIRONMENTS IN THE NORTHERN GREAT BARRIER REEF REGION"

INTRODUCTION

This project had as its primary aim the identification of types and quantities of agricultural chemicals which are regularly applied to terrestrial environments in north eastern Queensland and which may subsequently form inputs to marine environments. The prospects of such chemicals being implicated in Crown of Thorns Starfish outbreaks is an implicit but unstudied element of the research context, and this particular project was simply concerned with identifying both quantity, timing and spatial patterns of agricultural chemical applications.

It is clear that a detailed knowledge of all the areas likely to produce runoff to the marine environment was impossible with the resources available and discussions between the Great Barrier Reef Marine Park Authority officers and the research team established the direct focus of this project on the Baron River catchment. This particular catchment was identified as locationally significant; of sufficient size to be a major potential contributor and consisting of a remarkably diverse set of agricultural land use types. A study of land use within the Barron River catchment would reveal a significant set of information relevant to the northern region of the Great Barrier Reef.

The aim of the project was therefore more precisely defined as the quantification of agricultural chemical inputs within the Barron River catchment. Associated stream and marine environmental chemical studies would benefit from such basic knowledge through reference to timing of applications and an appreciation of the maximum magnitudes of chemicals which might be periodically released from the catchment to the marine environment.

The work of Rasmussen (1986 *et seqq.* pers. comm.) has drawn attention to the significance of phosphorous in some marine organisms and it was clear that the primary agricultural chemicals of interest were the nutrients used as fertilizers for plant crops; notably nitrogen, phosporous and potassium. Although many other agricultural chemicals are applied, the quantities are relatively small and the residual properties poorly understood in so far as marine environments are concerned.

BRIEF DESCRIPTION OF THE STUDY AREA

The area studied consists of a single major river catchment of approximately 210,000 hectares in area. Within this catchment there is a great variation in rainfall, soil types, geology, topography and vegetation - reflecting the typical diversity of the region. The Barron River follows a meandering course from its headwaters in the south of the catchment (near Mt Hypipamee National Park at an elevation of 1,100 metres) over a total distance of about 165 km, to disgorge slightly north of Cairns city.

In general terms the catchment farming land use consists of intensive grazing in the south, primarily dairying on steeply dissected country west of Malanda but with beef cattle also. Cropping of maize and peanuts occurs on the more level sections of basaltic tableland in the Atherton, Tolga area with a declining tobacco industry near Mareeba. Orchards have recently expanded throughout the catchment and there is a small area of sugar cane near the mouth of the river on the coastal plain.

Apart from the agricultural and grazing enterprises the catchment includes several sizable urban settlements (Atherton and Mareeba are the main towns), a major water reservoir (Lake Tinaroo) which was built for irrigation purposes; a hydro-electricity scheme using the Barron River flow near Kuranda and a recent pattern of land subdivision for rural retreat and other forms of closer settlement. New agricultural developments include tree crops such as Custard Apple and Macadamia, which add to the well developed Avocado, Mango and Lychee plantings. Potatoes have been grown on an increasing area and appear to have a good future outlook if export markets can be developed.

Approximately 75% of the catchment area is forested and the remaining cleared area is confined to the southern area above the Tinaroo Dam (mostly cleared), and then along the immediate vicinity of the Barron River, initially in the western part of the catchment but with a few areas cleared along the river and its tributaries as it flows east from the tableland, through the coastal ranges to the plain. Much of the uncleared land is State Forest, subject to periodic logging in the past.

It is difficult to estimate the number of farmers in the Barron River catchment as most data-bases are organized around Local Government boundaries or on other regional bases. Excluding small properties (< 10 ha) it is suspected that about 650 separately managed farming properties are involved in agricultural activities within the catchment (extrapolation from this study data).

METHODOLOGY

In May 1987 a pilot study was undertaken involving personal interviews of farmers on the Atherton Tableland in order to gain an appreciation of land use and of chemical use. The design of the questionnaire was based on a broad understanding of landuse plus discussions with officers of the Queensland Water Resources Commission and Department of Primary Industry. The Department of Mapping and Survey was at the time about to conduct a trial of REGIS (a Geographic Information System proposed for State use), and it was decided that some advantage might be gained from combining efforts. Unfortunately the major focus of the REGIS study was limited to the area above the Tinaroo Dam and eventually no significant input to the present project was possible using REGIS. It remains a clear potential however that a Geographic Information System should ideally be developed for terrestrial catchments for future land management analysis.

With the experience of the pilot survey it became apparent that the study faced two related problems. The initial idea of using a mail questionnaire was considered to be unreliable as the motivation to participate was likely to be weak. Personal interview techniques are much more able to achieve good response rates. At the time of the pilot survey some resistance was discoverd to questions about agricultural chemicals and although this had been anticipated in the questionnaire design (couched in a land use study framework) it soon became apparent that some farmers were concerned about revealing their chemical application practices.

A complication developed subsequently when a great deal of publicity followed the discovery of residual chemicals in meat exported to the USA. The effect of this was to considerably heighten awareness of the problems associated with farm chemical use and it appeared to increase the level of suspicion in some farmers when interviewed. Unfortunately the cost of obtaining on-site personal interviews is much greater then mail survey costs and as the budget was quite small it was decided to develop close ties with a new initiative of the Queensland Water Resources Commission in the prospect of mutual benefits. Although the Queensland Water Resources Commisssion was only interested in the Lake Tinaroo part of the catchment (because of concern at the prospects of eutrophication in the Lake), their assistance could help expand the number of interviews possible.

Amongst landowners in the catchment there is great heterogeneity of practices and this fact, coupled with the diversity of land use options available, meant that a high level of response would be essential if conclusions were to be extrapolated over the entire catchment. To assist in obtaining a comprehensive cover the area was divided into sub-compartments with each boundary drawn to retain a reasonable level of internal consistency. Sampling would be undertaken within each sub-compartment and all extrapolations would be made within sub-compartments only. Above the Tinaroo Dam the sub-compartments were based on sub-catchments, primarily for later study of stream water quality on a sub-catchment level. Below the dam convenient size and relative homogeneity were employed in determining boundaries. Thus several large compartments are mostly uncleared forest land.
No precise number of farms was selected for interview but rather a time budget was prepared based on the available funds. Because of the support of the QWRC in the area above the Tinaroo Dam it was possible to achieve a very high proportion of farms interviewed. As a percentage of agricultural land included in the study the compartment values ranged from 16% to 96%. A total of 401 interviewed farmers provided surveys which were usable. Figure 1 sets out the details of interview cover by compartment. (The attached land use map shows compartment boundaries.)

