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## **Trial recommendations for the amelioration of a degraded chromosol landscape: Duri District, Northern NSW.**

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### **Abstract**

The chromosol soils of the Duri district range from highly to moderately degraded. The poorer condition results in high overland flow, reduced plant available water, and can lead to greater recharging of lower lying vertosol soils, which have a greater salt store and as a consequence of recharging may result in salt mobilization. Application of fertilizer and sub-clovers on chromosols has been analyzed to determine economic benefits on two properties in the Duri area. Using a low (\$80) and high (\$130) pasture establishment cost for improving the grass- *Danthonia spp* dominated chromosol soils. Total Farm Gross Margins (TFGM) were modeled (Hassall & Associates Pty Ltd.) on a dominate (68%) degraded chromosol site (Site 1) and a vertosol dominated (25% chromosol) site (Site 2). Results for Site 1 indicated that there was an increase in TFGM in subsequent years with a low establishment cost. Increasing the establishment cost resulted in an initial decrease in TFGM, with subsequent years leading to TFGM improvement. However, the degraded nature of this soil makes the short term improvements highly unlikely. Site 2 has less potential for pasture improvement due to the limited chromosol area within this property. However, result of the modeling indicate that under both low and high establishment costs, depending upon seasonal conditions, it may take years before greater returns are observed. In fact to warrant the investment a minimum carrying capacity of 3.5 DSE/ha at Site 1 and 3.5 to 4.5 DSE/ha at Site 2 is required. Overall further investigation into remediation options are needed, with farmer negotiation an important aspect of any recommendation.

### **Introduction**

Low fertile Chromosol soils are common through the North-West Slopes of northern NSW. The district of Duri, located 20km south west of Tamworth, has a large proportion of its soil as Chromosols. The extensive rolling hills, with relief up to 100m, have a long cropping history. Small block sub-divisions were largely used for cereal cropping. Today this is still a common practice however grazing of perennial pastures, or a combination of cropping and rotational grazing is becoming more widespread. The low fertility of Chromosols, and their susceptibility to structural degradation, does not allow this soil type to be continuously cropped. Consequently grazing of both native and improved pastures is the recommended management practice (Banks, 2001). Native pastures comprise 2.8 of the 3.4 million hectares of pasture grazed in the region (Scott, 2004). These native pastures are an important component of grazing enterprises in this area. The balance of pastures are improved, pure lucerne for hay production or lucerne- based pasture stands.

The combined effect of hard-setting soils and reduced ground cover leads to higher run-off flows, leaving less moisture available for pasture production. Research remediation of Chromosols has targeted pasture species (Lodge *et al.*, 1991, Boschma and Scott, 2000), fertilizer application (Lodge, 1989, Lodge, 1980, Lodge and Roberts, 1979) and grazing rates (Lodge and Roberts, 1979, Lodge *et al.*, 1999, Lodge *et al.*, 2003a, Lodge *et al.*, 2003b). Most significantly has been the recommendation that legumes be incorporated into pastures to increase the protein and energy deficiencies of native pastures (Archer *et al.*, 1985).

With the addition of fertilizer and legumes, ground cover and litter are increased which provide greater capture and use of rainfall (Lodge *et al.*, 2001). Once remediation of the pasture has been undertaken, grazing rates can be assessed to identify the most productive result from the pasture under existing climatic conditions. In general the introduction of annual legumes and an application of fertilizer (125 kg/ha superphosphate) has resulted in improved grazing rates from 2.2 Dry Sheep Equivalent (DSEs)/ha (farmer average on native and naturalized pastures with no improvements, continuously grazed (Lodge and Roberts, 1979)) up to 9.2 DSE/ha (Lodge *et al.*, 2003b). During periods of unfavorable climatic conditions, continuous grazing results in reduced herbage mass and ground cover. As a result periods of grazing rest are recommended, not only will this provide opportunity for increases in pasture herbage mass but seeding and seedling establishment is improved (Wilson *et al.*,

1984, Lodge, 1995). Key principles from this work have been utilized by landholder initiated research schemes such as Sustainable Grazing Systems (Barlow, et. al. 2003) and subsequent Sustainable Grazing on Saline Lands program in the region.

