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Abstract

The new carbon faming initiative (CFI) has raised a number of issues in regards to how producers may determine on-farm methane (CH_4) and nitrous oxide (N_2O) emissions. This project has modelled emissions of the green house gases (GHG) CH_4 and N20 from lamb production and evaluated a 'do now' emissions management strategy across 50 years of variable climate (1961-2011). A measure of emissions intensity (kg CO_2e/kg live weight) of lamb production on the Northern Tablelands of Australia for low and high productivity landscapes has been evaluated. The Sustainable Grazing Systems (SGS) pasture model and GrassGro have been used to perform 50 year simulations and FarmGas, an inventory calculator, was used to calculate emissions over a 1 year period. Differences between packages in growth and emissions estimates exist. SGS, over 50 years, estimated 15,330 *vs.* 8.410 kg CO_2e/year of enteric CH_4 emissions and 4.08 *vs.* 4.86 kg/kg emissions intensity for high and low productivity landscapes, respectively; and 10.39 *vs.* 3.42 t CO_2e/ha/year of N_2O for high and low productivity landscapes, respectively. GrassGro, over 50 years, estimated 24,154 *vs.* 11,510 kg CO_2e/year of enteric CH_4 and 8.53 *vs.* 9.50 kg /kg emissions intensity for high and low productivity landscapes, respectively. FarmGas, over 1 year, estimated 20,823 *vs*. 10,229 kg CO_2e/year of enteric CH_4 and 5.43 *vs*. 6.04 kg/kg emissions intensity for high and low productivity landscapes, respectively; and 3,267 *vs.* 1,584 kg CO_2e/year of N_2O for high and low productivity landscapes, respectively with a total intensity of 6.28 *vs.* 6.97 for high and low productivity landscapes, respectively. In conclusion, total emissions are higher for high productivity landscapes but in terms of intensity, high productivity landscapes produce less CH_4 per product produced on more highly productive landscapes. This finding was consistent across all emissions calculators used, but the magnitude of emissions and of emission intensities varied with the calculator used.

Executive summary

This project developed a simulation of lamb production on the Northern Tablelands of Australia using: (1) the Sustainable Grazing Systems (SGS) pasture model (www.imj.com.au/sgs); and (2) the GrassGro (Donnelly et al. 1998) decision support tool; and (3) A 1 year inventory of GHG using The FarmGas (Australia Farm Institute, 2010) inventory calculator. In each of the packages, where possible, the total amount of enteric methane (CH4) and nitrous oxide (N2O) has been estimated. In this study lamb live weight (LW) at point of sale (i.e. 24 weeks old) is used as the product produced. An emissions intensity [emissions per product produced (kg CO2e/kg LW)] is calculated for high and low productivity landscapes. Simulations were conducted over 50 years (01/09/1961 to 21/03/2010). Where appropriate the observed values collected from the Trevenna project (B.CHH.1033) have been compared to the predictions from the simulations.

Results

SGS

Mean lamb weights at 24 weeks of age over a 50 year simulation were estimated at 39.13 *versus* 36.02 kg for high and low productivity landscapes, respectively. Stock respiration (kg CO2e/year) (i.e. enteric CH4) was 15,330 *vs.* 8.410 for high and low productivity landscapes, respectively; and the emissions intensity was 4.08 *vs.* 4.86 kg CO2e/kg LW for high and low productivity landscapes, respectively. N20 was 10.39 *vs.* 3.42 t CO2e/ha/year for high and low productivity landscapes, respectively.

GrassGro

Over a 50 year simulation mean wether lamb weights at 24 weeks of age were estimated at 31.10 *vs.* 26.73 kg for high and low productivity landscapes, respectively and ewe lamb weights at 24 weeks of age were estimated at 27.87 *vs.* 23.74 kg for high and low productivity landscapes, respectively. Total enteric CH4 production was 24,154 *vs.* 11,510 kg CO2e/year for high and low productivity landscapes, respectively; and the emissions intensity was 8.53 *vs.* 9.50 kg CO2e/kg LW for high and low productivity landscapes, respectively.

FarmGas

Total enteric CH4 production was 20,823 *vs*. 10,229 kg CO2e/year for high and low productivity landscapes, respectively; and the emissions intensity 5.43 *vs*. 6.04 for high and low productivity landscapes, respectively. N20 emissions of 3,267 *vs.* 1,584 kg CO2e/year for high and low productivity landscapes, respectively. Total emissions intensity was therefore 6.28 *vs.* 6.97 kg CO2e/kg LW for high and low productivity landscapes, respectively.

Discussion on modelling

The 3 packages (SGS, GrassGro, and FarmGas) all provide some important baseline figures for the Northern Tablelands of Australia. Differences between all packages did occur with GrassGro having the highest CH4 estimates followed by FarmGas and then SGS. The GrassGro and FarmGas methods of estimating CH4 are based on the Blaxter & Clapperton (1965) empirical equation and the SGS model is based on energy in CH4 per gross energy intake of: forage 6% and concentrate 4%. Both methods rely heavily on intake and therefore if the models get intake wrong then subsequently the estimates will be wrong. As reported in B.CCH.1033 the observed values from the FTIR study were approx. 20 g CH4/head/day. The observed values therefore give some credence to the estimated values from the packages. All 3 packages can be used to estimate CH4 production provided good input data is supplied. Both SGS and FarmGas report N20 emissions but it is difficult to determine the accuracy of estimated N2O and further data collection of N2O is required before solid comparisons can be made.

Conclusions

A ‘do now’ management strategy of improving pasture productivity, simulated across 50 years of variable climate, can reduce the amount of CH_4 emitted per unit of lamb produced. The Trevenna project (B.CCH.1033) demonstrated this ‘do now’ management strategy over a 2 year period. Both the SGS and GrassGro 50 year simulations demonstrated that emissions intensity of lamb from high productivity landscapes is less than from low productivity landscapes. However, variation in estimates of total CH4 emissions and of live weight of lambs occurred between simulations. The FarmGas calculations of total CH4 emissions were similar to the GrassGro results. Differences in total CH4 emissions between these 2 simulation packages and the FarmGas inventory calculator need to be evaluated. The differences in total enteric CH4 in the simulations may be attributed to the methods of calculating enteric CH4 (Table 8 footnote and Table 9 footnote).

The average observed lamb LW for the flocks ranged from 33 to 40 kg and 39 to 45 kg on the 4^{th} April 2011 for low and high productivity landscapes. When simulated over 50 years it would be expected that the average over 50 years would be lower than the observed values in 2011 due to the excellent season in 2011. GrassGro results as mentioned above were lower than the SGS results.

Each package used in this study is quite different and the question the user is addressing will ultimately determine which package should be used. Techniques to measure CH4 and N2O in the paddock are still under development therefore actual estimates of CH4 and N2O are highly variable. Hence, when actual measurements are scarce, estimates of CH4 and N2O from the 3 packages can provide some important baseline figures for the Northern Tablelands of Australia.

Knowledge has been gained through the simulations and inventory calculation: (1) in terms of how much enteric CH4 is emitted; (2) the variability between packages; and (3) consistency of the emission intensity result when simulated across 50 years.

Recommendations

The SGS package is highly suitable for research scientists to gain insight into animal production systems and GrassGro is a valuable tool that can assist livestock officers make management decisions. The differences in the prediction of lamb live weights in SGS and GrassGro need further investigation. This study demonstrated a ‘do now’ management strategy and the data validated against observed data (01/09/2010 to 21/03/2011) provides a valuable data set that could be used in future simulation studies to test carbon farming initiative (CFI) methodologies. Significant improvements have already been made in predicting pasture species on the Northern Tablelands but further developments are required.

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Background

There is considerable interest nationally and internationally in reducing methane emissions from livestock. A practical demonstration of methane management strategies (B.CCH.1033) for the sheep industry was established at the University of New England (UNE) field site, Trevenna, Armidale, NSW. Project B.CCH.1033 collected data on green house gases (GHG) (CH4, N2O and CO2 fluxes) for both low and high productivity sheep production systems and demonstrated at field days the technologies used to estimate methane (e.g. FTIR, SF6 canisters, and estimates of CH4 from decision support tools (e.g. GrazFeed, GrasGro, SGS, and FarmGas)) and the intensity of production (CH4/unit of production). In addition to GHG, soil composition, pasture biomass (green and dead), botanical composition and production data were collected.

Project objectives

Use the data collected from the Trevenna sheep production demonstration site (B.CCH.1033) to:

1) Simulate over 50 years the pasture and sheep production system on the Northern Tablelands and compare actual measured values with simulated values where available using:
    - GrassGro (CSIRO), and
    - SGS (IMJ consultants)
2) Calculate inventory C budgets using:
    - FarmGas (Australian farm C budget model. Farm institute site), and

Outcomes:

- A study comparing the estimates of CH_4 as CO_2 equivalents (CO_2e) using GrassGro and SGS.
- Estimates of CH_4 (CO_2e) and N20 (CO_2e) using FarmGas.

Methodology

A 36-hectare demonstration site at Trevenna, University of New England, Armidale on the Northern Tablelands of New South Wales was established to give livestock producers a practical insight into the magnitude of carbon fluxes, especially methane (CH_4), associated with crossbred lamb production. A replicated study over two years was established to compare animal productivity and emissions of low (3.7 DSE/ha) and high (6.7 DSE/ha) productivity landscapes. Data collected (soil, pasture, sheep production, and GHG) from the 1st year (10th Sept 2010– 4th April 2011) has been used to enter initial values into the simulation packages (SGS and GrassGro) and challenge simulated values with observed values i.e., ground truth the package so that producers and research scientists can gain confidence in the results from the simulation. The FarmGas calculator is a static calculation over a specified period and is easier to use than the simulation packages. Again the data collected from the Trevenna site (B.CCH.1033) was used to perform the FarmGas calculations. The results from SGS and GrassGro over a 50 year simulation and the results from FarmGas over 1 year were used to estimate total on-farm CH_4 emissions and the intensity of emissions per unit product. The unit of product in this study is lamb live weight at time of sale.

Methods

<u>Trevenna Demonstration Site</u>

The Trevenna demonstration site, located at the University of New England, on the Northern Tablelands of New South Wales (30^o 30'S 151^o 40' E) comprises 36 ha, split between high and low productivity systems. An overview of the site has been described by McPhee et al. (2010). The 'Trevenna' demonstration site has been subdivided into 18 paddocks: 9 allocated for high productivity improved pastures and 9 allocated for low productivity predominately native pastures. The paddocks averaged 2ha ranging from 1.8-2.2 ha. Each landscape was classified into classes (A, B and C) based on an EM38 electromagnetic induction survey. Within each class 3 paddocks were allocated. There were 6 flocks: 3 high and 3 low productivity flocks. Flocks were rotationally grazed through 3 paddocks so that each flock had a turn in each landscape class (A, B and C). The high productivity flocks were stocked at 6.7 DSE/ha (i.e. 32 ewes and single lambs rotationally grazing 6ha) and the low productivity flocks were stocked at 3.7 DSE/ha (i.e. 16 ewes and single lambs rotationally grazing 6ha).

Data Collection

Data was collected to feed into the GrassGro and SGS decision support systems to estimate the amount of methane produced. Data collected was also used as inputs to the FarmGas (2010) greenhouse inventory calculator. The measurements taken include:

- Soil moisture measurements taken on a weekly basis. Measurements were taken using a Diviner moisture probe (Sentek Technologies, Sydney). The moisture probe used was a capacitance probe that uses the electrical conductivity of a soil to determine the moisture content (Thomas, 1966). The access tubes were located within one paddock of each land class within each landscape. The measurements were taken in 10cm increments to a depth of 50cm.
- Herbage mass measurements were undertaken on a monthly basis when the animals were rotated between paddocks. Pre and post grazing measurements were undertaken using the median quadrat technique (Bell, 2007). A scan of each quadrat was taken using a Crop Circle (Holland Scientific equipment model ACS210) scanner. The data from the observed values and the scans have been used to develop a Normalised Difference Vegetation Index (Trotter et al., 2010)
- Botanical compositions were conducted 4 times per year, once per season using the method described by Tothill et al. (1992).
- Lambs were weighed on a monthly basis, when mobs were rotated between paddocks. These monthly lamb weights were recorded using their National Livestock Identification System Radio Frequency Identification tag. Condition score, fleece weights, and quality of fleece were also recorded.

SGS

The SGS model (Johnson, 2003) was used to perform a 50 year simulation of high and low productivity sheep production systems. The soil parameters in the SGS model were stabilised over a 10 year period from 1960 to 1970 before a full 50 year simulation from 1960-2010 was conducted. Each of the 2 landscapes was modelled separately for 3 flocks on each landscape that was rotational grazed across 3 paddocks from 1st September to 10th April (Tables 1 to 4) and in 5 paddocks during winter (Tables 2 and 4) using the information recorded from the Trevenna site (McPhee at al., 2010; B.CCH.1033). Data used from the site included: herbage mass, species composition and stocking density. Tables 1 to 5 were used to set up the simulation and a sigmoidal animal growth curve was selected.

Within the SGS model supplementary feeding was established to begin feeding when ewes dropped below 40kg liveweight. Below this weight forage and concentrate supplements were fed at a rate calculated by the model to produce liveweight gains. The implementation of supplementary feeding within the SGS model occurred when the pasture quantity and quality was insufficient to maintain liveweight. Actual on-farm supplementary feeding was supplied to ewes as per the UNE animal ethics requirements.

The simulation was run using historical weather data for Armidale Airport Automatic Weather Station, NSW (30.5°S 151.6°E) (BOM, 2011). The initial pasture availability at the beginning of September 2010 was used as the starting herbage mass 1st September, 1960. The botanical composition assessment conducted in September was used as inputs to the SGS model. The soil nutrients and water values were used from the normalised values obtained in the 10 year scenario (1960-1970). Following the simulation the data produced was processed using the statistical package R. To ensure accuracy of the model the baseline simulation was run from the 1st September 2010 through to the 31st of March 2011. This enabled the predicted values from the simulation to be compared to the observed values of herbage mass, botanical composition, soil moisture and lamb weights.

GrassGro

The GrassGro decision support system was used to perform a 50 year simulation of high and low productivity sheep production systems. Parameter values were stabilised during the acceptability run over 50 years from 1960-2011. Each of the 2 landscapes were modelled separately based on 1 flock on low productivity (ewes n=48) and high productivity (ewes n=96) landscape that were rotational grazed across 3 paddocks from 1st September to 10th April (Tables 1 to 3; and Table 5) and in 1 paddock during winter (Tables 2 and 4) using the information available from the Trevenna site (B.CCH.1033). The GrassGro simulation was based on a notional stocking rate of 2 ewes and 1 ewe/ha for high and low productivity landscapes, respectively; the total number of hectares for each landscape was 48 ha (i.e, the winter paddock was adjusted so that the total area was 48 ha for each landscape). The observed data over a 9 month simulation was used to check that the simulated values were a reasonably good fit. Full details of inputs are provided in Appendix 1. The CH4 production/year was calculated in excel that used the mean CH4 output per ewe and lamb over the 50 year simulation for each landscape.

FarmGas

FarmGas was used to calculate an estimate of methane and N2O output. Seasonal averages were taken (e.g. weights of ewes and lambs across seasons; Note: seasonal values for pasture availability were also entered based off the estimated total and green pasture availability reported in Tables 17 to 32) and entered into FarmGas

Units

The units used in this study are CO2e: 1 g CH4 ~ 21 g CO2e; and 1 g N2O ~ 310 g CO2e. Note: authors acknowledge that these figures have changed i.e. 1 g CH4 ~ 25 g CO2e is the new CO2e but results in this study are based on the old CO2e.

Measure of intensity

The measure of intensity in this study is derived as kg CO2e per kg LW.

Results

SGS

The production data results are given in Table 7. Mean lamb weights over a 50 year simulation were estimated at 39.13 *versus* 36.02 kg for high and low productivity landscapes, respectively. GHG emissions are reported in Table 8. Enteric CH4 (kg CO2e/year) was 15,330 vs. 8.410 for high and low productivity landscapes, respectively; and the lamb intensity 4.08 vs. 4.86 for high and low productivity landscapes, respectively.

GrassGro

The production data and GHG emission results are given in Table 9. Over a 50 year simulation mean wether lamb weights were estimated at 31.10 *versus* 26.73 kg for high and low productivity landscapes, respectively and ewe lamb weights were estimated at 27.87 *versus* 23.74 kg for high and low productivity landscapes, respectively. Total enteric CH4 production (calculated as shown in Table 10; reported in Table 9) was 24,154 vs. 11,510 kg CO2e/year for high and low productivity landscapes, respectively; and the lamb intensity 8.53 vs. 9.50 for high and low productivity landscapes, respectively.

<u>FarmGas</u>

The CH4 and N2O values calculated in FarmGas are reported in Table 12. Total enteric CH4 production (Table 12) was 20,823 *vs*. 10,229 kg CO2e/year for high and low productivity landscapes, respectively; and the lamb intensity 5.43 *vs*. 6.04 for high and low productivity landscapes, respectively. N20 emissions of 3,267 *vs.* 1,584 kg CO2e/year for high and low productivity landscapes, respectively. Total intensity was therefore 6.28 *vs.* 6.97 for high and low productivity landscapes, respectively.

Table 1. Area of paddocks for low and high productivity landscapes.

Low productivity		High productivity	
Paddock	**Area (ha)**	**Paddock**	**Area (ha)**
HA1	1.8	FA1	2.2
HA2	1.8	FA2	2.1
HA3	2.0	FA3	2.1
HB1	1.8	FB1	2.1
HB2	1.9	FB2	2.1
HB3	2	FB3	2.2
HC1	1.8	FC1	2.1
HC2	1.9	FC2	2.0
HC3	2.0	FC3	1.9
Total area	17.0	Total area	18.8

Table 2. Area of paddocks used for winter grazing and predominant pasture species.

Paddock	Area (ha)	Species
D1	5	C3
D2	2.5	C3
S1	2.1	C3
McMillian	6.1	Fescue/Paspalum
Millgate	20	Fescue/Phalaris[1]

1. Estimate of 1,300 kg DM/ha of improved pasture

Table 3. Ewe and lamb stock numbers for low and high productivity landscapes in year1.

	Low productivity		High productivity	
Month	**Ewe**	**Lamb**	**Ewe**	**Lamb**
Jan	48	45	96	94
Feb	48	45	96	94
Mar	48	45	96	94
Apr	48	44	96	93
May	48	-	96	-
Jun	48	-	96	-
Jul	48	-	96	-
Aug	48	-	96	-
Sep	48	45	96	94
Oct	48	45	96	94
Nov	48	45	96	94
Dec	48	45	96	94

Table 4. Movement dates for flocks between paddocks across the low and high productivity landscapes

Date		Flock	Paddock	Flock	Paddock
In	**Out**	**Low**	**Low**	**High**	**High**
1 Sep	9 Oct	1,2,3	HB3, HC3, HA2	4,5,6	FC3, FB3, FA3
10 Oct	31 Oct	1,2,3	HC2, HA1, HB1	4,5,6	FA1, FC2, FB1
1 Nov	30 Nov	1,2,3	HA3, HB2, HC1	4,5,6	FB2, FA2, FC1
1 Dec	31 Dec	1,2,3	HB3, HC3, HA2	4,5,6	FC3, FB3, FA3
1 Jan	31 Jan	1,2,3	HC2, HA1, HB1	4,5,6	FA1, FC2, FB1
1 Feb	29 Feb	1,2,3	HA3, HB2, HC1	4,5,6	FB2, FA2, FC1
1 Mar	31 Mar	1,2,3	HB3, HC3, HA2	4,5,6	FC3, FB3, FA3
Winter grazing					
1 Apr	15 Apr	All flocks	D1		
16 Apr	27 Apr	All flocks	D2		
28 Apr	5 May	All flocks	D1		
6 May	8 May	All flocks	S1		
9 May	29 May	All flocks	McMillian		
30 May	7 Aug	All flocks	Millgate		
8 Aug	31 Aug	All flocks	D1		

Table 5. Soil parameter values used in SGS simulations

Variable	Value
Soil	
Bulk Density	1.3g/cm^3
Saturated point	48% of Volume
Field Capacity	35% of Volume
Permanent Wilting point	16% of Volume

Table 6. Soil parameter values used in GrassGro simulations

	Low productivity		High productivity	
	Topsoil	**Subsoil**	**Topsoil**	**Subsoil**
Cummulative depth (mm)	300	700	200	900
Water content at F.C. (m^3.m^3)	0.27	0.30	0.27	0.30
Water content at W.P. (m^3.m^3)	0.13	0.20	0.13	0.20
Bulk density (Mg/m3)	1.40	1.70	1.20	1.50
Sat.hyd.conductivity (mm/hr)	30.00	3.00	30.00	10.00
Initial water content (m^3.m^3)	0.15	0.23	0.15	0.23
Soil evap.	3.3	-	3.3	-
Soil albedo	0.17	-	0.17	-

Table 7. Mean values of production data over a 50 year SGS simulation for high and low productivity landscapes; mean (±SD)

	High Productivity	**Low Productivity**
Total Intake, kg/d/animal	0.97 (0.21)	1.14 (0.10)
ME past intake, MJ/d	10.61 (2.22)	11.70 (0.48)
Ewe wt, kg	49.79 (0.430	49.82 (0.55)
Lamb wt, kg	**39.13** (0.92)	**36.02** (1.57)
CW, kg	17.33 (0.39)	16.03 (0.66)
% live intake	88.62 (8.63)	88.87 (8.49)
% dead intake	11.38 (8.63)	11.13 (8.49)
Greasy fleece sheared: (kg/animal)	2.45 (0.02)	2.45 (0.02)

Table 8. Mean values of GHG emissions over a 50 year SGS simulation for high and low productivity landscapes; mean (±SD)

	High Productivity	Low Productivity
C fixed: (tC/ha/year)	154.22 (15.94)	127.28 (13.66)
C fixed: (tCO2e/ha/year)	565.47 (58.46)	466.7 (50.09)
Soil C fixed: (tC/ha/year)	139 (26.14)	103.89 (23.01)
Soil C fixed: (tCO2e/ha/year)	509.66 (95.88)	380.93 (84.35)
Soil C respiration: (tC/ha/year)	136.57 (23.15)	103.08 (19.41)
Soil C respiration: (tCO2e/ha/year)	500.77 (84.88)	377.96 (71.17)
N2O emission: (kgN/ha/year)	21.32 (7.21)	7.03 (3.07)
N2O emission: (tCO2e/ha/year)[1]	10.39 (3.51)	3.43 (1.49)
Stock CO2 respiration: (tC/ha/year)	9.83 (0.68)	5.08 (0.31)
Stock CO2 respiration: (tCO2e/ha/year)	36.06 (2.46)	18.63 (1.13)
Stock CH4 respiration: (tC/ha/year)	0.55 (0.04)	0.28 (0.02)
Stock CH4 respiration: (kg CO2e/year)[2]	**15,330** (1.06)	**8,410** (0.54)
Emissions intensity[3] (kg CO_2e/kg LW)	**4.08** (-)	**4.86** (-)

1. Observed values in Autumn = 1.49 and 0.37 kg CO2e/ha/day on high and low productivity landscapes, respectively in Autumn; 0.97 kg and 0.074 kg CO2e/ha/day on high and low productivity landscapes, respectively in Winter (See BCCH 1033 report for more detail). Based on 310 CO2e = 1 g N2O.
2. Equates to calculations based on energy in CH4 per gross energy intake of; forage 6%; concentrate 4%; equates to 19.89 and 13.26 g CH4 (kg d.wt intake)$^{-1}$. Based on 1 g CH4 ~ 21 g CO2e
3. Intensity calculated as total stock CH4 respiration/(no lambs x lamb wts given in Table 7 above).

Table 9. Mean values of production data and GHG emissions over a 50 year GrassGro simulation for high and low productivity landscapes; mean (±SD)

	High Productivity	**Low Productivity**
Methane production main flock[1] (g/head/d)	24.52 (3.98)	23.86 (3.53)
Methane production Young sheep (g/head/d)	16.43 (10.43)	14.68 (9.34)
Feed budget (Animal intake)[2] (kg/head/d)	1.34 (0.97)	1.18 (0.37)
Total ME intake (MJ/head)	10.44 (2.58)	9.93 (2.16)
Available herbage[3] (Green DM (P1)) (kg/ha)	2288.13 (946.95)	1002.50 (369.75)
Available herbage[3] (Dead+Litter (P1)) (kg/ha)	4193.02 (900.49)	1732.81 (358.35)
Digestibility[3] (Green (P1)) (%)	56.48 (4.93)	58.28 (5.57)
Total animal methane[4] (kg CO_2e/year)	**24,154** (-)	**11,510** (-)
Sale weight (Wether Lambs) (kg)	**31.10** (-)	**26.73** (-)
Sale weight (Ewe Lambs) (kg)	**27.87** (-)	**23.74** (-)
Lamb intensity[5] (kg CO_2e/kg LW)	**8.53** (-)	**9.50** (-)

1. Estimate of methane based on Blaxter & Clapperton (1965) empirical equation
2. Notational stocking rate = 2 and 1/ha for high and low productivity landscapes, respectively, with 48ha total area across all paddocks for each landscape.
3. Only 1 of 4 paddocks reported
4. Total stock methane ((kg CO_2e/year) was calculated using the methane production values of main flock and young sheep reported in this table. A spread sheet calculated values for 3 within landscape classes and a winter paddock fro each landscape; total area = 48 ha (See Table 10)
5. Intensity calculated as total animal methane/[no lambs x (avg of wether and lamb wts)]. Note total animal methane = no of ewes x CH_4 output of ewes + no. lambs x CH_4 output of lambs.

Table 10. Excel calculations for calculating total (T) stock methane emissions in kg CO2e across landscapes (LS) (low and high productivity) within landscape classes (A,B, and C) and during autumn/winter (W) grazing, for ewe (E) and lamb (L) numbers based off mean methane output (g/head) simulated over 50 years in GrassGro

						CH4 (g/head)			Total			
LS	**Pdk**	**ha**	**days**	**Ewes (n)**	**Lambs (n)**	**E**	**L**	**g CH4**	**(kg CH4/ ha)**	**CO2e (g)**	**(kg CO2e)**	**(kg CO2e) /ha**
Low Prod												
A	**HA3**	5.6	59	48	48	23.86	14.68	109,145	19	21	2,292	409
B	**HB3**	5.7	71	48	48	23.86	14.68	131,344	23	21	2,758	484
C	**HC3**	5.7	53	48	48	23.86	14.68	98,046	17	21	2,059	361
	W	31	183	48	0	23.86		209,586	7	21	4,401	142
T		48	366						**66**		**11,511**	**1,396**
	High Prod											
A	**FA3**	6.4	59	96	96	24.52	16.43	231,941	36	21	4,871	761
B	**FB3**	6.4	71	96	96	24.52	16.43	279,115	44	21	5,861	916
C	**FC3**	6	53	96	96	24.52	16.43	208,354	35	21	4,375	729
	W	29.2	183	96	0	24.52		430,767	15	21	9,046	310
T		48	366						**129**		**24,154**	**2,716**

Table11. Weights of ewes and lambs across seasons for low and high productivity landscapes.

	Low productivity		High productivity	
Season	Ewe	Lamb	Ewe	Lamb
Spring	42.33	16.98	44.98	16.71
Summer	43.46	29.01	45.08	31.35
Autumn	47.55	35.30	47.55	39.97
Winter	40.92		41.11	

Table 12. Annual (1 Sept 2010 to 30 August 2011) Methane (CH4) and Nitrous Oxide (N20) values calculated using FarmGas

	High Productivity	**Low Productivity**
Total CH4 (kg CO2e)	**20,823**	**10,229**
Total CH4 (CO2e/ha)	1,108	602
Total CH4 (CO2e/DSE)	92	91
Total CH4 (CO2e/ewe)	217	218
N20 (kg CO2e)	3,267	1,584
N20 (CO2e/ha)	174	93
N20 (CO2e/DSE)	14	14
N20 (CO2e/ewe)	34	34
Total (kg CO2e)	24,094	11,815
Total (CO2e/ha)	1,282	695
Total (CO2e/DSE)	107	105
Total (CO2e/ewe)	251	251
CH4 Intensity[1] (kg CO2e/kg LW)	**5.43**	**6.04**
Total Intensity[2] (kg CO2e/kg LW)	**6.28**	**6.97**

1. Intensity calculated as total CH4 from stock/(no lambs x lamb wts given in Table # above).
2. Intensity calculated as total (CH4 from stock plus N20)/(no lambs x lamb wts given in Table 11 above).

Table 13. Observed pasture for total herbage mass (THM) green herbage mass (GHM), dead herbage mass (DHM), and ratio of green to dead (RGT) across landscapes at pasture assessment dates in year 1 from September to March; mean (±SD).

	Low productivity				High productivity			
Date	**THM**	**GHM**	**DHM**	**RGT**	**THM**	**GHM**	**DHM**	**RGT**
8.09.2010	4911	184	4727	0.04	2988	1359	1629	0.49
	(1353)	(192)	(1407)	(0.05)	(801)	(814)	(1097)	(0.28)
18.10.2010	3765	757	3088	0.2	2274	1981	293	0.84
	(1453)	(972)	(1627)	(0.28)	(940)	(1098)	(511)	(0.26)
9.11.2010	5382	2936	2446	0.58	7330	6617	713	0.9
	(1444)	(1393)	(1899)	(0.29)	(3039)	(2910)	(790)	(0.09)
7.12.2010	6033	1193	4841	0.2	8793	3690	5103	0.45
	(1343)	(1080)	(1580)	(0.17)	(3125)	(3124)	(4208)	(0.36)
1.02.2011	5077	1160	3917	0.23	6881	1271	5610	0.19
	(1601)	(810)	(1443)	(0.13)	(1395)	(691)	(1380)	(0.11)
9.03.2011	5147	1526	3621	0.3	6362	2017	4345	0.29
	(1413)	(978)	(1390)	(0.16)	(1983)	(1533)	(1083)	(0.17)

Table 14. Pasture quality of green biomass in year 1 across paddocks at selected dates

Date	Pdk	NDF (%)	CP (%)	DMD (%)	DOMD (%)	ME (MJ/kg DM)
18/10/10	FA1	51	16.7	69	65	10.2
18/10/10	FA3	56	13.8	66	63	9.7
18/10/10	FB1	49	11.9	77	72	11.6
18/10/10	FB3	-	-	-	-	-
18/10/10	FC2	53	18.7	65	62	9.5
18/10/10	HA1	55	12.1	63	60	9.2
18/10/10	HA2	49	16.4	75	71	11.4
18/10/10	HB1	54	11.1	67	63	9.9
18/10/10	HB3	52	16.8	65	62	9.6
18/10/10	HC2	49	16.6	59	57	8.5
18/10/10	HC3	55	13	63	60	9.3
1/02/11	FA2	55	13.8	58	56	8.3
1/02/11	FB1	61	12.8	53	52	7.5
1/02/11	FC1	57	16.4	62	59	9
1/02/11	FC2	64	11.6	58	56	8.3
1/02/11	HA1	62	8	52	51	7.4
1/02/11	HB1	61	5.8	52	51	7.3
1/02/11	HC1	53	8.1	59	57	8.5
1/02/11	HC2	60	3.6	55	53	7.8
9/03/11	FA2	59	19.2	59	57	8.5
9/03/11	FA3	59	12.9	56	55	8.1
9/03/11	FB2	56	19.1	60	58	8.7
9/03/11	FB3	54	15.6	61	59	8.9
9/03/11	FC1	62	15.6	56	54	8
9/03/11	FC3	53	16.1	62	59	9
9/03/11	HA3	65	7.8	56	54	8
9/03/11	HB2	64	7.1	53	51	7.4
9/03/11	HC1	66	6	55	53	7.8

Table 15. Pasture quality of dead biomass in year 1 across paddocks at selected dates

Date	Pdk	NDF (%)	CP (%)	DMD (%)	DOMD (%)	ME (MJ/kg DM)
18/10/10	FA1	-	-	-	-	-
18/10/10	FA3	64	8.1	59	57	8.5
18/10/10	FB1	73	6.2	39	39	4.9
18/10/10	FB3	59	9.5	57	55	8.3
18/10/10	FC2	73	8.3	43	43	5.7
18/10/10	HA1	74	5.9	40	41	5.3
18/10/10	HA2	-	-	-	-	-
18/10/10	HB1	67	7.9	44	44	6
18/10/10	HB3	68	8.9	42	42	5.5
18/10/10	HC2	76	6.2	39	38	4.3
18/10/10	HC3	-	-	-	-	-
1/02/11	FA2	73	5	41	42	5.5
1/02/11	FB1	78	7	41	41	5.4
1/02/11	FC1	69	8.9	46	45	6.2
1/02/11	FC2	68	8.8	44	44	6
1/02/11	HA1	71	3.9	39	40	5.1
1/02/11	HB1	69	4.8	44	44	5.9
1/02/11	HC1	52	6.1	51	50	7.1
1/02/11	HC2	63	4.2	45	45	6.1
9/03/11	FA2	71	12.5	47	46	6.4
9/03/11	FA3	68	9.8	50	49	7
9/03/11	FB2	71	12.5	45	45	6.2
9/03/11	FB3	58	13.5	54	52	7.6
9/03/11	FC1	68	11.5	42	43	5.7
9/03/11	FC3	70	10.8	45	45	6
9/03/11	HA3	67	7.3	46	46	6.3
9/03/11	HB2	70	5.9	46	46	6.4
9/03/11	HC1	69	5.4	47	46	6.4

Table 16. Supplementary feed quality of lucerne hay (LH), faber beans (FB), and lupins (LU) fed to ewes in year 1 and year2

Date	Feed	DM (%)	NDF (%)	ADF (%)	CP (%)	IOA (%)	OA (%)	DMD (%)	DOMD (%)	ME (MJ/ kg DM)	CF (%)
Year 1											
05-Aug-10	LH	86.1	47	32	21.1	9	91	62	59	9	-
05-Aug-10	FB	92.4	14	7	25.3	4	96	85	84	12.9	1.4
07-Sep-10	LH	87.7	44	31	22.2	10	90	67	64	10	-
Year 2											
23-Aug-11	LU	92.0	38	18	37	4	96	82	81	14.6	9.3

Tables 10 to 25 provide details of pasture biomass (total, green, and dead) at sampling dates based on botanical composition sampling dates for each paddock within a sample class.

Table 17. Total herbage biomass (THM) and green herbage biomass (GHM) based on Normalized Difference Vegetation Index (**NDVI**) conversion to biomass (kg DM/ha), botanical composition (01.09.2010) across species for paddocks (1 to 3) within land classes A, B, and C on low productivity landscapes (i.e., on the hills (H)) sampled 29.08.2010

	B.Comp (%)	**Pasture Biomass (kg DM/ha)**					
	Land class	**HA1**		**HA2**		**HA3**	
Species	**A**	**THM**	**GHM**	**THM**	**GHM**	**THM**	**GHM**
C3 Native	59	7876	315	7434	297	7567	303
C4 Native	37	4940	198	4662	186	4745	190
P.Rye	2	267	11	252	10	256	10
Other	2	267	11	252	10	256	10
Total	100	13350	534	12600	504	12825	513
	Land class	**HB1**		**HB2**		**HB3**	
Species	**B**	**THM**	**GHM**	**THM**	**GHM**	**THM**	**GHM**
C3 Native	61	8723	349	8235	329	6481	259
C4 Native	21	3003	120	2835	113	2231	89
Other	18	2574	103	2430	97	1912	76
Total	100	14300	572	13500	540	10625	425
	Land class	**HC1**		**HC2**		**HC3**	
Species	**C**	**THM**	**GHM**	**THM**	**GHM**	**THM**	**GHM**
C3 Native	18	3938	158	2578	103	2925	117
C4 Native	55	12031	481	7879	315	8938	358
Phalaris	2	438	18	286	11	325	13
Other	24	5250	210	3438	138	3900	156
Annual	1	219	9	143	6	162	6
Total	100	21875	875	14325	573	16250	650

Table 18. Total herbage biomass (THM) and green herbage biomass (GHM) based on NDVI conversion to biomass (kg DM/ha), botanical composition (01.09.2010) across species for paddocks (1 to 3) within land classes A, B, and C on high productivity landscapes (i.e., on the flats (F)) sampled 29.08.2010

	B.Comp (%)	Pasture Biomass (kg DM/ha)					
	Land class	**FA1**		**FA2**		**FA3**	
Species	**A**	**THM**	**GHM**	**THM**	**GHM**	**THM**	**GHM**
C3 Native	2	73	36	83	41	97	47
C4 Native	1	37	18	42	20	48	24
P Rye	93	3401	1667	3878	1900	4496	2203
White Clover	3	110	54	125	61	145	71
Other	1	37	18	42	20	48	24
	100	3657	1792	4169	2043	4835	2369
	Land class	**FB1**		**FB2**		**FB3**	
Species	**B**	**THM**	**GHM**	**THM**	**GHM**	**THM**	**GHM**
C3 Native	1	49	24	29	14	33	16
C4 Native	11	537	263	323	158	359	176
P Rye	37	1808	886	1086	532	1208	592
White Clover	1	49	24	29	14	33	16
Other	36	1759	862	1056	518	1176	576
Annual Grass	14	684	335	411	201	457	224
Total	100	4886	2394	2935	1438	3265	1600
	Land class	**FC1**		**FC2**		**FC3**	
Species	**C**	**THM**	**GHM**	**THM**	**GHM**	**THM**	**GHM**
C3 Native	1	58	29	57	28	57	28
C4 Native	6	349	171	342	167	344	168
Phalaris	14	815	399	797	391	802	393
P Rye	59	3435	1683	3361	1647	3380	1656
Tall Fescue	7	408	200	399	195	401	196
Paspalum	1	58	29	57	28	57	28
Brome	3	175	86	171	84	172	84
Other	9	524	257	513	251	516	253
Total	100	5822	2853	5696	2791	5729	2807

Table 19. Total herbage biomass (THM) and green herbage biomass (GHM) based on NDVI conversion to biomass (kg DM/ha), botanical composition (01.09.2010) across species for paddocks (1 to 3) within land classes A, B, and C on low productivity landscapes (i.e., on the hills (H)) sampled 18.10.2010

	B.Comp (%)	**Pasture Biomass (kg DM/ha)**					
	Land class	**HA1**		**HA2**		**HA3**	
Species	**A**	**THM**	**GHM**	**THM**	**GHM**	**THM**	**GHM**
C3 Native	59	5694	1139	2997	599	5006	1001
C4 Native	37	3570	714	1880	376	3139	628
P Rye	2	193	39	102	20	170	34
Other	2	193	39	102	20	170	34
Total	100	9650	1930	5080	1016	8485	1697
	Land class	**HB1**		**HB2**		**HB3**	
Species	**B**	**THM**	**GHM**	**THM**	**GHM**	**THM**	**GHM**
C3 Native	61	5212	1042	5280	1056	2544	509
C4 Native	21	1794	359	1818	364	876	175
Other	18	1538	308	1558	312	751	150
Total	100	8545	1709	8655	1731	4170	834
	Land class	**HC1**		**HC2**		**HC3**	
Species	**C**	**THM**	**GHM**	**THM**	**GHM**	**THM**	**GHM**
C3 Native	18	2392	478	1789	358	1902	380
C4 Native	55	7310	1462	5467	1093	5811	1162
Phalaris	2	266	53	199	40	211	42
Other	24	3190	638	2386	477	2536	507
Annual Grass	1	133	27	99	20	106	21
Total	100	13290	2658	9940	1988	10565	2113

Table 20. Total herbage biomass (THM) and green herbage biomass (GHM) based on NDVI conversion to biomass (kg DM/ha), botanical composition (01.09.2010) across species for paddocks (1 to 3) within land classes A, B, and C on high productivity landscapes (i.e., on the flats (F)) sampled 18.10.2010

	B.Comp (%)	Pasture Biomass (kg DM/ha)					
	Land class	FA1		FA2		FA3	
Species	**A**	**THM**	**GHM**	**THM**	**GHM**	**THM**	**GHM**
C3 Native	2	146	123	150	126	83	70
C4 Native	1	73	62	75	63	42	35
P Rye	93	6810	5720	6987	5869	3882	3261
White Clover	3	220	185	225	189	125	105
Other	1	73	62	75	63	42	35
Total	100	7323	6151	7513	6311	4174	3506
	Land class	**FB1**		**FB2**		**FB3**	
Species	**B**	**THM**	**GHM**	**THM**	**GHM**	**THM**	**GHM**
C3 Native	1	63	53	47	39	23	19
C4 Native	11	695	584	512	430	248	208
P Rye	37	2339	1965	1722	1446	834	700
White Clover	1	63	53	47	39	23	19
Other	36	2276	1912	1675	1407	811	681
Annual Grass	14	885	743	652	547	316	265
Total	100	6321	5310	4654	3909	2254	1893
	Land class	**FC1**		**FC2**		**FC3**	
Species	**C**	**THM**	**GHM**	**THM**	**GHM**	**THM**	**GHM**
C3 Native	1	79	66	70	59	49	41
C4 Native	6	474	398	420	353	295	248
Phalaris	14	1106	929	980	823	689	578
P Rye	59	4660	3915	4129	3469	2902	2438
Tall Fescue	7	553	464	490	412	344	289
Paspalum	1	79	66	70	59	49	41
Brome	3	237	199	210	176	148	124
Other	9	711	597	630	529	443	372
Total	100	7899	6635	6999	5879	4919	4132

Table 21. Total herbage biomass (THM) and green herbage biomass (GHM) based on NDVI conversion to biomass (kg DM/ha), botanical composition (01.09.2010) across species for paddocks (1 to 3) within land classes A, B, and C on low productivity landscapes (i.e., on the hills (H)) sampled 10.11.2010

	B.Comp (%)	**Pasture Biomass (kg DM/ha)**					
	Land class	**HA1**		**HA2**		**HA3**	
Species	**A**	**THM**	**GHM**	**THM**	**GHM**	**THM**	**GHM**
C3 Native	59	1433	831	1511	876	2969	1722
C4 Native	37	899	521	947	549	1862	1080
P Rye	2	49	28	51	30	101	58
Other	2	49	28	51	30	101	58
Total	100	2429	1409	2560	1485	5033	2919
	Land class	**HB1**		**HB2**		**HB3**	
Species	**B**	**THM**	**GHM**	**THM**	**GHM**	**THM**	**GHM**
C3 Native	61	1367	793	2083	1208	1518	880
C4 Native	21	471	273	717	416	522	303
Other	18	403	234	615	357	448	260
Total	100	2241	1300	3416	1981	2488	1443
	Land class	**HC1**		**HC2**		**HC3**	
Species	**C**	**THM**	**GHM**	**THM**	**GHM**	**THM**	**GHM**
C3 Native	18	1096	635	736	427	767	445
C4 Native	55	3347	1942	2247	1304	2345	1360
Phalaris	2	122	71	82	47	85	49
Other	24	1461	847	981	569	1023	594
Annual Grass	1	61	35	41	24	43	25
Total	100	6086	3530	4086	2370	4264	2473

Table 22. Total herbage biomass (THM) and green herbage biomass (GHM) based on NDVI conversion to biomass (kg DM/ha), botanical composition (01.09.2010) across species for paddocks (1 to 3) within land classes A, B, and C on high productivity landscapes (i.e., on the flats (F)) sampled 10.11.2010

	B.Comp (%)	**Pasture Biomass (kg DM/ha)**					
	Land class	**FA1**		**FA2**		**FA3**	
Species	**A**	**THM**	**GHM**	**THM**	**GHM**	**THM**	**GHM**
C3 Native	2	97	87	126	114	141	127
C4 Native	1	49	44	63	57	70	63
P Rye	93	4517	4065	5867	5281	6551	5896
White Clover	3	146	131	189	170	211	190
Other	1	49	44	63	57	70	63
Total	100	4857	4371	6309	5678	7044	6340
	Land class	**FB1**		**FB2**		**FB3**	
Species	**B**	**THM**	**GHM**	**THM**	**GHM**	**THM**	**GHM**
C3 Native	1	45	41	44	40	51	46
C4 Native	11	496	446	485	437	557	501
P Rye	37	1667	1500	1632	1469	1873	1686
White Clover	1	45	41	44	40	51	46
Other	36	1622	1460	1588	1429	1823	1641
Annual Grass	14	631	568	617	556	709	638
Total	100	4506	4055	4410	3969	5063	4557
	Land class	**FC1**		**FC2**		**FC3**	
Species	**C**	**THM**	**GHM**	**THM**	**GHM**	**THM**	**GHM**
C3 Native	1	57	51	45	41	73	66
C4 Native	6	340	306	271	244	437	393
Phalaris	14	794	715	632	569	1019	917
P Rye	59	3348	3013	2664	2398	4294	3864
Tall Fescue	7	397	357	316	284	509	458
Paspalum	1	57	51	45	41	73	66
Brome	3	170	153	135	122	218	196
Other	9	511	460	406	366	655	590
Total	100	5674	5107	4516	4064	7278	6550

Table 23. Total herbage biomass (THM) and green herbage biomass (GHM) based on NDVI conversion to biomass (kg DM/ha), botanical composition (01.09.2010) across species for paddocks (1 to 3) within land classes A, B, and C on low productivity landscapes (i.e., on the hills (H)) sampled 08.12.2010

	B.Comp (%)	**Pasture Biomass (kg DM/ha)**					
	Land class	**HA1**		**HA2**		**HA3**	
Species	**A**	**THM**	**GHM**	**THM**	**GHM**	**THM**	**GHM**
C3 Native	59	6449	1290	6906	1381	10593	2119
C4 Native	37	4044	809	4331	866	6643	1329
P Rye	2	219	44	234	47	359	72
Other	2	219	44	234	47	359	72
Total	100	10930	2186	11705	2341	17955	3591
	Land class	**HB1**		**HB2**		**HB3**	
Species	**B**	**THM**	**GHM**	**THM**	**GHM**	**THM**	**GHM**
C3 Native	61	5783	1157	4740	948	7631	1526
C4 Native	21	1991	398	1632	326	2627	525
Other	18	1706	341	1399	280	2252	450
Total	100	9480	1896	7770	1554	12510	2502
	Land class	**HC1**		**HC2**		**HC3**	
Species	**C**	**THM**	**GHM**	**THM**	**GHM**	**THM**	**GHM**
C3 Native	18	2640	528	3141	628	1464	293
C4 Native	55	8066	1613	9598	1920	4474	895
Phalaris	2	293	59	349	70	163	33
Other	24	3520	704	4188	838	1952	390
Annual Grass	1	147	29	174	35	81	16
Total	100	14665	2933	17450	3490	8135	1627

Table 24. Total herbage biomass (THM) and green herbage biomass (GHM) based on NDVI conversion to biomass (kg DM/ha), botanical composition (01.09.2010) across species for paddocks (1 to 3) within land classes A, B, and C on high productivity landscapes (i.e., on the flats (F)) sampled 08.12.2010

	B.Comp (%)	**Pasture Biomass (kg DM/ha)**					
	Land class	**FA1**		**FA2**		**FA3**	
Species	**A**	**THM**	**GHM**	**THM**	**GHM**	**THM**	**GHM**
C3 Native	2	120	54	115	52	192	86
C4 Native	1	60	27	58	26	96	43
P Rye	93	5566	2504	5349	2407	8932	4019
White Clover	3	180	81	173	78	288	130
Other	1	60	27	58	26	96	43
Total	100	5984	2693	5751	2588	9604	4322
	Land class	**FB1**		**FB2**		**FB3**	
Species	**B**	**THM**	**GHM**	**THM**	**GHM**	**THM**	**GHM**
C3 Native	1	70	32	46	21	89	40
C4 Native	11	771	347	510	230	979	440
P Rye	37	2595	1168	1716	772	3292	1481
White Clover	1	70	32	46	21	89	40
Other	36	2525	1136	1670	751	3203	1441
Annual Grass	14	982	442	649	292	1246	561
Total	100	7013	3156	4638	2087	8898	4004
	Land class	**FC1**		**FC2**		**FC3**	
Species	**C**	**THM**	**GHM**	**THM**	**GHM**	**THM**	**GHM**
C3 Native	1	73	33	89	40	112	51
C4 Native	6	440	198	531	239	674	303
Phalaris	14	1026	462	1240	558	1573	708
P Rye	59	4324	1946	5226	2352	6629	2983
Tall Fescue	7	513	231	620	279	786	354
Paspalum	1	73	33	89	40	112	51
Brome	3	220	99	266	120	337	152
Other	9	660	297	797	359	1011	455
Total	100	7329	3298	8858	3986	11236	5056

Table 25. Total herbage biomass (THM) and green herbage biomass (GHM) based on NDVI conversion to biomass (kg DM/ha), botanical composition (01.03.2011) across species for paddocks (1 to 3) within land classes A, B, and C on low productivity landscapes (i.e., on the hills (H)) sampled 04.01.2011

	B.Comp (%)	Pasture Biomass (kg DM/ha)					
	Land class	HA1		HA2		HA3	
Species	**A**	**THM**	**GHM**	**THM**	**GHM**	**THM**	**GHM**
C3 Native	30	2480	496	2128	426	3472	694
C4 Native	39	3223	645	2767	553	4514	903
White Clover	1	83	17	71	14	116	23
Paspalum	23	1901	380	1632	326	2662	532
Other	7	579	116	497	99	810	162
Total	100	8265	1653	7095	1419	11575	2315
	Land class	**HB1**		**HB2**		**HB3**	
Species	**B**	**THM**	**GHM**	**THM**	**GHM**	**THM**	**GHM**
C3 Native	50	3602	720	3532	706	4625	925
C4 Native	44	3170	634	3109	622	4070	814
Tall Fescue	1	72	14	71	14	92	18
Other	5	360	72	353	71	462	92
Total	100	7205	1441	7065	1413	9250	1850
	Land class	**HC1**		**HC2**		**HC3**	
Species	**C**	**THM**	**GHM**	**THM**	**GHM**	**THM**	**GHM**
C4 Native	60	7215	1443	8649	1730	3288	658
P Rye	8	962	192	1153	231	438	88
Tall Fescue	2	240	48	288	58	110	22
Other	30	3608	722	4324	865	1644	329
Total	100	12025	2405	14415	2883	5480	1096

Table 26. Total herbage biomass (THM) and green herbage biomass (GHM) based on NDVI conversion to biomass (kg DM/ha), botanical composition (01.03.2011) across species for paddocks (1 to 3) within land classes A, B, and C on high productivity landscapes (i.e., on the flats (F)) sampled 04.01.2011

