

**Appendix 5.** Structure and operation of the GRASP model.

Main program

- Organise input/output and control the logical flow.
- Call for daily climate data and soil, plant and animal parameters to calculate daily soil water balance and plant growth.
- Call for simulation of annual crop growth if required.
- Call for management information at the appropriate time.
- Repeat operations daily for desired period and printout results at time intervals specified by the user.
- Call for probability analysis if sufficient data.

Subroutines (in the order in which they occur in the main program listing)

- AINPUT - Used for entering text while in the interactive mode of operation.
- DEFAUL - Writes values from the parameter file to a file and to the screen.
- IINPUT - Used for entering integer values, checking that they fall within a specified (sensible) range. Default values are supplied.
- INTERA - Used for changing parameter values in the interactive mode of operation.
- ERRCHK - A check on selected parameter values as with IINPUT.
- METONE - Locates appropriate climatic data within the computer system.
- METSTA - Interactive location of specific climatic data.
- TREERT - Calculates tree root distribution for subsequent tree water use.
- METIN - Reads climatic data into the model.
- SOIL - Calculates soil moisture variables, for example, soil evaporation, plant transpiration, tree water use, water supply index, runoff, drainage, adjusted soil water and totals using climatic data and calculated biomass.
- TEMPER - Calculates a temperature index for the selected pasture community.
- GROWPL - Calculates all pasture components, for example, growth limited by moisture, temperature and cover, regrowth, death and detachment rates, litter disappearance rates, consumption by animals, trampling losses and totals.
- BASALA - Calculates a dynamic basal area using summer rainfall.
- BURN7 - Resets various pasture components following fire.
- CROPEM - Simulates management of an annual crop through fallow, planting and harvest, with feedbacks to GROWPL.
- MANAGE - Causes management changes within the model on specified days, covering stocking rate, starting liveweight, pasture harvest, burning, irrigation, runoff, resetting soil moisture and nitrogen

uptake. Observed values from experiments (Chapter 3) are entered here and compared with predictions made by the model.

- RESETSM- Resets soil moisture each year.
- PDISTX - Calculates probability distribution of climatic, soil water balance and growth components in annual totals if more than ten years are modeled, and calls subroutine PDIST to obtain deciles.
- RUNOF2 - Calculates runoff as a function of pasture cover and soil moisture.
- NUPTAK - Calculates nitrogen uptake.
- ANIMAL - Calculates daily liveweight gain of beef cattle taking into account the size of the animal, restriction on intake when pasture yield is low and season. Sheep are converted to beef equivalents.
- NTSDM - Calculates nitrogen content of dry matter accounting for uptake and losses via detachment and nutrient dilution as pastures age.
- GDLW - Calculates liveweight gain from number of green days (McCown 1980).
- NLWG - Calculates liveweight gain from dietary N (Siebert and Hunter 1977).
- PDIST - Calculates deciles of the cumulative probability distribution for each observation and returns them to PDISTX.

#### Operating the GRASP model

There are two modes of operating the GRASP model, interactive and batch. Interactive operation enables one treatment of one experiment to be analysed many times while varying parameters between runs. This mode is used while calibrating the model to a particular data set. Batch operation enables a number of runs to be performed in the one operation. This mode is used for simulation studies once calibration is completed.

Both modes use three main file groups (input files, main program and subroutines and output files).

A number of files are used as input to GRASP. The most important are the parameter and management record files. Values in these files are used to calibrate the model to individual data sets. Parameters define physical and biological processes (derived from Chapter 3) and others are used as switches to select alternatives. Together they cover soil water storage characteristics, soil evaporation, runoff, plant cover, plant temperature index, plant growth, plant senescence and litter breakdown, nitrogen uptake, grazing, simulation control, climate stations and experimental observations.

The main program and subroutines, described above, manage the flow of data and equations describing the biological processes within the model. Parameter values from the input files are used as coefficients in these equations. In this way the main program and subroutines are independent of the parameters describing individual sites, and do not require modification for each new data set.

A number of output files are produced by the model. These are used for examining results during either calibration or simulation studies.

**Appendix 6.** Default parameter file used as input to the GRASP forage production model

		PARAMETER values for Gunsynd from ron gun	
		First number = parameter code number	1
		Second number = parameter value	2
		SOIL PARAMETERS	4
20	100.000	Thickness (mm) of soil layer 1 (surface 100mm approx) which can be air dried. Nemonic = SW(8,1).	6
21	400.000	Thickness (mm) of soil layer 2. This layer cannot dry below permanent wilting point, and is the main zone of root activity. Nemonic = SW(8,2).	7
22	500.000	Thickness (mm) of soil layer 3. The lower limit of this layer is the limit of root penetration ( =SW(8,3)).	8
26	36.000	SW(2,1) Layer 1 maximum soil moisture (mm).	9
27	174.000	SW(2,2) Layer 2 maximum soil moisture (mm).	10
28	105.000	SW(2,3) Layer 3 maximum soil moisture (mm).	11
19	10.000	AIRDRY Layer 1 air dry soil moisture content (mm).	12
29	15.000	SW(3,1) Layer 1 wilting point soil moisture (mm).	15
30	70.000	SW(3,2) Layer 2 minimum soil moisture (mm).	16
31	65.000	SW(3,3) Layer 3 minimum soil moisture (mm).	17
		SOIL EVAPORATION	19
33	4.000	EPLIM Upper limit to daily soil evaporation (mm/day)	20
		STARTING SOIL MOISTURE also used when p289 is a date	21
23	15.000	SW(9,1) Starting value for soil moisture layer 1 (mm).	22
24	108.000	SW(9,2) Starting value for soil moisture layer 2 (mm).	23
25	71.000	SW(9,3) Starting value for soil moisture layer 3 (mm).	24
		RUNOFF	26
270	0.000	0 for free draining soils, 1for runoff as a f(yield)	28
271	1150.000	tsdm yield at 50% cover for run-off calculation	29
272	0.950	k value in cover=y**k / (y**k + p271**k)	30
273	1.000	maximum runoff of rainfall at zero cover, wet soil	31
		I15 Brian P= 1.016+0.465*cos,	33
		I15 Charters = 0.9+0.7*cos	35
		I15 Capella = 0.867+0.582*cos	36
104	1.016	constant in I15 equation I15=p104+p105*cos(dayno+15)	37
105	0.465	slope in I15 equation I15=p104+p105*cos(dayno+15)	38
		OBSERVED SOIL MOISTURE	39
282	0.000	if=1.0 reset to observed soil moisture in management file	40
		ROOT DISTRIBUTION	41
106	0.500	relative supply of layer 3 cf layers 1,2. Usually 0.5	42
		PLANT COVER	43
210	2.000	Selector for cover function; 1=f(time) P(38...43) ,2=f(yields).	44
38	0.625	SCOV mean ) SCOV = P38 +P39*cos(0.01720*(idayno+P40))	45
39	0.325	SCOV amplitude ) = total surface cover calculated as a	46
40	-30.000	SCOV lag ) function of time.(-30 : max cover=Jan30	47
41	0.425	GCOV mean ) GCOV = P41 +P42*cos(0.01720*(idayno+P43))	48
42	0.325	GCOV amplitude ) = green surface cover calculated as a	49
43	-30.000	GCOV lag ) function of time.(-30 : max cover=Jan30	50
45	1600.000	green yield (kg/ha) when green cover for transpiration is 50%	51
107	1.000	A value to transform green cover to POT TRANS/PAN	52
		PLANT TEMPERATURE INDEX selection parameters.	53
209	4.000	TIX 1=FSS, 2=GP , 3= NP ,4= use p61 and p62 ,5= tix=1.0	54
		6=maize, 7=combined NP, 8=NP f(max,min)	55
61	14.000	If temp is less than P61, temperature index (TIX) is zero.	56
62	24.000	As temp increases from P61 to P62, TIX increases from 0 to 1.	57
63	45.000	As temp increases from P62 to P63, TIX remains at 1.	58

64	50.000	As temp increases from P63 to P64, TIX decreases from 1 to 0.0	67
		PLANT SOLAR RADIATION INDEX & INTERCEPTION	69
46	1600.000	green yield (kg/ha) when radiation interception is 50%	70
8	12.000	Radiation use efficiency kg/ha per MJ/sqm of solar radiation	71
		PLANT GROWTH	73
5	6.800	Initial plant density e.g. % basal area	74
6	0.000	Potential daily regrowth rate (kg/ha/day/unit of density)	75
		This is with water, temperature and light non-limiting,	76
		(growth index = 1), and represents the potential rate at	77
		which a pasture will regrow in the first few weeks after	78
		burning or cutting. Density unit is same as P5	79
7	15.000	Transpiration efficiency (kg/ha/mm of transpired at vpd 20hPa)	81
		Daily growth =p(7)*vpdix*daily transpiration	82
		vpd is vapour pressure deficit input from met data with .v51	83
		vpdix=10/(vpd*f(height))	85
		te=p(7)*vpdix	87
94	1.500	Multiplier of VPD for zero height	88
95	20.000	Height at which VPD multiplier = 1.0	89
96	10.000	Height (cm) of 1000 kg/ha	90
		height=p(96)*(tsdm/1000.0)	91
		vpdhgt=amax1(1.0,amin1(p(94),	92
		\$ 1.0+(height-p(95))*(p(94)-1.0)/(0.0-p(95)) )	93
		if(vpd.gt.10.0)vpdix=amax1(0.0,amin1(1.0,10.0/(vpd*vpdhgt) )	94
		SOIL MOISTURE SUPPLY EFFECT ON PLANT GROWTH	96
274	0.000	if=1 use denmead and shaw for limiting soil moisture index	97
275	13.000	layer 1 p275*awr1**2 mm/day	98
276	13.000	layer 2 p276*awr2**2 mm/day	99
277	3.600	layer 3 p277*awr3**2 mm/day	100
149	0.400	Soil water index at which above-ground growth stops.	102
		PLANT SENESCENCE AND LITTER BREAKDOWN	104
9	0.100	Soil water index. Maximum green cover = amin1(0.99,swix/p(9))	106
11	2.000	Minimum screen temperature (c) at which green cover = 0%	107
10	0.002	death constant ) DEATH = (P51*(1-swix) + P10) * green pool	108
51	0.013	death slope ) where swix = soil water index	109
13	0.002	Prop of standing dry matter detached per day. DETAC = P13* SDM2	111
258	401.000	Detachment of old pool begins month,day	112
15	0.500	Proportion of pasture which can be eaten by stock. The rest is	113
		lost by trampling. DEIN2 = TINT/P15 - TINT	114
		P16 and P18 are constants for litter breakdown	116
		BREAK = (SW(6,1) * temp/25 * P16 + P18 * stockrate)*litter pool	117
		Thus, breakdown is rapid when soil water in layer 1 is high,	118
		when temperature is high, and the pasture is grazed.	119
16	0.040	rate of litter breakdown when hot and wet	121
18	0.000	Coefficient of stocking rate on litter breakdown	122
		GRAZING	124
		P142, P143 & P144 define an intake restriction index from the	126
		proportion of pasture eaten (PCON) and total standing DM.	127
		RESTR = max(0.0, min( P142 + P143 * PCON, TSDM/P144, 1.0)	128
		When RESTR = 0, intake is fully restricted, and	129
		when RESTR = 1, intake is not restricted	130
		McCaskill's model	
117	0.000	Output for animal model to lw21.ogp 0=no output	
118	18.000	Default animal age (months) when LW's are reset	
119	1.000	No. of experimental treatment for liveweight gain	
120	1.000	Animal model; 0 or 1 for utilization model, 2 for GRASP green	
		days, 3 for WATBAL green days, 4 for old diet N method,	
		5 for new diet N method	
121	0.493	Animal growth rate for green days (native 0.493, imp 0.613)	

