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DROUGHT STRATEGIES AND RESOURCE VALUATION IN PASTORAL AREAS

E. J. WARING

University of New England

INTRODUCTION

The use of inventory analysis to determine the optimum *ex ante* stocking rate and level of drought reserves in high risk areas has been discussed recently by several authors. Basically the method adopted depends on matching the risk of incurring replacement expenditure subsequent to losing some of the livestock carried against the probable cost of feeding the whole or part of the flock through the drought and of holding fodder.

If stock are of sufficiently high value relative to fodder, as may be the case particularly where old-established studs are concerned, it will pay to carry the entire flock or herd through any drought. This is the situation to which the analysis of Candler¹ especially applies. In other cases it will be more economic to dispose of some sheep (or let them die) in droughts of sufficient severity, even if their owners have made no miscalculation regarding the size of the optimum fodder reserve which should be maintained.

Dillon and Mauldon² have shown how, in these circumstances, wool, stock and fodder prices influence the optimum stocking rate and size of fodder reserves for sheep. In those areas where stock feed on edible scrub and similar perennial plants immediate past drought history, by reason of its effect on indigenous fodder reserves, must also be taken into account in determining stocking rates and the amount of conserved fodder to be held in reserve. Thus the optimum stocking rate and fodder reserve are not constant over time.

On typical pastoral properties total stock numbers are made up of individuals of varying age and different sexes; "sheep" or "cattle" are accordingly differentiated resources producing not only meat, hides or wool as the case may be, but also their own replacements. If the age and sex composition of a flock or herd is varied these products may be produced in differing proportions. It is usual, for example, for wethers to cut more wool than ewes and hence for wool and lambs to be competing products over their possible range of substitution.

¹ Wilfred Candler, "The Optimum Fodder Reserve—An Inventory Problem", *Journal of Farm Economics*, Vol. XLI, No. 2 (May, 1959), pp. 257-262. Wilfred Candler, "On the Economics of Drought Reserves", *This Review*, Vol. 26, No. 4 (December, 1958), pp. 215-266.

² John L. Dillon and R. G. Mauldon, "Inventory Analysis and the Economics of Fodder Conservation", *The Economic Record*, Vol. XXXV, No. 71 (August, 1959), pp. 209-218. R. G. Mauldon and John L. Dillon, "Droughts, Fodder Reserves and Stocking Rates", *The Australian Journal of Agricultural Economics*, Vol. 3, No. 2 (December, 1959), pp. 45-57.

EFFECTS OF DROUGHT ON LIVESTOCK VALUATIONS

Considering sheep in the areas of significant drought risk in New South Wales the price of ewes is normally higher than the price of wethers of comparable age and breeding. Sales of ewes tend to be limited to the aged or culled portions of established flocks.

Despite the setbacks of intermittent drought the sheep industry in Australia has probably been seeking to expand continually. On this assumption sheep prices should at all times have closely approximated the full capitalized value of expected future revenue from them.

Wether prices after a drought could be influenced by two factors:—

- (i) A belief that the immediately ensuing period will be of better than average seasonal conditions.
- (ii) A change in the relative valuation of sheep and non-sheep resources following a reduction in sheep numbers.

Since the “breaking” of a drought is not normally considered as an instantaneous process, stockowners must be faced with a formidable problem in formulating expectations concerning post-drought weather. To the extent that pastoralists hold favourable short-term expectations after drought, wethers, which give a higher or immediate return, would tend to increase in value relatively more than ewes.³

On the other hand the almost invariable consequence of drought of any appreciable severity is a reduction in the current lamb crop, probably accompanied by the death of existing stock. In the aggregate these losses can only be replaced by rearing lambs (or calves in the case of cattle). It follows that at the end of a drought graziers are faced with definite knowledge that stock numbers are less than before hand which is a positive incentive to value breeding stock more highly relative to non-breeding stock than was the case beforehand.

On these assumptions the price of all stock might be expected to be increased when restocking becomes necessary after a drought but the price of females could increase by more than the price of wethers in the case of sheep.

The longer the drought lasts, the greater the expected rate of reduction in sheep numbers, and hence the greater the rate of rise in ultimate prices to be paid on restocking.

³ In recent discussion with Cobar graziers one, who has been running wethers for some forty years, stated that individual droughts did not directly influence the price he paid for replacements. His stocking policy was such that long periods (twelve months or more) without effective rain had little influence on stock losses. It was claimed that the annual return from a wether net of direct operating expenses was less than 15s. 0d. and under such circumstances there appears to be little scope for the payment of inflated prices for wethers after drought.

Generally, it would seem that the risk of drought is a factor influencing the relative values of different classes of stock. On properties where sheep and cattle are run the latter are classed as the more "risky" in many cases.⁴ Young ewes are classed as more liable to lasting ill effects than sexually mature ewes; old sheep may be expected to give some of their return by fattening prior to sale and this procedure may become obviously impossible before a drought is far advanced.

