Pastures in Vanuatu

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Foreword

THE beef cattle industry in Vanuatu has great potential, both for the domestic and export markets. Although land for pasture is not limiting, the poor quality of pasture grasses results in small weight gains, late turnoff of steers, and low-weight carcasses of only moderate finish.

Present knowledge of the industry throughout Vanuatu is sketchy. The Government of Vanuatu therefore sought assistance from Australia for a survey of pastures throughout the country.

This technical report presents the findings of that survey, carried out by the Department of Agriculture at the University of Queensland and funded by ACIAR. It provides valuable information on the potential and limitations of pasture improvement for the beef cattle industry in Vanuatu, as well as giving guidance to both ACIAR and the Australian Development Assistance Bureau (ADAB) in planning projects for further research and development in the industry.

The authors would like to dedicate this publication to the livestock producers from estates, plantations and smallholdings throughout Vanuatu, and the technical personnel who gave their enthusiastic support. It is hoped that the findings and recommendations of the survey will give a significant thrust to the development of their industry.

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Summary

At the invitation of the Government of Vanuatu, and with support from the Australian Centre for International Agricultural Research (ACIAR), the University of Queensland conducted a survey of pastures in Vanuatu in 1984. The aim of the survey was to identify the potential and limitations of pasture improvement and to make recommendations for applied research and development.

Vanuatu has one of the greatest potentials for expansion of commercial cattle production in the southwest Pacific because of high cattle numbers (100 000 in 1983), abundant land of high fertility, a currently operating marketing infrastructure and a large area of coconut plantations. There is a concerted Government effort to stimulate the industry as an alternative to copra and thus provide increased foreign exchange earnings. Government sponsored programs are currently in place to improve the breeding, husbandry, and marketing of cattle with the objective of holding lucrative export contracts and to supply a growing local demand.

The importance of improving pastures in Vanuatu has been widely recognised as the major constraint to improved beef production and this has led to a request for the University of Queensland to survey pasture and soil resources. Advice was requested by the Vanuatu Government, the Australian Development Assistance Bureau (ADAB) and ACIAR on applied research, development, extension and training activities which might be necessary to address limitations identified in the survey.

Seventy-eight properties including 22 estates and 44 smallholdings were sampled on Efate, Santo, Malakula, Pentecost, Ambae, Ambrym and Tanna. Key information sought included animal stocking rates and production data, pasture botanical composition, weed species and their control, pasture and grazing management.

Animal Production from Various Pasture Types

Four major pasture types were identified. Carpet (*Axonopus compressus*) and T grass (*Paspalum conjugatum*) in combination with native legumes are the major grazing resource (about 30–40% of total area) but have only about 33% of the fattening potential of improved grass/legume pastures, which comprise approximately 2% of the total pasture resource. In addition, the latter pastures turn off premium slaughter weight cattle (230 kg carcass) 1.5–2 years earlier.

Buffalo grass (*Stenotaphrum secundatum*) pastures under old, moderately shaded plantation coconuts (20–30% of national grazing area) have a similar productivity potential to unshaded carpet grass pastures. Heavily shaded native grass, and to a minor extent buffalo grass pastures, under dense coconuts and bush, comprise an estimated 25–30% of the total grazed area and have nil fattening potential.

Pasture Species

The principal native grasses are carpet grass and T grass. The survey indicated that T grass usually invades newly cleared bush areas but is gradually replaced by the more palatable carpet grass. Buffalo grass (vegetatively propagated) occurs under most plantation coconuts but comprises only a small area of smallholdings, although present on 41% of all units. In open and shaded areas, buffalo grass displays exceptional competitive ability with weeds due to its dense, prostrate habit and tolerance of heavy grazing.

The majority of new improved pasture development (into cleared bush areas or degraded native pastures) is likely to involve signal grass (*Brachiaria decumbens*) which is sown with glycine (*Neonotonia wightii* cv. Tinaroo). Guinea grass (*Panicum maximum* — cvs. Common, Hamil) combines better with twining legumes but has poorer weed control than signal. There is scope for mixed, complementary guinea/signal grass/twining legume pastures.

Under careful management, creeping guinea (cv. Embu) and para (*B. mutica*) grass/legume pastures could be used to obtain higher growth rates than those obtained from signal alone, because of their higher nutritive value.

Koronivia grass (*B. humidicola*) is recommended for new, open smallholder development and for heavily grazed areas on estates. It should be established vegetatively from nurseries with creeping legumes hetero (*Desmodium heterophyllum*) and *D. canum*. It is preferred over other improved grasses on high pH coralline soils.

Glycine has been the major sown legume but often declines markedly after 5–10 years grazing, particularly in dry years. The testing of alternative legumes, leucaena *(Leucaena leucocephala)*, centro *(Centrosema pubescens)* and puero *(Pueraria phaseoloides)* is strongly recommended. Leucaena occurs naturally and is potentially the most productive and persistent legume for new, open pastures (e.g. in hedgerows with signal) and for shaded, degraded (nitrogen deficient) carpet and buffalo pastures. Under careful grazing management it will not become a weed.

The native legume *D. canum* occurs most commonly in buffalo and carpet pastures and less so in T grass pastures. It prefers higher pH, high phosphorus soils. The other common native legume, *Mimosa pudica*, is more widely distributed than *D. canum* and is best managed under continuous rather than rotational grazing.

Pasture Establishment

The major limitation to planting improved pastures is the high cost of establishment, notably clearing. Well supervised manual clearing of light to medium density bush costs 10 000 to 14 000 VT/ha (appropriate to Ni-Vanuatu and small estate producers) and efficient bulldozer clearing of heavy bush areas was costed at 25 000 VT/ha (1983 prices). There is scope for improvement of efficiency of manual and mechanical clearing as well as integrating manual and mechanical clearing systems. Basic principles of establishing and managing sown and vegetatively propagated pastures are not well understood.

Weed Control

Cassia tora (pistache), *Solanum torvum* (pico), *Sida rhombifolia* (Paddy's lucerne), *Sida acuta* (broom weed), *Stachytarpheta urticifolia* (blue rat's tail), *Elephantopis spicatus* (wild tobacco), *Lantana camara* (lantana), *Mikania micrantha* (Mile-a-minute, American rope) are regarded as the current major weed species in pastures. Methods are given for control of most of these species.

Soil Fertility

The majority of Vanuatu pasture development has been on coastal coralline and uplifted calcareous/volcanic ash soils. In general, these soils are fertile (by Pacific standards) and well supplied with plant nutrients, but on both soil types, low available soil nitrogen limits productivity of pure swards of improved grasses, and native and buffalo grasses. On coastal soils, Institut de Recherches pour les Huiles et Oleagineux (IRHO) have reported a significant yield increase in buffalo grass in response to applied nitrogen (N) and potassium (K). Soils largely derived from volcanic ash (Tanna, Ambrym, Aobe, N. Malakula) have no nutritional limitations for pasture growth.

On parts of the Santo plateau, and at Montmartre, Vanuatu Livestock Development Ltd. (VLD) and Siviri on Efate, grass and legume tissue concentrations of 0.06-0.14% phosphorus (P) were recorded, which are sub-optimal for maximum animal growth (0.18%) and lactation (0.22% P). Adequate levels of soil phosphorus are essential for pasture growth and the persistence of legumes. Soil phosphorus is likely to be most limiting on the higher (older) plateau areas of Santo and on soils derived from basic volcanic rocks (N. Tanna) and volcanic tuffs (Efate). Further monitoring of the extent of the soil phosphorus limitation is recommended.

Sodium concentrations in 69% of pastures samples were below recommended levels for growth (0.07% Na in dietary intake), and all species were deficient (< 0.1% Na) for maximum milk production on a commercial dairy near Vila. Koronivia grass (0.19% Na) and buffalo grass (0.65% Na) are clearly Na accumulators. Sulfur concentrations of most pasture species averaged 0.33%, which were adequate, but were high in *Leucaena* (0.75% S) and T grass (1.1% S) and marginal in signal grass. Copper status was marginal for animal growth in some Malakula buffalo grass pastures. Levels of iron, manganese and zinc were adequate.

Smallholder Cattle

From 1971 to 1983, the national smallholder herd (including subsistence cattle) increased by about 300% to 32 000 cattle grazed principally on poor quality and overgrazed pastures (mainly carpet and T grasses with a small percentage of buffalo grass) under dense coconuts. However, 82% of smallholder coconut farms do not have cattle, indicating the enormous potential for expansion of cattle numbers in this sector. In general, cattle husbandry standards are poor (most have one paddock, no water, little improved pasture, insufficient or poor quality bulls) and there is a general lack of understanding of the importance of feeding for animal growth. It is recommended that smallholders be advised to thin coconut stands to benefit both copra yields and undersown pasture growth.

Attitudes to cattle raising vary from commercial to non-commercial, determined largely by access to

markets and activity of the Government Livestock Service. Enthusiasm for cattle raising is greatest on Santo, where access to markets is available and the Livestock Service actively provides assistance with organisation of transport, loans, advice on cattle husbandry, and by provision of better bulls. As a result, Santo smallholders have increased their supply of slaughter cattle to the abattoir from 4 to 25% over the past two years. However, only 17% of these cattle reach premium quality.

Although 41% of smallholders have planted buffalo grass, sown areas are inadequate. We endorse the current Department of Agriculture, Livestock and Forestry (DALF) recommendation for this vigorous species, which is shade and grazing tolerant under coconuts. For open pastures Koronivia grass in conjunction with hetero *(Desmodium heterophyllum)* is recommended.

Estate Cattle

In 1983, there were 56 000 estate sector cattle compared with 72 800 in 1971. Numbers during this period have increased by 21% on Efate and decreased by 29% on Santo. The estate sector is commercially oriented towards export markets although a significant local market exists in Vila (about 45% of throughput). In Santo, 55.5% of estate steers grown on T grass and carpet grass pastures achieve premium quality. The best commercial properties on Efate, turning off steers from improved grass/legume pastures, achieve up to 100% export quality. Several examples of overstocking on estate properties were found where growth rates and reproductive performance were below optimum. Mating systems were either uncontrolled, seasonal or mating for 9 months of the year. Calving percentages ranged from less than 40% (brucellosis affected) to 85%+ in the case of two herds on Efate grazing improved grass/legume pastures at near optimum stocking rates.

Most estate managers interviewed indicated a desire for some *Bos indicus* blood in their herds. Currently, all high grade Charolais bulls from IRHO and Brahman cross bulls from Mon Biftek and VLD are readily sold.

Approximately 20% of Efate estate pastures have improved grasses (about 3000 ha), usually without a legume, while only about 400 ha of improved grass pastures occur on Santo. Enormous potential exists to increase the area and quality of improved pastures by the introduction of better grasses and legumes, particularly leucaena. The survey found that many estate managers, who had secured leases and were benefiting from high copra prices, were genuinely interested in establishing improved pastures. Progressive managers realised that profitability, given adequate calving rates, was primarily determined by the fattening potential of improved open pastures. Advisory support to this sector will clearly be welcomed, and it is likely to be quickly implemented.

Ni-Vanuatu Plantation Cattle

Ni-Vanuatu plantations (generally operating on abandoned estates) will have an increasing impact on cattle production, particularly on Santo, Malakula and Pentecost.

For this sector to succeed commercially, plantation managers require a better knowledge of pasture management, weed control, grazing management and animal husbandry. This could be addressed by upgrading the technical content of the Montmartre Ni-Vanuatu management training course and a more active Plantation Support Association. Secure tenure, the use of copra income to finance coconut replanting and pasture improvement, and reliable access to markets will improve productivity of this sector.

