7.0 CLOSING DISCUSSION AND CONCLUSIONS

In this thesis the role of modelling at a level useful for managing native pastures was described. An approach based on ecological principles was used to estimate sustainable "safe" long-term grazing capacities for individual properties in south-west Queensland. The methodology using systems analysis and modelling entailed:

1. Collection of net primary production data from the dominant land systems in south-west Queensland (Chapter 3);
2. Calibration of the plant production model GRASP for each of these land systems using these data (Chapter 4);
3. Validation of the plant production model GRASP using independent data from south-west Queensland (Chapter 4);
4. Combination of model outputs and resource inventories for individual land systems to estimate average pasture growth. Analysis of grazing practices on individual benchmark properties in conjunction with grazing trials to estimate "safe" levels of forage utilisation (15%-20%) for any location in south-west Queensland (Chapter 5);
5. Examination of real-time forage utilisation on 46 properties over the period 1986 to 1988 (Chapter 5); and,
6. Application and evaluation of a method for use by land managers and administrators for the estimation of "safe" grazing capacities for individual properties and the identification of the strengths and weaknesses of the approach (Chapter 5 and 6).

The hypothesis to be tested was that through the measurement of key plant production relationships, and extrapolation of these over time and space, that grazing capacities for individual properties could be estimated, and related to sustainable levels of forage utilisation.

Results from Chapters 3 to 5 support this hypothesis.

Chapter 3 indicated that primary production from a range of land systems could be measured and related to water use (evapo-transpiration) over short periods of time. The impact of the vapour pressure deficit (VPD) on water use efficiency and subsequent estimates of pasture growth was highlighted. The effects of tree basal area, total soil nitrogen and phosphorus, a moisture index and species composition (C3 vs C4) on pasture productivity and nitrogen utilisation were also indicated. Regression analysis using simple multiplicative indices of these factors explained up to 97% of the variation in the data for the time period under observation. However, the successful extrapolation of these results required the use of simulation modelling to handle the temporal and spatial variability in forage production relationships. Lauenroth *et al.* (1986) and Redman (1992) suggested this approach was the most promising procedure to estimate above-ground net primary production.

In Chapter 4, calibration, validation and extrapolation results indicated the suitability of using the GRASP model in a modelling approach to predict long-term patterns of forage production in south-west Queensland. From the results of simulations extrapolating the point based data, equations based on the water use efficiencies (rainfall) for selected pasture types were developed to estimate forage growth at a regional scale.

Some limitations of the version of the GRASP model used (version GVT74) were identified and described in Chapter 4 and are summarised in Table 7.1. The question arose as to the level of accuracy

required. Methods for sampling and calculating above-ground net primary production were chosen at a similar level of resolution as the objectives of the study (Singh *et al.* 1975). In order to estimate long-term "safe" grazing capacities of properties in south-west Queensland, predictions of annual patterns of forage production were required. Short term fluctuations in forage production, although important for grazing management on seasonal basis, were less relevant to the long-term requirements of this study and the limitations of the GRASP model (version GVT74) (Table 7.1) while real, were considered less relevant to the examination of long-term forage production. The use of water use efficiencies (kg/ha/mm rainfall) to simplify model output adequately estimated long-term fluctuations in forage production (Table 4.8).

Table 7.1 Limitations identified in the GRASP model (version GVT74) during calibration to nine sites and validation with 6 data sets from south-west Queensland and the impact of these limitations on the estimation of "safe" grazing capacities.

