ON THE ECONOMICS OF DROUGHT RESERVES

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In this article a new approach to one aspect of the economics of drought reserves will be discussed. In particular attention will be directed to the uncertainty of drought feed requirements. If future feed requirements were known with certainty then drought would lose many of its terrors, adequate reserves could be accumulated in time to meet a dry spell and unnecessary reserves could be dispensed with. The main worries associated with drought are the uncertainty as to when a drought will begin and how long it will last. Essentially in this article the aim will be to develop one new approach to the problems of risk and uncertainty raised by drought.

The example used could have been more detailed and more realistic (for instance, the possibility of selling sheep, or buying grain and lucerne hay, rather than wheaten hay, could have been considered). Similarly, the problems of fodder deterioration and possible income tax effects have been ignored. This extra detail has not been included, because though it might have made the article more realistic for some readers, particular assumptions would have made it less realistic for others. In any case there would have been a tendency for the main principles of the argument to be lost in a mass of special assumptions.

SPECIAL ASSUMPTIONS

Suppose that the property being considered has the general characteristics:

(*a*) Wheaten hay can be grown (or bought) and stored in a "normal" year for £8 per ton.

(*b*) The stocking is conservative so that by the time it is necessary to feed, wheaten hay has risen to £16 a ton.

(*c*) Stock are not fed until it becomes essential and then they are fed 2 lb. of wheaten hay per day (or ½ cwt. per four weeks).

(*d*) The grazier believes he can safely get 8 per cent on his money if he invests in industrial shares. (That is, if he decides on a financial rather than a fodder reserve, he will earn 8 per cent each year that a drought does not occur.)

(*e*) The grazier is unwilling to consider the possibility of selling sheep early in the drought, or letting them die. (It will be shown later that there is no reason why these possibilities should not have been included in the analysis.)

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TWO COSTS OF A DROUGHT RESERVE

There are two costs associated with a drought reserve:

(*a*) The cost of tying money up in a fodder reserve when it is not needed, and

(*b*) the cost of not having a reserve when it is needed.

To consider either of these costs in isolation is to obtain an entirely one-sided view of the drought reserve which it would be economic to carry.

It has been assumed above, that a half-hundredweight of wheaten hay will keep a sheep alive for a month. It follows that when wheaten hay costs £8 a ton a sheep can be fed for a month for 4s. 0d., but when the price of wheaten hay rises to £16 a ton, then the cost of feeding a sheep rises to 8s. 0d. per month. At the same time, if 4s. 0d. is tied up in fodder reserves for a year when it could have been earning interest at 8 per cent per annum, then the interest sacrificed is 4d. These possible costs, for a month, can be expressed as in Table I, in which a cost is attached to each of the possible combinations of having (not having) a fodder reserve when it is (is not) needed. In Table I what has been assumed earlier is restated, and the data emphasises that there is a (small) cost to having a fodder reserve in a year when it is not needed. The 0 reflects that there is no cost if there is no reserve and it is not needed. The point to be emphasised in Table I is that, for one month, at least, it is possible to attach sensible cash costs to fodder reserve policies, in the event that a drought does, or does not, occur.

TABLE I

Costs Depending on Reserves and Requirements

	Feed	
	Needed	Not Needed
	s. d.	s. d.
Reserve	4 0	4
No Reserve	8 0	0

A SIX-MONTHS DROUGHT

As a first attempt at realism, suppose that experience has suggested that one year in ten a grazier will have to feed for six months, but that in the other nine years though there may be dry snaps he will not actually have to start feeding. If Table I is expanded to Table II the costs of having none to six-months fodder reserve are obtained.

TABLE II

Cost of Feeding a Sheep for Six Months With and Without a Drought Reserve

Drought Reserve	Drought	No Drought	Ten-year Total	Average Annual Cost
	s. d.	s. d.	s. d.	s. d.
None	48 0	....	48 0	4 10
1 month	44 0	0 4	47 0	4 8
2 months	40 0	0 8	46 0	4 7
3 months	36 0	1 0	45 0	4 6
4 months	32 0	1 3	43 3	4 4
5 months	28 0	1 7	42 3	4 3
6 months	24 0	1 11	41 3	4 2

The grazier's possible drought reserves are listed on the left of Table II, the associated costs of feeding one sheep for a six-months drought are given beneath the "Drought" column, while the interest sacrificed if fodder is stored but not needed appears in the "No Drought" column.