	B.Comp (%)	Pasture Biomass (kg DM/ha)					
	Land class	FA1		FA2		FA3	
Species	A	THM	GHM	THM	GHM	THM	GHM
C4 Native	7	174	78	280	126	177	80
P Rye	29	720	324	1161	522	735	331
White Clover	1	25	11	40	18	25	11
Brome	57	1416	637	2281	1027	1444	650
Other	6	149	67	240	108	152	68
Total	100	2484	1118	4002	1801	2533	1140
	Land class	FB1		FB2		FB3	
Species	B	THM	GHM	THM	GHM	THM	GHM
C4 Native	40	1341	604	1070	482	1204	542
P Rye	31	1040	468	829	373	933	420
Tall Fescue	8	268	121	214	96	241	108
White Clover	8	268	121	214	96	241	108
Other	12	402	181	321	144	361	162
Annual Grass	1	34	15	27	12	30	14
Total	100	3353	1509	2676	1204	3009	1354
	Land class	FC1		FC2		FC3	
Species	C	THM	GHM	THM	GHM	THM	GHM
C4 Native	4	360	162	318	143	243	109
Phalaris	21	1889	850	1672	752	1275	574
P Rye	7	630	283	557	251	425	191
Tall Fescue	2	180	81	159	72	121	55
White Clover	4	360	162	318	143	243	109
Paspalum	34	3058	1376	2707	1218	2064	929
Other	28	2518	1133	2229	1003	1700	765
Total	100	8993	4047	7962	3583	6071	2732

Table 27. Total herbage biomass (THM) and green herbage biomass (GHM) based on NDVI conversion to biomass (kg DM/ha), botanical composition (01.03.2011) across species for paddocks (1 to 3) within land classes A, B, and C on low productivity landscapes (i.e., on the hills (H)) sampled 01.02.2011

	B.Comp (%)	Pasture Biomass (kg DM/ha)					
	Land class	HA1		HA2		HA3	
Species	**A**	**THM**	**GHM**	**THM**	**GHM**	**THM**	**GHM**
C3 Native	30	1409	324	1774	408	2151	495
C4 Native	39	1831	421	2306	530	2796	643
White Clover	1	47	11	59	14	72	16
Paspalum	23	1080	248	1360	313	1649	379
Other	7	329	76	414	95	502	115
Total	100	4696	1080	5913	1360	7170	1649
	Land class	**HB1**		**HB2**		**HB3**	
Species	**B**	**THM**	**GHM**	**THM**	**GHM**	**THM**	**GHM**
C3 Native	50	2189	504	2922	672	2685	618
C4 Native	44	1926	443	2571	591	2363	543
Tall Fescue	1	44	10	58	13	54	12
Other	5	219	50	292	67	268	62
Total	100	4378	1007	5843	1344	5370	1235
	Land class	**HC1**		**HC2**		**HC3**	
Species	**C**	**THM**	**GHM**	**THM**	**GHM**	**THM**	**GHM**
C4 Native	60	3125	719	4263	980	4276	983
P Rye	8	417	96	568	131	570	131
Tall Fescue	2	104	24	142	33	143	33
Other	30	1563	359	2131	490	2138	492
Total	100	5209	1198	7104	1634	7126	1639

Table 28. Total herbage biomass (THM) and green herbage biomass (GHM) based on NDVI conversion to biomass (kg DM/ha), botanical composition (01.03.2011) across species for paddocks (1 to 3) within land classes A, B, and C on high productivity landscapes (i.e., on the flats (F)) sampled 01.02.2011

	B.Comp (%)	Pasture Biomass (kg DM/ha)					
	Land class	FA1		FA2		FA3	
Species	**A**	**THM**	**GHM**	**THM**	**GHM**	**THM**	**GHM**
C4 Native	7	367	70	820	156	1029	195
P Rye	29	1520	289	3396	645	4261	810
White Clover	1	52	10	117	22	147	28
Brome	57	2988	568	6675	1268	8376	1591
Other	6	315	60	703	134	882	168
Total	100	5242	996	11711	2225	14695	2792
	Land class	**FB1**		**FB2**		**FB3**	
Species	**B**	**THM**	**GHM**	**THM**	**GHM**	**THM**	**GHM**
C4 Native	40	2354	447	4695	892	5899	1121
P Rye	31	1824	347	3638	691	4572	869
Tall Fescue	8	471	89	939	178	1180	224
White Clover	8	471	89	939	178	1180	224
Other	12	706	134	1408	268	1770	336
Annual Grass	1	59	11	117	22	147	28
Total	100	5884	1118	11737	2230	14747	2802
	Land class	**FC1**		**FC2**		**FC3**	
Species	**C**	**THM**	**GHM**	**THM**	**GHM**	**THM**	**GHM**
C4 Native	4	681	129	559	106	707	134
Phalaris	21	3578	680	2937	558	3714	706
P Rye	7	1193	227	979	186	1238	235
Tall Fescue	2	341	65	280	53	354	67
White Clover	4	681	129	559	106	707	134
Paspalum	34	5793	1101	4755	903	6013	1142
Other	28	4770	906	3916	744	4952	941
Total	100	17037	3237	13984	2657	17684	3360

Table 29. Total herbage biomass (THM) and green herbage biomass (GHM) based on NDVI conversion to biomass (kg DM/ha), botanical composition (01.03.2011) across species for paddocks (1 to 3) within land classes A, B, and C on low productivity landscapes (i.e., on the hills (H)) sampled 08.03.2011

	B.Comp (%)	Pasture Biomass (kg DM/ha)					
	Land class	HA1		HA2		HA3	
Species	**A**	**THM**	**GHM**	**THM**	**GHM**	**THM**	**GHM**
C3 Native	30	2189	657	2148	644	2059	618
C4 Native	39	2846	854	2792	838	2677	803
White Clover	1	73	22	72	21	69	21
Paspalum	23	1678	503	1647	494	1579	474
Other	7	511	153	501	150	480	144
Total	100	7297	2189	7160	2148	6863	2059
	Land class	**HB1**		**HB2**		**HB3**	
Species	**B**	**THM**	**GHM**	**THM**	**GHM**	**THM**	**GHM**
C3 Native	50	2912	874	2178	654	3488	1046
C4 Native	44	2562	769	1917	575	3070	921
Tall Fescue	1	58	17	44	13	70	21
Other	5	291	87	218	65	349	105
Total	100	5823	1747	4357	1307	6977	2093
	Land class	**HC1**		**HC2**		**HC3**	
Species	**C**	**THM**	**GHM**	**THM**	**GHM**	**THM**	**GHM**
C4 Native	60	4876	1463	5316	1595	5054	1516
P Rye	8	650	195	709	213	674	202
Tall Fescue	2	163	49	177	53	168	51
Other	30	2438	731	2658	797	2527	758
Total	100	8127	2438	8860	2658	8423	2527

Table 30. Total herbage biomass (THM) and green herbage biomass (GHM) based on NDVI conversion to biomass (kg DM/ha), botanical composition (01.03.2011) across species for paddocks (1 to 3) within land classes A, B, and C on high productivity landscapes (i.e., on the flats (F)) sampled 08.03.2011

	B.Comp (%)	Pasture Biomass (kg DM/ha)					
	Land class	FA1		FA2		FA3	
Species	**A**	**THM**	**GHM**	**THM**	**GHM**	**THM**	**GHM**
C4 Native	7	985	286	531	154	1330	386
P Rye	29	4081	1183	2201	638	5509	1598
White Clover	1	141	41	76	22	190	55
Brome	57	8021	2326	4326	1255	10828	3140
Other	6	844	245	455	132	1140	331
Total	100	14072	4081	7590	2201	18997	5509
	Land class	**FB1**		**FB2**		**FB3**	
Species	**B**	**THM**	**GHM**	**THM**	**GHM**	**THM**	**GHM**
C4 Native	40	6262	1816	2927	849	5572	1616
P Rye	31	4853	1407	2268	658	4319	1252
Tall Fescue	8	1252	363	585	170	1114	323
White Clover	8	1252	363	585	170	1114	323
Other	12	1879	545	878	255	1672	485
Annual Grass	1	157	45	73	21	139	40
Total	100	15655	4540	7317	2122	13931	4040
	Land class	**FC1**		**FC2**		**FC3**	
Species	**C**	**THM**	**GHM**	**THM**	**GHM**	**THM**	**GHM**
C4 Native	4	322	93	577	167	630	183
Phalaris	21	1692	491	3031	879	3309	959
P Rye	7	564	164	1010	293	1103	320
Tall Fescue	2	161	47	289	84	315	91
White Clover	4	322	93	577	167	630	183
Paspalum	34	2739	794	4907	1423	5357	1553
Other	28	2255	654	4041	1172	4411	1279
Total	100	8055	2336	14431	4185	15755	4569

Table 31. Total herbage biomass (THM) and green herbage biomass (GHM) based on NDVI conversion to biomass (kg DM/ha), botanical composition (01.03.2011) across species for paddocks (1 to 3) within land classes A, B, and C on low productivity landscapes (i.e., on the hills (H)) sampled 20.04.2011

	B.Comp (%)	Pasture Biomass (kg DM/ha)					
	Land class	HA1		HA2		HA3	
Species	A	THM	GHM	THM	GHM	THM	GHM
C3 Native	30	867	260	1107	332	1184	355
C4 Native	39	1127	338	1439	432	1539	462
White Clover	1	29	9	37	11	39	12
Paspalum	23	665	199	849	255	908	272
Other	7	202	61	258	77	276	83
Total	100	2890	867	3690	1107	3946.667	1184
	Land class	HB1		HB2		HB3	
Species	B	THM	GHM	THM	GHM	THM	GHM
C3 Native	50	1888	566	1962	588	1978	594
C4 Native	44	1662	499	1726	518	1741	522
Tall Fescue	1	38	11	39	12	40	12
Other	5	189	57	196	59	198	59
Total	100	3777	1133	3923	1177	3957	1187
	Land class	HC1		HC2		HC3	
Species	C	THM	GHM	THM	GHM	THM	GHM
C4 Native	60	3922	1177	3002	901	2230	669
P Rye	8	523	157	400	120	297	89
Tall Fescue	2	131	39	100	30	74	22
Other	30	1961	588	1501	450	1115	334
Total	100	6537	1961	5003	1501	3717	1115

Table 32. Total herbage biomass (THM) and green herbage biomass (GHM) based on NDVI conversion to biomass (kg DM/ha), botanical composition (01.03.2011) across species for paddocks (1 to 3) within land classes A, B, and C on high productivity landscapes (i.e., on the flats (F)) sampled 20.04.2011

	B.Comp (%)	Pasture Biomass (kg DM/ha)					
	Land class	FA1		FA2		FA3	
Species	**A**	**THM**	**GHM**	**THM**	**GHM**	**THM**	**GHM**
C4 Native	7	807	234	1032	299	1001	290
P Rye	29	3344	970	4276	1240	4147	1203
White Clover	1	115	33	147	43	143	41
Brome	57	6573	1906	8405	2437	8151	2364
Other	6	692	201	885	257	858	249
Total	100	11531	3344	14745	4276	14300	4147
	Land class	**FB1**		**FB2**		**FB3**	
Species	**B**	**THM**	**GHM**	**THM**	**GHM**	**THM**	**GHM**
C4 Native	40	4186	1214	5606	1626	2749	797
P Rye	31	3244	941	4344	1260	2130	618
Tall Fescue	8	837	243	1121	325	550	159
White Clover	8	837	243	1121	325	550	159
Other	12	1256	364	1682	488	825	239
Annual Grass	1	105	30	140	41	69	20
Total	100	10466	3035	14014	4064	6872	1993
	Land class	**FC1**		**FC2**		**FC3**	
Species	**C**	**THM**	**GHM**	**THM**	**GHM**	**THM**	**GHM**
C4 Native	4	375	109	397	115	316	92
Phalaris	21	1970	571	2086	605	1659	481
P Rye	7	657	190	695	202	553	160
Tall Fescue	2	188	54	199	58	158	46
White Clover	4	375	109	397	115	316	92
Paspalum	34	3190	925	3378	980	2686	779
Brome	0	2627	762	2782	807	2212	641
Other	28	9383	2721	9934	2881	7900	2291

Tables 33 to 36 provide details of animal productivity in 2010-2011 and the results of the pseudo slaughter in April 2011 and March 2012.

Table 33. Ewe weights (kg) across flocks on low and high productivity landscapes in year 1; mean (±SD)

	Low productivity Flocks			High productivity Flocks		
Date	**1**	**2**	**3**	**4**	**5**	**6**
21.07.2010	40.77	41.07	40.93	40.87	41.55	40.92
	(2.91)	(4.39)	(3.43)	(3.60)	(3.69)	(3.49)
02.09.2010	43.00	44.98	46.60	44.11	45.50	44.52
	(5.15)	(3.17)	(2.97)	(4.38)	(3.97)	(4.01)
19.10.2010	39.20	39.13	42.26	45.29	45.49	42.84
	(4.05)	(2.23)	(4.01)	(4.67)	(4.82)	(5.14)
11.11.2010	40.16	42.60	45.25	43.25	46.38	47.61
	(4.52)	(2.54)	(3.68)	(4.94)	(5.05)	(5.72)
8.12.2010	42.33	40.58	43.46	41.14	42.55	42.10
	(4.11)	(2.98)	(4.07)	(3.81)	(5.39)	(5.01)
4.01.2011	43.86	43.05	45.46	45.55	46.37	45.14
	(4.00)	(2.97)	(3.78)	(3.83)	(4.34)	(5.47)
2.02.2011	44.59	43.96	46.52	46.40	50.37	46.61
	(4.34)	(3.34)	(3.77)	(4.92)	(5.64)	(5.55)
8.03.2011	46.90	45.86	46.72	45.06	48.09	46.92
	(4.71)	(3.35)	(5.34)	(4.78)	(4.47)	(5.45)
5.04.2011	46.48	47.44	48.05	50.09	47.58	46.54
	(4.73)	(3.49)	(4.17)	(4.71)	(9.97)	(5.22)
15.04.2011	44.23	44.74	44.23	47.84	48.58	47.94
	(4.61)	(3.58)	(3.46)	(4.72)	(4.77)	(5.45)

Table 34. Lamb weights (kg) across flocks on low and high productivity landscapes in year 1; mean (±SD)

	Low productivity Flocks			High productivity Flocks		
Date	**1**	**2**	**3**	**4**	**5**	**6**
8.10.2010	14.96	13.73	13.45	12.73	13.17	13.41
	(2.73)	(2.84)	(2.50)	(3.30)	(2.73)	(2.39)
11.11.2010	20.55	18.75	20.59	19.77	20.26	20.88
	(2.38)	(3.43)	(2.06)	(3.64)	(2.62)	(2.79)
8.12.2010	25.84	23.61	26.34	25.08	25.63	26.75
	(2.73)	(3.55)	(2.15)	(3.78)	(2.76)	(2.76)
4.01.2011	31.15	28.26	31.50	32.22	32.03	32.37
	(2.98)	(4.64)	(2.74)	(4.37)	(3.34)	(2.98)
02.02.2011	31.73	29.49	33.74	37.20	34.59	36.27
	(2.86)	(4.47)	(3.21)	(4.56)	(3.24)	(2.97)
8.03.2011	35.87	31.33	38.00	39.14	38.37	39.82
	(4.85)	(5.33)	(3.70)	(4.42)	(3.09)	(3.39)
4.04.2011	37.01	33.00	39.91	44.54	40.52	38.60
	(3.95)	(5.86)	(3.62)	(4.74)	(3.11)	(7.99)

Table 35. Greasy wool production data for year 1 (July 2010) across flocks on low and high productivity landscapes

	Low productivity Flocks			High productivity Flocks		
Date	**1**	**2**	**3**	**4**	**5**	**6**
Fleece.wt.	2.67	3.07	3.15	2.87	2.88	2.97
	(0.37)	(0.72)	(0.66)	(0.47)	(0.44)	(0.48)
Staple.length	81.83	80.00	79.40	79.94	77.89	79.67
	(11.43)	(11.44)	(7.70)	(8.59)	(12.63)	(8.10)
Staple.strength	37.31	40.80	33.88	35.61	36.85	39.18
	(6.47)	(10.50)	(9.74)	(7.14)	(7.02)	(6.60)
Fibre.diameter	16.67	16.12	16.67	16.51	16.33	16.33
	(1.10)	(1.21)	(1.50)	(0.94)	(1.57)	(1.10)

Table 36. Production data at pseudo slaughter date (4.04.2011) across flocks for low and high productivity landscapes

	Low productivity Flocks			High productivity Flocks		
Date	**1**	**2**	**3**	**4**	**5**	**6**
Eye.Muscle.Area (mm^2)	24.36	19.38	23.79	24.94	24.90	24.66
	(2.59)	(3.69)	(2.29)	(2.87)	(2.51)	(2.88)
Fat.Depth (mm)	2.50	1.63	2.57	3.02	2.58	2.97
	(1.00)	(0.52)	(0.90)	(0.66)	(0.71)	(0.93)
GR (mm)	10.21	7.69	10.14	12.58	12.00	12.55
	(3.14)	(2.75)	(2.44)	(2.16)	(1.71)	(2.41)
Carcass.Weight (kg)	16.59	13.79	17.09	18.06	17.62	18.28
	(2.16)	(2.69)	(1.92)	(2.05)	(1.40)	(1.66)
Dressing Percent (%)	45.10	43.82	44.92	46.14	45.92	46.04
	(1.54)	(1.82)	(1.11)	(1.08)	(0.88)	(1.12)

Conference and Symposium Papers

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Appendix 1.

GrassGro Low Productivity Landscape

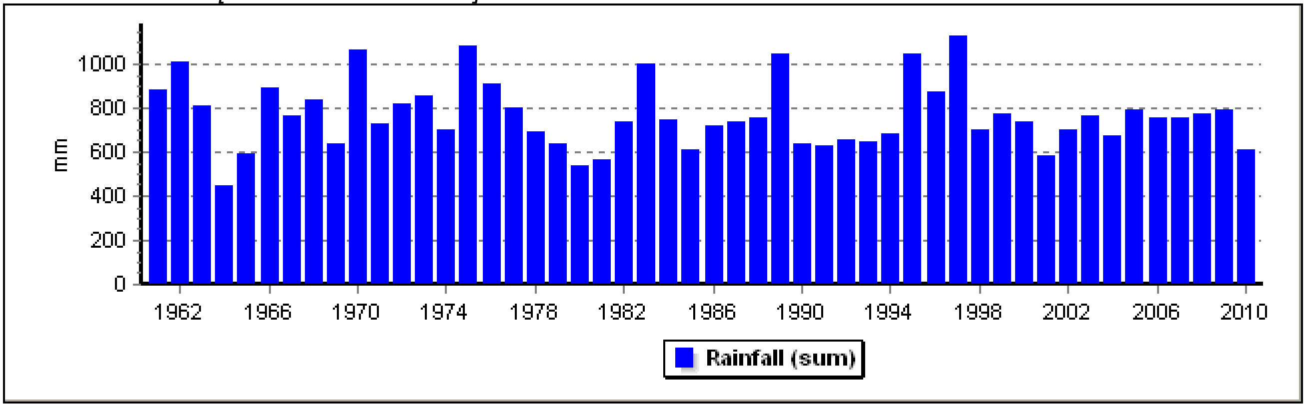
09 Apr 2012 17:02

Acceptability report - All flocks of Ewes @ Trevenna Low Prod

1/09/1961 - 21/03/2011
Mean annual rainfall for years tested
Mean annual rainfall *[1 Jan - 31 Dec, 1962-2010]*

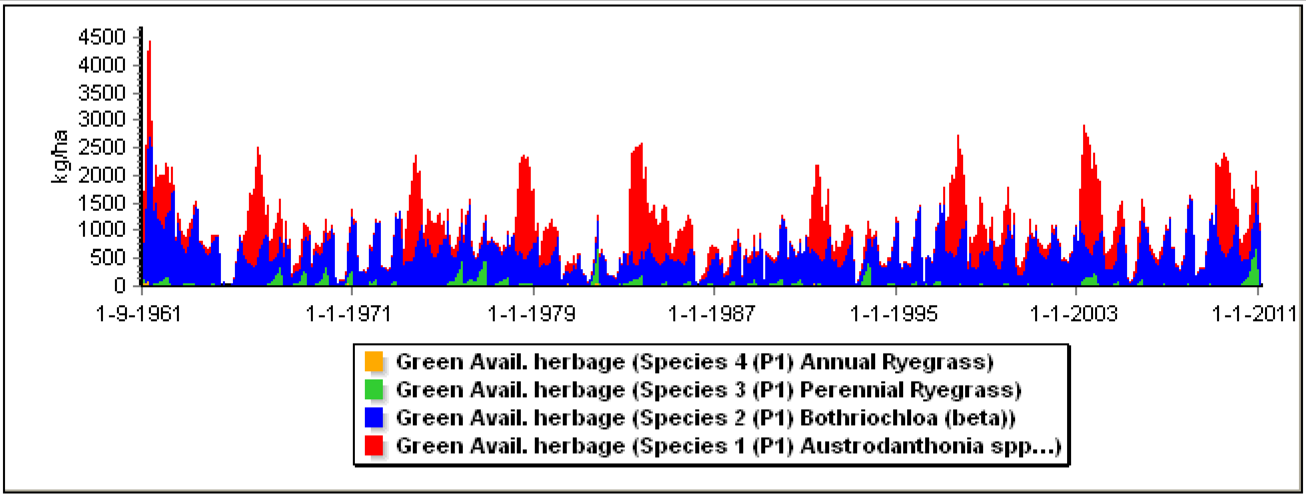
Date	Rainfall (sum) (mm)
-	766

Annual rainfall by years
Total annual rainfall *[1/09/1961 - 21/03/2011]*

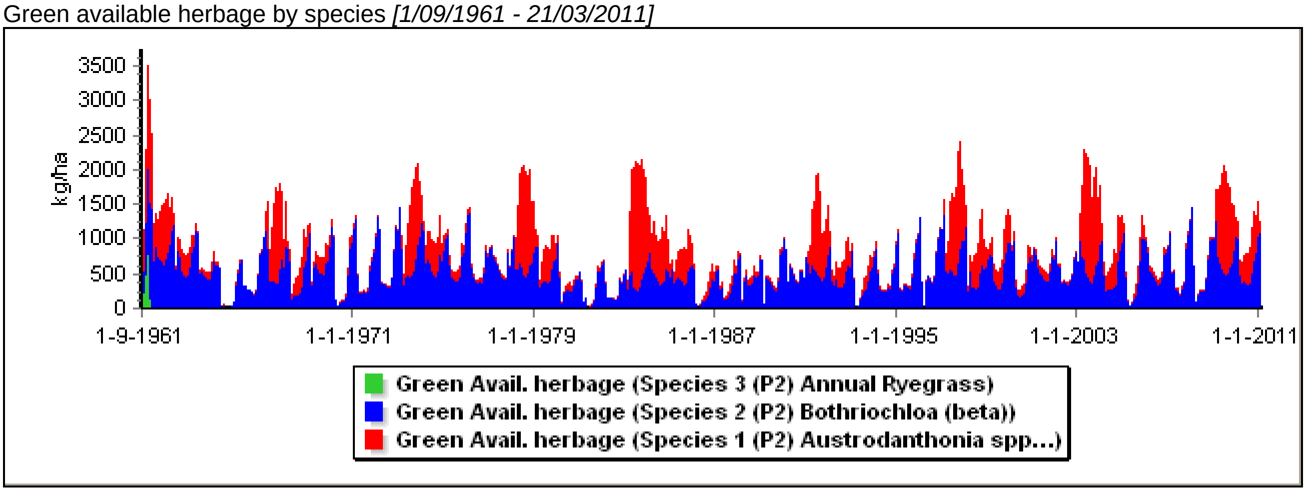


Production over years

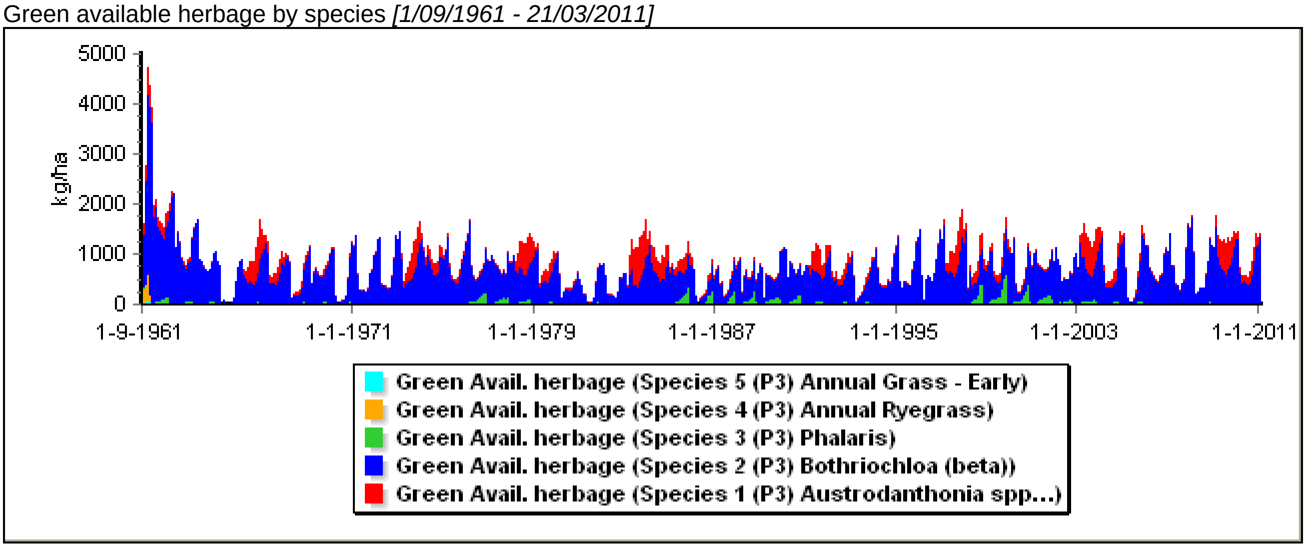
Pasture composition by years - Paddock 1
Green available herbage by species *[1/09/1961 - 21/03/2011]*



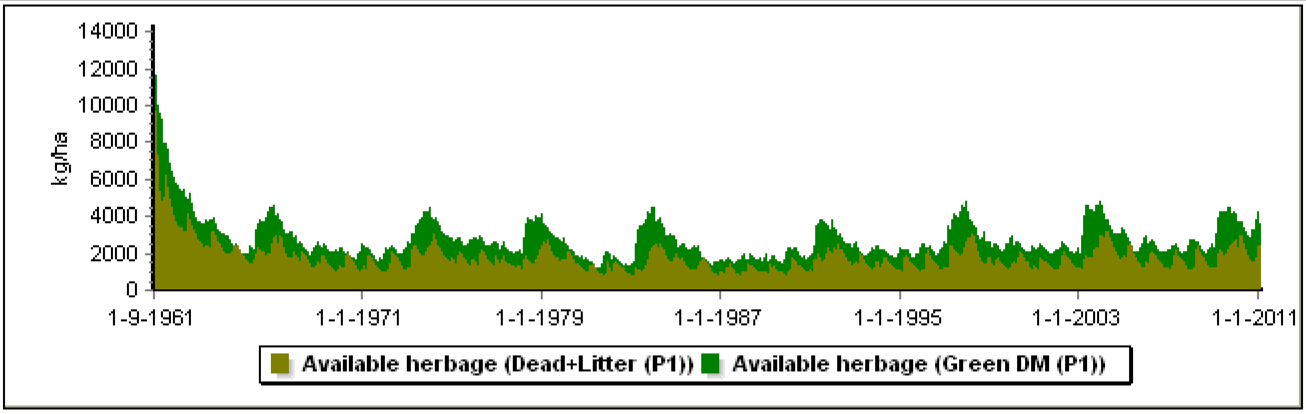
Pasture composition by years - Paddock 2
Green available herbage by species *[1/09/1961 - 21/03/2011]*



Pasture composition by years - Paddock 3
Green available herbage by species *[1/09/1961 - 21/03/2011]*

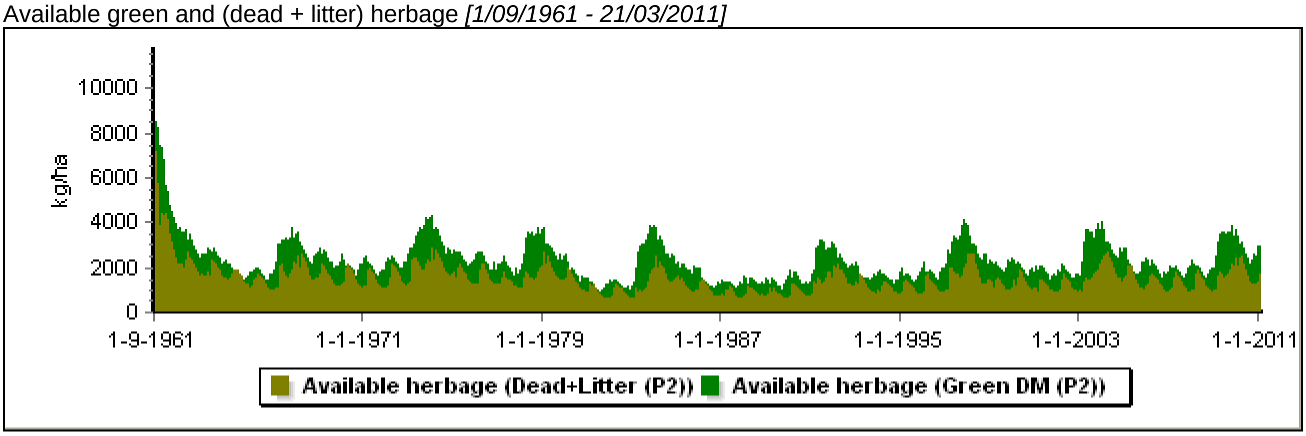


Pasture availability by years - Paddock 1
Available green and (dead + litter) herbage *[1/09/1961 - 21/03/2011]*



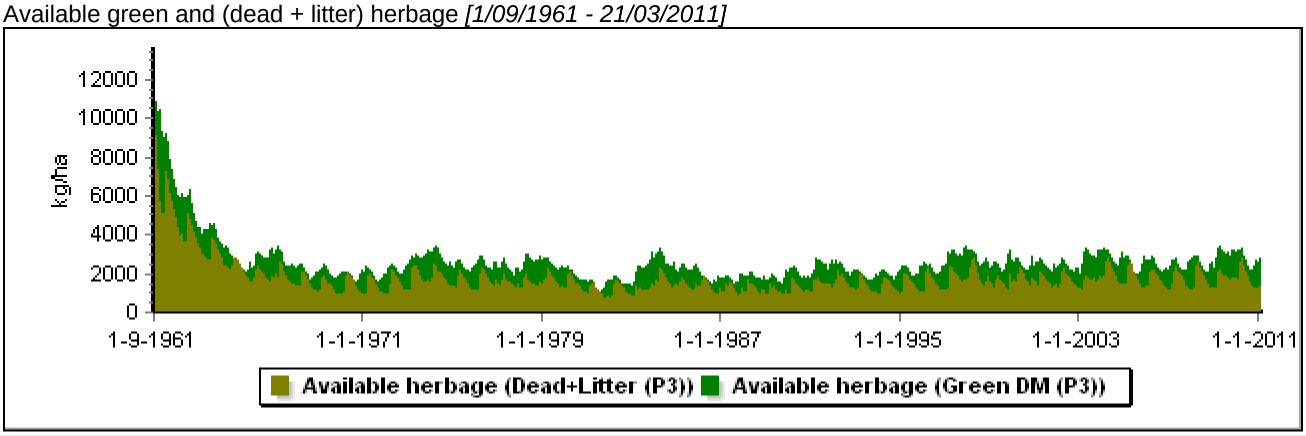
Pasture availability by years - Paddock 2

Available green and (dead + litter) herbage *[1/09/1961 - 21/03/2011]*



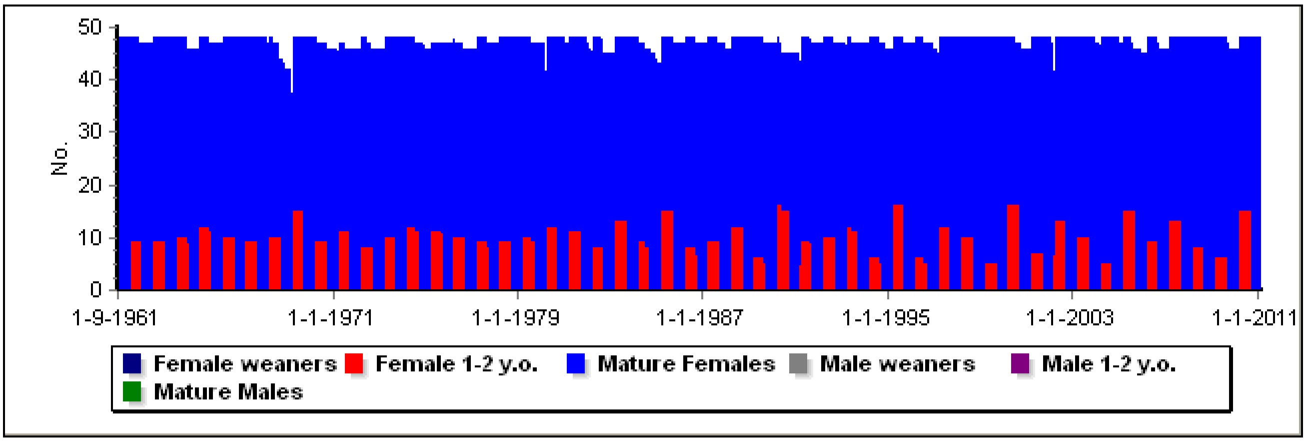
Pasture availability by years - Paddock 3

Available green and (dead + litter) herbage *[1/09/1961 - 21/03/2011]*



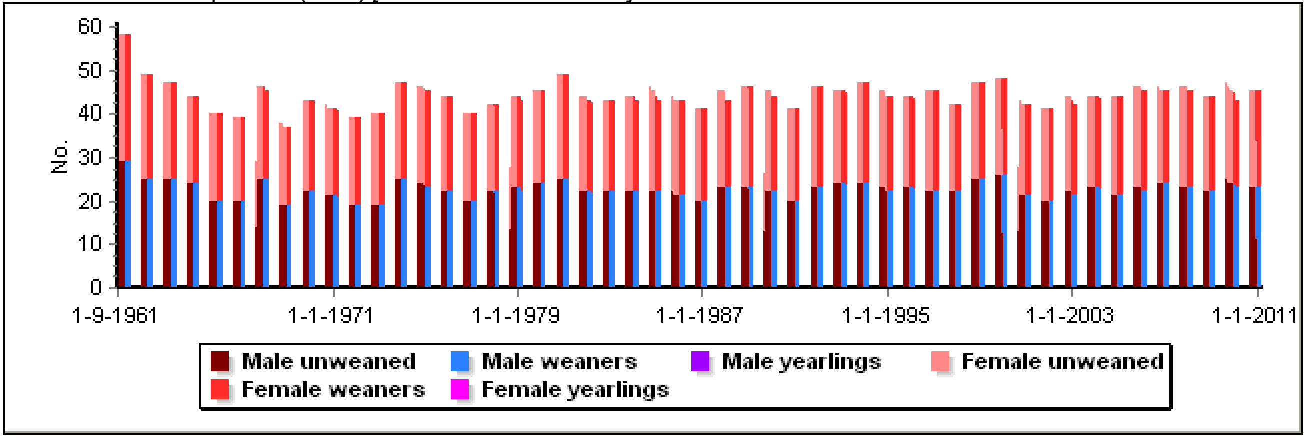
Numbers of sheep in the main flock

Number of animals present (head) *[1/09/1961 - 21/03/2011]*



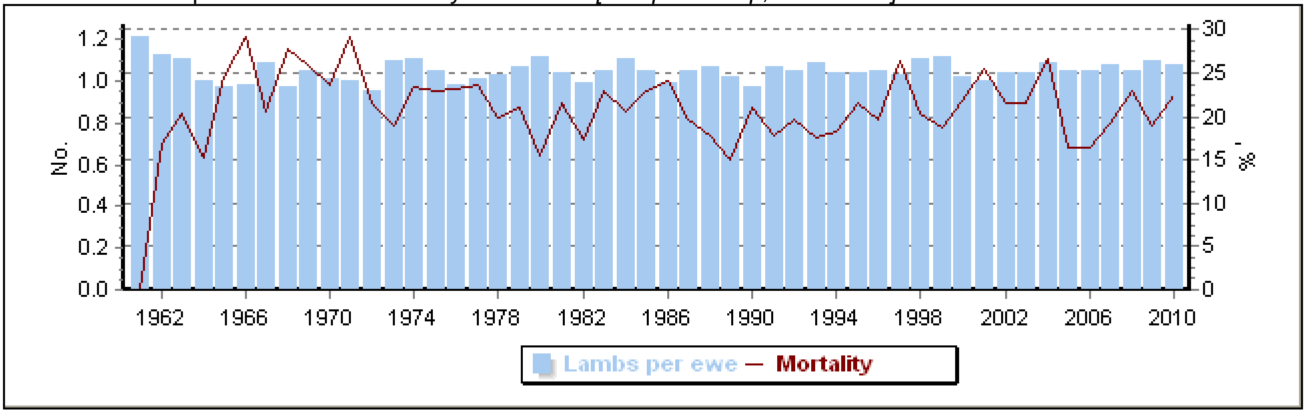
Numbers of young sheep

Number of animals present (head) *[1/09/1961 - 21/03/2011]*



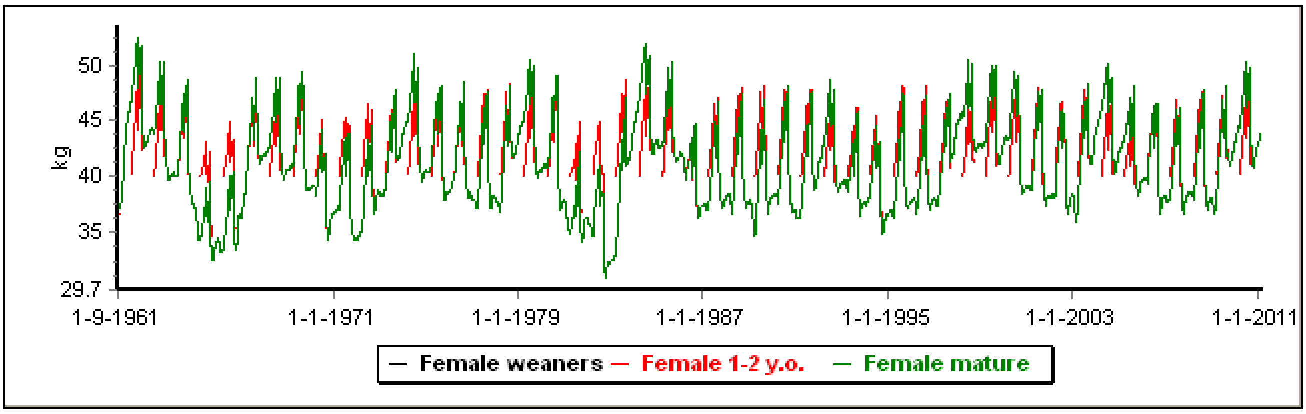
Lamb mortality

Number of lambs per ewe and the mortality rate at birth *[8 Sep - 12 Sep, 1961-2010]*



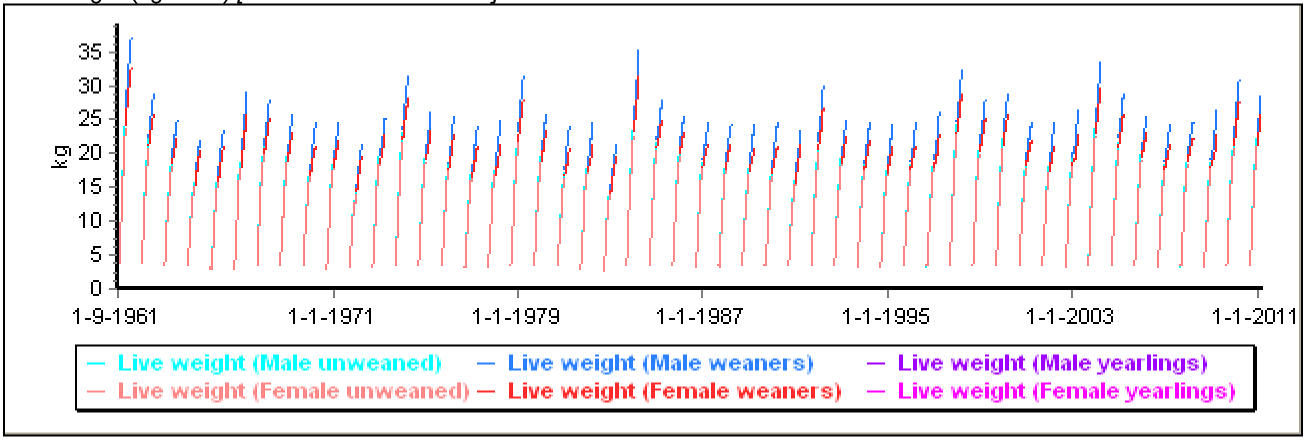
Live weight of female sheep in the main flock

Live weight of each class (kg/head) *[1/09/1961 - 21/03/2011]*



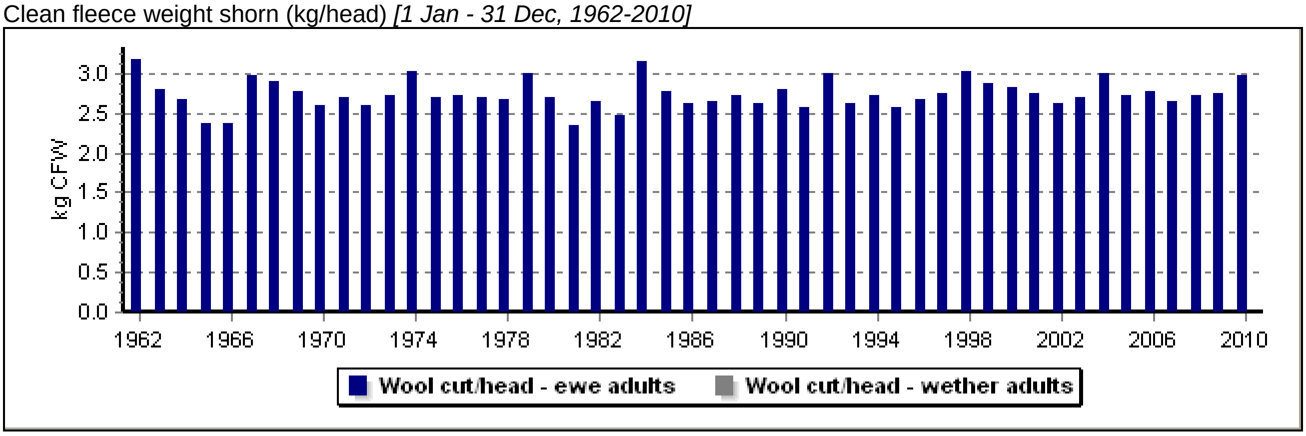
Live weight of young sheep

Live weight (kg/head) *[1/09/1961 - 21/03/2011]*



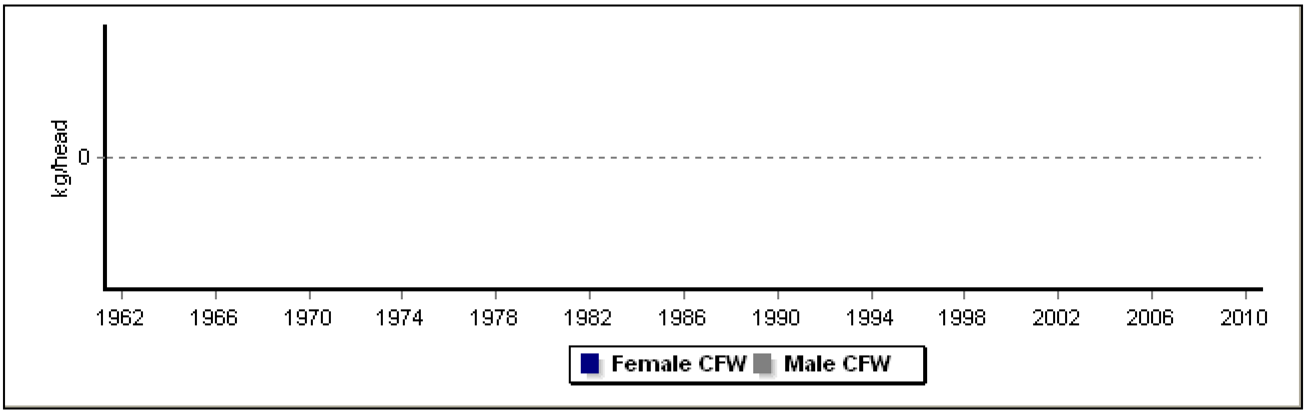
Fleece weight shorn each year for sheep in the main flock

Clean fleece weight shorn (kg/head) *[1 Jan - 31 Dec, 1962-2010]*



Fleece weight shorn each year for young sheep

Clean fleece weight shorn (kg/head) *[9 Jul - 10 Jul, 1962-2010]*



Average annual wool production of age classes in the main flock

Long term average annual clean fleece weight (kg/head) and fleece fibre diameter (micron) *[1 Jan - 31 Dec, 1962-2010]*

Date	CFW -main flock						Fleece fibre diameter				
	Female weaners (max) (kg/head)	Female 1-2 y.o. (max) (kg/head)	Female mature (max) (kg/head)	Male weaners (max) (kg/head)	Male 1-2 y.o. (max) (kg/head)	Male mature (max) (kg/head)	Female weaners (av.) (microns)	Female 1-2 y.o. (av.) (microns)	Female mature (av.) (microns)	Male weaners (av.) (microns)	Male 1-2 y.o. (av.) (microns
-	n/a	2.77	2.73	n/a	n/a	n/a	n/a	17.3	17.3	n/a	n/a

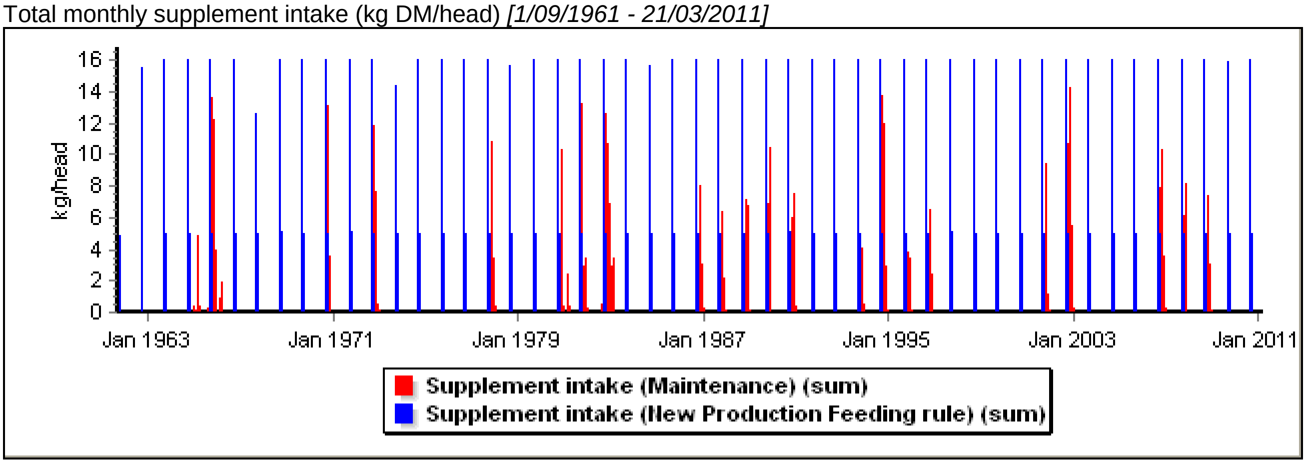
Average wool production of young sheep

Long term average clean fleece weight (kg/head) and fleece fibre diameter (micron) *[9 Jul - 10 Jul, 1962-2010]*

Date	CFW -young sheep					Fleece fibre diameter				
	Unweaned (max) (kg/head)	Male weaners (max) (kg/head)	Male yearlings (max) (kg/head)	Female weaners (max) (kg/head)	Female yearlings (max) (kg/head)	Unweaned (av.) (microns)	Male weaners (av.) (microns)	Male yearlings (av.) (microns)	Female weaners (av.) (microns)	Female yearlings (av.) (microns)
-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

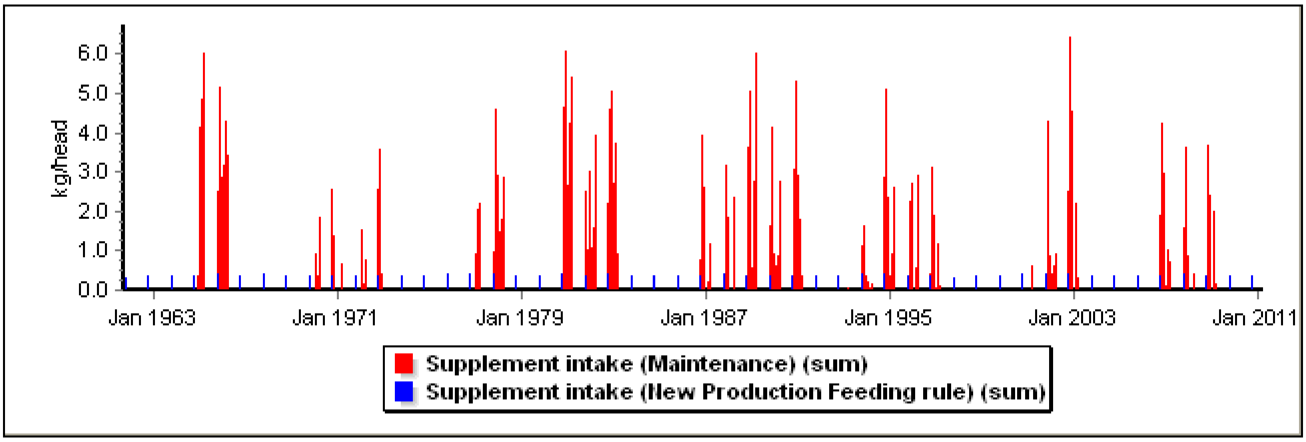
Supplement intake of sheep in the main flock