There is a common adage regarding drought strategies—"sell and repent, but sell early". The normal practice is to sell wethers first, reflecting their lower initial value and possibly the change in their expected value relative to ewes as drought progresses. Everist and Moule⁵ refer to the desirability of keeping a proportion of wethers on Queensland properties in high drought risk areas as a "safety valve" to relieve excessive grazing pressure. It may be true that wethers can withstand a more restricted diet than ewes but in its context the statement appears to refer to wethers as a class of stock which their owner will have few qualms about selling if conditions become adverse.

Finally, part of the drought reserve on a property, the "buffer" for short periods without effective rain, consists of indigenous reserves of burr, perennials and hayed-off material. When this is reduced in amount by a drought of sufficient severity, the landowner has an inducement to maintain a reduced grazing pressure after the drought until such reserves are restored to the desired level. This should tend to keep stock prices below the level which they would have reached before the drought if a similar reduction from some other cause (say, a devastating disease) had occurred. Up to lambing the feed requirements of ewes and wethers do not differ to a great extent so the landholder could well decide to permit his flock numbers and reserves to increase at somewhat the same rate by breeding from ewes mated post drought rather than by buying replacements.

VALUING STOCK IN DROUGHT SITUATIONS

It appears that criteria to determine which stock should be disposed of during a drought would be useful in these circumstances. Any procedure to establish such criteria must take account of the probabilities of droughts of different length being experienced. The relatively brief duration of weather records in most parts of Australia does not appear to inspire graziers with much confidence in probabilities derived from their analysis. Nonetheless, as suggested by Candler,⁶ the stockowner can ascribe values to a most probable outcome based on weather records⁷ showing the likelihood of rain in different months for a number of centres, modified perhaps

⁴ See, for example, Keith O. Campbell and Warren F. Musgrave, "Economic Aspects of the Association of Beef Cattle with Sheep Production in South-Eastern Australia", Department of Agricultural Economics, University of Sydney, *Research Bulletin No. 3*, 1958.

⁵ Everist, S.L., and Moule, G. R., "Studies in the Environment of Queensland, 2, The Climatic Factor in Drought". *The Queensland Journal of Agricultural Science*, Vol. 9, No. 3 (September, 1952), p. 185.

⁶ Wifred Candler, "The Optimum Fodder Reserve—An Inventory Problem". *loc. cit.*

⁷ See for example Everist and Moule, *loc. cit.*, McClymont, G. L. "Handfeeding of Sheep, Sydney, N.S.W. Department of Agriculture (1957).

White, R. C. L. *Drought and Effective Rainfall Frequency in Pastoral N.S.W. West of the Wheat Belt*. Preliminary Report issued by Commonwealth Meteorological Bureau (Aust.). Mimeo. (1951).

by his experience on the particular property and his individual risk preference. The fairly simple procedure outlined below may be of use in assisting stockowners to determine a rational policy based on their expectations for the future where these can be used to fix values for the variables involved.

Let us consider an area such as Cobar where a drought period apparently began about July, 1959. The probabilities of rain in each month of the year at Cobar given by McClymont⁸ are shown in Table 1.

TABLE 1
Percentage Chance of Effective Rainfall at Cobar, New South Wales (Based on Records for 70 Years)

Month of Drought Ending	Length of Drought	Percentage Chance of Effective Rain
October	3	15
November	4	31
December	5	31
January	6	10
February	7	14
March	8	15
April	9	18
May	10	34
June	11	55
July	12	46
August	13	40
September	14	18
October	15	15

A pastoralist examining these figures at the beginning of October, 1959, might have expected a probability distribution somewhat as shown in Table 2.

TABLE 2
Probability of Drought Ending After n Months

Last Drought Month	Months of Drought (n)	Probability of Drought Ending (P)
September	0	·05
October	1	·20
November	2	·20
December	3	·15
January	4	·01
February	5	·02
March	6	·02
April	7	·05
May	8	·15
June	9	·10
July	10	·05

⁸ *loc. cit.*

Sheep Prices

Suppose the grazier has a line of sheep which he considers would be worth £3 per head if the drought broke next day or at any time in the next three months. He believes that if he had to replace them after six months drought the price of comparable sheep would be £3 10s. 0d. while, if the drought lasted for the full ten months he considers just possible⁹ the price to replace them would be £4 5s. 0d.