Interrelationship Between Smallholder and Estate Sectors

The viability of the beef industry in Vanuatu requires an increase in the number and quality of cattle delivered to the abattoirs.

Currently, most of the export beef is produced by the estate plantations, with a limited but increasing contribution from smallholders. Poor quality pastures under dense coconuts, poor husbandry standards and the disincentive of inaccessible markets make it exceedingly difficult for smallholders to produce fat cattle. It is therefore strongly recommended that smallholders (excluding those on Santo with sown quality pastures) concentrate on the breeding of weaners and store cattle for sale to the estate sector on Santo and Efate, which has the resources to produce fat cattle. For this proposal to work effectively, entrepreneurial estate managers will need to establish a network of road and barge transport and adequately remunerate smallholders for their cattle. The advantages of this system will be: (a) breeding is more compatible with poorer quality pastures under coconuts; (b) barging and transport of young stock is more economical than for mature animals; (c) barging of fat cattle incurs substantial penalties through bruising; (d) excess young cattle can be quickly turned off overgrazed pastures; (e) cow/calf operations are simpler than breeding and fattening.

In conclusion, we stress that while the estate sector is most likely to benefit initially from pasture improvement, the viability of smallholder units depends on the vigour of the estate sector. Financial benefits will most certainly flow through to Ni-Vanuatu producers as their motivation, management expertise and opportunity for commercial cattle raising increases.

Recommendations for Pasture Development

Many of the recommendations of the report have immediate application and should be disseminated to cattle producers via the Extension Service. In addition, a number of gaps in knowledge have been highlighted which should be investigated in a practical farm-oriented research program. To carry out these recommendations, we suggest that a pasture improvement unit of two officers be established in Vanuatu as part of the Australian Government aid program. These officers should have research, extension and training responsibilities. We believe that such a program will complement existing activities of the Department of Agriculture Livestock and Fisheries and will contribute to an effective and well balanced stimulus to the Vanuatu cattle industry.

Survey Report

At the invitation of the Government of Vanuatu, and with support from the Australian Centre for International Agricultural Research (ACIAR), the University of Queensland conducted a survey of pastures in Vanuatu in 1984. The aim of the survey was to identify the potential and limitations of pasture improvement and to make recommendations for applied research.

Vanuatu has a large cattle population by Pacific Island standards. There is excellent potential to expand the beef industry to meet both domestic and overseas demands with considerable financial benefits to the government, the estate, and smallholder sectors. Improvement of Vanuatu pastures will be a key factor in successful expansion of beef production; hence, a survey was conducted in the latter half of 1984 to define the nature, productivity, and limitations of Vanuatu pastures, and to make recommendations for future pasture improvement activities.

We wish first to summarise the main features of the Vanuatu cattle industry to provide some background to our pasture survey. Recent (1983) census data show that there are about 100 000 cattle in the national herd; this represents a decline of approximately 10 000 head since the last census was taken in 1971. The cattle population is split approximately 66% in the estate sector and 34% in the smallholder and subsistence sectors. Census data show that the decline has occurred primarily through a reduction in cattle numbers held in the estate sector, whilst the smallholder sector has experienced a threefold increase in herd numbers since the last census in 1971. Cattle are located mainly on Santo, Efate, Malakula, Pentecost, and Tanna. However, all major island groups have cattle populations. Estate sector cattle are concentrated on the main islands of Efate and Santo whilst smallholder cattle are found mainly on Santo, Pentecost, Malakula, and Tanna (see Appendix 1).

Vanuatu already has a fledgling beef export industry, which the government is firmly committed to expand in order to diversify foreign exchange earnings away from copra. Export-standard abattoirs are situated on Santo and Efate, and some infrastructure already exists for the supply of cattle to these abattoirs to meet existing export contracts for both premium and cull cattle to markets in Europe, Japan, the Caribbean and Bougainville. However, limited availability of cattle for slaughter means that abattoirs are being operated at approximately half their capacity (1983 abattoir throughput: Santo—7731 head; Vila—5275 head). The opportunity exists to consolidate and expand these markets, provided the supply of export quality steers from farms can be increased in number and reliability. If this cannot be attained quickly, Vanuatu risks losing lucrative export contracts.

There are several reasons why Vanuatu is well situated to promote beef production. These include: (a) abundance of accessible land of relatively high fertility; (b) the possibility of a reliable income from low labour input and at low cost compared to the more intensive plantation crop alternatives; cattle production is therefore within reach of the Ni-Vanuatu people; (c) the potential for ready integration of cattle into a large area of coconut plantations in both estate and smallholder sectors, and for significant production improvement on present holdings; cattle can be used to control weeds and grass growth under coconuts, as well as providing an additional source of income.

Limitations to improved beef production in Vanuatu may be categorised as follows: (a) feeding — inadequate quantity and quality of pasture available per grazing animal; (b) breeding — limited distribution of tropically adapted crossbred cattle, particularly bulls; inbreeding amongst a significant percentage of 'local'

and 'local' × European genotypes; (c) animal husbandry — lack of segregation of classes of stock, uncontrolled mating, inadequate bull/cow ratios, use of old bulls, lack of timely weaning and drenching of weaners, lack of proper culling procedures for infertility, and the lack of drinking water; (d) marketing — poor access to domestic markets and low prices for weaners, store cattle and export quality cattle.

The Department of Agriculture, Livestock and Forestry (DALF) currently has programs to address deficiencies in most of these areas. However, they have recognised that poor feed supply and feed quality is the major limitation to beef production, and this led to a request to the Australian Centre for International Agricultural Research and the University of Queensland to conduct a survey of pastures in Vanuatu.

This report details the survey methodology and the main results, and gives recommendations for future pasture improvement activities.

Objectives of Survey

(a) To survey the present state of pasture resources and to document existing information on pasture establishment and soil fertility status.

(b) To identify the major limitations to improved pasture development.

(c) To advise the Vanuatu Government, ACIAR, and ADAB on research and development activities necessary to overcome these limitations.

Survey Methodology

The survey was conducted in Vanuatu during September, October and November of 1984. Information was gathered and soil and pasture samples taken from 78 properties as follows: government farms/stations 4, schools/missions 5, smallholders 44, Ni-Vanuatu plantations 3, and estate sector 22.

In order to cover major cattle producing areas, the islands of Efate, Santo, Malakula, Pentecost, Ambae, Ambrym, and Tanna were surveyed. Key information was sought from each property concerning animal stocking rates, animal production data, pasture botanical composition, weed species and their control, pasture establishment and grazing management. To assess pasture quality and soil fertility, samples of soil and pasture were taken from representative sites from all islands for chemical analysis in Brisbane.

Results and Recommendations

The key issues which will be discussed in the results section are as follows:

- levels of animal production from various pasture types
- pasture species in use
- some recommended new species
- methods of clearing and pasture establishment
- weed control
- soil fertility and chemical composition of pastures
- production sectors —
  - (a) smallholder cattle
  - (b) Ni-Vanuatu plantation cattle
  - (c) estate cattle
  - (d) interrelationship between smallholder and estate sectors

Levels of Animal Production from Various Pasture Types

From the survey it was possible to estimate levels of animal production from the four major pasture types under optimum management for fattening. These data are shown in Table 1. It is estimated that approximately 40% of the national grassland resource is open native pastures comprising mainly carpet grass (*Axonopus compressus*) and T grass (*Paspalum conjugatum*). Finishing steers grazing these pastures at 1.5 animals/ha gain beef at the rate of 165 kg/ha/year and successfully reach export quality, but at 3.5–4 years of age. (Export quality beef is defined as carcasses of at least 230 kg and under 4 years of age; such carcasses command a premium price.) For comparison, top quality improved signal grass (*Brachiaria decumbens*)/legume pasture grazed at 2.5 steers/ha produces liveweight gains of 525 kg of beef/ha/year and export quality carcasses at 2 years of age. This shows a threefold improvement in beef production over native pastures, and a turnoff 1.5–2 years earlier. Clearly, by converting existing open native grass pastures to improved grass/legume pastures, there is tremendous scope for improving exports.

Approximately 30% of the current national pasture resource can be found under old coconut plantations and consists mainly of buffalo grass (*Stenotaphrum secundatum*). From Table 1 it can be seen that the fattening potential of these pastures is similar to open carpet grass pastures. Even under optimum management it is difficult to consistently produce export quality beef from such pastures. Improvement of these pastures will be difficult because of the lack of high quality pasture species adapted to shaded environments. One option which merits study under controlled conditions is the introduction of wide rows of leucaena into plantations.

Table 1. The potential of the major pasture types for fattening cattle to premium weight in Vanuatu.

Pasture type	*Approx. % of total pasture area*	*Estimated stocking rate*	*Estimated liveweight gain*	
			kg/hd/day	*kg/ha/yr*
Open carpet/T grass with native legumes	36–44	1.5	0.32	175
Improved grass (with sown legumes)	4–5 (1–2)	2.5	0.58	525
Buffalo & carpet grass under old coconuts	28–32	1.5	0.32	175
Heavily shaded pastures under dense coconuts and bush	25–30	Nil potential for export fattening		

About 86% of smallholder cattle graze under coconuts, the majority of which are extremely dense (greater than 200 stems/ha). This is due to the lack of a soundly based thinning policy and the random establishment of new seedlings from fallen nuts. Such pastures have no export fattening potential and are best suited to breeding. The heavy shade conditions in these plantations precludes the successful introduction of higher quality and more productive pasture species apart from buffalo grass. Heavy shading also decreases the productivity and nutritive value of grass species, and decreases their competitiveness with broad leafed weed species.

We emphasise that Table 1 shows the average growth rates up to 3.5–4 years for good managers on the representative pasture types. These figures do not accurately reflect the growth rates attained up to weaning, and from weaning to 2.5 years, which are naturally much higher. The estimated potential growth rates of young cattle (up to 2.5 years of age) for various open pasture types are listed in Table 2.

Pasture Species in Use

In this section we will discuss the main pasture species used in Vanuatu and consider their important characteristics. Reference will also be made to new species which have potential.

GRASSES

T grass (Paspalum conjugatum) and Carpet grass (Axonopus compressus) These species are the principal native grasses in Vanuatu. Both are low-growing creeping perennial grasses. Newly cleared areas are commonly colonised by T grass. However, with time, such areas are invaded by carpet grass which becomes dominant. This latter species is more palatable to livestock, as evidenced by a lower average grazed height relative to T grass. Once carpet grass and T grass become rank (i.e. > 15 cm height) cattle tend to

Table 2. Recorded liveweight gains of young cattle (< 30 months) from various pasture types.

