Standardisation between livestock classes: the use and misuse of the stock unit system

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Abstract

The stock unit (SU) system is used extensively in New Zealand agriculture. These applications include inter- and intra-farm comparisons, rural lending and valuation, and farm system design and analysis. The livestock classes and performance levels to which SU conversion factors are applied has increased significantly since Professor Coop defined the ewe equivalent (EE) system, and now includes deer, goats and other non-conventional livestock species. This has led to a proliferation of SU values and their incorrect application and interpretation, especially in between-farm comparative analysis. Benchmarking provides a more economically rational way of improving the profitability of livestock farms than the use of standards based on SUs. Obtaining agreement on the specifications of animal-pasture-financial models to allow users to derive substitution rates between stock classes according to their farm's resources and management practice is preferred to publishing national standards for SUs.

Keywords: comparative analysis, livestock classes, standardisation, stock unit

Introduction

The stock unit (SU) system is used extensively in New Zealand agriculture and its associated service industries. These applications include inter- and intra-farm comparisons (Fitzharris 1982; Baker 1993), rural lending and valuation (Valuation New Zealand (VNZ) six-monthly reports), farm monitoring and policy advice (MAFPol 1994), enterprise analysis by gross margins (Fleming & Burtt 1991) and farm system design and analysis (e.g., Keeling *et al.* 1991). The range of livestock classes to which SU conversion factors are applied has increased significantly since Coop (1965) defined the ewe equivalent (EE) system, and now includes deer and goats (Donaldson 1987), and other non-conventional livestock species. In addition, the range of productive performance within the original sheep categories has changed substantially, and this perhaps, more than the greater diversity of livestock species, has led to a proliferation of SU values and inconsistencies between end-users in their application and interpretation (Crawford & Anderson 1994). Not surprisingly, SUs have become a point of debate amongst farmers and in the rural service sector.

This paper considers the standardisation of the SU system by: reviewing its development, describing the modifications made for greater liveweight ranges and productive performance, and outlining the economic principles behind standardisation. Limitations of the SU system and the potential to resolve these are discussed.

Evolution of the system in New Zealand

Crawford & Anderson (1994) reviewed the history of livestock standards and the SU system in New Zealand. In brief, the SU concept was first reported by Fawcett & Patton (1929) as a means to assess economic performance in agriculture. Some 30 years later Hutton (1954) defined SUs for measuring the carrying capacity of farms in Waipa County (Table 1). Jackson (1963) subsequently used these standardisation factors to assess the productivity of different pastoral areas in New Zealand. The major breakthrough occurred in 1965 when Coop defined the "standard ewe" upon which the SU system is based as:

> ... 54.4 kg in the autumn at mating and gains weight by 2.3 kg per annum …. It enters the breeding flock as a 45.3 kg two tooth and leaves it as a 59 kg ewe some six years later. The mean flock lambing percentage is taken as 100%, so this ewe will have a single lamb, which will be weaned at 22.7–27.2 kg liveweight at 3.5 months of age. The ewe's lactation will be 113 kg milk ... It will be shorn once in summer.

This ewe consumed 815 lb pasture of 62% DOM (approx. 595 kg DM) per year, based on feed requirements published at that time. These were derived mainly from indoor trials, with notional adjustments for

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grazing and walking activity under pastoral grazing. The limitations of the ewe equivalents (EE) (Table 1) derived from these data were acknowledged: "... [the EE] must therefore be regarded as approximates … additional sources of error arise from the effects of the environment ..." He further elaborated on the "EE figures" in an address to the Canterbury Chamber of Commerce (Coop 1967). In particular he suggested they: provided a measure of what livestock was, rather than could be, carried; could be applied to assess productivity of different farms or land classes, and used as a "rough guide" to determine relative carrying capacity of different stock classes and for land valuation.

The SU values were extended by Scott & Adam for the Cornforth & Sinclair (1984) fertiliser recommendation model and were informally reviewed by the New Zealand Meat & Wool Board Economic Service (NZMWBES) in 1992 to reflect the changed circumstances and greater diversity of pastoral systems now in use (Crawford & Anderson 1994). Donaldson (1987) commented on SU standisation and included a table of conversion factors for goats. He also referred to the unit production assessment (UPA) method developed by King (1982) to compare properties classified by soil type. King integrated productivity with SU values, but his system enjoyed only limited local adoption.