I.D.	TOTAL AREA	FOREST	FARM	INTERVIEWED	%
A	6400	4000	2400	2234	93
B	5710	3250	2460	1400	57
C	2500	460	2040	1878	92
D	6000	250	5750	4783	83
E	6430	1880	4550	3633	80
F	4130	90	4040	2970	74
G	2460	420	2040	1391	68
H	3200	810	2390	780	33
I	1840	140	1700	1154	68
J	3940	2800	1140	1093	96
X	7275	7275	-	-	-
TOTALS	49885	21375	28510	21316	75
DAM AREA	3375				
	53260				
K	5785	1178	4607	1211	26
L	7300	2448	4852	2840	59
M	17750	13481	4269	2924	68
N	6740	3883	2857	1539	54
O	9060	1710	7350	3600	49
P	4110	750	3360	888	26
Q	6450	-	6450	1043	16
R	21200	16610	4590	1911	42
S	5720	3224	2496	1229	49
T	7000	3400	3600	2272	63
U	14930	13010	1920	1055	55
Y	31400	31400	-	-	-
Z	20200	20200	-	-	-
TOTALS	157645	111294	46351	20512	44

Notes: the urban areas are included with forest area totals; the "farm" area includes some uncleared forest land which is within the border of the farm properties.

FIGURE 1. SURVEYED PROPERTIES BY COMPARTMENT.

A copy of the questionnaire is appended and it can be seen that the design somewhat masks the agricultural chemical details within a broader land use study. Although refusal rates were low, some questionnaires were subsequently found to be unusable and were discarded for the analysis. The results of the survey were compiled based on the raw data from the respondents. A great variety of fertilizer types are used in the area and for consistency all were converted to equivalent elemental values of the nutrients included. Figures presented throughout this report do not therefore refer to, for example, the quantity of 'superphosphate' applied or the quantity of 'urea' applied, but rather to the quantity of elemental P and S (in the case of superphosphate) and elemental N in the case of urea.

Compartment summation involved the following tasks:

(a) compilation of land use type and associated fertilizer use rates;

(b) estimation of total cleared/farmed land within the compartment, based on 1986 aerial photographs and 1:50,000 topographic sheets (1987);

(c) calculation of proportions of each land use type interviewed;

(d) extrapolation of that same proportion over the farmland within that compartment not included in the study;

(e) application of mean compartment rates of fertilizer to the extrapolated land areas within that compartment.

Applying this technique it is clear that given the consistency of land use change from south to north and east, and the relative homogeneity of each compartment, conclusions reached will be as reliable as possible from a sample study. This is particularly true of the sub-catchments above the dam where there is only one sample cover rate below 50% and half of the sub-catchments have response levels of more than 80%.

LANDUSE IN THE BARRON RIVER CATCHMENT

Although over half of the catchment is in private ownership only 24% is currently used for intensive agriculture (including beef and dairy cattle grazing on improved pastures). The remainder is forested, most of it is State Forest but considerable areas in private ownership but not yet cleared. No attempt has been made to examine such areas as the focus has been on positively identified agricultural areas. Figure 2 lists the major land use types identified from the farm surveys with the areas given based on the calculated proportions for each compartment. Separation is made for above and below dam figures as it is quite clear that the dam is a major element in the potential transfer of agricultural chemicals to the marine environment (see below).

From the figure it is clear that the most extensive agricultural land use is beef cattle grazing (45% of the agricultural land), followed by dairy cattle grazing (18%). It should be noted that virtually all dairy cattle grazing occurs above the dam whereas about 65% of the beef cattle area occurs below the dam. Maize and peanuts occupy 12% and 10% of the area respectively with other uses much less important in terms of area. Orchards cover 3% of the agricultural land; sugar 4% but virtually confined to the coast; rice and potatoes about 1% each with tobacco now diminished to 2% of the area.

An appreciation of typical practices, especially with regard to agricultural chemical applications, is essential to interpret prospective contributions to streams. The major land uses are listed below and each is briefly described. Subsequently a more detailed account of the chemicals used will be given.

	ABOVE DAM ESTIMATED TOTAL HA	%	BELOW DAM ESTIMATED TOTAL HA	%	TOTAL AREA HA
DAIRYING	9382	41	40	-	9422
BEEF	8048	35	15222	53	23270
MAIZE	3024	13	2976	10	6000
PEANUTS	1504	7	3431	12	4935
TOBACCO	-	-	1284	5	1284
ORCHARDS	412	2	1060	4	1472
POTATOES	239	1	378	1	617
SUGAR	60	.	1974	7	2034
OTHER	70	.	2053	7	2123
RICE	-	-	474	1	474
TOTAL AG.	22739	100	28892	100	51631
FORESTED	27146		128753		155899
AREA OF DAM	3375				3375
TOTALS	53260		157645		210905

FIGURE 2. MAJOR LANDUSE IN THE BARRON RIVER CATCHMENT.

(a) Beef Cattle

Practices are highly variable ranging from a few intensively run operations with significant supplemenatary feeding, through to grazing cattle on rough unimproved country. Both nitrogenous and phosphatic fertilizers are applied, especially where improved pastures and fodder crops are grown, but the average rates of application are low compared with dairy. Some topdressing with fertilizer takes place in the early part of the wet season (November to January) and sometimes also towards the end of the wet season (May).

(b) Dairy Cattle

Most of the dairy properties are in the southern, higher elevation and wetter parts of the catchment and it has long been a practice of dairy farmers to use extremely high levels of superphosphate. Pastures respond very well to both N and P fertilizers and as dairying is typically a more intensive grazing industry than beef, with much higher returns, application levels of fertilizers are high. Within the Eacham Shire the mean density per 1000 ha of dairy cattle reaches over 200 and is almost 100 in the more northern areas of the tableland but intensive property management produce much higher rates.On a grass legume pasture the DPI recommended rates are 1 cow/ha; on grass nitrogen pastures the carrying capacity is recommended at 2 1/2 cows/ha. Most properties grow patches of feed which are heavily fertilized to help maintain milk yields through the winter months. Fertilizing is likely to occur throughout the year, especially in association with rainfall. The DPI recommended rates for intensive dairy produciton are 44 kg P/ha and 62 kg K/ha. No set rate for N is recommended as it depends upon the pasture type. Average herd size is a little over 100 milking cows on a typical holding of between 100-150 ha.