Pasture type	*Liveweight gain (kg/ha/yr)*	*Stocking rate (AU/ha)*	*Average daily gains (kg/hd/day)*
	(a) Growth from weaning to 30 months		
Signal + twining legume — Rentabao	550–600	2.5	0.58
Guinea + twining legume–Rentabao	550–600	2.5	0.58
Koronivia + native legume — Montmartre	420	2.0	0.44
Para/guinea-no legume-Saroutou[a]	390–440	1.8	0.44–0.50
Open buffalo + native legume — Vila[b]	390	1.8	0.43
Open carpet + native legume — Santo	350	1.8	0.40
	(b) Growth to weaning		
Open carpet + native legume — Luganville (9 months)			0.60–0.65
Open para/guinea-no legume-IRHO (7–8 months)			0.85
Open signal grass, green panic + glycine (5–6 months)			1.0

Animal Unit equivalents:
One 450-kg steer gaining weight = 1 animal unit (AU); one 300-kg steer/heifer = 0.75 AU; one 200-kg weaner = 0.6 AU.
[a] Rotational grazing with Charolais cattle, 15-year average, IRHO, understocked generally.
[b] Weightman (1977).

patch graze certain areas and leave others ungrazed. The unpalatability of T grass may be related to the higher sulfur levels it accumulates (see Table 3). Both species are quite shade tolerant and can be found under coconuts and in bush areas; however, dry matter productivity in full sunlight, up to 12 tonnes dry matter/ha/yr (Coulon et al. 1983), is less than half that of introduced species. The native grasses are, however, better adapted to poorer soils and shaded situations.

We found that the content of the native legume (*Desmodium canum*) is generally higher in carpet grass than T grass. The reason for this is not fully understood. As mentioned previously, these species provide the majority of open grazing in Vanuatu. They are also common in smallholder coconut areas but less common in old coconut plantations where buffalo grass is the preferred species.

We observed that carpet grass provides a better ground cover than T grass, and consequently is less susceptible to weed invasion, particularly after heavy grazing.

Buffalo grass (Stenotaphrum secondatum) Buffalo grass is widespread in Vanuatu and is the recommended species for all smallholder development and shaded situations. It is a low growing perennial grass with vigorous stolons. Many of the large plantings of buffalo grass were made 30–50 years ago. Forty percent of smallholders have planted some buffalo grass but in recent times this momentum has not been maintained. Under heavy shade, buffalo grass is more productive and vigorous than carpet or T grass, and in consequence is able to compete effectively with weeds. Establishment is by vegetative cuttings and this can be done by hand in smallholder areas or with disc harrows into prepared seed beds in larger coconut plantations. Early grazing of such areas is not recommended so that the cuttings root firmly.

Buffalo grass is considered to be less productive than carpet grass and T grass in the cool dry season. It combines well with the native legumes *Desmodium canum* and mimosa. Twining legumes (e.g. glycine, siratro) persist only at low stocking rates (about 1.0 AU/ha) because of the vigour of the species. Buffalo grass has exceptional weed control characteristics and is tolerant of heavy grazing, making it ideally suited to the cattle/coconut system, but cattle prefer open to shaded buffalo grass. However, poor nutritive value means that average liveweight gain per head rarely exceeds 0.32 kg/head/day in a commercial fattening situation. It is therefore difficult to fatten cattle to export quality within the required time limit. Buffalo grass is eminently suitable for breeding and is recommended for this purpose; young stock should be removed from buffalo grass pastures to open higher quality pastures for fattening. As previously mentioned, there may be scope for improving the quality of buffalo-based pastures by the introduction of shrub legumes such as leucaena to improve the quality of diets selected by grazing animals. Optimum grazed height for buffalo grass is about 15 cm.

Signal grass (Brachiaria decumbens) Signal grass is the most productive grass for newly cleared areas. It is a creeping perennial species and has also been used successfully for regeneration of degraded pastures. It has the advantage that seed is available and large areas

Table 3. Mean macronutrient concentrations of plucked tips of major pasture species averaged over all soil types samples (NRC 1976).

Species	*N*	*P*	*K*	*Ca*	*Mg*	*S*	*Na*
				% of Nutrient			
Koronivia	1.74	0.17	1.68	0.30	0.26	0.19	0.19
Buffalo	2.11	0.29	1.95	0.60	0.35	0.41	0.65
Signal	2.16	0.22	2.65	0.48	0.27	0.22	0.04
Glycine	3.41	0.21	1.86	1.25	0.40	0.26	0.03
Leucaena	5.14	0.32	2.19	0.94	0.27	0.75	0.01
Carpet	2.20	0.30	2.09	0.38	0.33	0.29	0.03
T grass	2.31	0.26	2.38	0.60	0.52	0.94	0.02
D. canum	2.82	0.23	1.37	1.03	0.28	0.24	0.04
Mimosa	3.29						
			Minimum levels for dietary intake —				
(a) growth	1.3–1.5	0.19	0.31–0.43	0.43	0.15	0.17*	0.07
(b) lactation		0.23		0.32	0.18	0.17	0.10

Plant Ca, Mg, S and trace elements were determined by inductively coupled plasma emission spectrometer (ICP) and flame photometer (Na) following nitric-perchloric digestion. Recommended levels are taken from ARC (1980) unless otherwise indicated.
*Rees and Minson (1978).

can be planted quickly. Signal, like other grass seeds, should be stored only at low moisture content (around 10%) or should be air freighted immediately prior to planting. Germination can be improved by immersion of seed in concentrated sulfuric acid for 5 min (Whiteman and Mendra 1982).

Signal grass sown with glycine (*Neonotonia wightii*) or alternatively, new legumes yet to be introduced, is likely to be the mainstay of estate development in Vanuatu. Although signal grass can withstand stocking rates in excess of 2.5 AU/ha, companion twining legumes cannot. On Efate, high levels of beef production have been obtained on signal/glycine pastures for periods of up to 5 years. However, latterly legume contents have declined. This problem of twining legumes not persisting at higher stocking rates has been partly overcome by two separate property owners who have incorporated the tufted guinea grass (*Panicum maximum*). In such complementary mixed grass swards, signal grass controls weeds and guinea tufts are colonised by twining legumes. Signal grass yields are less affected in the cool season than guinea, para, green panic, and Embu (Coulon et al. 1983).

On one farm, it was observed that leucaena combined well with signal grass to form a highly productive pasture. This species combination may well prove to be the most productive and persistent pasture for open areas in Vanuatu. On Santo, it was observed that signal combined well with the native legumes *Desmodium canum* and *Mimosa pudica*. Signal grass is a vigorous species, hence very competitive with weeds. Well established and managed signal effectively controls pico and pistache, provided some supplementary timely herbicide applications are also made. Signal grass pastures should not be grazed shorter than 20 cm.

Guinea grass (Panicum maximum) and green panic (Panicum maximum var. trichoglume) Guinea grass and green panic were the most common species in earlier pasture plantings made in Vanuatu. They form a higher quality pasture than signal grass because they combine better with legumes, but they are more prone to weed invasion. Green panic is less suited than guinea to coastal coralline (rendzina) and was less productive than guinea on plateau soils in IRHO trials. It is recommended that rank guinea grass pastures should be slashed and continuously (not rotationally) grazed. In a number of cases, a stable glycine content of 10–15% in 10–15-year-old guinea and green panic pastures was observed where grazing pressure had been lenient, especially during the dry season.

On Santo, creeping guinea grass (cv. Embu) has persisted well with glycine for 9–10 years. In IRHO trials, Embu guinea was one of the most productive grasses tested. It has also demonstrated more tolerance of cold season temperatures and shade than the other guinea grasses (cv. Common and cv. Hamil). On Santo, a vegetative planting of Embu on approximately 1 metre squares dominated a T grass/carpet grass pasture after 9 months.

Koronivia grass (Brachiaria humidicola) Koronivia grass is the most suitable species for open smallholder pastures because it can be established from locally available cuttings and is more resistant to heavy grazing than signal. It is more productive and of higher quality than buffalo grass and should be planted with the creeping legume hetero. It is a useful species for heavily grazed situations such as along laneways and around stockyards. It is well adapted to high pH coralline soils and in these situations it is preferred to signal grass, green panic or guinea grass. Cuttings established in October–November are likely to become erect (associated with flowering) and a very light grazing has been shown to promote tillering.

Koronivia grass on the Guadalcanal Plains of the Solomon Islands (2000 mm rain/year with a distinct May–October dry season) maintained useful (7%) levels of twining legumes (centro, siratro) at stocking rates up to 1.8 animals/ha (Smith 1983).

Para grass (Brachiaria mutica) Para grass is the best adapted species for wet conditions. It is a creeping perennial and combines well with twining legumes. It has a high nutritive value and is therefore suitable for dairy production. Para grass is readily established from vegetative cuttings. However, it is susceptible to overgrazing and weed invasion and this is accentuated by the practice of rotational grazing. Para/legume pastures are very suitable for finishing underweight steers to export standard as they are of higher quality than signal/legume pastures, but must be grazed at lower stocking rates. Para grass/centro pastures, continuously grazed at 2.5 AU/ha on the Guadalcanal Plains averaged 550–600 kg liveweight gain/ha (Smith 1983).

Other grasses *Brachiaria reptans*, *B. subquadripara*, *Digitaria* sp., *Dicanthium* sp. and *Heteropogon* sp. were locally significant, minor native grass species.

LEGUMES

The presence of legumes in pastures is extremely important for providing nitrogen for grass growth and better quality forage for grazing animals. The main legumes being used in Vanuatu are briefly discussed as follows:

Glycine (Neonotonia wightii cv. Tinaroo) Glycine is the major sown legume in Vanuatu. A twining perennial, it combines well with signal, guinea, and green panic, but often declines markedly after 5–10 years grazing, particularly in dry years. It is suited to the well drained fertile basaltic soils especially of higher pH, but it is not tolerant of overgrazing. The glycine content of grazed pastures on Efate was noticeably higher in the wet season than in the dry season.

Desmodium canum *Desmodium canum* is a native, low growing legume, which occurs most commonly in carpet and buffalo pastures. It generally comprises only a small part (less than 10%) of most pastures, although higher levels were recorded on higher rainfall sites with high soil phosphorus (e.g. 50% *D. canum* at Bwatnapni, Pentecost).

Mimosa *Mimosa pudica* is also a native legume and is distributed across a greater range of soil types than *Desmodium canum*. It is thorny, and only leaf tips and flowers are eaten, providing a good protein supplement particularly in the dry season. It is best managed under continuous rather than rotational grazing, as plants are kept short by the continuous grazing action of cattle. Too much mimosa will reduce feed intake because cattle can only nibble soft shoots. Mimosa dominance can be overcome by slashing, followed by continuous grazing.

A thornless variety of the giant sensitive weed, *Mimosa invisa* var. Inermis, forms a productive, creeping sward which controls weed growth in coffee groves on Tanna. It clearly has potential for pasture improvement, particularly in heavily grazed situations. However, the issue of whether this variety can revert to the thorny type must be resolved.

Leucaena (Leucaena leucocephala) Leucaena (Cassis) occurs naturally in Vanuatu and is potentially the most productive and persistent legume for improved grass pastures. At present its value has not been widely recognised and many people are concerned about its weed potential if widely used in pastures. However, some producers have realised its value for fattening cattle. Some of the best smallholder and estate cattle surveyed had leucaena in their diet. It is doubtful if leucaena will ever become a weed provided it is properly managed. Plucked leucaena leaf material had the highest protein and phosphorus content of any legume sampled (e.g. from Lelepa Island — 5.85% N, 0.42% P.)

Other legumes Siratro *(Macroptilium atropurpureum)* was rarely encountered in grazed pastures other than the white grass area of Tanna and N. Efate. Senescence in the wet season was reported, indicating the presence of the disease *Rhizoctonia*. *Desmodium intortum* cv. Greenleaf formed a stable component of some grazed pastures at Elbee ranch, Rentabao on Efate and at Lakatoro Agricultural Station, Malakula, but tended to be disfavoured because of the high price of seed.