As would be expected, the most expensive outcome for the grazier occurs when he has no fodder reserve and a drought occurs—in this case he has to feed for six months on purchased hay costing 8s. 0d. per month, or a total of 48s. 0d. Similarly, the least expensive outcome occurs when the grazier has no drought reserve and it is not needed. (In this case he does not even forego interest since he has not invested in a drought reserve.) The cost of 32s. 0d. associated with a (six-months) drought, and a fodder reserve for four months is made up of four months feeding stored fodder (which cost 4s. 0d. per month) and two months feeding purchased hay at 8s. 0d. per month.

In Table II the costs for "Drought" and "No Drought" of different fodder reserves have been listed. But it has also been assumed that past experience suggests that a drought will occur only one year in ten. In the remaining nine years it will be unnecessary to feed. Of course, it is impossible to say, in advance, which year it will be necessary to feed, and if the grazier is unlucky he may have to feed for six months in, say, two of four years. But, by-and-large, on-the-average, in-the-long-run, the grazier expects to have to feed for only one year in ten. The "Ten-Year Total" column of Table II gives the grazier's total fodder (and interest) bill for ten years if he has only one drought. The ten-year total cost of a six-months fodder reserve is given as 41s. 3d., this is made up of one (drought) year with a fodder bill of 24s. 0d. and nine normal years with an interest bill of 1s. 11d. In the final column of Table II, the ten-year total cost has been divided by ten to give the average annual cost of feeding a sheep for each of the grazier's possible fodder reserve policies.

In Table II the lowest cost plan would be to have a six-months fodder reserve—a reserve built up in "normal" years when the cost of wheaten hay is £8 a ton. A six-months fodder reserve will cost an average of 4s. 2d. a

year. Of this 1s. 11d. pays interest at 8 per cent on the 24s. 0d. invested in fodder, and the remaining 2s. 3d. goes into securities as a "sinking fund" to provide the money needed to replace the fodder reserve after a drought.

LONGER DROUGHT AND CHANGING PRICES

The above example was altogether too simple to be realistic. Droughts occur more than one year in ten, are of differing duration and the cost of fodder does not simply double but increases more or less continuously as the drought proceeds. Attention will first be focussed on the varying duration of droughts. This raises the difficult problem of "when is a drought a drought?" Whether a grazier has to feed his stock depends on the season and his stocking policy. Thus a lightly-stocked property may survive a dry snap while on a neighbouring overstocked property it is necessary to feed for a couple of months. To overcome this difficulty and avoid confusion as to what is meant by a drought, the discussion now proceeds in terms of the total months of feeding (per year). As an example, it might be supposed that in the last 50 years a grazier had found it necessary to feed for the months shown in the number of years given below.

Total Months Feeding (*i.e.*, length of drought)	Years out of 50
0	40
1	3
2	2
3	1
4	0
5	1
6	1
7	0
8	1
9	0
10	1

In the above example it has been unnecessary to feed at all in 40 of the 50 years (*i.e.*, on average, it has been necessary to feed for one month or more, in one of every five years). It has been necessary to feed for (exactly) one month in three of the 50 years, for (exactly) three months in one of the 50 years, and it has never been necessary to feed for (exactly) four months, *i.e.*, if it has been necessary to feed for more than three months, it has been necessary to feed for five, six or more months.

In Table III the costs for each of the grazier's eleven alternative policies (from zero to a ten-months fodder reserve) are given according as the drought lasts from zero to ten months. If a seven-month reserve is maintained and it is necessary to feed for three months, the cost is 13s. 3d. This is made up of 12s. 0d., the cost of feeding three months supply of stored fodder costing 4s. 0d. a month, plus 1s. 3d., the interest at 8 per cent per annum on 16s. 0d. (the value of the four months "surplus" fodder reserve). The "50-Year Total" column of Table III gives the grazier's total

fodder (and interest) bill for each fodder reserve, if the periods of feeding occur with the frequency given above. Thus the total cost of £14 13s. 5d. for a nine-month fodder reserve is made up of:

	s.	d.				s.	d.		£	s.	d.
40 years with no drought costing	2	11	p.a.	=	40 ×	2	11	=	5	16	8
3 years with 1 month feeding costing	6	7	p.a.	=	3 ×	6	7	=	0	19	9
2 years with 2 months feeding costing	10	3	p.a.	=	2 ×	10	3	=	1	0	6
1 year with 3 months feeding costing	13	11	p.a.	=					0	13	11
1 year with 5 months feeding costing	21	3	p.a.	=					1	1	3
1 year with 6 months feeding costing	25	0	p.a.	=					1	5	0
1 year with 8 months feeding costing	32	4	p.a.	=					1	12	4
1 year with 10 months feeding costing	44	0	p.a.	=					2	4	0
Total Cost for 50 years									14	13	5

The average annual cost is, of course, obtained by dividing the total cost by 50.