(c) **Maize**

This crop is rain grown on the tableland and soil preparation and planting is closely associated with rainfall. Ideally the ground is prepared by plowing as soon as possible after harvest (September-November if the soil is suitable). Planting occurs following the first rains, ideally in December but it may be from November to February depending on the season. High levels of N & P are used, with urea used later (after planting). The Department of Primary Industry is advising farmers to practice a system of minimum tillage.

(d) **Peanuts**

Most farmers growing maize also grow peanuts which hase been a profitable crop. Cultivation timing is similar to maize but much less nitrogen is used and much greater levels of phosphorous. The relative profitablility of peanuts not only supports high levels of P fertilizer but a large use of herbicides, fungicides and insecticides.

(e) **Rice**

This crop is very recent in the catchment and only a small area is at present planted (most of the new areas of rice are outside the catchment boundary). Two crops per year are grown by irrigation using a wet ponding system. Typically planting occurs in May-June and again in December-January. Very high levels of N are used.

(f) **Potatoes**

Despite its small present area this crop may become very important in the future. Soil conditions on the tableland suits potatoes very well and the outlook is for an expansion of area. This is the greatest utilizer of chemicals with N, P & K levels extremely high.

(g) Tobacco

Although of primary importance in the establishment of the Mareeba-Dimbulah irrigation scheme, based on water from Tinaroo Dam, tobacco has recently declined markedly within the catchment area. Many farmers have sold their quotas to properties outside the catchment and now grow other crops. Regionally, in the last decade the number of growers has declined from 603 to 338. Tobacco is planted around April-May and uses relatively high levels of N, P & K.

(h) Orchards

Moderate levels of N, P & K are applied to most orchard crops in the area, especially in January-February but also on other occasions. Recent expansions have occured in avocados, lychees, mangoes and also custard apples and macadamias.

AGRICULTURAL CHEMICAL USE

The details for chemical use are derived entirely from the farm interviews and are presented in two different ways. Initially a summary of total use of fertilizer by each major land use class is presented. This is based on the mean value for each class and totals take account of those properties which did not use fertilizer. Subsequently the discrete compartment values are presented. These totals will be useful in examining stream concentrations in runoff water for sub-catchments, especially those areas above the dam.

(a) Above the Dam

As can be seen from Figure 3, the total quantities of fertilizer applied each year are impressive, amounting in the case of nitrogen to over 910 tonnes within the catchment above the dam. Dairying occupies 41% of this catchment (above dam) but contributes 52% of the N, 46% of P and 59% of K.

	N	P	K	S	
ORCHARD	16545	4898	5667	1938	kg
412 ha	*40*	*12*	*13.8*	*12.7*	*kg/ha*
DAIRY	475348	111738	146267	90643	kg
9382 ha	*51*	*12*	*15.6*	*9.7*	*kg/ha*
BEEF	82918	47616	47572	56261	kg
8048 ha	*10.3*	*5.9*	*5.9*	*7.0*	*kg/ha*
MAIZE	230631	41092	7152	23381	kg
3024 ha	*86.2*	*13.6*	*2.4*	*7.7*	*kg/ha*
POTATOES	35947	27256	22229	53568	kg
238.5 ha	*151*	*114.3*	*93.2*	*224.6*	*kg/ha*
PEANUTS	15116	5570	2297	7073	kg
1504 ha	*10*	*3.7*	*1.5*	*4.7*	*kg/ha*
SUGAR etc	24330	7094	16130	10643	kg
130 ha	*187*	*54.5*	*124*	*82*	*kg/ha*

TOTALS FOR ABOVE DAM :

N = 910835 KG / YR
P = 245264 KG / YR
K = 247314 KG / YR
S = 243507 KG / YR

FIGURE 3. ELEMENTAL NUTRIENTS APPLIED ABOVE THE DAM.

Although potatoes occupy only 1% of the land area they contribute 4% of N and an astonishing 11% of P. There is a clear implication here from the potential for expansion of potatoes. Maize occupies 13% of the agricultural land area above the dam but contributes 29% of N and 17% of P.

(b) Below the Dam

Figure 4 lists the elemental nutrient contributions from fertilizers applied to each major landuse for the area below the Tinaroo Dam. Maize occupies 10% of the agricultural land but contributes 23% of N and 22% of P. Sugar, with 7% of the land has 26% of N and 11% of P while tobacco on only 5% of the land contributes 15% of N, 14% of P and a massive 52% of K. As was the case above the dam, potatoes are a major user of chemical fertilizers with around 1% of the area contributing 5% N, 10% P and 7% K.

(c) Total Catchment Figures

		ABOVE DAM	BELOW DAM
N	2,056,057 kg/year	44%	56%
P	734,497 kg/year	33%	67%
K	971,708 kg/year	25%	75%
S	665,636 kg/year	37%	63%
AGRIC. LAND	51,631 ha	44%	56%

Within the total catchment the strong contribution of maize to the total N figure stands out (12% of area, 25% of N). Similarly potatoes occupy a mere 1% of the total catchment but contribute 15% of P. Thus an increase from the present 617 ha of potatoes to an area of perhaps 2000 ha would have a major effect on phosphorous contributions.

	N	P	K	S	
ORCHARD	76692	14466	62334	45869	kg
1060 ha	72.4	13.6	58.8	43.3	kg/ha
PEANUTS	30467	92182	4439	83763	kg
3431 ha	8.9	26.9	1.3	24.4	kg/ha
MAIZE	263321	105324	1287	39130	kg
2976 ha	88.5	35.4	0.4	13.1	kg/ha
BEEF	94023	64644	8357	64656	kg
15222 ha	6.2	4.2	0.5	4.2	kg/ha
POTATOES	55778	46720	47341	68549	kg
378 ha	147.6	123.6	125.2	181	kg/ha
RICE	86150	13310	2519	13325	kg
474	181.8	28	5.3	28	kg/ha
TOBACCO	167461	68863	373112	41525	kg
1284 ha	130.4	53.6	290	32.3	kg/ha
FEED	38806	17917	598	20064	kg
1648	23.5	10.8	.36	12.2	kg/ha
SUGAR	292525	55736	213987	36164	kg
1974	148	28.2	108.4	18.32	kg/ha
OTHER	39999	10071	10420	9084	kg
445	89.8	22.6	23.4	20.4	kg/ha

TOTALS FOR BELOW DAM :
N = 1145222 KG/YR
P = 489233 KG/YR
K = 724394 KG/YR
S = 422129 KG/YR

FIGURE 4. ELEMENTAL NUTRIENTS APPLIED BELOW THE DAM.