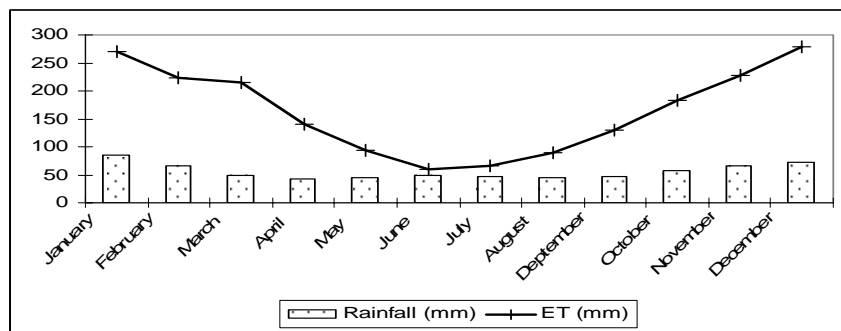
This paper aims to examine the economic implications of remediating a highly degraded chromosol site at Duri, investigate the implications of remediation on the hydrological balance and discussions of potential long-term effects.

Native pastures constitute more than 80% of the pastured area of North West Slopes and Plains area of NSW making them the most significant component of grazing industries in the region. The role of native pastures in providing habitat and sustaining ecological functions for biodiversity have received a greater profile with the advent of Catchment Management Authorities (CMA's). CMA's are currently providing a variety of investment incentives to maintain or enhance native pasture areas as part of management agreements to promote conservation. Nonetheless, landholders have long recognized the value of native pastures, as a stand-by feed reserve. They have found that native species are more resilient to seasonal variations and with good management will persist under drought conditions, their importance to the grazing industries should not be understated.

However the quality and productivity of these pastures is highly variable due to the highly erodable, hard-setting nature of the chromosol soil. These problems affect large stretches of native pastures throughout the region. Producers are seeking the best-bet recommendations to remedy these problems and secure a long term improvement in the resource condition of the soils and increased productivity from their pastures. The study sites at Duri are representative of the resource issues experienced by producers on chromosol soils throughout the region and thus provide an opportunity to evaluate a range of alternative recommendations, drawing upon research and producer input.

### Methods

The district of Duri is located 20km south-west of Tamworth, North-West NSW. The climate of this area is one of summer dominant rainfall, generally falling as storms. The mean rainfall for the area is 673mm. Evaporation exceeds rainfall year round (Fig. 1) with a mean minimum in June of 60mm, and mean maximum of 279mm recorded in December. Mean maximum and minimum temperatures for the area are 31.9 and 2.9 °C for the months of January and July respectively. Mean monthly relative humidity is highest in June, 53% and lowest in November at 35% (BOM, Tamworth Airport).



**Figure 1. Mean annual rainfall and evaporation recorded at the Tamworth airport (Bureau of Meteorology).**

The research site, Duri Key Research Site, is one of eight sites established across NSW to investigate hydrological processes and their implication for salinity. The Duri Key Site does not have any salty discharges within its sub-catchment, however substantial salinity does exist up stream of the site and the Timbumburi Creek, which passes through the middle of the sub-catchment, transports salt (base flow EC of 2.1 dS/m) to the Peel River at Tamworth.

There are two main soil types within the Duri area. The chromosol landscape has been described as having widespread gully and sheet erosion risk, with localized; water logging, poor drainage, high runoff, shallow soils, and the potential risk of both recharge and discharge areas (Banks, 2001). Vertosol

soil is found along the flood plains and as a result is more prone to localized water logging with widespread run-on and flood risks. Again there are widespread risks of erosion, with localized permanently high water tables and poor drainage. This soil type also has the potential for both recharge and discharge areas (Banks, 2001). The soils are complex and highly variable due to extremely variable underlying Devonian geology (Banks, 2001).