The SU system has not been widely embraced by New Zealand dairy farmers, possibly because fewer species and classes of livestock are managed than on sheep and beef cattle properties. Nevertheless Holmes (1998, pers. comm.) in the mid-1980s, in response to misleading use of the "sheep SU system" in dairying, proposed a system of standardisation for the dairy cow based on a Jersey cow weighing 350 kg, producing 150 kg milkfat (260 kg milksolids (MS)) and consuming 3.23 t DM/year. Relative to this, a Freisian cow weighing 450 kg, producing the same MS and eating 3.72 t DM/year, was equivalent to 1.20 "Dairy Stock Unit (DSU)". Holmes *et al.* (1989) later tabulated the annual feed requirements and stocking rate (cows/per 10 t DM eaten/ha) for Jersey and Freisian cows ranging from 350 to 425 and 400 to 550 kg liveweight, respectively, and producing between 140 and 220 kg milkfat (244 to 383 kg MS) per lactation. These data indicate breed substitution rates, but even more usefully, anyone wishing to evaluate dairy systems could access the same spreadsheet (Brookes *et al.* 1993) and generate feed consumption estimates for any management, cow liveweight and MS production combination. The most widely applied livestock standard in New Zealand dairying is the "base" dairy cow for measuring genetic progress. This is defined as an average New Zealand cow (403 kg mature weight, born in 1985) and her replacement (approx. 20%) consuming 4500 kg DM (of 10.5 MJME/kg DM) per annum and producing 317 kg MS (Garrick *et al.* 1997).

Table 1 Examples of the variation in stock unit conversion factors reported in different sources. (Adapted from Crawford & Anderson 1994).

Stock Class	Hutton (1953/54)	Coop (1965/67)	NZMWBES (1992)[a]	MAF (1993)[b]	Lincoln (1991)[c]
Ewes	1.0	0.8–1.1	1.0	1.0	0.65–1.45
Hoggets		0.6	0.7	0.6–0.7	0.7–1.2
Rams	0.75	0.8	0.8	0.8	1.0
Beef cows	5.5	6.0	5.5	6.0	3.7–6.3
Heifers	4.0	4.5	4.5	4.5–6.0	4.5–6.0
Weaners	2.0	3.5	3.5	4.0	3.5
Hinds			1.9	1.9	1.9
Other deer			1.8	1.2–1.8	1.2–1.8
Stags			2.1	2.2	2.1
Goats 1 yr +			0.8	0.7	
Goats 1 yr			0.5	0.7	
Dairy cows	5.1–6.9	6.5–8.5		7.0	4.6–9.0

[a] New Zealand Meat and Wool Board's Economic Service, Wellington.
[b] SU values used in the MAF Policy Farm Monitoring Reports.
[c] Figures quoted in the Lincoln University Farm Technical Manual (Fleming & Burtt 1991).

Case studies of sheep systems: SU conversion factors

Garrick (1994) explained why the SU system is not a good measure of the efficiency of flocks across farms with different ewe sizes and lambing performance (lambs tailed/ewes mated). His SU conversion factors for 10 kg and 20% increments in liveweight and lambs tailed per ewe mated, respectively, are summarised in Table 2. The base ewe was assumed to weigh 55 kg (pre-mating), wean one lamb at 25 kg and consume 550 kg DM per annum. Feed consumption for the other ewe "types" was calculated using the Brookes *et al.* (1993) spreadsheet model of sheep feed requirements. Seasonal variation in "SU equivalents" increases with ewe performance (Table 2). This effect, as discussed later, impacts on both pasture production and feed quality (Romero-Garcia 1998). Garrick (1994) derived the extra revenue (or marginal value product (MVP)) for liveweight x performance combinations to illustrate that increasing performance per SU through heavier and more prolific ewes was not necessarily the economically optimum strategy for a farm (as implied in most extension addresses on ways to improve sheep farm profitability). Garrick's data were updated for 1998 costs and prices using the Parker *et al.* (1998) sheep enterprise model to show that flocks with identical SUs (n=1818) and GM could comprise 1452 (55 kg, 140% lambing); 1245 (65 kg, 160% lambing), or 1097 (75 kg, 180% lambing) ewes. The extra value per kg while reducing ewe liveweight from 55 to 45 kg and maintaining 100% lambing was $7.40, whereas increasing lambs tailed from 100 to 120% with 55 kg ewes generated $5.55 per 1% change in lambing. Thus, between farm comparisons based on SUs (or kg liveweight/ha) do not adequately show the economic effects of varying ewe liveweight and prolificacy. Similarly, Crawford & Lowe (1994) queried the suitability of the SU system for comparing the profitability of beef cattle policies, especially in terms of the higher marginal cost of winter versus spring pasture.