122	-0.163	Animal growth rate for non-green days (native -0.163, imp -0.043	
142	1.050	Intercept in equation of reln between intake and utilisation	132
143	-0.500	Slope in equation of reln between intake and utilisation	133
144	230.000	Yield (kg/ha) at which intake restriction no longer operates	134
145	70.000	Expected live weight gain (kg/hd) in summer at low stocking rate	136
146	35.000	Expected live weight gain (kg/hd) in autumn at low stocking rate	137
147	10.000	Expected live weight gain (kg/hd) in winter at low stocking rate	138
148	35.000	Expected live weight gain (kg/hd) in spring at low stocking rate	139
		These values are used only to adjust intake.	140
150	0.000	Initial stocking rate (weaners/ha, live weight = 200 kg)	142
		SIMULATION CONTROL	145
261	1.000	batch operation=0 ;interactive=1	147
203	1900.000	Starting year of simulation; 1800 to begin at start of metfile.	148
204	7.000	Starting month of simulation	149
206	0.000	Number of days in simuln run,last date : 1st Mar 1986=198603	150
		if=0 150 years	151
		CLIMATE STATIONS	153
263	39039.000	Station no. of AUSTCLIM station from menu	155
		option(39039=GAYNDAH)	
264	42.000	No. of daily (rainfall) station in pmbstat2.pat, 1=BrianPastures	156
250	6.000	if=1 full daily met data, if=3 weekly austclm	157
		4=daily rain in dr2 format, with either AUSTCLIM or station p269	158
		6=daily rain + daily climate, no in p269 type 1	159
269	8.000	monthly climate station type 5 in pmbstat2, if=0 AUSTCLIM	160
		OUTPUT CONTROL	162
		mndy=monthday eg 0315 is 15th March	164
		P247 - Output of totals : 365=yearly,91=seasonally,30=monthly,	165
		7=weekly,1=daily,999=each observation. If P247=mndy and	166
		182 Nov-Apr, 183 Dec-May, 988 for each management date	100
		P249 = 0 then probabilities will be printed.	167
		p247=9901 for totals between srate change	
		for totals between obs,code 15 must be first rec on date	
		P248 - Output of model : 365=yearly,91=seasonally,30=monthly,	168
		7=weekly,1=daily,999=each observation, 988=soil moisture	169
		P249 - if = 1,totals are summed; if = 0 and P247 = mndy then	170
		probabilities will be printed	171
		P262 - Output to screen : 365=yearly,91=seasonally,30=monthly,	172
		7=weekly,1=daily,999=each observation,988=soil moisture	173
		11=growth model, 12= total days for each growth limit	174
		988=soilmoisture, 977=runoff, 976=water balance on p247	175
246	132.000	Output type: 80=80 column output, 132= 132 output 0=132 col	177
247	999.000	Output of totals:365 - 999=yr - obs.If=mndy & P249=0,print prob	178
		999 for pasture observations, 988 for soil moisture	179
		For probabilities p247=date e.g 930 is 30th September	180
248	0.000	Output of model:365=yr,91=seas,30=mthly,7=wkly,1=daily,999=obs	181
		999 for pasture observations, 988 for soil moisture	182
249	1.000	if=1,totals are summed;if=0 and P247=mndy then probs are printed	183
262	999.000	Output to screen:365=yr,91=seas,30=mthly,7=wkly,1=daily,999=obs	184
		999 for soil moisture & pasture observations,	185
		998 for detailed pasture observations, green, dead, litter	186
		988 for soil moisture	187
		978 for nitrogen change in TSDM	
		977 for runoff output to screen	188
		976 for water balance in long term simulations & tree water use	189
		975 for tree water use	190
		974 for nitrogen uptake	191
		973 for output of both water balance & nitrogen uptake on p247	192
		972 for surface conditions and litter breakdown	

		971 for simulation output for GRASSMAN	
		284 for TE & RUE growth analysis	193
		286 for rainfall use efficiency on screen	194
		11 for growth model debugging	195
		12 for growth model debugging	196
259	1.000	Output to screen: 1= stop screen scrolling	197
283	1.000	if=1 ET output to file soilwa18.ogp, p246 must be 132	199
284	2.000	if=1 TE output to file pasture9.ogp, p246 must be 132	200
		if=2 RFUE,ETUE,TUE	
		if=3 Comparison of N models	
		if=970 for daily output used in estab4	
211	0.000	if=1-365 gives output of observed & predicted , and simulated : 365=yearly,91=seasonally,30=monthly, 7=weekly,1=daily,999=each observation,mndy=monthday output in mongro15.ogp or m1	
285	0.000	if=1 monthly growth output to file mongro15.ogp, p211 must be 0	201
		if=2 monthly growth in rainman output	
286	0.000	if=1 rainfall use efficiency to rainue17.ogp, p246 must be 132	202
287	0.000	if=1 runoff output to pastur19.ogp, only days with rain GE p287 p270 must be 1 for output, p246 must be 132	203
		soil water deficit, cover, I15, rain, run-off are output	205
		ANNUAL CROP MANAGEMENT	207
		To be used only in simulation studies of annual forage	209
		P151, P152 & P153 control 3 decision rules for planting a crop.	210
		Crop can be planted if the avail water ratio in the whole profile > P151, in layer 1 > P152	211
			212
251	0.000	if=1 call crop emergence subroutine and use options P252to 260.	214
151	0.500	Min available water ratio in total profile required for planting	215
152	0.900	Min available water ratio in layer one required for planting	216
153	0.300	Max awr in layer one so it`s dry enough to plant	217
252	901.000	First date for planting; month day 0901 = 1st Sept.	218
253	1231.000	Last date for planting; month day 1231 = 31st Dec.	219
254	25.000	Yield at emergence (kg/ha)	220
255	10.000	Number of days from planting to emergence	221
256	90.000	Number of days from emergence to end of crop growth	222
260	70.000	Number of days from emergence to end of green growth	223
257	401.000	End of crop on month, day due to temperature	224
		PASTURE BURNING MANAGEMENT	226
265	0.000	if=1 call pasture burning subroutine and use options 266-7	228
266	1001.000	First date of burning; month day 1001 = 1st Oct	229
267	0.000	Threshold yield required for burn; total standing DM kg/ha	230
268	0.000	if=1 call dynamic basal area subroutine	231
288	5.000	Water (ET) use efficiency for basal area change barea=(growly+ETsu*p(288))/1000.0	232
			233
290	0.000	Date for resetting soil moisture to p23..25, 930 is 30th Sept	235
		TREE WATER USE	237
291	0.000	MATURE TREE BASAL AREA	
292	0.000	Layer 1 minimum soil moisture (mm) with trees	239
293	0.000	Layer 2 minimum soil moisture (mm) with trees.	240
294	0.000	Layer 3 minimum soil moisture (mm) with trees.	241
295	100.000	Layer 4 available water (trees only)	242
296	300.000	Maximum rooting depth of trees in cm	243
297	1.440	Tree Root length at surface, rl= p297*exp(-p298*z)	
298	0.610	Tree Root length exponent, rl= p297*exp(-p298*z)	
299	100.000	asw4 Starting value for soil moisture layer 4 (mm), trees only	
		NITROGEN UPTAKE	245
97	5.000	N uptake (kg/ha) at zero transpiration, N=p(97)+p(98)*(trans/100	246
98	5.800	N uptake per 100 mm of transpiration	247

## Appendices

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99	23.000	Maximum N uptake (kg/ha)	248
100	2.500	Maximum % N in growth	249
101	0.400	% N at zero growth Nitrogen index = (%N-p101)/(p102-p101)	250
102	0.500	% N at maximum growth Nitrogen index = (%N-p101)/(p102-p101)	251
103	1.000	N uptake per 100 mm of soil water	247
108	0.000	Proportional decline per day in % N for green material	
109	0.015	Proportional decline per day in % N for dead material	
110	1.000	Minimum % N in green & maximum in dead	249
111	0.400	Minimum % N in dead	
112	915.000	Date for resetting Nitrogen uptake	
300	0.000	Indicates end of parameter file	253

**Appendix 7.** Diaries describing steps taken to calibrate the GRASP model to individual sites.

Biddenham

1. Soil moisture, soil depth, dry matter yield, green cover and nitrogen concentration, perennial grass basal area and tree basal area data were entered in a parameter file specific for Biddenham (bidd2.mrx). Where data was missing or unavailable the entry was left blank. In most cases this was confined to soil moisture data for the third layer in the profile, due to difficulty in auguring dry soil.

2. Daily rainfall for the site was entered in a file suitable as input to GRASP (bidd.dr2). Temperature, evaporation, solar radiation and vapor pressure deficit data for Charleville was used (chlv8690.v51). The site was 80km north of Charleville.

3. The temperature response appropriate for the C4 Mitchell grass community was selected in this parameter file.

4. The best estimates of the wettest and driest soil moisture profiles (from Chapter 3) were entered in the parameter file for each layer (0-10cm, 10-50cm and 50-85cm).

5. Estimates of potential growth rate, transpiration efficiency, soil moisture effect on green cover and rate of nitrogen uptake per mm of transpiration (from data presented in Chapter 3) were entered in the parameter file.

6. The model was run, and calibrated using the above two parameters to check that modelled dry matter yields approximated observed dry matter yields.

7. Steps 4-6 were repeated to manually calibrate growth and soil moisture parameters. The model was again run to check the differences between observed and modeled wettest and driest soil moisture profiles. A regression analysis comparing modeled and observed soil moisture for the total profile calculated a RMS of 13. Using output from the model the parameters describing the wettest and driest profiles were modified, given the dates of measurement were not necessarily wilting point and field capacity. The new values for each layer were estimated as follows;

Wilting point = modeled lowest - 1.0

Field capacity = modeled highest + 1.0

8. The simulation results allowed an interpretation of the observed soil moisture. Model results indicated there was little variation in the moisture content in the third layer between the 26.02.87 and 29.10.87. Statistical analysis of the fluctuations in moisture in this layer, indicated no significant changes between observations over this period (Appendix 3, Table 9.2). The average modeled moisture content for the third layer over this period was 81.1 mm. This value was entered in the parameter file where data were unavailable for the third layer due to the difficulty in auguring dry soil to allow calculation of accumulative evapo-transpiration.

9. The model was run again using 81.1 mm as the start up value for layer three.

10. Despite an RMS of 13, on several dates modeled soil moistures varied from those observed.

On 07.01.87 a dry profile was observed in contrast to a wet profile being predicted by the model. A check on the rainfall data indicates rain fell the day before the observation. The Biddenham site is located some 3km from the house and it is likely that the rain measured on 06.01.87 fell some days



earlier, therefore allowing the profile to dry down. Thus, the difference between simulated and observed is likely to be due to possible error in the recording date for rain.

On 10.12.87 the observed soil moisture for the second layer was drier (by 23mm) than that predicted by the model. However, the moisture observed on this date for the 0-50cm layer was not significantly different to that observed on 08.04.87, and hence is considered a realistic value. As these are both the significantly driest profiles at this depth, large cracks forming in these soils, and the resulting circulation of air could dry these soils to these levels. The model does not simulate drying of the 10-50cm zone below wilting point and hence in the absence of green cover at this date, simulated ET (mainly soil evaporation) is too low.

Cracks may also explain the significant increase in soil moisture for the third layer on 17.12.86. The previous observation (21.11.86) indicated a dry profile. Rainfall of 60mm between these periods may have fallen as several storms and water flow down cracks may explain the significant increase in soil moisture.

Thus, application of the model to cracking clays will require modification of soil evaporation functions and also allow infiltration to lower soil layers (for example Clewett 1986).

11. With the model calibrated with soil moisture data, attention was directed towards plant growth. Chapter 3 describes the significant changes in yield and green cover. Model results are compared to observed data. In general, predicted yields reflected observed values. However, the model did not reflect significant decline in yields occurring after the fourth and eleventh observations.