NON-FERTILIZER CHEMICALS

The interviews attempted to identify other agricultural chemicals used in the Barron catchment, particularly biocides. Despite some problems of interpretation over the farmers' names for products and the list of registered chemicals a very large list of products was accumulated. A total of 115 products are given in Table I, together with the active constituent, company name and the purpose of the product. The Table helps illustrate the very wide variety of agricultural chemicals which are added to the Barron River catchment. Most are normally used in minute quantities compared with fertilizers and many have limited residual lives in soil.

Very few generalizations can be made. Typically peanuts are grown with much use of fungicides, herbicides and insecticides. The fungicide Bravo (chlorothalonil) is applied every 10-14 days during the growing season by most peanut farmers. With minimum tillage larger numbers of herbicides are also used (especially Fusilade and Dual which are post-emergent sprays). Maize involves less use of biocides and the grazing activities only very minor use. Orchards use a greater variety but the area involved is small. Given the great variety and complexity of biocides applied a more detailed analysis is beyond the scope of this report.

TABLE 1 NON-FERTILIZER AGRICULTURAL CHEMICALS APPLIED IN THE BARRON RIVER CATCHMENT, IDENTIFIED FROM FARM SURVEY.

TRADE NAME	ACTIVE CONSTITUENT	COMPANY	PURPOSE
2,4,5-T BUTYL 40	2,4,5-T, BUTYL	ACL	HERBICIDE
2,4,5-T BUTYL 80	2,4,5-T, BUTYL	ACL	HERBICIDE
AFUGAN	PYRAZOPHOS	HOECHST	FUNGICIDE
AGRAL 600	NON-IONIC WETTER	ICI	WETTING AGENT
ALIETTE	FOSETYL-AL	M&B	FUNGICIDE
AMBUSH	PERMETHRIN	ICI	INSECTICIDE
AMICIDE 50	2,4-D,AMINE	NUFARM	WEEDKILLER
AMICIDE LO-500	2,4-D,AMINE	NUFARM	WEEDKILLER
AMINE 50	2,4-D,AMINE	BARMAC	WEEDKILLER
APOLLO SC	CLOFENTEZINE	SCHERING	MITICIDE
ATRAZINE 80	ATRAZINE	ACL	HERBICIDE
AZODRIN 400	MONOCROTOPHOS	SHELL	INSECTICIDE
BARRICADE S	CHLORFENVINPHOS	SHELL	CATTLE DIP
BASAGRAN	BENTAZONE	BASF	HERBICIDE
BAYCOR 250	BITERTANOL	BAYER	FUNGICIDE
BAYCOR 300	BITERTANOL	BAYER	FUNGICIDE
BAYTICOL	FLUMETHRIN	BAYER	TICKICIDE
BENLATE	BENOMYL	DU PONT	FUNGICIDE
BLAZER	ACIFLUORFEN	R&H	HERBICIDE
BRAVO	CHLOROTHALONIL	AG CHEM	FUNGICIDE
BRUSHKILLER 40	2,4,5-T, BUTYL 2,4-D,ETHYL ESTER	NUFARM	HERBICIDE
BUGMASTER	CARBARYL	YATES	INSECTICIDE
BUTICIDE 2,4D-B	2,4-DB	NUFARM	HERBICIDE
CARBARYL	CARBARYL	CHEMSPRAY	INSECTICIDE
CARBARYL	CARBARYL	KENDON	INSECTICIDE
COPPER OXYCHLORIDE	COPPER AS OXYCHLOR	GF	FUNGICIDE
COPPER OXYCHLORIDE	COPPER AS OXYCHLOR	TERRA	FUNGICIDE
D-500	2,4-D,AMINE	FARMCO	WEEDKILLER
D-C-TRON	PETROLEUM OIL	AMPOL	SPRAY OIL
DIMETHOATE	DIMETHOATE	NUFARM	INSECTICIDE
DIMETHOATE 40	DIMETHOATE	ACL	INSECTICIDE
DIHOSEB-400	DIHOSEB	CFL	HERBICIDE
DIPTEREX	TRICHLORFON	BAYER	INSECTICIDE
DITHANE M-45	MANCOZEB	ACL	FUNGICIDE
DITHANE M-45	MANCOZEB	AG CHEM	FUNGICIDE
DIURON	DIURON	BAYER	HERBICIDE
DIURON 500 F	DIURON	HOECHST	HERBICIDE
DP 600	DICHLORPROP	FARMCO	HERBICIDE
DUAL	METOLACHLOR	CIBA-GEIGY	HERBICIDE
EDB 15	EDB	CHEM-AIR	SOIL FUMIGANT
EDB 193%	EDB	CFL	NEMATICIDE
ENDOSULFAN	ENDOSULFAN	ACL	INSECTICIDE
EDOSULFAN 240 ULV	ENDOSULFAN	CFL	INSECTICIDE
EPTAM	EPTC	STAUFFER	HERBICIDE
FURADAH 10G	CARBOFURAN	FMC	NEMATICIDE
FUSILADE	FLUAZIFOP-BUTYL	ICI	HERBICIDE
FUSILADE 212	FLUAZIFOP-P,BUTYL	ICI	HERBICIDE
GOAL	OXYFLUORFEN	R&H	HERBICIDE
GRAMOXONE	PARAQUAT	ICI	HERBICIDE
GRAMOXONE W	PARAQUAT	ICI	HERBICIDE
GRAZON	TRICLOPYR,BUTOXY PICLORAM,AMINE	DOW	HERBICIDE
GUSATHION A	AZINPHOS-ETHYL	BAYER	INSECTICIDE
KELTHANE	DICOFOL	HORTICO	MITICIDE
KELTHANE EC	DICOFOL	ACL	MITICIDE
KOCIDE	COPPER AS HYDROXID	SHELL	FUNGICIDE
KOCIDE MULTICROP	COPPER AS HYDROXID	BELL-BOOTH	FUNGICIDE