The Duri Key Site encompasses six privately-owned properties, two of which are of interest in this report. Site 1 is a total of 491 hectares with predominantly chromosol (333 ha), vertosol (146 ha) and mixed alluvial clay (12 ha) soils. Site 2, a smaller block of 190 ha comprises of 142 ha of vertosol and 48 ha of chromosol. Chromosol soils on Site 1 are highly degraded in comparison to similar soils at Site 2. The farming system conducted on Sites 1 and 2 comprise cattle breeding enterprises, turning off store or vealer progeny in response to seasonal conditions. Stock graze on a mix of lucerne and native grass pastures dominated by Wallaby grass (*Danthonia spp.*). Winter feed reserves include standing pasture, hay produced on farm in addition to forage oats sown to supplement stock during the winter months. Some grain may be produced, generally barley or oats as the season permits, or otherwise bought in as feed shortages dictate. Property values are artificially high given their proximity to Tamworth and do not reflect the agricultural productivity or earnings potential of the farms.

### Hydrology

The hydrological balance is comprised of water inputs such as rainfall (P) and soil profile store ( $\Delta W$ ), and water losses from evapotranspiration (Et), overland flow (R), lateral flow (L) and deep drainage (D). Of these components, we are directly measuring P (manual and automatic rain gauges),  $\Delta W$  (CPN 503 DR Hydroprobe, with strategically placed access tubes across the research site), Et (Viasala micrometeorological stations) and R (bounded run-off plots and in stream gauging stations). The other terms can be derived from the equation:

$$D + L = P + \Delta W - Et - R$$

Hydrology of Sites 1 and 2 were determined for the chromosol soils of each property, vertosol hydrology was not considered in this report. There is no micrometeorological station at Site 2, consequently to assist with understanding water use at Site 2 in the absence of a direct measure of Et, biomass and leaf area index (LAI) were measured at both sites. All standing biomass and litter were collected separately from eight 0.25 m<sup>2</sup> quadrates within each site at periods that coincided with soil moisture measurement dates. From this sample, dry matter yield and LAI (Li-cor Li 3100) were determined. Plant LAI is used to calculate the ratio of soil evaporation (Es) to Et, using the equation:

$$Es/Et = \exp(-0.61LAI) \quad (\text{Denmead } et al., 1996)$$

There is over three years hydrological data available, however only data from summer 2003/04 is used in this report due to extensive rainfall over this period.

### Economic Analysis

A marginal analysis of pasture improvement was conducted for the two sites monitored above, using the Evaluation of Alternatives for Salinity Management (EAASM) model developed by Hassell and Associates (2004) for NSW Agriculture.

Information requirements for pasture establishment traditionally rely upon detailed whole farm development budgets, discounted to impute the impact of time on the returns from the investment (Makeham and Malcolm (1982)). The circumstances of both the producers at each site differ considerably and it was the aim of the analysis to focus on the relativities of the benefits from improving pastures on the chromosol soils. From the outset, neither producers were able to make the necessary detail available for a more detailed analysis until some form of improvement could be demonstrated on 'paper', thus the analysis approach aimed to evaluate the benefits of pasture establishment from a producer perspective using a crude 'back of the envelope' form of analysis which aims to answer the questions "Will it pay me to improve and how much will it cost"?

Given that the cost of pasture establishment varies, two pasture establishment cost structures were investigated, \$80/ha (Scenario 1) and \$130/ha (Scenario 2) to provide reference points in our discussions with producers. The results do not include interest costs on borrowed capital: however, they do provide some insight into the likely return and order of magnitude of returns on capital.

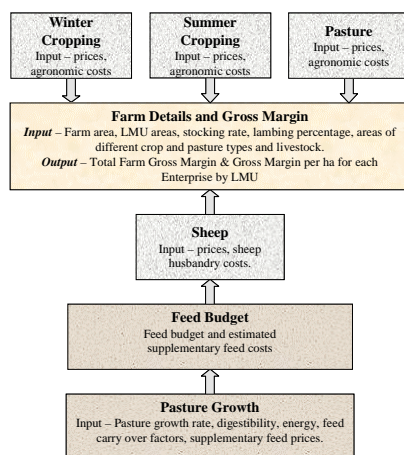
An annual topdressing of fertilizer was used in the analysis, in order to build the fertility of each site. However, it is common practice for producers in the area to apply a biannual application of fertilizers in this district with more frequent application being applied where properties have high stocking rates or irrigated pastures.

