Using long term seasonal rainfall records to predict the likelihood of above or below average total annual rainfall in a summer rainfall environment

G. M. Lodge

NSW Department of Primary Industries, Tamworth Agricultural Institute,
4 Marsden Park Rd, Calala NSW 2340

Timely decisions on matching forage supply and livestock demand are critical for efficient and profitable livestock production and the sustainable use of the pasture and soil resource bases. Pasture growth is a major source of forage that is markedly affected by rainfall and so a climate risk analysis tool that can predict early in the year, with a reasonably high degree of certainty as to whether or not the current year is likely have above or below average rainfall could be extremely important for decision making. Rainfall (daily, monthly, or yearly) is probably the best kept and most often discussed record on many properties. Yet these records are rarely used to examine and make predictions about the environment in which producers conduct their businesses. This paper examines how such records may be used to provide valuable insights into what sort of seasons may lie ahead.

Methods

A two-stage approach was used. Firstly, long term monthly rainfall data for Tamworth (1889-1980, Clewett *et al.* 2003) were used to identify likely predictors and secondly these predictors were independently applied to data sets from 1981 to 2004.

Based on rainfall data (Table 1), each calendar year for Tamworth (January to December, 1889-1980) was then categorised as being either; wet (i.e actual annual rainfall >674 mm), marginally dry (annual rainfall between 674 and 674 x 0.9 mm), dry (annual rainfall between 674 x 0.9 and 674 x 0.75), very dry (annual rainfall between 674 x 0.75 and 674 x 0.67 mm), or, extremely dry (annual rainfall <674 x 0.67 mm). Calculated values therefore corresponded to 90, 75 and 67% of average annual rainfall.

Historical (1889-1980) actual summer (December to February) rainfall (mm) and annual rainfall categories (wet, marginally dry, dry, very dry, and extremely dry) for Tamworth were then tabulated and used to examine whether or not actual summer rainfall was a predictor of likely total annual rainfall in that year. If summer rainfall was <227 mm (summer predictor), then total rainfall for that year was predicted to be below average. Conversely, if summer rain was >227 mm rainfall for the year then total rainfall for that year was predicted to be above average.

A similar process was then used to examine years for Tamworth (1889-1980) in which autumn rainfall was less than mean autumn rainfall (134 mm, autumn predictor) and summer and autumn rainfall was less than the long term mean (361 mm, summer + autumn predictor). This gave predictors that could be used at the end of February (end of summer) or end of May (end of autumn) each year. All calculations were automated in a Microsoft Excel spreadsheet.

This approach was then applied to long term rainfall records (Clewett *et al.* 2003) for the centres of Barraba, Glen Innes and Inverell in the summer dominant rainfall zone of northern NSW (Table 1) to assess the value of using current summer and autumn rainfall

Table 1. Mean long term annual, summer (December to February) and autumn (March to May) rainfall (mm) and the proportion (%) of annual rainfall that occurs in summer for 4 centres in northern NSW

Centre	Period of record	Mean rainfall (mm)			Proportion
		Annual	Summer	Autumn	(%)
Tamworth	1889-1980	674	227	134	33.6
Barraba	1883-1980	687	239	138	34.8
Glen Innes	1881-1980	845	301	160	35.6
Inverell	1875-1980	764	270	156	35.4

Table 2. The number of years categorised as extremely dry, very dry, dry, marginally dry and wet based on total annual rainfall and the proportion of years correctly predicted by the summer (S), autumn (A) and S + A predictors for 2 periods of rainfall data (1889-1980 and 1981-2004) for Tamworth NSW

	1889-1980				1981-2004			
Year		Percentage of years predicted				Percentage of years predicted		
	No. years	Summer predictor	Autumn predictor	S + A predictor	No. years	Summer predictor	Autumn predictor	S + A predictor
Extremely dry	6	83	100	100	2	100	50	100
Very dry	10	60	70	90	1	100	100	100
Dry	18	83	67	78	6	67	67	67
Marginally dry	10	60	40	70	2	100	50	100
Wet	47	68	46	63	13	62	54	85
All years	91	70	56	73	24	71	59	83
Years <average	44	73	66	82	11	82	64	82

as a predictor of likely total annual rainfall in that year. To further examine the validity of these predictors, similar analyses were also undertaken for Tamworth and these 3 locations in northern NSW for a separate, independent set of years from 1981 to 2004. Analyses were also undertaken for the centres of Bingara, Manilla, Somerton, Nundle, Yetman, and Spring Ridge, but are not presented in this paper.