Feed Costs

If the sheep are in good condition at the commencement of the drought and some feed is available in the paddock from falling leaves and the like the grazier may consider 10 lb. wheat per sheep per month adequate for the next three months. Thereafter they would probably require full feeding at 13-14 lb. SE per month (about 20 lb. wheat).¹⁰

If the drought lasts more than six months he would be likely to feed a small supplement of lucerne hay (or provide a Vitamin A supplement) in place of part of the wheat at an extra cost of 2s. 0d. per sheep per month.¹¹

It could be assumed that the grazier expects wheat to be available at 18s. 0d. per bushel fed out, and that each sheep will grow 0.6 lb. wool per month on drought rations worth 5s. 0d. per lb. net of selling costs if sold as shorn wool. This return from drought wool would offset the cost of purchased fodder to a degree. On these assumptions a table of feed costs per month could be drawn up as follows:—

Time			Feed Cost per month	Wool Value month	Net Cost per month
			s. d.	s. d.	s. d.
0-3 months	..	..	3 0	3 0	...
3-6 months	..	..	6 0	3 0	3 0
6-10 months	..	..	8 0	3 0	5 0

⁹ It will be noted that in Table 2 the sum of the respective probabilities of drought of 0-10 months duration adds to 1.0. The hypothetical grazier has decided that the drought will last for no more than 10 months at the extreme. More than one fall of rain over a period of six weeks to two months is needed to break a drought. This tends to justify the low values placed on the chances of an immediate break, or a break between January and April. The high probability of rain in June, July and August encourages the belief that the drought will break by July. This is not to say, of course, that the drought *will* break by August, 1960, nor that sheep could not be fed profitably for more than ten months if fodder were available. It is worthy of note that the probabilities of Table 1 refer to higher falls of rain than considered necessary by White (*loc. cit.*) to initiate and maintain growth of the native forage plants usually found at Cobar. The tables and subsequent discussion are intended merely to illustrate a general method. The bimodal character of the distribution reflects a tendency for dry months in Central N.S.W. to be "clustered together".

¹⁰ Based on P. K. Briggs, M. C. Franklin and G. L. McClymont "Maintenance Rations for Merino Sheep IV. The Performance of Adult Merino Ewes Fed Daily at Three Levels of Energy Intake", *Australian Journal of Agricultural Research*, Vol. 8, No. 1 (January, 1957), pp. 75-82.

¹¹ Alternatively the 2s 0d. extra charge per month could be the result of an increase in price of wheat purchased when the drought is well under way.

If it is desired to determine whether sheep should be kept or disposed of several methods can be used to establish a present value for the sheep, the most flexible may be a combined graphical and arithmetic one.

If it were known with certainty that the drought would last for zero months then the cost of feeding would be nil, and the present value would be that assumed earlier, viz., £3. Similarly if it were known exactly that the drought would end after 10 months a sheep fed for this period would have an assumed replacement value of £4 5s. 0d. and the cost of feeding the sheep would be:—

3 months @ 3s. 0d.

3 months @ 6s. 0d.

4 months @ 8s. 0d.

Total 59s. 0d.

Less 10 months drought wool @ 3s. 0d. = 30s. 0d.

Net Cost = 29s. 0d.

The present value of the sheep would be £4 5s. 0d. less 29s. 0d. = £2 16s. 0d.

So, if one were certain the drought would last ten months, and of the other assumptions made, it would "pay" to buy a sheep at the outset for any sum less than £2 16s. 0d. and feed it through the drought, provided funds were in hand to buy the feed. Alternatively if more than £2 16s. 0d. could be obtained for the sheep at the beginning of the drought it would "pay" to sell.¹²

¹² In the normal situation when drought length is not known with certainty, "pay" of course means pay in the long run provided the same policy were consistently followed and the assumed probability distribution were close to the mark. According to the Friedman-Savage hypothesis graziers, who might fall into the "intermediate" or "relatively high" income classes, might have two possible utility functions for choices involving risk. The moderate income group may be attracted by insurance against relatively large losses and be willing to pay a premium to assume moderate risks. The high income group may be averse to insurance plans involving rather large losses and prefer certainty to moderate risk and moderate risk to extreme risk. The proposal to buy or sell sheep may represent the assumption of moderate risks. It is of interest that a majority of well over one hundred Cobar and Nyngan graziers with whom this proposal was discussed were averse to the idea of trading in sheep during drought. This is in part a reflection of unwillingness to mix strains of sheep. Most were apparently stocked at conservative rates (below D_0 using Dillon and Mauldon's notation). Comparatively very few sheep had been hand-fed up to April, 1960, at Cobar and Nyngan, although the owners of small properties in particular had sold some sheep (mainly aged wethers). These stocking rates in part reflect an institutional restraint imposed by Western Lands Board stocking policy.