Parameter file for Biddenham (BIDD2.MRX)

PARAMETER values for Biddenham Mitchell grass Charleville 1986/7

		layer 3 missing values 81.0 replaced with 81.0	
26	42.0	SW(2,1) Layer 1 maximum soil moisture (mm).	15
27	113.0	SW(2,2) Layer 2 maximum soil moisture (mm).	16
28	107.0	SW(2,3) Layer 3 maximum soil moisture (mm).	17
19	12.0	AIRDRY Layer 1 air dry soil moisture content (mm).	19
29	14.0	SW(3,1) Layer 1 wilting point soil moisture (mm).	20
30	64.0	SW(3,2) Layer 2 minimum soil moisture (mm).	21
31	81.1	SW(3,3) Layer 3 minimum soil moisture (mm).	22
		STARTING SOIL MOISTURE also used when p289 is a date	28
23	15.0	SW(9,1) Starting value for soil moisture layer 1 (mm).	29
24	80.0	SW(9,2) Starting value for soil moisture layer 2 (mm).	30
25	118.0	SW(9,3) Starting value for soil moisture layer 3 (mm).	31
33	2.0	EPLIM Upper limit to daily soil evaporation (mm/day)	26
		RUNOFF	33
270	1.0	0 for free draining soils, 1 for runoff as a f(yield)	35
271	1150.0	yield at 50% cover for run-off calculation	36
272	1.0	k value in $cover = y^{**}k / (y^{**}k + p271^{**}k)$	37
273	1.0	maximum runoff of rainfall at zero cover, wet soil	38
		I15 Brian P= 1.016+0.465*cos,	
		I15 Charters = 0.9+0.7*cos	
		I15 Capella = 0.867+0.582*cos	
104	1.0	constant in I15 equation $I15 = p104 + p105 * \cos(\text{dayno} + 15)$	43
105	0.5	slope in I15 equation $I15 = p104 + p105 * \cos(\text{dayno} + 15)$	43
		ROOT DISTRIBUTION	
106	0.5	relative supply of layer 3 cf layers 1,2. Usually 0.5	
45	1200.0	green yield (kg/ha) when green cover for transpiration is 50%	58
46	1400.0	green yield (kg/ha) when radiation interception is 50%	70

209	4.0	TIX 1=FSS, 2=GP , 3= NP ,4= use p61 and p62 ,5= tix=1.0 6=maize, 7=combined NP, 8=NP f(max,min)	62 63
61	14.0	If temp is less than P61, temperature index (TIX) is zero.	64
62	24.0	As temp increases from P61 to P62, TIX increases from 0 to 1.	65
63	35.0	As temp increases from P62 to P63, TIX remains at 1.	66
64	45.0	As temp increases from P63 to P64, TIX decreases from 1 to 0.0	67
5	4.0	Initial plant density e.g. % basal area	74
6	2.0	Potential daily regrowth rate (kg/ha/day/unit of density)	75
7	21.0	Transpiration efficiency (kg/ha/mm of transpired at vpd 20 mb	81
9	1.0	Soil water index. Maximum green cover = amin1(0.99,swix/p(9))	106
11	-4.0	Minimum screen temperature (c) at which green cover = 0%	107
13	0.0	Prop of standing dry matter detached per day. DETAC = P13* SDM2	111
258	801.0	Detachment of old pool begins month,day	112
96	20.0	Height (cm) of 1000 kg/ha	90
97	2.0	N uptake (kg/ha) at zero transpiration, N=p(97)+p(98)*(trans/100	246
99	21.0	Maximum N uptake (kg/ha)	248
101	0.5	% N at zero growth Nitrogen index = (%N-p101)/(p102-p101)	250
102	0.6	% N at maximum growth Nitrogen index = (%N-p101)/(p102-p101)	251
100	2.5	Maximum % N in growth	249
108	0.0	Proportional decline per day in % N for green material	
109	0.0	Proportional decline per day in % N for dead material	
110	1.0	Minimum % N in green & maximum in dead NOT USED in gvt72	
111	0.6	Minimum % N in dead	
263	44021.0	Station no. of AUSTCLIM station from menu option(39039=GAYNDAH)	155
264	13.0	No. of daily (rainfall) station in pmbstat2.pat, 1=BrianPastures	156
250	6.0	if=1 full daily met data, if=3 weekly austclm 4=daily rain in dr2 format, with either AUSTCLIM or station p269 6=daily rain + daily climate, no in p269 type 1	157 158 159
269	10.0	monthly climate station type 5 in pmbstat2, if=0 AUSTCLIM	160
206	730.0	Number of days in simuln run,last date : 1st Mar 1986=198603	150
211	7.0	if=1-365 gives output of observed & predicted , and simulated : 365=yearly,91=seasonally,30=monthly, 7=weekly,1=daily,999=each observation,mndy=monthday output in mongro15.ogp or m1	
262	999.0	Output to screen:365=yr,91=seas,30=mthly,7=wkly,1=daily,999=obs	184
98	12.0	N uptake per 100 mm of transpiration	247
284	0.0	if=1 TE output to file pasture9.ogp, p246 must be 132	200
300	0.0	Indicates end of parameter file	253

Biddgun	19861121	2 reset yld	0.0	50.0	0.0	0.60	0.00	
Biddgun	19861121	14reset soil	19.9	81.7	81.1	0.00	0.00	extrapolated
Biddgun	19861121	16observatio	19.9	81.7	73.6	0.10	0.00	
Biddgun	19861217	19reset soil	19.5	100.5	95.8	13.10	0.00	
Biddgun	19861217	15observatio	19.5	215.7	85.6	13.10	2.57	
Biddgun	19861217	2 reset yld	86.0	0.0	0.0	2.57	0.00	
Biddgun	19861217	15observatio	19.5	215.7	85.6	13.10	2.57	
Biddgun	19861217	16observatio	19.5	100.5	95.8	13.10	0.00	
Biddgun	19870107	15observatio	19.4	194.9	187.0	16.50	2.12	
Biddgun	19870107	19 reset yld	187.0	0.0	0.0	2.12	0.00	
Biddgun	19870107	16observatio	19.4	89.1	86.4	16.50	0.00	
Biddgun	19870226	15observatio	28.4	196.6	1144.0	44.90	1.23	
Biddgun	19870226	16observatio	28.4	90.1	78.0	44.90	0.00	
Biddgun	19870318	15observatio	15.1	179.5	1633.0	16.80	0.82	
Biddgun	19870318	16observatio	15.1	82.8	81.7	16.80	0.00	
Biddgun	19870408	15observatio	13.4	167.3	949.8	6.80	0.66	
Biddgun	19870408	16observatio	13.4	72.8	81.1	6.80	0.00	
Biddgun	19870429	15observatio	21.5	184.2	1237.6	4.10	0.00	

Biddgun	1987042916observatio	21.5	82.7	80.0	4.10	0.00	
Biddgun	1987052115observatio	17.3	183.6	1129.4	2.90	0.59	
Biddgun	1987052116observatio	17.3	82.2	84.0	2.90	0.00	
Biddgun	1987061215observatio	14.4	178.0	1040.5	0.60	0.64	
Biddgun	1987061216observatio	14.4	79.7	83.9	0.60	0.00	
Biddgun	1987062415observatio	40.9	229.7	1288.6	2.00	0.74	
Biddgun	1987062416observatio	40.9	108.9	79.8	2.00	0.00	
Biddgun	1987071615observatio	23.7	181.5	1463.2	1.20	0.64	
Biddgun	1987071616observatio	23.7	84.8	73.1	1.20	0.00	
Biddgun	1987081115observatio	28.8	201.6	1678.2	3.90	0.64	
Biddgun	1987081116observatio	28.8	91.5	81.3	3.90	0.00	
Biddgun	1987082615observatio	28.4	209.1	1177.3	7.90	0.63	
Biddgun	1987082616observatio	28.4	99.6	81.1	7.90	0.00	
Biddgun	1987091815observatio	17.4	184.8	1126.7	5.50	0.65	
Biddgun	1987091816observatio	17.4	86.3	81.1	5.50	0.00	
Biddgun	1987100815observatio	35.9	215.9	1092.6	5.30	0.63	
Biddgun	1987100816observatio	35.9	95.4	84.6	5.30	0.00	
Biddgun	1987102915observatio	19.3	188.5	1405.4	7.00	0.65	
Biddgun	1987102916observatio	19.3	86.5	82.7	7.00	0.00	
Biddgun	1987112516observatio	30.2	112.8	83.0	0.00	0.00	
Biddgun	1987121016observatio	16.0	64.0	81.1	0.00	0.00	layer 3=118
ppm30	1988080215obs	0.0	0.0	0.0	0.00	0.00	ppm=30
file end	99990000 for GRASP						

#### Charleville site

1. Soil moisture, soil depth, dry matter yield, green cover and nitrogen concentration, perennial grass basal area and tree basal area data were entered in a parameter file specific for the Charleville site (mulga.mrx). Where data was missing or unavailable the entry was left blank.
2. Daily climate from the Charleville Bureau of Meteorology (1km away) was entered in a file suitable as input to GRASP (chlv8690.v51). This data included daily rainfall, maximum and minimum temperature, 9am wet and dry bulb temperature, pan evaporation, and vapor pressure deficits. Daily solar radiation was estimated using the TAMSIM program.
3. The temperature response appropriate for the predominantly C3 mulga grass community was selected in this parameter file.
4. The best estimates of the wettest and driest soil moisture profiles (from Chapter 3) were entered in the parameter file for each layer (0-10cm, 10-50cm and 50-100cm). Due to the proximity of *Acacia aneura* trees, a mature tree basal area was estimated at 0.5 m<sup>2</sup>/ha. The default distribution of roots in the profile was chosen
5. Estimates of potential growth rate, transpiration efficiency, soil moisture effect on green cover and rate of nitrogen uptake per mm of transpiration (from Chapter 3) were entered in the parameter file.
6. The model was run, and calibrated using the potential regrowth rate and transpiration efficiency to check that modelled dry matter yields approximated observed dry matter yields.
7. Steps 4-6 were repeated to manually calibrate growth and soil moisture parameters. The model was again run to check the differences between observed and modeled wettest and driest soil moisture profiles. Calculating runoff as a function of yield improved the simulation of soil moistures. A regression analysis indicated a good comparison between modeled and observed soil moisture for the total profile (RMS 5).

8. Simulation results allowed an interpretation of the observed soil moisture. While cover levels were low (first three months following initial mowing) the model underestimated water use from the 10-50cm layer of the profile. As layer 1 and layer 3 varied little from the observed it was postulated that neighbouring trees may be using water from layer 2. The effect of a different root distribution based on the shallow rooting nature of *Acacia aneura* was investigated (0-10cm 19.1%, 10-50cm 47.4%, 50-100cm 24.5% and 100-150cm 9%). A simulation study using a high tree basal area (5 m<sup>2</sup>/ha) and low grass basal area (1%) indicated little impact of tree root distribution on dry matter production. (Simulated dry matter yields were 250 kg/ha under the modified root distribution and 265 kg/ha under the default root distribution).

High soil evaporation rates during periods of low cover offer an alternative explanation for the low moisture contents of the 10-50cm zone.

9. With the model calibrated with soil moisture data, attention was directed towards plant growth. Chapter 3 describes the significant changes in yield and green cover. Model results are compared to observed data. In general, predicted yields reflected observed values.

Parameter file for Charleville site (MULGA.MRX)

PARAMETER values for DPI mulga site Charleville site 1986/7

26	13.0	SW(2,1) Layer 1 maximum soil moisture (mm).	15
27	40.8	SW(2,2) Layer 2 maximum soil moisture (mm).	16
28	37.8	SW(2,3) Layer 3 maximum soil moisture (mm).	17
19	1.0	AIRDRY Layer 1 air dry soil moisture content (mm).	19
29	1.1	SW(3,1) Layer 1 wilting point soil moisture (mm).	20
30	13.0	SW(3,2) Layer 2 minimum soil moisture (mm).	21
31	22.8	SW(3,3) Layer 3 minimum soil moisture (mm).	22
		STARTING SOIL MOISTURE also used when p289 is a date	28
23	1.0	SW(9,1) Starting value for soil moisture layer 1 (mm).	29
24	13.0	SW(9,2) Starting value for soil moisture layer 2 (mm).	30
25	22.8	SW(9,3) Starting value for soil moisture layer 3 (mm).	31
33	8.0	EPLIM Upper limit to daily soil evaporation (mm/day)	26
		TREE WATER USE	237
291	0.5	MATURE TREE BASAL AREA	
292	1.0	Layer 1 minimum soil moisture (mm) with trees	239
293	13.0	Layer 2 minimum soil moisture (mm) with trees.	240
294	20.0	Layer 3 minimum soil moisture (mm) with trees.	241
295	15.0	Layer 4 available water (trees only)	242
296	150.0	Maximum rooting depth of trees in cm	243
297	1.4	Tree Root length at surface, $rl = p297 * \exp(-p298 * z)$	
298	0.6	Tree Root length exponent, $rl = p297 * \exp(-p298 * z)$	
299	0.0	asw4 Starting value for soil moisture layer 4 (mm), trees only	
		RUNOFF	33
270	1.0	0 for free draining soils, 1 for runoff as a f(yield)	35
271	1150.0	yield at 50% cover for run-off calculation	36
272	1.0	k value in $cover = y^{**k} / (y^{**k} + p271^{**k})$	37
273	1.0	maximum runoff of rainfall at zero cover, wet soil	38
45	1200.0	green yield (kg/ha) when green cover for transpiration is 50%	58
46	1400.0	green yield (kg/ha) when radiation interception is 50%	70
209	4.0	TIX 1=FSS, 2=GP, 3= NP, 4= use p61 and p62, 5= tix=1.0	62
		6=maize, 7=combined NP, 8=NP f(max,min)	63
61	9.0	If temp is less than P61, temperature index (TIX) is zero.	64
62	18.0	As temp increases from P61 to P62, TIX increases from 0 to 1.	65
63	30.0	As temp increases from P62 to P63, TIX remains at 1.	66