Results and discussion

Relationship between summer and autumn rainfall and total annual rainfall for Tamworth

For the years 1889-1980 (91 years) summer rainfall was positively correlated ($P<0.01$) with total annual rainfall for Tamworth ($r=0.53$), but poorly correlated with total rainfall from March to December ($r=0.07$). Similarly, for the Tamworth long term rainfall data, autumn, and summer and autumn rainfall was positively correlated with total annual rainfall ($r=0.37$ and $r=0.68$, respectively), but poorly correlated with rainfall for the rest of the year ($r=-0.11$ and $r=-0.08$, respectively). Hence, any predictive ability of summer and/or autumn rainfall was related to its contribution to total annual rainfall each year, rather than its ability to predict rainfall in the rest of that year. Over all years (1889-2004, 115 years) summer rainfall was also positively correlated ($P<0.01$) with total annual rainfall ($r=0.51$), but poorly correlated with total rainfall from March to December ($r=0.05$).

Importantly, the predictors (described in detail below) only indicate if total annual rainfall is likely to be above or below average. Matching of year categories (wet, marginally dry, dry, very dry, and extremely dry) to predicted outcomes can only be done retrospectively.

Tamworth - 1889-1980 rainfall

For this 91 year period, approximately half of the years (50.5%) had above average total annual rainfall (Table 2). There were 6 extremely dry (1902, 1919, 1923, 1946, 1965, and 1980; 6.6% of all years), 10 very dry (11%), 18 dry (19.8%) and 10 marginally dry years (Table 2).

For all years, the summer predictor (actual summer rainfall <mean summer rainfall) correctly categorised 70% of years as having either above or below average rainfall, while the autumn and summer + autumn predictors correctly categorised 56 and 73% of years, respectively (Table 2). For the 44 years with total annual rainfall below average, the summer predictor correctly identified 32 (73%) of those years (Table 2), while the autumn and autumn + summer predictors identified 29 (66%) and 36 (82%) of years, respectively. The summer predictor correctly identified 5 of the 6 extremely dry years (83%), 6 of the 10 very dry years (60%), 15 of the 18 dry years (83%), 6 of the10 marginally dry years (60%), and 32 of the 47 wet years (68%). Compared with the summer predictor the autumn predictor had a higher proportion of correctly identified extremely and very dry years (Table 2). For years with below average rainfall, the summer + autumn predictor had the highest proportion of correctly identified years (Table 2), but this was to be expected since this predictor uses rainfall data

for a 6-month period and cannot be applied until the end of May.

Clearly, based on these long term data the summer predictor provided a means of predicting with reasonably high certainty (about 70%) whether or not total annual rainfall in that year was likely to be either above or below average. Moreover, this prediction was available at the end of February, increasing awareness of the likely production potential for that year at an early stage and allowing timely decisions to be made about the sowing of forage crops such as oats. It also gives some lead time for decisions about likely pasture improvement and fertiliser strategies, stocking rates and stock types, the need for supplements and the likelihood of achieving livestock target weights in that year. The autumn predictor was not as reliable (56%, Table 2) and compared with the summer predictor the summer + autumn predictor only increased the correct identification of year type by 3% (70 to 73%, Table 2). There was also some indication that the summer + autumn predictor was better at predicting extremely dry, very dry and dry years (>77%, Table 2), than those years that were marginally dry or wet (<71%, Table 2).