TABLE 3

Net Value of Sheep at End of Drought

Months of Drought			End of Drought Net Value	Probability of Drought Ending
			£	
0 ..	..	..	3.0	.05
1 ..	..	..	3.0	.20
2 ..	..	..	3.0	.20
3 ..	..	..	3.0	.15
4 ..	..	..	3.0	.01
5 ..	..	..	2.95	.02
6 ..	..	..	3.05	.02
7 ..	..	..	3.05	.05
8 ..	..	..	2.95	.15
9 ..	..	..	2.85	.10
10 ..	..	..	2.8	.05

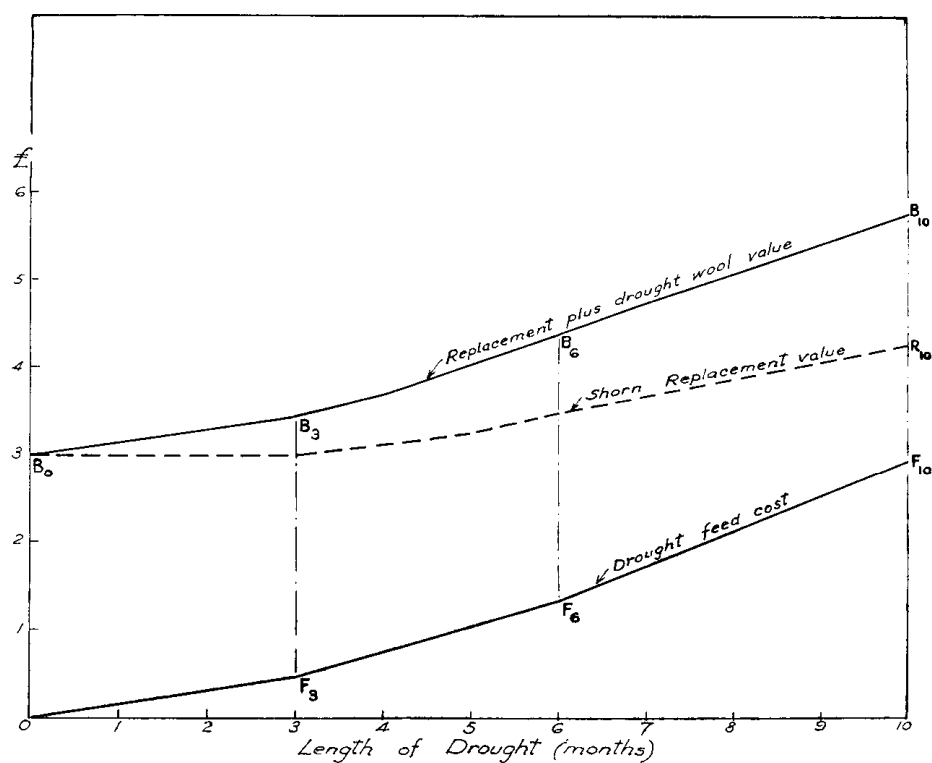


Fig. 1.—Hypothetical Future Feed and Replacement Costs and Drought Wool Revenue from a Sheep at Cobar, New South Wales, 1st October, 1959.

The duration of the drought can only be expressed in terms of some largely subjective probability distribution such as that postulated earlier, but if such a probability distribution is known present values can be ascribed to the sheep at any time through the drought.¹³

We might graph the example above as in Fig. 1, where the line OF represents the increasing cost of feeding a sheep from zero to ten months and the line $B_0 R_{10}$ represents the increasing value of the shorn sheep as a replacement after droughts of zero to ten months' duration. The line $B_0 B_{10}$ represents the increasing replacement value of the sheep and the wool it grows during the drought.

The length of the line $B_{10} F_{10}$ representing the difference between the (replacement and wool) revenue and feed cost for a sheep after ten months' drought, has been calculated but could be measured to represent £2 16s. 0d. $B_3 F_3$ represents £3, $B_6 F_6$ is £3 10s. 0d.—($3 \times 3s. 0d.$) = £3 1s. 0d. Similarly values can be derived for the difference between feed and replacement cost for a drought of any length from zero to ten months.

These values and the corresponding probabilities are shown in Table 3.