Total monthly supplement intake (kg DM/head) *[1/09/1961 - 21/03/2011]*



Supplement intake of all young sheep

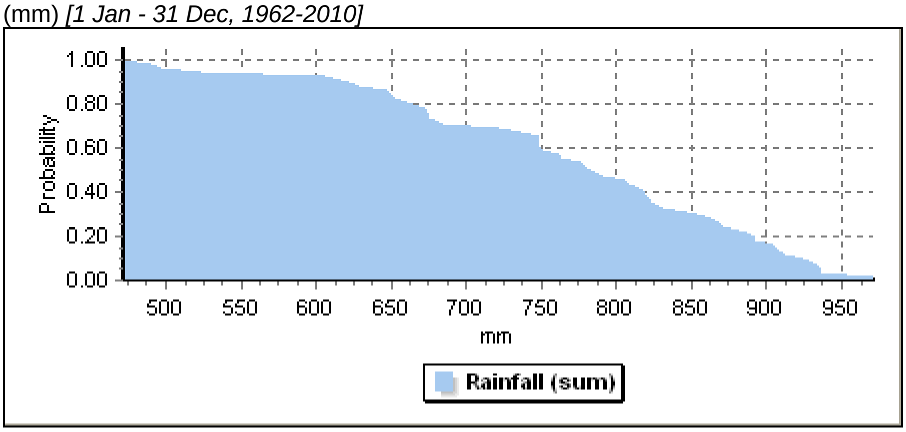
Total monthly supplement intake for all young sheep (kg DM/head) *[1/09/1961 - 21/03/2011]*



Variability of the whole farm system

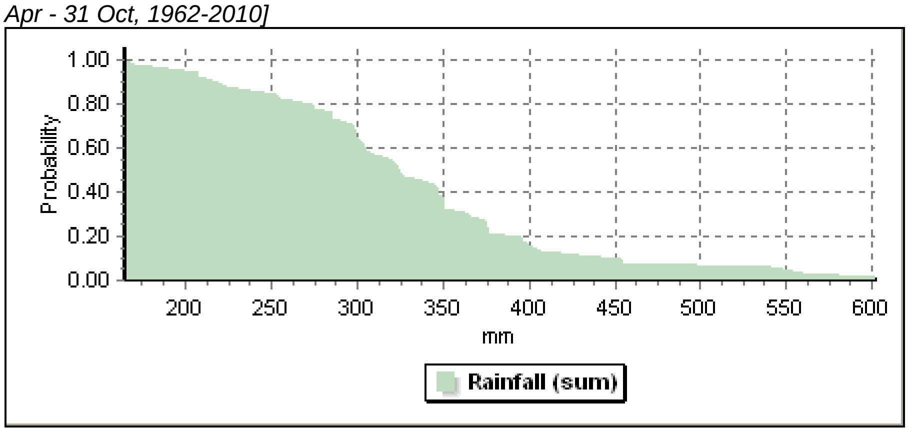
Distribution of annual rainfall

The probability (shown on the vertical axis) of annual rainfall exceeding the value shown on the horizontal axis (mm) *[1 Jan - 31 Dec, 1962-2010]*



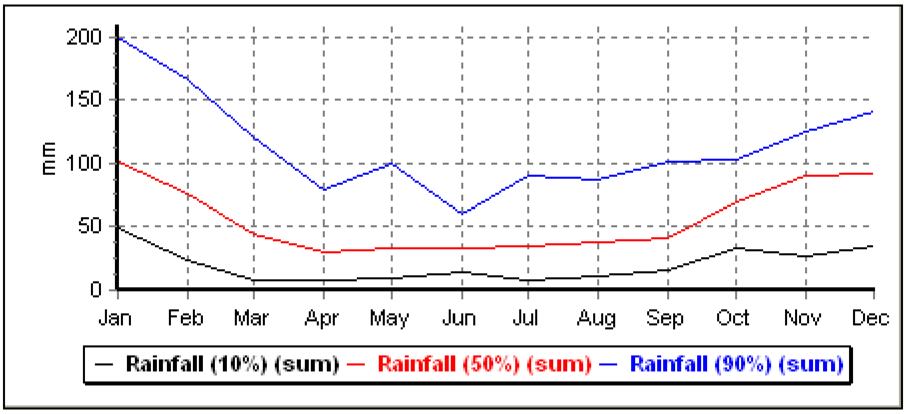
Distribution of growing season rainfall

The probability of rainfall between 1 Apr and 31 Oct exceeding the value shown on the horizontal axis (mm) *[1 Apr - 31 Oct, 1962-2010]*



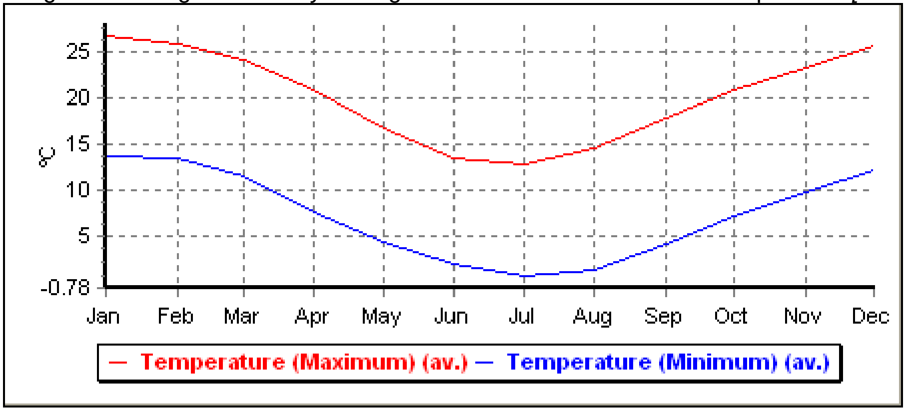
Monthly rainfall

Percentiles for monthly rainfall *[1 Jan - 31 Dec, 1962-2010]*



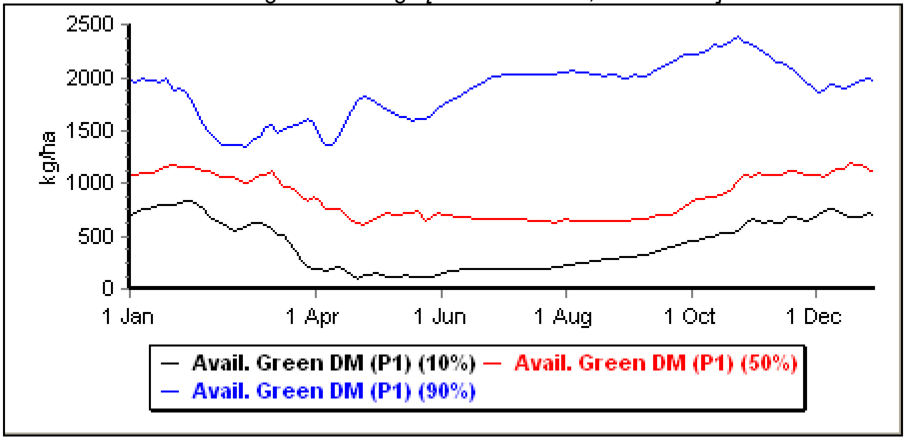
Temperature

Long term average of monthly average maximum and minimum air temperature *[1 Jan - 31 Dec, 1962-2010]*



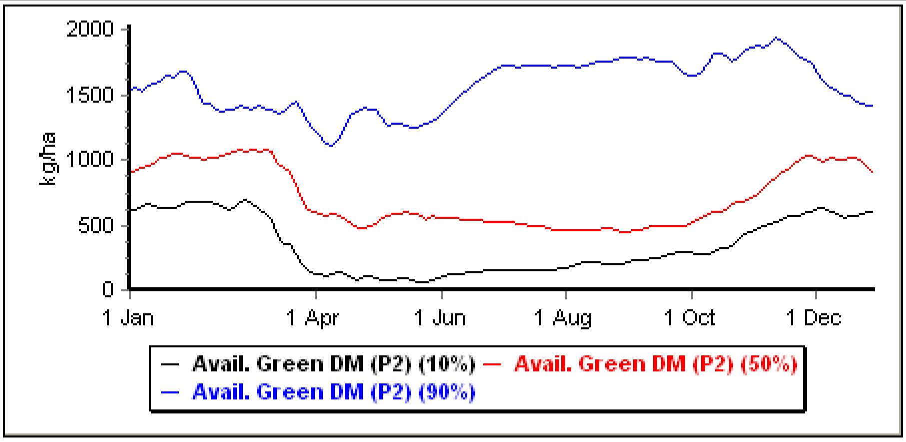
Pasture supply - green - Paddock 1

Percentiles for available green herbage *[1 Jan - 31 Dec, 1962-2010]*

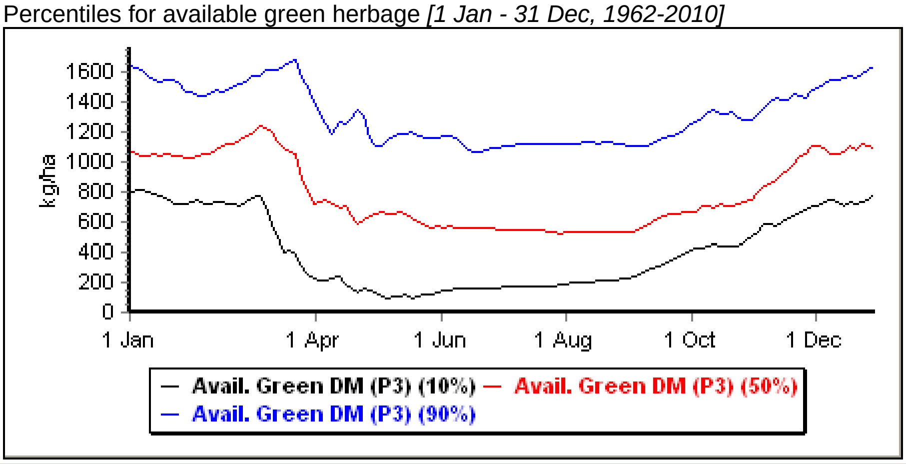


Pasture supply - green - Paddock 2

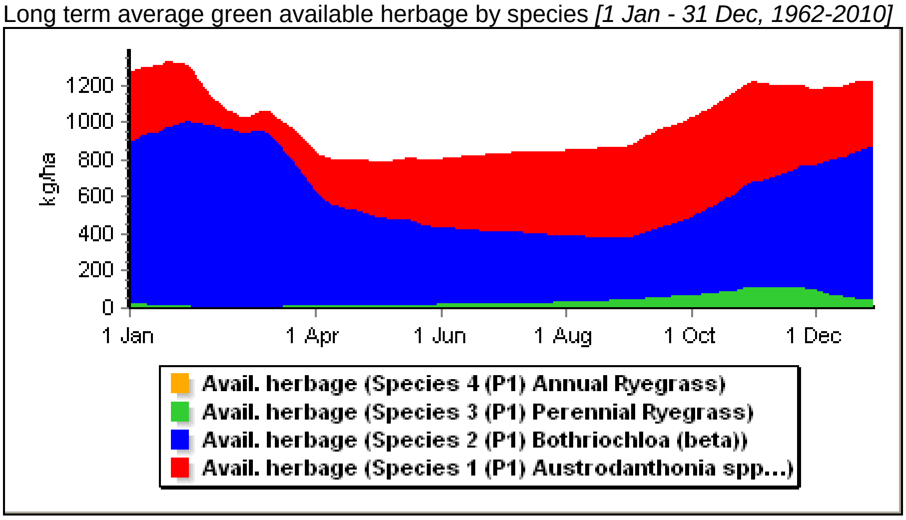
Percentiles for available green herbage *[1 Jan - 31 Dec, 1962-2010]*



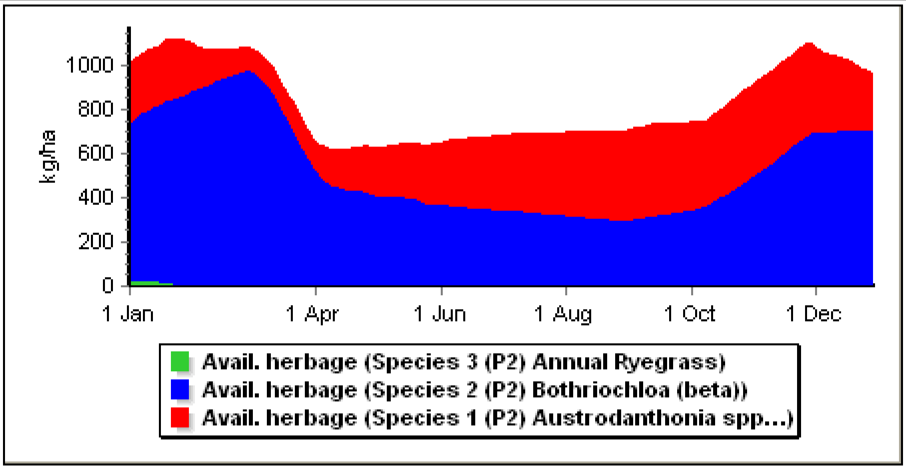
Pasture supply - green - Paddock 3
Percentiles for available green herbage *[1 Jan - 31 Dec, 1962-2010]*



Average pasture composition - Paddock 1
Long term average green available herbage by species *[1 Jan - 31 Dec, 1962-2010]*

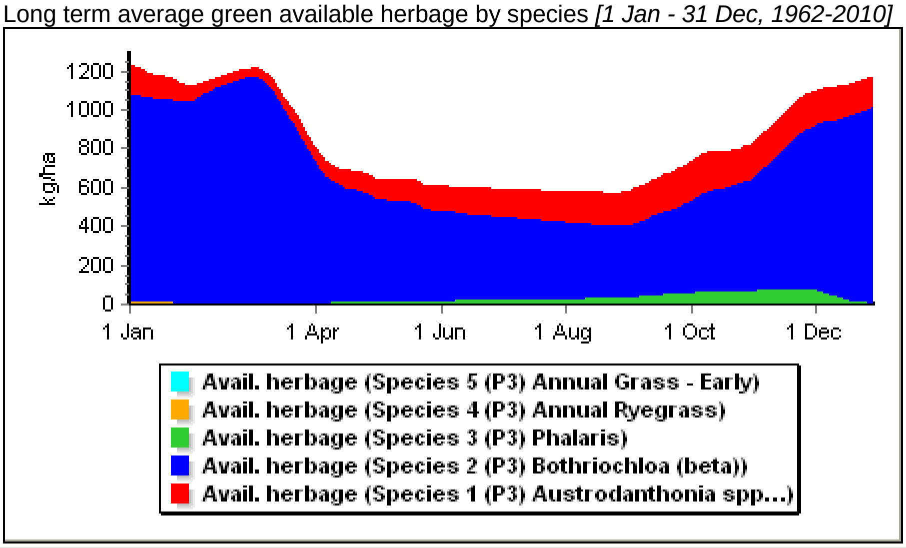


Average pasture composition - Paddock 2
Long term average green available herbage by species *[1 Jan - 31 Dec, 1962-2010]*



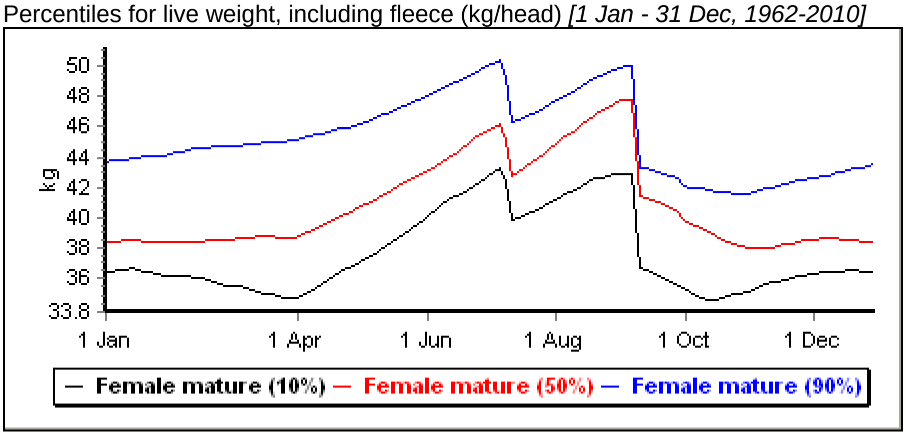
Average pasture composition - Paddock 3

Long term average green available herbage by species *[1 Jan - 31 Dec, 1962-2010]*



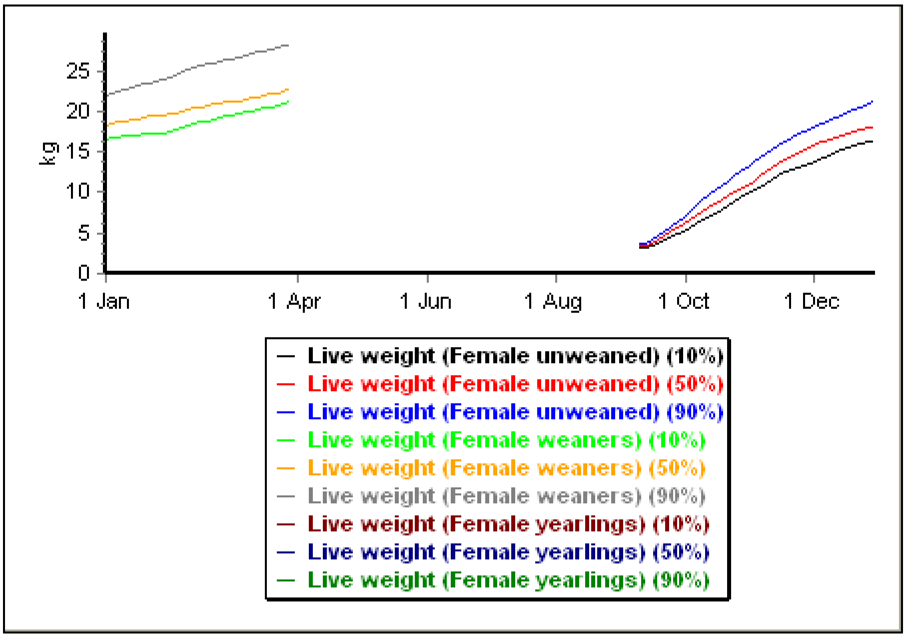
Variability in live weight of mature female sheep in the main flock

Percentiles for live weight, including fleece (kg/head) *[1 Jan - 31 Dec, 1962-2010]*



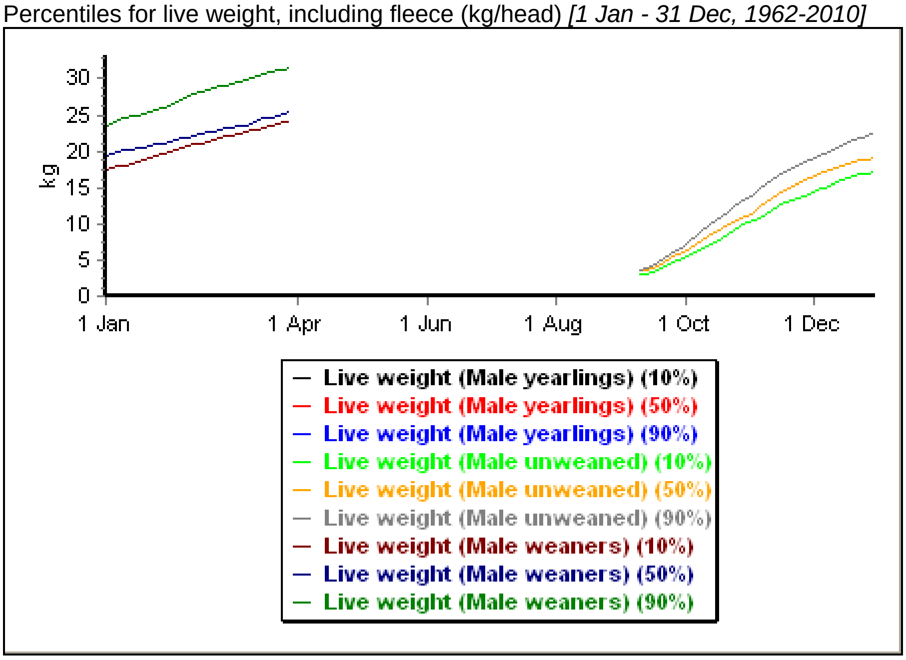
Variability in live weight of ewe lambs

Percentiles for live weight, including fleece (kg/head) *[1 Jan - 31 Dec, 1962-2010]*



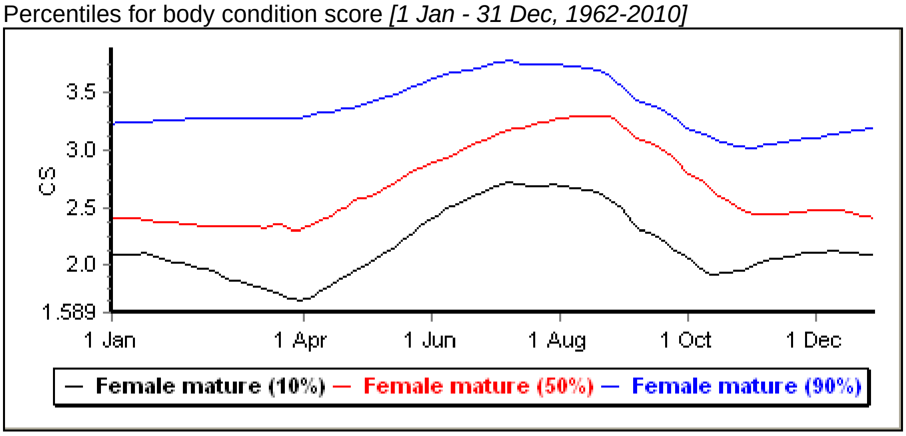
Variability in live weight of wether lambs

Percentiles for live weight, including fleece (kg/head) *[1 Jan - 31 Dec, 1962-2010]*



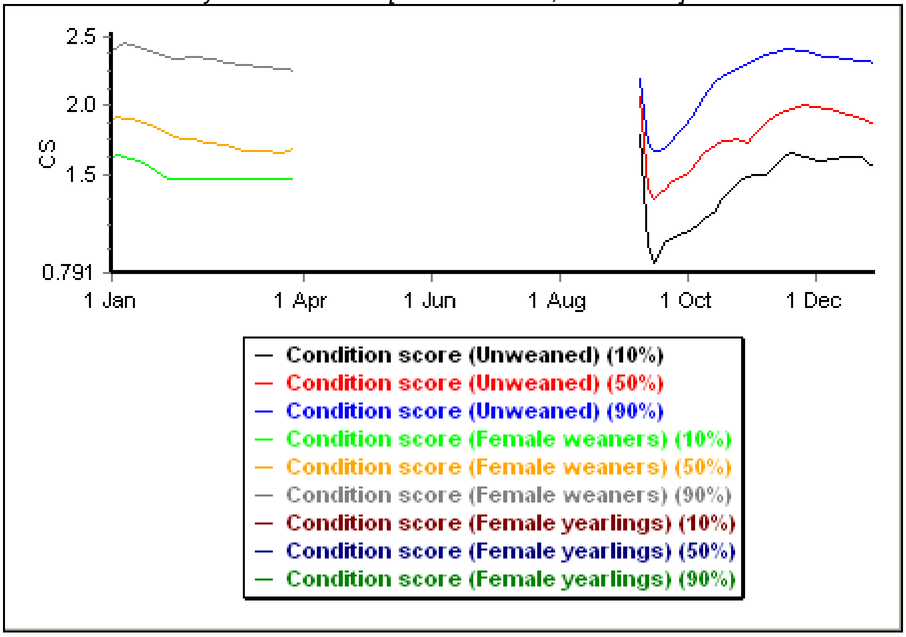
Variability in body condition of mature female sheep in the main flock

Percentiles for body condition score *[1 Jan - 31 Dec, 1962-2010]*



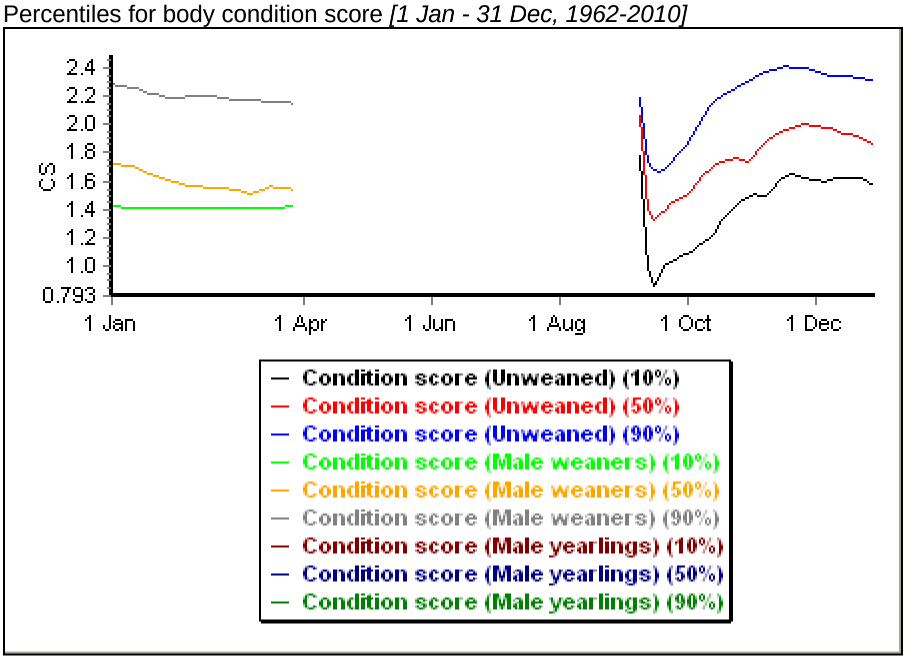
Variability in body condition of ewe lambs

Percentiles for body condition score *[1 Jan - 31 Dec, 1962-2010]*



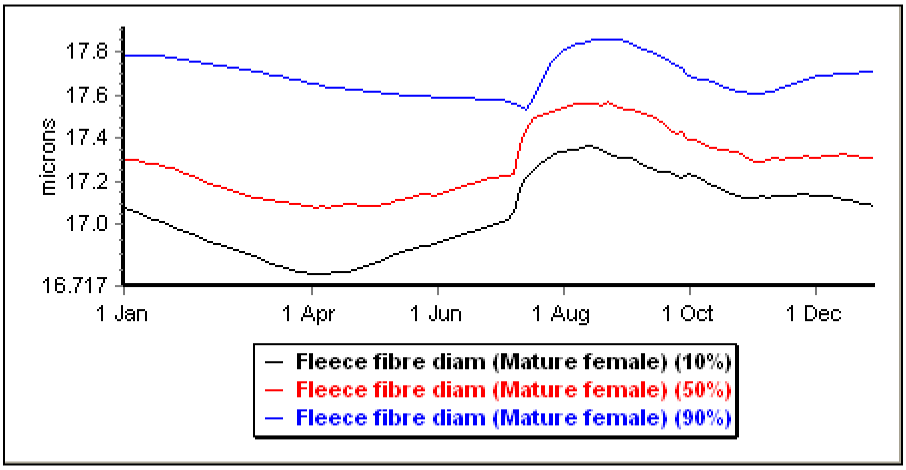
Variability in body condition of wether lambs

Percentiles for body condition score *[1 Jan - 31 Dec, 1962-2010]*



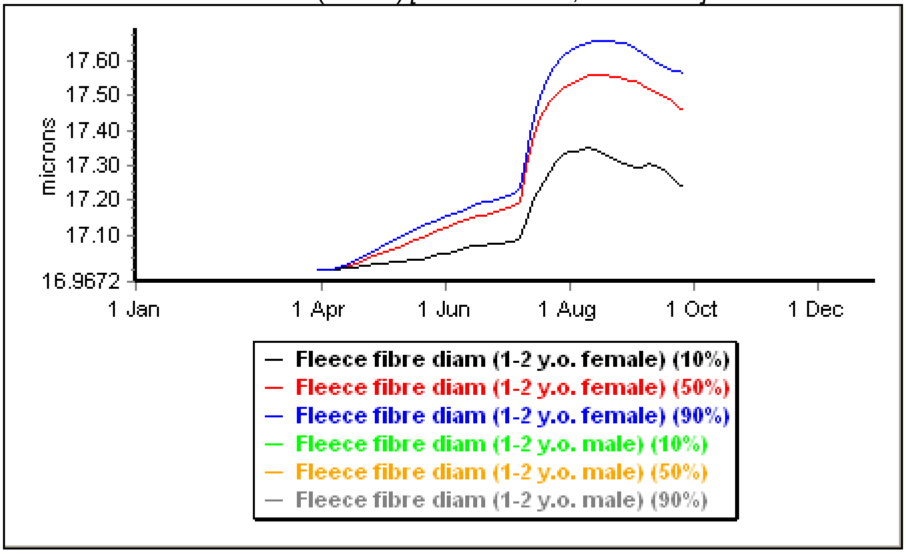
Variability in fibre diameter of mature female sheep in the main flock

Percentiles for fibre diameter (micron) *[1 Jan - 31 Dec, 1962-2010]*



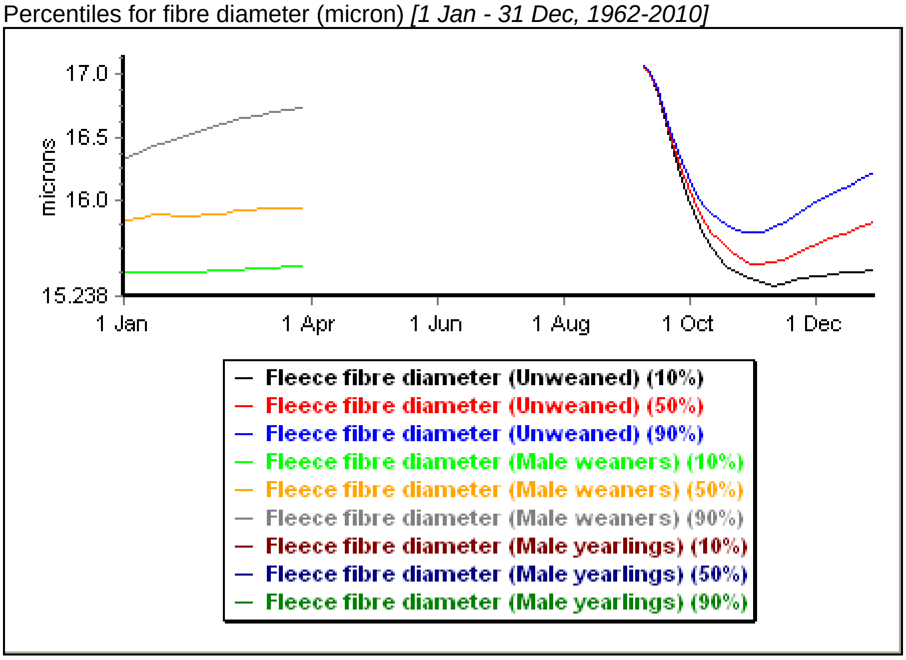
Variability in fibre diameter of 1-2 year old sheep in the main flock

Percentiles for fibre diameter (micron) *[1 Jan - 31 Dec, 1962-2010]*



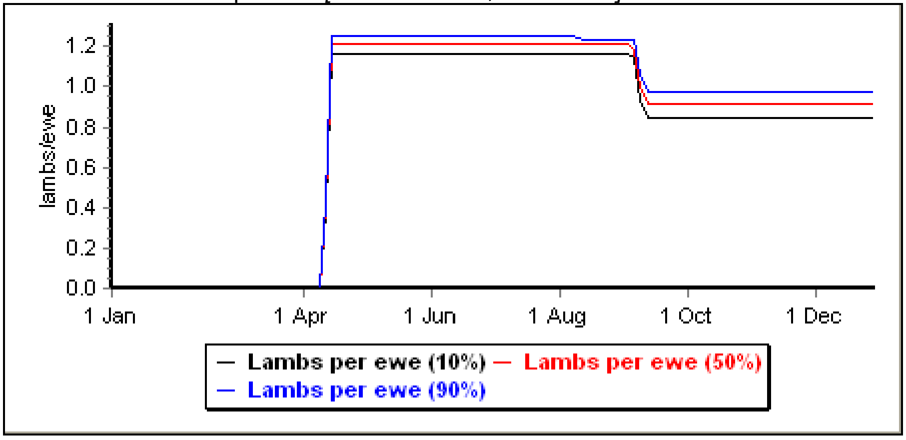
Variability in fibre diameter of young wethers (unweaned and weaned)

Percentiles for fibre diameter (micron) *[1 Jan - 31 Dec, 1962-2010]*



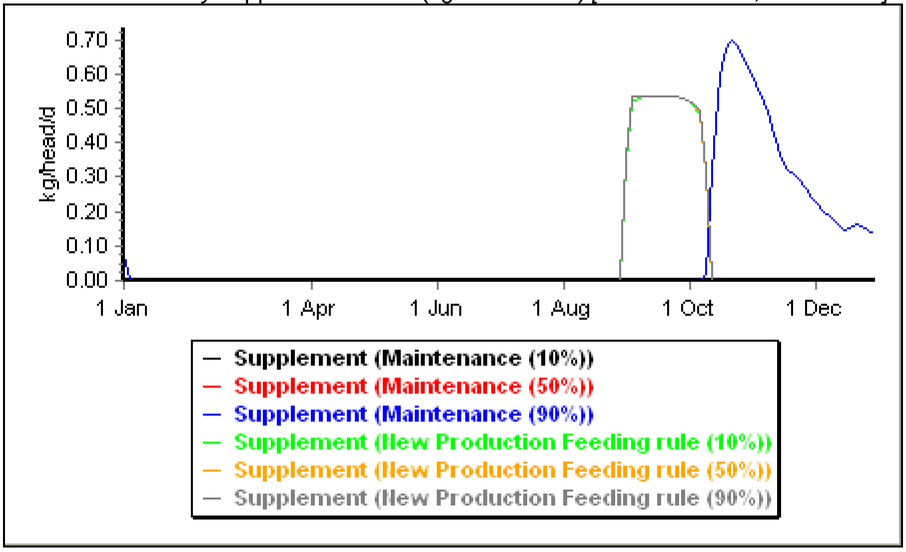
Lambs per ewe

Percentiles for lambs per ewe *[1 Jan - 31 Dec, 1962-2010]*



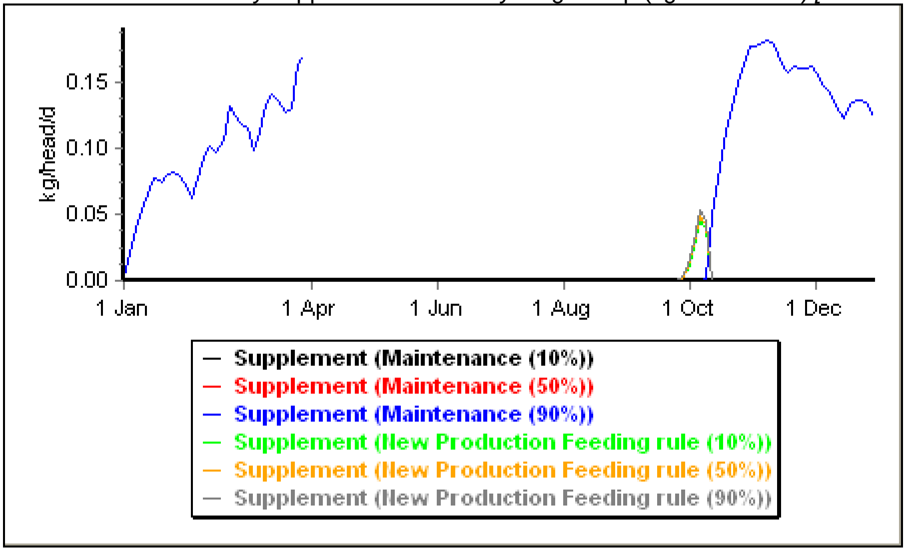
Variability in intake of maintenance and production supplement of the main flock

Percentiles for daily supplement intake (kg DM/head/d) *[1 Jan - 31 Dec, 1962-2010]*



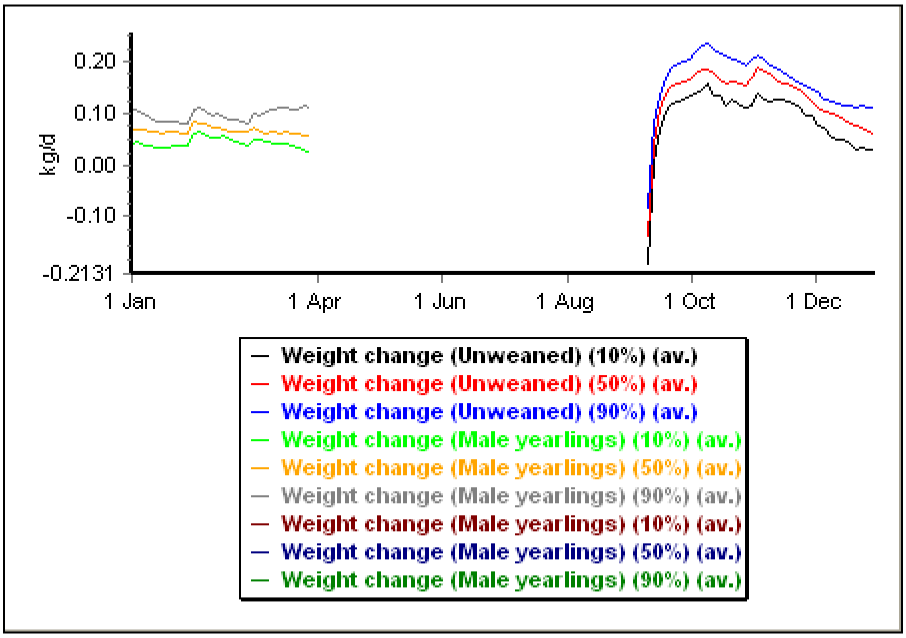
Variability in intake of maintenance and production supplement of young sheep

Percentiles for total daily supplement intake of young sheep (kg DM/head/d) *[1 Jan - 31 Dec, 1962-2010]*



Variability in average daily gain (ADG) of wether lambs

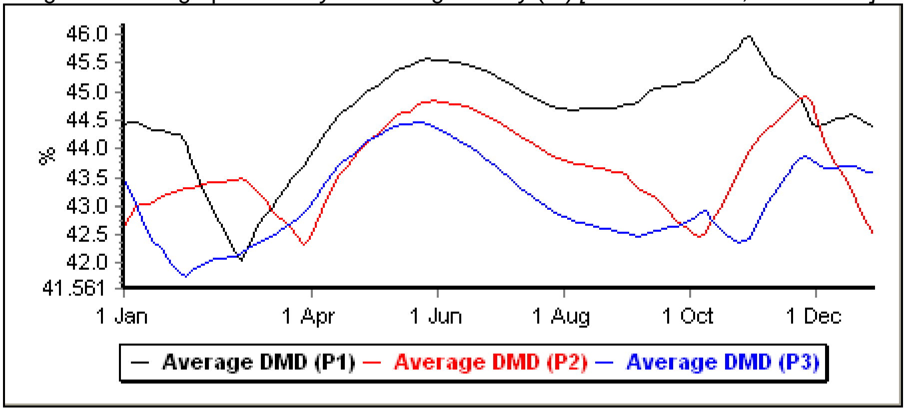
Percentiles for average daily live weight gain -not fleece (kg/head/d) *[1 Jan - 31 Dec, 1962-2010]*



Pasture quality

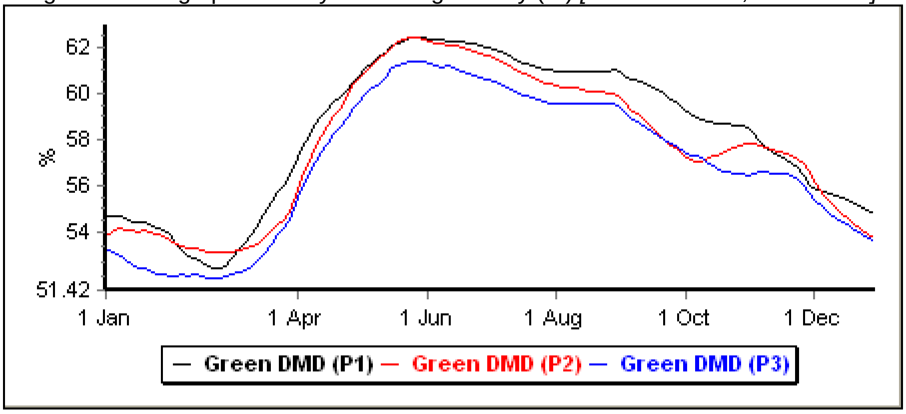
Average quality of all herbage in each paddock

Long term average pasture dry matter digestibility (%) *[1 Jan - 31 Dec, 1962-2010]*



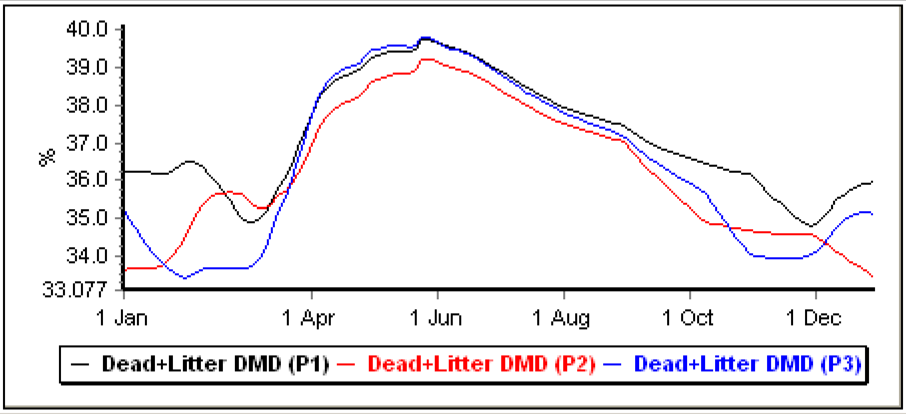
Average quality of green herbage for each paddock

Long term average pasture dry matter digestibility (%) *[1 Jan - 31 Dec, 1962-2010]*



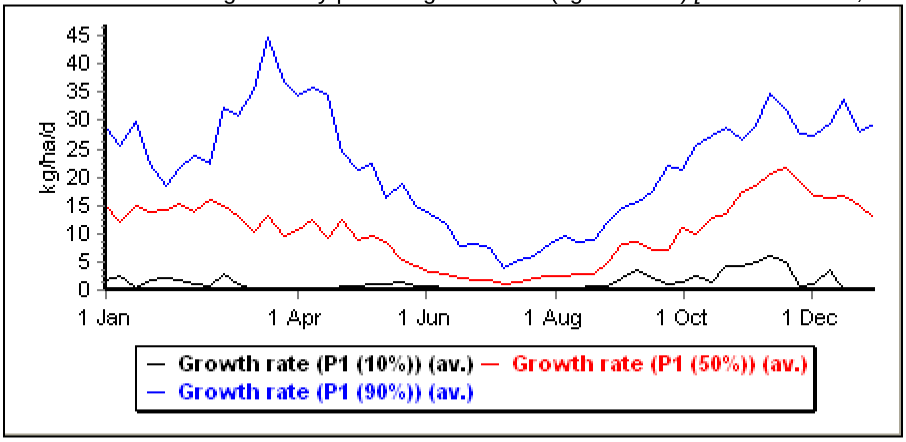
Average quality of dead herbage and litter for each paddock

Long term average pasture dry matter digestibility (%) *[1 Jan - 31 Dec, 1962-2010]*



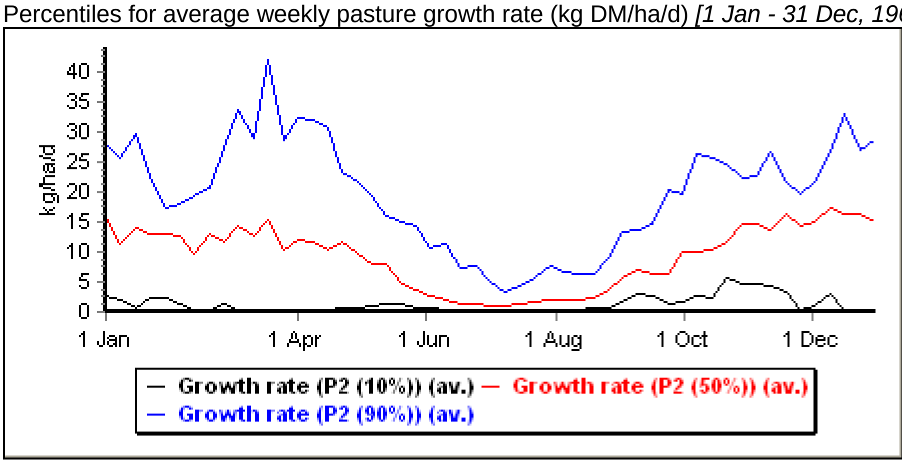
Variability in pasture growth rate - Paddock 1

Percentiles for average weekly pasture growth rate (kg DM/ha/d) *[1 Jan - 31 Dec, 1962-2010]*



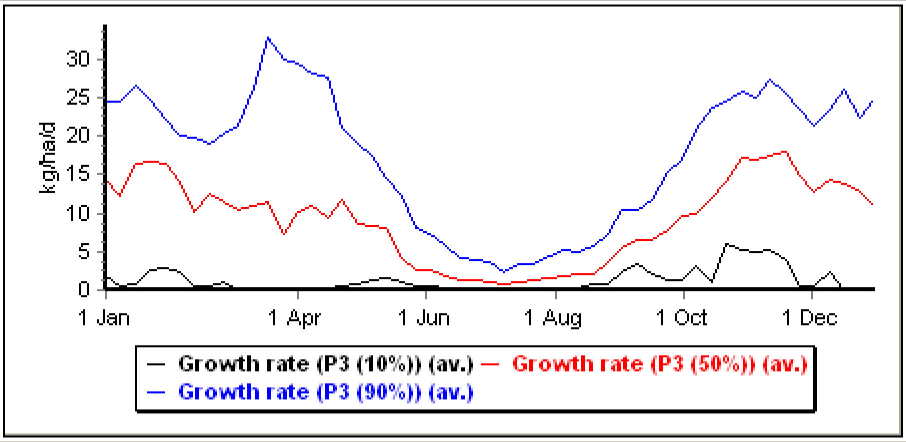
Variability in pasture growth rate - Paddock 2

Percentiles for average weekly pasture growth rate (kg DM/ha/d) *[1 Jan - 31 Dec, 1962-2010]*



Variability in pasture growth rate - Paddock 3

Percentiles for average weekly pasture growth rate (kg DM/ha/d) *[1 Jan - 31 Dec, 1962-2010]*



Pasture growth rates for each paddock

Long term average pasture growth rates *[1 Jan - 31 Dec, 1962-2010]*

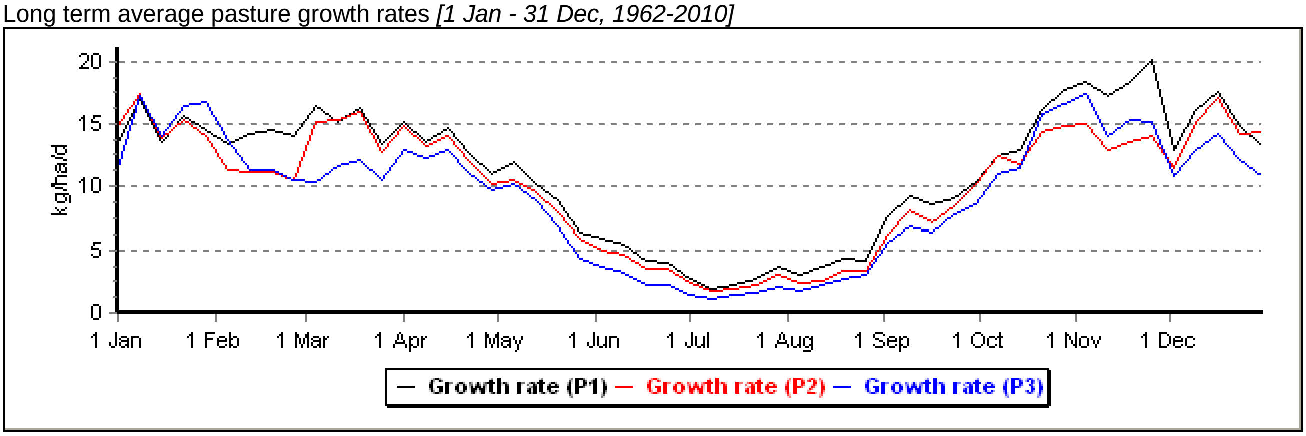


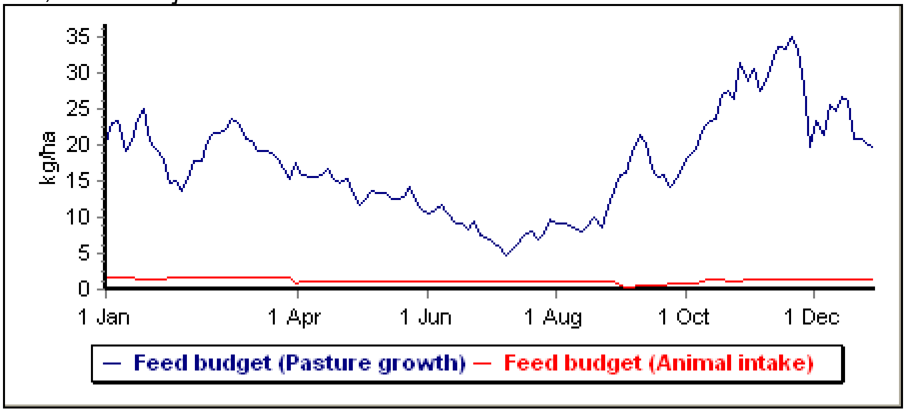
Table of average monthly pasture and sheep growth rates

Long term average pasture and sheep growth rates, averaged over each month *[1 Jan - 31 Dec, 1962-2010]*

Date	Pasture growth	Pasture growth	Pasture growth	Weight change (Unweaned)	Weight change (Male weaners)	Weight change (Female weaners)	Weight change (Main mob)					
	P1 (av.) **(kg/ha/d)**	**P2** (av.) **(kg/ha/d)**	**P3** (av.) **(kg/ha/d)**	(av.) **(kg/d)**	(av.) **(kg/d)**	(av.) **(kg/d)**	**Female weaners** (av.) **(kg/d)**	**Female 1-2 y.o.** (av.) **(kg/d)**	**Female mature** (av.) **(kg/d)**	**Male weaners** (av.) **(kg/d)**	**Male 1-2 y.o.** (av.) **(kg/d)**	**Male mature** (av.) **(kg/d)**
Jan	14	14	15	n/a	0.064	0.044	n/a	n/a	-0.009	n/a	n/a	n/a
Feb	13	11	12	n/a	0.073	0.051	n/a	n/a	-0.006	n/a	n/a	n/a
Mar	15	15	11	n/a	0.068	0.049	n/a	n/a	-0.008	n/a	n/a	n/a
Apr	14	13	12	n/a	n/a	n/a	n/a	0.049	0.053	n/a	n/a	n/a
May	9	8	7	n/a	n/a	n/a	n/a	0.043	0.047	n/a	n/a	n/a
Jun	4	4	2	n/a	n/a	n/a	n/a	0.037	0.043	n/a	n/a	n/a
Jul	3	2	1	n/a	n/a	n/a	n/a	0.010	0.014	n/a	n/a	n/a
Aug	4	3	3	n/a	n/a	n/a	n/a	-0.024	-0.016	n/a	n/a	n/a
Sep	9	8	7	0.094	n/a	n/a	n/a	-0.081	-0.075	n/a	n/a	n/a
Oct	14	12	13	0.170	n/a	n/a	n/a	n/a	-0.051	n/a	n/a	n/a
Nov	19	14	16	0.156	n/a	n/a	n/a	n/a	0.012	n/a	n/a	n/a
Dec	15	15	12	0.086	n/a	n/a	n/a	n/a	0.001	n/a	n/a	n/a

Feed budget

Long term average daily pasture growth and intake of pasture by the whole enterprise (kg DM/ha/d) *[1 Jan - 31 Dec, 1962-2010]*



Pasture utilization rate

The long term average amount of pasture consumed by all stock as a proportion of the amount of pasture grown over the period tested (%) *[21 Mar - 21 Mar, 2011-2011]*

Date	Utilization rate (%)
21 Mar	7

Economics

Production summary

Long term average pasture and sheep production. For selected financial year *[1 Jul - 30 Jun, 1962/1963 - 2009/2010]*

Farm System		All flocks of Ewes @ Trevenna Low Prod
Total annual pasture yield (NPP) (sum)	kg/ha	6217
Dry sheep equivalents (av.)	dse/ha	1.5
Wool cut - total flock (sum)	kg CFW/ha	3
Wool cut - lambs (sum)	kg CFW/ha	0
Shorn fibre diameter - ewe adults (av.)	microns	17.2
Shorn fibre diameter - wether adults (av.)	microns	n/a
Shorn fibre diameter - lambs (av.)	microns	n/a
Meat sold - total (sum)	kg LW/ha	30
Meat sold - young stock (sum)	kg LW/ha	23
Wthr/ram Lambs Sale wt (av.)	kg	26.5
Ewe Lambs Sale wt (av.)	kg	23.6
Supplement fed/area (New Production Feeding rule) (sum)	tonnes/ha	0.024
Supplement fed/area (Maintenance - main flock) (sum)	tonnes/ha	0.013
Supplement fed/area (Maintenance - young (wnr) stock) (sum)	tonnes/ha	0.002

Gross margin

Long term average gross margin. For selected financial year *[1 Jul - 30 Jun, 1962/1963 - 2009/2010]*

Farm System		All flocks of Ewes @ Trevenna Low Prod
Net wool income - main flock	$/ha	1
Net wool income - young stock	$/ha	0
Sale income - young stock	$/ha	28

Sale income - cast-for-age	$/ha	11
Sale income - sold at foot	$/ha	0
TOTAL INCOME	$/ha	40
Maintenance supplement	$/ha	3
Production supplement	$/ha	6
Shearing costs	$/ha	4
Animal husbandry	$/ha	5
Replacements purchased	$/ha	28
Rams purchased	$/ha	4
Sale costs	$/ha	2
Pasture costs	$/ha	0
TOTAL EXPENSES	$/ha	52
GROSS MARGIN	$/ha	-13

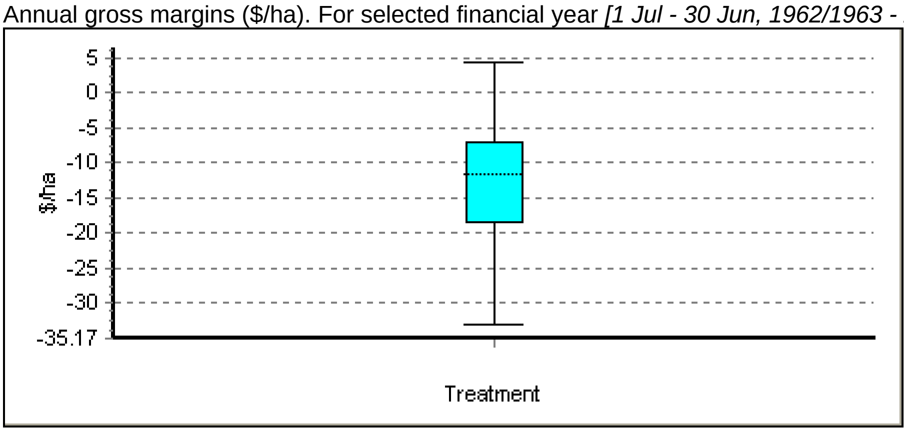
Variability of Gross Margin

Long term standard deviation of the annual gross margin *[1 Jul - 30 Jun, 1962/1963 - 2009/2010]*

Farm System		All flocks of Ewes @ Trevenna Low Prod
Total income/ha	$/ha	5.30
Total expense/ha	$/ha	9.09
Gross margin/ha	$/ha	8.64

Boxplot of gross margins

Annual gross margins ($/ha). For selected financial year *[1 Jul - 30 Jun, 1962/1963 - 2009/2010]*

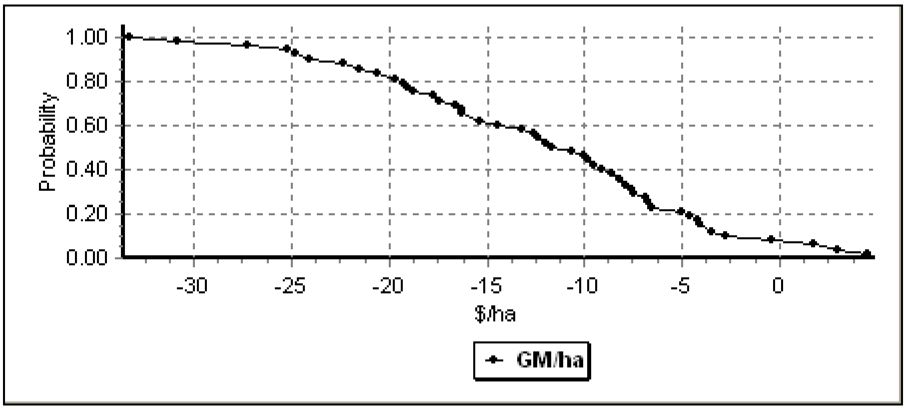


Interpretation of boxplot

The box shows the middle 50% of values (the interquartile range). The horizontal line inside the box is the median. The lines extending above and below the box (whiskers) show the upper and lower quartiles (25% of values). Beyond the whiskers, outlying values are shown by dots and extreme values are shown by asterisks. "Outlying values" lie more than 1.5 times the interquartile range beyond the upper and lower quartiles. "Extreme values" lie more than 3.0 times the interquartile range beyond the upper and lower quartiles.