Some Recommended New Species

There are several new grass species which we recommend should be introduced and evaluated. Nadi blue grass *(Dichanthium caricosum)* and koronivia grass should be evaluated on the dry north side of Efate and perhaps Malakula. For dairy production, Embu, batiki blue *(Ischaemum aristatum)* and various setaria species should be evaluated against green panic, para and signal currently in use at Melektree dairy near Vila.

New legumes for evaluation and introduction include: (a) centro *(Centrosema pubescens)* and puero *(Pueraria phaseoloides)* for use in signal grass pastures; (b) hetero for use in signal and koronivia pastures; (c) puero as a cover crop to control weeds, notably *Mikania*, under young coconuts and in other situations.

Methods of Clearing and Pasture Establishment

We found that the major limitation to planting new areas of pastures is the high cost of establishment. It is important to identify the most cost-effective methods of clearing and establishing pastures into different types of 'black bush.' There were also several instances where poor establishment of improved species had resulted in severe weed invasion. This could be related to poor techniques during the establishment phase.

Some costs of well supervised clearing suitable for pastures obtained during the survey are listed in Table 4.

Table 4. Cost of well supervised clearing from a range of forest types in Vanuatu (1983–84 prices).

Type of bush	*Method of clearing*	*Cost*
1. Light burao black bush (Santo)	Axes, frill poisoning, bush knives	10 000 VT/ha
2. Heavy black bush (Rentabao, Efate)	D8 bulldozer felling, windrowing, burning & ploughing	25 000 VT/ha
3. Moderate-heavy black bush (Tanna)	Underbrushing light bush, axe felling all except large trees and cutting up of logs	14 400 VT/ha

Examples 1 and 3 are appropriate for smallholder, Ni-Vanuatu plantation and small estate operators, and costs were based on 1983–84 contract clearing rates. Considerable variation in the efficiency of bulldozer operation was noted. Not enough care was being taken during windrowing to avoid movement of top soil. The use of blades fitted with root rakes would help overcome this problem. There appeared to be a lack of awareness of the effects of removal of top soil (particularly from shallow soils) on long term pasture productivity by both estate and government Bush Clearing Unit (BCU) operators.

A comprehensive review of bush clearing methods for agricultural development in Vanuatu involving government officers and private property managers was made in a seminar held at Santo in May 1983 (Anon. 1983).

We believe there is scope for the clearing of light black bush (i.e. primary or secondary forest with relatively few large trees) using bulldozer strip clearing, and the subsequent rapid establishment of sown (mainly signal/legume) or vegetatively propagated pastures (koronivia/legume) and sequential manual or chain saw clearing of inter-row bush over a period of 9–18 months.

A recurring problem was the failure of both estate and smallholder producers to balance their clearing programs against the area of pasture they could properly establish in the same season given their particular resource constraints (finance, labour, machinery). All producers need to realise that long term productivity from expensive improved pastures is jeopardised unless a vigorous, weed free grass/legume sward is established within the first year following planting.

We observed that the successful establishment of seeded grass and legume pastures was associated with the following conditions: (a) adequate seed bed; (b) good quality seed; (c) correct sowing rates; (d) even distribution of seed; (e) good soil/seed contact; (f) some timely chemical weed control; (g) no grazing until full ground cover was achieved.

Too often producers, mainly from the estate sector, failed to maximise returns to investment in improved pastures by neglecting the above, particularly (b), (c), (d), (e) and (g). Recommended seeding rates are available from seed merchants.

The successful establishment of pastures from vegetative cuttings was associated with the following conditions: (a) adequate supply of adjacent planting material; (b) checking of growth of existing pasture by cultivation or heavy grazing; (c) preferably use of rooted cuttings firmly planted into moist soil; (d) plantings on 1.0–1.5 m squares in the wet season; (e) no grazing until complete ground cover by sown species was achieved.

Weed Control

Vanuatu contains a vigorous and diverse weed flora. Frequently, excessive weed growth has reduced pasture and animal productivity in both estate and smallholder sectors. We observed that weed problems in pastures were usually the result of one or more of the following factors.

(a) *Clearing systems used.* There is often significant disturbance of soil following bulldozer clearing and this promotes the emergence of several problem weeds such as *Cassia tora* (pistache or wild peanut) and *Solanum torvum* (pico). These weeds are less troublesome following manual clearing.

(b) *Poor establishment of pastures.* When quick ground cover does not occur following sowing, due to either low seeding rates, poor seed or uneven distribution of seed, an environment is created for rapid ingress of weeds, causing subsequent management difficulties.

(c) *Overstocking of pastures.* Heavy stocking, especially during the establishment phase, and in some cases the use of rotational grazing, has created the opportunity for weed growth.

(d) *Low levels of soil fertility* which mitigate against vigorous pasture growth.

(e) *Excessive levels of shade* in smallholder plantations, selectively favouring broad leafed weed species and hindering pasture species.

(f) *The practice of burning coconut husks* in plantations, creating bare soil areas for weeds to occupy. Total removal of nuts from plantations for copra cutting; or field copra cutting and scattering of husks through 20–25 cm high, buffalo grass pastures (e.g. Ballande, Malakula), or the use of pulverising machines such as 'tritters' are several alternative management strategies.

WEED SPECIES

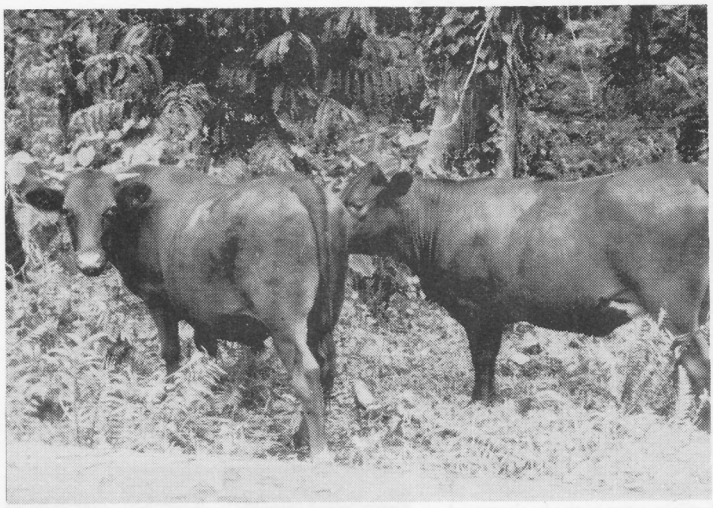
The following section summarises the major pasture weed species in Vanuatu and lists their occurrence and appropriate control measures for both estate and smallholder sectors. The survey showed that a small number of producers were adequately controlling weeds using a variety of methods but this information was poorly circulated.

Cassia tora (pistache, wild peanut) This weed is a major problem on many islands. On Efate, it has been controlled most successfully by the establishment of vigorous signal grass/glycine pasture with some spot

Embu grass under sparse old coconuts with buffalo grass in the background — Montmartre, Efaté.

Solanum torvum establishes readily on many bulldozer-disturbed soils and grows rapidly in the absence of vigorous pasture competition.

Mikania micrantha (mile-a-minute) is a major weed problem under young coconuts.



Smallholder heifers, 13.5 months old, and weighing 280-300 kg on Ambrym.

Overgrazing of carpet grass pastures (2-4 cm high) by smallholder cattle (about 3 AU/ha). Cattle being supplemented with *Hibiscus* from living fence.

spraying of 2,4–D (800 ml/200 litres of water). This concentration will not kill well established glycine or centro and is effective if applied at the 2–6-leaf stage of growth. Hand weeding is effective for small areas. Unfortunately, in many cases producers have waited until plants were in excess of 30 cm high when 2,4–D is not effective. Concentrated 2,4,5–T does not offer reliable control. In Fiji, large pistache plants are killed with Tordon 50–D or 75–T either by spray or rope wick application. Rope wick application has the advantage that it kills only the target weed touched and requires small volumes of water for preparation of the solution. In Fiji, in cultivated situations, pistache is effectively controlled by the pre-emergent herbicide metribuzin (Lexone) at 0.70 kg active ingredient (a.i.)/ha (Wallis et al. 1984).

Severe infestations of recently emerged *Cassia tora* under coconuts can be controlled by first spraying with 2,4–D at the above rates, followed by the establishment of buffalo grass at the beginning of the wet season. For open pasture areas, land should be cultivated and established to signal or koronivia grass following spraying of young seedlings.

Solanum torvum (pico) *Solanum torvum* is widely distributed and if uncontrolled, severely shades pastures and reduces their accessibility to livestock. Its presence is usually symptomatic of overgrazing and/or poor pasture establishment. Germination of pico is promoted by soil disturbance. In newly established pastures, pico is best controlled by spot spraying with 2,4–D Amine or Ester 80 (700–800 ml/200 litres of water) when plants are less than 50 cm high. Large thickets of pico are best controlled by slashing and spraying the young active leaf regrowth at the same rate. For smaller areas on both estate and smallholdings, pico plants may be dug out or cut stumps painted with 2,4,5–T in diesel.

Sida rhombifolia (Paddy's lucerne) The ingress of *Sida rhombifolia* into pastures usually occurs following overgrazing when bare soil is exposed. Although it is eaten to some extent by cattle, it is often a worse problem under a rotational grazing system. Scattered large plants are best hand pulled while young seedlings may be spot sprayed with 2,4–D (500ml/200 litres of water). In large dense infestations, slashing just prior to flowering followed by spraying of young active regrowth with 2,4,5–T (2 kg a.i/ha) is probably the most realistic option. Some producers feel that repeated slashing will reduce the vigour of this weed. As with control of all weeds, the establishment of vigorous robust grasses such as koronivia and buffalo is the best method of control. The planting of these grasses along laneways and in holding yards where overstocking is common will reduce the incidence of this weed.

Sida acuta (broom weed) Broom weed is potentially a greater pest than *Sida rhombifolia* because it is not eaten by cattle. Control can be effected by the spraying of young seedlings with 2,4–D (2 kg a.i./ha), or by hand weeding.

Stachytarpheta urticifolia (blue rat's tail) Blue rat's tail is a serious pest in pastures as it tends to form dense clumps which reduce pasture productivity. Hand pulling or spraying with a 2% solution of 2,4,5–T in diesel onto cut stumps may be effective. The chemical control of mature blue rat's tail requires further investigation.

Elephantopis spicatus (wild tobacco) Wild tobacco is a serious weed in pastures on Malakula and Ambrym. At Sarmette it has been suppressed by disc harrowing of weedy native grass pastures and the subsequent establishment of buffalo grass. This weed is not readily hand pulled and may be controlled when young by spraying with 2,4–D (2 kg a.i./ha). The chemical control of mature wild tobacco requires further investigation.

Lantana camara (lantana) Lantana is a serious weed problem on Tanna and Efate. It poses particular problems for coconut collection in plantations as well as for cattle which may be poisoned by grazing lantana. Mechanical control is only successful if the entire root system is removed. Control may be possible if the above-ground plant is cut, dried and burnt, followed by establishment of a vigorous grass pasture. Chemical control can be effected by spraying with dichlorprop (300–500ml/200 litres of water). For misting, 75 ml of 2,4–D Amine (Butoxone 50)/litre of water is effective. Basal bark applications of 2,4-D and 2,4,5-T in diesel (1% solution) are also effective.

Psidium guajava (Guava) Guava can be a major problem in rundown coconut plantations. Large plants are most effectively controlled chemically by injecting 2 ml of Velpar L (hexazinone) into the soil at the base of the plant.