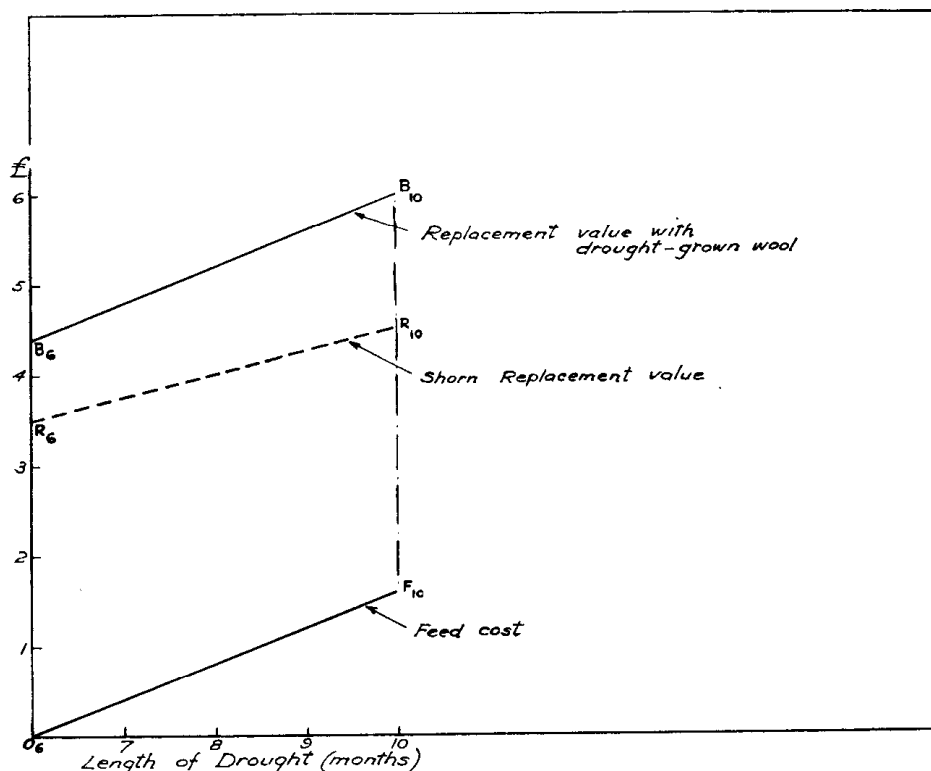


Fig. 2.—Hypothetical Future Values of Drought Wool and Replacement Sheep and Feed Costs, Cobar, New South Wales, 1st April, 1960.

¹³ The logic of this determination might be illustrated in this way. Consider a sweepstake on ten horses with prizes of £3 for first, £2 for second, £1 for third. Then of the ten chances represented by the horses there is 1 of winning £3, 1 of winning £2, 1 of winning £1 and 7 of winning nothing, so the present value of "drawing" a horse is—

$$\frac{(1 \times 3) + (1 \times 2) + (1 \times 1) + (7 \times 0)}{10} \\ = £0.6 \text{ or } 12s. 0d.$$

Thus the present value of a sheep, with the assumptions listed, at the beginning period is the difference between replacement value and feeding cost net of wool grown for droughts of 0-10 months' duration multiplied by the appropriate probability for each drought length, or,

$$\begin{aligned} &£3.0 \times .05 + £3.0 \times .15 \dots\dots\dots £2.8 \times .05 \\ &= £2.842 \\ &= £2 \text{ 16s. 10d.} \end{aligned}$$

Accordingly a grazier in these circumstances should not sell such sheep at the beginning of October, the time to which this present value applies, for less than £2 16s. 10d. If he could buy sheep for less, had the capital and would not otherwise strain his resources by doing so, he should logically be prepared to buy similar sheep at any lower price.

Suppose now that the drought has been in progress up to the point F_0 , i.e., the end of March in the example. At this point, 63 of the 100 chances of the original probability distribution have gone and, although the drought is obviously nearer its end, the chances of its lasting the full 10 months have increased from .05 (5 in 100) to .135 (5 in 37). This assumes that the landowner has not recast his probability distribution in the light of additional experience. At this point a new figure such as Fig. 2 can be prepared to determine the new present value of a sheep which has been fed so far.

All past expenditure on feed should be disregarded. $O_0 B_0$ represents the value of the shorn sheep as a replacement plus the value of 6 months' drought wool it has grown since last valued, i.e., £3 10s. 0d. + 6 x 3s. 0d.

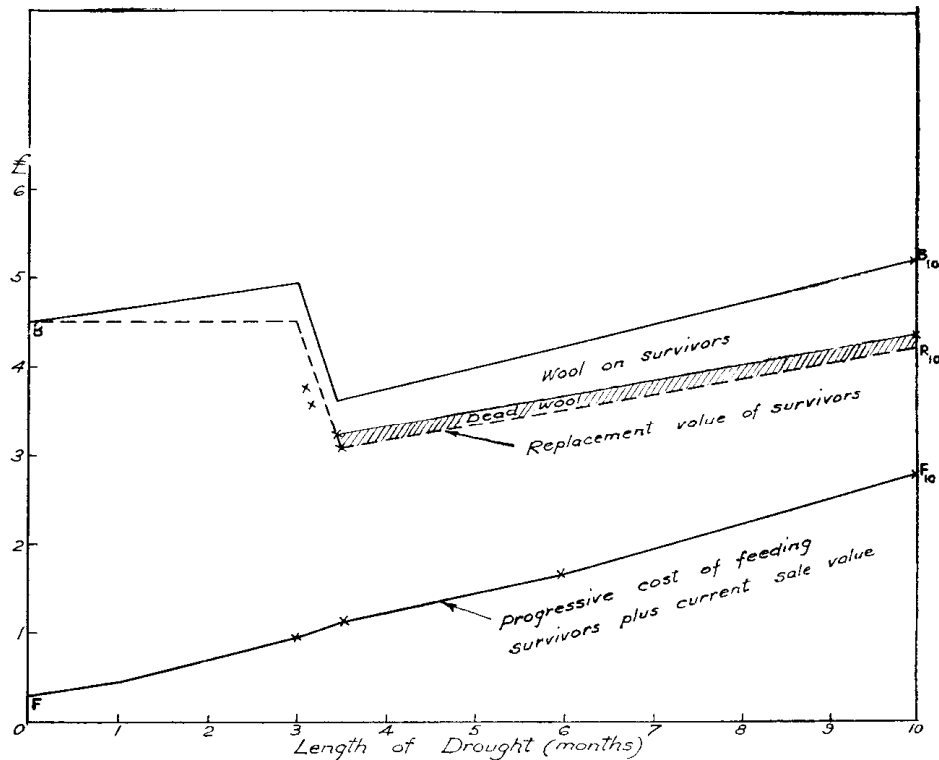


Fig. 3.—Graph Constructed to Determine Revenue per Sheep from Feeding Hypothetical Ewe Flock in Drought.