Limitation	Impact on "safe" grazing capacity estimations.
1. Over-estimation of soil moisture in dry profiles.	Over-estimation of calculated rainfall use efficiency, forage growth and grazing capacity.
2. Under-estimation of soil moisture in wet profiles.	Under-estimation of calculated rainfall use efficiency, forage growth and grazing capacity. Over a number of years it is likely this limitation and the one above would cancel each other.
3. Rapid wetting and drying of the profile not predicted for cracking clay soils.	Short term changes in green cover and forage growth may not be predicted. This would have an impact on the prediction of shorter term stocking rates. However, as the impact on predicting the end of season yield was small the impact on longer-term grazing capacities would also be small.
4. Rates and timing of detachment of plant material not well predicted.	May lead to an under or over-prediction of forage yield, rainfall use efficiency and grazing capacity. This would have a greater impact on the prediction of shorter term stocking rates and over time a smaller impact on grazing capacities.
5. Under-estimation of peak yield.	Conservative estimation of calculated rainfall use efficiencies, forage growth and grazing capacity.
6. Inability to accommodate multiple species (e.g. annual/ephemeral species, mixes of C3 and C4 species and change over time in species composition).	Inability to include pasture quality and species change in the estimation of grazing capacities. Potential over-estimation of grazing capacity on land systems dominated by unpalatable species and where pasture degradation is not reflected by tree and shrub foliage projected canopy cover (%).
7. Inability to predict significant short term fluctuations in yield.	Similar consequences to the fourth limitation above.

In Chapter 5, the rainfall use efficiency concept was used to simplify the results of the simulation studies in Chapter 4 to enable the estimation of potential annual average forage growth for any land system in south-west Queensland. The effects of geographical location, trees and shrubs on forage growth were accounted for to produce an ecologically based estimate of the long-term grazing capacity for any land system in south west Queensland.

The methodology was repeatable enabling it to be applied equally to individual properties to provide an individual "safe" grazing capacity for that property. This alleviated problems of inaccurate estimates of property grazing capacities when determined using district average capacities. The repeatability of the method enables a review of "safe" grazing capacities if changes in pasture condition or pasture production occur for a particular property or land system on the property (e.g. an increase in shrub density or the clearing of timber and introduction of improved pasture.)

The methodology also enabled the examination of the risks associated with stocking rate decisions and resultant levels of pasture utilisation. For 46 properties in south-west Queensland, utilisation of annual average growth was 30.7% during the years 1986 to 1988. However, the range of pasture utilisation varied from 5% to 100% with 81% of properties exceeding 15% utilisation considered "safe" for mulga pastures based on benchmark properties, grazing trial results and consensus data.

Chapter 6 described the role two experienced graziers from south-west Queensland played in the application and evaluation of the methodology for estimating grazing capacities developed in Chapter 5. A number of strengths and weaknesses in the approach were identified and summarised in Table 6.4.

Despite these limitations the methodology offered a means to quantitatively review carrying capacities to remove the subjectivity and perceived inaccuracies surrounding the Department of Lands rated carrying capacities. The Department of Lands is at the front-line in government land administration. There is an expectation that it will be more proactive in influencing sustainable land use. If the Department of Lands adopts the model evaluated by the grazier consultants, the values the agency uses will become more dynamic and better reflect land condition. There will also be a greater chance that grazing capacities will more closely reflect grazing practice on soundly managed benchmark properties. For land administrators, this will lead to greater confidence in the information base allowing more informed decisions regarding sustainable land management and administration. For land managers, there will be greater ownership for the information used by land administrators.

Coupled with financial and economic analyses for property aggregations, improved estimates of appropriate property size could be examined using the methodology. The determination of "living areas" would then have a quantifiable basis. Definition and implementation of drought assistance policies could also be improved with use of the methodology. Instances where disregard for resource capability and seasonal conditions inducing early "droughts" could be better identified. The method would also enable the assessment of the financial impacts and risk flowing from changes in commodity prices and cost structures associated with rural industry.

Beyond the existing rural industries of the region, alternative uses of rangelands offer different perspective’s on acceptable levels of resource use. For example a “safe” grazing capacity for livestock production may have adverse effects on nature conservation. As society broadens its views of rangeland values, and as groups with conflicting values compete for rangeland resources, it is increasingly important to define degradation in relation to a particular use (Abel pers. comm.).

There is room for further refinement of the methodology (Tables 6.4 and 7.1) requiring a commitment from researchers and funding bodies. Any improvements must adhere to the ecological principles developed and focus on utilisation as the measure of "safe" grazing capacities for native pastures. Further application and evaluation must also build on the attempt at using a participatory approach to technology transfer described in Chapter 6. Through this, our understanding of the risks associated with grazing in south-west Queensland, and our ability to "safely" utilise the resource will be improved.