Vitex trifolia This weed is a problem in the white grass area of Tanna. Control is currently only achieved by hand removal of all plant roots. It has a very extensive root system and suckers readily. Research is required into chemical control methods for this weed species.

Culphea carthagenensis (Tar weed) Tar weed is a problem on various parts of Santo and there are no locally proven methods of chemical control. Further investigation is recommended.

Mikania micrantha (Mile-a-minute) This weed species usually occurs in undergrazed pastures, especially under coconuts. The best form of control is by continuous grazing at the appropriate stocking rate, as *Mikania* is palatable to cattle and susceptible to trampling. It is also susceptible to spraying with 2,4-D (0.75 kg a.i./ha) but two applications 6 weeks apart are required. If *Mikania* is chemically controlled under very young coconuts it should be replaced with a vigorous legume cover crop such as centro, puero or calopo.

Ferns Various fern species including *Nephrolepis*, *Pteris* and *Blechnum* pose major problems for some smallholders. Species such as *Nephrolepis* should be hand pulled while rhizomatous species should be frequently brushed (every 6 weeks) or preferably dug out. The control of ferns in heavily shaded situations is difficult because of the poor growth and hence competitiveness of grass species.

Grass weeds *Paspalum paniculatum* comprises significant percentages of grazed swards on the Santo plateau and N. Efate (Siviri). At IRHO, *P. paniculatum* comprised 37% of a 15-year-old guinea pasture. It is less palatable than T grass and is a potential major weed species in mixed grass swards. Its spread may be associated with low available soil nitrogen. At Mon Biftek, koronivia grass, under heavy grazing (2.8 AU/ha) is invading *P. paniculatum*. Other locally significant weeds noted were:

Imperata cylindrica (blady grass) — Malakula, Tanna.
Miscanthus sp. (sedges) — wet areas e.g. Mele Plain, parts of Tanna.
Cyperus rotundus (nut grass) — scattered distribution.
Cyperus aromaticus (navua sedge) — wet areas, market gardens.
Synedrella nodiflora, Ageratum conzyoides, Emilia sonchifolia — recently disturbed or overgrazed areas.
Asclepias curassavica (gendarme — poisonous) — scattered distribution.
Elephantopis mollis (broadleafed tobacco weed) — scattered distribution.
Urena lobata — Tanna.
Crotalaria sp. (rattlepod) — Tanna.
Kleinhovia hospida (namatal) — recently cleared areas — only effective control is burning dry branches against stump.
Cassia occidentalis (large leafed cassia) — Santo.
Mimosa sp. (spiny mimosa) — Siviri, Efate.
Mimosa invisa (giant sensitive weed) — Malakula.
Amaranthus spirobus (spiny Amaranth) — VLD, La Cressonniere.

Soil Fertility and Chemical Composition of Pastures

SOIL FERTILITY

The Vanuatu archipelago consists of predominantly volcanic rocks, coral limestone plateaux and sedimentary terraces. Generally widespread volcanic ash deposits and climatic variations, associated with island alignment to prevailing southeast rain-bearing winds, have combined to produce a complex pattern of soil formation.

The major broad soil types for pastures are:

- shallow coastal soils formed from recently uplifted coral (rendzinas);
- interior soils on uplifted calcareous parent material of varying geologic age and volcanic ash input (ferrallitic);
- interior volcanic soils formed from lava flows, breccias, tuffs;
- relatively recent volcanic ash soils (andosols);
- alluvial soils.

The largest areas of grazed pastures are on Santo and Efate, on red-brown high clay ferrallitic soils (rich in iron oxides, kaolin and containing small amounts of gibbsite) and on rendzinas. During the survey, soil and plant samples were collected from a range of sites. A summary of the major soil fertility data is presented in Table 5 and discussed as follows.

Phosphorus Mean available soil P levels and associated mean pasture levels for each soil type are shown in Table 5.

The range of available P measured for the various soil types was as follows:

Soil Type	*Range of available P (ppm) (B.S.E.S. method)*
Volcanic ash soils	35–62
Alluvial soils	33–34
Coastal rendzinas	18–23
Interior soils on calcareous terraces	2.5–12
Volcanic lava soils	0–3

Mean pasture P concentrations did not correlate well with available soil levels although the ash soils had both highest available soil P levels and pasture P concentrations. In view of the predominantly alkaline pH range (6.8–8.2) further work is required to investigate other soil tests to define minimum soil P levels for pasture growth. For highly weathered, North Queensland soils (mainly of volcanic origin), a B.S.E.S. level of 15–17.5 ppm P is regarded as the critical minimum level to maintain stable legume component (Standley 1980; Bruce and Bruce 1972).

Table 5. Mean soil fertility data for major cattle-producing areas of Vanuatu.

				Phosphorus levels			*Nitrogen levels*		*Potassium levels*
Island	*Soil type*	*Broad location*	*O.M.%*	*Soil N (BSES P) (ppm)*	*Plucked pasture (%)*	*pH*	*Total soil N (%)*	*Plucked grass (%)*	*Plucked pasture (%)*
Efate	Red brown plateau clay soils (FR)	S,E,N	9.7	12.3	0.21	6.7	0.64	2.23	2.22(1.10–3.37)
	Coastal soils (R)		8.4	22.7	0.18	8.2	0.70	2.10	1.59(0.21–2.78)
	Dark brown clay soils (FS)	NW, Lelepa Moso	10.1	4	0.25	7.0	0.53	Mainly leucaena	2.19
	Alluvial soils	Mele plain	6.5	32.7	0.25	6.6	0.35	1.93	2.07
Malakula	Andic red-brown to brown plateau clay soils (FS)	NW	8.5	10	0.29	6.5	N.A.	2.0	1.8
	Andic alluvial soils	Central E	7.4	34	0.44	7.0	N.A.		2.2
Santo	Red brown plateau soils (FR)	E,S	7.7	2.4	0.25	6.5	N.A.	2.1	2.04(1.02–2.56)
	Coastal soils (R)		8.6	18.1	0.31	7.3	N.A.		1.54(1.02–2.19)
Pentecost	Volcanic soils	S	5.7	1	—	6.1	N.A.	2.1	1.95(1.15–2.47)
	Alluvial soils	S	9.2	5	0.28	6.4	N.A.		
	Karst plateau soils	Central N		3	0.31	6.8	N.A.		
Ambrym	Andosols	SE, SW	3.3	35	0.26	6.3	N.A.	2.1	2.1(1.36–2.64)
Tanna	Andosols	C, W	N.A.	62	0.38	6.7	N.A.	2.3	2.5(1.66–4.0)
	Volcanic soils	N		3		5.9			
Ambae	Andosols	SW	6.0	10	0.54	6.4	N.A.	2.1	2.83(2.23–3.67)

O.M. = organic matter determined by the method of Walkley and Black (Black 1965).
BSES P = plant available phosphorus extracted using 0.005 NH_2SO_4 (Kerr and Von Steiglitz 1938).
pH determined using 1 soil:5 water. Plant samples were treated with Kjeldahl digestion, N and P determined by autoanalyser and K by flame photometer.
Total soil N was determined following Kjeldahl digestion (Saffigna 1976).
N.A. = not available. Ranges of values quoted in parentheses.
Quantin nomenclature
FR = ferrallitic — red brown clay soils on plateau and terraces. R = Rendzina.
FS = fersiallitic dark brown, often cracking clay soils on uplifted limestone, higher base status than FR soils.
Andic = influenced by volcanic ash; Andosols — derived totally from volcanic ash.

Frequently ferrallitic soils on Efate (range of 0–57 ppm) and Santo (range of 0–15 ppm) had sown legume P concentrations of 0.24–0.27% P, which is generally regarded as optimal for growth of most legumes (Andrew and Robins 1969).

Generally on all soil types, P levels of less than 3 ppm were associated with sub-optimal P concentrations for in-grass and legume samples. Properties which extend onto volcanic soils derived from lava flows, breccias (Tanna, Pentecost) on andesitic or dacitic tuffs (e.g. parts of E. Rentabao, W. La Cressonniere, Toara — Matarisu) are likely to have long term improved pasture productivity limited by low P availability.

VLD soils near the Teouma escarpment had 2 ppm available P and grew glycine with 0.06% P in young tissue, whereas 2–3 km to the southeast the same plateau soils had 57 ppm available P and 0.17% P in plucked, dry season glycine. Clearly, in some instances, P nutrition as well as grazing management is implicated in the poor persistence of sown legumes. Furthermore, mean soil data support the view of

Quantin (1972–78) that ferrallitic soils east of the Teouma River (Rentabao Series) have higher levels of available phosphorus than those west of the Teouma (Vila Series).

Phosphorus levels on the Santo plateau (average 2.5 ppm) were considerably lower than for the Efate plateau (average 12.3 ppm) but this difference was not reflected in plant P levels. On Santo, lowest P levels were recorded at Mon Biftek, Sarunda, My Plantation and Leconte's property near Fanefo (0–1 ppm). On the southern and eastern border of the plateau, P levels were generally > 3 ppm.

The value of deep rooted legumes is illustrated by leucaena which had the highest recorded mean P concentrations in leaf (0.32% P) yet grew on low P soils (4 ppm on north Efate). Centro and puero appear to have a lower P requirement for growth than glycine and therefore may be more suitable for marginal P soils.

Nitrogen Total soil N levels for Efate (mean 0.59% N) are high and reflect the high soil organic matter levels (9.9%). Mele alluvial soils have the lowest organic matter (6.5%), total N (0.35%) and grass nitrogen contents (1.93%). From experience in the Pacific, maximum productivity of improved tropical grasses is usually associated with plucked leaf N levels of 2.1–2.3% N. In the survey, 49% of grass samples had N levels below 2.1%.

IRHO nitrogen trials on coastal and pleateau soils on Santo and fertiliser response observations on green panic swards (at VLD) indicate that improved grass productivity can be obtained by increasing N availability. This may be achieved through fertilisation (prohibitively expensive) or by the incorporation of vigorous legumes.

The influence of legumes on N concentrations of grasses is illustrated by the following results:

(a) a 5-year-old Rentabao signal grass pasture with 25% glycine showed 2.06% N in the wet season, while an adjacent low legume signal sward of similar age showed only 1.65% N.
(b) an 8-year-old Embu–glycine pasture on the Solway-Netting property on Santo showed grass N concentrations of 2.61% whereas grass only Embu swards at IRHO had only 1.21% N.
(c) 15-year-old guinea–glycine swards at PRV, Norsup, Malakula showed grass N concentrations of 2.27% N, whereas low legume guinea swards at IRHO of similar age had grass N concentrations of only 1.64%.

Nitrogen levels of improved grasses (particularly signal, Embu and guinea) were consistently lower than native and buffalo grass levels.

Potassium Soil potassium levels were not determined, but mean plant levels provide a useful index of K availability.

Mean pasture K concentrations were highest on Tanna ash soils (2.5%) and lowest on coastal coralline soils on Efate and Santo (1.5%). Acute K deficiency was recorded on coastal soils of Efate with soil depths of less than 8–10 cm (0.21–0.25% K in signal and buffalo grasses). In a wet area of Rentabao, Hamil pastures appeared K deficient and plucked leaf sample K concentrations (1.1%) were marginal. On VLD rendzinas, the application of 100 kg K/ha increased green panic K levels from 0.92 to 1.79%.