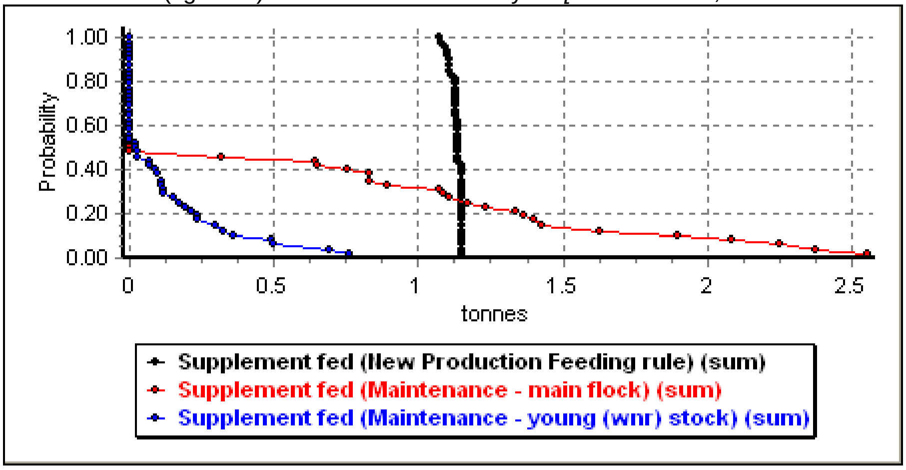
Cumulative distribution of annual gross margins

The probability (on the vertical axis) of exceeding the gross margin value shown on the horizontal axis. For selected financial year *[1 Jul - 30 Jun, 1962/1963 - 2009/2010]*



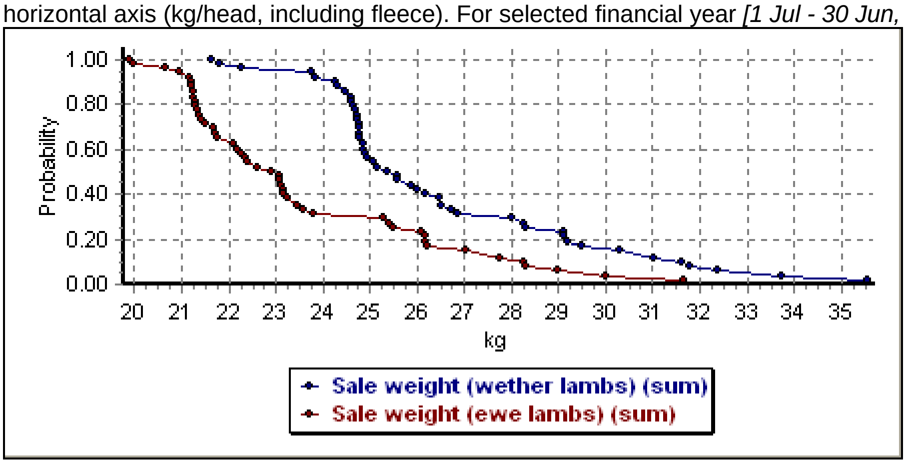
Cumulative distribution of total supplement fed to whole enterprise

The probability (on the vertical axis) of the total supplement fed in any year exceeding the value shown on the horizontal axis (kg/head). For selected financial year *[1 Jul - 30 Jun, 1962/1963 - 2009/2010]*



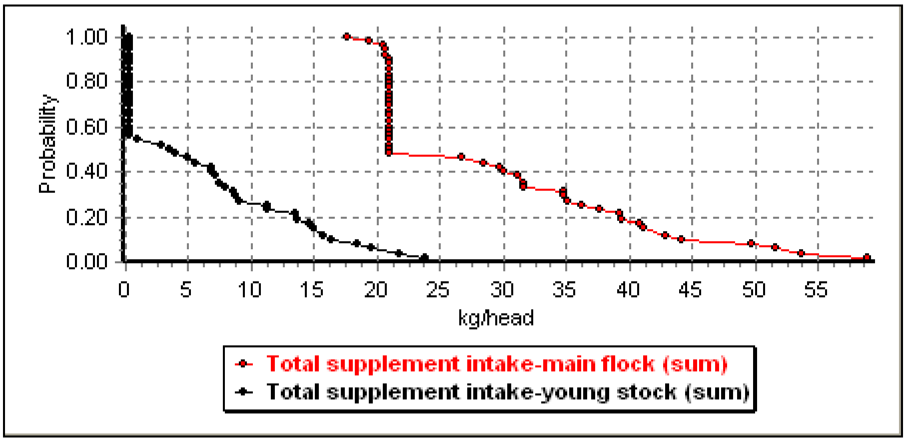
Cumulative distribution of live weight at sale of wether and ewe lambs (including fleece)

The probability (on the vertical axis) of the live weight at sale in any year exceeding the value shown on the horizontal axis (kg/head, including fleece). For selected financial year *[1 Jul - 30 Jun, 1962/1963 - 2009/2010]*



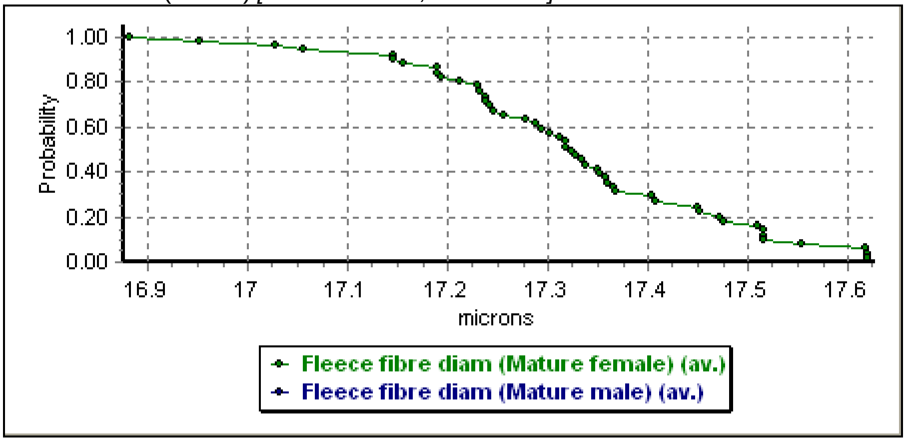
Cumulative distribution of total supplement intake of sheep in main flock and young stock

The probability (on the vertical axis) of the total supplement intake in any year exceeding the value shown on the horizontal axis (kg/head). For selected financial year *[1 Jul - 30 Jun, 1962/1963 - 2009/2010]*



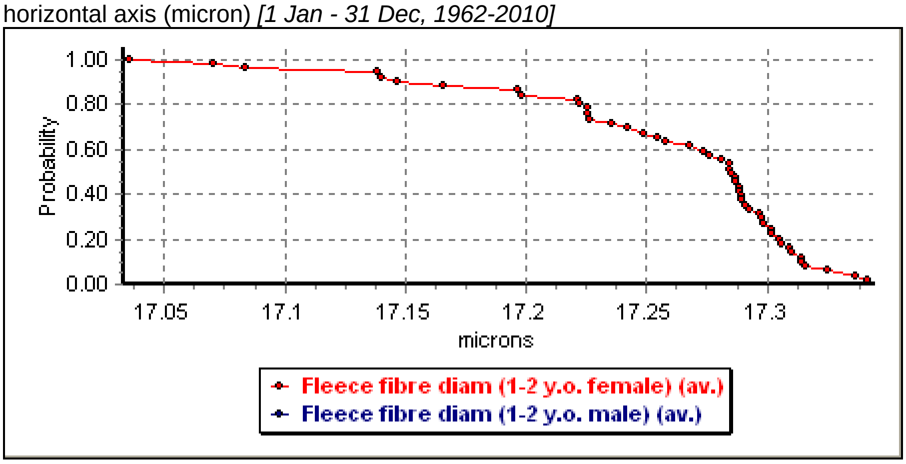
Cumulative distribution of the average fleece fibre diameter of mature sheep

The probability (on the vertical axis) of the fleece fibre diameter in any year exceeding the value shown on the horizontal axis (micron) *[1 Jan - 31 Dec, 1962-2010]*



Cumulative distribution of the average fleece fibre diameter of 1-2 year old sheep in the main flock

The probability (on the vertical axis) of the fleece fibre diameter in any year exceeding the value shown on the horizontal axis (micron) *[1 Jan - 31 Dec, 1962-2010]*



Sustainabilty

Pasture production and water balance

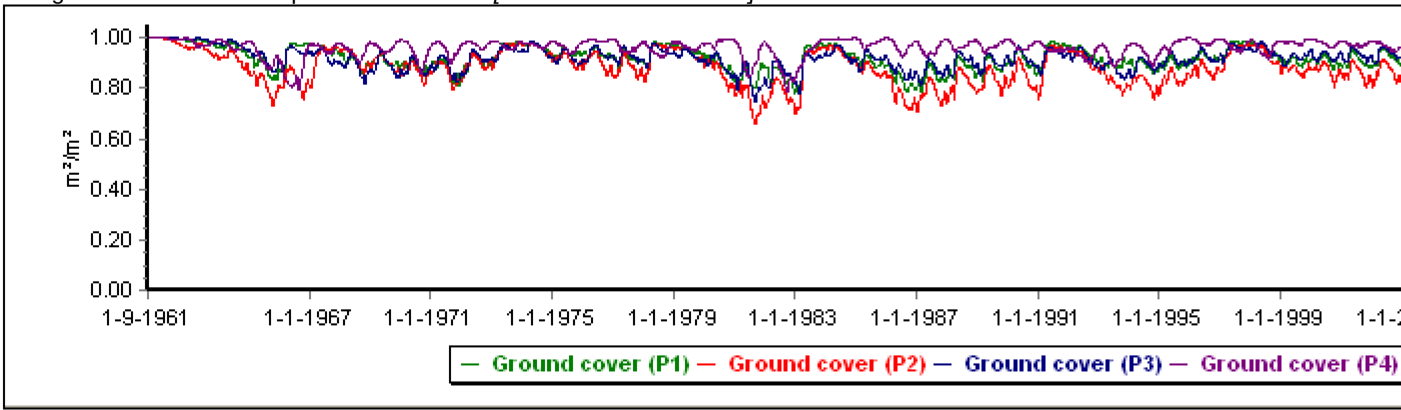
Long term average pasture productivity *[1 Jan - 31 Dec, 1962-2010]*

Farm System		All flocks of Ewes @ Trevenna Low Prod
Pasture growth (P1)	kg/ha	4040

Pasture growth (P2)	kg/ha	3634
Pasture growth (P3)	kg/ha	3369
Yearly Rainfall	mm	766
Actual evapotranspiration (P1)	mm	700
Actual evapotranspiration (P2)	mm	696
Actual evapotranspiration (P3)	mm	699
Actual evapotranspiration (P4)	mm	682
Runoff (P1)	mm	0
Runoff (P2)	mm	0
Runoff (P3)	mm	0
Runoff (P4)	mm	3
Drainage below rooting zone (P1)	mm	66
Drainage below rooting zone (P2)	mm	70
Drainage below rooting zone (P3)	mm	67
Drainage below rooting zone (P4)	mm	81

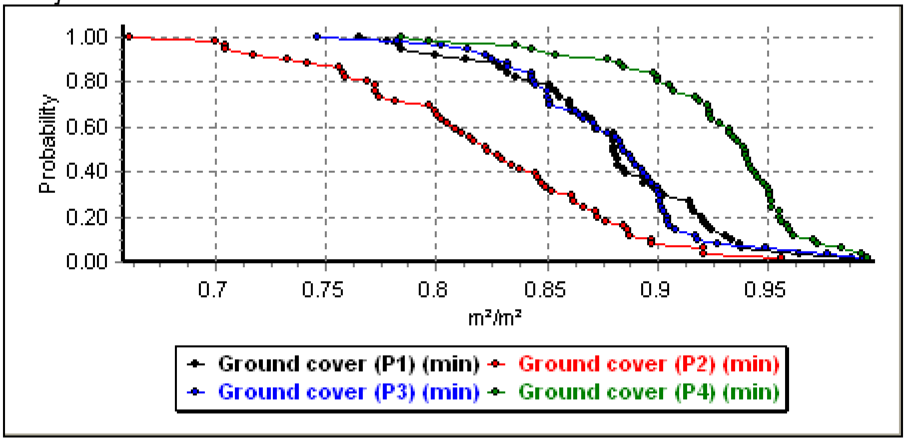
Ground cover over years

The ground cover for each paddock over time *[1/09/1961 - 21/03/2011]*



Cumulative distribution function for minimum ground cover

The probability (shown on the vertical axis) of the minimum ground cover in a year exceeding the value shown on the horizontal axis *2010]*



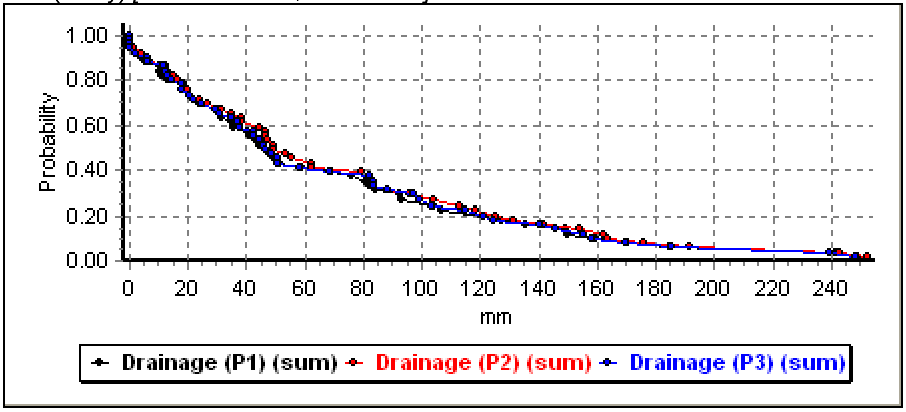
Methane production

Long term annual average methane production *[1 Jan - 31 Dec, 1962-2010]*

Date	Methane production -main flock	Methane production -young sheep
	(sum) (g/head)	(sum) (g/head)
-	8713	2983

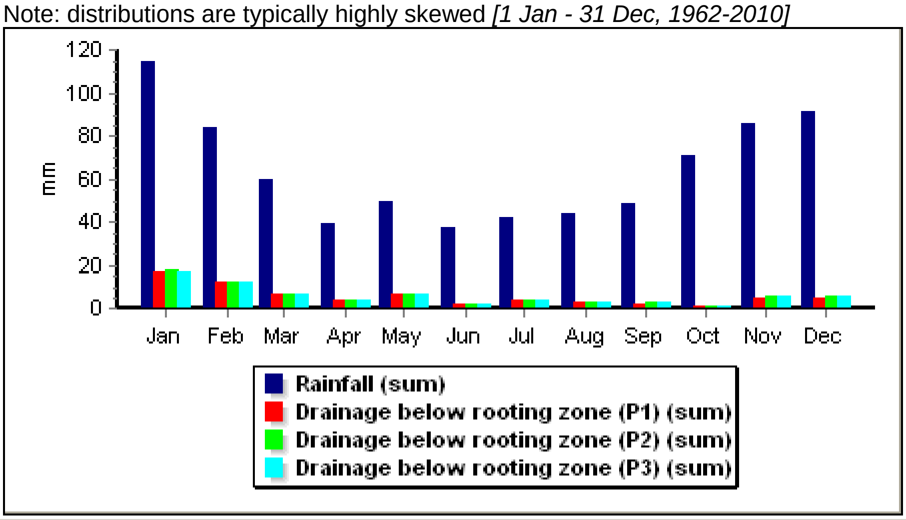
Cumulative distribution function for deep drainage

The probability (shown on the vertical axis) of the total amount of soil water draining below the root zone each year exceeding the va
axis (mm/y) *[1 Jan - 31 Dec, 1962-2010]*



Timing of drainage

Long term average monthly rainfall (mm/month) and drainage of water below the root zone (mm/month)
Note: distributions are typically highly skewed *[1 Jan - 31 Dec, 1962-2010]*



Farm System description

Initial values of Farm System

Farm System	
Name	All flocks of Ewes @ Trevenna Low Prod
Enterprise type	Ewe
Tested	Over 1 Sep 1961 to 21 Mar 2011
Passed	No
Pasture parameters	*C:\Temp\grassgro 2012-03.prm GrassGro March 2012*, last edited 13 Jul 2011 by Andrew Moore
Animal parameters	*standard*, last edited 09 Feb 2004 by Andrew Moore

Property: Trevenna	
Number of paddocks	4
Total area	48 ha

Weather: Armidale Silo Data	
Weather station	Armidale Silo Data *(from D:\Documents and Settings\mcpheem\Desktop\GrassGro3\custom.set)*
Latitude	30°31'S
Longitude	151°40'E
Data period	1 Jan 1961 to 21 Mar 2011
SILO file	D:\Documents and Settings\mcpheem\My

	Documents\GrassGro\weather\armidalesilodata.txt
Wind speed	2.0 m/s
Last edited	20 Mar 2012

Paddock: HA3	
Area	5.6 ha
Steepness	Moderate
Fertility	0.40
Reduce wind to	100%

Soil: New Soil	
Soil albedo	0.17
Soil evaporation	3.3 mm/d^{½}
SCS runoff curve no.	Using default

	Topsoil	**Subsoil**
Cumulative depth (mm)	300	700
Field capacity (m^3/m^3)	0.27	0.30
Wilting point (m^3/m^3)	0.13	0.20
Bulk density (Mg/m^3)	1.40	1.70
Saturated conductivity (mm/hr)	30.00	3.00
Initial water (m^3/m^3)	0.13	0.20

Pasture: Hills Landscape Within A

Population	**Austrodanthonia spp. (tableland)**	**Bothriochloa (beta)**	**Perennial Ryegrass**	**Annual Ryegrass**
Phenology	Vegetative (900)	Vegetative (900)	Reproductive (200)	Vegetative (359)
Live DM (kg/ha)	302	190	10	10
Standing dead DM (kg/ha)	7264	4555	246	246
Litter DM (kg/ha)	714	448	10	10
Below ground DM (kg/ha)	7400	4600	250	250
Max. rooting depth (mm)	600	600	500	500
Seed DM (kg/ha)	-	-	-	200

Paddock: HB3	
Area	5.7 ha
Steepness	Undulating
Fertility	0.40
Reduce wind to	100%

Soil: New Soil	
Soil albedo	0.17
Soil evaporation	3.3 mm/d^{½}
SCS runoff curve no.	Using default

	Topsoil	**Subsoil**
Cumulative depth (mm)	300	700
Field capacity (m^3/m^3)	0.27	0.30
Wilting point (m^3/m^3)	0.13	0.20
Bulk density (Mg/m^3)	1.40	1.70
Saturated conductivity (mm/hr)	30.00	3.00
Initial water (m^3/m^3)	0.13	0.20

Pasture: Hills Landscape Within B			
Population	**Austrodanthonia spp. (tableland)**	**Bothriochloa (beta)**	**Annual Ryegrass**
Phenology	Vernalizing (0.00)	Vegetative (0)	Vegetative (0)
Live DM (kg/ha)	258	89	76
Standing dead DM (kg/ha)	6222	2142	1836
Litter DM (kg/ha)	622	214	184
Below ground DM (kg/ha)	6500	2200	1900
Max. rooting depth (mm)	500	600	500
Seed DM (kg/ha)	-	-	0

Paddock: HC2	
Area	5.7 ha
Steepness	Undulating
Fertility	0.40
Reduce wind to	100%

Soil: New Soil	
Soil albedo	0.17
Soil evaporation	3.3 mm/d^{½}
SCS runoff curve no.	Using default

	Topsoil	Subsoil
Cumulative depth (mm)	300	700
Field capacity (m^3/m^3)	0.27	0.30
Wilting point (m^3/m^3)	0.13	0.20
Bulk density (Mg/m^3)	1.40	1.70
Saturated conductivity (mm/hr)	30.00	3.00
Initial water (m^3/m^3)	0.13	0.20

Pasture: Hills Landscape Within C					
Population	**Austrodanthonia spp. (tableland)**	**Bothriochloa (beta)**	**Phalaris**	**Annual Ryegrass**	**Annual Grass - Early**
Phenology	Vernalizing (0.00)	Vegetative (0)	Vegetative (0)	Vernalizing (0.00)	Vernalizing (0.00)
Live DM (kg/ha)	102	315	11	138	6
Standing dead DM (kg/ha)	2475	7564	275	1210	137
Litter DM (kg/ha)	248	756	28	121	14
Below ground DM (kg/ha)	2500	7850	300	1300	150
Max. rooting depth (mm)	500	600	500	500	500
Seed DM (kg/ha)	-	-	-	0	0

Paddock: Winter grazing	
Area	31.0 ha
Steepness	Undulating
Fertility	0.60
Reduce wind to	100%

Soil: New Soil	
Soil albedo	0.17
Soil evaporation	3.5 mm/d^{½}
SCS runoff curve no.	Using default

	Topsoil	Subsoil

Cumulative depth (mm)	150	1000
Field capacity (m^3/m^3)	0.30	0.34
Wilting point (m^3/m^3)	0.15	0.23
Bulk density (Mg/m^3)	1.40	1.60
Saturated conductivity (mm/hr)	60.00	2.00
Initial water (m^3/m^3)	0.15	0.23

Pasture: Hills Landscape Within C				
Population	**Austrodanthonia spp. (tableland)**	**Phalaris**	**Perennial Ryegrass**	**Annual Grass - Early**
Phenology	Vernalizing (0.00)	Vegetative (0)	Vernalizing (0.00)	Vernalizing (0.00)
Live DM (kg/ha)	117	13	156	6
Standing dead DM (kg/ha)	2808	312	3744	156
Litter DM (kg/ha)	281	31	37	16
Below ground DM (kg/ha)	2900	320	3900	160
Max. rooting depth (mm)	500	500	500	500
Seed DM (kg/ha)	-	-	-	0

Livestock: New Livestock		
Breed	Small Merino	
Standard reference weight	40.0	kg
Greasy fleece weight	3.60	kg
Fibre diameter	17.0	microns
Fleece yield	70	%
Ram breed	Border Leicester (Mature ram: 84.0 kg)	
Death rate: adults	2.0	%/year
Death rate: weaners	2.0	%/year

Initial values							
	Ewes	**Wether Lambs**	**Wether Weaners**	**Ewe Weaners**	**Wether Yearlings**	**Ewe Yearlings**	
Live weight including fleece and conceptus	42.5	20.0	25.4	22.1	46.9	39.5	kg
Greasy fleece weight	0.50	1.11	1.00	0.84	2.07	1.73	kg
Fibre diameter	16.7	17.0	17.0	27.0	17.0	17.0	microns

Management policy: New Ewe Management policy		
Stocking rate	**Rate**	1.0/ha
Shearing date	**Main flock**	10 Jul
	Weaners	10 Jul
Replacement rule	**Purchase**	Purchase ewes on 2 Apr at age 18 months, live weight 40 kg and C.S. 3.0
	Cast for age	Sell stock aged 6 to 7 years on 1 Apr

Reproduction rule: New Reproduction rule	
First join at	1 years
Mating date	14 Apr
Conception at CS 3	(1) 76% (2) 24% (3) 0%
Birth date	10 Sep
Castration	yes
Weaning date	1 Jan

One ram per	50 ewes
Keep rams for	5.0 years
Sell young ewes	Sell 0 year old animals on 31 Mar
Sell young wethers	Sell 0 year old animals on 31 Mar

Maintenance Feeding rule: New Maintenance Feeding rule	
Main flock/herd	
Mature Females	Feed in paddock, applying the rule: If animal condition falls to 1.5 during 1 Jan to 31 Dec feed to maintain condition of the thinnest animals
Immature Females	Feed in paddock, applying the rule: If animal condition falls to 1.5 during 1 Jan to 31 Dec feed to maintain condition of the thinnest animals
Immature Males	Feed in paddock, applying the rule: If animal condition falls to 1.0 during 1 Jan to 31 Dec feed to maintain condition of the thinnest animals
Weaner flock/herd	
Weaners	Feed in paddock, applying the rule: If animal condition falls to 1.5 during 1 Jan to 31 Dec feed to maintain condition of the thinnest animals
Supplement	

Supplement: Maize	
Ingredient	**Maize**
Proportion of mix (%)	100
Dry matter content (%)	87
Dry matter digestibility (%)	87
ME:DM (MJ/kg)	14.1
Crude protein (%)	10
Rumen-degradable protein (%)	80

Production Feeding rule: New Production Feeding rule	
Feeding rule	Fixed amount of 0.60 kg/d to All Stock in Paddock from 1 Sep to 10 Oct
Supplement	

Supplement: Hay/Beans, field			
Description	Need the mix in these		
Ingredient	**Hay**	**Beans, field**	**Overall mix**
Proportion of mix (%)	50	50	100
Dry matter content (%)	89	89	89
Dry matter digestibility (%)	64	86	75
ME:DM (MJ/kg)	8.5	13.7	11.1
Crude protein (%)	16	31	23
Rumen-degradable protein (%)	68	91	83

Pasture rule: New Pasture rule	
Reset on	1 Mar

Grazing rule: Grazing rotation	
Ewes	
From 1 Jan to 31 Jan	31 days in "HC2"
From 1 Feb to 29 Feb	29 days in "HA3"
From 1 Mar to 31 Mar	7 days in "HB3"
From 1 Apr to 31 Aug	153 days in "Winter grazing"
From 1 Sep to 9 Oct	39 days in "HB3"
From 10 Oct to 31 Oct	22 days in "HC2"
From 1 Nov to 30 Nov	30 days in "HA3"
From 1 Dec to 31 Dec	31 days in "HB3"

Ewe Weaners	
Same as	Ewes
Wether Weaners	
Same as	Ewe Weaners, Ewes

Costs: New Costs			
Ewe Shearing		$4.50	/head
Shearing Lambs		$3.50	/head
Ewe Husbandry		$3.00	/head
Lamb Husbandry		$2.00	/head
Ewe Replacement		$130.00	/head
Rams		$1000.00	/head
Sheep sales commission		4	%
Sheep sales cost		$0.00	/head
Pasture cost		$0.00	/ha
Supplement costs	Hay	$300.00	/t
	Beans, field	$250.00	/t
	Maize	$200.00	/t

Prices: New Prices			
Wool prices for ewes			
	Fleece price	800	c/kg
	Av. Fleece Price	5.0	%
	Wool commission	7.0	%
Ewe sales			
	Base price	260.0	c/kg
	Dressing percentage	43.0	%
	Skin price	$15.00	/head
Ewe lamb sales			
	Base price	450.0	c/kg
	Dressing percentage	45.0	%
	Skin price	$15.00	/head
Wether lamb sales			
	Base price	0.0	c/kg
	Dressing percentage	0.0	%
	Skin price	$0.00	/head

GrassGro 3.2.5. Build: 23 Aug 2011

GrassGro High Productivity Landscape

09 Apr 2012 17:06

Acceptability report - All flocks of Ewes @ Trevenna High Prod

1/09/1961 - 21/03/2011

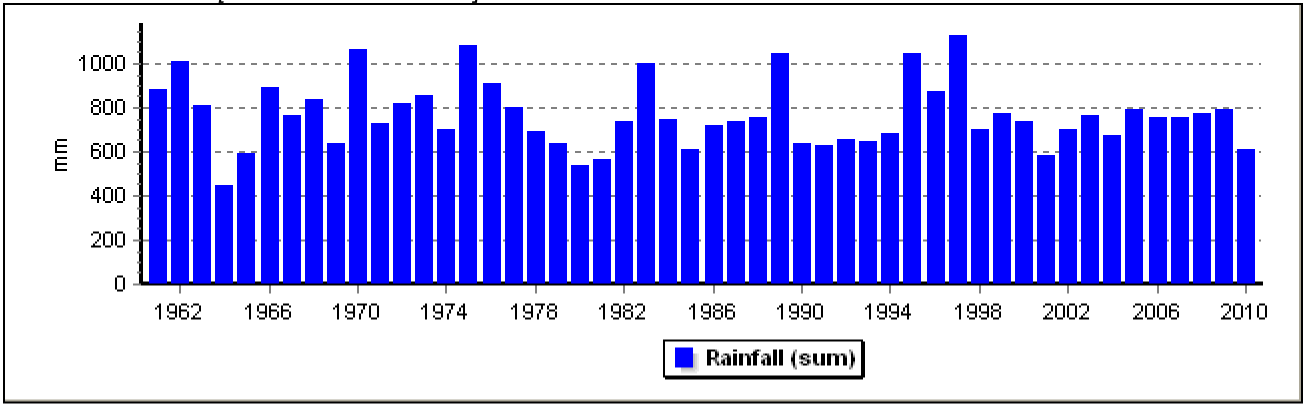
Mean annual rainfall for years tested

Mean annual rainfall *[1 Jan - 31 Dec, 1962-2010]*

Date	Rainfall (sum) (mm)
-	766

Annual rainfall by years

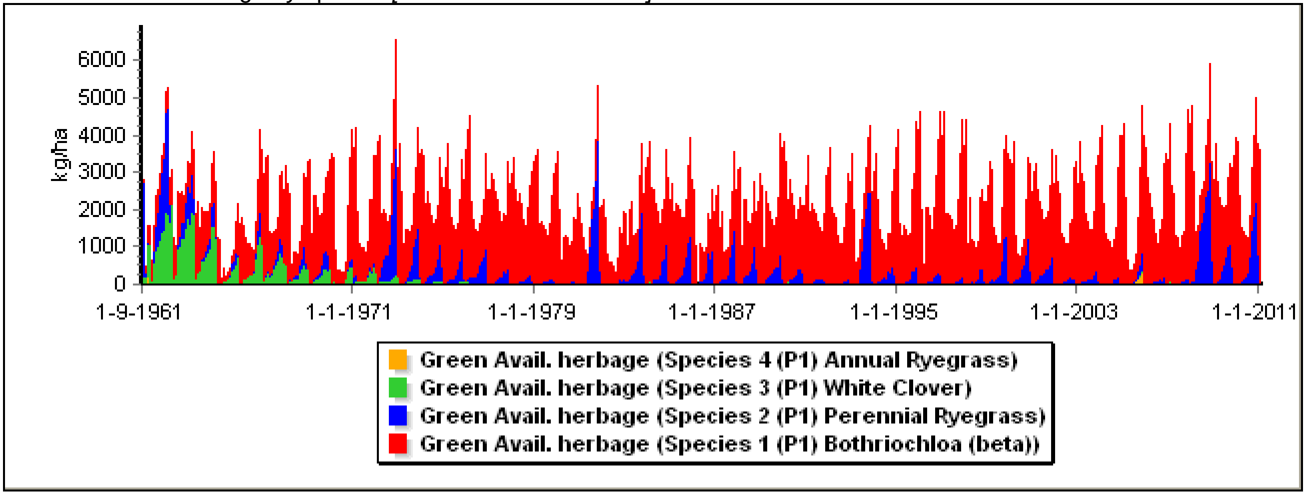
Total annual rainfall *[1/09/1961 - 21/03/2011]*



Production over years

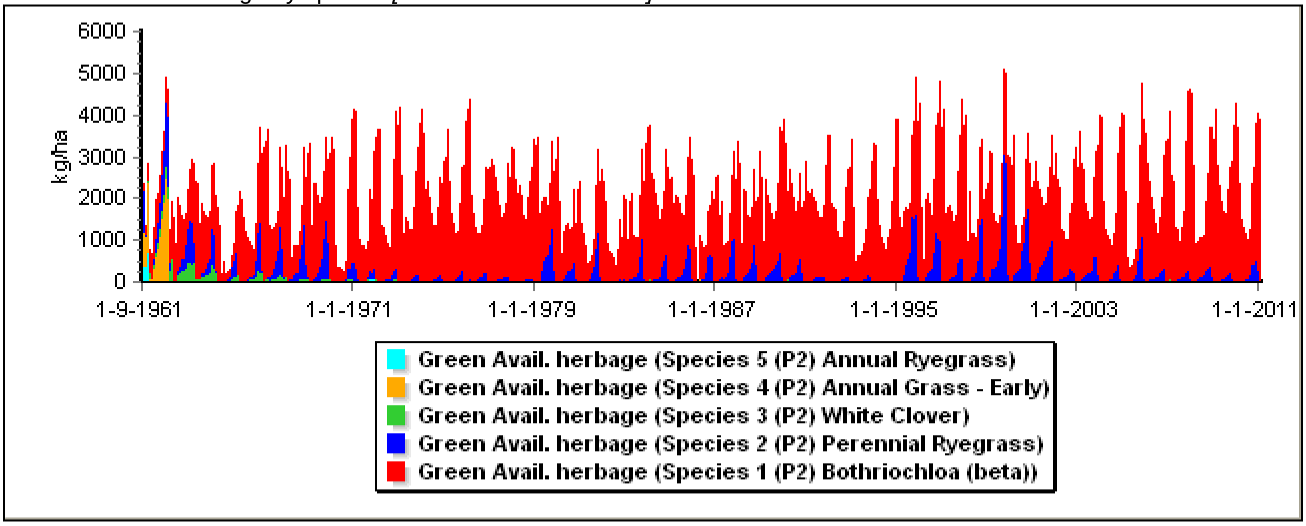
Pasture composition by years - Paddock 1

Green available herbage by species *[1/09/1961 - 21/03/2011]*



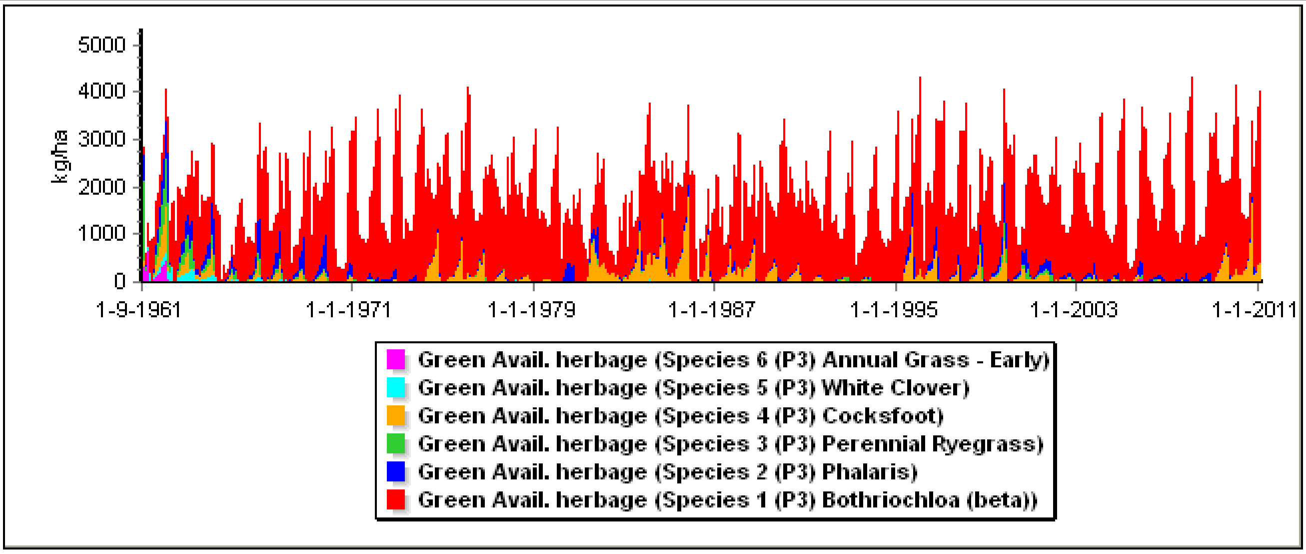
Pasture composition by years - Paddock 2

Green available herbage by species *[1/09/1961 - 21/03/2011]*

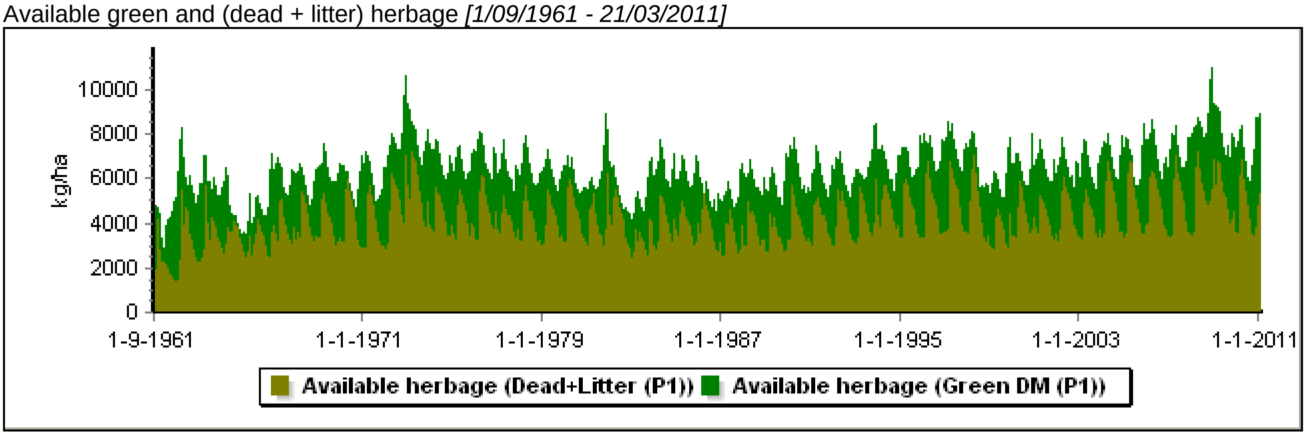


Pasture composition by years - Paddock 3

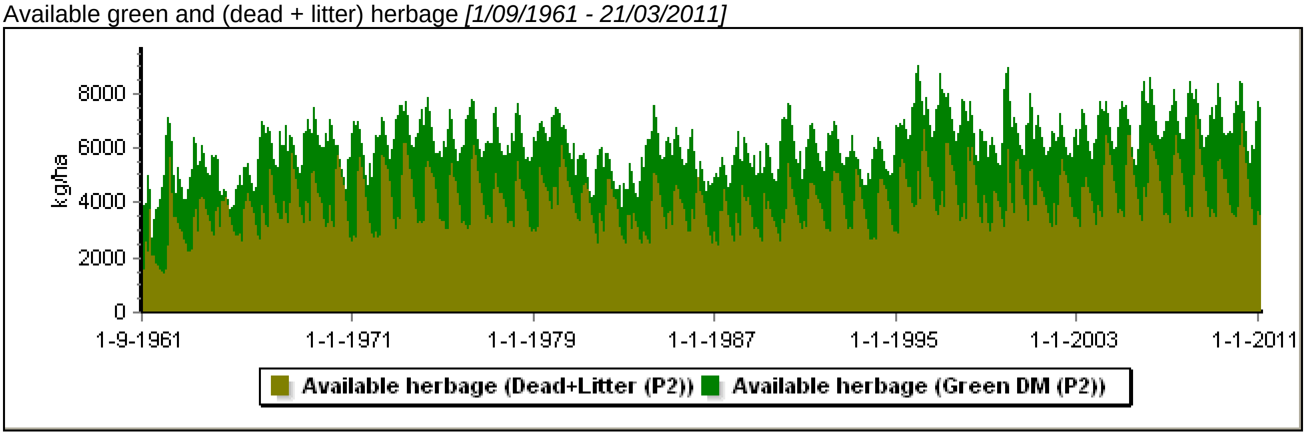
Green available herbage by species *[1/09/1961 - 21/03/2011]*



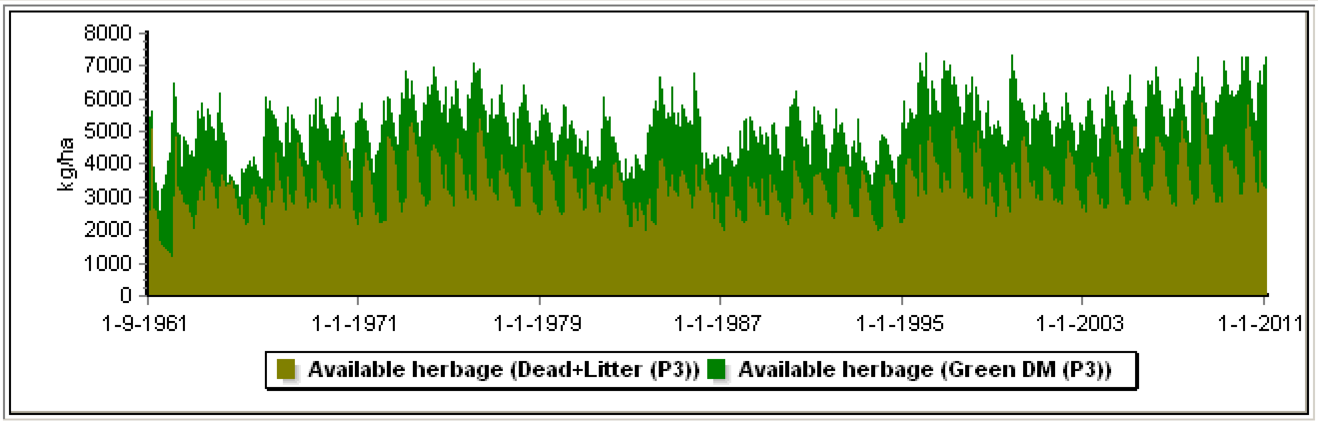
Pasture availability by years - Paddock 1
Available green and (dead + litter) herbage *[1/09/1961 - 21/03/2011]*



Pasture availability by years - Paddock 2
Available green and (dead + litter) herbage *[1/09/1961 - 21/03/2011]*

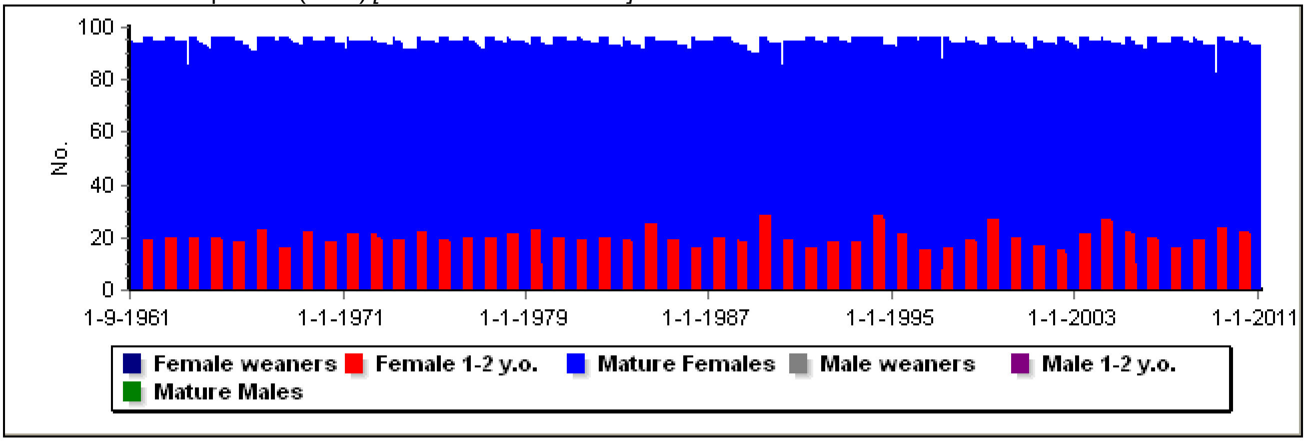


Pasture availability by years - Paddock 3
Available green and (dead + litter) herbage *[1/09/1961 - 21/03/2011]*



