Impacts of Vegetation Thickening on Woodland Stocking Rates for the Murweh Shire

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October 2003

An equation relating carrying capacity to tree cover density for grazed woodlands.

Carrying capacity (CC) is a function of forage growth (FG), which is in turn determined by a number of variables, one of which is tree cover density.

The algorithms required to model CC for the south west Queensland region (including the Murweh Shire) were developed as a result of the Safe Carrying Capacity project (SCC) undertaken by the Queensland Department of Primary Industries in the 1990's.

This model has been substantially ground truthed at the individual property level and is widely accepted by both landholders and government, to the extent that use of the model to assess property capability and viability has been a compulsory component of government schemes of assistance in the region.

The model works as a three step process;

1. Potential Forage Growth (PFG) for an area of land is calculated,

   $$PFG(kg) = RUE(kg/ha/mm) * VPDI * RAIN(mm) * AREA(ha)$$

   RUE: Rainfall Use Efficiency of the subject land system
   VPDI: Vapour Pressure Differential Index
   RAIN: Annual Average Rainfall
   AREA: Area of the subject Land System

2. PFG is discounted for the prevalence of woody species to determine FG. The discount factor (WI) is a function of canopy Foliage Projective Cover (FPC).

   $$FG(kg) = PFG(kg) * WI * 1.168$$

   $$WI = 1.008 - 0.945 * (1 - e^{0.105 * FPC})^{(0.55 + 1.00)}$$

3. FG is converted to a 'safe' carrying capacity by considering the 'safe' level of forage utilization.

   $$CC(dse) = [FG(kg) * Safe\ utilization\ \%] / Annual\ consumption\ per\ dse\ (kg)$$

The term 'safe' carrying capacity means the maximum long term average carrying capacity at which no change, or a gradual improvement, in land condition is experienced.

Combining these equations, the CC for the shire is determined as follows:

$$Shire\ CC = \frac{\{RUE * VPDI * RAIN * AREA * WI * 1.168 * Safe\ Utilisation\ \%\}}{Annual\ consumption\ per\ dse}$$

Isolating the variables

The model was developed to assess carrying capacity at a property level. The difficulty with applying the model across the entire shire lies in isolating the individual variables on a 'whole of shire' basis, some of these are easily determined, whilst others require more effort. The determination of each individual variable is outlined below:

Safe Utilisation %

In the development of the model considerable effort was expended in determining what is a 'safe' utilization %. Having regard to the information presented regarding these studies by Johnston *et. al.* (1996) a figure of 25% (0.25) can be adopted.

Annual consumption per DSE

The figure adopted by the SCC was 400kg (Johnston *et. al.* 1996). This figure has been adopted in our study.

AREA

The area of the Murweh Shire is 4,069,000 Ha. However for the purposes of this study we are only interested in the existing woodlands, therefore natural grasslands and cleared areas can be excluded from the total. The Statewide Landcover and Trees Study (2003) provides us with a base figure for wooded vegetation in the shire of 59.68% (2,428,380 ha) for (approximately) September 1999 and states that the average rate of clearing in the shire for the ensuing two year period was 90,903 ha / annum. If this clearing rate is extrapolated out until the date of the moratorium (16 May 2003) the wooded vegetation in the shire at that date would be approximately 2,095,069 ha. This figure has been adopted for this study.

VPDI

The VPDI (Vapour Pressure Differential Index) was developed and included to allow for differences in evaporation across the SCC study area (south west Queensland). Given that the Murweh Shire is only a small subset of the SCC study area, and that VPDI does not vary widely across it, it is felt that a constant VPDI of 1.00 (the value is indexed to Charleville in the geographic centre of the shire) could be adopted without compromising the validity of the model.

RAIN

Obviously rainfall is a key determinant of PFG. A rainfall gradient exists across the Murweh Shire, and therefore needs to be considered. A consideration of the location of rainfall isohyets across the shire (see Appendix 2) shows that the shire is reasonably centrally located between the 400mm and 600mm isohyets. We have therefore adopted an average value for RAIN of 500mm for the entire shire.