CHEMICAL COMPOSITION OF PASTURES

Protein The protein contents of 10% of grass samples were inadequate for animal growth (<9%). Protein contents of legumes declined in the following order: leucaena (32%) > glycine (21.3%) > mimosa (20.6%) > *D. canum* (17.6%). The protein content of *D. canum* was significantly lower on Efate than other islands.

Phosphorus Phosphorus contents of 19% of samples (mainly grasses) were limiting for maximum animal growth i.e. < 0.19% P. Further sites were below optimum for high-producing beef and dairy cows (<0.22% P).

Potassium Apart from two severely deficient sites on Efate, potassium concentrations in pastures were well above the critical minimum for animal growth (0.31–0.44%).

Calcium and magnesium Calcium levels were higher for legumes (particularly glycine, 1.25% Ca) than for grasses (0.30–0.60%). However, signal grass, glycine and carpet grass Ca levels at the Melektree dairy near Vila were marginal for growth and lactation requirements. There were no instances of magnesium deficiency.

Sulfur Sulfur levels were generally high reflecting continuing volcanic ash inputs into many soil types. However, signal grass on Efate frequently had S contents of 0.13–0.14% and such levels may limit animal intake and growth. Results for T grass confirmed its reputation as an accumulator of non-protein sulfur and leucaena levels of 0.75% are significantly higher than concentrations reported in Australia.

Sodium Buffalo grass and koronivia grass had extremely high mean Na contents of 0.65 and 0.19%, respectively. All other species, except green panic, were frequently sub-optimal (<0.07%) for animal growth requirements. Clearly, distance from salt spray is important, e.g. at VLD, 200 m from the coast, green

panic had 0.48% Na (mean of six sites) whereas on plateau soils, the average was 0.08% Na. A similar trend was noted with carpet grass on east Santo. It was the view of one Santo estate manager that plateau grazed cattle drink brackish water before fresh water when given access to both. IRHO has recorded average long term salt consumption rates of 30 g/hd/day.

Trace elements Copper levels are marginal on buffalo grass pastures at Norsup (6 ppm) and at Sarmette (8 ppm) on Malakula (recommended level in diet, 8–14 ppm). Mean iron, manganese and zinc levels of samples were 236, 74 and 55 ppm respectively (respective recommended levels in diet are 30, 10–20 and 12–25 ppm). Levels of cobalt, iodine and selenium in pastures have not been determined.

Production Sectors

SMALLHOLDER CATTLE

Numbers and distribution The 1983 Agricultural Census shows approximately 32 000 cattle in the smallholder and subsistence sectors. Subsistence cattle (5200 head) are regarded as those not held in a fixed enclosure. These figures indicate a threefold increase in smallholder cattle since the 1971 census and reflect the increasing interest of Ni-Vanuatu farmers in cattle ownership.

There are currently approximately 1900 smallholdings with an average herd size of 14; 86% of these units are under coconuts. Since there are around 16 000 coconut producers in Vanuatu, the potential for expansion of the coconut/cattle system is enormous. Most of the smallholder cattle can be found on Santo, Pentecost, Tanna and Malakula, but Ambae, Ambrym, Efate, and Tongoa also have significant numbers.

Husbandry In general, the standards of cattle husbandry are poor. Census data show that 75% of smallholder units have only one paddock (hence there is little segregation of weaners, growing cattle or breeding cows); only 41% of farmers have planted grass to improve feeding (usually only a small area of buffalo grass); 80% of holdings do not have permanent water (clearly a limitation to production in dry periods); and only 11% of units have stockyards to facilitate routine handling of cattle.

Reliable information on calving percentages was difficult to gather from most smallholders. A number of good managers recorded greater than 80% calving over 12–15-month periods. The presence of adequate feed, drinking water and most importantly, a bull, were reasons for this. The lack of bulls raises not only supply and distribution questions (e.g. Tanna and Pentecost), but also cultural problems. Bulls are large animals and hence, along with cows, cater best for big feasts. They also meet with sudden demise while trespassing on village gardens. The problems of lack of appreciation of the importance of active bulls seemed to be more acute where the extension service had been less active.

Local Illawarra-type cattle, provided not inbred, offer we believe the best maternal genotype for smallholders. A 12-month trial at IRHO (82/83) using young 'local' and 'local' × Charolais steers from various Santo plantations produced some of the highest recorded daily liveweight gains in Vanuatu (0.7–0.8 kg/hd/day). However, only a short trial period was used. There is a growing Santo smallholder demand for ¼ Brahman × local bulls from the government station, Mon Biftek. At this stage, government officers are not prepared to distribute greater than 25% *Bos indicus* bulls to smallholders due to animal temperament and management problems.

Marketing Poor access to commercial markets for farmers on outer islands clearly limits smallholder incomes from cattle and hence their desire to improve productivity. Census data show that in the year prior to the survey, only 28% of all cattle were sold alive while 45% were killed on the property and 27% were lost. Most of the 45% killed on the property would be for feasts and some would be sold in the community for meat. However, the figures show that the movement of live animals to the abattoir is quite low. There would be considerable scope for replacement of tinned meat by fresh meat at the village level if slaughtering was staggered and small quantities of beef were consumed quickly and/or refrigerated for later consumption.

Attitudes Within the smallholder sector, attitudes to cattle raising may be commercial, semi-commercial, or non-commercial. We found that attitudes to commercial cattle raising are largely determined by access to markets. Hence, Santo smallholders are the most commercially minded and have responded quickly to assistance from government livestock officers who have provided barge and road transport of cattle to the abattoir. Santo smallholders own 24% of the island's cattle and supply 20–25% of the abattoir throughput. This throughput has increased from 4% over the past 2 years, indicating the success of government extension and marketing programs. However, smallholders rarely supply export quality steers (about 17% of sales), indicating a lack of quality pastures and a regular water supply.

Some smallholders on Santo are now beginning to realise that the returns from labour input into cattle projects are attractive, especially if premium cattle are sold. Of the 50 smallholders on Santo regularly

serviced by the Government Smallholder Development Project under the supervision of the Regional Veterinary Officer since 1982, eight are capable of operating efficiently with no further assistance.

The non-commercial smallholders keep cattle as a source of beef for feasts, to control weeds under coconuts, for prestige and for a small cash income. These farmers generally have poor access to markets, and this acts as a disincentive to the adoption of improved techniques such as the planting of pastures, provision of drinking water and weed control practices. In this category, cattle management is secondary to copra production, village gardening and other culturally more important activities.

Pastures and grazing management The survey showed that smallholders generally had poorer quality and more weedy pastures than the estate sector. Pastures consisted mainly of naturalised carpet grass and T grass with small areas of buffalo grass. The poor standard of pasture was related to a lack of understanding of the importance of feeding, but also to the very high density of smallholder coconut stands (often 200 stems/ha). This density is too high for maximum copra production and the associated heavy shade means that native grasses, and to a lesser extent buffalo grass, have difficulty competing with weeds.

Most smallholders do not appreciate that shading reduces pasture growth and hence the number of animals that can be carried per hectare. For this reason, overgrazing of smallholder pastures was consistently more common under coconuts. Stock rates of 1–1.5 animals/ha under dense coconuts (25% light transmission) were observed. Such pastures have approximately 20–25% the growth potential of open pastures and hence should not be stocked at greater than 0.5 AU/ha. In addition, it was observed that farmers were not receptive to suggestions that coconut plantations should be thinned. Until these attitudes change, there is little that can be done to improve such pastures.

Many open pasture projects commenced understocked (about 1 animal/ha) and eventually became overstocked (3–4 animals/ha) as farmers failed to provide pasture paddocks to cater for the increased herd numbers. Frequently, cattle grazed in adjacent bush as a result, or in many cases, in bush within fenced paddocks. It is estimated that burao (*Hibiscus tiliaceus*) bush is capable of maintaining 0.4–0.5 AU/ha and along with associated creepers like *Merremia peltata*, *Mikania* and *Monstera* presents succulent forage which provides essential water intake. Smallholder cattle were more frequently set stocked than rotationally grazed.

Although buffalo grass occurs on 41% of smallholdings, these areas are usually small and there has been little recent effort to extend these areas. The highest proportion of buffalo grass was observed on Pentecost smallholdings. This may have been influenced by the presence of a well managed plantation at Lonorore which has a high proportion of buffalo grass planted. The lowest proportion of buffalo grass observed occurred on Malakula smallholdings although census data show a high level of initial planting occurred, perhaps reflecting the influence of the development assistance organisation SATEC. Buffalo pastures on all islands have consistently lower weed contents than carpet or T grass pastures. We recommend that buffalo grass continue as the preferred species under coconuts. However, for open pastures, koronivia grass is recommended. To facilitate koronivia plantings, it is recommended that koronivia, hetero and *Desmodium canum* be established in strategically placed nurseries (e.g. along the northeast coast of Santo), so that grass and legume material can be efficiently transferred to adjacent smallholders.

Mimosa was less common on smallholder pastures than on estate properties. *Desmodium canum* was the principal legume on smallholdings and higher proportions were observed on the high phosphorus soil types, for example, coralline soils, and the Pentecost and Tanna ash soils. Only one smallholder, Godden, on Pentecost, had sown legume in his pastures. We suggest that leucaena should be investigated for commercially oriented smallholders, and greater use should be made of pre-existing leucaena thickets.

The main weed species for smallholders are *Elephantopis spicatus* (wild tobacco), ferns, bush regrowth, *Mikania* and an inedible Convolvulacae creeper.

Management strategies The best smallholder cattle/coconut operations were seen on West Pentecost where coconuts are less dense, a higher proportion of buffalo grass has been planted, weed control is above average and water is available in most areas. *Desmodium canum* content was above average and cattle had the best average conditions of any island visited.

The best managed open pasture smallholdings occurred on Santo but only one had a significant area of improved grass (para grass). Smallholders at Malakula seemed to have particular problems, stemming from poor access to markets. The extension effort here has been marred by lack of continuity.

On Efate, smallholder cattle grazing pastures with a significant leucaena component had the best condition scores. Farmers recognised the value of leucaena in

carrying cattle through the dry season when no drinking water was present.

The affluence of Vanuatu village economies is largely determined by levels of copra produced. Tanna is notably poor because of the absence of coconuts (0.06 t copra/hd) compared with Malakula (0.5 t copra/hd) (Adam 1982). Improved cattle production along with coffee and vegetable production offers the best option for improving cash income.

ESTATE CATTLE

Numbers and distribution In 1983, there were 56 500 estate sector cattle in Vanuatu (almost entirely on Efate, Santo and Malakula), compared with 72 800 in 1971. During this period, cattle numbers on Efate increased by 21% to 23 200 head, whilst cattle numbers on Santo declined by 29% to 31 000 head. Cattle numbers on Malakula have remained constant at about 4000 head. On Efate, the greatest growth in cow numbers has occurred in a small number of large (greater than 500 breeders) properties. Bull/cow ratios have improved from 1:50 to 1:33 since 1971.

Marketing and production The estate sector is commercially orientated towards producing export quality steers and cull cows for the manufacturing trade. This sector is currently the mainstay of the export industry. Unfortunately, a large number of reproductive females have recently been slaughtered on Efate to fill export orders. In some cases fertile cows from overstocked estates were being slaughtered in preference to steers. In order to halt the decline of cattle numbers this practice has now been stopped by government officers.

From Santo abattoir figures, we found that 55.5% of estate steers grown on native carpet and T grass pastures reach premium quality with the best producer turning off 80% export quality steers. Average Vila output figures were not obtained, but the best commercial properties on Efate have significant proportions of improved grass/legume pastures and turn off 100% export quality steers.