LANNATE L	METHOMYL	DU PONT	INSECTICIDE
LANNATE LV	METHOMYL	CFL	INSECTICIDE
LARVIN 375	THIODICARB	UNION CARB	INSECTICIDE
LEBAYCID	FENTHION	BAYER	INSECTICIDE
LEGUMEX	2,4-DB	ACL	HERBICIDE
LORSBAN 25W	CHLORPYRIFOS	DOW	INSECTICIDE
LORSBAN 50 EC	CHLORPYRIFOS	DOW	INSECTICIDE
LORSBAN 50 ULV	CHLORPYRIFOS	DOW	INSECTICIDE
MAFU 500	DICHLORVOS	BAYER	INSECTICIDE
MALDISON 25 WP	MALDISON	ACL	INSECTICIDE
MALDISON 25%	MALDISON	MIDLAND	INSECTICIDE
MONITOR 580	METHAMIDOPHOS	SCHERING	INSECTICIDE
NEMACUR	FENAMIPHOS	BAYER	NEMATICIDE
NEMACUR 10G	FENAMIPHOS	BAYER	NEMATICIDE
NITOFOL	METHAMIDOPHOS	BAYER	INSECTICIDE
NU-TRAZINE	ATRAZINE	NUFARM	HERBICIDE
NUDRIN	METHOMYL	SHELL	INSECTICIDE
NUDRIN 225	METHOMYL	SHELL	INSECTICIDE
NUVACRON 400	MONOCROTOPHOS	CIBA-GEIGY	INSECTICIDE
ORTHENE 750 SP	ACEPHATE	SCHERING	INSECTICIDE
ORTHENE 800	ACEPHATE	SCHERING	INSECTICIDE
PERFEKTHION EC40	DIMETHOATE	BASF	INSECTICIDE
PLANTVAX 750W	OXYCARBOXIN	ICI	FUNGICIDE
PRIMATOL Z	AMETRYN	CIBA-GEIGY	HERBICIDE
PROPANIL	PROPANIL	FARMCO	HERBICIDE
PROTEIN INSECT LURE	PROTEIN	MAURI	INSECT LURE
RIDOMIL 250 EC	METALAXYL	CIBA-GEIGY	FUNGICIDE
RIDOMIL 250 WP	METALAXYL	CIBA-GEIGY	FUNGICIDE
RIDOMIL MZ WP	MANCOZEB METALAXYL	CIBA-GEIGY	FUNGICIDE
ROGOR	DIMETHOATE	CHEMSPRAY	INSECTICIDE
ROGOR	DIMETHOATE	HORTICO	INSECTICIDE
ROGOR 100	DIMETHOATE	RETEC	INSECTICIDE
ROUNDUP CT	GLYPHOSATE	MONSANTO	HERBICIDE
ROUNDUP HERBICIDE	GLYPHOSATE	MONSANTO	HERBICIDE
SENCOR 700	METRIBUZIN	BAYER	HERBICIDE
SENCOR T	METHABENZTHIAZURON	BAYER	HERBICIDE
SERTIN 186EC	SETHOXYDIM	SCHERING	HERBICIDE
SHIRTAN 120	MERCURY AS METHOXY	CFL	FUNGICIDE
SHIRWEED 50	2,4-D,AMINE	CFL	WEEDKILLER
SHIRWEED 50	2,4-D,AMINE	RETEC	WEEDKILLER
SPRAY,SEED	PARAQUAT DIQUAT	ICI	HERBICIDE
SULPHUR SPRAY	SULPHUR,DISPERS	RETEC	FUNGICIDE
SUMICIDIN ULV CSO	FENVALERATE	SHELL	INSECTICIDE
SUPRACIDE 400	METHIDATHION	CIBA-GEIGY	INSECTICIDE
SUSCON BLUE	CHLORPYRIFOS	CFL	INSECTICIDE
THIODAN	ENDOSULFAN	CHEMSPRAY	INSECTICIDE
THIODAN	ENDOSULFAN	HOECHST	INSECTICIDE
TILT 250EC	PROPICONAZOLE	CIBA-GEIGY	FUNGICIDE
TORDON 1040	2,4,5-T, ISO-OCTYL PICLORAM	DOW	HERBICIDE
TORDON 50-D	2,4-D,AMINE PICLORAM,AMINE	DOW	HERBICIDE
TREFLAN	TRIFLURALIN	NUFARM	HERBICIDE
TRIFORINE	TRIFORINE	KENDON	FUNGICIDE
TRYQUAT	PARAQUAT DIQUAT	ICI	HERBICIDE
USTILAN	ETHIDIMURON	BAYER	HERBICIDE
USTILAN 150	ETHIDIMURON	BAYER	HERBICIDE
VERNAM	VERNOLATE	STAUFFER	HERBICIDE
WETTABLE SULPHUR	SULPHUR,DISPERS	FRANK KING	FUNGICIDE
WHITE OIL	PETROLEUM OIL	BP	INSECTICIDE
WHITE OIL	PETROLEUM OIL	CHEM-AIR	INSECTICIDE

HISTORICAL PATTERN OF FERTILIZER USE

Data on historical use levels are unavailable for the catchment, however there is a good record from the Australian Bureau of Statistics local authority based data. Atherton Shire figures provide a good indication of the change in fertilizer use with time. Due to incomplete records it is not possible to separate phosphorous and nitrogen, but there is some evidence that both fertilizers were involved in the dramatic increase of the 1960-1974 period as shown in Figure 5. Levels of use were relatively constant and very low throughout the 1950-1960 decade, reaching just 144 tonnes in 1960. From that time a sharp increase occurred achieving 889 tonnes by 1966 and over 2000 tonnes in 1970 rising to over 3000 tonnes in 1973 and 1974. Subsequently a more erratic pattern remains consistently between 2000 and 3000 tonnes annual application. Despite the coarseness of such data (raw fertilizer rather than elemental values, shire rather than catchment based), the pattern of dramatic increase which emerges is consistant with changing land use practices. Current levels of use are not in conflict with the order of magnitude of elemental nutrients reported from this study.