64	45.0	As temp increases from P63 to P64, TIX decreases from 1 to 0.0	67				
5	4.4	Initial plant density e.g. % basal area	74				
6	1.5	Potential daily regrowth rate (kg/ha/day/unit of density)	75				
7	10.0	Transpiration efficiency (kg/ha/mm of transpired at vpd 20 mb)	81				
96	33.0	Height (cm) of 1000 kg/ha	90				
9	1.0	Soil water index. Maximum green cover = $\text{amin1}(0.99, \text{swix}/p(9))$	106				
11	-4.0	Minimum sreen temperature (c) at which green cover = 0%	107				
13	0.0	Prop of standing dry matter detached per day. $\text{DETAC} = P13 * \text{SDM2}$	111				
258	0.0	Detachment of old pool begins month,day	112				
97	2.0	N uptake (kg/ha) at zero transpiration, $N=p(97)+p(98)*(trans/100)$	246				
98	10.0	N uptake per 100 mm of transpiration	247				
99	22.0	Maximum N uptake (kg/ha)	248				
101	1.2	% N at zero growth Nitrogen index = $(\%N-p101)/(p102-p101)$	250				
102	1.3	% N at maximum growth Nitrogen index = $(\%N-p101)/(p102-p101)$	251				
108	0.0	Proportional decline per day in % N for green material					
109	0.0	Proportional decline per day in % N for dead material					
100	2.5	Maximum % N in growth	249				
110	1.0	Minimum % N in green & maximum in dead Not used in gvt72					
111	0.8	Minimum % N in dead					
263	44021.0	Station no. of AUSTCLIM station from menu option(39039=GAYNDAH)	155				
264	10.0	No. of daily (rainfall) station in pmbstat2.pat, 1=BrianPastures	156				
250	1.0	if=1 full daily met data, if=3 weekly austclm	157				
		4=daily rain in dr2 format, with either AUSTCLIM or station p269	158				
		6=daily rain + daily climate, no in p269 type 1	159				
269	0.0	monthly climate station type 5 in pmbstat2, if=0 AUSTCLIM	160				
203	1986.0	Starting year of simulation; 1800 to begin at start of metfile.	148				
204	7.0	Starting month of simulation	149				
206	730.0	Number of days in simuln run,last date : 1st Mar 1986=198603	150				
211	7.0	if=1-365 gives output of observed & predicted , and simulated : 365=yearly,91=seasonally,30=monthly, 7=weekly,1=daily,999=each observation,mndy=monthday output in mongro15.ogp or m1					
284	0.0	if=1 TE output to file pasture9.ogp, p246 must be 132	200				
300	0.0	Indicates end of parameter file	253				
mulgagun	19861024	2 reset yld	0.0	50.0	0.0	0.00	0.00
mulgagun	19861024	14reset soil	6.1	18.5	25.5	0.00	0.00
mulgagun	19861024	16observatio	6.1	18.5	25.5	0.00	0.00
mulgagun	19861205	15observatio	7.4	68.1	205.6	16.70	2.46
mulgagun	19861205	2 reset yld	205.6	0.0	0.0	2.46	0.00
mulgagun	19861205	15observatio	7.4	68.1	205.6	16.70	2.46
mulgagun	19861205	16observatio	7.4	25.2	35.5	16.70	
mulgagun	19861231	15observatio	1.1	38.4	242.6	9.10	1.79
mulgagun	19861231	16observatio	1.1	14.5	22.8	9.10	
mulgagun	19870121	15observatio	2.8	41.2	194.8	8.90	1.77
mulgagun	19870121	16observatio	2.8	15.2	23.2	8.90	
mulgagun	19870211	15observatio	3.1	52.9	275.4	19.60	2.08
mulgagun	19870211	16observatio	3.1	19.1	30.7	19.60	
mulgagun	19870304	15observatio	7.8	64.7	703.4	29.30	2.42
mulgagun	19870304	16observatio	7.8	26.3	30.7	29.30	
mulgagun	19870326	15observatio	13.0	84.1	645.2	17.10	1.20
mulgagun	19870326	16observatio	13.0	40.5	30.6	17.10	
mulgagun	19870416	15observatio	3.6	45.0	798.9	18.40	1.26
mulgagun	19870416	16observatio	3.6	16.4	24.9	18.40	
mulgagun	19870520	15observatio	4.7	49.9	720.1	6.60	1.04
mulgagun	19870520	16observatio	4.7	19.1	26.0	6.60	
mulgagun	19870611	15observatio	2.5	43.5	846.7	8.50	1.02
							gcov estimated

mulgagun	1987061116observatio	2.5	17.2	23.8	8.50		gcov estimated
mulgagun	1987070119 reset yld	240.0	372.0	0.0	1.45	0.00	
mulgagun	1987070115observatio	8.0	76.5	611.9	10.40	1.45	
mulgagun	1987070116observatio	8.0	33.6	34.9	10.40		
mulgagun	1987072915observatio	8.0	71.9	834.0	11.30	1.38	replace 1157.6
mulgagun	1987072916observatio	8.0	29.3	34.7	11.30		
mulgagun	1987081915observatio	9.7	79.7	905.3	12.50	1.67	
mulgagun	1987081916observatio	9.7	36.5	33.6	12.50		
mulgagun	1987090215observatio	5.0	65.5	943.1	16.30	1.72	
mulgagun	1987090216observatio	5.0	27.0	33.5	16.30		
mulgagun	1987092315observatio	3.1	45.7	1189.9	16.60	1.24	
mulgagun	1987092316observatio	3.1	18.2	24.4	16.60		
mulgagun	1987101515observatio	3.1	45.8	984.6	8.90	0.83	
mulgagun	1987101516observatio	3.1	17.8	25.0	8.90		
mulgagun	1987110516observatio	3.4	17.4	24.0	0.00		
mulgagun	1987112616observatio	3.6	17.4	24.0	0.00		
file end	99990000 for GRASP						

Parameter file for Airlie (AIRL2.MRX)

PARAMETER values for Airlie (Biddenham) Mitchell grass Charleville 1986/87

26	25.0	SW(2,1) Layer 1 maximum soil moisture (mm).	15
27	100.0	SW(2,2) Layer 2 maximum soil moisture (mm).	16
28	125.0	SW(2,3) Layer 3 maximum soil moisture (mm).	17
19	3.0	AIRDRY Layer 1 air dry soil moisture content (mm).	19
29	5.0	SW(3,1) Layer 1 wilting point soil moisture (mm).	20
30	40.0	SW(3,2) Layer 2 minimum soil moisture (mm).	21
31	50.0	SW(3,3) Layer 3 minimum soil moisture (mm).	22
		STARTING SOIL MOISTURE also used when p289 is a date	28
23	7.0	SW(9,1) Starting value for soil moisture layer 1 (mm).	29
24	37.0	SW(9,2) Starting value for soil moisture layer 2 (mm).	30
25	43.0	SW(9,3) Starting value for soil moisture layer 3 (mm).	31
33	2.0	EPLIM Upper limit to daily soil evaporation (mm/day)	26
		RUNOFF	33
270	0.0	0 for free draining soils, 1for runoff as a f(yield)	35
271	1150.0	yield at 50% cover for run-off calculation	36
272	1.0	k value in $cover=y^{**k} / (y^{**k} + p271^{**k})$	37
273	1.0	maximum runoff of rainfall at zero cover, wet soil	38
45	1000.0	green yield (kg/ha) when green cover for transpiration is 50%	58
46	1300.0	green yield (kg/ha) when radiation interception is 50%	70
209	4.0	TIX 1=FSS, 2=GP, 3= NP, 4= use p61 and p62, 5= tix=1.0	62
		6=maize, 7=combined NP, 8=NP f(max,min)	63
61	14.0	If temp is less than P61, temperature index (TIX) is zero.	64
62	24.0	As temp increases from P61 to P62, TIX increases from 0 to 1.	65
63	40.0	As temp increases from P62 to P63, TIX remains at 1.	66
64	50.0	As temp increases from P63 to P64, TIX decreases from 1 to 0.0	67
5	4.0	Initial plant density e.g. % basal area	74
6	0.5	Potential daily regrowth rate (kg/ha/day/unit of density)	75
7	10.0	Transpiration efficiency (kg/ha/mm of transpired at vpd 20 mb	81
9	0.1	Soil water index. Maximum green cover = $amin1(0.99,swix/p(9))$	106
11	-2.0	Minimum sreen temperature (c) at which green cover = 0%	107
13	0.0	Prop of standing dry matter detached per day. DETAC = P13* SDM2	111
258	401.0	Detachment of old pool begins month,day	112
96	30.0	Height (cm) of 1000 kg/ha	90
97	2.0	N uptake (kg/ha) at zero transpiration, $N=p(97)+p(98)*(trans/100$	246
98	5.0	N uptake per 100 mm of transpiration	247
99	13.5	Maximum N uptake (kg/ha)	248

Appendices

101	0.5	% N at zero growth	Nitrogen index = (%N-p101)/(p102-p101)	250
102	0.6	% N at maximum growth	Nitrogen index = (%N-p101)/(p102-p101)	251
108	0.0	Proportional decline per day in % N for green material		
109	0.0	Proportional decline per day in % N for dead material		
100	2.5	Maximum % N in growth		249
110	1.0	Minimum % N in green & maximum in dead	NOT USED in gvt72	
111	0.6	Minimum % N in dead		
263	44021.0	Station no. of AUSTCLIM station from menu option	(39039=GAYNDAH)	155
264	68.0	No. of daily (rainfall) station in pmbstat2.pat,	1=BrianPastures	156
250	6.0	if=1 full daily met data, if=3 weekly austclm		157
		4=daily rain in dr2 format, with either AUSTCLIM or station p269		158
		6=daily rain + daily climate, no in p269 type 1		159
269	10.0	monthly climate station type 5 in pmbstat2, if=0 AUSTCLIM		160
211	7.0	if=1-365 gives output of observed & predicted, and simulated : 365=yearly,91=seasonally,30=monthly,7=weekly,1=daily,999=each observation,mndy=monthday output in mongro15.ogp or m1		
262	999.0	Output to screen:365=yr,91=seas,30=mthly,7=wkly,1=daily,999=obs		184
206	730.0	Number of days in simuln run,last date : 1st Mar 1986=198603		150
284	0.0	if=1 TE output to file pasture9.ogp, p246 must be 132		200
300	0.0	Indicates end of parameter file		253

Airlie	19881110	2 reset yld	0.0	50.0	0.0	0.00	0.00	
Airlie	1988111014	reset soil	6.6	36.7	43.3	0.00	0.00	
Airlie	1988111016	observatio	6.6	36.7	43.3	0.00	0.00	est layer 3
Airlie	1989011615	observatio	10.4	88.6	53.0	2.30	0.00	
Airlie	1989011616	observatio	10.4	33.9	44.3	2.30	0.00	est layer 3
Airlie	1989022715	observatio	9.4	87.6	80.0	2.60	0.00	
Airlie	1989022716	observatio	9.4	34.5	43.8	2.60	0.00	est layer 3
Airlie	1989041015	observatio	16.6	132.9	45.0	7.80	0.00	
Airlie	1989041016	observatio	16.6	49.9	66.5	7.80	0.00	est layer 3
Airlie	1989070315	observatio	21.8	274.7	388.0	12.20	0.00	
Airlie	1989070316	observatio	21.8	112.0	140.9	12.20	0.00	
Airlie	1989081415	observatio	0.0	0.0	411.0	14.50	0.00	
Airlie	1989081419	observatio	0.0	0.0	0.0	14.50	0.00	
Airlie	1989092515	observatio	4.8	0.0	560.0	21.30	0.00	
Airlie	1989092516	observatio	4.8	15.6	43.3	21.30	0.00	est layer 3
Airlie	1989112815	observatio	10.9	146.9	1216.0	33.60	0.00	
Airlie	1989112816	observatio	10.9	62.6	73.4	33.60	0.00	est layer 3
Airlie	1990021215	observatio	6.3	69.3	1000.0	0.50	0.00	yield est.
Airlie	1990021216	observatio	6.3	28.4	34.6	0.00	0.00	est layer 3
Airlie	1990112815	observatio	0.0	0.0	1300.0	10.50	0.00	yld est.
file end	99990000	for GRASP						