The main principle illustrated in Table III is that a grazier's drought reserves can be too big as well as too small. Thus the grazier's average fodder bill rises 11 per cent (from 5s. 3d. to 6s. 1d.) from his least-cost reserve, if he carries either no reserve, or a reserve sufficient for the longest drought experienced in 50 years. It is necessary to emphasise that the exact results in Table III mean very little. It would be entirely incorrect to conclude that for all graziers the least-cost fodder reserve would be five months supply. The least-cost fodder reserve will vary with every change in physical conditions, management policy, and economic outlook. However, the method used above, and the general results obtained, should be applicable to a wide variety of properties.

Now that the general procedure for minimising the long-run costs of drought reserves has been established it is possible to improve the realism of the discussion by allowing for the increased fodder prices which may be expected as a drought proceeds. In particular, it may be supposed that the normal price for wheaten hay is £8 a ton, and that for the first two months of a drought hay costs £12 a ton, for the third to the sixth month it costs £16 a ton, and for the remaining months it rises to £20 a ton.

The costs in Table IV are obtained in much the same way as in Table III. Thus in Table IV the 84s. 0d. cost of feeding in a ten-month drought with zero fodder reserve is made up of:

	s.	d.				s.	d.		s.	d.
2 months feeding at	6	0	per month	=	2 ×	6	0	=	12	0
plus 4 months feeding at	8	0	per month	=	4 ×	8	0	=	32	0
plus 4 months feeding at	10	0	per month	=	4 ×	10	0	=	40	0
Total Cost of Feeding for 10 months									84	0

Table IV supports the suggestion in Table III that it may be uneconomic to store fodder to meet the worst of all possible droughts.

TABLE III

Cost of Feeding a Sheep for Various Periods With and Without a Drought Reserve

Drought Reserve	Months Feeding Required								50-Year Total	Average Annual Cost
	None	1	2	3	5	6	8	10		
	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	£ s. d.	s. d.
None	....	8 0	16 0	24 0	40 0	48 0	64 0	80 0	15 12 0	6 3
1 month	0 4	4 0	12 0	20 0	36 0	44 0	60 0	76 0	14 5 4	5 8
2 months	0 8	4 4	8 0	16 0	32 0	40 0	56 0	72 0	13 6 8	5 4
3 months	1 0	4 8	8 4	12 0	28 0	36 0	52 0	68 0	13 6 8	5 4
4 months	1 3	5 0	8 8	12 4	24 0	32 0	48 0	64 0	13 2 8	5 3
5 months	1 7	5 3	9 0	12 8	20 0	28 0	44 0	60 0	13 1 9	5 3
6 months	1 11	5 7	9 3	13 0	20 4	24 0	40 0	56 0	13 5 3	5 4
7 months	2 3	5 11	9 7	13 3	20 8	24 4	36 0	52 0	13 13 2	5 6
8 months	2 7	6 3	9 11	13 7	21 0	24 8	32 0	48 0	14 1 2	5 7
9 months	2 11	6 7	10 3	13 11	21 3	25 0	32 4	44 0	14 13 5	5 10
10 months	3 2	6 11	10 7	14 3	21 7	25 3	32 8	40 0	15 2 4	6 1
No. of years in 50 ..	40	3	2	1	1	1	1	1	....	....

TABLE IV

Cost of Feeding a Sheep for Various Periods With and Without a Drought Reserve—Variable Fodder Prices

Drought Reserve	Months Feeding Required								50-Year Total	Average Cost
	None	1	2	3	5	6	8	10		
	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	£ s. d.	s. d.
None	....	6 0	12 0	20 0	36 0	44 0	64 0	84 0	14 10 0	5 10
1 month	0 4	4 0	10 0	18 0	34 0	42 0	62 0	82 0	14 3 4	5 8
2 months	0 8	4 4	8 0	16 0	32 0	40 0	60 0	80 0	14 3 8	5 8
3 months	1 0	4 8	8 4	12 0	28 0	36 0	56 0	76 0	13 18 8	5 7
4 months	1 3	5 0	8 8	12 4	24 0	32 0	52 0	72 0	13 14 8	5 6
5 months	1 7	5 3	9 0	12 8	20 0	28 0	48 0	68 0	13 13 9	5 6
6 months	1 11	5 7	9 3	13 0	20 4	24 0	44 0	64 0	13 17 3	5 7
7 months	2 3	5 11	9 7	13 3	20 8	24 4	38 0	58 0	14 1 2	5 7
8 months	2 7	6 3	9 11	13 7	21 0	24 8	32 0	52 0	14 5 2	5 8
9 months	2 11	6 7	10 3	13 11	21 3	25 0	32 4	46 0	14 15 5	5 11
10 months	3 2	6 11	10 7	14 3	21 7	25 3	32 8	40 0	15 2 4	6 1
No. of years in 50 ..	40	3	2	1	1	1	1	1	....	....

