Tropical Grassland Society of Australia Inc.

2006 Presidential Address
The changing face of forage systems for subtropical dairying in Australia

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The revolution in tropical pasture development in the subtropics of Australia commenced with the establishment of the CSIRO Division of Tropical Pastures (DTP) headed by Jack Griffiths Davies in the early 1950s and the expansion of pasture groups in the Queensland Department of Primary Industries' (QDPI) Agriculture Branch, lead by Stan Marriot, Ross Humphreys and Joe Ebersohn, with a similar group being formed in northern NSW by the NSW Department of Agriculture. At the height of this thrust, DTP had 57 scientists involved in pasture research (Eyles *et al.* 1985) and QDPI had 100 scientists and technicians working throughout Queensland from the Atherton Tablelands in the north-east to Charleville in the south-west (Anon. 1974). While only a few of these were working solely on dairy pastures, the dairy industry gained significant value from the overall pasture research thrust. This scenario is in stark contrast to the current situation, where the Department of Primary Industries and Fisheries (DPI&F) has 2 scientists and 1 technician working on tropical and subtropical dairy pastures and CSIRO has none. The number of scientists conducting pasture research in the beef and sheep industries in Queensland is considerably fewer than 10.

In the 1950s, many small dairy farms were scattered throughout both the higher and lower rainfall regions of eastern Queensland. In 1967, there were still around 5000 dairy farms in Queensland, but the industry has continued to contract, with fewer than 800 farms in 2006 (Figure 1). Despite this dramatic fall in numbers, milk production in Queensland continued to increase until the effects of the deregulation of the dairy industry in Australia reversed this trend. Many factors have contributed to the increase in efficiency of dairy production, with improved animal nutrition, better animal genetics, better managerial skills of the farmers, increased fertiliser usage, increased availability of irrigation and the contraction of the industry to better-watered regions being some of the primary reasons. The Queensland Dairy Accounting Scheme (QDAS) has played a key role during the past 30 years. Within this programme, the Dairy Group in DPI&F collects physical and financial statistics from a selection of Queensland's dairy farmers, who have agreed to cooperate. These figures provide a benchmark to allow farmers to compare their performance with that of their peers in their region, other regions and the overall state. The results of this benchmarking strongly support the importance of home-grown forage in controlling farm profitability (Busby *et al.* 2004). Therefore, in this presentation, I intend focusing on the changes in the forage systems over the last 50–60 years.

Originally, dairy farmers relied on native grasses, which invaded those areas cleared of scrub or forest. This situation changed with the introduction and sowing of exotic pasture species from overseas. A detailed description of the early introduction of subtropical grasses and legumes is provided by Eyles *et al.* (1985). The introduction of paspalum (*Paspalum dilatatum*), kikuyu (*Pennisetum clandestinum*) and rhodes grass (*Chloris gayana*) had a profound effect on forage production on early dairy farms, and they are still the most important grasses for warm season production today (Anon. 1994). Many of the pioneering dairy farmers introduced small areas of these grasses on to their farms after being given small amounts of seed or cuttings by our early pasture research scientists (Lake 1984; Eyles *et al.* 1985).

Dairy farms were generally small, with areas ranging upwards from 12 hectares; many were on poor, sloping soils with only small patches of arable land. In 1914, the average herd size was 20 cows in the Dugandan area south of Boonah,