Parameter file for Lisnalee (LISN4.MRX)

PARAMETER values for Lisnalee Buffel (Biddenham Mitchell grass 1986/87)

26	12.0	SW(2,1) Layer 1 maximum soil moisture (mm).	15
27	45.0	SW(2,2) Layer 2 maximum soil moisture (mm).	16
28	85.0	SW(2,3) Layer 3 maximum soil moisture (mm).	17
19	4.0	AIRDRY Layer 1 air dry soil moisture content (mm).	19
29	4.0	SW(3,1) Layer 1 wilting point soil moisture (mm).	20
30	12.0	SW(3,2) Layer 2 minimum soil moisture (mm).	21
31	25.0	SW(3,3) Layer 3 minimum soil moisture (mm).	22
		STARTING SOIL MOISTURE also used when p289 is a date	28
23	8.0	SW(9,1) Starting value for soil moisture layer 1 (mm).	29
24	30.0	SW(9,2) Starting value for soil moisture layer 2 (mm).	30

25	57.0	SW(9,3) Starting value for soil moisture layer 3 (mm).	31
33	4.0	EPLIM Upper limit to daily soil evaporation (mm/day)	26
		RUNOFF	33
270	0.0	0 for free draining soils, 1for runoff as a f(yield)	35
271	1150.0	yield at 50% cover for run-off calculation	36
272	1.0	k value in cover= $y^{**k} / (y^{**k} + p271^{**k})$	37
273	1.0	maximum runoff of rainfall at zero cover, wet soil	38
		ROOT DISTRIBUTION	
106	0.5	relative supply of layer 3 cf layers 1,2. Usually 0.5	
45	800.0	green yield (kg/ha) when green cover for transpiration is 50%	58
46	1000.0	green yield (kg/ha) when radiation interception is 50%	70
209	3.0	TIX 1=FSS, 2=GP, 3= NP, 4= use p61 and p62, 5=tix=1.0 6=maize, 7=combined NP, 8=NP f(max,min)	62 63
61	14.0	If temp is less than P61, temperature index (TIX) is zero.	64
62	24.0	As temp increases from P61 to P62, TIX increases from 0 to 1.	65
63	40.0	As temp increases from P62 to P63, TIX remains at 1.	66
64	50.0	As temp increases from P63 to P64, TIX decreases from 1 to 0.0	67
5	6.2	Initial plant density e.g. % basal area	74
6	5.0	Potential daily regrowth rate (kg/ha/day/unit of density)	75
7	12.0	Transpiration efficiency (kg/ha/mm of transpired at vpd 20 mb	81
9	0.1	Soil water index. Maximum green cover = $amin1(0.99,swix/p(9))$	106
11	2.0	Minimum sreen temperature (c) at which green cover = 0%	107
13	0.0	Prop of standing dry matter detached per day. DETAC = P13* SDM2	111
258	515.0	Detachment of old pool begins month,day	112
96	30.0	Height (cm) of 1000 kg/ha	90
97	5.0	N uptake (kg/ha) at zero transpiration, $N=p(97)+p(98)*(trans/100)$	246
98	5.0	N uptake per 100 mm of transpiration	247
99	24.0	Maximum N uptake (kg/ha)	248
101	0.5	% N at zero growth Nitrogen index = $(\%N-p101)/(p102-p101)$	250
102	0.6	% N at maximum growth Nitrogen index = $(\%N-p101)/(p102-p101)$	251
108	0.0	Proportional decline per day in % N for green material	
109	0.0	Proportional decline per day in % N for dead material	
100	2.5	Maximum % N in growth	249
110	1.0	Minimum % N in green & maximum in dead NOT USED in gvt72	
111	0.6	Minimum % N in dead	
263	44021.0	Station no. of AUSTCLIM station from menu option(39039=GAYNDAH)	155
264	69.0	No. of daily (rainfall) station in pmbstat2.pat, 1=BrianPastures	156
250	6.0	if=1 full daily met data, if=3 weekly austclm 4=daily rain in dr2 format, with either AUSTCLIM or station p269 6=daily rain + daily climate, no in p269 type 1	157 158 159
269	10.0	monthly climate station type 5 in pmbstat2, if=0 AUSTCLIM	160
211	7.0	if=1-365 gives output of observed & predicted, and simulated : 365=yearly,91=seasonally,30=monthly, 7=weekly,1=daily,999=each observation,mndy=monthday output in mongro15.ogp or m1	
206	730.0	Number of days in simuln run,last date : 1st Mar 1986=198603	150
284	0.0	if=1 TE output to file pasture9.ogp, p246 must be 132	200
300	0.0	Indicates end of parameter file	253

Lisnalee	19890113 2 reset yld	0.0	50.0	0.0	0.00	0.00	
Lisnalee	1989011314reset soil	8.4	29.7	57.4	0.00	0.00	layer 3 est
Lisnalee	1989011316observatio	8.4	29.7	57.4	0.00	0.00	layer 3 est
Lisnalee	1989030215observatio	2.7	57.4	648.0	24.20	0.00	layer 3 est
Lisnalee	19890302 2 reset yld	500.0	148.0	0.0	0.00	0.00	
Lisnalee	1989030216observatio	2.7	14.7	40.0	24.20	0.00	layer 3 est
Lisnalee	1989041415observatio	7.3	101.3	1137.0	59.10	0.00	layer 3 est
Lisnalee	1989041416observatio	7.3	33.1	60.9	59.10	0.00	layer 3 est



Lisnalee	1989052315observatio	8.6	93.2	1052.0	43.00	0.00	layer 3 est
Lisnalee	1989052316observatio	8.6	28.6	56.0	43.00	0.00	layer 3 est
Lisnalee	1989070615observatio	6.9	112.8	1092.0	0.10	0.00	gcov zero
Lisnalee	1989070616observatio	6.9	41.1	64.8	0.10	0.00	gcov zero
Lisnalee	1989081715observatio	6.5	97.7	976.0	2.10	0.00	
Lisnalee	1989081716observatio	6.5	36.6	54.5	2.10	0.00	
Lisnalee	1989092815observatio	5.7	111.6	1385.0	7.50	0.00	
Lisnalee	1989092816observatio	5.7	35.5	70.4	7.50	0.00	
Lisnalee	1989120115observatio	2.8	59.1	1163.0	10.20	0.00	layer 3 est
Lisnalee	1989120116observatio	2.8	16.3	40.0	10.20	0.00	layer 3 est
Lisnalee	19900210 2 reset yld	500.0	282.0	0.0	0.00	0.00	
Lisnalee	1990022015observatio	11.5	110.8	782.0	0.20	0.00	layer 3 est
Lisnalee	1990022016observatio	11.5	32.7	66.6	0.20	0.00	layer 3 est
Lisnalee	1990051115observatio	6.3	134.6	2009.0	81.60	0.00	
Lisnalee	1990051116observatio	6.3	42.1	86.2	81.60	0.00	
Lisnalee	1990112215observatio	4.1	79.7	1267.0	0.00	0.00	layer 3 est
Lisnalee	1990112216observatio	4.1	27.7	47.9	0.00	0.00	layer 3 est
file end	99990000 for GRASP						

Parameter file for Maxvale (MAX2.MRX)

Maxvale (M3) Mulga/box flat loamy red earth PWJ, PARAMETERS from mulga 1986/87

26	15.0	SW(2,1) Layer 1 maximum soil moisture (mm).	15
27	71.0	SW(2,2) Layer 2 maximum soil moisture (mm).	16
28	96.0	SW(2,3) Layer 3 maximum soil moisture (mm).	17
19	1.0	AIRDRY Layer 1 air dry soil moisture content (mm).	19
29	1.1	SW(3,1) Layer 1 wilting point soil moisture (mm).	20
30	8.0	SW(3,2) Layer 2 minimum soil moisture (mm).	21
31	18.0	SW(3,3) Layer 3 minimum soil moisture (mm).	22
		STARTING SOIL MOISTURE also used when p289 is a date	28
23	8.0	SW(9,1) Starting value for soil moisture layer 1 (mm).	29
24	32.0	SW(9,2) Starting value for soil moisture layer 2 (mm).	30
25	56.0	SW(9,3) Starting value for soil moisture layer 3 (mm).	31
33	8.0	EPLIM Upper limit to daily soil evaporation (mm/day)	26
		TREE WATER USE	237
291	0.8	MATURE TREE BASAL AREA	
292	1.0	Layer 1 minimum soil moisture (mm) with trees	239
293	5.0	Layer 2 minimum soil moisture (mm) with trees.	240
294	15.0	Layer 3 minimum soil moisture (mm) with trees.	241
295	0.0	Layer 4 available water (trees only)	242
296	100.0	Maximum rooting depth of trees in cm	243
297	1.4	Tree Root length at surface, $rl = p297 * \exp(-p298 * z)$	
298	0.6	Tree Root length exponent, $rl = p297 * \exp(-p298 * z)$	
299	0.0	asw4 Starting value for soil moisture layer 4 (mm), trees only	
		ROOT DISTRIBUTION	
106	0.5	relative supply of layer 3 cf layers 1,2. Usually 0.5	
		RUNOFF	33
270	0.0	0 for free draining soils, 1for runoff as a f(yield)	35
271	1150.0	yield at 50% cover for run-off calculation	36
272	1.0	k value in $cover = y^{**}k / (y^{**}k + p271^{**}k)$	37
273	1.0	maximum runoff of rainfall at zero cover, wet soil	38
		PLANT GROWTH	
45	800.0	green yield (kg/ha) when green cover for transpiration is 50%	58
46	1000.0	green yield (kg/ha) when radiation interception is 50%	70
209	4.0	TIX 1=FSS, 2=GP, 3= NP, 4= use p61 and p62, 5= tix=1.0	62
		6=maize, 7=combined NP, 8=NP f(max,min)	63
61	9.0	If temp is less than P61, temperature index (TIX) is zero.	64

62	18.0	As temp increases from P61 to P62, TIX increases from 0 to 1.	65
63	34.0	As temp increases from P62 to P63, TIX remains at 1.	66
64	50.0	As temp increases from P63 to P64, TIX decreases from 1 to 0.0	67
5	2.7	Initial plant density e.g. % basal area	74
6	1.5	Potential daily regrowth rate (kg/ha/day/unit of density)	75
7	9.0	Transpiration efficiency (kg/ha/mm of transpired at vpd 20 mb	81
96	40.0	Height (cm) of 1000 kg/ha	90
9	0.1	Soil water index. Maximum green cover = $\text{amin1}(0.99, \text{swix}/p(9))$	106
11	-7.0	Minimum sreen temperature (c) at which green cover = 0%	107
13	0.0	Prop of standing dry matter detached per day. $\text{DETAC} = P13 * \text{SDM2}$	111
258	0.0	Detachment of old pool begins month,day	112
97	5.0	N uptake (kg/ha) at zero transpiration, $N=p(97)+p(98)*(trans/100$	246
98	9.0	N uptake per 100 mm of transpiration	247
99	12.0	Maximum N uptake (kg/ha)	248
101	1.2	% N at zero growth Nitrogen index = $(\%N-p101)/(p102-p101)$	250
102	1.3	% N at maximum growth Nitrogen index = $(\%N-p101)/(p102-p101)$	251
108	0.0	Proportional decline per day in % N for green material	
109	0.0	Proportional decline per day in % N for dead material	
100	2.5	Maximum % N in growth	249
110	1.0	Minimum % N in green & maximum in dead Not used in gvt72	
111	0.8	Minimum % N in dead	
203	1988.0	Starting year of simulation; 1800 to begin at start of metfile.	148
204	7.0	Starting month of simulation	149
263	44021.0	Station no. of AUSTCLIM station from menu option(39039=GAYNDAH)	155
264	10.0	No. of daily (rainfall) station in pmbstat2.pat, 1=BrianPastures	156
250	1.0	if=1 full daily met data, if=3 weekly austclm	157
		4=daily rain in dr2 format, with either AUSTCLIM or station p269	158
		6=daily rain + daily climate, no in p269 type 1	159
269	0.0	monthly climate station type 5 in pmbstat2, if=0 AUSTCLIM	160
211	7.0	if=1-365 gives output of observed & predicted , and simulated : 365=yearly,91=seasonally,30=monthly, 7=weekly,1=daily,999=each observation,mndy=monthday output in mongro15.ogp or m1	
206	730.0	Number of days in simuln run,last date : 1st Mar 1986=198603	150
284	0.0	if=1 TE output to file pasture9.ogp, p246 must be 132	200
300	0.0	Indicates end of parameter file	253