From a technical agronomic perspective, the option to improve the *Danthonia spp* pasture hinges upon the success of establishment, the potential response rate, palatability and quality of the pasture on each site. Additional benefits from maintaining groundcover and reducing erosion are further considerations not factored into the analysis (Lang and McDonald, 2005). The income generated from the pasture improvement must cover the cost of establishment, the risk of failure and the opportunity cost of applying funds to alternative investments (O’Connell and Young 2002). Future investigations will require much more financial information to ensure the options for each producer are fully evaluated.

The model structure is outlined in Figure 2.

### Evaluation of Agricultural Alternatives for Salinity Management (EAASM)

Developed for NSW DPI by Hassall & Associates Pty Ltd.



**Figure 2. Structure of the EAASM model**

The model is an excel spread sheet model built around a typical NSW Central West Farming System incorporating wool and prime lamb enterprises, cropping and pasture rotations. A key feature of the model is the inclusion of pasture growth and feed availability which reflects the number of DSEs that may be carried. The model also aims to match livestock requirements with pasture availability in order to determine supplementary feed requirements.

While maintaining the framework and functioning of the model, the content was modified to include the northern farming systems of the North West Slopes Region of NSW. These systems differ in that there is a greater reliance upon summer crop, grown in response to episodic summer rainfall. Pasture species, including tropical grasses and growth rates also differ (Scott, et al 2004). The model was calibrated using crop and livestock gross margin budgets for the North West Region produced by Scott (2005) and pasture growth data from McDonald (1999).

Grazing estimates drawn from McCormick, et. al. (1998) and Lodge, et. al., (2003b) were applied to each site to examine the marginal gross margin returns from the application of 125 kg/ha of single super phosphate and 5 kg/ha of subterranean clover to the *Danthonia spp.* dominated pasture stands populating the chromosol soils. Note: Pasture establishment costs are included in the model as an annuity figure (not as a lump sum total for the year of analysis). Pastures are to be annually top dressed with 125 kg of super phosphate every year. The life of the *Danthonia spp* pasture stand was considered to be 10 years. Sown improved legume-based pastures generally require renovation or re-

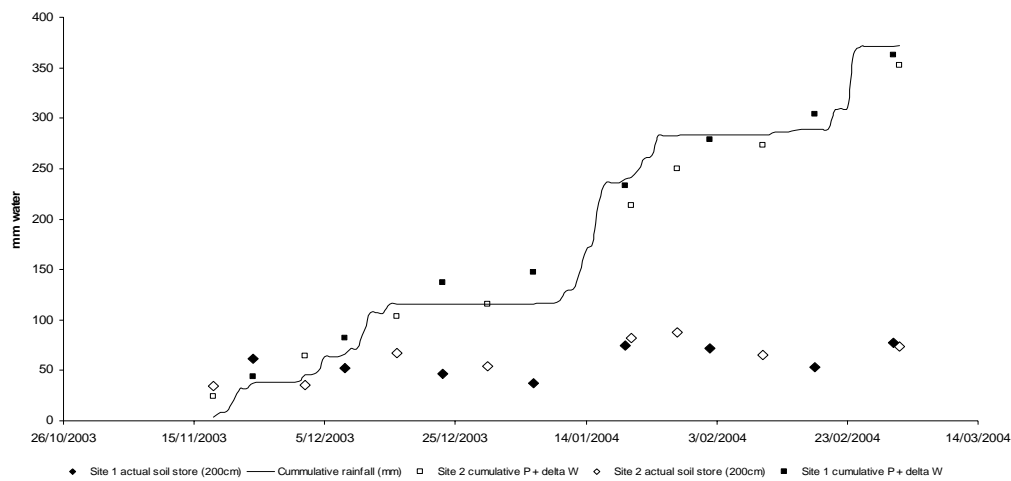
establishment every 5-7 years on the heavier vertosol soils. Well managed mixed legume-tropical pasture sward was estimated to have a stand life of 7 -10 years (Manning, B. personal communication).

Estimates noted above vary from 2.2 DSE/ha for grazed unimproved native pastures to 9.2 DSE/ha with fertilizer and legume inputs (Lodge et. al., (2003) and Lodge and Roberts, (1979)). McCormick, et. al. (1998) reports a carrying capacity of 2.5 DSE/ha on a set stocking basis for a scalded red brown earth (no treatments) with a 28% ground cover. The latter was selected as the base figure for highly degraded soil and pasture conditions. One DSE carrying capacity increments were applied to each site following the application of fertilizer and legume up to 5.5 DSE/ha.