Table 2 Stock unit conversion factors derived from a spreadsheet feed requirements model for ewes of different liveweight and prolificacy (Number of lambs tailed to ewes mated; NLT/EM). The seasonal feed requirements relative to winter are shown for a sub-set of the ewe size – prolificacy data (Source: Garrick 1994).

		Ewe liveweight (kg, pre-mating)			
		45	**55**	**65**	**75**
	80	0.82	0.93	1.03	1.14
Prolificacy	**100**	0.86	0.98	1.08	1.19
NLT/EM(%)	**120**	0.90	1.02	1.13	1.24
	140	0.94	1.06	1.17	1.28
	160	0.98	1.10	1.22	1.33
	180	1.02	1.14	1.26	1.37
	200	1.06	1.19	1.31	1.42
Spring	**100**	1.29	1.22	1.17	1.13
	120	1.32	1.24	1.19	1.14
	140	1.35	1.26	1.21	1.16
	160	1.38	1.29	1.23	1.17
Summer	**100**	0.79	0.78	0.77	0.76
	120	0.74	0.73	0.72	0.72
	140	0.70	0.69	0.69	0.68
	160	0.67	0.66	0.65	0.65
Autumn	**100**	0.72	0.73	0.73	0.73
	120	0.68	0.69	0.69	0.70
	140	0.65	0.65	0.66	0.76
	160	0.62	0.63	0.63	0.64

Amer & McEwen (1998) also calculated the number of ewes that a farm could carry of different body size and prolificacy. The feed supply was fixed for all options, but different pasture utilisation rates were applied to sheep classes. Feed requirements were derived from Geenty & Rattray (1987). Amer & McEwen's substitution rates relative to a 55 kg ewe (pre-mating) with 100 lambs tailed/100 ewes mated are shown in Table 3. They commented that their SU values were probably over-estimated for highly prolific flocks because increased losses of triplet and higher multiple-born lambs reduce late spring-early summer feed demand.

Table 3 Estimated SU conversion factors for ewes of different liveweight and prolificacy (derived from Amer & McEwen 1998).

		Ewe liveweight (kg, pre-mating)				
		55	**60**	**65**	**70**	**75**
	90	0.94	0.97			
Prolificacy	**100**	1.00	1.03	1.06		
NLT/EM(%)	**110**	1.06	1.09	1.12	1.15	
	120	1.12	1.15	1.18	1.21	1.24
	130	1.18	1.21	1.24	1.27	1.30
	140		1.27	1.30	1.33	1.36
	150			1.37	1.40	1.43

Table 4 Stock unit conversion factors estimated from a STOCKPOL analysis of a whole farm system for a Romney (Rn × Rn), East Friesian (EF) × Rn crossbred and an East Friesian (EF × EF) flock on medium to steep lower North Island hill country (Source: Romero-Garcia 1998).