PURCHASING A FODDER RESERVE DURING A DROUGHT

The same philosophy (of minimising the grazier's long-run, or average, feeding costs) can be adopted even after a drought has begun. The problem in this case would usually be whether it was worth continuing to feed sheep. A certain amount would have been spent on feed, and the grazier might feel that further feeding would only be throwing good money after bad. For this problem the policies (listed on the left) of Tables III or IV could be replaced by (or supplemented with) additional policies such as feeding all sheep, feeding breeders only, feeding young breeders, not feeding, selling after one month, and so on. To get the costs of these policies for different dry periods it would be necessary to have some idea of the likely cost of replacement stock.

To illustrate the problem of making a decision once a drought has commenced, the problem of buying additional fodder reserves, "early in the drought", will be considered. The purchases would be made after prices had begun to rise but before they were completely unreasonable. The danger is, of course, that the drought will end leaving the grazier with a large stock of high-cost fodder on his hands. Suppose now that the normal cost of wheaten hay was £8 a ton, and that the price has already risen to £12, but that if the drought continued another month the price would rise to £16, and if it continued another four months the price would rise to £20. The possible gain from the purchase of a ton of wheaten hay at £12 depends on the length of the drought. This may be represented as a small table:

	Length of Drought		
	Ends at Once	1 Month	4 Months
	£	£	£
Gain from Hay Purchase..	—4	4	8

The —£4, if the drought ends at once, reflects the £4 loss from purchasing hay at £12 and having the price fall (as a result of the rain) to £8 a ton, so that an asset worth £8 has been purchased for £12.

One of the difficulties in the way of making good decisions once a drought has commenced is the continual uncertainty as to whether it is going to just be an "extended dry snap" or a major drought. It is never possible, of course, to say "this drought *cannot* last longer than two more months" because it is always possible that a drought will turn out to be longer than any previously recorded. However, if it is decided to rely on past experience, then it is possible to show how the chances of a bad drought increase as the drought continues. In the first row of Table V the long-run, 50-year frequency of drought (used to compute Tables III and IV, is given) and it can be seen that at the beginning of the year, before it has begun to be dry, the chances of a ten-month drought are one year in 50.

TABLE V

Effect of Length of Dry Spell on Expected Length of Drought

Length of Dry Spell	Number of years it can be expected to be dry for a further—											Total Years
	None	1 month	2 months	3 months	4 months	5 months	6 months	7 months	8 months	9 months	10 months	
None	40	3	2	1	0	1	1	0	1	0	1	50
1 month	3	2	1	0	1	1	0	1	0	1	0	10
2 months	2	1	0	1	1	0	1	0	1	0	0	7
3 months	1	0	1	1	0	1	0	1	0	0	0	5
4 months	0	1	1	0	1	0	1	0	0	0	0	4
5 months	1	1	0	1	0	1	0	0	0	0	0	4
6 months	1	0	1	0	1	0	0	0	0	0	0	3
7 months	0	1	0	1	0	0	0	0	0	0	0	2
8 months	1	0	1	0	0	0	0	0	0	0	0	2
9 months	0	1	0	0	0	0	0	0	0	0	0	1
10 months	1	0	0	0	0	0	0	0	0	0	0	1

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In the second row of Table V the likely length of drought *once it has been dry for a month* is shown. In three years it is likely to rain very soon, in two years it will be dry for another month, in one year it will be dry for another two months, in one year it will be dry for another four months, and so on. There is a total of ten years (of the 50) when it is dry for one month or more, hence the chance of getting a further nine months dry (and hence a total feeding period of ten months) is one in ten. After six months dry, the chances of getting another four months dry (and hence a total feeding period of ten months) have increased to one in three. Explaining this another way, it might be said that at the beginning of the year, nothing is known exactly as to how the year will turn out. After it has been dry for one month, it is known that this is one of the years when a drought occurs, hence the chances of a bad drought are greatly increased. After six months dry, it is known that this is one of the worst three years in 50, hence the odds on a total of ten dry months can be raised from one in 50 to one in three.