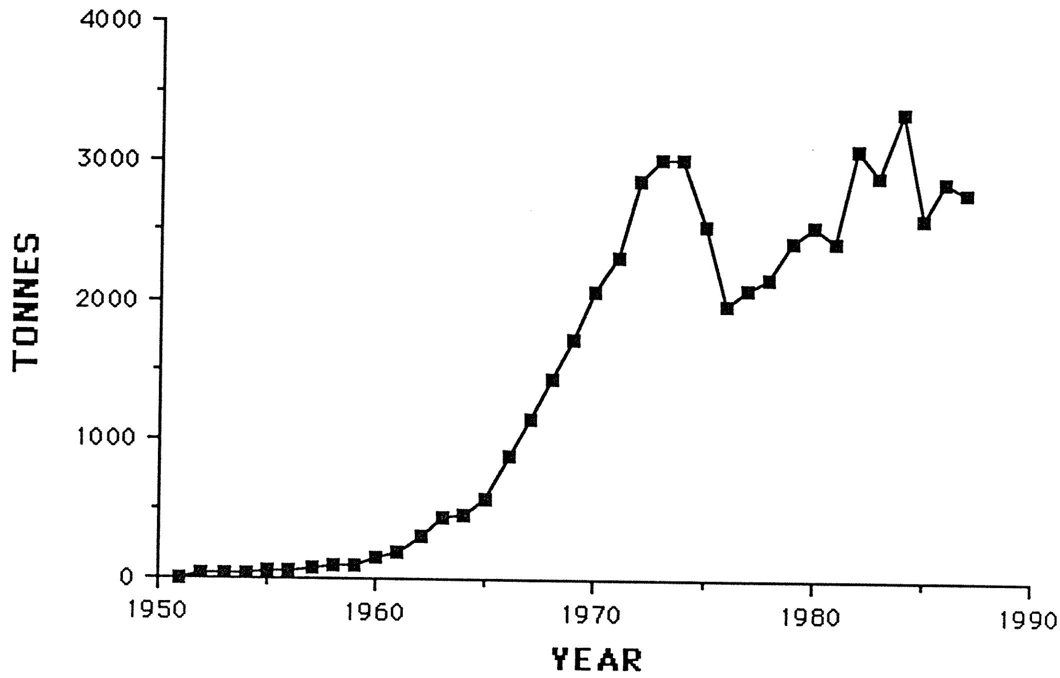


FIGURE 5. ANNUAL FERTILIZER USE IN ATHERTON SHIRE.
(based on ABS data : totals of all types)

POTENTIAL TRANSPORT OF AGRICULTURAL CHEMICALS INTO THE MARINE ENVIRONMENT

Of ultimate interest to the Authority is the potential for the agricultural chemicals applied each year in the catchment to end up in the marine environment. There can be little doubt that some proportion of the added fertilizer does enter the Barron River and reach the sea but to date no clear estimate is available. An illustration of the quantities which may be involved (perhaps a minimum rather than anything else) can be gleaned from a rough estimate compiled from monthly water quality analysis by the Queensland Water Resources Commission. Despite the questionable validity of such a approach (see below) the calculation of mean concentration of NO_3 and its application to mean annual outflow (below the dam) leads to an estimated export of 90 tonnes N per annum - about 10% of the estimated application of N to the catchment above the dam (export estimate from Grant Sadler, QWRC).

The difficulty in using existing stream water quality results arises from the likely existence of distinct pulses of nutrients within the catchment hydrology. The timing of most fertilizer applications either coincides with or immediately follows the major early rainfalls of the wet season (November to February). This combination is likely to produce brief periods of quickflow in which a high volume of nutrients may be transported in suspension or solution. Phosphorous is an element which is known to be transported primarily during runoff events and in particulate form associated with clay or organic material (Cullen, 1987). Given these circumstances also apply in the Barron River catchment, an unstudied but reasonable assumption, the magnitude of phosphorous transported to the marine environment in streams will be poorly measured by periodic fixed interval sampling. Such results will give a 'base flow' value for phosphorous export which may seriously under-estimate the real value. Sampling programs should therefore be designed around major runoff events and periods of intensive study may need to be interspersed with more regular sampling. It should also be clear that careful streamflow values (using appropriate gauging stations) will need to be matched with appropriate sub-catchments.

To date very little work has been undertaken which might shed light on the Barron catchment behaviour however an investigation of the crucial elements is now underway (program with which the writer is involved). Stream gauging station and water quality sampling have now been established for the Barron River above the dam by the Queensland Water Resources Commission and the results of these studies will be available to the Great Barrier Reef Marine Park Authority.

During February 1988 the PO_4 and NO_3 concentrations in one tributary of the Barron (Mazlin Creek) was closely monitored following a storm of 150 mm. At the early stage of the storm runoff concentrations increased, than rapidly declined to be followed within a few days by an increase (in the case of NO_3 quite dramatic). In this example the concentration of nutrients alone tells us nothing about the timing of maximum nutrient transport, which may occur near the base of the concentration curve. The absence of streamflow values leaves that issue uncertain. It is anticipated that the 1988/89 wet season will provide a much clearer picture of catchment nutrient transport, at least above the Tinaroo Dam.

THE ROLE OF TINAROO DAM

The Barron River catchment has a complex hydrological system due primarily to the intervention of Tinaroo Dam. While agricultural chemicals applied to farms above the dam account for almost half of the total catchment application, the presence of the dam provides a potential short and long term storage for nutrients and an opportunity to accumulate very high quantities of some chemicals. Constructed over the period 1953-1958 the storage first filled in 1963 (capacity 407,000 megalitres). It is designed to yield 205,000 megalitres annually for irrigation and 72,000 megalitres annually for power generation.

Occasional water quality samples in the Lake, and the appearance of macrophytes led to a concern by Queensland Water Resources Commission that the lake may become entrophic. In 1987 a Technical Advisory Committee was established and a program of study commenced which might help identify any need for such concern. The present study has both assisted and been assisted by the efforts of this program.

By early 1988 the results of more intensive water quality analyses were indicating very high levels of N and P in the lake waters with evidence of some bottom concentration of P. Algal biomass level was high and an active surface phytoplankton population was inferred. To date no details of phosphorous concentrations in bottom sediments are available but it would be expected that there is some storage of P in this form.

In general the dynamics of the Tinaroo Dam - Barron River system might be expected to include significant periodic release of P from temporary storage in bottom sediments and within biotic components. Surface water concentrations of PO4 were depressed in January, February and March 1988 due to algal growth indicating the need for total P (and total N) measurements to correctly monitor nutrient load. Without these, and sediment analysis, the potential for periodic pulse release remains unquantified. Despite this it can be inferred from studies elsewhere (Cullen, 1987) that such a pattern is likely. The likely frequency of major pulses is a topic for further analysis and the prospect of significant release of phosphorous from bottom sediments coinciding with a spillover from the dam to the downstream river could provide sufficient quantities of P to effect marine concentrations. This possibility is beyond the scope of the present report but should be given careful attention for future research.