RUE

The Carrying Capacity model developed RUE values (the efficiency with which a given land system will convert rainfall to Kg of forage) for each WARLUS (Western Arid Region Land Use Study) land system present in the study area. WARLUS (QDPI Division of Land Utilization 1974-1990) identified and mapped land systems down to a scale of 1:250,000 and consequently there are 1,787 different polygons mapped within the shire. Whilst it is theoretically possible to calculate the CC for each of these areas and then total these to give a shire CC, given the limited time available we have totaled the areas for each land system represented in the mapping and calculated the relative percentage of each, then used their respective RUE's to calculate a weighted average RUE for the shire. In determining this weighted average RUE we have excluded from the calculations those land systems which comprise the naturally open *astrebla spp.* grasslands as we are instructed to isolate our study to the timbered areas of the shire.

A problem we needed to overcome is that 929,800 ha of the shire (the portion east of longitude 147) is not covered by WARLUS data. We have made an adjustment to the shire weighted average RUE for this area by adopting for it a weighted average RUE of an adjacent ‘surrogate’ area which we have selected because in our experience the ‘surrogate’ area would have a similar mix of WARLUS land systems than that portion for which WARLUS data is unavailable.

Weighted average RUE for wooded land types covered by WARLUS = 1.893 (2,862,000ha)

Adopted RUE for wooded land types not covered by WARLUS = 1.957 (929,800ha)

Weighted average of above two areas = 1.908

By inserting the variables outlined above into the model, we can describe the carrying capacity of the Murweh Shire’s woodlands (CCMSW) as:

$$\mathbf{CCMSW} = \frac{1.908 * 1 * 500 * 2{,}095{,}069 * WI * 1.168 * 0.25}{400}$$

$$= 1{,}452{,}930 * WI$$

In other words, if WI = 1 (that is, if there was no effect from woody species) the Carrying Capacity of the Murweh Shire Woodlands is estimated by the model to be 1,452,930 DSE.

To express this in DSE / Ha we need only divide the result by the area of woodlands in the study:

$$CCMSW / ha = \frac{1{,}452{,}930 * WI}{2{,}095{,}069}$$

$$= 0.6935 * WI$$

Determining WI

Having determined values for the other variables we can now focus our attention on WI. The SCC model was developed for use at a property level, and therefore WI has normally been determined by manually measuring Projected Foliage Cover (FPC) and converting it to WI using the equation provided earlier. However given the extensive area covered by the shire, sampling and averaging the FPC of all woodlands is not practical, therefore data has been obtained from the Statewide Landcover and Trees study, which obtains data by remote sensing which is then able to be translated to FPC. The nearest date to the start of the moratorium for which data is available is from September 2001. FPC for the wooded area of the shire for this date is estimated by SLATS to be 23.6%.