= £4 8s. 0d. If the drought does not end for four months its shorn value was assumed to rise to £4 10s. 0d. and the ten months' drought wool will increase its value to £6, represented by B_{10} . The cost of feeding will be 8s. 0d. per month, represented by the line $O_6 F_{10}$. The replacement values of the shorn sheep after drought of 6-10 months are indicated by $R_6 R_{10}$.

The present value of a sheep at the end of the sixth drought month is

$$\text{thus } £\frac{2}{37} \times 4.40 + \frac{5}{37} \times 4.15 + \frac{15}{37} \times 3.90 + \frac{10}{37} \times 3.70 + \frac{5}{37} \times 3.65 \\ = £3.873 \text{ or } £3 \text{ 17s. 6d.}$$

It will be noted that this is less than the replacement value if the drought ended at this point, reflecting the quite high probability that the drought, having lasted six months, will go on for another two or three at least and that the value of drought wool only partly offsets the cost of feeding.

Of the present value of £3 17s. 6d. at April, 18s. 0d. is represented by drought wool so the present value of the sheep net of wool has increased since zero month and will continue to increase until it reaches £4 10s. 0d. at the end of the tenth month by which time we have assumed the drought will break.¹⁴

COMPARING VALUES OF DIFFERENT SHEEP IN DROUGHT

The values of sheep may, of course, vary from month to month irrespective of age and sex, or the time which has elapsed since shearing which influences the length of staple and hence the value of wool. Thus, for example, the value of wool per pound may increase during the drought or the value of a flock of in-lamb ewes may fall with increased death losses if it lasts until lambing.

Thus a flock of young in-lamb ewes which could be sold now for 6s. 0d. per head (skin value, say) and from which about 30 per cent death loss is expected in lambing, might be worth £4 10s. 0d. per head if the drought ended immediately. If the drought lasted ten months the survivors might be worth £6 plus the value of wool grown. Fig. 3 depicts the type of expected feed cost and expected revenue graphs which could be drawn for such a situation. For the example given, the anticipated difference between feeding and replacement cost for droughts of four-ten months is about £2 10s. 0d. per head. Present value is about £3 10s. 6d. more than salvage value. There is an opportunity cost attached to retaining the sheep, their present sale or salvage value, OF, or 6s. 0d. in Fig. 3.

A flock of wethers which could be sold at £2 per head at the commencement of the period or £4 if the drought broke and which one expected to have a replacement value of £4 after ten months drought, would be expected to suffer less drought deaths and to cost less for feed in the early stages. Fig. 4 applies to such a situation. The "present value" of a wether with the assumptions made is about £1 9s. 6d. above current or salvage value.

¹⁴ A more sophisticated procedure would require discounting the anticipated return from drought survivors and charging interest on the expenditure on feed. It has been assumed that these factors have been taken into account in assessing probabilities for drought duration and future prices.

Theoretically the risk-discounted present value of the profit to be made by feeding ewes or wethers should tend to be the same but this need not be so where buyers and sellers assess risks differently at a particular time.¹⁵ So the owner of two categories of stock might be better off selling one under some circumstances and the other under apparently similar conditions if numbers must be reduced.

THE INFLUENCE OF CAPITAL AVAILABILITY

An individual with insufficient feed or capital reserves to feed all stock through the longest expected drought may decide to feed all for as long as possible and then, if needs be, let them die. Alternatively he may reduce stock numbers progressively during the drought so that some survive. Many strategies might be adopted in the latter circumstance.