Husbandry In the estate sector, there is tremendous variation in standards of pasture management, weed control and animal husbandry. From the data collected from estate properties, stocking rates were estimated as optimum levels for the various pasture types (Table 6). From these estimates it can be seen that several estate properties on Efate and Santo were overstocked during the 1984 dry season. For example, in August 1984, VLD carried approximately 2.6 AU/ha on degraded improved pastures and buffalo grass pastures. In September 1984, SFV at Mawutor grazed cattle under old coconuts at 2.5–3 AU/ha and this resulted in calving percentages of approximately 50%.

Table 6. Stocking rates in relation to pasture type on estates in Vanuatu. (IRHO trials indicate that mean dry season production of the grasses described in this report is 54% of wet season production.)

	Suggested optimum stocking rates (AU/ha)	
Pasture type	*Wet season*	*Dry season*
Open native pastures	1.6–1.8	1.2–1.4
Buffalo grass & native pasture in moderate shade	1.3–1.5	1.0–1.2
Improved grass/legume pastures	2.5	1.8–2.0
Degraded improved pastures	2.2.–2.5	1.5–1.7

On Santo, one estate producer with open carpet grass/*Desmodium canum* and mimosa pastures has increased calving percentages from 40 to 77% in a three year period by maintaining average stocking rates at about 1.8 AU/ha, hand pulling of weeds, the introduction of new young Brahman crossbred bulls and converting to seasonal mating.

In herds with uncontrolled mating (often associated with overstocking), there appeared to be an August–October calving peak which may reflect anoestrous during the previous dry season. Most producers felt that January–February born calves were adversely affected by the wet season. Nationally, calving percentages in the estate sector ranged from less than 40% (brucellosis affected herds), to greater than 85% in the case of two herds on Efate grazing improved grass/ legume pastures at near optimum stocking rates.

The issue of animal husbandry and particularly herd fertility in Vanuatu is being addressed in detail in a longer term study of all production sectors by Veterinary Officer, Ms Katrine Bazeley.

Most estate managers interviewed indicated a desire for some *Bos indicus* blood in their herds. They valued local cattle as dams provided they were not inbred. Currently all high grade Charolais bulls from IRHO are being readily sold and all VLD and Mon Biftek ½ Brahman cross bulls are finding a ready market in the estate sector. In addition, a number of estates on Efate are selling Brahman cross bulls. During the first half of 1984, VLD sold 15 Brahman cross bulls, but ultimately, VLD is projected to produce 150 selected bulls (mainly Brahman cross) per year which would be capable of servicing 25 000 to 30 000 cows (Seifert 1984).

Pastures Only a small proportion of the estate plantations have improved pastures (other than buffalo grass) and these are located mainly on Efate (approximately 3000 ha). However, most estate managers interviewed expressed strong interest in pasture improvement on their properties. This was found to be

associated with the availability of leases, improved copra prices, and improved abattoir prices for export quality cattle. There appears to be growing confidence in the industry and a commitment to pasture improvement in order to obtain high levels of production and improve profitability. It is appreciated by all that the supply of good quality cattle to the abattoirs is vital to the consolidation of existing export contracts.

We recommend that informed technical support should be available to producers wishing to expand their areas of improved pastures. This will ensure that maximum benefit is obtained from the considerable investment necessary to establish improved pastures. In the past, the importance of maintaining a vigorous legume component with improved grass has not been widely appreciated.

NI-VANUATU PLANTATION CATTLE

Three Ni-Vanuatu plantations were visited — Lonorore and Sandling on Pentecost and Leroux on Santo. Managers from both plantations on Pentecost had received basic business management training through the management training course at Montmartre.

For Ni-Vanuatu plantations (generally set up on abandoned estates) to succeed commercially, the following will be required:

- Better knowledge of pasture management, weed control, grazing management and animal husbandry. This could be significantly addressed through upgrading the technical side of the Montmartre course, which offers an excellent service, given its resource constraints. The Plantation Support Association, under active and professional management, intends to provide technical and management advice and physical inputs.
- Clearly defined leases and stable tenure and an enthusiasm for improved animal production and pasture improvement.
- Use of copra income to finance coconut replanting and pasture improvement.
- Reliable access to intra-island and inter-island markets.

INTERRELATIONSHIP BETWEEN SMALLHOLDER AND ESTATE SECTORS

The expansion of the beef industry in Vanuatu requires that a close economic relationship be fostered between the estate and smallholder sectors. Both sectors are critical to the successful development of an export beef industry which requires both quantity and reliability of production, i.e. the industry needs a minimum critical size to be viable.

Clearly it is government policy to promote smallholder involvement in the developing beef industry, but in the short term a healthy estate sector is vital to the long term success of the smallholder sector. Most of the export beef is presently produced by the larger plantations, and this should be encouraged so that existing markets can be consolidated.

The current contribution of commercial smallholders to beef exports is small, and should increase slowly over an extended period as extension of improved techniques becomes more effective. As mentioned earlier in the report, poor accessibility to the abattoirs on Efate and Santo is a major and costly problem for cattle producers on outlying islands. In addition, the dense coconuts, associated poor quality pastures and lack of water supply on most smallholdings make it difficult for farmers to produce premium beef.

It is therefore strongly recommended that smallholders concentrate on breeding weaners for the estate sector, which has the resource to fatten quickly to export quality on high quality improved pastures on Santo and Efate. Naturally, some of the more commercially-minded smallholders on Santo and Efate will also be able to participate in fattening operations.

This suggestion has several advantages:

(a) Breeding of young stock is compatible with the poorer quality pastures under coconuts found on most smallholdings.
(b) Barging and road transport of young stock will be more economical than transport of mature animals.
(c) Barging of fat cattle would incur substantial price penalties through bruising.
(d) Excess young animals can be quickly turned off from overgrazed smallholdings and this is likely to improve the nutrition of cows and hence calving percentages.
(e) Cow/calf operations are less complicated than breeding/fattening operations.
(f) Weaners and store cattle can then be fattened on farms close to the abattoirs reducing subsequent transport costs and bruising.

For this proposal to work effectively, the following recommendations need to be implemented:

(a) Entrepreneurial estate managers must have improved pastures available for a fattening operation.
(b) A network involving road and barge transport as well as collection centres on outer islands within economic barging distance must be established. It would be preferable for the private sector rather than the Vanuatu government to operate inter-island barging of weaners and store cattle.
(c) Smallholders must be adequately remunerated for their stock to create a positive incentive for the sale of young stock. At present, payments made to

smallholders for young stock seem too low with the result that farmers are encouraged to hold their animals through to maturity in an attempt to achieve the higher abattoir prices.

Since there are large areas available for improved pasture development, particularly on Santo, there is likely to be rapid expansion in cattle fattening on improved pastures, and this should increase the price paid for stock from outlying areas and from Santo smallholders. Thus we predict a fairly direct and immediate benefit to smallholders when pasture improvement in the estate sector creates a demand for young stock from the smallholder sector.

In conclusion, it is stressed that although the estate sector is most likely to benefit initially from pasture improvement activities, the viability of the smallholder units depends largely on the vigour of the larger plantations. Financial benefits will most certainly flow though to Ni-Vanuatu producers in time as their motivation, management expertise and opportunity for commercial cattle raising increases, a process which is already very apparent on Santo where livestock extension has been more successful than elsewhere in Vanuatu.

Recommendations for Future Pasture Development

Many of the recommendations contained in the text of the report for pasture establishment, grazing management and weed control have immediate application to all sectors of the industry and can be disseminated without delay by the Extension Service. In addition, the survey has highlighted a number of important gaps in our understanding which clearly need to be investigated. We suggest that a solution to these problems via a well directed research effort will have a significant practical pay-off.

To facilitate our recommendations, we strongly suggest that a pasture improvement unit be established in Vanuatu with research, extension and training responsibilities. This would involve the stationing of a long-term pasture agronomist and an animal production officer in Vanuatu with the broad objectives of increasing the rate and quality of turnoff of cattle from Vanuatu pastures via a practical farm-oriented program. This strengthening of pasture improvement effort will complement existing Department of Agriculture, Livestock and Forestry initiatives to improve the marketing, animal husbandry and breeding of beef cattle. The elements of the proposed program are summarised below.

Research Program

Some important areas requiring further research, and possible sites, are listed as follows:

(a) evaluation of methods of pasture establishment with a view to reduction of weed invasion;
(b) evaluation of alternative twining legumes such as centro and puero for use with signal grass, hetero for use in smallholder grass pastures, and puero as a cover crop to control weeds in young coconuts;
(c) evaluation of the animal production potential of signal + leucaena, koronivia + hetero/twining legumes and guinea + twining legumes (VLD plateau soils);
(d) evaluation of methods of incorporating *Leucaena* into buffalo grass pastures and estimation of their productivity (PRV, Malakula);
(e) investigation of the effectiveness of various chemicals, with and without buffalo grass competition, for the control of *Elephantopis spicatus* (Malakula, Ambrym, Pentecost);
(f) evaluation of integrated biological/chemical weed control packages for the control of *Sida* spp, *Stachytarpheta* sp. and *Culphea* sp. (Soleway-Netting property, Santo);
(g) evaluation of methods of control of *Vitex trifolia* on Tanna;
(h) continued pasture and soil fertility monitoring in the major cattle areas.

Assistance to Extension Service

Support for the existing Livestock Extension Service should involve:

(a) establishment of on-farm demonstrations;
(b) provision of technical information to extension officers;
(c) assistance with the production of various graded extension packages involving slides, posters, pamphlets and management handbooks.

DEMONSTRATIONS

Extension officers, livestock officers and veterinary officers and pasture/animal production specialists need to identify motivated, community-involved contact farmers. On-farm demonstrations should be set up and field days should be conducted to highlight the differences in animal production, pasture quality and weed control achieved when recommended techniques are adopted. This approach applies to all production sectors.

Key demonstrations might illustrate, for example:

- establishment of koronivia/hetero/*D. canum* into newly cleared areas (East Santo);
- the value of buffalo grass planting under coconuts in

suppressing weeds and the effect of thinning coconuts in promoting buffalo grass growth (Ambrym, Malakula);

- the liveweight gain potential of leucaena hedgerows planted into existing pure grass pastures (Efate).

INFORMATION

Pasture/animal production specialists should provide information for extension packages, lectures for extension officers, extension assistants, livestock officers, veterinarians, secondary school students, agriculture teachers and talks/discussions with interested producer organisations such as the Plantation Support Association.

EXTENSION PACKAGES

Extension packages should contain appropriately detailed technical information presented in visual displays, slides, management handbooks and pamphlets. New packages would be designed to complement extension packages already in use.

Support for Agricultural Training Institutions

An important facet of the overall pasture program should be to provide course material, curriculum development assistance and where appropriate, specialist topic lectures for Tagabe Agricultural Training School, Malapoa and Matevulu High Schools, Montmartre Training Centre and Navota Farm Mission School. All these schools have livestock courses in their curriculum, and we suggest that they should have access to the most recent pasture improvement information for incorporation into these courses. Furthermore, lectures given to all secondary schools throughout the country will promote the wider dissemination of information and better understanding of the importance of pasture improvement. This would ensure a long-term impact on beef production in Vanuatu.

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Appendices

Appendix Table 1. Smallholder and estate (including Ni-Vanuatu plantations) cattle numbers by island (1983 census).