CONCLUSIONS

This study has carefully and accurately identified the major agricultural chemicals applied within the Barron River catchment for the study year 1986/87. Both the types of fertilizers and the timing of applications have been investigated using personal interviews from 401 farmers within the catchment. An annual amount of 2,056 tonnes of elemental N, 734 tonnes of P and 971 tonnes of K was applied to the catchment in the 1986/87 season. With regard to phosphorous the major contributing land use above the dam was dairying followed by beef and maize. Below the dam maize and peanuts provided most of the P, followed by tobacco, beef and sugar. The prospects for significant increase of P application in the future were linked to a potential expansion in potatoes, the crop with the greatest application rate for P. Nitrogen addition to the catchment also come mainly from dairying above the dam, followed by maize. Below the dam sugar, maize and tobacco apply most of the nitrogenenous fertilizers. While the application levels above and below the dam were similar with regard to nitrogen (Figures 3 and 4) almost twice as much P (489 tonnes) is applied below the dam as above, while three times as much K is applied below the dam as above. The major users of K fertilizers are tobacco and sugar with potatoes also applying high levels per hectare.

Historical data from annual ABS surveys show a dramatic increase in the use of fertilizers within the Atherton Shire (part of the catchment) beginning in the decade of the 1960s and peaking in 1974 (Figure 5). Controlled releases mean some water flows down the Barron River from the Dam each year but overflow conditions are irregular. The first occurred in 1963 and subsequently in both 1964 and 1965 followed by a long break to 1971, 1972, 1974 (large overflow), 1976, 1977, 1979 and 1981. Since 1981 no overflow has occurred. It is unclear what such an historical pattern of dramatically increasing fertilizer use and infrequent spillover flows might mean in terms of occasional large pulses of nutrients. This subject might be explored more fully by a detailed study of catchment hydrology. If a figure of 10% of applied nutrients is exported from the catchment at infrequent intervals the resultant quantities might be highly significant in downstream marine receiving waters.

RECOMMENDATIONS

The Authority may wish to further explore the potential for terrestrial inputs into marine ecosystems and the following recommendations should be considered:

(a) The Authority might support the continued efforts of the Tinaroo Dam Technical Advisory Committee and associated research involving the Department of Geography at James Cook University, the Department of Ecosystem Management at University of New England and the Queensland Water Resources Commission. This work will develop a much clearer understanding of the runoff process and will eventually produce a nutrient budget for the dam.

(b) The Authority might fund a short-term concentrated effort to monitor early wet season dynamics in the Barron River so that a much more accurate estimate of nutrient load could be made.

(c) A desktop study of all major terrestrial catchments adjacent to the reef region might be undertaken using ABS data and an attempt to identify any patterns in the fertilizer use data which may relate to known COTS dynamics. Such a study may reveal additional areas for more detailed analysis.

ACKNOWLEDGEMENTS

The writer acknowledges the valuable assistance to this project from the Queensland Water Resources Commission, especially the Regional Engineer at Mareeba, Mr Bill Souter, and his Assistant Engineer Mr Grant Sadler. In addition useful practical advice on farming practices were willingly provided by officers of the Queensland Department of Primary Industry, especially Mr John Fitzpatrick of Atherton and Mr Mark Lavers of Malanda. The other members of the Tinaroo Dam Technical Advisory Committee also shared their expertise and experience in an unstinting fashion. Primary thanks must go to the more tham 400 farmers who participated in the study - without their voluntary assistance the details would have been impossible to collect. Pilot survey work was undertaken by third-year students at James Cook University Geography Department and the final surveys conducted by staff of the Queensland Water Resources Commission for most of the farms above the dam and by Research Assistants Chris Fisher, Hans Guttman and Steve Raaymakers for the areas below the dam. In addition Chris Fisher undertook much of the compilation of the data from the surveys. To all of these people thanks are due.

REFERENCE

Cullen, P., 1987 ***Phosphorous exports from Rural Lands.*** AWRC Research Project Completion Report, Dept of Resources and Energy, 25 pp.

JAMES COOK UNIVERSITY OF NORTH QUEENSLAND

DEPARTMENT OF GEOGRAPHY

BARRON RIVER CATCHMENT LAND USE STUDY - 1987

NAME OF PROPERTY AND/OR FARMER: ____________________

EXACT LOCATION OF PROPERTY: ____________________

GRID REFERENCE ON 1:100 000 TOPOGRAPHIC MAP: ____________________

NAME OF INTERVIEWER: ____________________

DATE: ______ TIME INTERVIEW STARTS: ______ TIME FINISHED: ______

INTRODUCTION: I am from the Geography Department at James Cook University and we are studying land use in the Barron River catchment. Would you be willing to assist us by answering our short questionnaire concerning land use on your property?

IF REFUSAL: RECORD WHY: ____________________

CALL BACK ANOTHER TIME?: ____________________

FIRST SOME QUESTIONS ABOUT THIS PROPERTY.

1 WHAT IS THE AREA OF YOUR PROPERTY? ____________________
(CHECK - IS ANSWER ACRES OR HECTARES)

2 IS ALL OF YOUR PROPERTY DEVELOPED? YES/NO
IF NO WHAT PERCENTAGE IS UNCLEARED LAND ______ % ______

(OR AREA : ha/acres)

3 a) PLEASE DESCRIBE THE MAJOR LAND USES ON YOUR PROPERTY:
(use show card)

LAND USE		INDICATE (hectares or acres) AREA
PASTURE FOR GRAZING:	DAIRY?	______
	BEEF?	______
CROPS FOR STOCKFEED: What types?	OATS	______
	COWPEAS	______
	DOLICHOS LABLAB	______
	LUCERNE	______
Other? ______		______

ACRICULTURAL CROPS: MAIZE ______

SORGHUM ______

PEANUTS ______

SOYBEANS ______

TOBACCO ______

POTATOES ______

OTHER VEGETABLES ______

TREE CROPS: TYPE ______ ______

(Fruit etc) ______ ______

SUGAR CANE - FOR COASTAL FARMS ______

3 b) If your property is grazing, about how many animals do you graze on average?

______

4 WE ARE INTERESTED IN YOUR USE OF FERTILIZER. PLEASE INDICATE THE TYPE OF FERTILIZER, THE AMOUNT APPLIED PER HECTARE/ACRE AND THE TIME OF APPLICATION (Month)

LAND USE TYPE	FERTILIZER USED	AMOUNT APPLIED	TIME APPLIED

5 a) WE ARE ALSO INTERESTED IN YOUR USE OF WEEDICIDES AND INSECTICIDES. PLEASE INDICATE THE TYPE OF CHEMICAL USED (NAME) AND THE QUANTITY USED, AND TIME APPLIED.