$$WI = 1.008 - 0.945 * (1 - e^{0.105 * FPC})^{(0.55 + 1.00)}$$

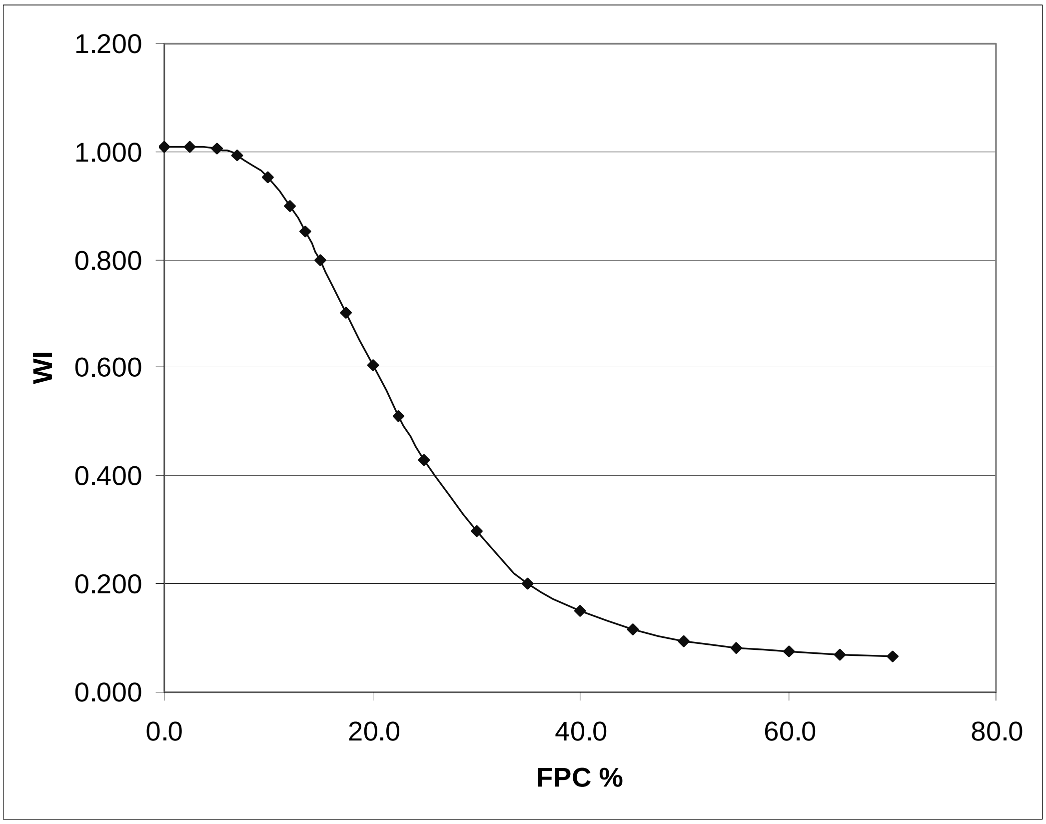
$$= 1.008 - 0.945 * (1 - e^{0.105 * 23.6})^{(0.55 + 1.00)}$$

$$= 0.4734$$

If we insert this value into the SCC equation we obtain a value for CCMSW of 687,817 dse and a value for CCMSW / ha of 0.328 dse/ha.

An FPC of 23.6% places the shires woodlands on the steepest portion of the slope for this curve as demonstrated on figure 1 which graphs this relationship.

Figure 1: Relationship of WI to FPC



If we adopt an FPC of 23.6% for the date of commencement of the moratorium, assume no further management of woody vegetation is undertaken, and FPC is assumed to increase at 1% per year, then the SCC model predicts the impacts on Carrying Capacity for the currently wooded areas of the shire over the next 20 tears as shown on the following table (Table 1) and Graph (Figure 2).