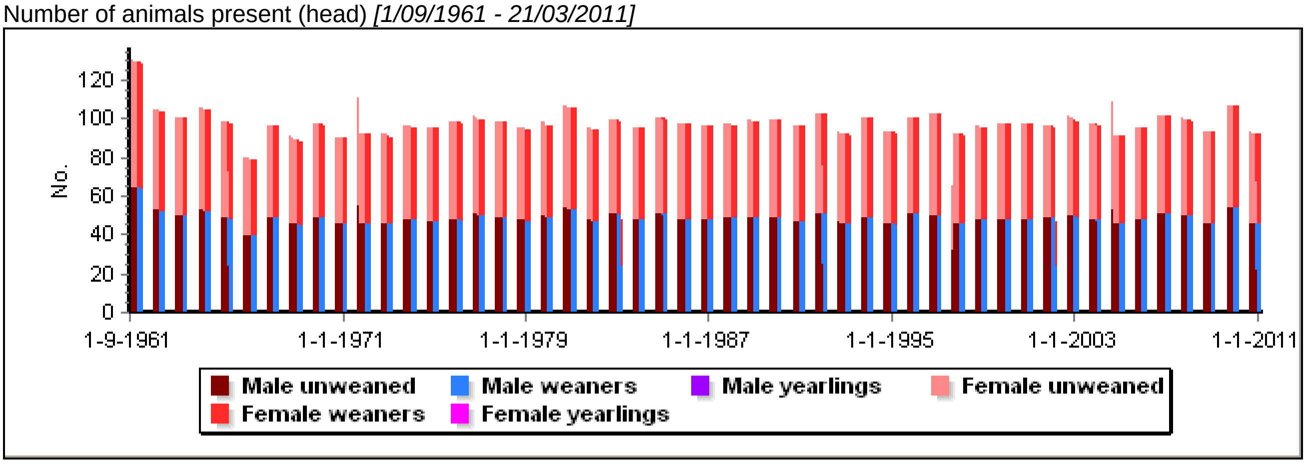
Numbers of sheep in the main flock

Number of animals present (head) *[1/09/1961 - 21/03/2011]*



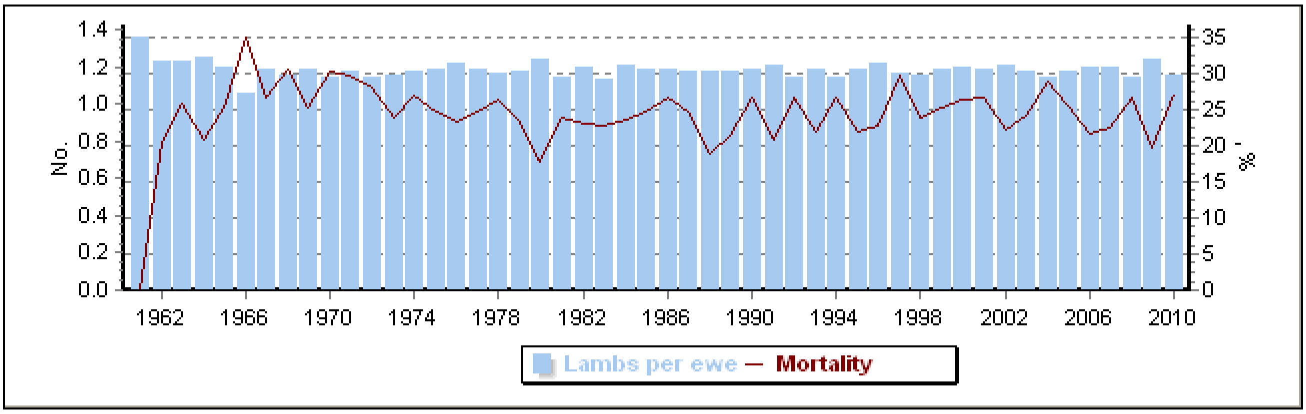
Numbers of young sheep

Number of animals present (head) *[1/09/1961 - 21/03/2011]*



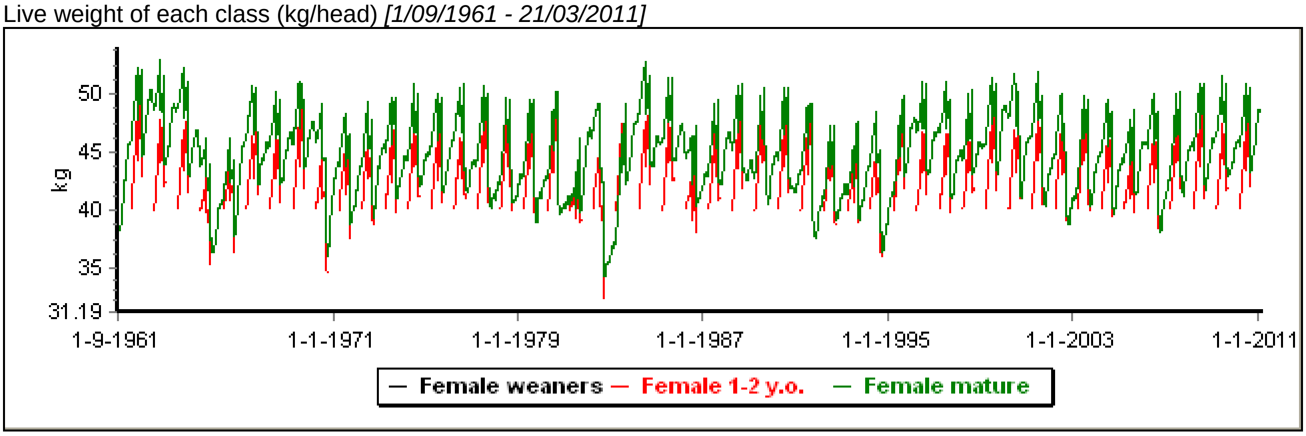
Lamb mortality

Number of lambs per ewe and the mortality rate at birth *[8 Sep - 12 Sep, 1961-2010]*



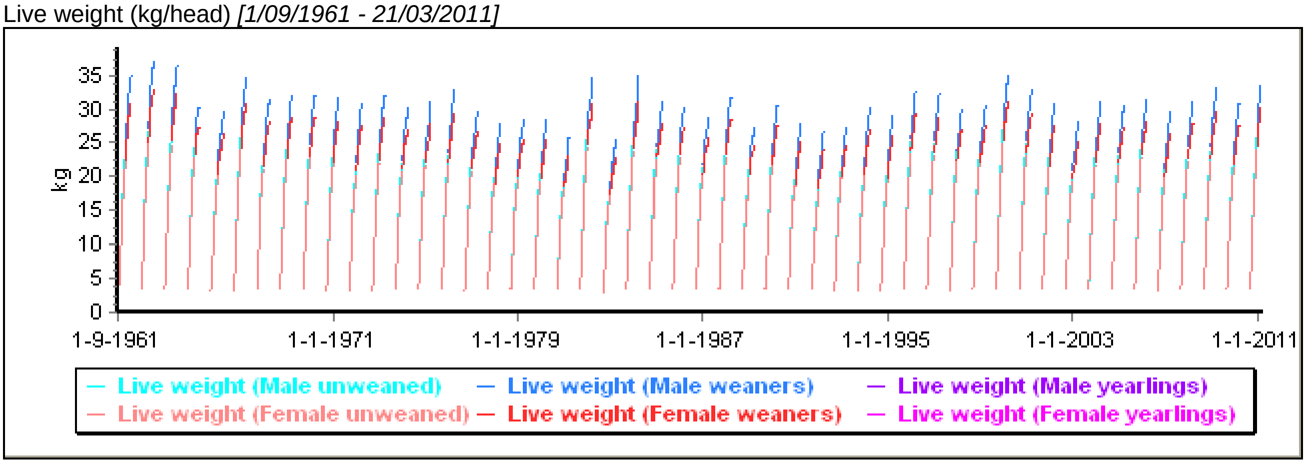
Live weight of female sheep in the main flock

Live weight of each class (kg/head) *[1/09/1961 - 21/03/2011]*



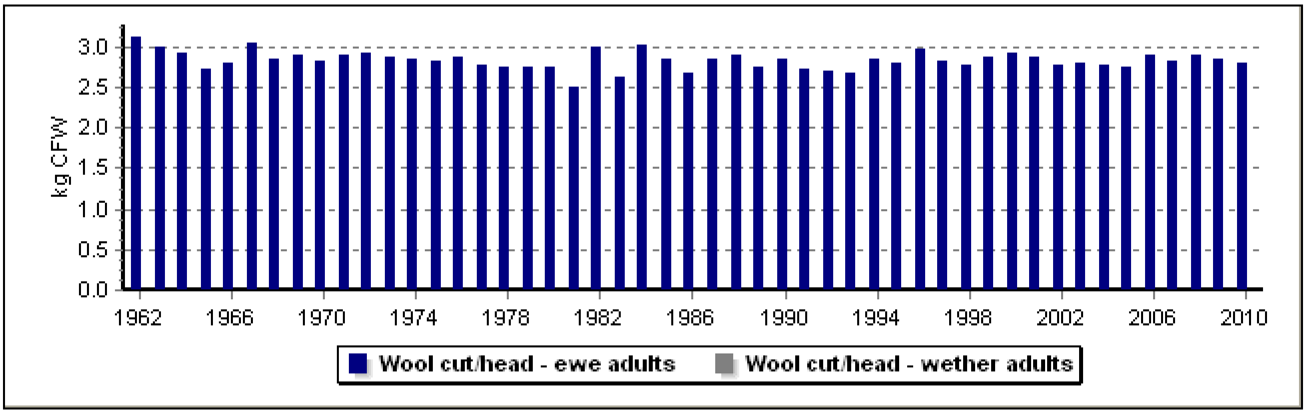
Live weight of young sheep

Live weight (kg/head) *[1/09/1961 - 21/03/2011]*



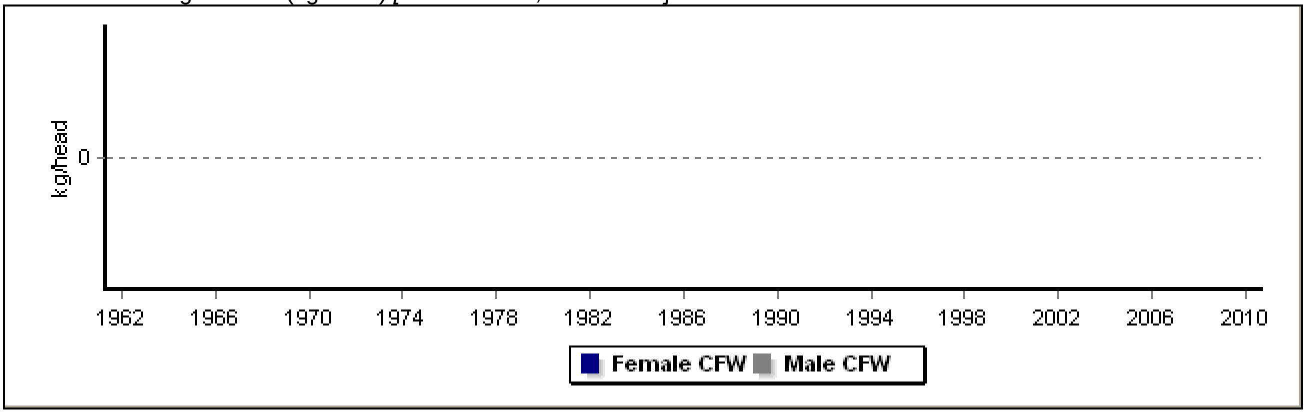
Fleece weight shorn each year for sheep in the main flock

Clean fleece weight shorn (kg/head) *[1 Jan - 31 Dec, 1962-2010]*



Fleece weight shorn each year for young sheep

Clean fleece weight shorn (kg/head) *[9 Jul - 10 Jul, 1962-2010]*



Average annual wool production of age classes in the main flock

Long term average annual clean fleece weight (kg/head) and fleece fibre diameter (micron) *[1 Jan - 31 Dec, 1962-2010]*

Date	CFW -main flock					Fleece fibre diameter				
	Female weaners (max) (kg/head)	Female 1-2 y.o. (max) (kg/head)	Female mature (max) (kg/head)	Male weaners (max) (kg/head)	Male 1-2 y.o. (max) (kg/head)	Male mature (max) (kg/head)	Female weaners (av.) (microns)	Female 1-2 y.o. (av.) (microns)	Female mature (av.) (microns)	Male weaners (av.) (microns)	Male 1-2 y.o. (av.) (microns
-	n/a	2.71	2.86	n/a	n/a	n/a	n/a	17.2	17.4	n/a	n/a

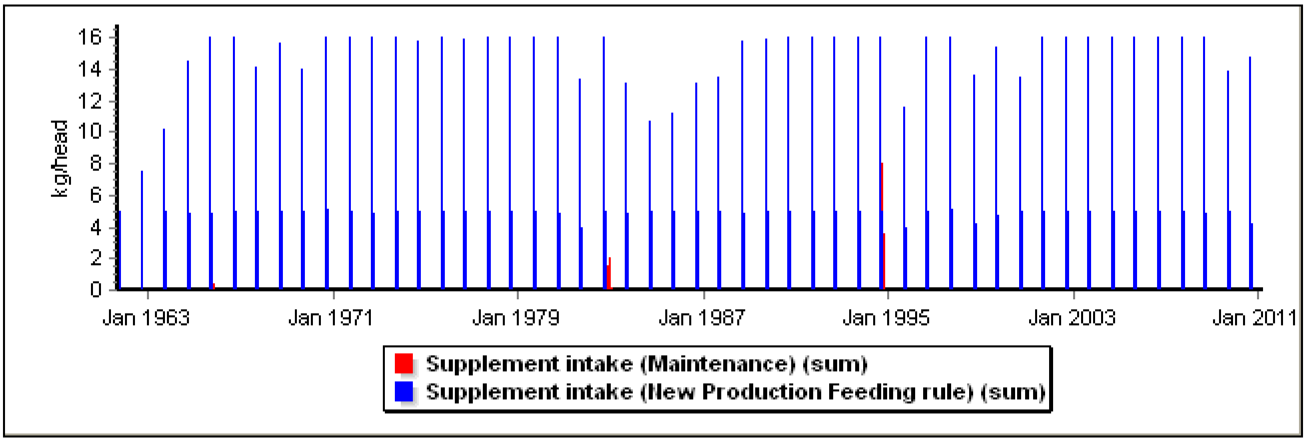
Average wool production of young sheep

Long term average clean fleece weight (kg/head) and fleece fibre diameter (micron) *[9 Jul - 10 Jul, 1962-2010]*

Date	CFW -young sheep					Fleece fibre diameter				
	Unweaned (max) (kg/head)	Male weaners (max) (kg/head)	Male yearlings (max) (kg/head)	Female weaners (max) (kg/head)	Female yearlings (max) (kg/head)	Unweaned (av.) (microns)	Male weaners (av.) (microns)	Male yearlings (av.) (microns)	Female weaners (av.) (microns)	Female yearlings (av.) (microns)
-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

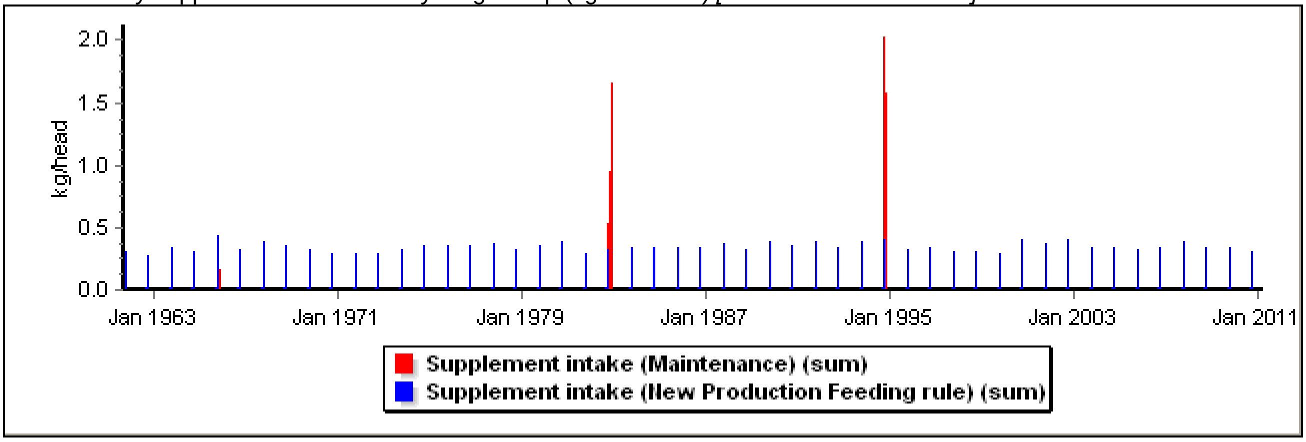
Supplement intake of sheep in the main flock

Total monthly supplement intake (kg DM/head) *[1/09/1961 - 21/03/2011]*



Supplement intake of all young sheep

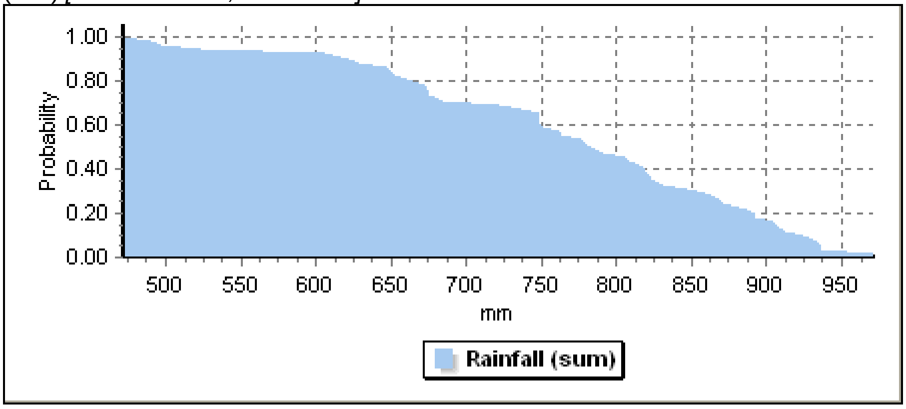
Total monthly supplement intake for all young sheep (kg DM/head) *[1/09/1961 - 21/03/2011]*



Variability of the whole farm system

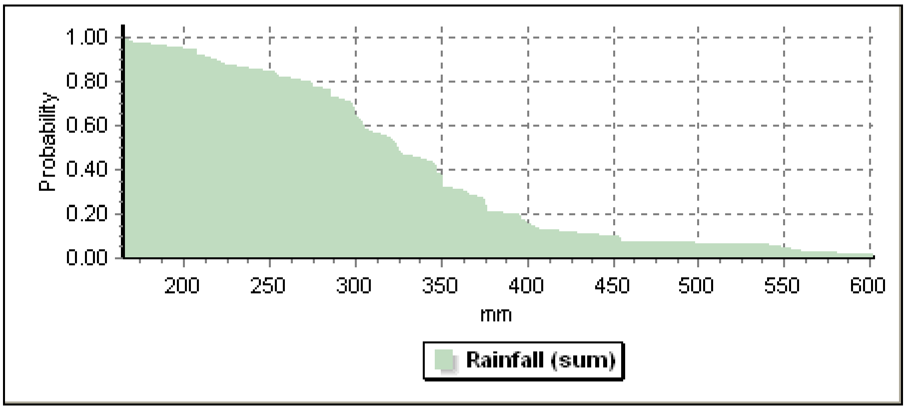
Distribution of annual rainfall

The probability (shown on the vertical axis) of annual rainfall exceeding the value shown on the horizontal axis (mm) *[1 Jan - 31 Dec, 1962-2010]*



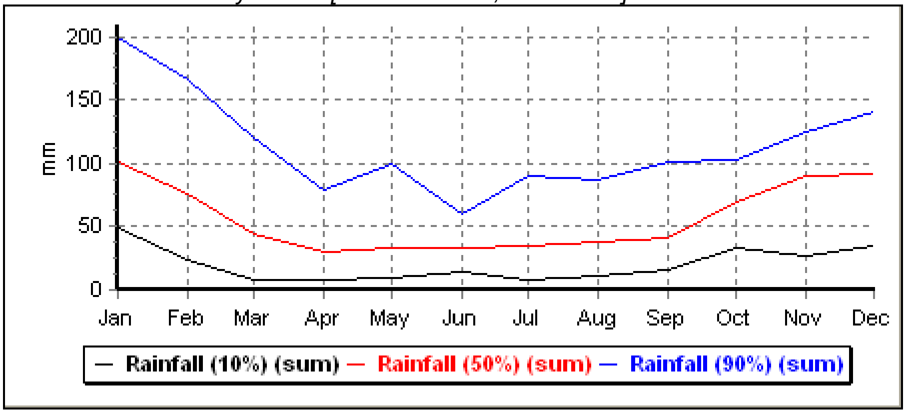
Distribution of growing season rainfall

The probability of rainfall between 1 Apr and 31 Oct exceeding the value shown on the horizontal axis (mm) *[1 Apr - 31 Oct, 1962-2010]*



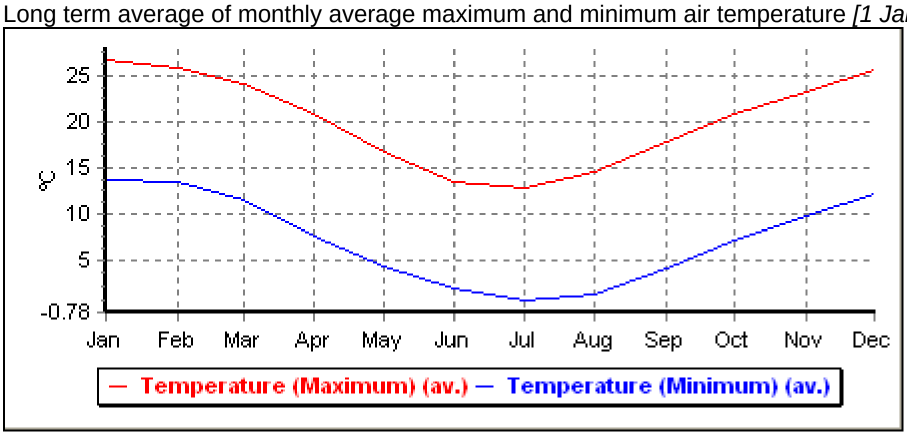
Monthly rainfall

Percentiles for monthly rainfall *[1 Jan - 31 Dec, 1962-2010]*



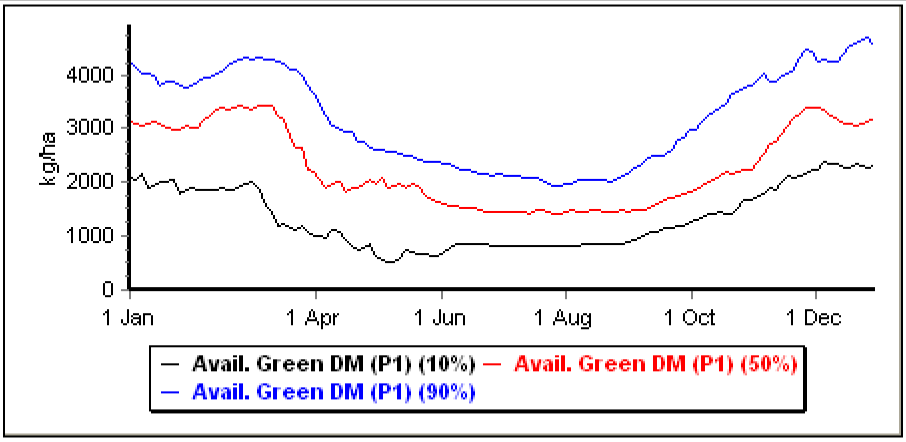
Temperature

Long term average of monthly average maximum and minimum air temperature *[1 Jan - 31 Dec, 1962-2010]*



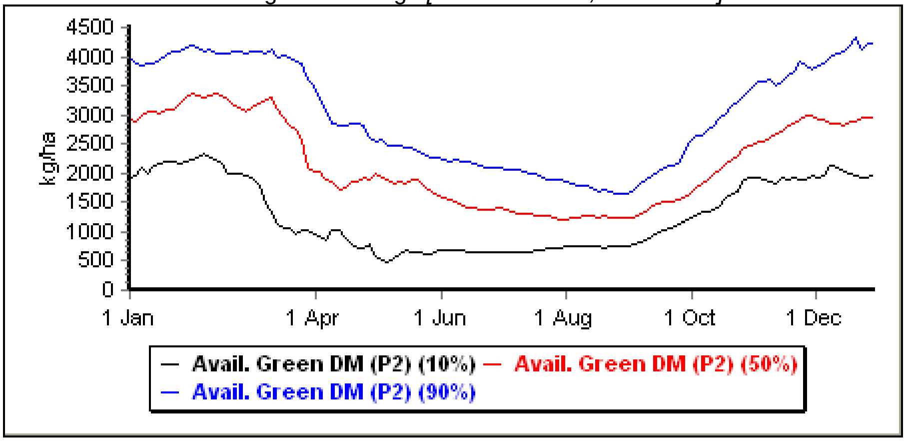
Pasture supply - green - Paddock 1

Percentiles for available green herbage *[1 Jan - 31 Dec, 1962-2010]*



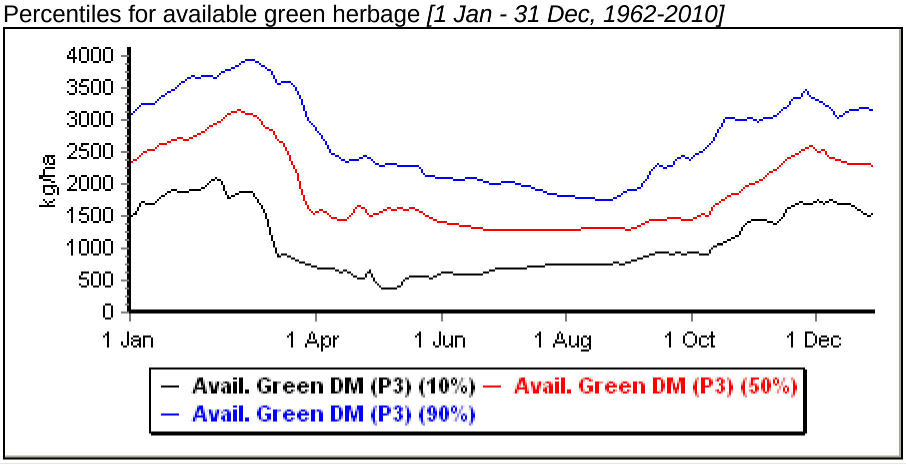
Pasture supply - green - Paddock 2

Percentiles for available green herbage *[1 Jan - 31 Dec, 1962-2010]*



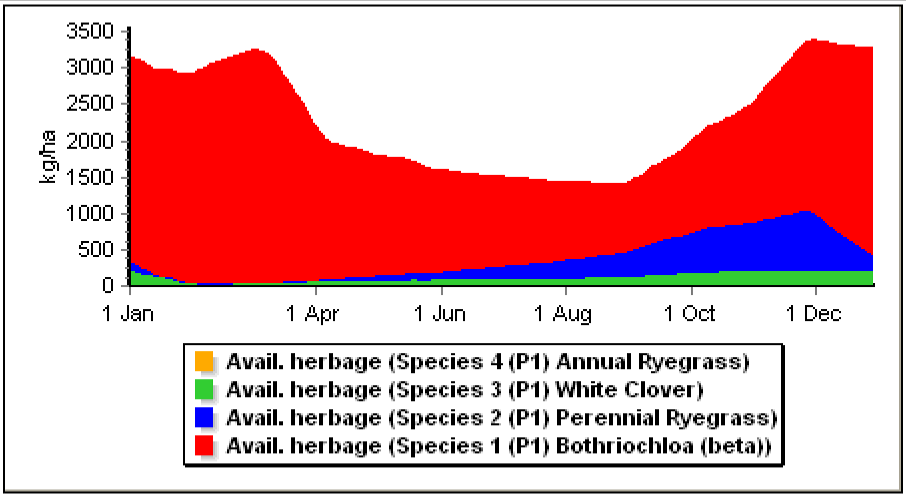
Pasture supply - green - Paddock 3

Percentiles for available green herbage *[1 Jan - 31 Dec, 1962-2010]*



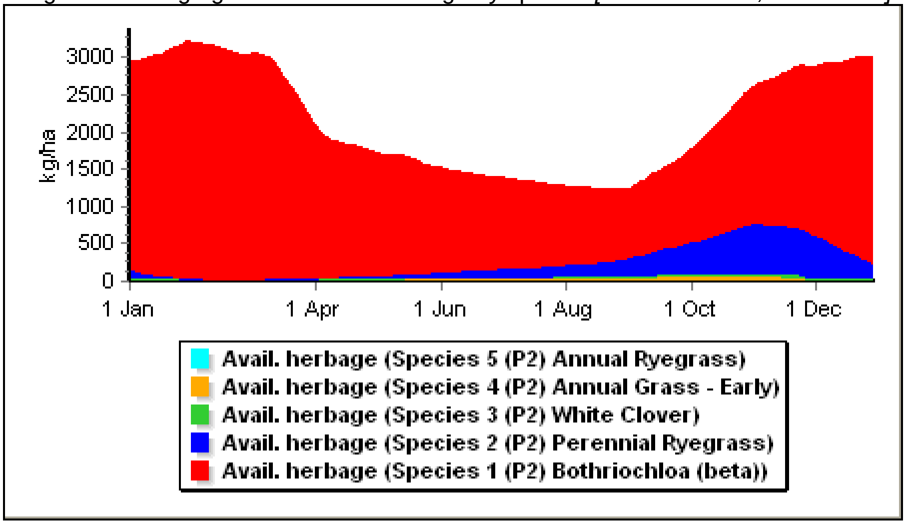
Average pasture composition - Paddock 1

Long term average green available herbage by species *[1 Jan - 31 Dec, 1962-2010]*



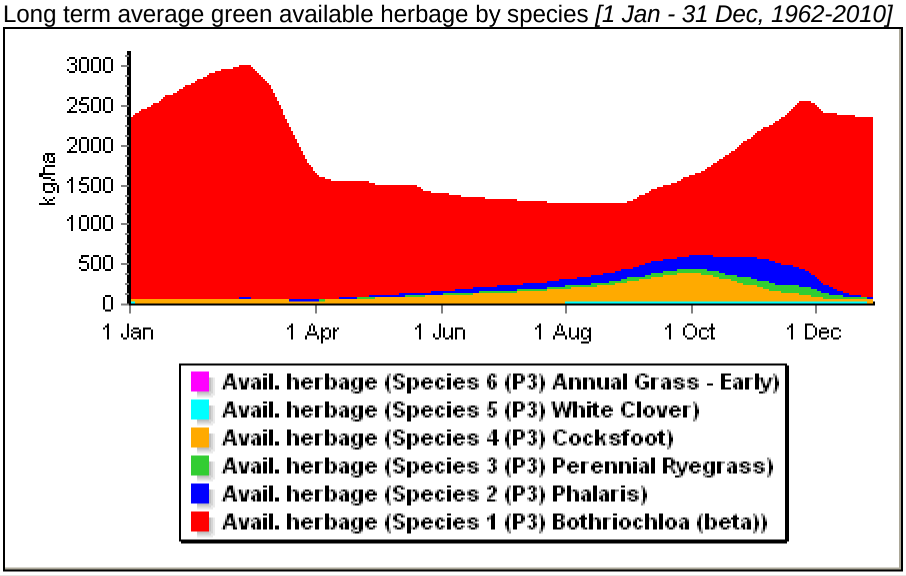
Average pasture composition - Paddock 2

Long term average green available herbage by species *[1 Jan - 31 Dec, 1962-2010]*



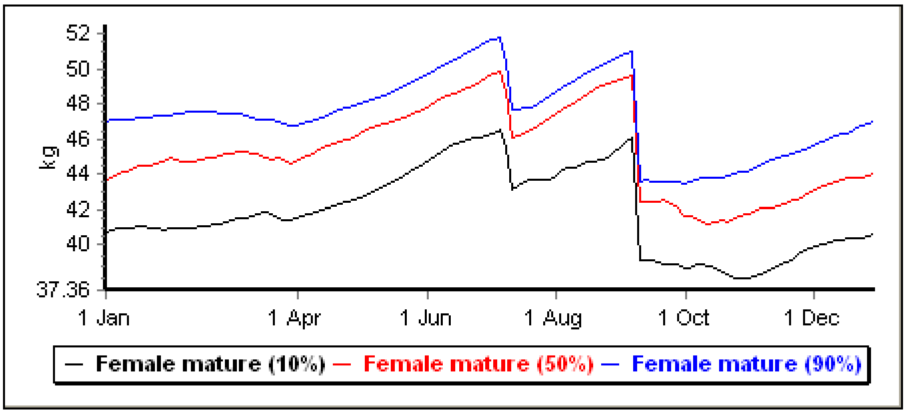
Average pasture composition - Paddock 3

Long term average green available herbage by species *[1 Jan - 31 Dec, 1962-2010]*



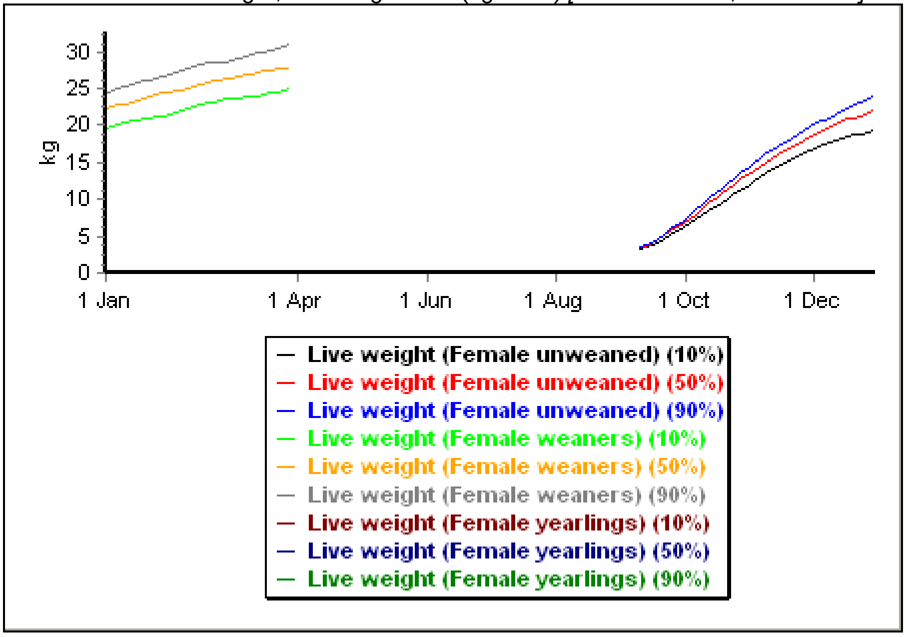
Variability in live weight of mature female sheep in the main flock

Percentiles for live weight, including fleece (kg/head) *[1 Jan - 31 Dec, 1962-2010]*



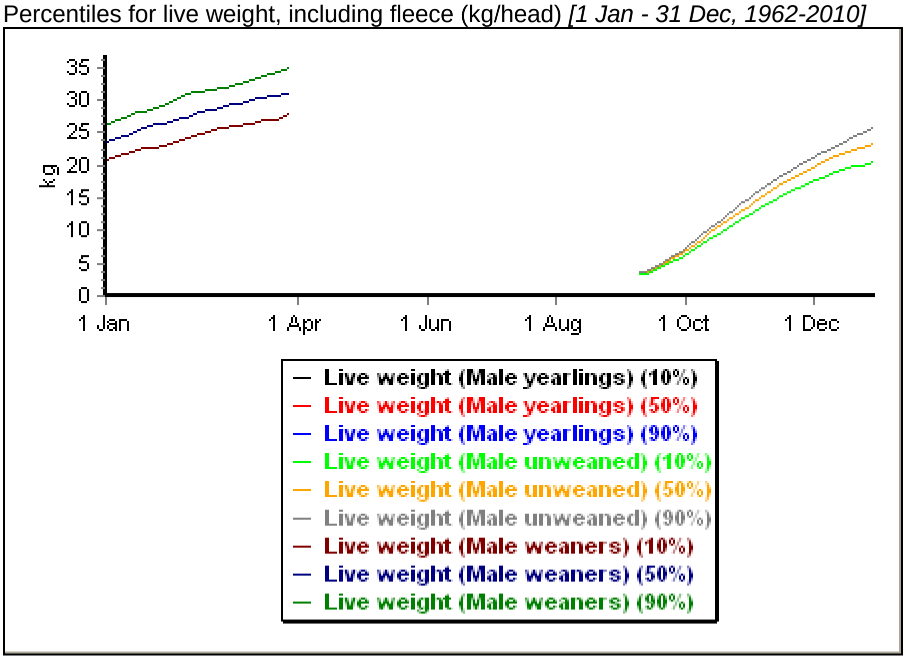
Variability in live weight of ewe lambs

Percentiles for live weight, including fleece (kg/head) *[1 Jan - 31 Dec, 1962-2010]*



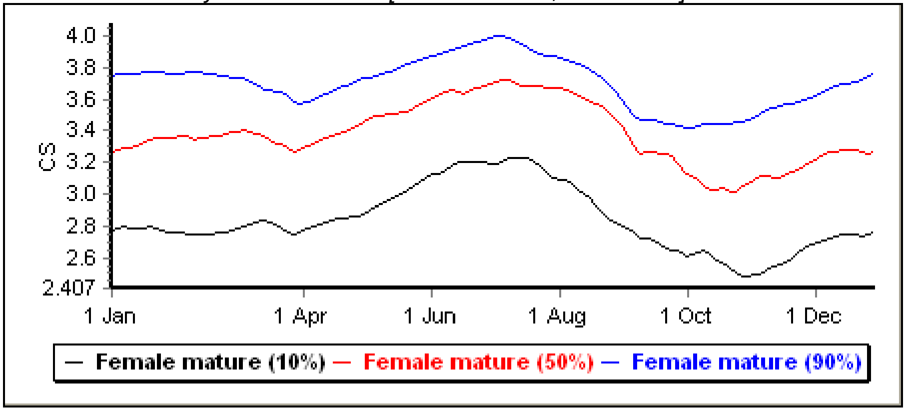
Variability in live weight of wether lambs

Percentiles for live weight, including fleece (kg/head) *[1 Jan - 31 Dec, 1962-2010]*



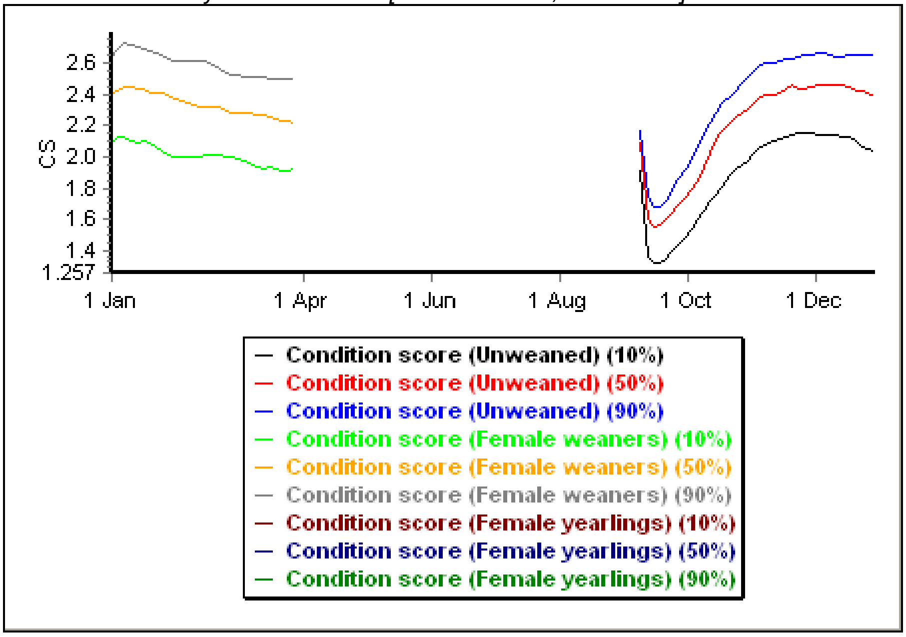
Variability in body condition of mature female sheep in the main flock

Percentiles for body condition score *[1 Jan - 31 Dec, 1962-2010]*



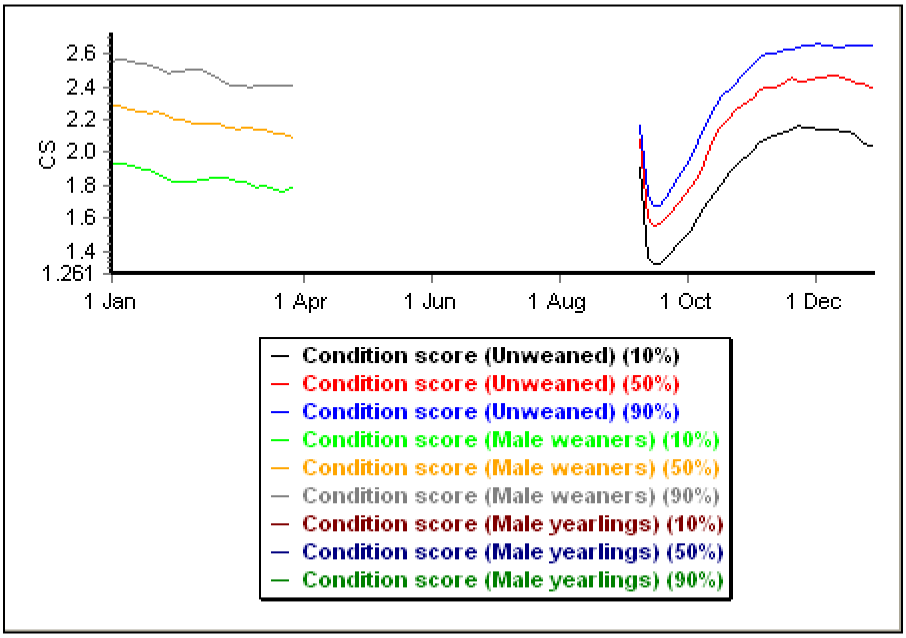
Variability in body condition of ewe lambs

Percentiles for body condition score *[1 Jan - 31 Dec, 1962-2010]*



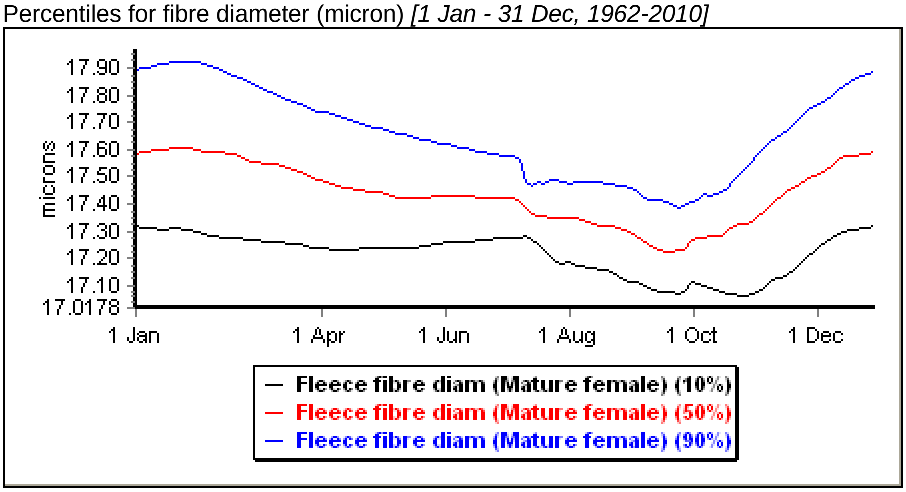
Variability in body condition of wether lambs

Percentiles for body condition score *[1 Jan - 31 Dec, 1962-2010]*



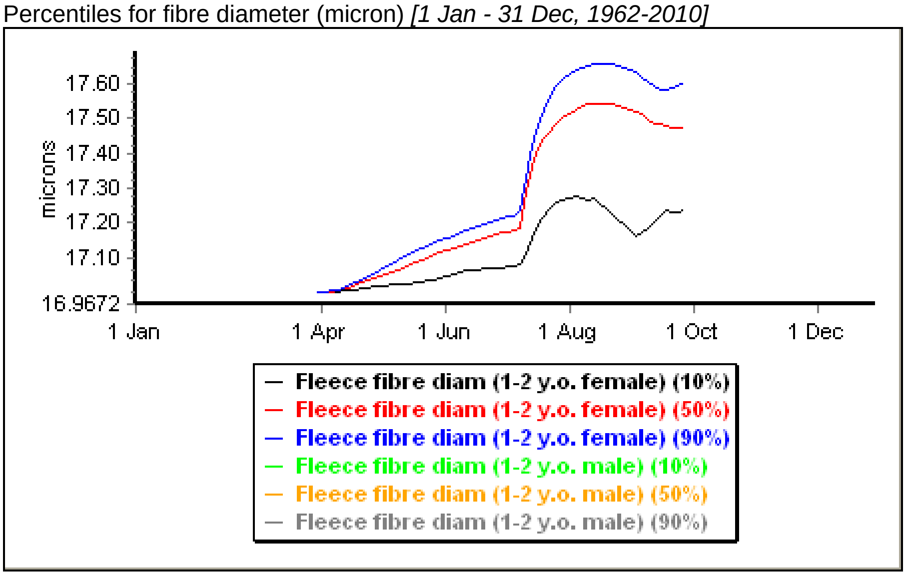
Variability in fibre diameter of mature female sheep in the main flock

Percentiles for fibre diameter (micron) *[1 Jan - 31 Dec, 1962-2010]*



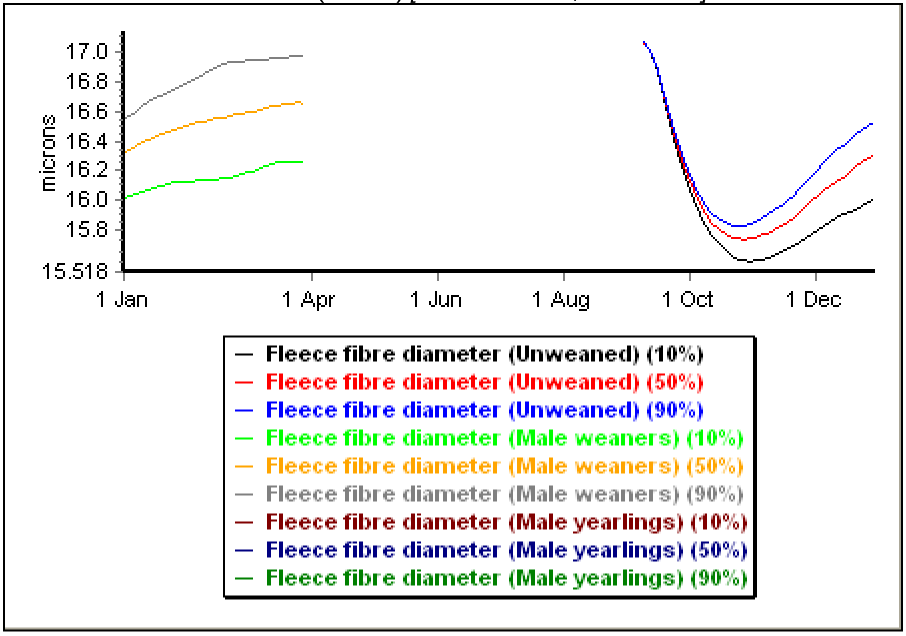
Variability in fibre diameter of 1-2 year old sheep in the main flock

Percentiles for fibre diameter (micron) *[1 Jan - 31 Dec, 1962-2010]*



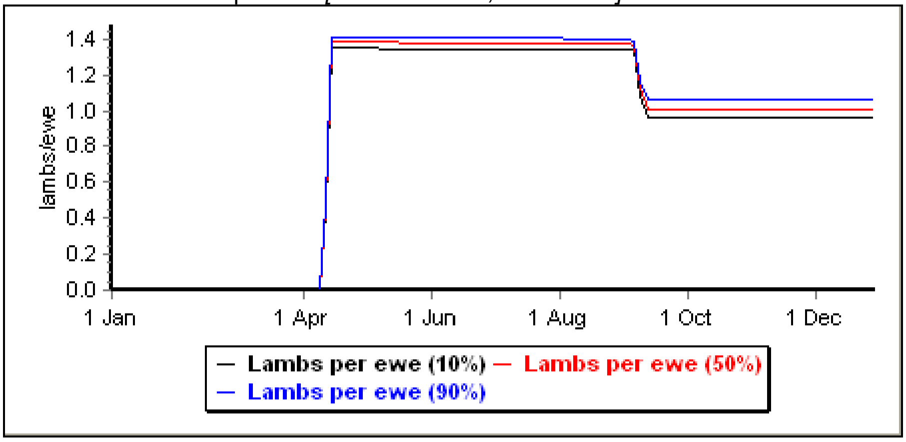
Variability in fibre diameter of young wethers (unweaned and weaned)