## Results

### Hydrology

The Et for Site 1 for the summer of 2003/04 was 299.2 mm and P for the same period was 333.8mm. Hence in this season rainfall exceeded Et, this is due mainly to an extensive rain event in mid January 2004. Figure 3 displays some of the key hydrological data for this period, where it can be seen that a rain event of 120mm was recorded over 9 days in January 2004.



**Figure 3. Hydrological data: cumulative rainfall, stored soil moisture and cumulative rainfall + change in soil store, for Duri Chromosol Site 1 and 2.**

The  $\Delta W$  for Site 1 and 2 for the summer period were 15.1 and 39.6mm respectively. Indicating that Site 2 was able to store 24.5mm more moisture than site 1. Assessment of the soil profile for soil moisture at various depths highlights that at Site 2 a greater amount of water was stored at depth. Considering the soil profile in the absence of the evaporative layer (ie 0-50cm) allows for close examination of the profile where plant uptake of moisture is controlling change (Fig. 4a and b). The higher amount of moisture present at depth in Site 2's profile indicates that a greater amount of moisture was lost from Site 1 as surface flow. A bounded run-off plot at site 1 during this storm event indicated that there was 32 KL/ha run-off from this site.

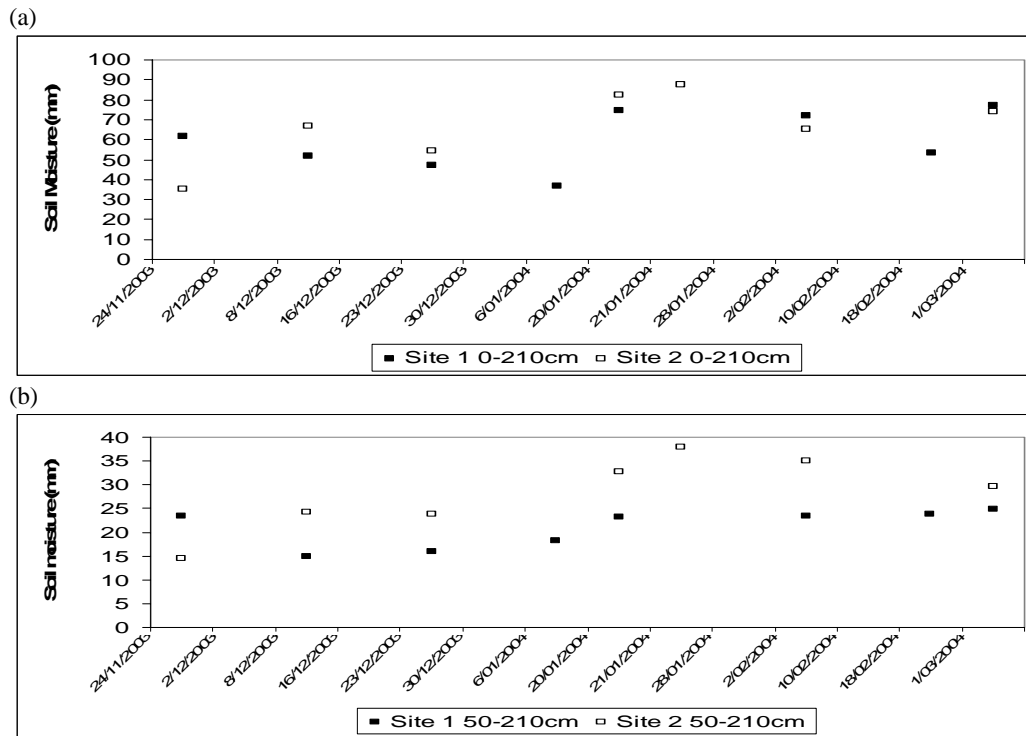


Figure 4a and b. Actual soil moisture for site 1 and 2 at depth range 0-210cm (a) and 50-210cm (b).