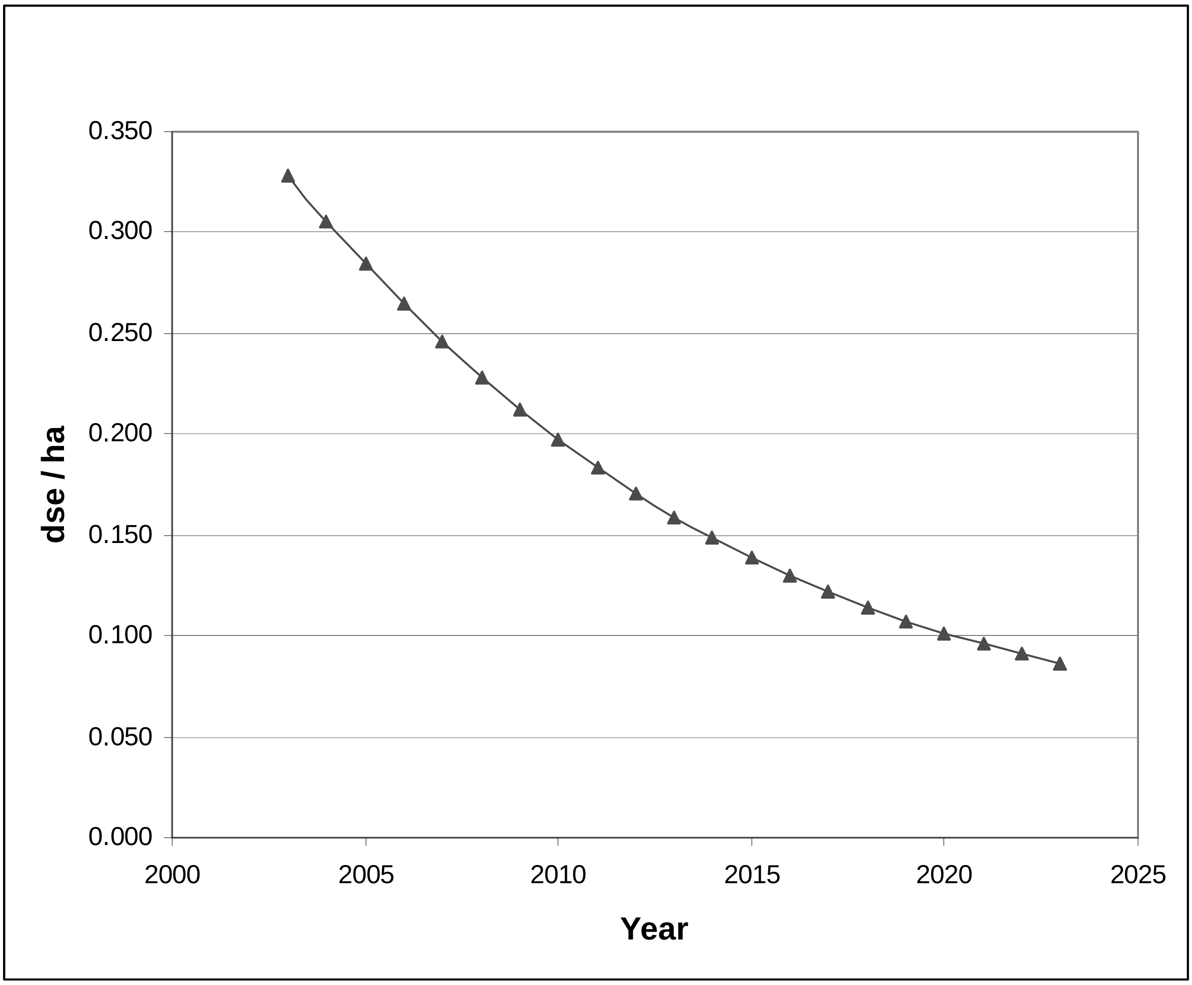
1% per year increase in FPC

The 'rule of thumb' 1% increase in FPC per year is not to our knowledge supported by published data. The figure is based on studies undertaken by Dr Ian Beale (formerly Charleville Pastoral Laboratory – QDPI) and was developed by comparing FPC measurements taken from 1960's and 1990's aerial photography for a range of undisturbed locations in and around the Murweh Shire. FPC was measured from the aerial photography by scanning the images and converting the digital images to binary rasters by using a pixel threshold to pick up the tree canopy. An average increase of approximately 1% per year in FPC was found for each location studied.

Table 1: Safe Carrying Capacity Project Modeling - Estimated Impacts of Vegetation Thickening on Carrying Capacity for the Murweh Shire Woodlands

Year	FPC	WI	CC (total dse)	CC (dse/ha)
2003	23.6	0.4734	687,817	0.328
2004	24.6	0.4409	640,597	0.306
2005	25.6	0.4102	595,992	0.284
2006	26.6	0.3813	554,002	0.264
2007	27.6	0.3546	515,209	0.246
2008	28.6	0.3292	478,305	0.228
2009	29.6	0.3059	444,451	0.212
2010	30.6	0.2844	413,213	0.197
2011	31.6	0.2645	384,300	0.183
2012	32.6	0.2462	357,711	0.171
2013	33.6	0.2294	333,302	0.159
2014	34.6	0.2140	310,927	0.148
2015	35.6	0.2000	290,586	0.139
2016	36.6	0.1871	271,843	0.130
2017	37.6	0.1754	254,844	0.122
2018	38.6	0.1647	239,298	0.114
2019	39.6	0.1550	225,204	0.107
2020	40.6	0.1462	212,418	0.101
2021	41.6	0.1382	200,795	0.096
2022	42.6	0.1309	190,189	0.091
2023	43.6	0.1244	180,744	0.086

Figure 2: Safe Carrying Capacity Project Modeling - Projected Impact of Vegetation Thickening on Carrying Capacity for the Murweh Shire Woodlands



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