Percentiles for fibre diameter (micron) *[1 Jan - 31 Dec, 1962-2010]*



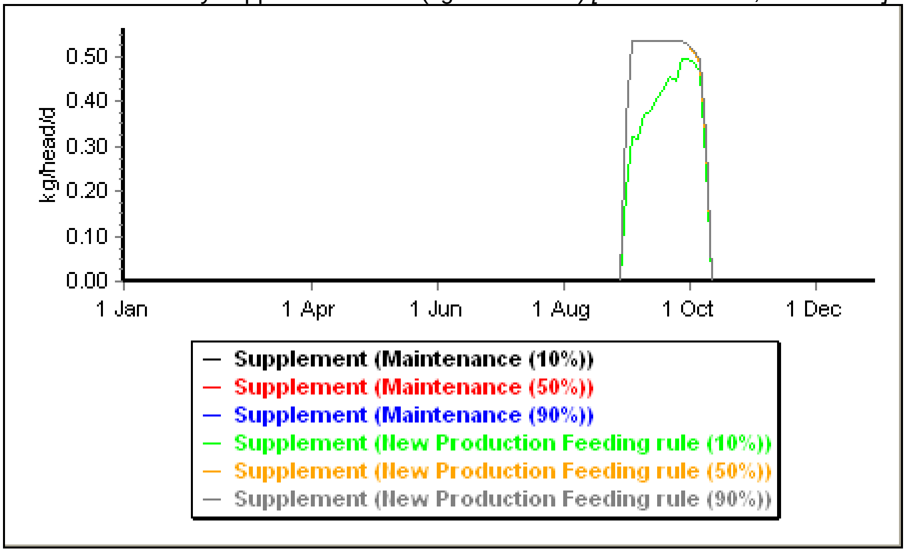
Lambs per ewe

Percentiles for lambs per ewe *[1 Jan - 31 Dec, 1962-2010]*



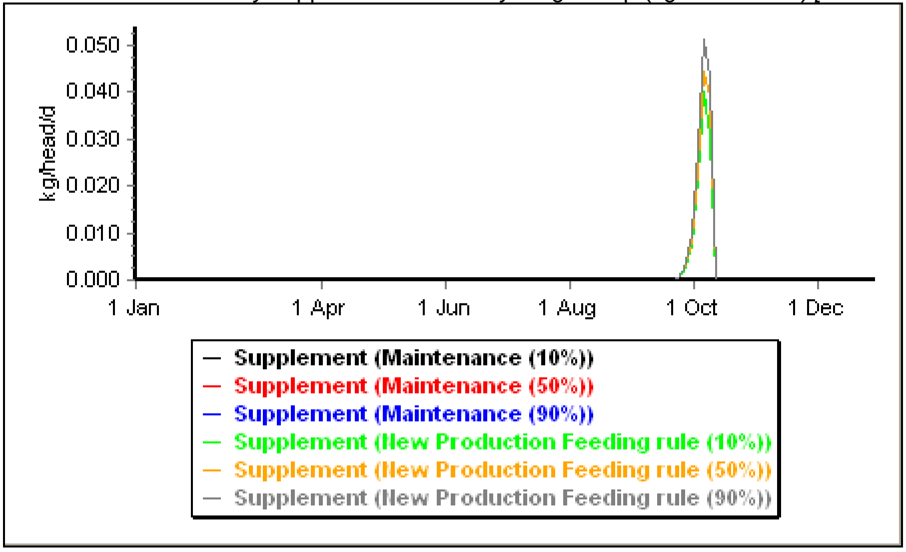
Variability in intake of maintenance and production supplement of the main flock

Percentiles for daily supplement intake (kg DM/head/d) *[1 Jan - 31 Dec, 1962-2010]*



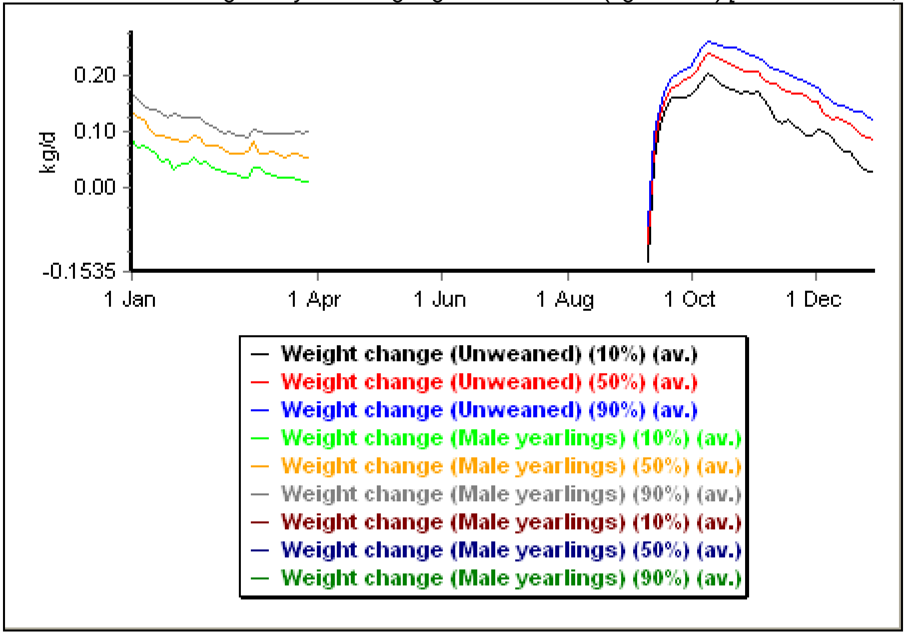
Variability in intake of maintenance and production supplement of young sheep

Percentiles for total daily supplement intake of young sheep (kg DM/head/d) *[1 Jan - 31 Dec, 1962-2010]*



Variability in average daily gain (ADG) of wether lambs

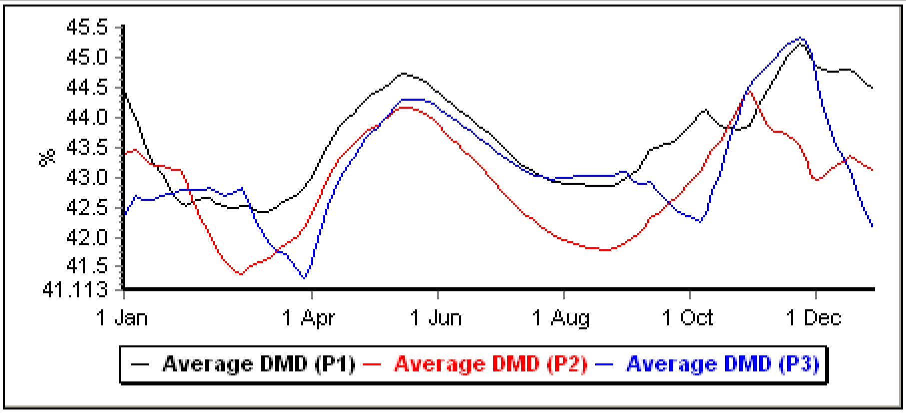
Percentiles for average daily live weight gain -not fleece (kg/head/d) *[1 Jan - 31 Dec, 1962-2010]*



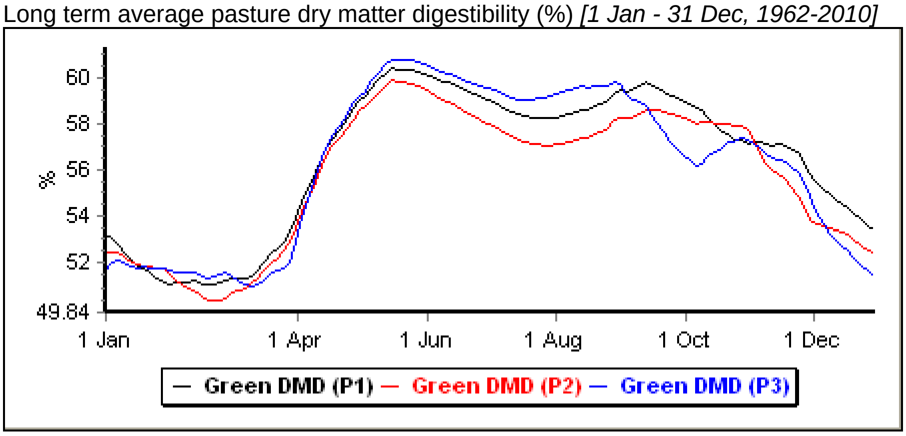
Pasture quality

Average quality of all herbage in each paddock

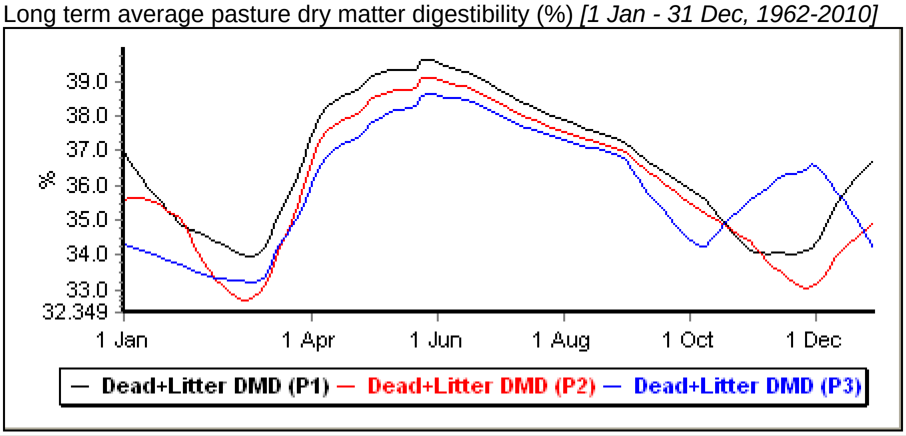
Long term average pasture dry matter digestibility (%) *[1 Jan - 31 Dec, 1962-2010]*



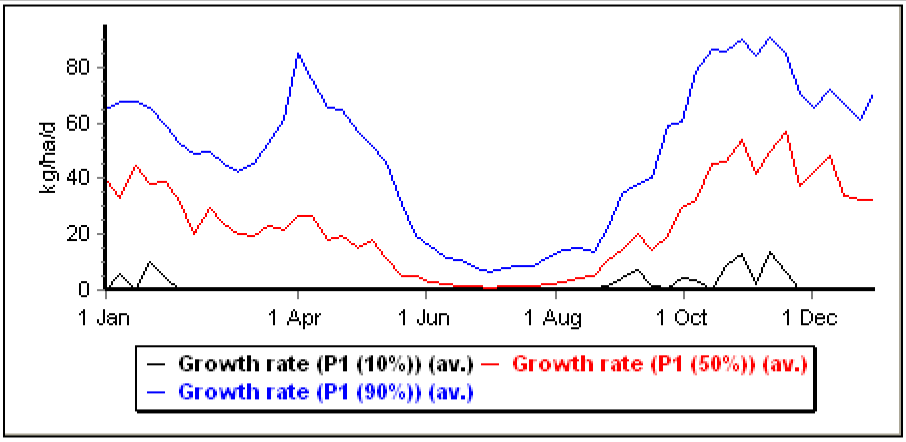
Average quality of green herbage for each paddock
Long term average pasture dry matter digestibility (%) *[1 Jan - 31 Dec, 1962-2010]*



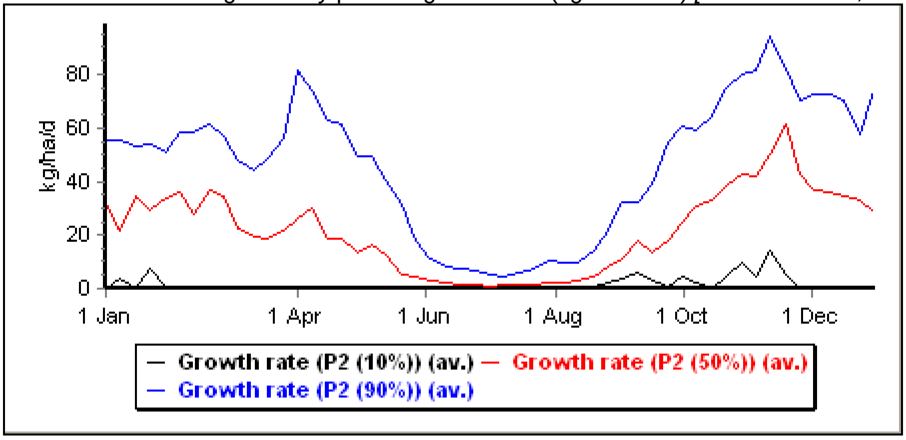
Average quality of dead herbage and litter for each paddock
Long term average pasture dry matter digestibility (%) *[1 Jan - 31 Dec, 1962-2010]*



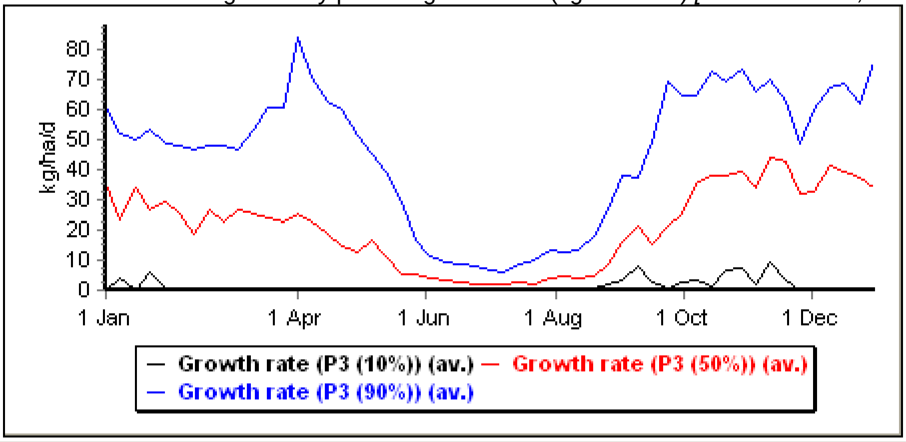
Variability in pasture growth rate - Paddock 1
Percentiles for average weekly pasture growth rate (kg DM/ha/d) *[1 Jan - 31 Dec, 1962-2010]*



Variability in pasture growth rate - Paddock 2
Percentiles for average weekly pasture growth rate (kg DM/ha/d) *[1 Jan - 31 Dec, 1962-2010]*



Variability in pasture growth rate - Paddock 3
Percentiles for average weekly pasture growth rate (kg DM/ha/d) *[1 Jan - 31 Dec, 1962-2010]*



Pasture growth rates for each paddock
Long term average pasture growth rates *[1 Jan - 31 Dec, 1962-2010]*

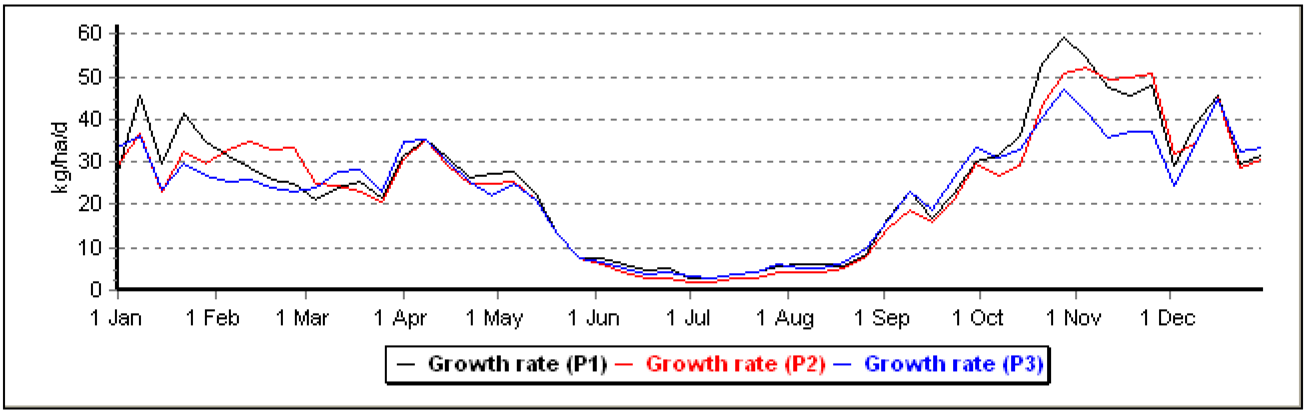


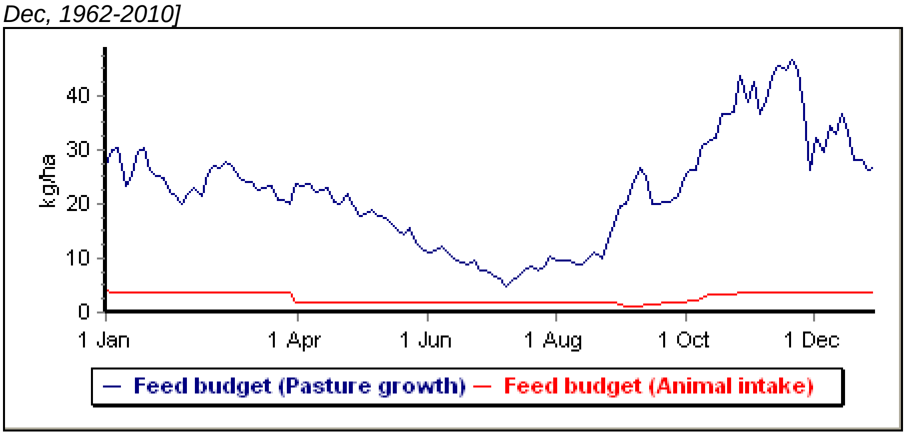
Table of average monthly pasture and sheep growth rates

Long term average pasture and sheep growth rates, averaged over each month *[1 Jan - 31 Dec, 1962-2010]*

Date	Pasture growth	Pasture growth	Pasture growth	Weight change (Unweaned)	Weight change (Male weaners)	Weight change (Female weaners)	Weight change (Main mob)					
	P1 (av.) (kg/ha/d)	P2 (av.) (kg/ha/d)	P3 (av.) (kg/ha/d)	(av.) (kg/d)	(av.) (kg/d)	(av.) (kg/d)	Female weaners (av.) (kg/d)	Female 1-2 y.o. (av.) (kg/d)	Female mature (av.) (kg/d)	Male weaners (av.) (kg/d)	Male 1-2 y.o. (av.) (kg/d)	Male mature (av.) (kg/d)
Jan	37	30	29	n/a	0.099	0.075	n/a	n/a	0.013	n/a	n/a	n/a
Feb	27	32	24	n/a	0.070	0.053	n/a	n/a	-0.003	n/a	n/a	n/a
Mar	23	24	26	n/a	0.059	0.045	n/a	n/a	-0.010	n/a	n/a	n/a
Apr	30	29	29	n/a	n/a	n/a	n/a	0.048	0.034	n/a	n/a	n/a
May	17	16	15	n/a	n/a	n/a	n/a	0.041	0.028	n/a	n/a	n/a
Jun	5	4	4	n/a	n/a	n/a	n/a	0.035	0.022	n/a	n/a	n/a
Jul	4	3	4	n/a	n/a	n/a	n/a	0.006	-0.018	n/a	n/a	n/a
Aug	7	6	7	n/a	n/a	n/a	n/a	-0.032	-0.049	n/a	n/a	n/a
Sep	21	19	23	0.119	n/a	n/a	n/a	-0.036	-0.044	n/a	n/a	n/a
Oct	42	35	36	0.217	n/a	n/a	n/a	n/a	-0.005	n/a	n/a	n/a
Nov	47	49	36	0.172	n/a	n/a	n/a	n/a	0.027	n/a	n/a	n/a
Dec	35	34	34	0.109	n/a	n/a	n/a	n/a	0.020	n/a	n/a	n/a

Feed budget

Long term average daily pasture growth and intake of pasture by the whole enterprise (kg DM/ha/d) *[1 Jan - 31 Dec, 1962-2010]*



Pasture utilization rate

The long term average amount of pasture consumed by all stock as a proportion of the amount of pasture grown over the period tested (%) *[21 Mar - 21 Mar, 2011-2011]*

Date	Utilization rate (%)
21 Mar	12

Economics

Production summary

Long term average pasture and sheep production. For selected financial year *[1 Jul - 30 Jun, 1962/1963 - 2009/2010]*

Farm System		All flocks of Ewes @ Trevenna High Prod
Total annual pasture yield (NPP) (sum)	kg/ha	8026
Dry sheep equivalents (av.)	dse/ha	3.2
Wool cut - total flock (sum)	kg CFW/ha	6
Wool cut - lambs (sum)	kg CFW/ha	0
Shorn fibre diameter - ewe adults (av.)	microns	17.4
Shorn fibre diameter - wether adults (av.)	microns	n/a
Shorn fibre diameter - lambs (av.)	microns	n/a
Meat sold - total (sum)	kg LW/ha	76
Meat sold - young stock (sum)	kg LW/ha	59
Wthr/ram Lambs Sale wt (av.)	kg	31.0
Ewe Lambs Sale wt (av.)	kg	27.8
Supplement fed/area (New Production Feeding rule) (sum)	tonnes/ha	0.047
Supplement fed/area (Maintenance - main flock) (sum)	tonnes/ha	0.001
Supplement fed/area (Maintenance - young (wnr) stock) (sum)	tonnes/ha	0.000

Gross margin

Long term average gross margin. For selected financial year *[1 Jul - 30 Jun, 1962/1963 - 2009/2010]*

Farm System		All flocks of Ewes @ Trevenna High Prod
Net wool income - main flock	$/ha	2
Net wool income - young stock	$/ha	0
Sale income - young stock	$/ha	71
Sale income - cast-for-age	$/ha	24
Sale income - sold at foot	$/ha	0
TOTAL INCOME	$/ha	97
Maintenance supplement	$/ha	0
Production supplement	$/ha	13
Shearing costs	$/ha	9
Animal husbandry	$/ha	10
Replacements purchased	$/ha	55
Rams purchased	$/ha	8
Sale costs	$/ha	4
Pasture costs	$/ha	0
TOTAL EXPENSES	$/ha	99
GROSS MARGIN	$/ha	-2

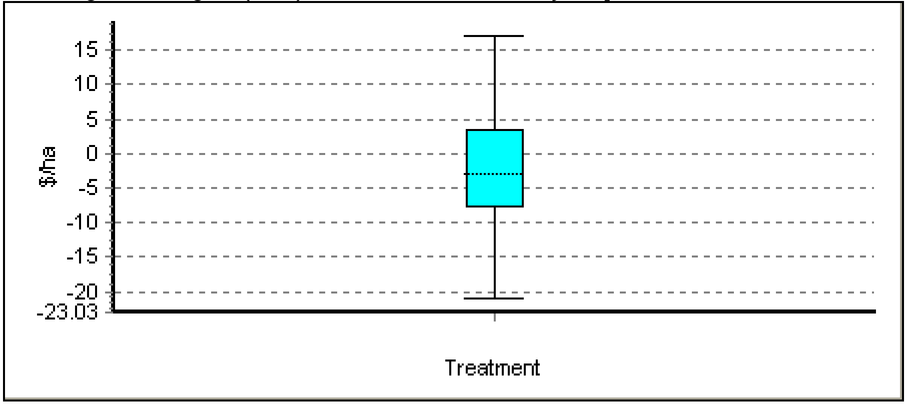
Variability of Gross Margin

Long term standard deviation of the annual gross margin *[1 Jul - 30 Jun, 1962/1963 - 2009/2010]*

Farm System		All flocks of Ewes @ Trevenna High Prod
Total income/ha	$/ha	7.69
Total expense/ha	$/ha	8.66
Gross margin/ha	$/ha	8.58

Boxplot of gross margins

Annual gross margins ($/ha). For selected financial year *[1 Jul - 30 Jun, 1962/1963 - 2009/2010]*

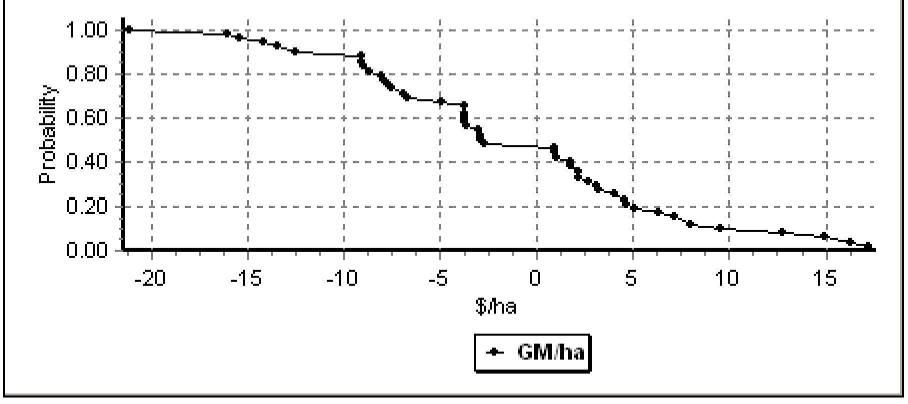


Interpretation of boxplot

The box shows the middle 50% of values (the interquartile range). The horizontal line inside the box is the median. The lines extending above and below the box (whiskers) show the upper and lower quartiles (25% of values). Beyond the whiskers, outlying values are shown by dots and extreme values are shown by asterisks. "Outlying values" lie more than 1.5 times the interquartile range beyond the upper and lower quartiles. "Extreme values" lie more than 3.0 times the interquartile range beyond the upper and lower quartiles.

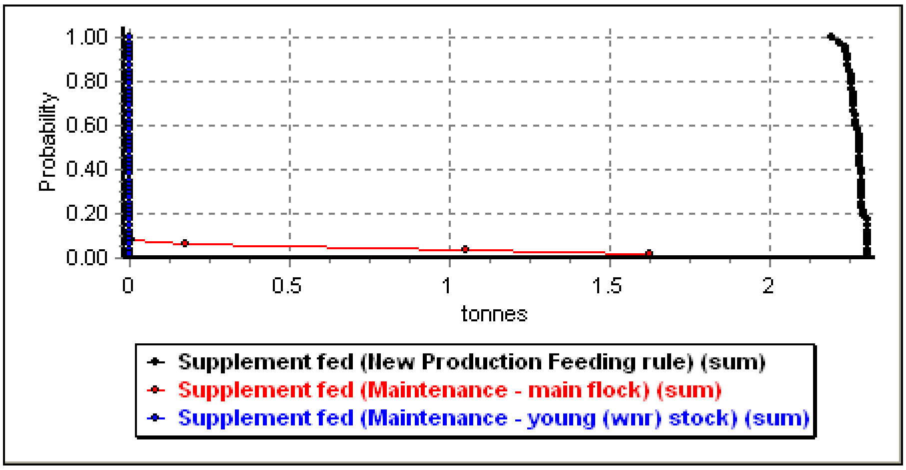
Cumulative distribution of annual gross margins

The probability (on the vertical axis) of exceeding the gross margin value shown on the horizontal axis. For selected financial year *[1 Jul - 30 Jun, 1962/1963 - 2009/2010]*

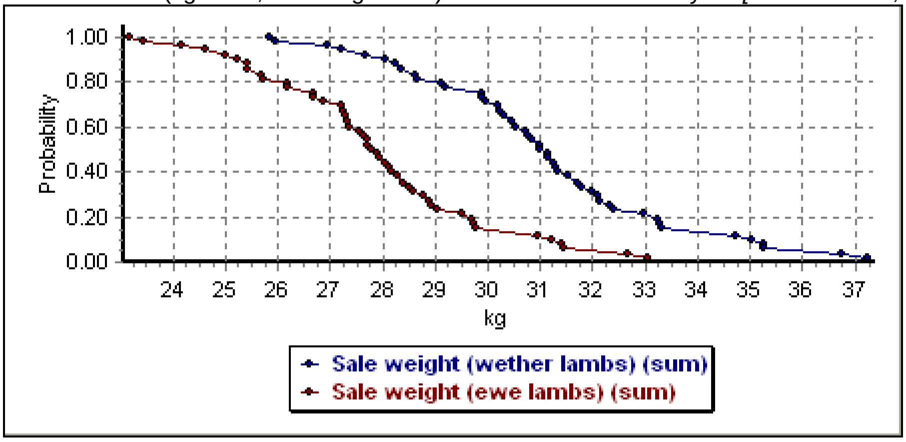


Cumulative distribution of total supplement fed to whole enterprise

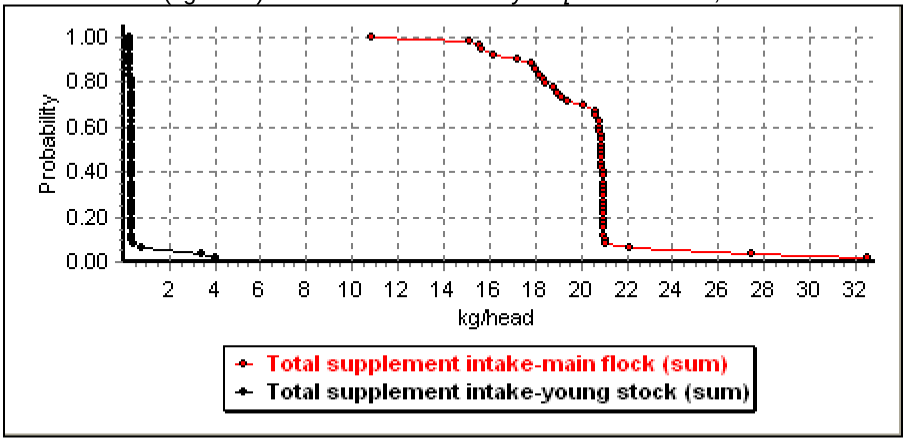
The probability (on the vertical axis) of the total supplement fed in any year exceeding the value shown on the horizontal axis (kg/head). For selected financial year *[1 Jul - 30 Jun, 1962/1963 - 2009/2010]*



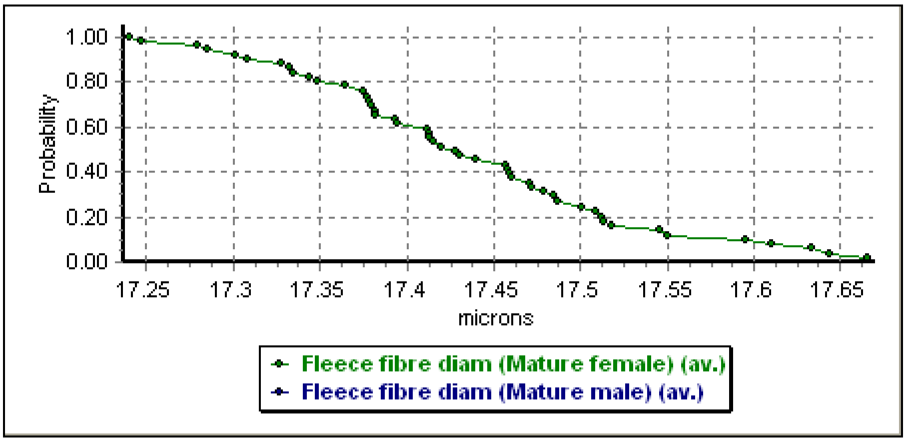
Cumulative distribution of live weight at sale of wether and ewe lambs (including fleece)
The probability (on the vertical axis) of the live weight at sale in any year exceeding the value shown on the horizontal axis (kg/head, including fleece). For selected financial year *[1 Jul - 30 Jun, 1962/1963 - 2009/2010]*



Cumulative distribution of total supplement intake of sheep in main flock and young stock
The probability (on the vertical axis) of the total supplement intake in any year exceeding the value shown on the horizontal axis (kg/head). For selected financial year *[1 Jul - 30 Jun, 1962/1963 - 2009/2010]*

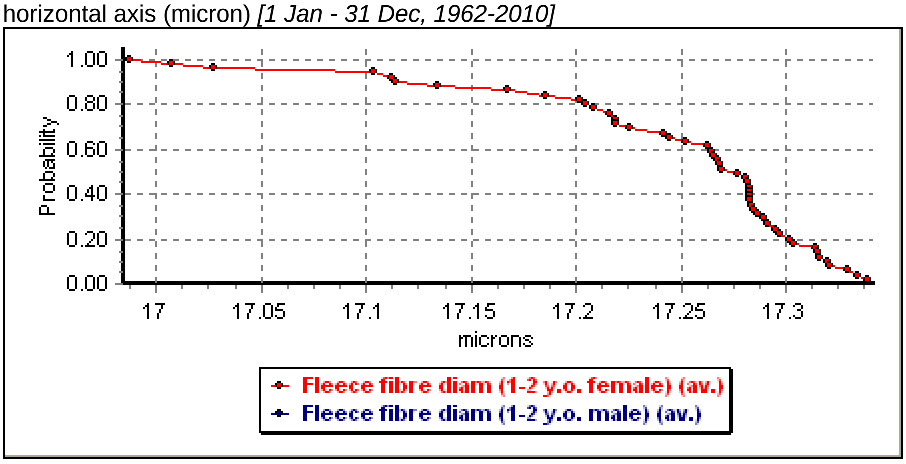


Cumulative distribution of the average fleece fibre diameter of mature sheep
The probability (on the vertical axis) of the fleece fibre diameter in any year exceeding the value shown on the horizontal axis (micron) *[1 Jan - 31 Dec, 1962-2010]*



Cumulative distribution of the average fleece fibre diameter of 1-2 year old sheep in the main flock

The probability (on the vertical axis) of the fleece fibre diameter in any year exceeding the value shown on the horizontal axis (micron) *[1 Jan - 31 Dec, 1962-2010]*



Sustainabilty

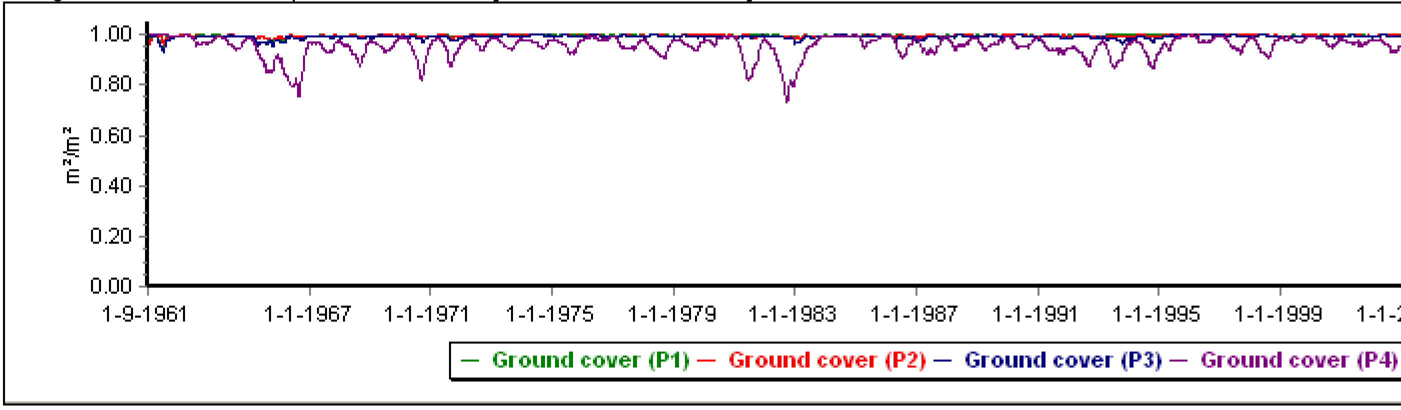
Pasture production and water balance

Long term average pasture productivity *[1 Jan - 31 Dec, 1962-2010]*

Farm System		All flocks of Ewes @ Trevenna High Prod
Pasture growth (P1)	kg/ha	8978
Pasture growth (P2)	kg/ha	8491
Pasture growth (P3)	kg/ha	8183
Yearly Rainfall	mm	766
Actual evapotranspiration (P1)	mm	709
Actual evapotranspiration (P2)	mm	708
Actual evapotranspiration (P3)	mm	708
Actual evapotranspiration (P4)	mm	682
Runoff (P1)	mm	0
Runoff (P2)	mm	0
Runoff (P3)	mm	0
Runoff (P4)	mm	3
Drainage below rooting zone (P1)	mm	58
Drainage below rooting zone (P2)	mm	58
Drainage below rooting zone (P3)	mm	59
Drainage below rooting zone (P4)	mm	82

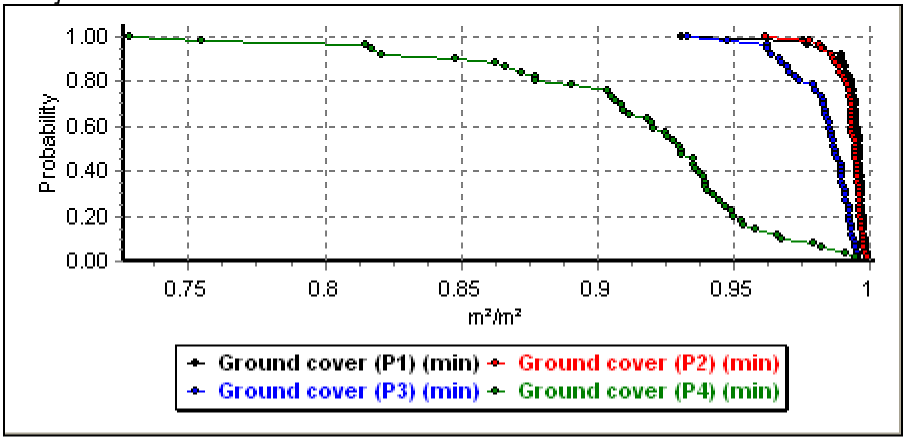
Ground cover over years

The ground cover for each paddock over time *[1/09/1961 - 21/03/2011]*



Cumulative distribution function for minimum ground cover

The probability (shown on the vertical axis) of the minimum ground cover in a year exceeding the value shown on the horizontal axis *2010]*



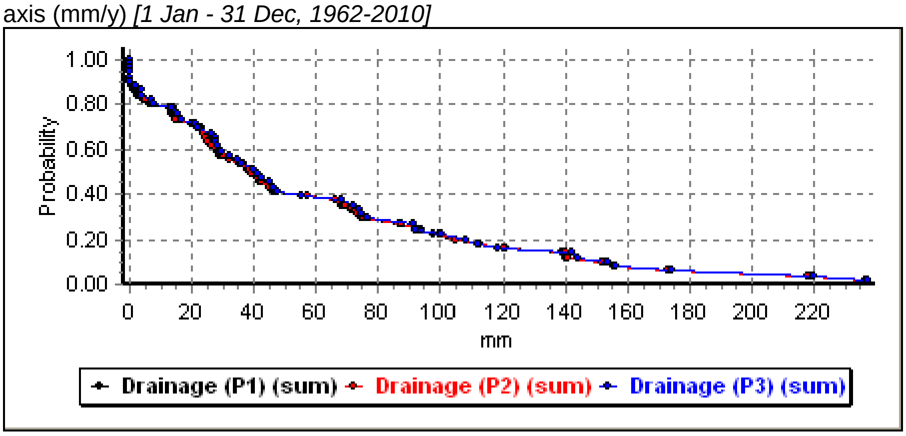
Methane production

Long term annual average methane production *[1 Jan - 31 Dec, 1962-2010]*

Date	Methane production -main flock	Methane production -young sheep
	(sum) (g/head)	(sum) (g/head)
-	8957	3340

Cumulative distribution function for deep drainage

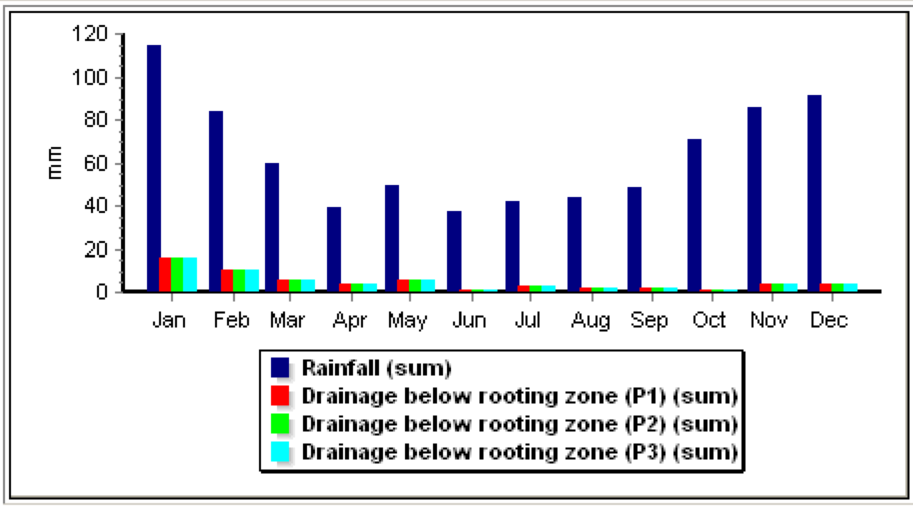
The probability (shown on the vertical axis) of the total amount of soil water draining below the root zone each year exceeding the va axis (mm/y) *[1 Jan - 31 Dec, 1962-2010]*



Timing of drainage

Long term average monthly rainfall (mm/month) and drainage of water below the root zone (mm/month)

Note: distributions are typically highly skewed *[1 Jan - 31 Dec, 1962-2010]*



Farm System description

Initial values of Farm System

Farm System	
Name	All flocks of Ewes @ Trevenna High Prod
Enterprise type	Ewe
Tested	Over 1 Sep 1961 to 21 Mar 2011
Passed	No
Pasture parameters	*C:\Temp\grassgro 2012-03.prm GrassGro March 2012*, last edited 13 Jul 2011 by Andrew Moore
Animal parameters	*standard*, last edited 09 Feb 2004 by Andrew Moore

Property: Trevenna	
Number of paddocks	4
Total area	48 ha

Weather: Armidale Silo Data	
Weather station	Armidale Silo Data *(from D:\Documents and Settings\mcpheem\Desktop\GrassGro3\custom.set)*
Latitude	30°31'S
Longitude	151°40'E
Data period	1 Jan 1961 to 21 Mar 2011
SILO file	D:\Documents and Settings\mcpheem\My Documents\GrassGro\weather\armidalesilodata.txt
Wind speed	2.0 m/s
Last edited	20 Mar 2012

Paddock: FA1	
Area	6.4 ha
Steepness	Level
Fertility	0.90
Reduce wind to	100%

Soil: New Soil	
Soil albedo	0.17
Soil evaporation	3.3 mm/d^{½}
SCS runoff curve no.	Using default

	Topsoil	**Subsoil**
Cumulative depth (mm)	200	900

Field capacity (m^3/m^3)	0.27	0.30
Wilting point (m^3/m^3)	0.13	0.20
Bulk density (Mg/m^3)	1.20	1.50
Saturated conductivity (mm/hr)	30.00	10.00
Initial water (m^3/m^3)	0.13	0.20

Pasture: Flatss Landscape Within A				
Population	**Bothriochloa (beta)**	**Perennial Ryegrass**	**White Clover**	**Annual Ryegrass**
Phenology	Vegetative (900)	Reproductive (200)	Vegetative (900)	Vegetative (650)
Live DM (kg/ha)	18	1667	54	18
Standing dead DM (kg/ha)	19	1831	56	19
Litter DM (kg/ha)	2	17	5	2
Below ground DM (kg/ha)	1500	2000	500	60
Max. rooting depth (mm)	600	500	390	500
Seed DM (kg/ha)	-	-	200	100

Paddock: FB2	
Area	6.4 ha
Steepness	Level
Fertility	0.90
Reduce wind to	100%

Soil: New Soil	
Soil albedo	0.17
Soil evaporation	3.3 mm/d^{½}
SCS runoff curve no.	Using default

	Topsoil	**Subsoil**
Cumulative depth (mm)	200	900
Field capacity (m^3/m^3)	0.27	0.30
Wilting point (m^3/m^3)	0.13	0.20
Bulk density (Mg/m^3)	1.20	1.50
Saturated conductivity (mm/hr)	30.00	10.00
Initial water (m^3/m^3)	0.13	0.20

Pasture: Flatss Landscape Within A					
Population	**Bothriochloa (beta)**	**Perennial Ryegrass**	**White Clover**	**Annual Grass - Early**	**Annual Ryegrass**
Phenology	Vegetative (900)	Reproductive (200)	Vegetative (900)	Vegetative (350)	Vegetative (350)
Live DM (kg/ha)	158	532	14	518	201
Standing dead DM (kg/ha)	165	554	15	538	210
Litter DM (kg/ha)	17	55	2	54	21
Below ground DM (kg/ha)	320	1050	30	1020	400
Max. rooting depth (mm)	600	500	390	500	500
Seed DM (kg/ha)	-	-	200	100	100

Paddock: FC3	
Area	6.0 ha
Steepness	Level

Fertility	0.90
Reduce wind to	100%

Soil: New Soil	
Soil albedo	0.17
Soil evaporation	3.3 mm/d^{½}
SCS runoff curve no.	Using default

	Topsoil	**Subsoil**
Cumulative depth (mm)	200	900
Field capacity (m^3/m^3)	0.27	0.30
Wilting point (m^3/m^3)	0.13	0.20
Bulk density (Mg/m^3)	1.20	1.50
Saturated conductivity (mm/hr)	30.00	10.00
Initial water (m^3/m^3)	0.13	0.20

Pasture: Flatss Landscape Within A						
Population	**Bothriochloa (beta)**	**Phalaris**	**Perennial Ryegrass**	**Cocksfoot**	**White Clover**	**Annual Grass - Early**
Phenology	Vegetative (900)	Vegetative (100)	Reproductive (200)	Vegetative (100)	Vegetative (900)	Vegetative (350)
Live DM (kg/ha)	168	393	1656	196	10	330
Standing dead DM (kg/ha)	176	409	1724	205	2	300
Litter DM (kg/ha)	17	55	2	54	2	10
Below ground DM (kg/ha)	320	1050	30	1020	12	10
Max. rooting depth (mm)	600	500	500	500	390	500
Seed DM (kg/ha)	-	-	-	-	200	100

Paddock: Winter grazing	
Area	29.2 ha
Steepness	Undulating
Fertility	0.60
Reduce wind to	100%

Soil: New Soil	
Soil albedo	0.17
Soil evaporation	3.5 mm/d^{½}
SCS runoff curve no.	Using default

	Topsoil	**Subsoil**
Cumulative depth (mm)	150	1000
Field capacity (m^3/m^3)	0.30	0.34
Wilting point (m^3/m^3)	0.15	0.23
Bulk density (Mg/m^3)	1.40	1.60
Saturated conductivity (mm/hr)	60.00	2.00
Initial water (m^3/m^3)	0.15	0.23

Pasture: Hills Landscape Within C				
Population	**Austrodanthonia spp. (tableland)**	**Phalaris**	**Perennial Ryegrass**	**Annual Grass - Early**
Phenology	Vernalizing (0.00)	Vegetative (0)	Vernalizing (0.00)	Vernalizing (0.00)

Live DM (kg/ha)	117	13	156	6
Standing dead DM (kg/ha)	2808	312	3744	156
Litter DM (kg/ha)	281	31	37	16
Below ground DM (kg/ha)	2900	320	3900	160
Max. rooting depth (mm)	500	500	500	500
Seed DM (kg/ha)	-	-	-	100

Livestock: New Livestock

Breed	Small Merino	
Standard reference weight	40.0	kg
Greasy fleece weight	3.60	kg
Fibre diameter	17.0	microns
Fleece yield	70	%
Ram breed	Border Leicester (Mature ram: 84.0 kg)	
Death rate: adults	2.0	%/year
Death rate: weaners	2.0	%/year

Initial values

	Ewes	Wether Lambs	Wether Weaners	Ewe Weaners	Wether Yearlings	Ewe Yearlings	
Live weight including fleece and conceptus	44.0	20.0	20.0	20.0	20.0	20.0	kg
Greasy fleece weight	0.50	1.11	1.00	0.84	2.07	1.73	kg
Fibre diameter	16.7	17.0	17.0	17.0	17.0	17.0	microns

Management policy: New Ewe Management policy

Stocking rate	**Rate**	2.0/ha
Shearing date	**Main flock**	10 Jul
	Weaners	10 Jul
Replacement rule	**Purchase**	Purchase ewes on 2 Apr at age 18 months, live weight 40 kg and C.S. 3.0
	Cast for age	Sell stock aged 6 to 7 years on 1 Apr

Reproduction rule: New Reproduction rule

First join at	1 years
Mating date	14 Apr
Conception at CS 3	(1) 63% (2) 37% (3) 0%
Birth date	10 Sep
Castration	yes
Weaning date	1 Jan
One ram per	50 ewes
Keep rams for	5.0 years
Sell young ewes	Sell 0 year old animals on 31 Mar
Sell young wethers	Sell 0 year old animals on 31 Mar

Maintenance Feeding rule: New Maintenance Feeding rule

Main flock/herd

Mature Females	Feed in paddock, applying the rule: If animal condition falls to 1.5 during 1 Jan to 31 Dec feed to maintain condition of the thinnest animals
Immature Females	Feed in paddock, applying the rule: If animal condition falls to 1.5 during 1 Jan to 31 Dec feed to maintain condition of the thinnest animals

Immature Males	Feed in paddock, applying the rule: If animal condition falls to 1.0 during 1 Jan to 31 Dec feed to maintain condition of the thinnest animals
Weaner flock/herd	
Weaners	Feed in paddock, applying the rule: If animal condition falls to 1.5 during 1 Jan to 31 Dec feed to maintain condition of the thinnest animals
Supplement	

Supplement: Maize	
Ingredient	**Maize**
Proportion of mix (%)	100
Dry matter content (%)	87
Dry matter digestibility (%)	87
ME:DM (MJ/kg)	14.1
Crude protein (%)	10
Rumen-degradable protein (%)	80

Production Feeding rule: New Production Feeding rule	
Feeding rule	Fixed amount of 0.60 kg/d to All Stock in Paddock from 1 Sep to 10 Oct
Supplement	

Supplement: Hay/Beans, field			
Description	Need the mix in these		
Ingredient	**Hay**	**Beans, field**	**Overall mix**
Proportion of mix (%)	50	50	100
Dry matter content (%)	89	89	89
Dry matter digestibility (%)	64	86	75
ME:DM (MJ/kg)	8.5	13.7	11.1
Crude protein (%)	16	31	23
Rumen-degradable protein (%)	68	91	83

Pasture rule: New Pasture rule	
Reset on	1 Mar

Grazing rule: Grazing rotation	
Ewes	
From 1 Jan to 31 Jan	31 days in "FA1"
From 1 Feb to 29 Feb	29 days in "FB2"
From 1 Mar to 31 Mar	7 days in "FC3"
From 1 Apr to 31 Aug	153 days in "Winter grazing"
From 1 Sep to 9 Oct	39 days in "FC3"
From 10 Oct to 31 Oct	22 days in "FA1"
From 1 Nov to 30 Nov	30 days in "FB2"
From 1 Dec to 31 Dec	31 days in "FC3"
Ewe Weaners	
Same as	Ewes
Wether Weaners	
Same as	Ewe Weaners, Ewes

Costs: New Costs		
Ewe Shearing	$4.50	/head
Shearing Lambs	$3.50	/head
Ewe Husbandry	$3.00	/head
Lamb Husbandry	$2.00	/head
Ewe Replacement	$130.00	/head
Rams	$1000.00	/head
Sheep sales commission	4	%

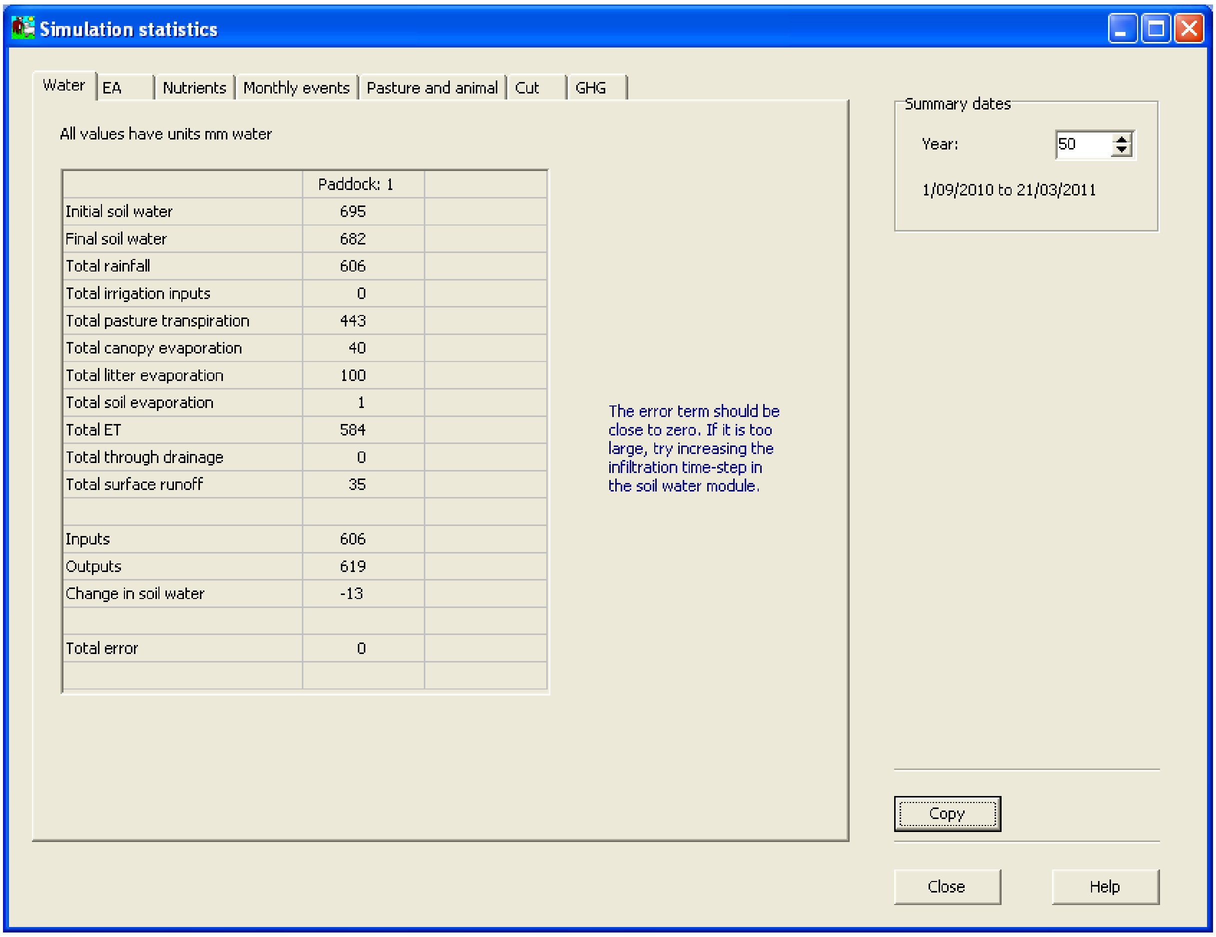
Sheep sales cost		$0.00	/head
Pasture cost		$0.00	/ha
Supplement costs	Hay	$300.00	/t
	Beans, field	$250.00	/t
	Maize	$200.00	/t

Prices: New Prices			
Wool prices for ewes			
	Fleece price	800	c/kg
	Av. Fleece Price	5.0	%
	Wool commission	7.0	%
Ewe sales			
	Base price	260.0	c/kg
	Dressing percentage	43.0	%
	Skin price	$15.00	/head
Ewe lamb sales			
	Base price	450.0	c/kg
	Dressing percentage	45.0	%
	Skin price	$15.00	/head
Wether lamb sales			
	Base price	0.0	c/kg
	Dressing percentage	0.0	%
	Skin price	$0.00	/head

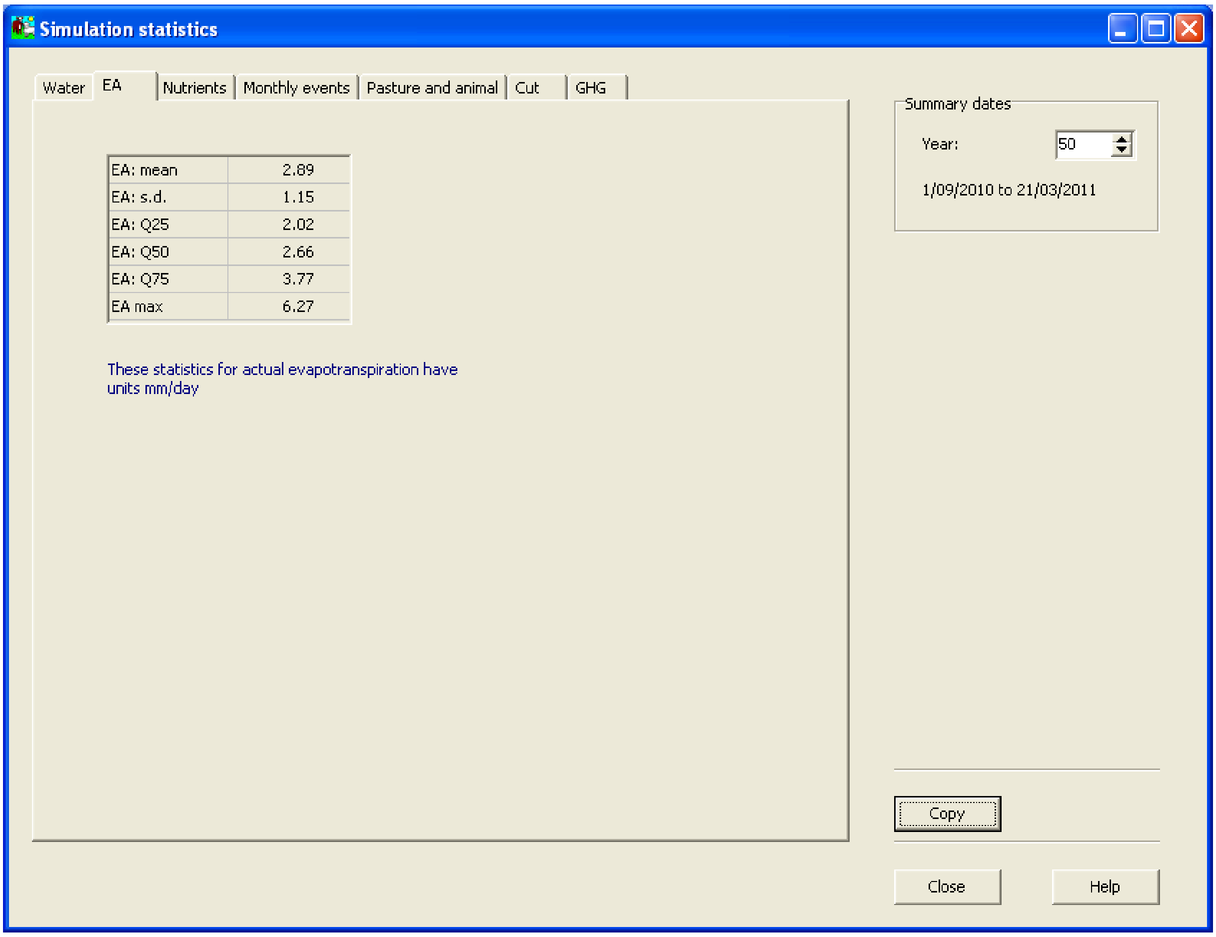
GrassGro 3.2.5. Build: 23 Aug 2011

SGS High Productivity Landscape Paddock FA2, Flock 5

Note: only 1 paddock and 1 flock to illustrate the simulation.