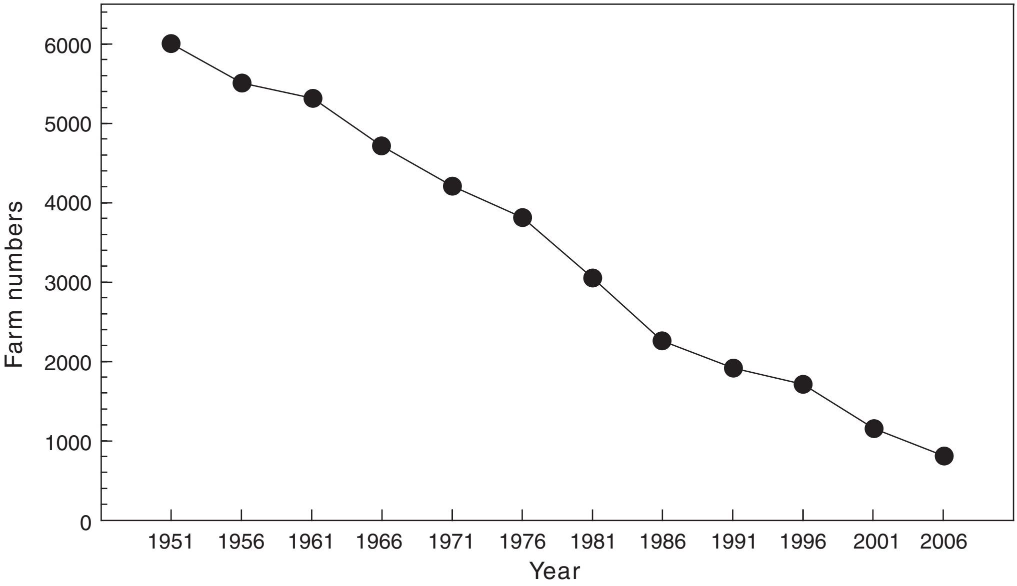

Figure 1. Changes in dairy farm numbers in Queensland over the period 1951–2006 (extracted from Lake 1984 and Anon. 2006).

between 20 and 30 cows on the Darling Downs and 40 cows in the Esk and Beaudesert areas in southern Queensland. Generally, the districts with the largest herd sizes also had the largest farm areas and the lowest costs of production (Lake 1984). This contrasts with the current situation, where the average herd size is around 180 cows, producing around 5500 L/cow (Busby *et al.* 2004). Total production in Queensland and northern NSW is around 800 M L (Anon. 2005).

During the past 40 years, a number of surveys have been conducted, which provide factual information on how the industry has changed over time. Rees *et al.* (1972) published a survey of 82 dairy farms in the Wide Bay district, which assessed the factors driving dairy production during the period 1964–1970. They found that fat production per cow was related to the areas sown to improved tropical pastures and summer forages, but superphosphate application rate on non-sown pasture areas, irrigation, nitrogen fertiliser, the areas sown to temperate pastures and levels of supplementary feeding influenced both per cow and per hectare production. Tropical pastures and summer forages did not improve production per hectare because they did not increase the carrying capacity on farms. This was largely because the calving pattern (calving in July–September) did not allow best utilisation of the higher feed quantity and quality. This survey also highlighted the importance of winter feed from temperate species, particularly when irrigation was available.

From 1969 to 1974, a second survey of dairy farming systems and pasture performance was conducted throughout Queensland (Lowe *et al.* 1986). Farms were selected from those participating in the Dairy Pasture Subsidy Scheme, through which the Queensland Government paid subsidies to farmers to encourage the planting of tropical pastures as a means of improving farm productivity. Unfortunately, in response to farmer pressure, the scheme was modified to include the sowing of lucerne (*Medicago sativa*) and temperate pastures and this tended to dilute the scheme's impact on the uptake of tropical species. Within the survey, a sample pasture was selected on each of 184 randomly selected farms and studied by an assessment panel over a 5-year period.

The survey provided a snapshot of the dairy farms and the forage systems in use at the time. Thirty-one percent of the farms were larger than 100 ha, with only 11% milking more than 100 cows. Only 20% of the herds were pure Holstein-Friesian, in marked contrast to the situation of the last 2 decades where pure Holstein-Friesian herds dominated the dairy scene. Forty-four percent of farms still supplied cream to the factory and only 4% of those supplying milk produced more than 225 000 L per annum. It also provided a picture of the forage base: 33% of the farms had 40 ha or more of dryland improved pastures, 26% had 120 ha or more of naturalised or native pastures, 22% had more than 15 ha of summer crops and 24% had more than 15 ha of winter crops. Only 1% had more than 20 ha of irrigated pastures. Supplements were an important forage source on 33% of farms, but the level of supplement fed was low by today's standards. The survey also contained details of the types of soils, site physical details and fertility. More than half had phosphorus levels above 30 mg/kg, 31% had potassium levels above 0.6 mmol(+)/100 g and 86% had a pH of less than 6.5.