Maxvale	19880914	2 reset yld	0.0	50.0	0.0	0.00	0.00	
Maxvale	19880914	14reset soil	7.8	31.6	56.2	0.00	0.00	
Maxvale	19880914	16observatio	7.8	31.6	56.2	0.10	0.00	
Maxvale	19881209	15observatio	0.0	0.0	20.0	0.30	0.00	
Maxvale	19890119	15observatio	1.6	28.7	72.0	2.60	0.00	
Maxvale	19890119	16observatio	1.6	9.3	17.8	2.60	0.00	est 1 3
Maxvale	19890301	15observatio	1.5	25.3	54.0	0.20	0.00	
Maxvale	19890301	16observatio	1.5	8.1	15.7	0.20	0.00	est 1 3
Maxvale	19890412	15observatio	5.6	69.8	85.0	7.00	0.00	
Maxvale	19890412	2 reset yld	0.0	85.0	0.0	0.00	0.00	
Maxvale	19890412	16observatio	5.6	21.0	43.2	7.00	0.00	est 1 3
Maxvale	19890522	15observatio	14.4	181.1	278.0	0.00	0.00	
Maxvale	19890522	16observatio	14.4	71.2	95.5	16.70	0.00	est gcov
Maxvale	19890705	15observatio	10.0	149.8	444.0	26.70	0.00	
Maxvale	19890705	16observatio	10.0	46.6	93.2	26.70	0.00	
Maxvale	19890817	15observatio	3.9	113.0	495.0	19.60	0.00	
Maxvale	19890817	16observatio	3.9	25.5	83.6	19.60	0.00	
Maxvale	19890928	15observatio	5.5	81.3	742.0	16.70	0.00	est 1 3
Maxvale	19890928	16observatio	5.5	25.5	50.4	16.70	0.00	
Maxvale	19891201	15observatio	2.2	38.6	399.0	3.10	0.00	est 1 3

Maxvale	1989120116observatio	2.2	12.5	23.9	3.10	0.00	
Maxvale	1990022015observatio	6.4	42.7	550.0	3.10	0.00	est yld,gcov
Maxvale	1990022016observatio	6.4	9.9	26.4	3.00	0.00	est yld, l3
file end	99990000 for GRASP						

Parameter file for Turn Turn (TURN2.MRX)

Turn Turn (S2) Eulo Sandplain sandy red earth PWJ, PARAMETERS from mulga 1986/87

26	13.0	SW(2,1) Layer 1 maximum soil moisture (mm).	15
27	30.0	SW(2,2) Layer 2 maximum soil moisture (mm).	16
28	33.0	SW(2,3) Layer 3 maximum soil moisture (mm).	17
19	1.0	AIRDRY Layer 1 air dry soil moisture content (mm).	19
29	1.1	SW(3,1) Layer 1 wilting point soil moisture (mm).	20
30	6.0	SW(3,2) Layer 2 minimum soil moisture (mm).	21
31	10.0	SW(3,3) Layer 3 minimum soil moisture (mm).	22
		TREE WATER USE	237
291	2.0	MATURE TREE BASAL AREA	
292	1.0	Layer 1 minimum soil moisture (mm) with trees	239
293	6.0	Layer 2 minimum soil moisture (mm) with trees.	240
294	10.0	Layer 3 minimum soil moisture (mm) with trees.	241
295	50.0	Layer 4 available water (trees only)	242
296	300.0	Maximum rooting depth of trees in cm	243
297	1.4	Tree Root length at surface, $rl = p297 * \exp(-p298 * z)$	
298	0.6	Tree Root length exponent, $rl = p297 * \exp(-p298 * z)$	
299	0.0	asw4 Starting value for soil moisture layer 4 (mm), trees onl	
		STARTING SOIL MOISTURE also used when p289 is a date	28
23	4.0	SW(9,1) Starting value for soil moisture layer 1 (mm).	29
24	18.0	SW(9,2) Starting value for soil moisture layer 2 (mm).	30
25	21.0	SW(9,3) Starting value for soil moisture layer 3 (mm).	31
33	8.0	EPLIM Upper limit to daily soil evaporation (mm/day)	26
		RUNOFF	33
270	0.0	0 for free draining soils, 1for runoff as a f(yield)	35
271	1150.0	yield at 50% cover for run-off calculation	36
272	1.0	k value in $cover = y ** k / (y ** k + p271 ** k)$	37
273	1.0	maximum runoff of rainfall at zero cover, wet soil	38
		PLANT GROWTH	
45	750.0	green yield (kg/ha) when green cover for transpiration is 50%	58
46	900.0	green yield (kg/ha) when radiation interception is 50%	70
209	4.0	TIX 1=FSS, 2=GP, 3= NP, 4= use p61 and p62, 5=tix=1.0	62
		6=maize, 7=combined NP, 8=NP f(max,min)	63
61	9.0	If temp is less than P61, temperature index (TIX) is zero.	64
62	18.0	As temp increases from P61 to P62, TIX increases from 0 to 1.	65
63	30.0	As temp increases from P62 to P63, TIX remains at 1.	66
64	50.0	As temp increases from P63 to P64, TIX decreases from 1 to 0.0	67
5	1.6	Initial plant density e.g. % basal area	74
6	1.5	Potential daily regrowth rate (kg/ha/day/unit of density)	75
7	8.0	Transpiration efficiency (kg/ha/mm of transpired at vpd 20 mb)	81
9	0.1	Soil water index. Maximum green cover = $amin1(0.99, swix/p(9))$	106
11	-7.0	Minimum sreen temperature (c) at which green cover = 0%	107
13	0.0	Prop of standing dry matter detached per day. DETAC = $P13 * SDM2$	111
258	0.0	Detachment of old pool begins month,day	112
96	40.0	Height (cm) of 1000 kg/ha	90
97	5.0	N uptake (kg/ha) at zero transpiration, $N = p(97) + p(98) * (trans/100)$	246
98	13.0	N uptake per 100 mm of transpiration	247
99	12.0	Maximum N uptake (kg/ha)	248
101	1.2	% N at zero growth Nitrogen index = $(\%N - p101) / (p102 - p101)$	250
102	1.3	% N at maximum growth Nitrogen index = $(\%N - p101) / (p102 - p101)$	251

108	0.0	Proportional decline per day in % N for green material	
109	0.0	Proportional decline per day in % N for dead material	
100	2.5	Maximum % N in growth	249
110	1.0	Minimum % N in green & maximum in dead Not used in gvt72	
111	0.8	Minimum % N in dead	
263	44021.0	Station no. of AUSTCLIM station from menu option(39039=GAYNDAH)	155
264	67.0	No. of daily (rainfall) station in pmbstat2.pat, 1=BrianPastures	156
250	6.0	if=1 full daily met data, if=3 weekly austclm	157
		4=daily rain in dr2 format, with either AUSTCLIM or station p269	158
		6=daily rain + daily climate, no in p269 type 1	159
269	10.0	monthly climate station type 5 in pmbstat2, if=0 AUSTCLIM	160
211	7.0	if=1-365 gives output of observed & predicted , and simulated : 365=yearly,91=seasonally,30=monthly, 7=weekly,1=daily,999=each observation,mndy=monthday output in mongro15.ogp or m1	
206	730.0	Number of days in simuln run,last date : 1st Mar 1986=198603	150
284	0.0	if=1 TE output to file pasture9.ogp, p246 must be 132	200
300	0.0	Indicates end of parameter file	253

Turn Turn	19880920 2 reset yld	0.0	10.0	0.0	0.00	0.00	
Turn Turn	1988092014reset soil	3.5	18.3	21.6	0.00	0.00	
Turn Turn	1988092016observatio	3.5	18.3	21.6	0.00	0.00	
Turn Turn	1988120715observatio	2.4	24.0	11.0	0.20	0.00	
Turn Turn	19881207 2 reset yld	0.0	10.0	0.0	0.00	0.00	
Turn Turn	1988120716observatio	2.4	9.6	12.0	0.20	0.00	est l3
Turn Turn	1989011715observatio	1.9	24.0	11.3	0.50	0.00	
Turn Turn	1989011716observatio	1.9	10.1	12.0	0.50	0.00	est l3
Turn Turn	1989022815observatio	1.8	21.6	10.8	1.10	0.00	
Turn Turn	1989022816observatio	1.8	9.0	10.8	1.10	0.00	est l3
Turn Turn	1989041115observatio	6.0	61.8	16.8	1.60	0.00	
Turn Turn	19890411 2 reset yld	0.0	17.0	0.0	0.00	0.00	
Turn Turn	1989041116observatio	6.0	24.9	30.9	1.60	0.00	est l3
Turn Turn	1989070415observatio	5.6	67.5	302.0	21.40	0.00	
Turn Turn	1989070416observatio	5.6	28.1	33.8	21.40	0.00	
Turn Turn	1989081515observatio	0.0	0.0	370.0	18.20	0.00	
Turn Turn	1989081516observatio	0.0	0.0	0.0	18.20	0.00	
Turn Turn	1989092615observatio	2.3	29.1	371.0	7.00	0.00	
Turn Turn	1989092616observatio	2.3	12.2	14.6	7.00	0.00	est l3
Turn Turn	1989112915observatio	2.7	33.8	258.8	5.00	0.00	
Turn Turn	1989112916observatio	2.7	13.5	17.6	5.00	0.00	
Turn Turn	1990021315observatio	0.7	12.6	0.0	5.00	0.00	est yld cover
Turn Turn	1990021316observatio	0.7	5.6	6.3	0.00	0.00	est l3
file end	99990000 for GRASP						

Parameter file for Wittenburra Open (WITOP2.MRX)

Wittenburra open (H2) Eulo hard mulga red earth PWJ, Parameters from mulga 1986/87

20	100.0	Thickness (mm) of soil layer 1 (surface 100mm approx) which can be air dried. Nemonic = SW(8,1).	6
			7
21	400.0	Thickness (mm) of soil layer 2. This layer cannot dry below permanent wilting point, and is the main zone of root activity. Nemonic = SW(8,2).	8
			9
			10
22	300.0	Thickness (mm) of soil layer 3. The lower limit of this layer is the limit of root penetration ( =SW(8,3)).	11
			12
26	13.0	SW(2,1) Layer 1 maximum soil moisture (mm).	15
27	55.0	SW(2,2) Layer 2 maximum soil moisture (mm).	16
28	45.0	SW(2,3) Layer 3 maximum soil moisture (mm).	17