AREA SPRAYED	TYPE OF CHEMICAL USED	AMOUNT USED (TOTAL)	TIME APPLIED (Month)

b) DO YOU USE AERIAL SPRAYING? YES/NO

IF YES, APPROXIMATELY WHAT AREA EACH YEAR ____________________

6 DO YOU USE IRRIGATION ON YOUR PROPERTY? YES/NO

IF YES, WHAT AREA? ____________________

7 DOES YOUR FARM HAVE ANY EROSION PROBLEMS? YES/NO

IF YES, (a) WHAT PERCENTAGE OF YOUR FARM IS AFFECTED? __________

(b) HOW BAD IS THE PROBLEM?

Major problem Minor problem No problem

8 a) WITH REGARD TO FUTURE LAND USE ON YOUR PROPERTY, DO YOU EXPECT IT WILL STAY MUCH THE SAME AS AT PRESENT OR DO YOU THINK IT WILL CHANGE?

Same/Change

b) IF YOU EXPECT FUTURE LAND USE TO CHANGE, WHAT DO YOU THINK WILL CHANGE?

LESS OF ______________________________

MORE OF ______________________________

NEW LAND USE TYPE ______________________________

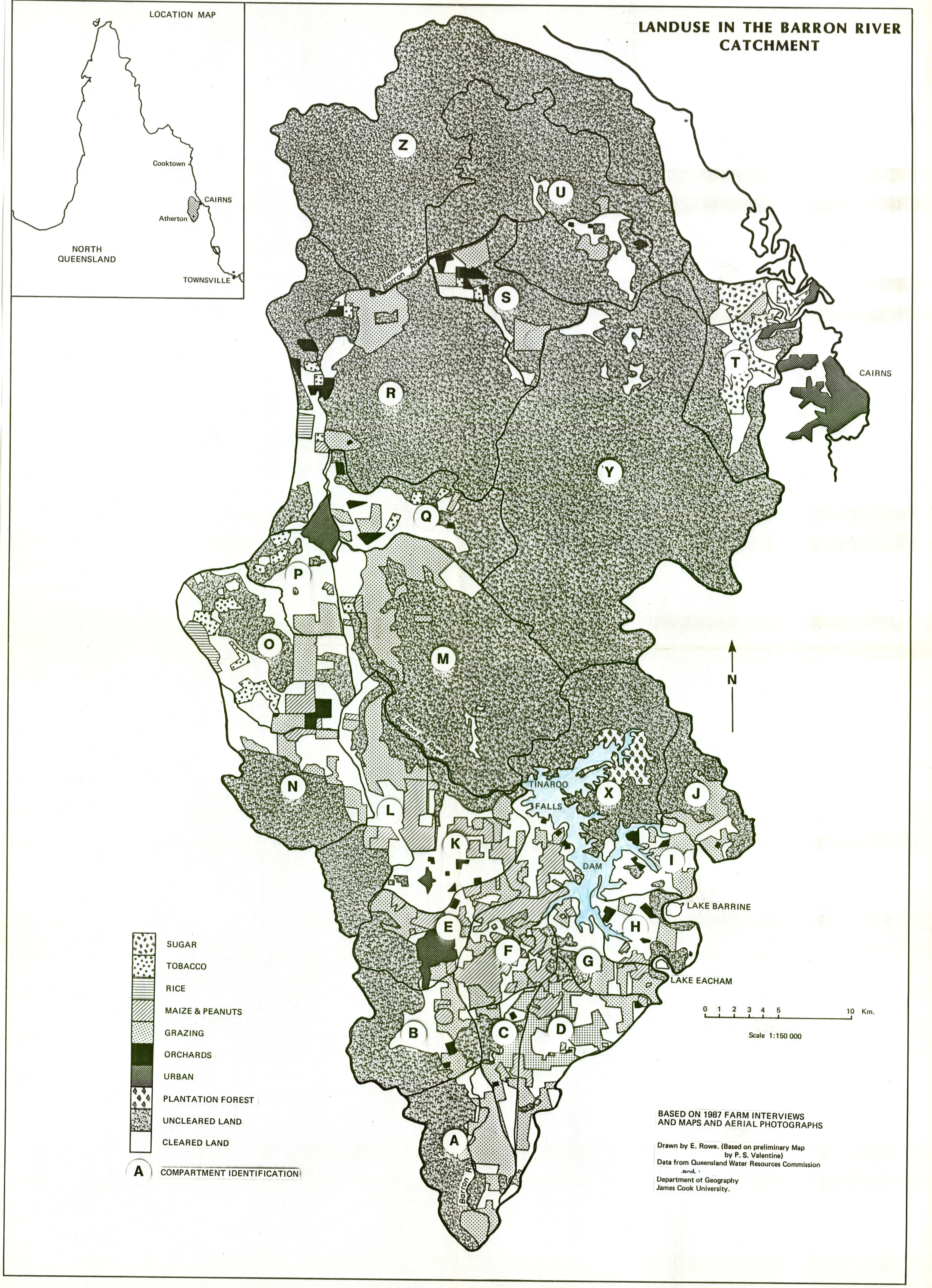
9 WHAT DO YOU BELIEVE IS THE MAJOR PROBLEM FACED BY PROPERTY OWNERS IN YOUR AREA?

____

____

____

THANK YOU VERY MUCH FOR YOUR COOPERATION. WE APPRECIATE YOUR ASSISTANCE


LANDUSE IN THE BARRON RIVER CATCHMENT
LOCATION MAP
Cooktown
CAIRNS
Atherton
NORTH QUEENSLAND
TOWNSVILLE
Barron River
CAIRNS
Z
U
S
R
T
Y
Q
P
O
M
N
L
K
TINAROO FALLS DAM
X
J
I
LAKE BARRINE
H
E
F
G
LAKE EACHAM
B
C
D
A
N
0 1 2 3 4 5 10 Km.
Scale 1:150 000
SUGAR
TOBACCO
RICE
MAIZE & PEANUTS
GRAZING
ORCHARDS
URBAN
PLANTATION FOREST
UNCLEARED LAND
CLEARED LAND
COMPARTMENT IDENTIFICATION
BASED ON 1987 FARM INTERVIEWS AND MAPS AND AERIAL PHOTOGRAPHS
Drawn by E. Rowe. (Based on preliminary Map by P. S. Valentine)
Data from Queensland Water Resources Commission and
Department of Geography James Cook University.