Table 1 shows the performance of both tropical grasses and legumes over all regions in Queensland at that time. Only siratro (*Macroptilium atropurpureum* cv. Siratro) pastures increased in vigour during the survey, while most of the other species declined dramatically during the 5 years. Pangola (*Digitaria eriantha* subsp. *pentzii*), Kazungula setaria (*Setaria sphacelata*) and Pioneer rhodes grass were the best performing grasses. White clover (*Trifolium repens*) was the only temperate species to survive into the final year. Just over half the pastures, which commenced the survey, remained viable at the end, although only 17% were rated as still giving satisfactory levels of production and having a favourable balance of species after 5 years. Two years after the survey finished in 1974, few of these tropical pastures remained. During this 2-year period, most farms had changed their enterprises and now supplied milk rather than cream to the factories. It appears as though the resultant stocking rate increase to achieve economic milk production levels (because of the larger capital investment and higher production costs required) was the main reason for the demise of twining tropical legume-based pastures.

A third survey of 95% of all Queensland dairy farmers in 1987 was conducted by the Department of Primary Industries. It has provided the most comprehensive information on Queensland dairying ever produced (Anon. 1988). The survey suggested that average farm area was 204 ha, 82% of which contributed to the dairy enterprise. Fifty-one percent of all farms had no irrigation and only 32% of those with an irrigation capacity were classed as fully irrigated (*i.e.* with more than 0.132 ha of irrigation per cow). Average herd size was 96 cows, so the effective stocking rate was around 1 cow/2 ha. On reflection, this overall stocking rate should have allowed twining tropical legumes to perform reasonably well, given that a stocking rate of around 1 cow/ha was normally recognised as the critical stocking rate for persistence (Jones and Jones 1978; Anon. 1994).

This survey also provided a snapshot of forage systems in use in the various regions (Table 2). The major source of feed was grass-dominant pasture, either tropical grass in summer or ryegrass in winter. Tropical grass-legume technology was seriously embraced only on the Atherton

Table 1. Visual assessment of the growth and vigour of selected sown grasses and legumes sown on surveyed farms in the first and fifth year (extracted from Lowe *et al.* 1986).

Species	No. of farms sown on	% rated 'strong growth' in:-	
		Year 1	Year 5
Legumes			
Desmodium intortum (Greenleaf desmodium)	31	45	13
Desmodium uncinatum (Silverleaf desmodium)	28	36	7
Glycine wightii (Tinaroo glycine)	28	50	5
G. wightii (Cooper glycine)	19	47	0
Macroptilium atropurpureum (siratro)	67	6	15
Medicago sativa (lucerne)	97	37	3
Trifolium repens (white clover)	38	40	13
Grasses			
Setaria sphacelata (Kazungula setaria)	28	79	32
Setaria sphacelata (Nandi setaria)	26	73	15
Panicum maximum var. *trichoglume* (green panic)	87	70	24
Panicum maximum (Gatton panic)	12	92	17
Chloris gayana (Pioneer rhodes grass)	20	80	25
Panicum maximum (Guinea grass)	3	100	33
Digitaria eriantha subsp. *pentzii* (pangola grass)	5	100	40
Lolium x boucheanum (Grasslands Manawa ryegrass)	11	91	0
Lolium perenne (Kangaroo Valley ryegrass)	12	91	0

Table 2. Comparison of the sources of forage on Queensland dairy farms in 1986–87 and 1994–95 (extracted from Anon. 1988; Kerr *et al.* 1996).

Forage type	1986–87			1994–95		
	Farm No.	Area (ha)	Area/farm[2]	Farm No.	Area (ha)	Area/farm[2]
Raingrown						
Lucerne	233	2 263	9.7	180	2 064	11.5
Improved grass	835	34 512	41.3	953	62 803	65.9
Grass-legume	266	16 605	62.4	298	17 215	57.7
Winter/spring crop	1047	30 056	28.7	640	20 579	32.2
Summer/autumn crop	1142	22 851	20.0	879	19 409	22.0
Unimproved grass	1018[1]	193 897[1]	190.5	843	76 571	90.8
Irrigated						
Clover	118	849	7.2	124	1 067	8.6
Lucerne	397	3 943	9.9	389	5 103	13.1
Improved grass	228	2 678	11.7	229	5 095	22.2
Winter/spring crop	184	2 015	11.0	171	1 438	8.4
Summer/autumn crop	233	2 185	9.4	346	3 760	10.9
Ryegrass	589	6 155	10.5	517	7 550	14.6
Ryegrass-clover	271	2 663	9.8	379	5 337	14.1

[1] Estimated, not presented in survey.
[2] Calculated average from total area and total number of farms.