Table 1 displays the herbage mass, LAI and ground cover for each site at strategic sampling dates over the summer period. From this data it is clearly seen that Site 2 has a far more productive pasture than Site 1. The reduced LAI of Site 1 results in the majority of Et coming from soil evaporation. Hence changes in soil profile store at site 1 are dominated by soil evaporation. Site 2 in comparison has a greater amount of Et dominated by plant transpiration as is indicated with herbage mass differences between the two sites. Ground cover at Site 1 is consistently lower than site 2 by up to 30%. The ratio of Es:Et (soil evaporation compared to total evapotranspiration) can be used to assess the partitioning of soil and plant contributions to evapotranspiration. The closer to 1 the result the greater amount of Et is dominated by soil evaporation. This result is calculated using LAI, hence reduced LAI on the 1/12/2003 at Site 2 tends to indicate that there is a large proportion of ET coming from soil evaporation. However the high ground cover in fact acts as a buffer and minimizes soil evaporation.

Table 1: Herbage mass, ground cover and LAI for pasture at Sites 1 and 2.

Date	Site 1				Site 2			
	Herbage mass (kg/ha)	Ground cover (%)	LAI	Es:Et	Herbage mass (kg/ha)	LAI	Ground cover (%)	Es:Et
25/11/2003	108.3	46.8	0.04	0.976				
1/12/2003					154.5	0.01	85.8	0.994
21/12/2003					251.1	0.31	86.0	0.828
6/1/2004	75.6	54.1	0.04	0.976				
2/2/2004	118.7	57.7	0.27	0.848				
10/2/2004					663.04	0.73	88.4	0.641
18/2/2004	178.1	57.0	0.23	0.869				

### Economic Analysis

The resulting whole farm gross margins from the economic analysis are reported in Table 2.

**Table 2: Total Farm Gross Margin Returns from pasture improvement scenarios**

	Carrying Capacity of Chromosol Soils	Carrying Capacity of Vertosol Soils	Total Farm Gross Margin Scenario 1	Total Farm Gross Margin Scenario 2	No. of Spring Calving Cows
<b>Site 1</b>	<b>333 ha</b>	<b>146 ha</b>	<b>\$/ha</b>	<b>\$/ha</b>	<b>15 DSE/Cow</b>
Base Case No sub or super – Run 1	2.5	8	92.91	92.91	133
With Sub and Super – Run 2	3.5	8	93.66	89.02	156
With Sub and Super – Run 3	4.5	8	110.58	105.94	178
With Sub and Super – Run 4	5.5	8	138.17	133.54	200
Producer estimate of carrying capacity	6	8	151.30	146.66	211
<b>Site 2</b>	<b>48 ha</b>	<b>142 ha</b>	<b>\$/ha</b>	<b>\$/ha</b>	<b>15 DSE/Cow</b>
Base Case No sub or super– Run 1	2.5	8	178.32	178.32	84
With Sub and Super – Run 2	3.5	8	171.10	167.85	87
With Sub and Super – Run 3	4.5	8	181.48	178.23	90
With Sub and Super – Run 4	5.5	8	192.22	188.97	93
Producer estimate of carrying capacity	8	10	269.51	266.25	120

The model is not dynamic and required a sequence of runs (Runs 1 through to 4) in order to generate the results, once the parameters of each site were imputed the DSE carrying capacity for the chromosol soil areas were altered. Run 1 using the base 2.5 DSE carrying capacity, Run 2 through to Run 4 included increase of 1 DSE increments with the addition of pastures costs. These were altered to reflect the scenario being examined ie. Scenario 1 representative pasture establishment cost for chromosol soils in the area where improvement is undertaken by the producer and Scenario 2 where pasture establishment costs included the use of a contractor. The livestock carrying capacity of the vertosol soil type was not altered as no pasture improvement was to be conducted on these areas. The livestock carrying capacity of 8 DSEs for the vertosol soils was selected as a conservative estimate for these areas.

As noted, above the model attempts to match feed availability with livestock requirements. Therefore the incremental change in DSEs, generates a change in cow numbers (rated at 15 DSE/cow). The change in cow numbers influence the Total Farm Gross Margin (TFGM) for the site. A producer estimate of the carrying capacity for each soil type was also imputed to compare the apparent pasture productivity, with cow numbers being run, the results of this comparison are discussed below.