Tamworth - 1981-2004 rainfall

Applying these predictors to the 24 year data set from 1981-2004 gave similar results to those above. For all years, the summer predictor correctly categorised 71% of years as having either above or below average rainfall, while the autumn and summer + autumn predictors correctly categorised 58 and 83% of years, respectively (Table 2). For the 11 years that total annual rainfall was below average, the summer predictor identified 9 (82%) of those years (Table 2), while the autumn and autumn + summer predictors, identified 7 (64%) and 9 (82%) of the years, respectively. The summer predictor correctly identified the 2 extremely dry years (1982 and 1994) and 1 very dry year (2002), 4 of the 6 dry years (67%), both of the marginally dry years, and 8 of the 13 wet years (62%). For all years, the summer + autumn predictor again had the highest proportion of correctly identified years (83%, Table 2).

Table 3. Number of years classified as extremely dry (ED), very dry (VD), dry (D), marginally dry (MD) and wet (W) and the proportion for all years (All) and those years in which total annual rainfall was below average (<Av.) together with the proportion (%) of years correctly predicted to be in these categories by the summer (S), autumn (A) and S + A predictors. Data are presented 2 periods of rainfall data (start of record to 1980 and 1981-2004) for Barraba, Glen Innes and Inverell, NSW

No. of years	Number and proportion (%) of years correctly identified													
	Start of record to 1980							1981-2004						
and predictor	ED	VD	D	MD	W	All	<Av.	ED	VD	D	MD	W	All	<Av.
							Barraba							
No. of years	12	7	24	9	47	99	52	2	0	5	4	13	24	11
Summer	83	86	83	56	75	77	79	100	-	60	100	69	75	82
Autumn	92	86	63	44	47	59	69	100	-	60	50	62	63	64
S + A	92	100	83	22	76	76	77	100	-	80	75	69	75	82
							Glen Innes							
No. of years	7	8	22	18	44	99	55	0	1	3	3	17	24	7
Summer	86	63	82	67	61	69	69	-	100	33	100	82	79	71
Autumn	100	75	55	61	55	61	61	-	100	100	33	52	58	71
S + A	100	88	86	56	64	72	72	-	100	100	67	82	83	86
							Inverell							
No. of years	9	9	22	14	51	105	54	1	1	3	5	14	24	10
Summer	89	56	68	50	49	57	65	100	100	100	20	71	67	60
Autumn	89	78	59	64	55	62	69	100	100	33	60	50	54	60
S + A	100	89	68	43	69	70	70	100	100	67	40	71	67	60

Other centres

Similar to Tamworth, approximately 50% of years had above average rainfall for Barraba, Glen Innes and Inverell, although in the period 1981-2004 there were a higher proportion of years with above average rainfall, particularly for Glen Innes (Table 3). For the longer term data (start of record to 1980, Table 4) the summer predictor correctly categorised 77, 69 and 57% of all years at Barraba, Glen Innes and Inverell, respectively as having above or below average annual rainfall, with the lower value for Inverell being related to only a 50% success rate for marginally dry and wet years. From 1981 to 2004, the summer predictor correctly categorised 75, 79 and 67% of all years at Barraba, Glen Innes and Inverell, respectively as having above or below average annual rainfall and these values were similar to those obtained using the S + A predictor later in the year (Table 3).

Conclusions

In the summer rainfall zone of northern NSW, a summer predictor (actual summer (December to February inclusive) rainfall <mean summer rainfall) at the end of February each year correctly identified 57 to 77% of years with total annual rainfall above or below average. These analyses on their own or when combined with those such as rapid, negative changes in the Southern Oscillation Index (Clewett *et al.* 2003) may provide simple, but powerful tools for analysing rainfall data and including climate risk assessment in the on-farm decision making processes.

References

Clewett JF, Clarkson NM, George DA, Ooi SH, Owens DT, Partridge IJ, Simpson GB (2003) 'Rainman StreamFlow version 4.3: a comprehensive climate and stream flow analysis package on CD to assess seasonal forecasts and manage climate risk.' (Department of Primary Industries: Brisbane)