	Paddock: 1	
Initial soil water	695	
Final soil water	682	
Total rainfall	606	
Total irrigation inputs	0	
Total pasture transpiration	443	
Total canopy evaporation	40	
Total litter evaporation	100	
Total soil evaporation	1	
Total ET	584	
Total through drainage	0	
Total surface runoff	35	
Inputs	606	
Outputs	619	
Change in soil water	-13	
Total error	0	


Simulation statistics
Water
EA
Nutrients
Monthly events
Pasture and animal
Cut
GHG
EA: mean 2.89
EA: s.d. 1.15
EA: Q25 2.02
EA: Q50 2.66
EA: Q75 3.77
EA max 6.27
These statistics for actual evapotranspiration have units mm/day
Summary dates
Year: 50
1/09/2010 to 21/03/2011
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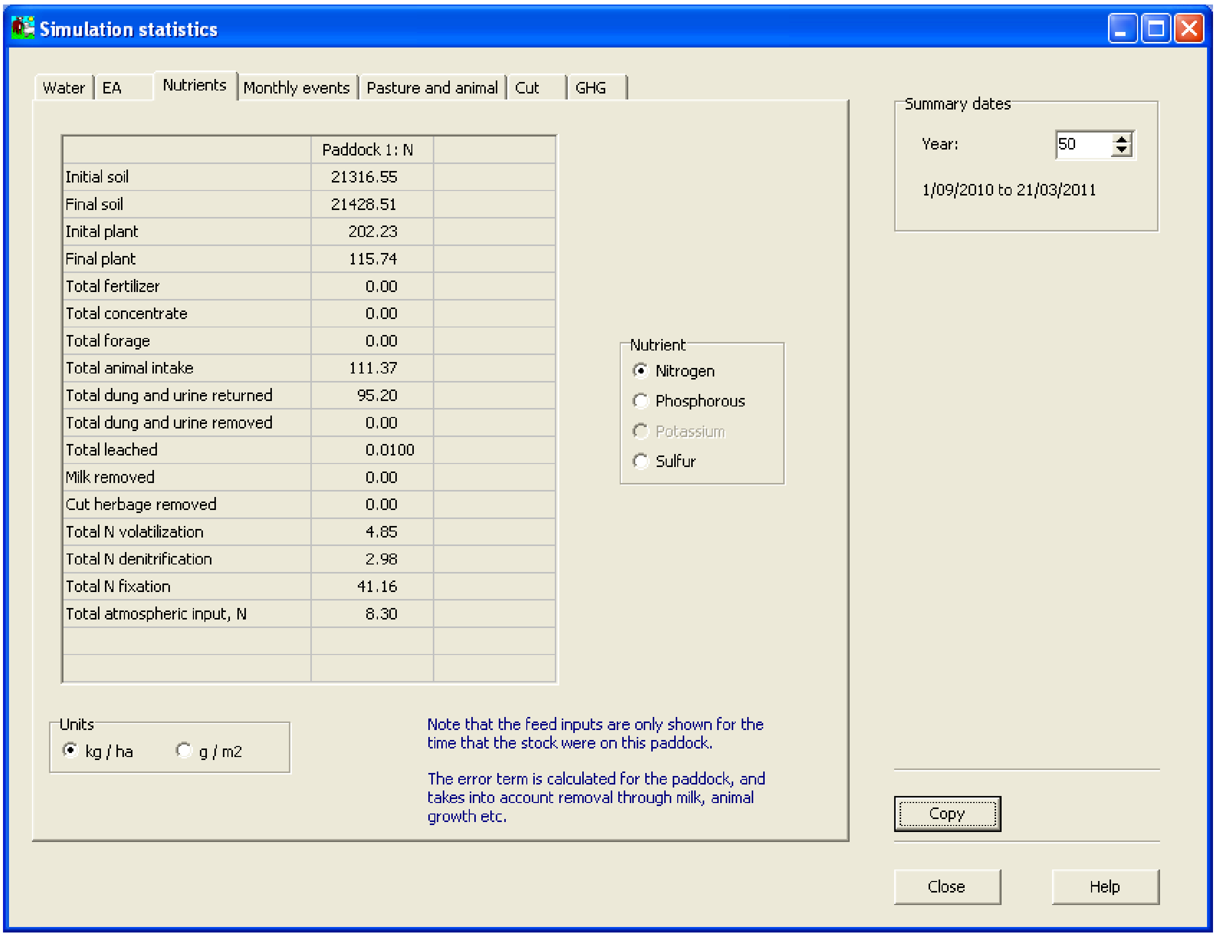
Simulation statistics
Water
EA
Nutrients
Monthly events
Pasture and animal
Cut
GHG
Paddock 1: N
Initial soil 21316.55
Final soil 21428.51
Inital plant 202.23
Final plant 115.74
Total fertilizer 0.00
Total concentrate 0.00
Total forage 0.00
Total animal intake 111.37
Total dung and urine returned 95.20
Total dung and urine removed 0.00
Total leached 0.0100
Milk removed 0.00
Cut herbage removed 0.00
Total N volatilization 4.85
Total N denitrification 2.98
Total N fixation 41.16
Total atmospheric input, N 8.30
Nutrient
Nitrogen
Phosphorous
Potassium
Sulfur
Summary dates
Year: 50
1/09/2010 to 21/03/2011
Units
kg / ha
g / m2
Note that the feed inputs are only shown for the time that the stock were on this paddock.
The error term is calculated for the paddock, and takes into account removal through milk, animal growth etc.
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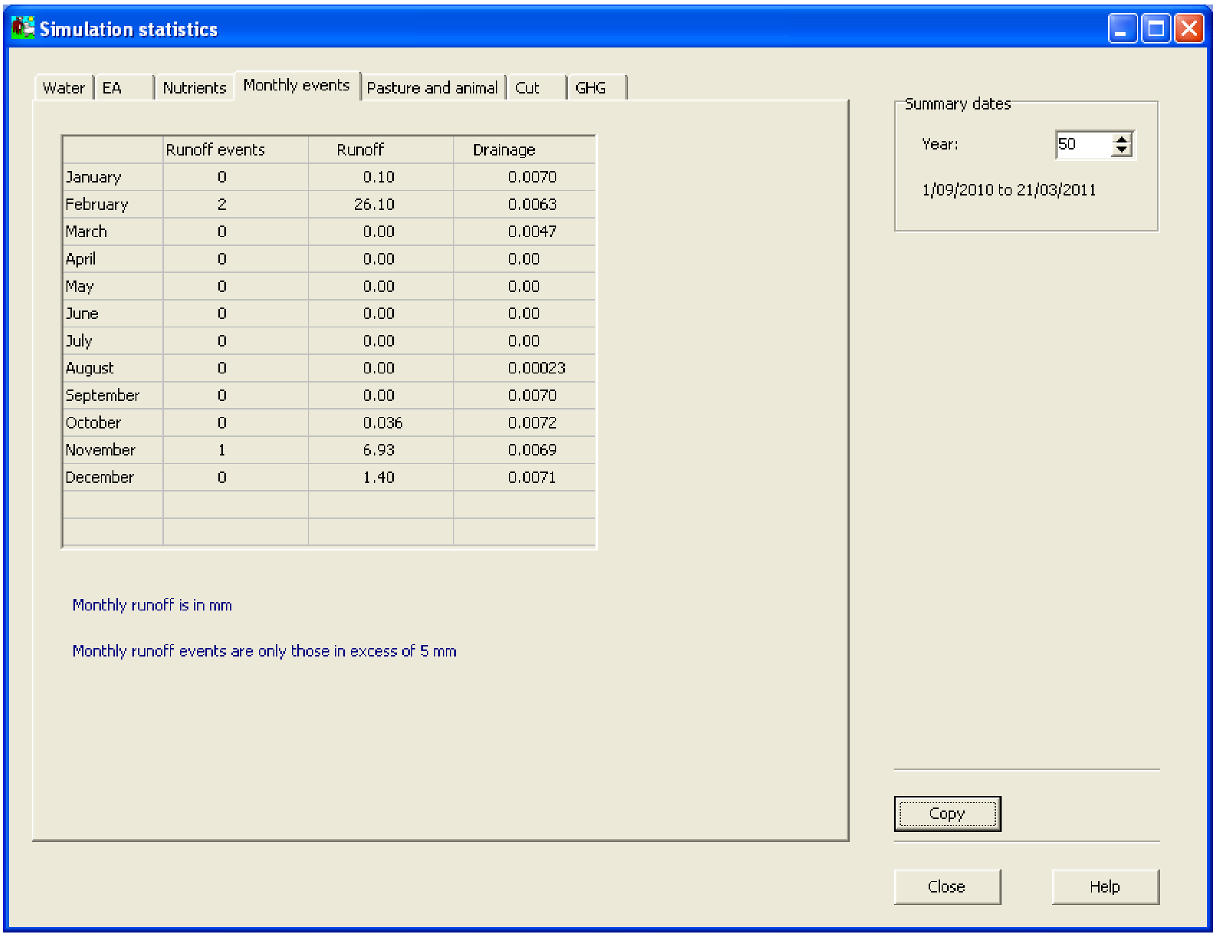
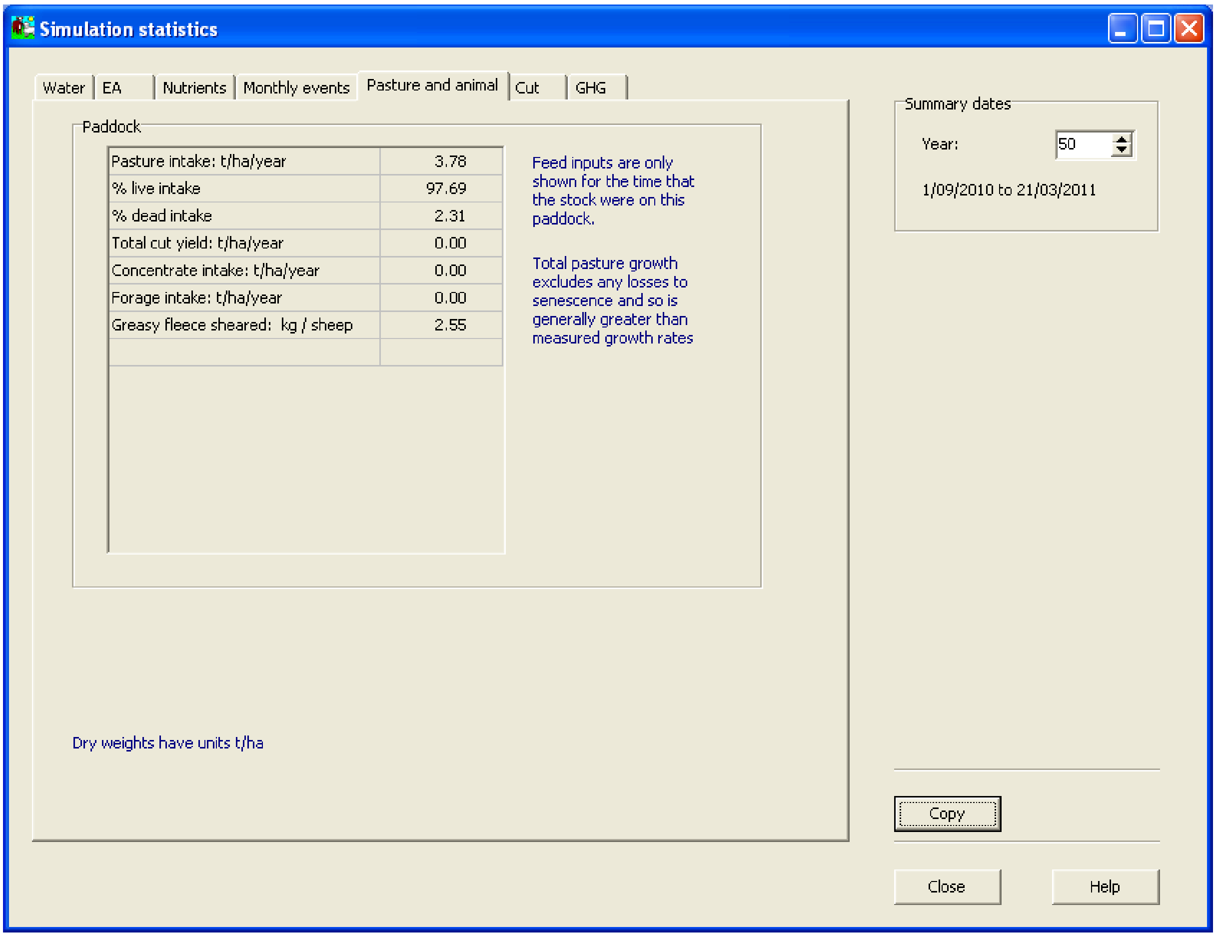


	Runoff events	Runoff	Drainage
January	0	0.10	0.0070
February	2	26.10	0.0063
March	0	0.00	0.0047
April	0	0.00	0.00
May	0	0.00	0.00
June	0	0.00	0.00
July	0	0.00	0.00
August	0	0.00	0.00023
September	0	0.00	0.0070
October	0	0.036	0.0072
November	1	6.93	0.0069
December	0	1.40	0.0071


Simulation statistics
Water
EA
Nutrients
Monthly events
Pasture and animal
Cut
GHG
Paddock
Pasture intake: t/ha/year 3.78
% live intake 97.69
% dead intake 2.31
Total cut yield: t/ha/year 0.00
Concentrate intake: t/ha/year 0.00
Forage intake: t/ha/year 0.00
Greasy fleece sheared: kg / sheep 2.55
Feed inputs are only shown for the time that the stock were on this paddock.
Total pasture growth excludes any losses to senescence and so is generally greater than measured growth rates
Dry weights have units t/ha
Summary dates
Year: 50
1/09/2010 to 21/03/2011
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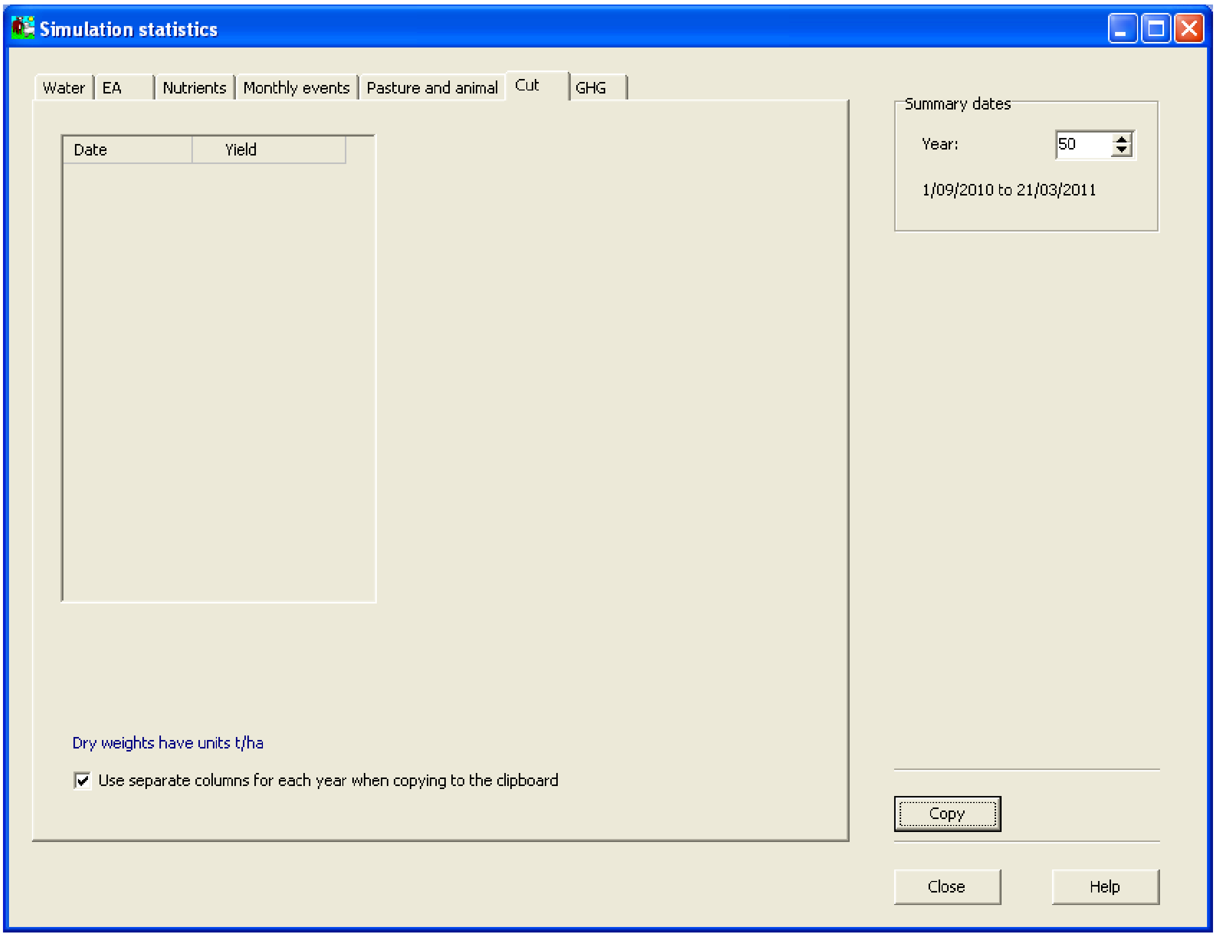
Simulation statistics
Water
EA
Nutrients
Monthly events
Pasture and animal
Cut
GHG
Date
Yield
Dry weights have units t/ha
Use separate columns for each year when copying to the clipboard
Summary dates
Year:
50
1/09/2010 to 21/03/2011
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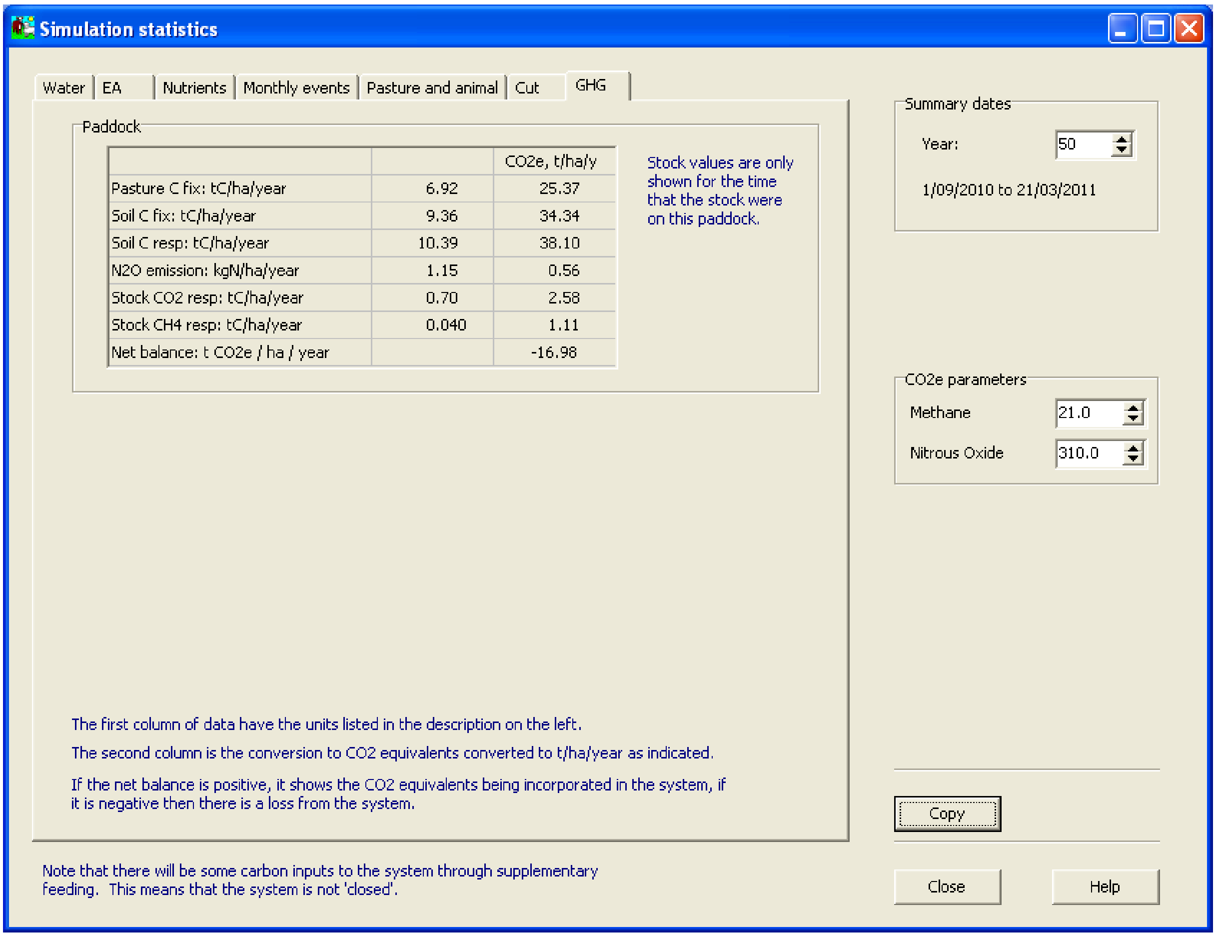
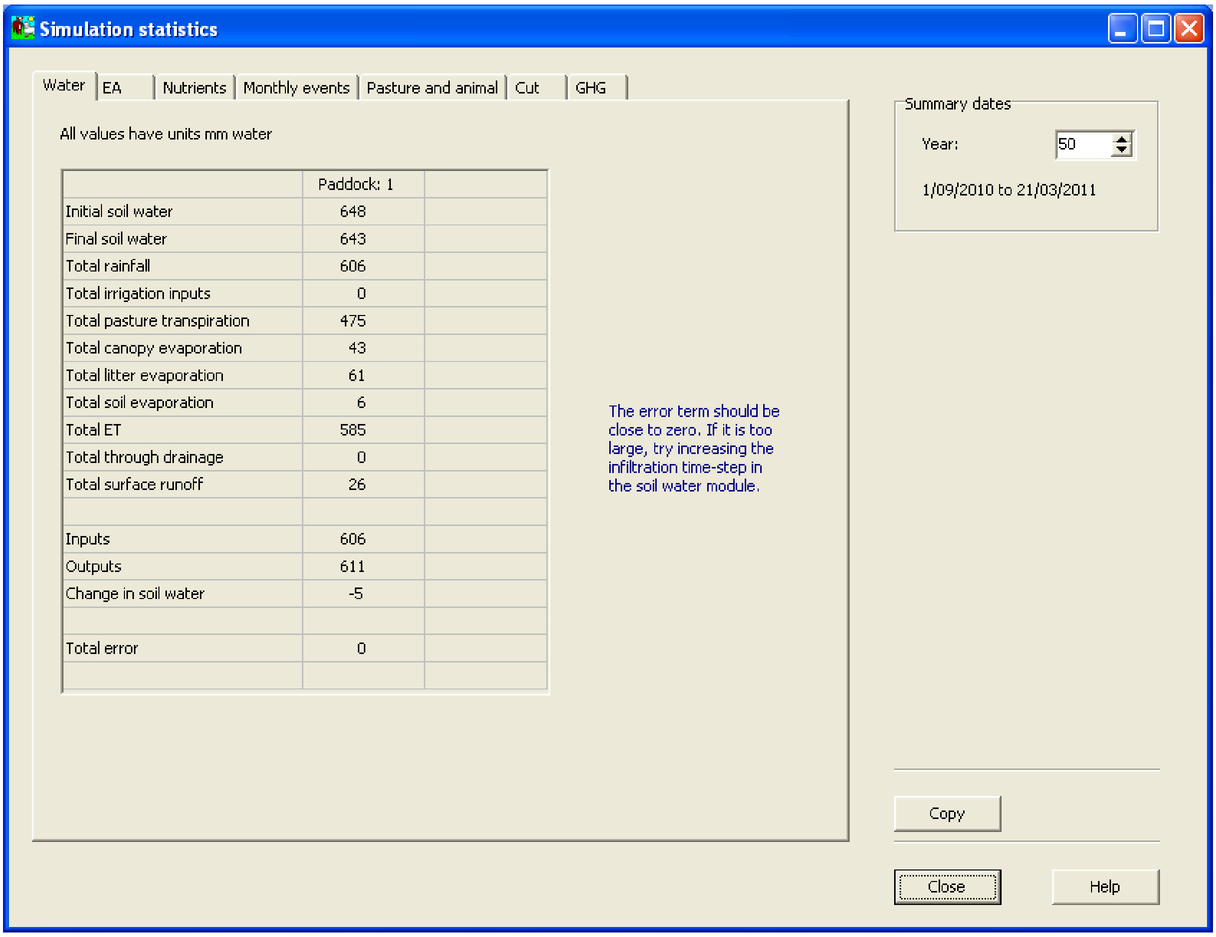


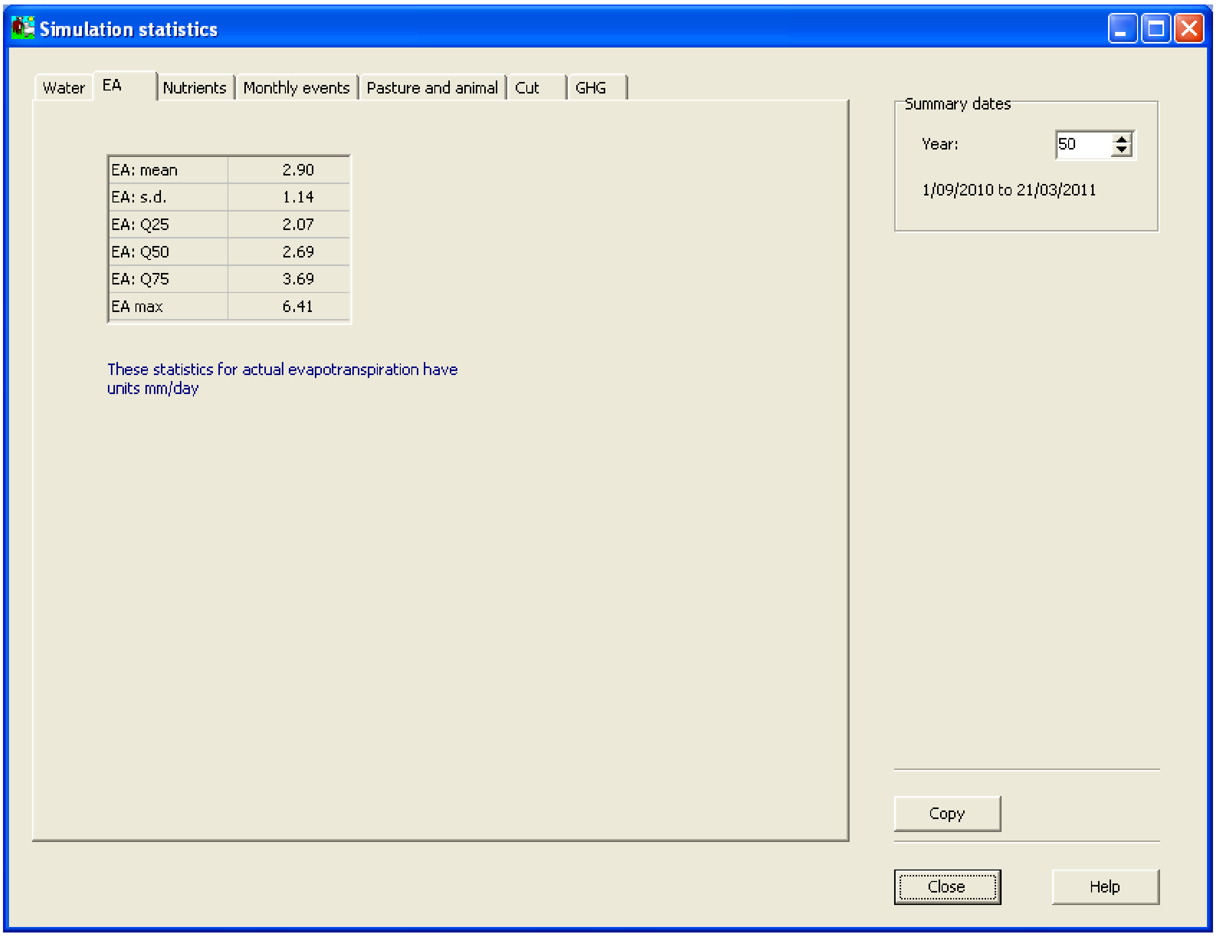
		CO2e, t/ha/y
Pasture C fix: tC/ha/year	6.92	25.37
Soil C fix: tC/ha/year	9.36	34.34
Soil C resp: tC/ha/year	10.39	38.10
N2O emission: kgN/ha/year	1.15	0.56
Stock CO2 resp: tC/ha/year	0.70	2.58
Stock CH4 resp: tC/ha/year	0.040	1.11
Net balance: t CO2e / ha / year		-16.98

SGS Low Productivity Landscape Paddock HB3, Flock 1

Note: only 1 paddock and 1 flock to illustrate the simulation.



	Paddock: 1	
Initial soil water	648	
Final soil water	643	
Total rainfall	606	
Total irrigation inputs	0	
Total pasture transpiration	475	
Total canopy evaporation	43	
Total litter evaporation	61	
Total soil evaporation	6	
Total ET	585	
Total through drainage	0	
Total surface runoff	26	
Inputs	606	
Outputs	611	
Change in soil water	-5	
Total error	0	


Simulation statistics
Water
EA
Nutrients
Monthly events
Pasture and animal
Cut
GHG
EA: mean 2.90
EA: s.d. 1.14
EA: Q25 2.07
EA: Q50 2.69
EA: Q75 3.69
EA max 6.41
These statistics for actual evapotranspiration have units mm/day
Summary dates
Year: 50
1/09/2010 to 21/03/2011
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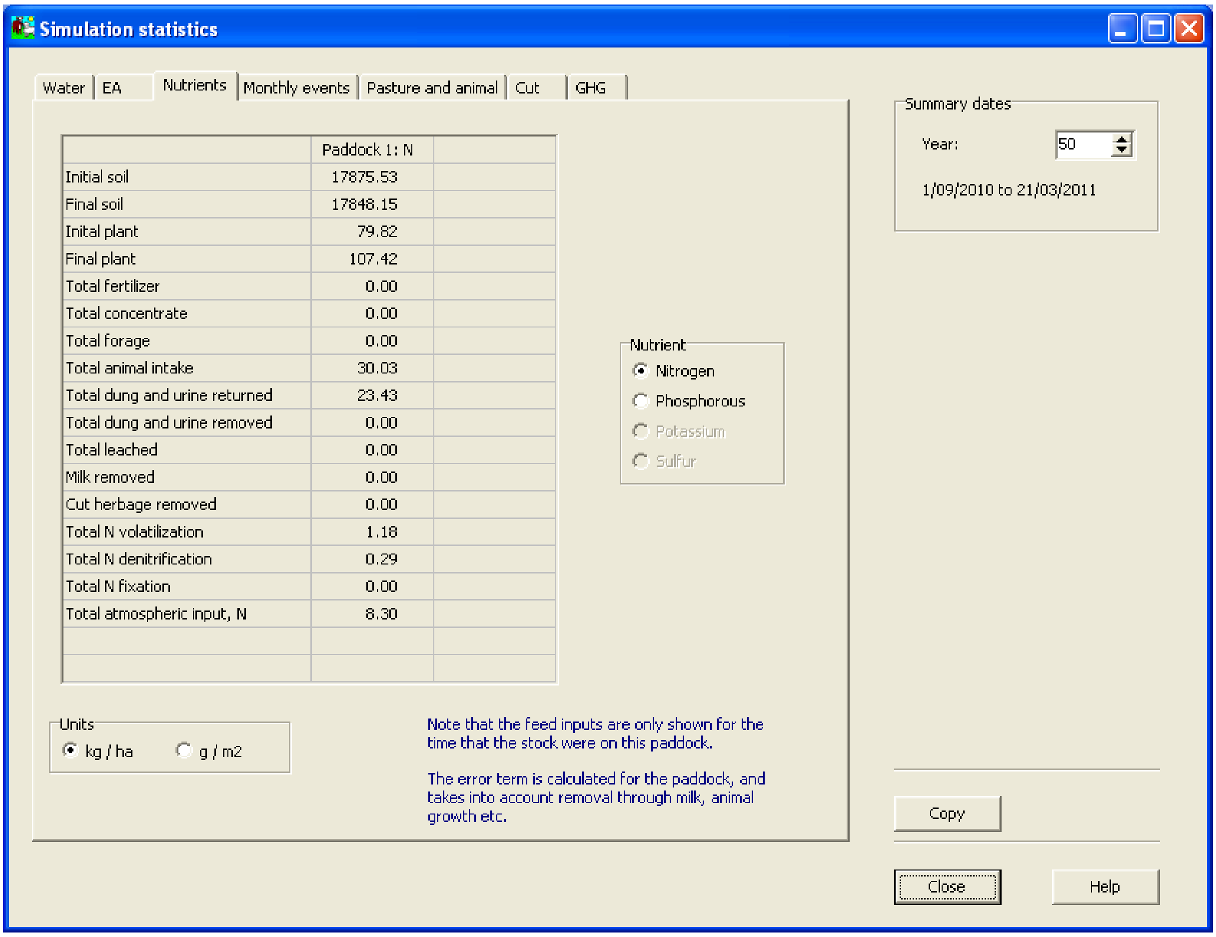
Simulation statistics
Water
EA
Nutrients
Monthly events
Pasture and animal
Cut
GHG
Paddock 1: N
Initial soil 17875.53
Final soil 17848.15
Inital plant 79.82
Final plant 107.42
Total fertilizer 0.00
Total concentrate 0.00
Total forage 0.00
Total animal intake 30.03
Total dung and urine returned 23.43
Total dung and urine removed 0.00
Total leached 0.00
Milk removed 0.00
Cut herbage removed 0.00
Total N volatilization 1.18
Total N denitrification 0.29
Total N fixation 0.00
Total atmospheric input, N 8.30
Nutrient
Nitrogen
Phosphorous
Potassium
Sulfur
Units
kg / ha
g / m2
Note that the feed inputs are only shown for the time that the stock were on this paddock.
The error term is calculated for the paddock, and takes into account removal through milk, animal growth etc.
Summary dates
Year: 50
1/09/2010 to 21/03/2011
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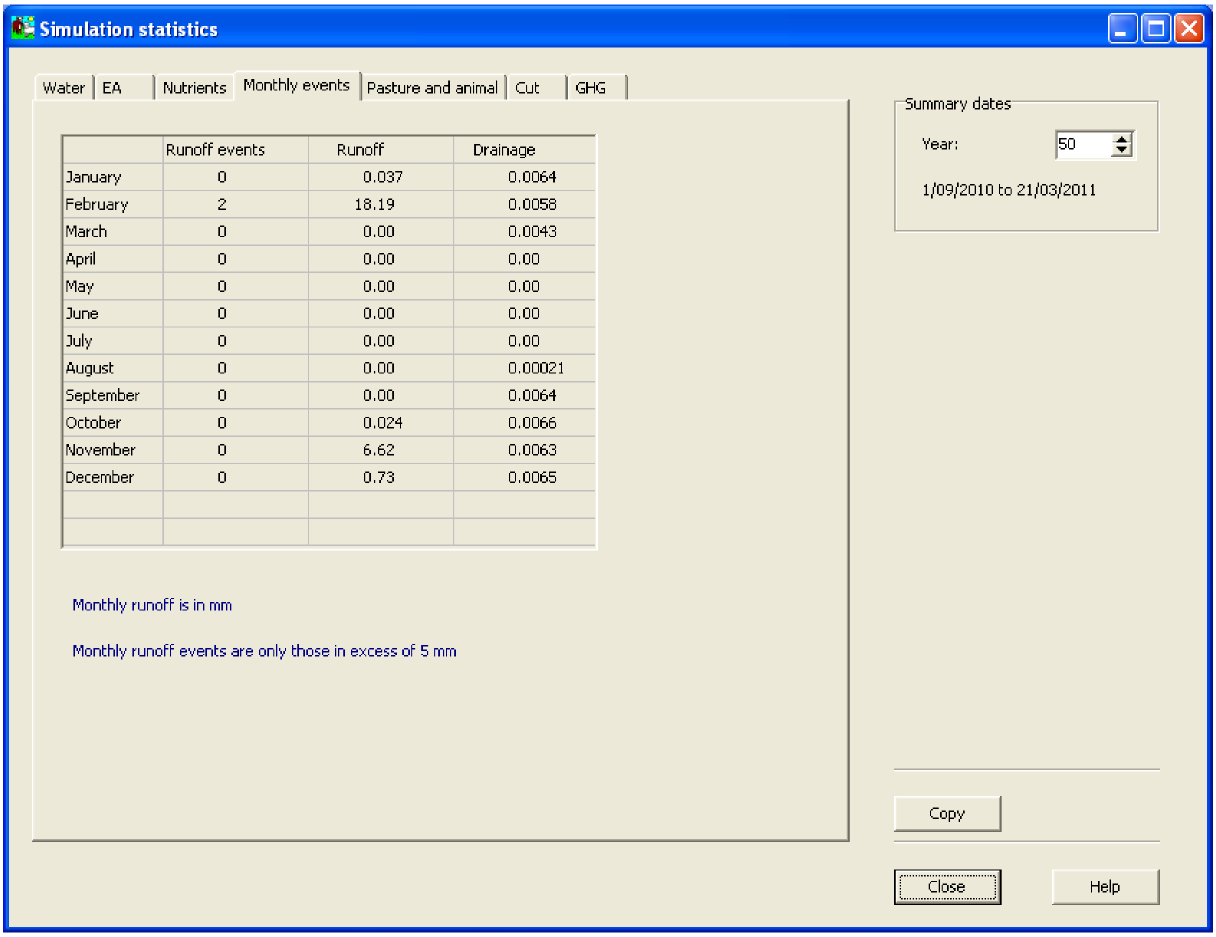
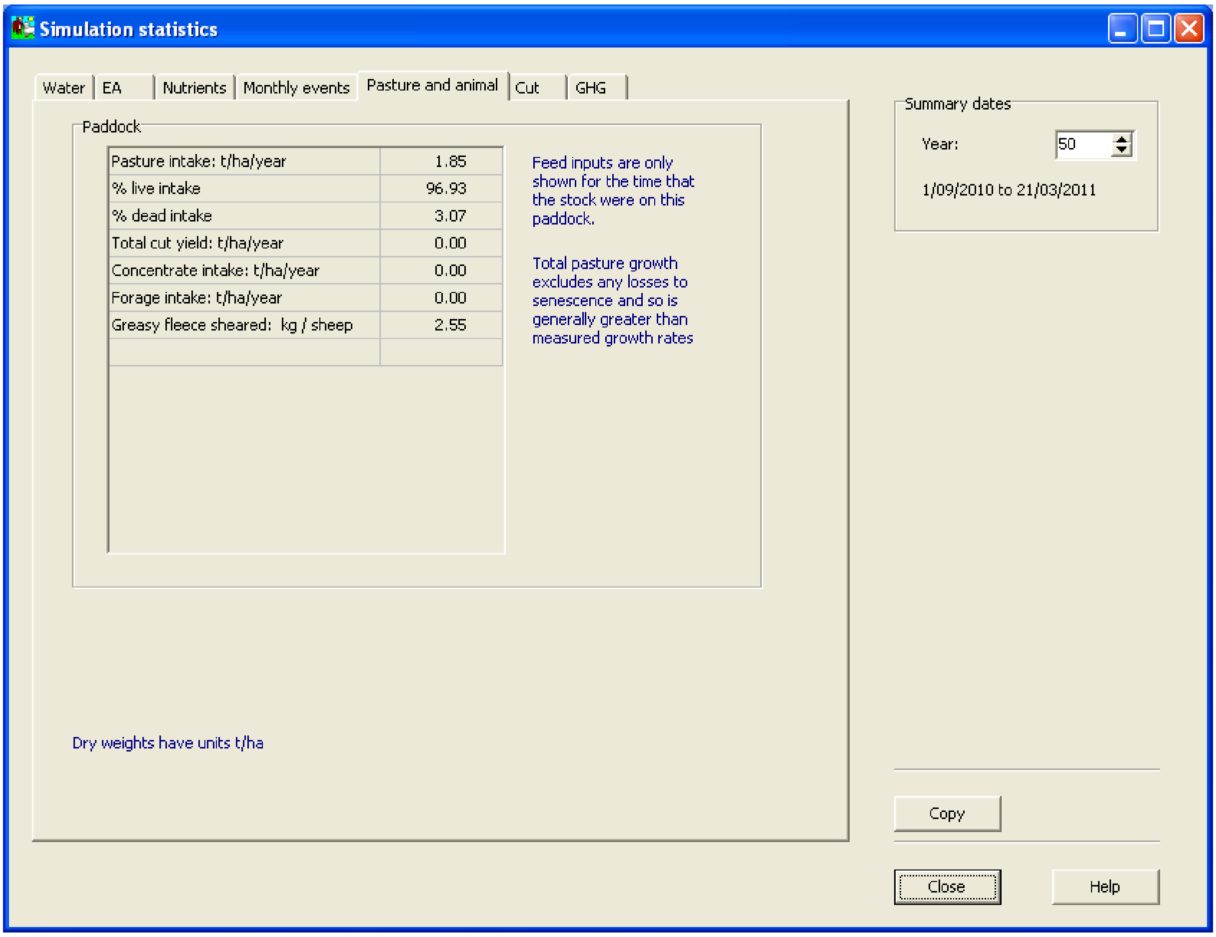


	Runoff events	Runoff	Drainage
January	0	0.037	0.0064
February	2	18.19	0.0058
March	0	0.00	0.0043
April	0	0.00	0.00
May	0	0.00	0.00
June	0	0.00	0.00
July	0	0.00	0.00
August	0	0.00	0.00021
September	0	0.00	0.0064
October	0	0.024	0.0066
November	0	6.62	0.0063
December	0	0.73	0.0065