### Discussion

From the outset it is clear that Site 1 with the greater proportion of chromosol soils, has the greatest potential to improve the livestock carrying capacity. On the other hand, it is also the most degraded of the sites and therefore less likely to achieve significant improvements in the short term. Site 2 is much



less degraded with a higher proportion of vertosol soil. The chromosol soil has a greater potential to respond to fertilizer and seed applications in the short time frame, with the threat of bloat becoming a problem. Grazing pressure and lack of fertilizer application are the two external factors affecting productivity at Site 1. These combined with a depleted soil structure have resulted in reduced soil moisture holding capacity of this profile. Similar findings were identified by Murphy and Lodge (2001), they highlighted that the chromosol system is rain driven and pasture herbage mass response is greatest after rainfall. In systems where there was low ground cover (<40%), bare soil exposure was predicted to result in up to 18% more evaporation of total rainfall compared to systems with a ground cover (>85%) (Lodge *et al.*, 2001).

The key hydrological implications of this study are;

- ground cover and herbage mass are essential to reduce surface water flow,
- ground cover and herbage mass are essential to minimize soil evaporation,
- chromosol soils are rain driven systems, they do not have a large plant available moisture stores.
- Over cropped and less-structured chromosols impede rainfall infiltration, accelerating surface water flow.
- Increased overland flow from chromosols onto vertosols may greatly increase vertosol soil profile recharge and
- vertosols have a greater salt store and recharging of this profile may result in salt mobilization.

The Economic analysis in Scenario 1 involves an annualized pasture establishment cost of \$50/ha, plus an annual top dressing of super of \$30/ha, a total of \$80/ha in year 1. Scenario 2 involves an annualized pasture establishment cost of \$100/ha, plus an annual top dressing of super of \$30/ha, a total of \$130/ha in year 1.

Examining the results, where pasture improvement costs are minimal (Scenario 1) there is increase in TFGM for Site 1. Under Scenario 2 there is a slight decline in the TFGM reflecting the influence of the higher pasture establishment costs.

This contrasts with Site 2 which experiences a decline in TFGM under both Scenarios 1 and 2, where the DSE increases from 2.5 to 3.5 DSE, highlighting the need for the property to generate additional income to cover the initial pasture improvement costs. In this situation the initial pasture improvement costs are recouped between 3.5 to 4.5DSEs, generating a slightly higher TFGM in Scenario 1 for Site 2 and returning a TFGM similar to the base case with no seed or super in the case of Scenario 2.

In the latter situation the landholder would have to question the merits of investing \$130/ha in pasture improvement costs in yielding a return similar to the base case with no seed or fertilizer. The property owner of Site 2 must ensure the pasture renovation costs are minimised (such as in Scenario 1) or alternatively achieve a much greater improvement in carrying capacity than 4.5 DSE. However this analysis does not reflect the cash flow implications of the pasture improvement program, nor does it highlight the value of marginal feed. Bathgate (2003) contends that pasture species that contribute a small number of grazing days during periods of scarcity may be more valuable than those species that provide a larger contribution during times when feed is plentiful (ie. when the marginal value of feed is low). He argues that, in physical terms, more stock units may be run or conversely less supplementary feed is required to maintain existing stock numbers during periods of short supply.

An examination of the relative return on capital was undertaken to establish the 'ball park' figure for discussion with producers. This involved expressing the change (increase or decrease) in TFGM/ha as a percentage of the cost of pasture establishment. Note: these figures do not include the cost of borrowed capital or reflect cashflow implications.

The relative return on investments for each Scenario are presented in Table 3.

**Table 3: Returns on Marginal Capital from pasture improvement**

	Total Farm Gross Margin Scenario 1	Scenario 1 Pasture Est. Costs \$80/ha	Total Farm Gross Margin Scenario 2	Scenario 2 Pasture Est. Costs \$130/ha	No. of Spring Calving Cows