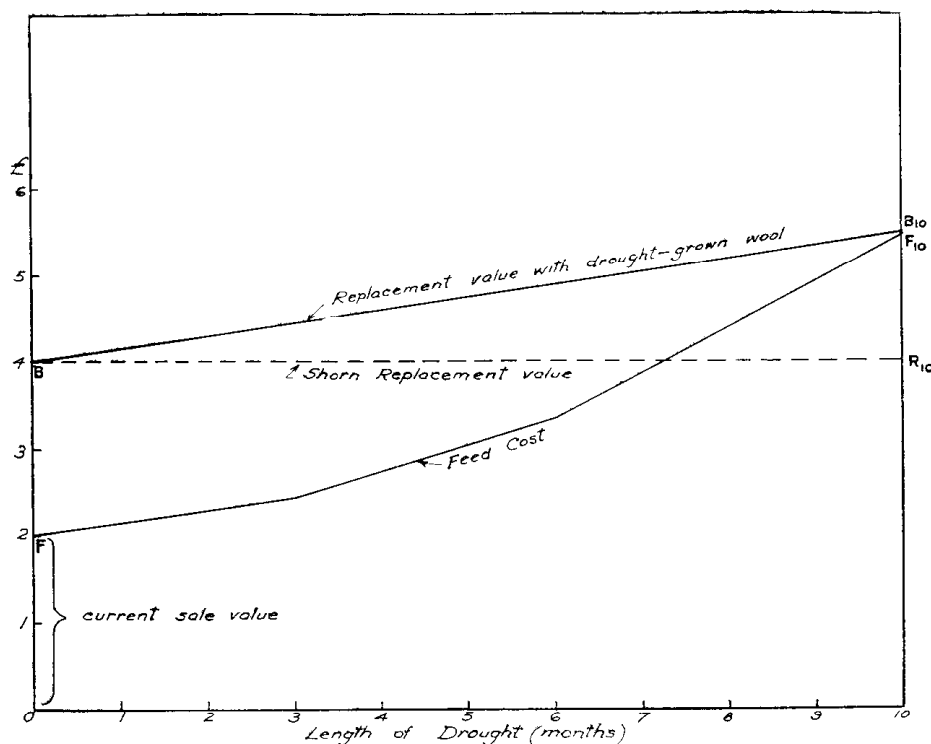


Fig. 4: Valuation of Hypothetical Wether Flock.

If, for example, sheep which could be sold for dead-wool value only were close to shearing it might be worthwhile to retain them. If the sheep were of equal value, a policy of continual revaluation and disposal according to the changing probabilities of continued drought would be appropriate.¹⁶

¹⁵ Buyers and sellers may, of course, be located in areas of differing degrees of drought risk.

¹⁶ See Dillon and Mauldon, *loc. cit.*, pp. 215-217.

Suppose the landowner had reached the point in a drought when the probabilities of continued drought were assessed by him as in Table 2, and he had sufficient fodder reserves in hand for five months feeding. Then it would be approximately the case that every sheep immediately disposed of would permit another sheep to be carried through the longest drought expected. After a further month of drought, disposing of five sheep would permit four others to be carried for the nine more months the drought *could* last, and so on.

If the first sheep to be disposed of is of one class, say Class A, and that to be kept of Class B, then the expected differences between feed cost and value as survivors after different lengths of drought could be determined, there is assumed a 63 per cent chance of the drought lasting no more than a further five months and conversely a 37 per cent chance of it lasting six months or more. Accordingly:—

- (1) If no sheep are disposed of the expected revenue from feeding all sheep is 63 per cent of their combined present values as survivors of the first five months *plus* 37 per cent of their salvage value *minus* feed cost for five months *minus* present sale value (i.e. salvage value, dead-wool price or better), *plus* the present value of unused fodder.
- (2) For each A sheep sold the expected drought revenue from an A and a B sheep is:—
 Present sale value of an A sheep *plus* present value of a B sheep *plus* present value of surplus fodder *minus* current sale value of a B sheep *minus* cost of 10 months fodder for one sheep.¹⁷

As the drought progresses the proportion of the reassessed present values of A and B sheep to be credited to expected revenue and the present value of unused fodder will decrease fairly rapidly whereas the corresponding present value of a B sheep under condition (2) does not decrease as rapidly in our example. Hence the strategy of disposing of some sheep to permit greater certainty of maintaining the others tends to become more and more desirable as the drought progresses. The rate at which the policy would become most advantageous depends on the nature of the probability distribution adopted.

It will be apparent that if the present value of any class of sheep, say A, falls below salvage value, such sheep should be disposed of. A new strategy should then be prepared for the survivors. In practice stock-owners might tend to anticipate such events—the normal procedure would probably be to dispose of all individuals of a particular class at once, e.g., all aged wethers in one consignment, rather than make marginal adjustments to stock numbers.

CONCLUSIONS

Drought strategies vary between stock-owners and quite probably between districts. Two distinct strategies which appear to be quite commonly adopted are endeavouring to maintain the entire flock intact through all droughts and a policy of reducing numbers when fodder reserves are reduced to some level dictated by experience or a drought of more than some specific length seems imminent.

¹⁷ Numerical examples are given in Appendix 1.

It is to be expected that individuals might be motivated to adopt one or other of these policies, among other reasons, by the value they place on their stock and in accordance with their financial standing which is probably associated with individual patterns of risk preference.

At any time the individual stock on a property vary in relative value because of differences in age and sex. It is hypothesised that drought and the risk of drought should also vary the relative valuation of different classes of stock.