	Rn × Rn	EF × Rn	EF × EF
Wintering nos.			
- Ewes	1455	999	686
- Ewe hoggets	455	310	214
- Rams	20	14	9
Lambs weaned (%)			
- Ewes	117	138	230
- Ewe hoggets	-	80	100
Ewe liveweight (kg)	52	67	80
- kg sheep/ha	283	252	208
Stock unit (SU) factors			
- Ewe	1.00	1.25	1.54
- Ewe hogget	0.73	1.06	1.14
- Ram	0.88	1.01	1.12
Pasture production			
- kg DM year	6683	6452	6233
- Utilisation (%)	89.6	87.9	84.6
Wool production (kg/yr)	8408	6048	2793
Lambs sold (n)	1221	1392	1552
- lamb cwt (kg)	20.9	29.0	34.7

Romero-Garcia (1998) used STOCKPOL (Marshall *et al.* 1991) to derive SU equivalents for a Romney ewe (Rn × Rn), a heavy highly prolific ewe breed (e.g., East Friesian, EF × EF), and a cross of the two (EF × Rn) (Table 4). In constrast to Garrick (1994), this analysis incorporated the whole farm and therefore the interaction between the sheep and cattle (fixed) policies and pasture production. Annual pasture production was 3.5% and 6.7% less for the EF × Rn and EF × EF ewe systems than the Rn × Rn option, primarily because of the lax grazing associated with more lambs and fewer ewes during summer and autumn (as shown also in Table 2). In practice, a farmer would probably take steps to improve pasture utilisation as flock prolificacy increased, such as raising the proportion of cattle, or selling more lambs store pre-Christmas. The viability of these options could be quantified with STOCKPOL. The important issue here is that direct application of SUs to the breed comparison would not have highlighted their effects on pasture productivity/quality.

Comparative analysis and farm standards

The SU system is used extensively in comparative analysis to identify farm problems and opportunities (e.g., Baker 1993). The analysis is commonly reported as the 'top 10%' vs. the "rest", or "low" "medium" "high" groups (NZMWBES 1989), and is thus used to indicate areas for farm improvement. Essentially, the comparison of farm systems occurs at two levels: within farm across years (or between plans within a year); and across farms (both within and across years). To facilitate comparisons between enterprises, standards, such as those generated through the application of SUs, have been developed. Standards are the average values for a range of production and financial characteristics, and maybe quoted as actual values (e.g., gross farm income ($)), ratios (e.g., kg wool/su) or an index (e.g., UPA, King (1982)). Because resources between farms differ, adjustments to standards for variables such as soil type, rainfall, farm size, topography, and livestock policy are often made (e.g., as in PROFITWATCH (Anonymous 1998)). For within-year comparisons adjustments to status quo inventory levels are also required (Shadbolt 1997). Alternatively, several years' data for each farm helps to smooth the effect of atypical events.

Farm standards are a feature of United Kingdom farm management and this precipitated a lively debate in the early 1960s between agricultural economists and farm management specialists (Candler & Sargent 1962 vs. Blagburn 1962). The former argued that between-farm comparative analysis based on farm standards was not economically rational. This is because each farm's unique production function reflects resource quality and the local environment, as well as the preferences and managerial ability of the owner(s). These factors substantially influence how resources are allocated to production. Consequently, as Candler & Sargent (1962) demonstrated, differences in the values for farm standards do not necessarily measure technical or economic efficiency, and therefore responding to these "gaps" may lead to erroneous conclusions on how to alter the mix of inputs in order to improve profit. The important information for the individual farmer is, "What is the value of an additional unit of input?" Blagburn (1962) in acknowledging their economic argument, contended that standards were still able to broadly indicate areas for farm improvement. Some 30 years later, Malcolm & Makeham (1993) reiterated the importance of correctly applying economic principles in agriculture and in doing so, listed "common fallacious beliefs" concerning standards and ratios. This included the false belief that physical productivity ratios are equivalent to economic efficiency, and that "... comparisons of average technical ratios, such as kg/wool/ha or ... gross margins, or costs per dry sheep equivalent (DSE), between farms are valid and thus performance measures on one farm are useful guides for action for another farm. This is invalid." The SU system has been widely misused in this regard. The adoption of nationally agreed values for SUs is likely to perpetrate this misuse.