Simulation statistics
Water
EA
Nutrients
Monthly events
Pasture and animal
Cut
GHG
Paddock
Pasture intake: t/ha/year 1.85
% live intake 96.93
% dead intake 3.07
Total cut yield: t/ha/year 0.00
Concentrate intake: t/ha/year 0.00
Forage intake: t/ha/year 0.00
Greasy fleece sheared: kg / sheep 2.55
Feed inputs are only shown for the time that the stock were on this paddock.
Total pasture growth excludes any losses to senescence and so is generally greater than measured growth rates
Dry weights have units t/ha
Summary dates
Year: 50
1/09/2010 to 21/03/2011
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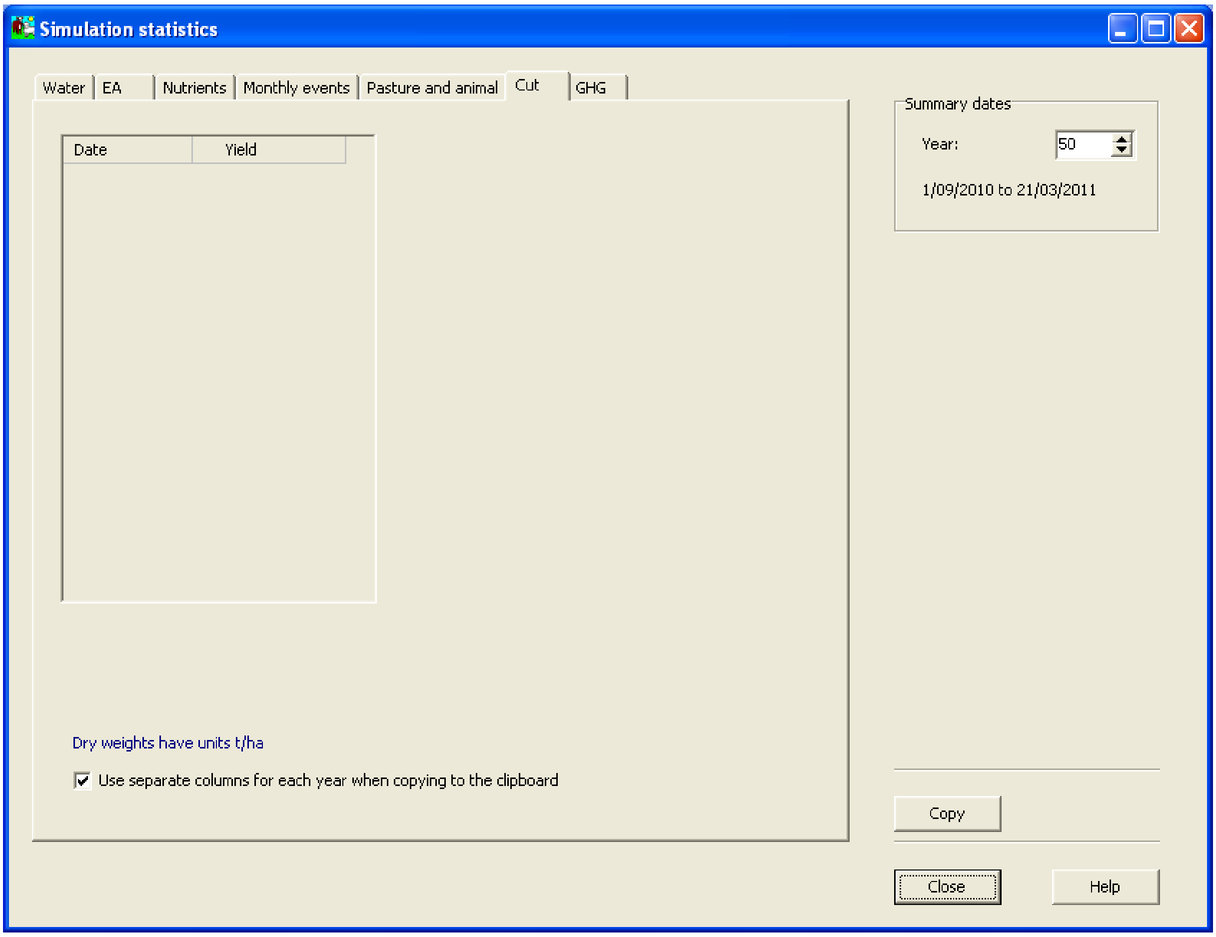
Simulation statistics
Water
EA
Nutrients
Monthly events
Pasture and animal
Cut
GHG
Date
Yield
Dry weights have units t/ha
Use separate columns for each year when copying to the clipboard
Summary dates
Year:
50
1/09/2010 to 21/03/2011
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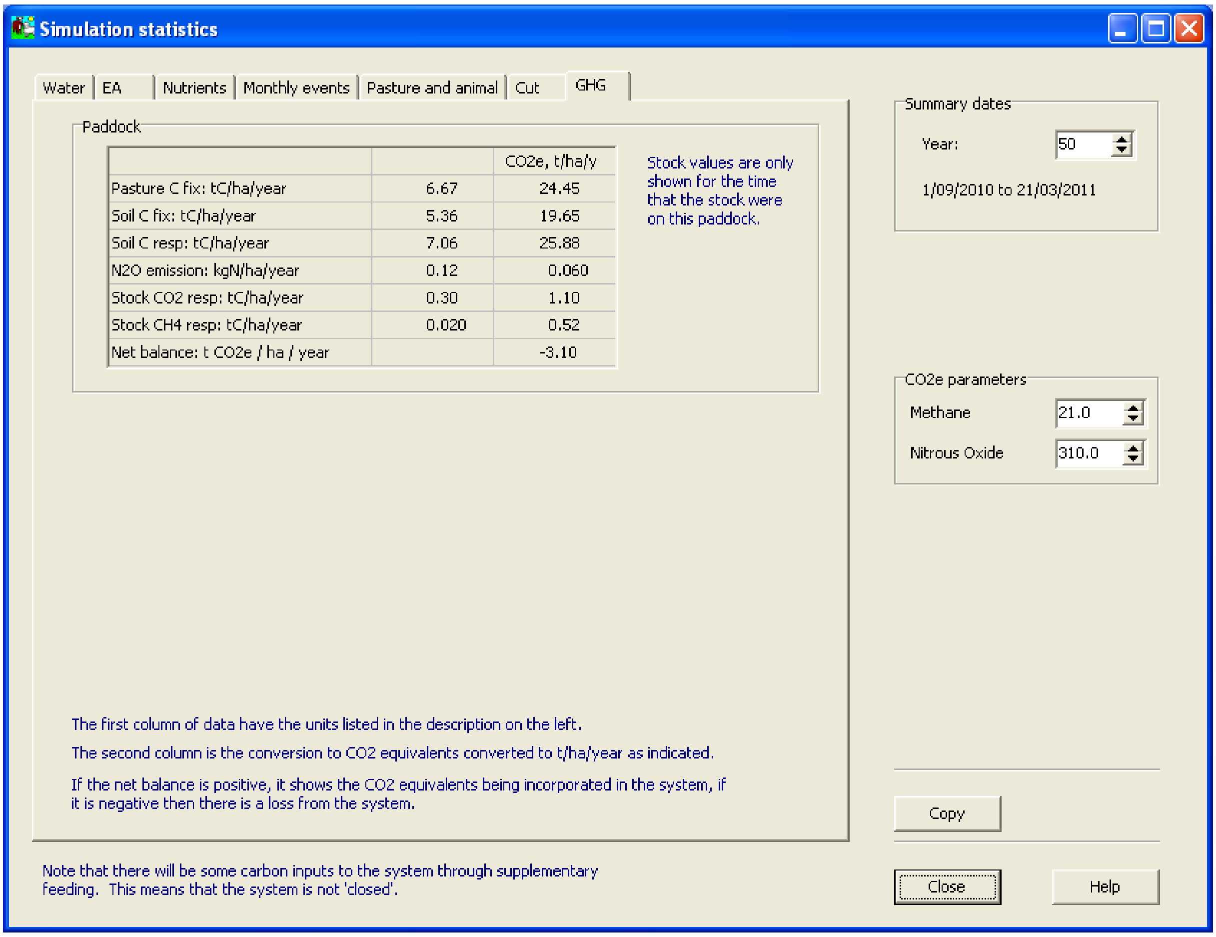
Simulation statistics
Water
EA
Nutrients
Monthly events
Pasture and animal
Cut
GHG
Paddock
CO2e, t/ha/y
Pasture C fix: tC/ha/year 6.67 24.45
Soil C fix: tC/ha/year 5.36 19.65
Soil C resp: tC/ha/year 7.06 25.88
N2O emission: kgN/ha/year 0.12 0.060
Stock CO2 resp: tC/ha/year 0.30 1.10
Stock CH4 resp: tC/ha/year 0.020 0.52
Net balance: t CO2e / ha / year -3.10
Stock values are only shown for the time that the stock were on this paddock.
The first column of data have the units listed in the description on the left.
The second column is the conversion to CO2 equivalents converted to t/ha/year as indicated.
If the net balance is positive, it shows the CO2 equivalents being incorporated in the system, if it is negative then there is a loss from the system.
Note that there will be some carbon inputs to the system through supplementary feeding. This means that the system is not 'closed'.
Summary dates
Year:
50
1/09/2010 to 21/03/2011
CO2e parameters
Methane
21.0
Nitrous Oxide
310.0
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Help

FarmGas Calculations for Low Productivity Landscape

FarmGAS Scenario - Setup ("Landing Page")

This is the 'test-bed' version of the FarmGAS Scenario Tool (Version 1.2, February 2012). It was developed to provide a template for construction of a Web-based version of the Scenario Tool which is located on the website of the Australian Farm Institute (www.farminstitute.org.au). Advice on, and approval for, the use of this spreadsheet should be obtained from the Australian Farm Institute.

The development of the Scenario Tool is part of a project undertaken by the Institute and Meat & Livestock Australia, under the Australian Government's Reducing emissions from livestock R&D Program which forms part of the Australia's Farming Future: Climate Change Research Program.

A detailed outline of this spreadsheet model and instructions on its use are provided in the FarmGAS Scenario Tool User Guide (Spreadsheet) which can be obtained from the Australian Farm Institute.

SCENARIO NAME and FARM LOCATION

Farm Name: Trevenna - Lamb Breed LOV
Scenario: Scenario 1 (Name of the scenario)
Scenario created on:
Last saved on:

State/Territory
Location of Farm: NSW / ACT
Region: Northern Tablelands
Location: NSW / ACT

FARM ENTERPRISES

Select farm GHG Calculators | **Select Enterprise Gross Margins**

Beef Cattle	☐	Beef Breeding Beef - Stores
Sheep	☒ x	
Intensive Livestock	☐	Beef Feedlot Pigs
Cropping (Dryland and/or Irrigated)	☐	(Maximum number = 15)
Horticulture	☐	(Maximum number = 15)
Trees	☐	

"Value" (price) of Carbon $23.00 **/ tonne (CO2-e)**

PASTURES and FARM AREAS

	hectares				
Total area of farm:	17.0	Livestock areas	17.0	Horticulture:	0.0
Total allocated to L/stock, Crops, Hort & Trees:	17.0	Cropping areas	0.0	Trees:	0.0
Remainder:	0				

Pasture areas:	hectares	Percent (%) of legume in the pastures		Area of pasture burnt each year (% of areas)	*Application of Nitrogen Fertiliser*	Area Fertilised (ha)	Quantity applied (Kgs/ha/yr)	% of Nitrogen in fertiliser
Dryland pastures - with legumes	17.0	2.9%	% 0.49	0.0%	Dryland pastures (legumes)	0.0	0.0	0%
Dryland pastures - other	0.0			0.0%	Dryland pastures (other)	0.0	0.0	0%
Irrigated pastures - with legumes	0.0	0.0%	% 0.00	0.0%	Irrigated pastures (legumes)	0.0	0.0	0%
Irrigated pastures	0.0			0.0%	Irrigated pastures (other)	0.0	0.0	0%
Total area of Pastures	17.0	Total area legume	0.5	0.0				

Note % legume can include mixed pasture (eg 30% lucerne, 70% native grasses)

from:	Feedlot	Piggery
Tonnes Waste (organic fertiliser):	0.0	0.0
Emissions (tonnes CO2-e):	0.0	0.0
Emissions (tonnes CO2-e) /tonne waste =	0.00	0.00

Do you want to include estimated GHG emissions from legume-based (i.e. Nitrogen-fixing) Pastures? YES

Calculation of GHG emissions from the legume pastures will require an estimate of the annual amount of residual pasture 'dry matter' (DM tonnes/ha) that is NOT:
a) eaten by stock
b) baled/silaged or
c) burnt.

	DM tonnes/ha	% legume content	Total Residual (legume) Dry Matter	
Dryland residual pasture	5.2	2.9%	2.6	tonnes/DM/year
Irrigated residual pasture	0.0	0.0%	0.0	tonnes/DM/year

% legume content is based on %value entered above

Savanna areas: (QLD & NTerritory only)	hectares	Area burnt each year
Savanna grasslands	########	500.0
Savanna woodland	########	100.0

The definition of 'savanna' is "...tropical and sub-tropical formations with continuous grass cover ocassionally interrupted by trees and shrubs". This includes monssonal through to semi-arid grasslands.

NOTE: Macros have been disabled to avoid "Virus warnings".
The file has been virus checked with latest virus software and should be safe if you wish to re-enable the macros.

Determination of Region & Lookup for WA Regions

Region =	**NSW / ACT**	
Western Australia	Others (blank)	
Select WA region		
South West	State/Territory Code:	1
Pilbara		
Kimberley		

FracWET default = **0**

State/Territory	Region	FracWET Codes 1=		Region No (Nathan's)
NSW / ACT	North Coast	NSW / A	0	10
NSW / ACT	South Coast	NSW / A	1	11
NSW / ACT	Northern Tablelands	NSW / A	0	12
NSW / ACT	Southern Tablelands	NSW / A	0	13
NSW / ACT	Northern Wheat/Sheep	NSW / A	1	14
NSW / ACT	Southern Wheat/Sheep	NSW / A	1	15
NSW / ACT	Western	NSW / A	0	16
Tasmania	North East	Tasman	1	17
Tasmania	East Coast	Tasman	0	18
Tasmania	Central North/Midlands/South	Tasman	1	19
Tasmania	Central Plateau/Derwent Valle	Tasman	1	20
Tasmania	West/South Coast	Tasman	1	21
Tasmania	North West	Tasman	1	22
Western Australia	South West	Western	1	1
Western Australia	Pilbara	Western	0	2
Western Australia	Kimberley	Western	1	3
Western Australia	Central West	Western	1	4
Western Australia	South Coastal	Western	0	5
Western Australia	Goldfields/Eucla	Western	0	6
Western Australia	Gascoyne	Western	0	7
Western Australia	Central Wheat Belt	Western	1	8
Western Australia	Interior	Western	0	9
South Australia	South East	South A	1	23
South Australia	Murray	South A	1	24
South Australia	Mid-North/Flinders	South A	0	25
South Australia	Pastoral	South A	0	26
South Australia	West Coast/Eyre	South A	0	27
Victoria	Mallee	VictoriaM	0	28
Victoria	Wimmera	VictoriaV	1	29
Victoria	Northern Country	VictoriaN	0	30
Victoria	North East Vic	VictoriaN	1	31
Victoria	East Gippsland	VictoriaE	1	32
Victoria	West/South Gippsland	VictoriaV	1	33
Victoria	Central	VictoriaC	1	34
Victoria	South West Vic	VictoriaS	1	35
Queensland	Central Highlands/Northern	Queensl	0	36
Queensland	Central West/Flinders	Queensl	0	37
Queensland	Channel Country	Queensl	0	38
Queensland	Maranoa/Warrego	Queensl	0	39
Queensland	Darling Downs/Burnett	Queensl	0	40
Queensland	North West/Gulf	Queensl	1	41
Northern Territory	Darwin-Daly	Northerr	1	42
Northern Territory	Arnhem-Roper	Northerr	1	43
Northern Territory	Victoria River-TennantCreek	Northerr	1	44
Northern Territory	Alice Springs	Northerr	0	45

Managing carbon in livestock systems: modelling options for net carbon balance (UNE/I&I NSW)

Partial results: GHG emissions ONLY

Wethers	0.00		0.00		0.00		0.00	

END of Data Entry Section

Greenhouse Gas Emissions

Default Emissions

	Tonnes /year	CO2 equivalent (tonnes/year) Total CO2-e	/ Hectare	/ DSE	/ Ewe
Methane (CH4) from Enteric =	0.53	11.14	0.66	0.10	0.24
Methane (CH4) from manure & urine =	0.00	0.00	0.00	0.00	0.00
Total Methane (CH4) =	0.53	11.14	0.66	0.10	0.24
Nitrous Oxide (N2O) from manure & urine =	0.01	1.75	0.10	0.02	0.04
	Total	12.89	0.76	0.11	0.27

Do you wish to change ("fudge") the final GHG estimates?

YES

Final "fudge" adjustment (to "Revised Emissions")

Direct emissions: Methane	Nitrous Oxide	***Indirect emissions*** Nitrous Oxide
0.0%		0.0%

Enter the % adjustment (+ or -)

Revised Emissions

	Tonnes /year	Total CO2-e	/ Hectare	/ DSE	/ Ewe	Difference: Tonnes CO2-e	%
Methane (CH4) from Enteric =	0.49	10.23	0.60	0.09	0.22	-0.91	-8.2%
Methane (CH4) from manure & urine =	0.00	0.00	0.00	0.00	0.00	0.00	-8.0%
Total Methane (CH4) =	0.49	10.23	0.60	0.09	0.22	-0.91	-8.2%
Nitrous Oxide (N2O) from manure & urine =	0.01	1.58	0.09	0.01	0.03	-0.16	-9.4%
	Total	11.81	0.69	0.11	0.25	-1.08	-8.3%
Total DSE's	113						
Total Breeding Ewes	47						

Lookup table column numbers -->	1	2	3	4	5	6	7	8	9	10	11	12
Season	Spring	Spring	Spring	Summer	Summer	Summer	Autumn	Autumn	Autumn	Winter	Winter	Winter
Numbers each month portioned by season (i.e. 1/3)												
Breeding Ewes	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	15.00	15.00	15.00	15.00
Maiden Ewes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other Ewes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lambs/Hoggets	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	0.00	0.00	0.00	0.00
Rams	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.33	0.00	0.00	0.00
Wethers	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Additional intake for milk production - source numbers (%):

Lookup table column numbers -->	1	2	3	4	5	6	7	8	9	10	11	12
Season	Spring	Spring	Spring	Summer	Summer	Summer	Autumn	Autumn	Autumn	Winter	Winter	Winter
Numbers each month as a portion (%) of total number on hand)												
Breeding Ewes - % lactating	94%	94%	94%	94%	0%	0%	0%	0%	0%	0%	0%	0%
Lambs/Hoggets - % receiving milk	100%	100%	100%	100%	0%	0%	0%	0%	0%	0%	0%	0%

Numbers for Gas Calculator

Class	NGGI Category	Season: Spring	Summer	Autumn	Winter
Breeding Ewes	Breeding Ewes	48	48	47	45
Maiden Ewes	Maiden Ewes	0	0	0	0
Other Ewes	Other Ewes	0	0	0	0
Lambs/Hoggets	Lambs/Hoggets	45	45	30	0
Rams	Rams	0	0	1	0
Wethers	Wethers	0	0	0	0
		93	93	78	45

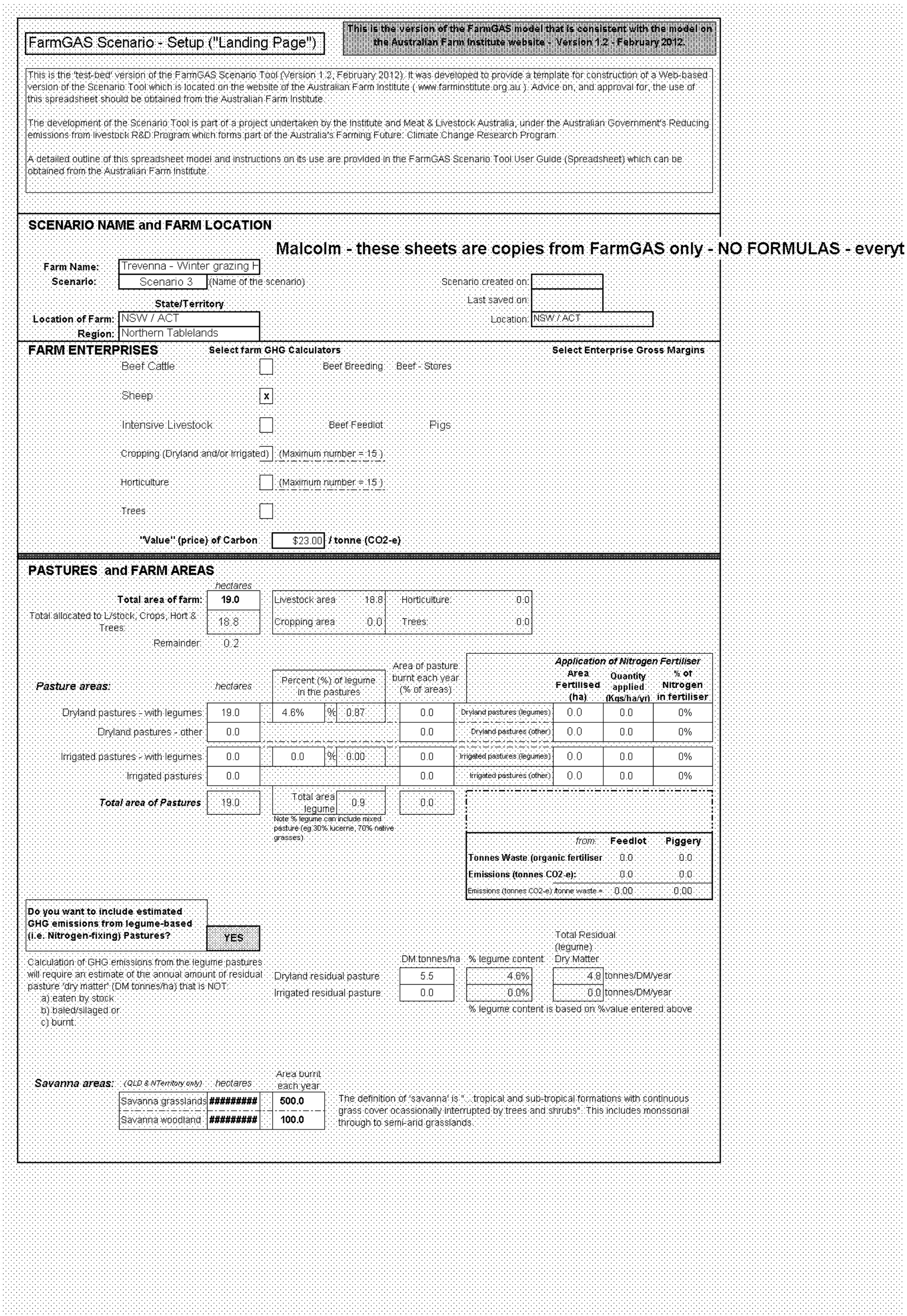
DSE Values & Total

/Hd	Total
2	94
1	0
1.2	0
0.6	18
3.0	1
1.0	0
TOTAL	**113**

Numbers for Gas Calculator - proportion lactating/receiving milk

Class	NGGI Category	Season: Spring	Summer	Autumn	Winter
Breeding Ewes - % lactating	Breeding Ewes	0.94	0.31	0.00	0.00
Lambs/Hoggets - % receiving milk	Lambs/Hoggets	1.00	0.33	0.00	0.00

FarmGas Calculations for High Productivity Landscape



FarmGAS Scenario - Setup ("Landing Page")

This is the version of the FarmGAS model that is consistent with the model on the Australian Farm Institute website - Version 1.2 - February 2012.

This is the 'test-bed' version of the FarmGAS Scenario Tool (Version 1.2, February 2012). It was developed to provide a template for construction of a Web-based version of the Scenario Tool which is located on the website of the Australian Farm Institute (www.farminstitute.org.au). Advice on, and approval for, the use of this spreadsheet should be obtained from the Australian Farm Institute.

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A detailed outline of this spreadsheet model and instructions on its use are provided in the FarmGAS Scenario Tool User Guide (Spreadsheet) which can be obtained from the Australian Farm Institute.

SCENARIO NAME and FARM LOCATION

Malcolm - these sheets are copies from FarmGAS only - NO FORMULAS - everyt

Farm Name: Trevenna - Winter grazing H
Scenario: Scenario 3 (Name of the scenario)
Scenario created on:
Last saved on:
State/Territory
Location of Farm: NSW / ACT
Region: Northern Tablelands
Location: NSW / ACT

FARM ENTERPRISES — **Select farm GHG Calculators** — **Select Enterprise Gross Margins**

Beef Cattle	[ ]	Beef Breeding Beef - Stores
Sheep	[x]	
Intensive Livestock	[ ]	Beef Feedlot Pigs
Cropping (Dryland and/or Irrigated)	[ ]	(Maximum number = 15)
Horticulture	[ ]	(Maximum number = 15)
Trees	[ ]	

"Value" (price) of Carbon $23.00 **/ tonne (CO2-e)**

PASTURES and FARM AREAS

	hectares				
Total area of farm:	**19.0**	Livestock area	18.8	Horticulture:	0.0
Total allocated to L/stock, Crops, Hort & Trees:	18.8	Cropping area	0.0	Trees:	0.0
Remainder:	0.2				

Pasture areas:	*hectares*	Percent (%) of legume in the pastures		Area of pasture burnt each year (% of areas)	*Application of Nitrogen Fertiliser*	Area Fertilised (ha)	Quantity applied (Kgs/ha/yr)	% of Nitrogen in fertiliser
Dryland pastures - with legumes	19.0	4.6% %	0.87	0.0	Dryland pastures (legumes)	0.0	0.0	0%
Dryland pastures - other	0.0			0.0	Dryland pastures (other)	0.0	0.0	0%
Irrigated pastures - with legumes	0.0	0.0 %	0.00	0.0	Irrigated pastures (legumes)	0.0	0.0	0%
Irrigated pastures	0.0			0.0	Irrigated pastures (other)	0.0	0.0	0%
Total area of Pastures	19.0	Total area legume	0.9	0.0				

Note % legume can include mixed pasture (eg 30% lucerne, 70% native grasses)

from:	Feedlot	Piggery
Tonnes Waste (organic fertiliser	0.0	0.0
Emissions (tonnes CO2-e):	0.0	0.0
Emissions (tonnes CO2-e) /tonne waste =	0.00	0.00

Do you want to include estimated GHG emissions from legume-based (i.e. Nitrogen-fixing) Pastures? YES

Calculation of GHG emissions from the legume pastures will require an estimate of the annual amount of residual pasture 'dry matter' (DM tonnes/ha) that is NOT:
a) eaten by stock
b) baled/silaged or
c) burnt.

	DM tonnes/ha	% legume content	Total Residual (legume) Dry Matter	
Dryland residual pasture	5.5	4.6%	4.8	tonnes/DM/year
Irrigated residual pasture	0.0	0.0%	0.0	tonnes/DM/year

% legume content is based on %value entered above

Savanna areas: *(QLD & NTerritory only)*	*hectares*	Area burnt each year
Savanna grasslands	#########	500.0
Savanna woodland	#########	100.0

The definition of 'savanna' is "...tropical and sub-tropical formations with continuous grass cover ocassionally interrupted by trees and shrubs". This includes monssonal through to semi-arid grasslands.

NOTE: Macros have been disabled to avoid "Virus warnings".

The file has been virus checked with latest virus software and should be safe if you wish to re-enable the macros.

thing has been copied only as values - Patrick

Determination of Region & Lookup for WA Regions

Region =	**NSW / ACT**	
Western Australia	Others (blank)	
Select WA region		
South West	State/Territory Code	1
Pilbara		
Kimberley		

FracWET default =	**0**

State/Territory	**Region**	**FracWET Codes 1**		**Region No (Nathan's)**
NSW / ACT	North Coast	NSW / /	0	**10**
NSW / ACT	South Coast	NSW / /	1	**11**
NSW / ACT	Northern Tablelands	NSW / /	0	**12**
NSW / ACT	Southern Tablelands	NSW / /	0	**13**
NSW / ACT	Northern Wheat/Sheep	NSW / /	1	**14**
NSW / ACT	Southern Wheat/Sheep	NSW / /	1	**15**
NSW / ACT	Western	NSW / /	0	**16**
Tasmania	North East	Tasmani	1	**17**
Tasmania	East Coast	Tasmani	[illegible]	**18**
Tasmania	Central North/Midlands/Sout	Tasmani	1	**19**
Tasmania	Central Plateau/Derwent Vall	Tasmani	1	**20**
Tasmania	West/South Coast	Tasmani	[illegible]	**21**
Tasmania	North West	Tasmani	1	**22**
Western Australia	South West	Westerr	1	**1**
Western Australia	Pilbara	Westerr	0	**2**
Western Australia	Kimberley	Westerr	1	**3**
Western Australia	Central West	Westerr	1	**4**
Western Australia	South Coastal	Westerr	0	**5**
Western Australia	Goldfields/Eucla	Westerr	0	**6**
Western Australia	Gascoyne	Westerr	0	**7**
Western Australia	Central Wheat Belt	Westerr	1	**8**
Western Australia	Interior	Westerr	0	**9**
South Australia	South East	South A	1	**23**
South Australia	Murray	South A	1	**24**
South Australia	Mid-North/Flinders	South A	0	**25**
South Australia	Pastoral	South A	0	**26**
South Australia	West Coast/Eyre	South A	0	**27**
Victoria	Mallee	Victorial	0	**28**
Victoria	Wimmera	Victoria'	1	**29**
Victoria	Northern Country	Victorial	0	**30**
Victoria	North East Vic	Victorial	1	**31**
Victoria	East Gippsland	Victorial	1	**32**
Victoria	West/South Gippsland	Victoria'	1	**33**
Victoria	Central	Victoria(	1	**34**
Victoria	South West Vic	Victoria:	1	**35**
Queensland	Central Highlands/Northern	Queensl	0	**36**
Queensland	Central West/Flinders	Queensl	0	**37**
Queensland	Channel Country	Queensl	0	**38**
Queensland	Maranoa/Warrego	Queensl	0	**39**
Queensland	Darling Downs/Burnett	Queensl	0	**40**
Queensland	North West/Gulf	Queensl	1	**41**
Northern Territory	Darwin-Daly	Northerr	1	**42**
Northern Territory	Arnhem-Roper	Northerr	1	**43**
Northern Territory	Victoria River-TennantCreek	Northerr	1	**44**
Northern Territory	Alice Springs	Northerr	0	**45**

Partial results: GHG emissions ONLY

Wethers	0.00		0.00		0.00		0.00	

END of Data Entry Section

Greenhouse Gas Emissions

Default Emissions

	Tonnes /year	CO2 equivalent (tonnes/year) Total CO2-e	/ Hectare	/ DSE	/ Ewe
Methane (CH4) from Enteric =	1.05	22.07	1.17	0.10	0.23
Methane (CH4) from manure & urine =	0.00	0.00	0.00	0.00	0.00
Total Methane (CH4) =	1.05	22.07	1.17	0.10	0.23
Nitrous Oxide (N2O) from manure & urine =	0.01	3.48	0.19	0.02	0.04
	Total	25.56	1.36	0.11	0.27

Do you wish to change ("fudge") the final GHG estimates?

NO

Final "fudge" adjustment (to "Revised Emissions")

Direct emissions:		*Indirect emissions*
Methane	Nitrous Oxide	Nitrous Oxide
0.0%		0.0%

Enter the % adjustment (+ or -)

Revised Emissions

	Tonnes /year	Total CO2-e	/ Hectare	/ DSE	/ Ewe	Difference Tonnes CO2-e	Difference %
Methane (CH4) from Enteric =	0.99	20.82	1.11	0.09	0.22	-1.25	-5.6%
Methane (CH4) from manure & urine =	0.00	0.00	0.00	0.00	0.00	0.00	-5.2%
Total Methane (CH4) =	0.99	20.83	1.11	0.09	0.22	-1.25	-5.6%
Nitrous Oxide (N2O) from manure & urine =	0.01	3.27	0.17	0.01	0.03	-0.21	-6.2%
	Total	24.09	1.28	0.11	0.25	-1.46	-5.7%
Total DSE's	226						
Total Breeding Ewes	96						

Lookup table column numbers -->	1	2	3	4	5	6	7	8	9	10	11	12
Season	Spring	Spring	Spring	Summer	Summer	Summer	Autumn	Autumn	Autumn	Winter	Winter	Winter
Numbers each month portioned by season (i.e. 1/3)												
Breeding Ewes	32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00
Maiden Ewes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other Ewes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lambs/Hoggets	31.33	31.33	31.33	31.33	31.33	31.33	31.33	0.00	0.00	0.00	0.00	0.00
Rams	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67	0.67	0.00	0.00
Wethers	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Additional intake for milk production - source numbers (%):

Lookup table column numbers -->	1	2	3	4	5	6	7	8	9	10	11	12
Season	Spring	Spring	Spring	Summer	Summer	Summer	Autumn	Autumn	Autumn	Winter	Winter	Winter
Numbers each month as a portion (%) of total number on hand)												
Breeding Ewes - % lactating	100%	100%	100%	100%	0%	0%	0%	0%	0%	0%	0%	0%
Lambs/Hoggets - % receiving milk	100%	100%	100%	100%	0%	0%	0%	0%	0%	0%	0%	0%

Numbers for Gas Calculator		Season			
Class	**NGGI Category**	**Spring**	**Summer**	**Autumn**	**Winter**
Breeding Ewes	Breeding Ewes	96	96	96	96
Maiden Ewes	Maiden Ewes	0	0	0	0
Other Ewes	Other Ewes	0	0	0	0
Lambs/Hoggets	Lambs/Hoggets	94	94	31	0
Rams	Rams	0	0	1	1
Wethers	Wethers	0	0	0	0
		190	190	128	97

DSE Values & Total /Hd	Total
2	192
1	0
1.2	0
0.6	33
3.0	1
1.0	0
TOTAL	**226**

Numbers for Gas Calculator - proportion lactating/receiving milk		Season			
Class	**NGGI Category**	**Spring**	**Summer**	**Autumn**	**Winter**
Breeding Ewes - % lactating	Breeding Ewes	1.00	0.33	0.00	0.00
Lambs/Hoggets - % receiving milk	Lambs/Hoggets	1.00	0.33	0.00	0.00

Impacts of a two degree increase in temperature on pasture growth in the Northern Tablelands of New South Wales

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[b] *NSW Department of Primary Industries, Ring Road Armidale NSW 2351*

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Abstract: Sheep production is the major contributor to the agricultural economy of the Northern Tablelands of New South Wales. In 1996/97 $109.1 million was derived from sheep production. There is a pressing need for agricultural industries to reduce their carbon footprint and global warming is a major concern. This study has simulated a sheep production system of a 36 ha research station called 'Trevenna' located at the University of New England, Armidale (30^o 30'S 151^o 40' E). The 'Trevenna' site has been set up as a demonstration site for producers, advisers, students, and researchers to gain insight into how to estimate and measure livestock enteric methane emissions.

The Sustainable Grazing Systems (SGS) model was used to simulate, over 50 years, pasture growth on the 'Trevenna' demonstration site . Simulations contrasted the impacts of a 2^{o}C change in temperature on herbage mass (t/ha) and pasture growth rate (kg C/ha/day). A validation check indicated that the predicted values from 1st Sep 2010 to 30th March 2011 fell within 10% of the observed values.

There was no effect of the 2^{o}C increase in temperature on green herbage mass ($P > 0.05$) but a significant difference for dead herbage mass and pasture growth rate ($P < 0.05$). The increase in dead herbage mass is discussed.

A significant effect of temperature on botanical composition ($P < 0.05$) was found with an increase in C4 native grasses (e.g. kangaroo grass, red grass, and wire grass) at the expense of other pasture species present in the sward. The impact of a 2^{o}C increase in temperature reduced the number of frosts (defined as mornings below 2^{o}C) and number of severe frosts (defined as mornings below 0^{o}C).

In conclusion, a 2^{o}C increase in temperature on the Northern Tablelands of New South Wales can be expected to increase pasture growth, particularly of C4 species, so supporting an increase in herbage mass.

Keywords: *Climate change, decision support system, herbage mass, senescence*

1. INTRODUCTION

A large proportion of the Northern Tablelands in New South Wales is grazed for sheep production, particularly fine-wool flocks. Within these grazing systems the majority of pastures are a combination of introduced, improved, and native species. The total value of agricultural production on the Northern Tablelands in 1996/97 was estimated at $217.8 million: 50.1% derived from sheep production; 41.7% derived from wool production; and 8.4% from prime lamb production (Alford et al., 2003). Herbage mass (kg DM/ha) is a key determinate of stocking rate that an enterprise can carry and therefore the amount of animal product that can be generated. Climate variability is a major issue confronting agriculture. There is a pressing need for agricultural industries to reduce their carbon footprint. Agricultural emissions (methane (CH_4) and nitrous oxide (N_2O)) comprise 16% of Australia's total emissions, and livestock emissions (enteric fermentation and manure management) contribute 69% of agricultural emissions (Department of Climate Change and Energy Efficiency 2010). Therefore, it is of great interest to determine the effects of a change in temperature on pasture production. Several studies have estimated the effects of an increase in minimum and maximum temperature on pasture production (Thornley and Cannell, 1997, Cullen et al., 2009). However, no specific studies on the Northern Tablelands have been undertaken. This study has simulated a sheep production system on a 36 ha research station called 'Trevenna' located at the University of New England, Armidale (30^{o} 30'S 151^{o} 40' E) using the Sustainable Grazing Systems (SGS) model (Johnson et al., 2003).

The objective of this study was to evaluate the impact of a 2^{o}C increase in temperature on pasture growth within a sheep production enterprise on the Northern Tablelands of New South Wales, Australia.

2. MATERIAL AND METHODS

2.1 Trevenna Demonstration Site

The Trevenna demonstration site, located at the University of New England, on the Northern Tablelands of New South Wales (30^{o} 30'S 151^{o} 40' E) comprises 36 ha, split between high and low productivity systems. An overview of the site has been described by McPhee et al. (2010). The 'Trevenna' demonstration site has been subdivided into 18 paddocks: 9 allocated for high productivity improved pastures and 9 allocated for low productivity predominately native pastures. The paddocks averaged 2ha ranging from 1.8-2.2 ha. Each landscape was classified into classes (A, B and C) based on an EM38 electromagnetic induction survey. Within each class 3 paddocks were allocated. There were 6 flocks: 3 high and 3 low productivity flocks. Flocks were rotationally grazed through 3 paddocks so that each flock had a turn in each landscape class (A, B and C). The high productivity flocks were stocked at 6.7 DSE/ha (i.e. 32 ewes and single lambs rotationally grazing 6ha) and the low productivity flocks were stocked at 3.7 DSE/ha (i.e. 16 ewes and single lambs rotationally grazing 6ha).

2.2 Data Collection

Data has been collected to feed into decision support systems to estimate the amount of methane produced. The data collected will also be used as inputs to greenhouse inventory calculators (e.g. FarmGas (2010)).The measurements taken include:

- Soil moisture measurements taken on a weekly basis. Measurements were taken using a Diviner moisture probe (Sentek Technologies, Sydney). The moisture probe used was a capacitance probe that uses the electrical conductivity of a soil to determine the moisture content (Thomas, 1966). The access tubes were located within one paddock of each land class within each landscape. The measurements were taken in 10cm increments to a depth of 50cm.
- Herbage mass measurements were undertaken on a monthly basis when the animals were rotated between paddocks. Pre and post grazing measurements were undertaken using the median quadrat technique (Bell, 2007). A scan of each quadrat was taken using a Crop Circle (Holland Scientific equipment model ACS210) scanner. The data from the observed values and the scans have been used to develop a Normalised Difference Vegetation Index (Trotter et al., 2010)
- Botanical compositions were conducted 4 times per year, once per season using the method described by Tothill et al. (1992).
- Lambs were weighed on a monthly basis, when mobs were rotated between paddocks. These monthly lamb weights were recorded using their National Livestock Identification System Radio Frequency Identification tag. Condition score, fleece weights, and quality of fleece were also recorded.

2.3 Simulation

The SGS model (Johnson, 2003) was used to perform a 50 year simulation of high and low productivity sheep production systems. The soil parameters in the SGS model were stabilised over a 10 year period from 1960 to 1970 before a full 50 year simulation from 1960-2010 was conducted. Each of the 2 landscapes was modelled separately for 3 flocks on each landscape that was rotational grazed across 3 paddocks using the information recorded from the Trevenna site (McPhee at al., 2010). Data used from the site included: herbage mass, species composition and stocking density. Table 1 reports the input values used in the simulations.

Within the SGS model supplementary feeding was established to begin feeding when ewes dropped below 40kg liveweight. Below this weight forage and concentrate supplements were fed at a rate calculated by the model to produce liveweight gains. The implementation of

Table 1. Input values used in the SGS model for ‘Trevenna’

Variable	Value
Farm	
Number of ewes	16 low productivity 32 high productivity
Farm Area	36ha
Paddocks	9 high productivity, 9 low productivity
Paddock Areas	1.8-2.2ha
Rotation	30 days each paddock
Irrigation	None
Soil	
Bulk Density	1.3g/cm^3
Saturated point	48% of Volume
Field Capacity	35% of Volume
Permanent Wilting point	16% of Volume
Fertiliser	
Application	May each year
Nitrogen- Urea	70[2]kg/ha Urea
Phosphorous	20[1]kg/ha
Sulphur	25[2]kg/ha
Animal	
Animal growth curve	Sigmoidal
Flocks	3 high productivity 3 low productivity
Mature liveweight of ewe	47kg
Starting liveweight of ewe flocks 1-6[3]	43.0,44.7,46.3, 44.1, 45.3,44.5kg
Minimum liveweight of ewe	35kg
Lambing date	12-Sep
Days from Birth to Removal	200
Average Lambs per ewe	1

1. 10kg/ha yearly after first application
2. no application after first year
3. flocks allocated to landscape classes as

supplementary feeding within the SGS model occurred when the pasture quantity and quality was insufficient to maintain liveweight. Actual on-farm supplementary feeding was supplied to ewes as per the UNE animal ethics requirements.

The simulation was run using historical weather data for Armidale Airport Automatic Weather Station, NSW (30.5^{o}S 151.6^{o}E) (BOM, 2011). The initial pasture availability at the beginning of September 2010 was used as the starting herbage mass 1st September, 1960. The botanical composition assessment conducted in September was used as inputs to the SGS model. The soil nutrients and water values were used from the normalised values obtained in the 10 year scenario (1960-1970). Following the simulation the data produced was processed using the Post Processor 3 program. The program specifically developed as part of the SGS project summarising the model output (Anon., 2011). The data was processed to provide monthly summaries of all factors. Following the historical simulation the weather data was combined with the CSIRO Mk 3.5 Model following the A2, medium emissions scenario, using the climate downscaling software tool WeatherMaker (Gordon et al., 2010). The daily weather output file from this program was used as the observed weather values for the SGS model where the minimum and maximum temperatures were increased by 2^{o}C. These weather values were then used with the same initial conditions for the historical weather data (baseline) scenario (i.e. 2 simulations were conducted: (1) baseline; and (2) a 2^{o}C increase in minimum and maximum temperatures of the baseline year).

To ensure accuracy of the model the baseline simulation was run from the 1st September 2010 through to the 31st of March 2011. This enabled the predicted values from the simulation to be compared to the observed values of herbage mass, botanical composition, soil moisture and lamb weights.

2.4 Statistical Analysis

The results from the simulation were analysed using the statistical package R (R Development Core Team, 2005). An analysis of variance was performed to compare the differences in herbage mass and pasture growth with a 2^{o}C increase in temperature. No statistical interpretation between landscapes can be made because only 1 year of the experiment has been conducted (i.e. not a replicated study). This study only evaluates the difference between the baseline and the 2^{o}C increase in temperature.

3. RESULTS

Following the 50 year simulation the observed versus predicted values of herbage mass, botanical composition, soil moisture, and lamb weights from 1st Sep 2010 to 30th March 2011 were found to be consistent and fell within 10% of the observed values, giving confidence in interpretation of modelled impacts on pasture growth over the 50 year time frame

The 50 year simulation showed no statistical difference ($P > 0.05$) between the baseline and 2^{o}C increase in temperature simulations for green herbage mass or total herbage mass, but a significant difference ($P < 0.05$) for dead herbage mass (Table 1). Nevertheless the 2^{o}C increase did increase total herbage mass compared to the baseline climate data (Table 1).

Table 1. Mean and standard deviation (SD), over 50 year simulation, green, dead and total herbage mass (tDM/ha) and mean gross positive growth rate[1] (kg carbon/ha/day) across sheep enterprises grazing low or high productivity landscapes, in the presence of historical temperatures (Baseline) and 2^{o}C increase in temperature

Landscape	Climate Scenario	Green Herbage Mass (tDM/ha)	SD	Dead Herbage Mass (tDM/ha)	SD	Total Herbage Mass (tDM/ha)	SD	Gross Positive Growth Rate[1] (kg C/ha/day)	SD
Low	Baseline	1.19	0.54	1.20^{a}	0.47	2.39	0.97	18.50^{a}	5.49
Low	2^{O} increase	1.26	0.58	1.37^{b}	0.57	2.63	1.03	20.56^{b}	7.00
High	Baseline	1.64	0.52	0.92^{a}	0.32	2.28	0.75	33.01^{a}	11.91
High	2^{O} increase	1.57	0.67	1.17^{b}	0.41	2.73	1.10	35.56^{b}	13.26

Differing superscripts in same column are significantly different ($P < 0.05$)

[1.] gross positive growth rate= daily gross photosynthesis + remobilised carbon from senescent tissue (Johnson, 2008)

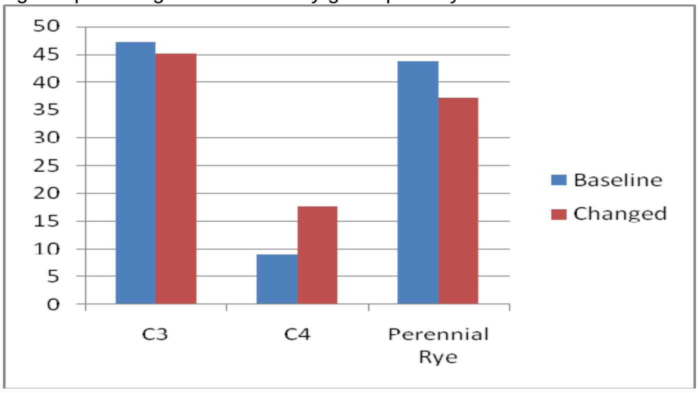

Figure 1. Predicted species abundance (%) across 50 year simulation of the high productivity landscape between Baseline

A lower amount of supplement was fed during the changed climate scenario, as a result of the greater herbage mass. In both the baseline and changed scenarios the concentrate intake was lower in the high productivity landscape, compared to the low productivity landscape.

In terms of the botanical composition the high productivity landscape (Figure 1) was statistically significant ($P < 0.05$) for all pasture species (C3 (e.g., weeping grass and common wheatgrass), C4 (e.g. kangaroo grass, red grass, and wire grass), White Clover, Perennial Rye) between the baseline and changed scenarios. However for the low productivity landscape (Figure 2) only C4 and Perennial Rye were statistically significant ($P < 0.05$) between the baseline and changed scenarios.

4. DISCUSSION

The higher gross positive growth rate (daily gross photosynthesis + remobilised carbon from senescent tissue) that occurred in the high productivity landscape compared to the low productivity landscape in both climate scenarios may be attributed to the botanical composition. Robinson and Archer (1988) showed that introduced species have a higher growth rate compared to native species. The low productivity landscape class consists predominantly of native pasture species, while the high productivity landscape consists of introduced perennial species (McPhee et al., 2010). The high productivity landscape is more responsive to additional fertility and to water, exhibiting a faster growth rate. The increase in growth rate as a result of a 2^{o}C increase is due to the warmer temperatures experienced and lower frost damage to plants.

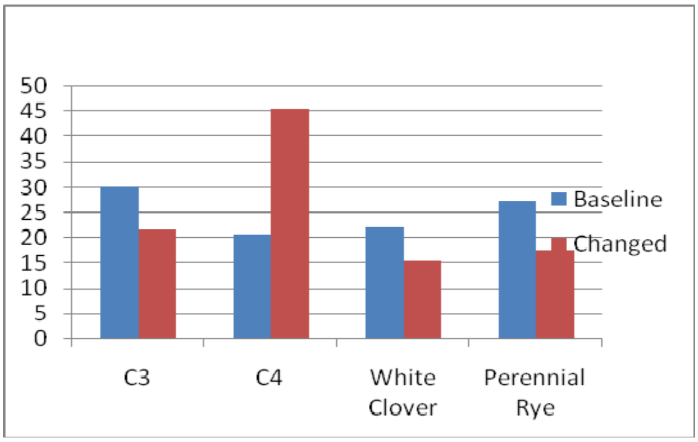

Figure 2. Predicted species abundance (%) across 50 year simulation of the low productivity landscape between Baseline (historical temperatures) and 2^{o}C increase in temperature (Changed).

The herbage mass present is a function of the growth rate and number of animals grazing. The results from this study show that a difference in pasture growth rate occurred when the minimum and maximum temperatures were increased by 2^{o}C and consequently a change in herbage mass. As the stocking rates were unchanged, the pasture consumption was unchanged. A net increase in herbage mass occurred because the stocking rate and consequently intake did not change.

As the temperature increased the number of frosts, (defined as mornings below 2^{o}C) was reduced. The number of severe frosts, (defined as mornings below 0^{o}C) also declined. The lower number of mild and severe frosts therefore increased the growth rate as the low temperature effects are reduced (Ludlow, 1980). This effect is more pronounced in the Spring and Autumn, as the mean minimum temperature during the Northern Tablelands winter is 0.95^{o}C (BOM, 2011). An increase in 2^{o}C results in the temperature remaining below the lower critical temperature of C4 grasses (4^{o}C) (Ivory and Whiteman, 1978). Hence, even in the warmer climate, cold temperatures remain a restriction to pasture growth. A reduction in pasture growth rate on the low productivity landscape may have occurred due to the high proportion of native C4 grasses (Figure 2). A mean increase of 2^{o}C will increase the mean minimum temperature to 2.95 degrees. This is above the lower critical temperature of many temperate introduced species, allowing increased pasture growth rate on the high productivity landscape.

The small increase in green herbage mass on the low productivity scenario in response to an increase in temperature may have occurred because of the reduction in plant death associated with reduction in frosts. This is contrasted with the decrease in green herbage mass that occurs in the high productivity landscape as a result of the 2^{o}C increase (Figure 1). This could have occurred on the low productivity landscape as a result of increased pasture intake and a decrease supplementary feed intake. Gurung et al. (1994) showed that sheep will graze green herbage in preference to dead.

The results from this study show that the increased proportion of C4 grasses that were found to be present as the temperature increased may be attributed to the temperature increase favouring their growth and therefore increasing the C4 herbage mass present in the sward. The magnitude of the increase was similar in both landscapes, approximately doubling in prevalence as the temperature increased.

In conclusion a 2^{o}C increase in minimum and maximum temperatures significantly increased pasture growth rate and the species abundance of the C4 grasses present in the sward; with this resulting in part from reduced frost impact on these species in warmer conditions. As stocking rate was not changed in the model, the extra pasture growth at the warmer temperature led to an increased accumulated mass of dead pasture.

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