If the stock-owner can ascribe to the probabilities that a drought, once started, will continue for given lengths of time, and predict corresponding sale or replacement values for restocking at the drought's end, then data from drought feeding experiments allow the determination of present values for sheep and cattle. These permit a decision as to which, if any, of the different classes of stock on the property should be disposed of, or whether more fodder should be purchased at known prices, at any time during the drought.

Criteria are suggested to determine appropriate within-drought strategies if fodder, capital or other resources are insufficient to permit carrying all stock through the longest expected drought.

APPENDIX 1

Expected Income from Two Alternative Drought Strategies

Assume two sheep (A and B) corresponding to the young in-lamb ewes and wethers to which the text and Figs. 3 and 4 refer, at a point in time where a drought of up to 10 months' duration with the probabilities of Table 2 is expected. The grazier is assumed to have fodder sufficient to maintain two sheep for five months or one sheep for ten months.

Case 1

Both Sheep Retained Five Months

Expected revenue = 63 per cent of present value of both sheep *plus* 37 per cent of salvage value of both sheep five months hence *minus* current sale value of both sheep *minus* feed cost for two sheep for five months *plus* present (expected) value of unused fodder.

Ewe Values

	£	s.	d.
Present value	3	16	6
Current sale value		6	0
Salvage value (5 months hence)	12	0	

(assuming 3 lb. wool carried at present plus 3 lb. grown in five months on drought rations, sold as dead wool for 2s. 0d. per lb.).

Wether Values

	£	s.	d.
Present value	3	9	6
Current sale value	2	0	0
Dead wool value after 5 months	15	0	(say)

Present Value of Unused Fodder for Two Sheep

There are chances of .05, .20, .20, .15, .01, .02 that five, four, three, two, one and nil months supply of fodder will go unused.

Fodder for the first three months cost 3s. 0d. per sheep per month (i.e., 6s. 0d. for two sheep) and 6s. 0d. per sheep per month for the fourth and fifth months. So the present expected value of the fodder remaining in five months' time if both sheep are kept is:—

42s. 0d.	×	.05	=	2s. 1d.
36s. 0d.	×	.20	=	7s. 2½d.
30s. 0d.	×	.20	=	6s. 0d.
24s. 0d.	×	.15	=	3s. 7d.
12s. 0d.	×	.01	=	1½d.
—s. 0d.	×	.02	=	0d.
Total				= 19s. 0d.

So the expected revenue retaining both sheep for the full five months is:—

$$\frac{63}{100} (£3.16s.6d. + £3.9s.6d.) + \frac{37}{100} (12s. 0d. + 15s. 0d.) - (£2 + 6s. 0d.) - (42s. 0d.) + (19s. 0d.) \text{ i.e. } £1 \text{ } 17s. \text{ } 0d.$$

Case 2*Wether Sold for £2, Ewe Retained*

Expected revenue from the two sheep:—Current sale value of wether *plus* present value of ewe *minus* current sale value of ewe *minus* current sale value of ewe *minus* value of 10 months' feed *plus* present value of unused fodder—

$$= (£2) + (£3 \text{ } 16s. \text{ } 6d.) - (6s. \text{ } 0d.) - (42s. \text{ } 0d.) + \text{present value unused fodder}.$$

This sum is obviously greater than £1 17s. 0d. so that the second strategy gives the higher expected return.

In this specific instance the total of the last four values in the equation obviously falls during the first five months of drought but if the current sale value of the wether were likely to rise during the drought, or if the assumed probability of rain in the first five months were higher than in the example chosen the optimum strategy might justify the risk of holding both sheep for some time.

APPENDIX 2

Determination of Probability Distribution for Droughts of Differing Length

As stated by White (loc. cit.) there appears to be a tendency for "clumping" of wet and dry months in the Far Central-West of New South Wales so that the expectation of rain in any month may be conditioned by the drought history of one or more preceding months. There appears to be a tendency among pastoralists in these areas to recall that previous severe droughts broke in certain months and place greatest weight on such months in formulating expectations for the duration of a given drought.

Under such conditions there seems to be some justification for formulating probability distributions within drought in the manner of Table 2.

I am grateful to Dr. John L. Dillon for the information that statistical examination of rainfall records for some other areas in Australia discloses zero or very weak correlations between the rainfall in one month and those preceding it. Under conditions of zero correlation between rainfall in consecutive months a probability table can be derived for a given drought on the assumption that the chance of its breaking in a given month is the product of the chance of effective rain in that month and the chance of the drought not having broken beforehand.

Thus if a drought is in progress and the chances of rain in each of the next two months are 20 per cent, then the chances of the drought breaking in the first and second months are 20 per cent and $(.80 \times .20) = 16$ per cent. If the probability of effective rain in the third month is 40 per cent, then the chance of the drought breaking in the third month is $.64 \times .40$ or 25.6 per cent.

The cumulative chance of the drought breaking within three months is 20 per cent + 16 per cent + 25.6 per cent = 61.6 per cent, which is equivalent to assessing the chance of its not breaking as $.80 \times .80 \times .60 = 38.4$ per cent.