19	2.0	AIRDRY Layer 1 air dry soil moisture content (mm).	19
29	2.0	SW(3,1) Layer 1 wilting point soil moisture (mm).	20
30	14.0	SW(3,2) Layer 2 minimum soil moisture (mm).	21
31	16.0	SW(3,3) Layer 3 minimum soil moisture (mm).	22
		TREE WATER USE	237
291	0.0	MATURE TREE BASAL AREA	
292	1.0	Layer 1 minimum soil moisture (mm) with trees	239
293	12.0	Layer 2 minimum soil moisture (mm) with trees.	240
294	15.0	Layer 3 minimum soil moisture (mm) with trees.	241
295	0.0	Layer 4 available water (trees only)	242
296	80.0	Maximum rooting depth of trees in cm	243
297	1.4	Tree Root length at surface, $rl = p297 * \exp(-p298 * z)$	
298	0.6	Tree Root length exponent, $rl = p297 * \exp(-p298 * z)$	
299	0.0	asw4 Starting value for soil moisture layer 4 (mm), trees only STARTING SOIL MOISTURE also used when p289 is a date	28
23	7.0	SW(9,1) Starting value for soil moisture layer 1 (mm).	29
24	27.0	SW(9,2) Starting value for soil moisture layer 2 (mm).	30
25	18.0	SW(9,3) Starting value for soil moisture layer 3 (mm).	31
33	1.0	EPLIM Upper limit to daily soil evaporation (mm/day)	26
		RUNOFF	33
270	0.0	0 for free draining soils, 1 for runoff as a f(yield)	35
271	1150.0	yield at 50% cover for run-off calculation	36
272	1.0	k value in $cover = y * k / (y * k + p271 * k)$	37
273	1.0	maximum runoff of rainfall at zero cover, wet soil	38
45	500.0	green yield (kg/ha) when green cover for transpiration is 50%	58
46	600.0	green yield (kg/ha) when radiation interception is 50%	70
		PLANT GROWTH	
61	9.0	If temp is less than P61, temperature index (TIX) is zero.	64
62	18.0	As temp increases from P61 to P62, TIX increases from 0 to 1.	65
63	30.0	As temp increases from P62 to P63, TIX remains at 1.	66
64	50.0	As temp increases from P63 to P64, TIX decreases from 1 to 0.0	67
5	0.5	Initial plant density e.g. % basal area	74
6	1.5	Potential daily regrowth rate (kg/ha/day/unit of density)	75
7	5.0	Transpiration efficiency (kg/ha/mm of transpired at vpd 20 mb)	81
9	0.1	Soil water index. Maximum green cover = $amin1(0.99, swix/p(9))$	106
11	-7.0	Minimum sreen temperature (c) at which green cover = 0%	107
13	0.0	Prop of standing dry matter detached per day. DETAC = $P13 * SDM2$	111
258	0.0	Detachment of old pool begins month, day	112
96	40.0	Height (cm) of 1000 kg/ha	90
97	5.0	N uptake (kg/ha) at zero transpiration, $N = p(97) + p(98) * (trans/100)$	246
98	9.0	N uptake per 100 mm of transpiration	247
99	18.0	Maximum N uptake (kg/ha)	248
101	1.2	% N at zero growth Nitrogen index = $(\%N - p101) / (p102 - p101)$	250
102	1.3	% N at maximum growth Nitrogen index = $(\%N - p101) / (p102 - p101)$	251
263	44021.0	Station no. of AUSTCLIM station from menu option(39039=GAYNDAH)	155
264	66.0	No. of daily (rainfall) station in pmbstat2.pat, 1=BrianPastures	156
250	6.0	if=1 full daily met data, if=3 weekly austclm 4=daily rain in dr2 format, with either AUSTCLIM or station p269 6=daily rain + daily climate, no in p269 type 1	157 158 159
269	10.0	monthly climate station type 5 in pmbstat2, if=0 AUSTCLIM	160
211	7.0	if=1-365 gives output of observed & predicted , and simulated : 365=yearly,91=seasonally,30=monthly, 7=weekly,1=daily,999=each observation,mndy=monthday output in mongro15.ogp or m1	
206	730.0	Number of days in simuln run, last date : 1st Mar 1986=198603	150
284	0.0	if=1 TE output to file pasture9.ogp, p246 must be 132	200
300	0.0	Indicates end of parameter file	253

Wittenopen	19880921 2 reset yld	0.0	5.0	0.0	0.00	0.00	
Wittenopen	1988092114reset soil	6.5	26.5	18.0	0.00	0.00	
Wittenopen	1988092116observatio	6.5	26.5	18.0	0.00	0.00	
Wittenopen	1988120715observatio	2.9	34.7	8.5	0.30	0.00	
Wittenopen	1988120716observatio	2.9	16.8	15.0	0.30	0.00	
Wittenopen	1989011715observatio	3.6	48.1	61.0	3.90	0.00	
Wittenopen	1989011716observatio	3.6	23.5	21.0	3.90	0.00	
Wittenopen	1989022815observatio	3.7	46.7	16.0	0.30	0.00	
Wittenopen	1989022816observatio	3.7	19.2	24.0	0.30	0.00	
Wittenopen	1989041115observatio	8.4	52.4	7.3	0.50	0.00	
Wittenopen	1989041116observatio	8.4	26.0	18.0	0.50	0.00	
Wittenopen	1989070415observatio	9.5	79.4	64.0	6.70	0.00	
Wittenopen	1989070416observatio	9.5	49.9	20.0	6.70	0.00	13 est dry
Wittenopen	1989081515observatio	0.0	0.0	178.0	10.70	0.00	
Wittenopen	1989092615observatio	5.2	43.3	260.0	5.90	0.00	
Wittenopen	1989092616observatio	5.2	20.1	18.0	5.90	0.00	
Wittenopen	1989112915observatio	0.0	0.0	0.0	0.00	0.00	no obs.
Wittenopen	1989112916observatio	0.0	0.0	0.0	0.00	0.00	no obs.
file end	99990000 for GRASP						

Parameter file for Wittenburra Enclosed (WITEX2.MRX)

Wittenburra enclosed (H2) Eulo hard mulga red earth PWJ, Parameters mulga 1986/87

20	100.0	Thickness (mm) of soil layer 1 (surface 100mm approx) which can be air dried. Nemonic = SW(8,1).	6 7
21	400.0	Thickness (mm) of soil layer 2. This layer cannot dry below permanent wilting point, and is the main zone of root activity. Nemonic = SW(8,2).	8 9 10
22	300.0	Thickness (mm) of soil layer 3. The lower limit of this layer is the limit of root penetration (=SW(8,3)).	11 12
26	13.0	SW(2,1) Layer 1 maximum soil moisture (mm).	15
27	55.0	SW(2,2) Layer 2 maximum soil moisture (mm).	16
28	45.0	SW(2,3) Layer 3 maximum soil moisture (mm).	17
19	2.0	AIRDRY Layer 1 air dry soil moisture content (mm).	19
29	2.0	SW(3,1) Layer 1 wilting point soil moisture (mm).	20
30	14.0	SW(3,2) Layer 2 minimum soil moisture (mm).	21
31	16.0	SW(3,3) Layer 3 minimum soil moisture (mm).	22
		TREE WATER USE	237
291	1.5	MATURE TREE BASAL AREA	
292	1.0	Layer 1 minimum soil moisture (mm) with trees	239
293	12.0	Layer 2 minimum soil moisture (mm) with trees.	240
294	15.0	Layer 3 minimum soil moisture (mm) with trees.	241
295	0.0	Layer 4 available water (trees only)	242
296	80.0	Maximum rooting depth of trees in cm	243
297	1.4	Tree Root length at surface, $rl = p297 * \exp(-p298 * z)$	
298	0.6	Tree Root length exponent, $rl = p297 * \exp(-p298 * z)$	
299	0.0	asw4 Starting value for soil moisture layer 4 (mm), trees only STARTING SOIL MOISTURE also used when p289 is a date	28
23	6.0	SW(9,1) Starting value for soil moisture layer 1 (mm).	29
24	30.0	SW(9,2) Starting value for soil moisture layer 2 (mm).	30
25	25.0	SW(9,3) Starting value for soil moisture layer 3 (mm).	31
33	1.0	EPLIM Upper limit to daily soil evaporation (mm/day)	26
		RUNOFF	33
270	0.0	0 for free draining soils, 1 for runoff as a f(yield)	35
271	1150.0	yield at 50% cover for run-off calculation	36
272	1.0	k value in $cover = y * k / (y * k + p271 * k)$	37
273	1.0	maximum runoff of rainfall at zero cover, wet soil	38

45	500.0	green yield (kg/ha) when green cover for transpiration is 50%	58
46	600.0	green yield (kg/ha) when radiation interception is 50%	70
PLANT GROWTH			
61	9.0	If temp is less than P61, temperature index (TIX) is zero.	64
62	18.0	As temp increases from P61 to P62, TIX increases from 0 to 1.	65
63	30.0	As temp increases from P62 to P63, TIX remains at 1.	66
64	50.0	As temp increases from P63 to P64, TIX decreases from 1 to 0.0	67
5	0.5	Initial plant density e.g. % basal area	74
6	1.5	Potential daily regrowth rate (kg/ha/day/unit of density)	75
7	6.0	Transpiration efficiency (kg/ha/mm of transpired at vpd 20 mb	81
9	0.1	Soil water index. Maximum green cover = $\text{amin}1(0.99, \text{swix}/\text{p}(9))$	106
11	-7.0	Minimum sreen temperature (c) at which green cover = 0%	107
13	0.0	Prop of standing dry matter detached per day. $\text{DETAC} = \text{P13} * \text{SDM2}$	111
258	0.0	Detachment of old pool begins month,day	112
96	40.0	Height (cm) of 1000 kg/ha	90
97	5.0	N uptake (kg/ha) at zero transpiration, $\text{N}=\text{p}(97)+\text{p}(98)*(\text{trans}/100$	246
98	9.0	N uptake per 100 mm of transpiration	247
99	18.0	Maximum N uptake (kg/ha)	248
101	1.2	% N at zero growth Nitrogen index = $(\%N-\text{p}101)/(\text{p}102-\text{p}101)$	250
102	1.3	% N at maximum growth Nitrogen index = $(\%N-\text{p}101)/(\text{p}102-\text{p}101)$	251
263	44021.0	Station no. of AUSTCLIM station from menu option(39039=GAYNDAH)	155
264	66.0	No. of daily (rainfall) station in pmbstat2.pat, 1=BrianPastures	156
250	6.0	if=1 full daily met data, if=3 weekly austclm	157
		4=daily rain in dr2 format, with either AUSTCLIM or station p269	158
		6=daily rain + daily climate, no in p269 type 1	159
269	10.0	monthly climate station type 5 in pmbstat2, if=0 AUSTCLIM	160
211	7.0	if=1-365 gives output of observed & predicted , and simulated : 365=yearly,91=seasonally,30=monthly, 7=weekly,1=daily,999=each observation,mndy=monthday output in mongro15.ogp or ml	
206	730.0	Number of days in simuln run,last date : 1st Mar 1986=198603	150
284	0.0	if=1 TE output to file pasture9.ogp, p246 must be 132	200
300	0.0	Indicates end of parameter file	253

Witten exc	19880921 2 reset yld	0.0	5.0	0.0	0.00	0.00
Witten exc	1988092114reset soil	6.3	30.1	25.1	0.00	0.00
Witten exc	1988092116observatio	6.3	30.1	25.1	0.00	0.00
Witten exc	1988120715observatio	3.5	35.9	4.0	0.00	0.00
Witten exc	1988120716observatio	3.5	17.1	15.3	0.00	0.00
Witten exc	1989011715observatio	3.2	39.0	19.0	1.10	0.00
Witten exc	1989011716observatio	3.2	18.6	17.2	1.10	0.00
Witten exc	1989022815observatio	2.8	31.9	7.0	0.30	0.00
Witten exc	1989022816observatio	2.8	15.9	13.2	0.30	0.00
Witten exc	1989041115observatio	8.1	55.9	0.0	0.70	0.00
Witten exc	1989041116observatio	8.1	26.6	21.2	0.70	0.00
Witten exc	1989070415observatio	10.0	102.3	157.0	16.40	0.00
Witten exc	1989070416observatio	10.0	49.0	43.3	16.40	0.00
Witten exc	1989081515observatio	0.0	0.0	228.0	29.10	0.00
Witten exc	1989092615observatio	4.9	49.3	193.0	0.50	0.00
Witten exc	1989092616observatio	4.9	23.6	20.8	0.50	0.00
Witten exc	1989112915observatio	5.0	45.5	0.0	0.00	0.00
Witten exc	1989112916observatio	5.0	24.6	15.9	0.00	0.00
file end	99990000 for GRASP					

Parameter file for Wongalee (WONG2.MRX)