Stating this yet another way, it can be said that for Tables III and IV it was assumed that in 40 out of 50 years it was not necessary to feed. That is, that in ten out of 50 years it was necessary to feed for one month, so that in *seven of the ten years when it was necessary to feed for one month it was also necessary to feed for two months or more.*

This may be stated more fully:

Of 50 years it is necessary to feed for one month or more in only ten years.
Of these ten years sheep must be fed for two months or more in seven years.
Of these seven years sheep must be fed for two months or more in five years.
Of these five years sheep must be fed for four months or more in four years.
Of these four years sheep must be fed for six months or more in three years.
Of these three years sheep must be fed for seven months or more in two years.
Of these two years sheep must be fed for ten months in one year.

Now suppose that the grazier has been feeding for two months (as he will have been in seven out of 50 years) and that he can still buy wheaten hay at £12 a ton, and that if the drought continues for another month (as it will do in five of these seven years) then the price of wheaten hay will go up to £16 a ton. Then, if the grazier has exhausted his own fodder reserve, his opportunities can be expressed as in Table VI.

TABLE VI

Possible Costs of Buying Wheaten Hay at £12 a Ton after Two-month Drought

	Rain	No Rain
	£	£
Purchase	4	12
No purchase	0	16

The £4 "cost" of buying and then having it rain represents the difference between the cost of hay, £12, and its value, £8, in a normal season.

From Table VI, a new table showing the costs of alternative buying policies after two months feeding can be constructed.

TABLE VII

"Cost" of Buying Hay After Two-month Drought

Supply Bought	Necessary to Feed for (months)						Total of 7 Years	Average
	None	1	3	4	6	8		
	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	£ s. d.	£ s. d.
None ..	..	8 0	24 0	32 0	52 0	72 0	9 8 0	1 6 10
1 month ..	2 0	6 0	22 0	30 0	50 0	70 0	9 2 0	1 6 0
2 months ..	4 0	8 0	20 0	28 0	48 0	68 0	9 0 0	1 5 9
3 months ..	6 0	10 0	18 0	26 0	46 0	66 0	8 18 0	1 5 5
4 months ..	8 0	12 0	20 0	24 0	44 0	64 0	9 0 0	1 5 9
5 months ..	10 0	14 0	22 0	26 0	40 0	60 0	9 2 0	1 6 0
6 months ..	12 0	16 0	24 0	28 0	36 0	56 0	9 4 0	1 6 3
7 months ..	14 0	18 0	26 0	30 0	38 0	52 0	9 12 0	1 7 5
8 months ..	16 0	20 0	28 0	32 0	40 0	48 0	10 0 0	1 8 7
Number of years in 7	2	1	1	1	1	1	..	..

Table VII refers, of course, to a situation where after a two-month dry spell the grazier has no further fodder stored on his property. The 6s. 0d. cost of purchasing a three-month supply just before the drought breaks corresponds to paying a premium of £4 per ton (or 2s. 0d. per half cwt.) on three months supply of fodder. The 66s. 0d. cost of purchasing three months supply when eight months supply is needed is made up of:

		s. d.		s. d.
3 months	feeding fodder bought for	6 0	per ½ cwt. =	18 0
plus 1 month	feeding fodder bought for	8 0	per ½ cwt. =	8 0
plus 4 months	feeding fodder bought for	10 0	per ½ cwt. =	40 0
	Total Cost of Feeding for 8 months			66 0

OTHER POINTS

The possibility of selling stock, obtaining agistment, or putting stock on the road has not been discussed. However, these reactions to drought could be examined in the same way as the building up of a fodder reserve—if sufficient were known about the likely drought prices.

The rate of interest is very important in deciding how big a fodder reserve the grazier can afford. The lower the rate of interest the more money he can afford to tie up in fodder reserves. Also the alternative uses for money should be carefully considered before it is tied up in a fodder

reserve. Thus the purchase of additional land less subject to drought, or the establishing of a lucerne stand might return 10 per cent or more *and* be a form of drought reserve.

If taxation is taken into account (*i.e.*, reserves are accumulated from money subject to high taxation and used to maintain income in a bad year) then the equalising effect on income will make fodder reserves much more attractive than has been suggested in this article.