Tablelands, where around 13 000 ha had been sown, compared with only 1 500 ha in SE Qld. On the other hand, the Darling Downs farmers used cropping and lucerne, rather than pasture technology, with 25 000 ha and 18 000 ha of winter and summer crops, respectively. Nitrogen fertiliser was applied at rates up to 120 kg/ha N to raingrown grass pastures and up to 500 kg/ha N to irrigated ryegrass. Overall, the milk production achieved from forage was around 2000 L/cow (2300 L on irrigated farms). It was concluded that net profit per cow could be increased significantly by increasing milk production from forage through the use of proven technology.

A further survey, but this time only on a sample population of 132 dairy farms, was undertaken in 1990–91 (Kerr 1993). Ninety-three of these farms had been involved in the previous survey, so direct comparisons of information were possible. This survey was also less detailed in the sources of forage used. Production per farm and per cow had increased on these 93 farms by 27% and 21%, respectively, but this increase appeared to come mainly from an 82% increase in the amount of supplements fed. While the number of cows increased by 6%, the farm area contributing to milk production actually decreased, giving an effective increase in stocking rate of around 11%. The area allocated to irrigated winter pastures increased by 5%, but there were drops of 4 % and 40 % in the levels of nitrogen and phosphorus fertilisers, respectively, used on farms. Potassium use had increased dramatically during the period. As part of the 1990–91 survey, all farmers in Queensland were surveyed by phone to collect information on specific production issues; this larger dataset showed that milk production per cow had increased by 12% since the previous survey.

A fifth survey in 1994–95 sampled an average of 40 % of farms over the state (Kerr *et al.* 1996). Farm numbers continued to decline, falling by 20% from 2135 to 1709 over the 10 years. Average stocking rate increased marginally (2.1 to 2.0 ha/cow), the area supplying feed for the milking herd decreased but total farm area and herd size increased. The number of dryland farms decreased only slightly, but there was a substantial increase in the number of irrigated farms. Irrigation area per farm had risen, with those considered only semi-irrigated (with less than 0.132 ha of irrigation per cow) falling dramatically. Milk production per farm and per cow increased by 61% and 43%, respectively. The number of farms using silage increased from 2% to 35%. Milk production per cow from forage increased overall, but fell on the Darling Downs, compared with the original survey.

The major changes in the feed base between the 1985–86 and 1994–95 surveys were in the area of dryland cropping, with much lower numbers of farms sowing smaller areas of both winter and summer crops in all regions except the Darling Downs (Table 2). Improved tropical grass areas increased dramatically but the grass-legume areas remained fairly static, as did the area sown to lucerne. Summer and winter crop areas under irrigation also fell. Main increases in irrigated pastures were in the areas sown to tropical and temperate grasses fertilised with nitrogen. While small relative to the areas of N-fertilised ryegrass, the areas of ryegrass-clover doubled. These increases were mainly a result of substantial increases in sowings in the south-east Queensland region.

Deregulation in 2000 produced major changes in the Queensland industry. Farm numbers have fallen from around 1700 to fewer than 900 in 6 years. Production per farm has not kept up with the attrition rate, so total production in the State has fallen (Anon. 2005). The general advice given to farmers to combat the loss of income resulting from considerably lower prices per litre for milk after deregulation was to increase the intensity of the enterprise [*i.e.* increase production per cow, size of the enterprise (cow numbers), stocking rates and inputs, particularly nitrogen fertiliser and level of silage and concentrates fed] (Busby *et al.* 2006).

Unfortunately, there is no new survey information to present the current picture in the Queensland industry, but the best estimates from public and private sector dairy advisers suggest that the feed base is now concentrated on N-fertilised tropical grasses and ryegrass, increased reliance on irrigation, increased sowings of summer (maize and sorghum) and winter (oats and barley) forage crops and relatively heavy supplementation. Cow numbers per farm have increased in all regions except north Queensland (Anon. 2005).