Island	*Estate*	*Smallholder*	*Subsistence*	*Total*
* Ambae	388	1 600	605	2 593
* Aore	3 532	0	0	3 532
* Santo	30 888	8 916	887	40 691
Maewo	0	574	80	654
Malo	2 115	780	181	3 076
Mere Lava	0	0	0	0
Mota	0	31	0	31
Mota Lava	0	23	6	29
Gaua	0	275	40	315
Torres	0	100	0	100
Ureparapara	0	0	10	10
Vanua Lava	0	298	20	318
* Ambrym	0	1 353	250	1 603
Lopevi	0	0	0	0
* Malakula	4 255	2 843	975	8 073
Paama	0	236	40	276
* Pentecost	1 469	3 642	595	5 706
* Efate	23 165	870	200	24 235
Emae-Makura	0	171	20	191
Emau	0	21	10	31
Epi	700	707	202	1 609
Nguna-Pele	0	21	10	31
Tongariki	0	10	5	15
Tongoa	0	893	320	1 213
Buninga	0	0	0	0
Mataso	0	0	0	0
Anatom	0	98	20	118
Aniwa	0	6	0	6
Erromango	0	262	50	312
Futuna	0	7	0	7
* Tanna	0	3 109	677	3 786

* Islands visited/surveyed.

Appendix Table 2. Properties visited/sampled during survey of Vanuatu pastures, September–December 1984.

Efate (E)

E1 VLD — Man. Fred Kleckham — Government Breeding Farm
E2 Montmartre — Charles Rogers — Ni-Vanuatu management training school and farm
E3 Melee — Kaloas Malaas/Kalulu — Cooperative
E4 Klemm's Hill — Vareapaga Community Project
E5 Magalulue — Jean Baptiste
E6 Siviri — Community Project — Edwin Aidhur
E7 Harris Plantation, Undine Bay
E8 Paonangisu — Esly — family project
E9 Nasinu — Amos — family project
E10 Matarisu — Toara — family project
E11 Malarip — John Morris — community project
E12 Eton — La Cressonniere — Pacific Grazing Co. — Keith Putt
E13 Eton — Robert Bruce — family project
E14 Eton — Tom Lorry — family project
E15 Rentabao — Elbee Development Co. — Joe Ernst
E16 Rentabao — Jacques Perronnet
E17 Rentabao — Yannick Milne
E18 Melee — Melektree Dairy — Jacques and Claude Nicholls
E19 Pukura — Claude Mitride
E20 Pointe du Diable — Mr. Laurent
E21 Tukutuku — Tukutuk — Andre Ali
E22 Lelapa Island — Chief Jack Norton
E23 Tagabe Agricultural School

Malakula (M)

M1 Norsup — PRV — Gabby Grilhault des Fontaines
M2 Sarmette — Ballande — Jean-Marc Riss
M3 Mbatambong — Stephen Willie
M4 Tchinetra Wala — Gilbert
M5 Nuatakh — Stilio Anwatek
M6 Branwe — Stephen Reuben
M7 Lakatoro — Agriculture Station
M8 Unmet — Veedle

Santo (S)

S1 Navota Farm — David McFarland
S2 Best Bay — Peter Morris
S3 Terre Rouge (Peyrolle) — Yves de Somerville
S4 Solway — Netting — Jacques Perronnet
S5 Leeman —
S6 Copravi — Mr. Elziere and Jean-Paul Savoir
Canal
Sarunda
Saroutou
Mawotur
S7 Chapuis — Mon Biftek
S8 Boularou — Abraham Gaua/Gubbay
S9 Fanefo — Leconte
S10 Palari — Bulebau
S11 My Plantation — Peter Colmar
S12 IRHO — Andre Calvez; Pascal Estragnat
S13 Matevulu School — Barry Werrick
S14 Turtle Bay — Shaen Egan
S15 Coulon, Shark Bay — Shaen Egan
S16 Koleu — Warren Nisa
S17 Lorethikarkar — Lawrence Wells
S18 Hog Harbour — Silias Gare

Continued

S19 Hog Harbour — Mara Williams
S20 Port Olry — Pierre Neveservette
S21 Port Olry — Gauloir Aru
S22 Leroux — Robert Nafoui

Aore (A)

A1 Port Lautour — SDA Mission
A2 Ratard — Dick Kerr

Aoba (Ao) (Ambae)

Ao 1 Vatu Tavui — Paul Maeto
Ao 2 Nasne — Wilson Tavuti

Ambrym (Am)

AM 1 Yanbili — Chief Jack Martin
Am 2 Pantenum — Lesley
Am 3 Utas — Jimi Ansen
Am 4 M Bareas — Patrice
Am 5 Endu — Boad
Am 6 Yeleva — John Morrison
Am 7 Sesivi — Marcel

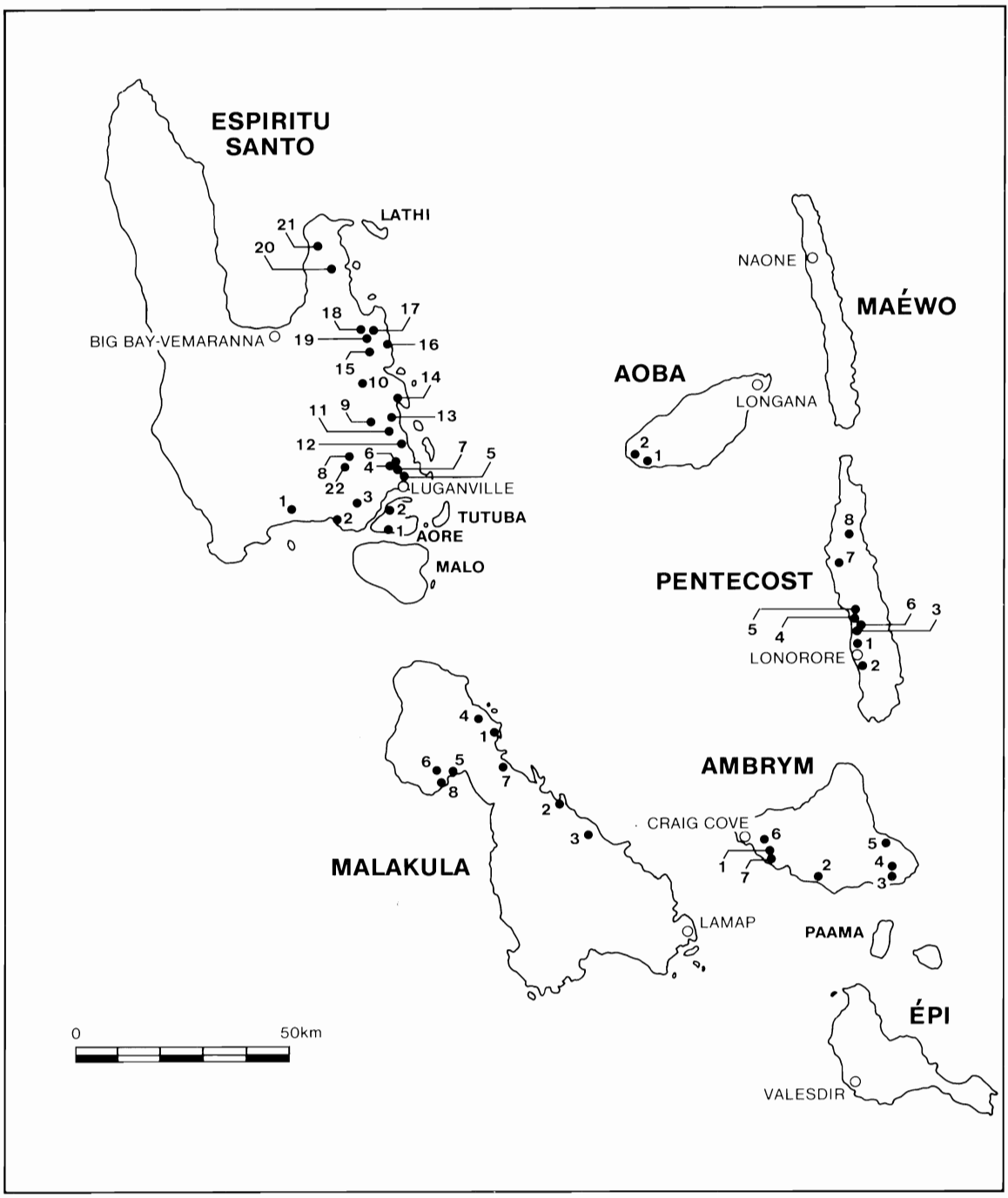
Pentecost (P)

P1 Lonorore Plantation
P2 Hotwata — Sandling Plantation
P3 Ruruwo — Joseph
P4 Vanvat — Morris Tabi
P5 Vanvat — Ray Tabi
P6 Vanvat — David Dungu
P7 Batnavne — Godden
P8 Wambagam — Alick

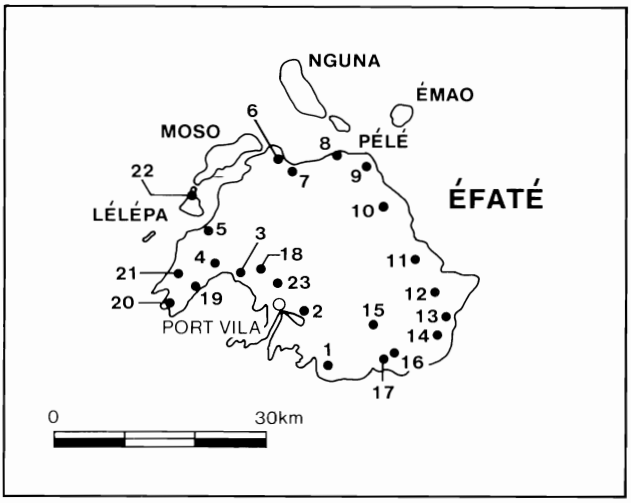
Tanna (T)

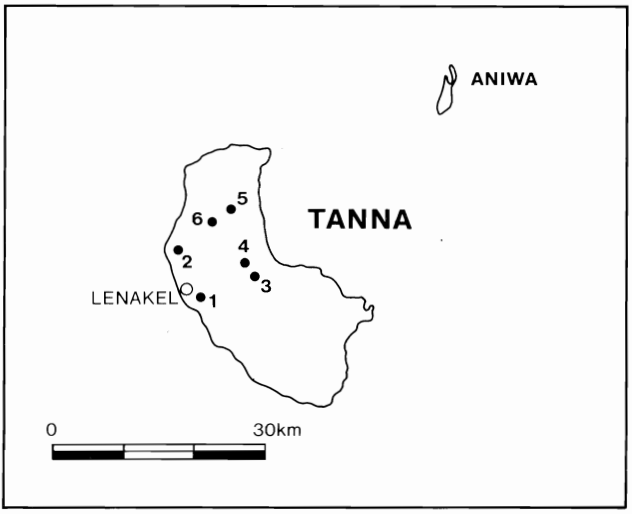
T1 Lobrmat — Peter Iasul
T2 Loanpakel — Kopalu — Whitegrass
T3 Ikeupow — Bob Kieng
T4 Lamlu — Noklam
T5 Enuahrat — Kaso Yatka
T6 Lewpukas — Moses

Appendix 3a. Map 1. Location of survey sites on Santo, Malakula, Ambrym, Pentecost and Aoba (Scale 1:1 270 000).



Appendix 3b. Map 2. Location of survey sites on Efate and Tanna (Scale 1:500 000 — from Quantin 1982).





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