Wongalee (N1) Spinifex heathland sandy yellowish earth PWJ			
PARAMETER values for mulga Charleville 1986/7			
26	22.0	SW(2,1) Layer 1 maximum soil moisture (mm).	15
27	85.0	SW(2,2) Layer 2 maximum soil moisture (mm).	16
28	95.0	SW(2,3) Layer 3 maximum soil moisture (mm).	17
19	1.1	AIRDRY Layer 1 air dry soil moisture content (mm).	19
29	2.1	SW(3,1) Layer 1 wilting point soil moisture (mm).	20
30	7.0	SW(3,2) Layer 2 minimum soil moisture (mm).	21
31	40.0	SW(3,3) Layer 3 minimum soil moisture (mm).	22
TREE WATER USE			237
291	0.5	MATURE TREE BASAL AREA	
292	1.0	Layer 1 minimum soil moisture (mm) with trees	239
293	5.0	Layer 2 minimum soil moisture (mm) with trees.	240
294	35.0	Layer 3 minimum soil moisture (mm) with trees.	241
295	110.0	Layer 4 available water (trees only)	242
296	300.0	Maximum rooting depth of trees in cm	243
297	1.4	Tree Root length at surface, $rl = p297 * \exp(-p298 * z)$	
298	0.6	Tree Root length exponent, $rl = p297 * \exp(-p298 * z)$	
STARTING SOIL MOISTURE also used when p289 is a date			28
23	5.0	SW(9,1) Starting value for soil moisture layer 1 (mm).	29
24	30.0	SW(9,2) Starting value for soil moisture layer 2 (mm).	30
25	48.0	SW(9,3) Starting value for soil moisture layer 3 (mm).	31
33	8.0	EPLIM Upper limit to daily soil evaporation (mm/day)	26
RUNOFF			33
270	0.0	0 for free draining soils, 1 for runoff as a f(yield)	35
271	1150.0	yield at 50% cover for run-off calculation	36
272	1.0	k value in $cover = y^{**k} / (y^{**k} + p271^{**k})$	37
273	1.0	maximum runoff of rainfall at zero cover, wet soil	38
104	0.9	constant in I15 equation $I15 = p104 + p105 * \cos(dayno + 15)$	43
105	0.6	slope in I15 equation $I15 = p104 + p105 * \cos(dayno + 15)$	43
45	1000.0	green yield (kg/ha) when green cover for transpiration is 50%	58
46	1300.0	green yield (kg/ha) when radiation interception is 50%	70
209	4.0	TIX 1=FSS, 2=GP, 3=NP, 4= use p61 and p62, 5=tix=1.0 6=maize, 7=combined NP, 8=NP f(max,min)	62 63
61	14.0	If temp is less than P61, temperature index (TIX) is zero.	64
62	24.0	As temp increases from P61 to P62, TIX increases from 0 to 1.	65
63	40.0	As temp increases from P62 to P63, TIX remains at 1.	66
64	50.0	As temp increases from P63 to P64, TIX decreases from 1 to 0.0	67
5	2.7	Initial plant density e.g. % basal area	74
6	4.5	Potential daily regrowth rate (kg/ha/day/unit of density)	75
7	10.0	Transpiration efficiency (kg/ha/mm of transpired at vpd 20 mb)	81
149	0.1	Soil water index at which above-ground growth stops.	102
9	0.1	Soil water index. Maximum green cover = $amin1(0.99, swix/p(9))$	106
11	2.0	Minimum sreen temperature (c) at which green cover = 0%	107
13	0.0	Prop of standing dry matter detached per day. $DETAC = P13 * SDM2$	84
258	601.0	Detachment of old pool begins month, day	112
96	20.0	Height (cm) of 1000 kg/ha	90
97	4.0	N uptake (kg/ha) at zero transpiration, $N = p(97) + p(98) * (trans/100)$	246
98	7.0	N uptake per 100 mm of transpiration	247
99	5.0	Maximum N uptake (kg/ha)	248
101	0.4	% N at zero growth Nitrogen index = $(\%N - p101) / (p102 - p101)$	250
102	0.5	% N at maximum growth Nitrogen index = $(\%N - p101) / (p102 - p101)$	251
108	0.0	Proportional decline per day in % N for green material	
109	0.0	Proportional decline per day in % N for dead material	
100	2.5	Maximum % N in growth	249
110	1.0	Minimum % N in green & maximum in dead NOT USED in gvt72	



111	0.6	Minimum % N in dead	
263	44021.0	Station no. of AUSTCLIM station from menu option(39039=GAYNDAH)	155
264	70.0	No. of daily (rainfall) station in pmbstat2.pat, 1=BrianPastures	156
250	6.0	if=1 full daily met data, if=3 weekly austclm	157
		4=daily rain in dr2 format, with either AUSTCLIM or station p269	158
		6=daily rain + daily climate, no in p269 type 1	159
269	10.0	monthly climate station type 5 in pmbstat2, if=0 AUSTCLIM	160
211	7.0	if=1-365 gives output of observed & predicted , and simulated : 365=yearly,91=seasonally,30=monthly, 7=weekly,1=daily,999=each observation,mndy=monthday output in mongro15.ogp or m1	
206	550.0	Number of days in simuln run,last date : 1st Mar 1986=198603	150
284	0.0	if=1 TE output to file pasture9.ogp, p246 must be 132	200
300	0.0	Indicates end of parameter file	253

Wongalee	19880922 2 reset yld	0.0	50.0	0.0	0.00	0.00	
Wongalee	1988092214reset soil	5.4	29.0	47.7	0.00	0.00	
Wongalee	1988092216observatio	5.4	29.0	47.7	0.00	0.00	
Wongalee	1988120715observatio	0.0	0.0	83.0	4.50	0.00	
Wongalee	1988120719observatio	0.0	0.0	0.0	4.50	0.00	
Wongalee	1989011615observatio	1.9	55.4	225.0	10.40	0.00	30 in l3
Wongalee	1989011616observatio	1.9	9.6	43.9	10.40	0.00	30 in l3
Wongalee	1989022715observatio	1.6	50.8	335.0	8.50	0.00	30.0
Wongalee	1989022716observatio	1.6	7.6	41.6	8.50	0.00	30.0
Wongalee	1989041015observatio	7.3	106.7	492.0	4.90	0.00	
Wongalee	1989041016observatio	7.3	40.9	58.5	4.90	0.00	
Wongalee	1989052215observatio	17.7	211.2	676.0	0.00	0.00	
Wongalee	1989052216observatio	17.7	85.0	108.5	0.00	0.00	
Wongalee	1989070315observatio	21.8	185.6	318.0	8.90	0.00	
Wongalee	1989070316observatio	21.8	75.6	88.2	8.90	0.00	
Wongalee	1989081415observatio	0.0	0.0	311.0	9.40	0.00	
Wongalee	1989081419observatio	0.0	0.0	0.0	9.40	0.00	
Wongalee	1989092515observatio	9.5	151.5	314.0	13.60	0.00	
Wongalee	1989092516observatio	9.5	56.9	85.1	13.60	0.00	
Wongalee	1989112815observatio	3.8	80.2	621.0	22.10	0.00	
Wongalee	1989112816observatio	3.8	27.5	48.9	22.10	0.00	
Wongalee	1990021215observatio	1.0	48.4	0.0	0.00	0.00	30.0
Wongalee	1990021216observatio	1.0	7.2	40.2	0.00	0.00	30.0
file end	99990000 for GRASP						

**Appendix 8.** Observed and predicted green cover (%) of pasture from nine native pasture primary productivity sites in south-west Queensland.

Site and Date	Observed Green Cover (%)	SD	Predicted Green Cover (%)
<b>Biddenham</b>			
21.11.86			
17.12.86	13.1 g	7.6	6.3
07.01.87	16.5 g	7.8	10.3
26.02.87	44.9 h	14.0	40.1
18.03.87	16.8 g	9.6	15.7
08.04.87	6.8 ef	4.5	12.8
29.04.87	4.1 c-f	2.3	8.6
21.05.87	2.9 b-d	2.9	11.6
12.06.87	0.6 a	1.2	7.8
24.06.87	2.0 a-c	1.8	7.4
16.07.87	1.2 ab	1.4	7.1
11.08.87	3.9 b-e	3.3	7.0
26.08.87	7.9 f	7.3	8.1
18.09.87	5.5 d-f	3.9	10.0
08.10.87	5.3 d-f	3.1	13.6
29.10.87	7.0 ef	5.5	21.2
25.11.87			
10.12.87			
<b>Charleville</b>			
24.10.86			
05.12.86	16.7 de	7.8	5.9
31.12.86	9.1 bc	5.5	5.7
21.01.97	8.9 bc	6.3	7.1
11.02.87	19.6 e	13.2	11.7
04.03.87	29.3 f	16.5	18.1
26.03.87	17.1 de	8.9	14.2
16.04.87	18.4 e	8.9	18.6
20.05.87	6.6 b	4.9	14.8
11.06.87	0.0 a	0.0	6.1
01.07.87	10.4 b-d	4.1	7.3
29.07.87	11.3 b-d	6.0	10.1
19.08.87	12.5 c-e	5.8	15.0
02.09.87	16.3 de	8.0	21.1
23.09.87	16.6 de	8.0	22.8
15.10.87	8.9 bc	5.1	13.1
05.11.87			
26.11.87			

**Appendix 8** Continued

Site and Date	Observed Green Cover (%)	SD	Predicted Green Cover (%)
<b>Airlie</b>			
10.11.88			
16.01.89	2.3 a	2.7	0.6
27.02.89	2.6 a	2.1	2.7
10.04.89	6.8 b	5.1	4.2
03.07.89	12.2 c	6.3	15.6
14.08.89	14.5 cd	5.5	15.3
25.09.89	21.3 d	5.8	17.4
28.11.89	33.6 e	6.3	40.1
12.02.90			
<b>Lisnalee</b>			
13.01.89			
02.03.89	24.2 d	5.9	29.9
14.04.89	59.1 f	14.4	59.8
23.05.89	43.0 e	14.1	58.4
06.07.89	0.0 a	0.0	0.3
17.08.89	2.1 b	1.4	0.0
28.09.89	7.5 c	3.7	2.4
01.12.89	10.2 c	4.5	23.8
20.02.90	0.2 a	0.1	36.7
11.05.90	81.6 g	14.4	71.0
22.11.90			
<b>Maxvale</b>			
14.09.88			
09.12.88	0.3 ab	0.6	1.9
19.01.89	2.6 cd	2.0	4.4
01.03.89	0.2 a	0.6	2.5
13.04.89	7.0 d	4.8	5.0
22.05.89	M	NC	8.4
05.07.89	26.7 f	7.9	19.8
17.08.89	19.6 ef	10.2	29.3
28.09.89	16.7 e	8.1	32.1
01.12.89	3.1 bc	4.8	23.1
20.02.90			

Appendix 8 Continued

Site and Date	Observed Green Cover (%)	SD	Predicted Green Cover (%)
<b>Turn Turn</b>			
20.09.88			
07.12.88	0.2 a	0.4	1.8
17.01.89	0.5 a	1.0	0.0
28.02.89	1.1 a	3.2	0.0
11.04.89	1.6 a	2.0	2.0
04.07.89	21.4 c	7.1	21.0
15.08.89	18.2 c	7.3	17.8
26.09.89	7.0 b	2.8	10.7
29.11.89	5.0 b	4.8	2.9
13.02.90			
<b>Wittenburra</b>			
<b>Open</b>			
21.09.88			
07.12.88	0.3 a	0.9	0.0
17.01.89	3.4 b	2.7	0.7
28.02.89	0.3 a	0.9	0.4
11.04.89	0.5 a	0.7	1.3
04.07.89	6.7 c	2.8	18.5
15.08.89	10.7 c	9.0	21.5
26.09.89	5.9 bc	1.0	13.5
<b>Wittenburra</b>			
<b>Enclosed</b>			
21.09.88			
07.12.88	0.0 a	0.0	0.1
17.01.89	1.1 a	1.6	0.5
28.02.89	0.3 a	0.3	0.0
11.04.89	0.7 a	1.0	0.8
04.07.89	16.4 b	16.3	20.4
15.08.89	10.4 b	9.1	19.4
26.09.89	0.5 a	0.7	11.5
29.11.89			
<b>Wongalee</b>			
22.09.88			
07.12.88	4.5 a	2.8	5.2
16.01.89	6.0 a	15.0	2.9
27.02.89	8.5 b	7.6	1.6
10.04.89	4.9 a	4.8	9.4
22.05.89	M	NC	23.7
03.07.89	8.9 b	6.2	0.4
14.08.89	9.4 b	6.2	0.0
25.09.89	13.6 bc	9.1	3.3
28.11.89	27.3 c	3.6	27.2
12.02.90			