As a result of deregulation, our research thrust in the dairy industry has changed. A combination of reduced research dollars, a reduced research workforce and more sophisticated models, with component models working together to mimic the whole dairy system, rather than just components, has resulted in models becoming an appropriate research tool. Models can investigate new ideas without ethical concerns or cost penalties to research stations or co-operating farmers. While models can never replace good old-fashioned field research, they can certainly add a further dimension by broadening the applicability of results. While the 'systems research' approach is not new, the increased pressure on farmers, researchers and industry administrators has stimulated greater interest in how research findings fit into the whole farm system, rather than how they affect various components. This has lead to a systems approach as a means of researching the problems confronting dairy farmers. The traditional replicated grazing experiment, with little leeway to make changes, has given way to unreplicated, small farmlets, where changes can be made within strict research aims and guidelines agreed at the start of the research.

The 'M5 Farmlet project – Sustainable dairy farm systems for profit' has been conducted at Mutdapilly to examine the 5 most popular systems used in the Queensland industry (Andrews *et al.* 2006a). The project has demonstrated that, by using the principles suggested above, the financial viability of farming systems in Queensland can continue to improve. In setting up these 5 farmlet systems, stocking rates, fertiliser rates and supplement levels were substantially increased over the State-wide averages shown in the surveys (Table 3). Limited-irrigation farmlets were allocated less than the area per cow considered in the surveys to be 'fully irrigated' and so, apart from the M4 and M5 farmlets, irrigation was not intensified, relative to the existing systems. Production systems aimed to mimic actual farms, reflecting the information collected in the surveys. The only significant change in farm management was the double cropping incorporated in the M3 system, which employed zero-till establishment. Only a small proportion of forage in farmlets M1–M4 came from legumes. M5 was the only farmlet where a legume (lucerne) contributed significantly to the forage base. However, the lucerne was not grazed, but conserved as hay and fed as part of a total mixed ration (TMR).

All farmlets in the M5 project produced a positive return on assets from September 2001 to August 2005 at average SE Qld milk prices – despite high concentrate costs and low water availability (Andrews *et al.* 2006b). Farmlet milk production ranged from 6150 L/cow/yr for the raingrown pasture farmlet to 9200 L/cow from the feedlot farmlet. The 2005 QDAS analysis (Busby *et al.* 2006) indicated that the average farm participating in the annual financial survey (producing 5300 L/cow) could economically increase production per cow by 500–1000 L. With the industry average being 4000 L/cow during the project period, M5 results suggest that a potential increase of 2000 L/cow over the whole State is possible. The regional average production per cow from home-grown feed is around 10 L/cow/d, which is well below the potential 13–17 L achieved from forage in this research (Andrews *et al.* 2006b).

Where to from here?

The volume of research, which has been conducted on tropical grasses and legumes, is staggering; CSIRO's DTP alone published some 1400 research articles, conference papers, memoranda, book chapters and books between 1959 and 1980. DPI&F and NSW DPI probably produced a similar number. The detail on species collections, pasture and animal production, nutrition, persistence, quality and management on a large range of grasses and legumes can best be described as massive. If that information had been communicated effectively enough to farmers and graziers, and correctly used by them, large increases in animal production in subtropical Australia should have resulted.

The sad reality is that, apart from the information on tropical grass-N systems, little of the vast amount of technology developed in the 1960s, 70s and 80s is being used today by the subtropical dairy industry. Despite the good intentions of staff in CSIRO and the State DPIs of Qld and NSW, the information was not always provided to dairy farmers and graziers in a usable and useful format or in sufficient quantity. The Tropical Grassland Society of Australia was formed with just that intention in mind. It is also obvious that, despite our good intentions, we have also fallen short of the mark and today are struggling to see where our future lies, with an ageing scientific membership, few new scientist members and even fewer producer members. The Society needs to rejuvenate itself and make sure it is relevant to members. The advantages of tropical pasture technology, in an economic sense, have not been fully explored, so the gap between scientific knowledge and practical application has remained the 'Achilles heel' of tropical pasture technology. There is also the evidence, presented here from the 1969 survey, that twining tropical legumes cannot tolerate the stocking rates required for modern dairying.

There has been better uptake of the 'high'n'rye' and other temperate species technology (Fulkerson *et al.* 1993), with large increases in areas sown and improved production levels. Considerable information on species and cultivar choice (Lowe *et al.* 2006; 2007), and fertiliser (Lowe *et al.*

Table 3. Description of the physical farmlet models, their feed base and achieved production levels at Mutdapilly Research Station (extracted from Andrews *et al.* 2006a; 2006b).