<i>Site 1</i>	<i>\$/ha</i>		<i>\$/ha</i>		<i>15 DSE/Cow</i>
Base Case No sub or super – Run 1 (2.5 DSE no treatment)	92.91		92.91		133
With Sub and Super – Run 2 (3.5 DSE)	93.66	+0.93%	89.02	-3%	156
With Sub and Super – Run 3 (4.5 DSE)	110.58	+22%	105.94	+10%	178
With Sub and Super – Run 4 (5.5 DSE)	138.17	+56.5%	133.54	+31%	200
Producer estimate of carrying capacity	151.30	+117%	146.66	+41%	211
<i>Site 2</i>	Total Farm Gross Margin Scenario 1	Scenario 1 Pasture Est. Costs \$80/ha	Total Farm Gross Margin Scenario 2	Scenario 2 Pasture Est. Costs \$130/ha	<i>15 DSE/Cow</i>
Base Case No sub or super– Run 1 (2.5 DSE no treatment)	178.32		178.32		84
With Sub and Super – Run 2 (3.5 DSE)	171.10	-14%	167.85	-8%	87
With Sub and Super – Run 3 (4.5 DSE)	181.48	+6%	178.23	-0.07%	90
With Sub and Super – Run 4 (5.5 DSE)	192.22	+27.8%	188.97	+8%	93
Producer estimate of carrying capacity	269.51	+114%	266.25	+68%	120

Makeham and Malcolm (1982) suggest that as a rule of thumb the return on capital should be at least 10% in order to warrant further investigation of the project option. From the above, Site 1 must achieve a carrying capacity in excess of 3.5 DSE/ha (Run 2) to warrant the investment in pasture establishment under both Scenarios, while Site 2 would benefit from pasture improvement achieving a carrying capacity between 3.5 and 4.5DSE/ha (or a value some where between Run 2 and 3) under Scenario 1 but would not under Scenario 2. The resulting returns calculated from Runs 1 to 4 (2.5 to 5.5 DSE/ha) at Site 2 would not warrant the investment in pasture improvement where pasture establishment costs were \$130/ha.

#### Cattle Numbers and Producer Estimates of Carrying Capacities

The results were calculated applying DSE increments ranging from 2.5 DSE/ha to 5.5 DSE/ha in order to examine the marginal return from pasture improvements. Comparing the producers own estimates of carrying capacities for Sites 1 and 2, it is interesting to note the magnitude of each estimate (Table 4). Both producers consistently carried more stock than the model had calculated. By implication, given the model is correct, both producers were overstocking their properties. Consequent impacts of the continued dry weather and overstocking during the period of study was evident at Site 1 and was reflected in stock health and condition of the pastures. Site 2 showed significantly less adverse decline in both stock and pasture conditions. Site 2 also fed a larger proportion of home grown fodder which alleviated the grazing pressure on the property

**Table 4: Producers own estimate of soil type and associated livestock carrying capacity**

Site Number	Area	Carrying Capacity Chromosol Soils	Carrying Capacity Vertosol Soils
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Site 1	491 ha	6	8
Site 2	190 ha	8	10

Cash flow constraints were the primary reason cited for the limited investment in renovation and pasture establishment. Both producers were relative newcomers to the district and recognized the need to seek information and advice regarding the management of their properties and their specific resource management issues.

Crosthwaite and Malcolm (2001) note in their analysis of fertilizing native pastures that it has a low initial investment and a long period of building to full productivity. The temporal nature of this relationship is yet to be estimated for the Duri chromosol study sites. The extent of degradation on Site 1 adds another dimension increasing the risk of failure of pasture establishment efforts. Given the cash flow constraints, the improvement of the native pasture base with legume and fertilizer was considered the most favorable option. Reducing stock numbers, combined with improved fencing and controlled grazing are strategies to be negotiated with the property owner. Alternative enterprise structures should also be examined in light of the long term nature of improvements required for this property.

The livestock carrying capacity of Site 2 benefits from the larger proportion of vertosol soils. A more intensive use of these areas, including the introduction of summer fodder crops are issues to be explored by the landholder. The producer at Site 2 had decided to restructure his breeding cow enterprise to accommodate more trading stock in order to utilize peak feed availability and maintain the flexibility to reduce stock numbers in response to seasonal conditions.

Continued hydrological research will reinforce the key management issues of maintaining ground cover levels to intercept rainfall in order to recharge the moisture profile of the chromosol soils, improving both pasture response and reducing the risk of erosion. Ferris and Malcolm (1999) comment that there are many mistakes to be made using crude measures like gross margins or DSE's and that where significant investments are to be applied, partial budgets (also see Patton 2001) and detailed whole farm analyses should be undertaken. The long term nature of investment required for Sites 1 and 2 dictates that further analysis is necessary to examine a range of options for each producer.

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