Benchmarking and the SU system

Benchmarking has become popular in the 1990s. The aim of benchmarking is to identify superior management practices and/or technologies and to transfer or adapt these to the case farm(s). To paraphrase Atkinson *et al.* (1995) benchmarking "... is a [farmer's] search for, and implementation of, the best way to do something as practised on other [farms or relevant industries]". To date its application in pastoral agriculture has essentially been an analogue of comparative analysis. Consequently, its power to change farm profitability largely remains unexploited. The three steps in benchmarking are to: identify examples of potential superior performance (such as through comparative analysis of farm business performance ratios (Shadbolt 1997)); establish whether performance is actually superior and if it is, how this is realised; and transfer, if appropriate, the management techniques/practices to the case farm. The SU system could play a role in the initial identification of superior performance, providing the limitations described earlier on technical and economic efficiency are recognised. Successful benchmarking focuses on farmer learning and the ongoing development of "best management practice" (including how to make more effective and efficient use of technology). Publishing standards of farm performance per SU for a farm discussion group, district or farm type, cannot achieve this outcome because they relate to averages rather than the "best" and they do not, by themselves, define the processes and resources through which outstanding performance is realised.

A modelling approach vs national standards

Irrespective of the concerns about the misuse of standards, the multiplicity of uses of the SU system poses a challenge in achieving an agreed set of national standards. At an industry or agricultural policy level, average values across farm and animal classes are required; at the intra-farm level, values for specific groups of animals are necessary. Rather than publishing tables that cover this large range of animal species and performance levels, a more efficient and consistent approach would be to obtain agreement on, and develop, computer-based algorithmns for modelling animal feed requirements in the context of different farm systems. The Internet would allow nationwide user access. There is already a substantial degree of commonality in models used to estimate sheep (see for example, Tables 2 and 3), beef cattle, dairy and deer feed requirements. A modelling approach to SU standardisation enables the user to customise the biological and management parameters to their farm system. Deriving SU equivalents is then a straightforward matter of dividing the intake per stock class by a "standard unit" – say, 550 kg DM of 10.5 MJ ME/kg DM per annum.

The simplest modelling approach is to mechanistically simulate only the animal demand component of the farming system as described by Brookes *et al.* (1993). However, because of the interaction between the livestock classes, pasture production and quality, and management (see Table 4), modelling the whole system provides more realistic estimates of animal substitution rates within a farm. While this introduces the challenge of simulating feed flows in pastoral systems, detailed sub-models of pasture production under grazing are available (e.g., STOCKPOL (Marshall *et al.* 1992)). Even if updated tables of "national" SUs were to be prepared, a modelling approach would be necessary to ensure consistency. Developing suitable models for Internet access is therefore required. These could be integrated with the national database under development by Meat NZ and Wools of NZ for sheep breeding (Geenty 1998). Model development will raise, again, the perennial issue of poorly defined input:output production functions for pastoral farms (Wragg 1970).

In order to identify the most profitable livestock system, farmers need to know the marginal change in profit associated with the options available. Since this depends on costs and prices, a financial model needs to be applied to the inputs and outputs from the biological model of livestock performance. Enterprise budgets (or gross margins) are usually adequate for this task. By constructing sensitivity tables, and assigning probabilities to the range of values used, the business risk associated with each option can also be estimated (Parker *et al.* 1998).

Conclusions

Livestock standards have been used in New Zealand in various ways for almost 80 years. However, the proliferation of their use in farming did not occur till the 1970s. Since that time, new standards have been derived, often in an *ad hoc* fashion and with limited empirical data, for a wider range of performance levels within stock classes and a greater diversity of farmed livestock species. The main misuse of the SU system has been in making between farm comparisons to identify "opportunities" for management action. Such comparisons may assist in the first stage of benchmarking by identifying farms with potentially superior management practice and technology use. The emphasis in benchmarking, however, is on farmers learning "best practice" rather than comparing their current performance with group or sector averages.

Computer models describing feed consumption by animal class within a whole farm system enable SU conversion factors, should they be necessary, to be derived for individual properties. Obtaining agreement on the specifications for these models is more important than agreeing on a national set of SUs, since the former provides a means of generating the latter. The Internet can make these generic models available to users in all sectors of agriculture. Integrating a financial model with the model of farm biology, allows the economic efficiency of farm systems to be estimated and the source(s) of greatest marginal gain to be identified. This will assist grassland farmers more than providing them with an agreed set of national SU standards.

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