Farmlet	Description	Calving pattern	Stocking rate (head/ha)	Milk production targets (L @ 305 days)	Off farm feed[1] (tonne DM/cow)	Winter forage	Summer forage	Actual milk production (L/cow)	Milk from home grown forage (L/ha)
M1	Raingrown pasture	100% spring	1.9	7 040	3 t Concentrate 1 t Hay/silage	Oats	Rhodes grass	6 148	4 862
M2	Limited irrigation pasture	50% spring 50% autumn	2.8	6 560	3 t Concentrate 1 t Hay/silage	Ryegrass	Rhodes grass	6 534	8 301
M3	Limited irrigation crops	30% spring 70% autumn	1.4	7 300	3 t Concentrate	Ryegrass, oats, lucerne	Forage sorghum, lablab, lucerne	6 871	5 013
M4	High irrigation pasture and crops	30% spring 70% autumn	2.8	7 100	3 t Concentrate	Ryegrass, prairie, fescue	Lucerne, forage sorghum	7 395	11 509
M5	Feedlot	All-year-round	4.3	9 650	3 t Concentrate	Maize, lucerne and barley silage		9 182	26 021

[1] Concentrate includes grain, protein meals, minerals and molasses.

2005) and grazing management (Fulkerson and Slack 1994; Fulkerson *et al.* 1994; Lowe *et al.* 2005) has been generated by recent research and this appears to have been more quickly adopted.

The reason for the differences in adoption between the 2 technologies appears to lie in the perceived needs of the farmers. Once farmers were required to produce milk throughout the year to satisfy milk processor needs, the cooler parts of the year became the most critical time for the forage base. It was far easier to supply feed in the warmer months with a greater range of options and fewer demands for high quality because of the calving patterns adopted. In addition, the fact that twining tropical legumes were not 'farmer-proof' and failed to persist under 'commercial farming management' and that, to achieve their potential, farmers needed to acquire greater management skills, caused them to look to alternatives. The tropical grass-N technology survived because of the ease of management and its ability to produce large amounts of feed, from which the animal could select a higher quality diet.

There have been some recent successes with legumes for the dairy industry, but these will never make a significant contribution to the industry as a whole. Amarillo grazing peanut (*Arachis pintoi*) and Shaw creeping vigna (*Vigna parkerii*) areas are increasing in the higher-rainfall areas of Queensland and northern NSW (R.G. Walker, J. Lindsay and K.F. Lowe, upublished data) and leucaena (*Leucaena leucocephala*) has been shown to be a useful autumn supplement on dairy farms (Lowe *et al.* 2004).

Currently, work is concentrating on ways to improve the utilisation and water use efficiency of the forage base of subtropical dairying. The major thrust of current research in NSW (Garcia *et al.* 2006) and in the future 'Forage Plu$' project in Queensland (M.N. Callow, personal communication) is to improve the productivity from the forage base. In the case of the Forage Plu$ project, this will include a return to the basics of forage production to ensure increased levels of milk from home-grown forage, while also including new technology to achieve reliable double, and possibly triple, cropping. The contribution of summer cropping will grow in the future, as summer crops are the most water-efficient forages and because they can provide the basis for TMRs. It seems unlikely that the industry will embrace full feedlotting and dairy feeding systems will be based on partial TMRs to supplement grazing.

The industry needs to be mindful of sustainability issues and it should be pointed out that all the options recommended to combat deregulation are likely to make the industry somewhat less sustainable. While double and triple cropping may be useful technology on good quality soils with few physical limitations (structure, slope, drainage, erodibility, *etc.*), it will obviously not be successful on marginal soils. In these situations, the trend is reversed, with producers being encouraged to move from cropping to permanent pastures, particularly on the marginal areas on the Darling Downs (G.A. Lambert, personal communication). No matter what the future of 'multiple cropping' systems is for the dairy industry, pastures will still form the major component of the forage base. The revelation that, for dairy farms of the 21st century to remain viable, they must achieve more from home-grown forage is not new and is as relevant today as it was in the 70s (Rees *et al.* 1972) and 80s (Anon. 1988). It remains for us both as researchers and end users to increase the efficiencies of their usage for the future success of the subtropical dairy industry.

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