Sustainability and productivity of two mine rehabilitation sown pastures in the Hunter Valley

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Abstract: *This study set out to provide data on whether mine rehabilitation sown pastures in the Hunter Valley can be as sustainable and productive as native pastures from the same area. Two comparisons were made over three years from 2014 to 2017. Rehabilitation pastures were found to have similar levels to native pastures for ground cover and heavy metal contamination of soils, plants and livestock. However, species diversity was much lower in the rehabilitation pastures. Dry matter yields, percentage green and growth rates of rehabilitation pastures were all equal to or higher than for native pastures. The differences in feed quality were not so clear cut. The data from this study suggested that many measures of sustainability and production of rehabilitation pastures can be equal to or better than the original native pastures of the area. However, more comparisons are needed to confidently make generalisations and more work may be needed to boost the biodiversity of rehabilitation pastures if high biodiversity is regarded as a desirable feature of these pastures.*

Key words: sown-tropical pasture, pasture quality

Introduction

This study was initiated by the Upper Hunter Mining Dialogue (UHMD), which is a group comprising stakeholders from coal mining, agriculture, community and environment groups, local and state government. The UHMD needed to answer questions being raised by the community around the sustainability and profitability of mine land that had been rehabilitated to pastures, but they had very limited data to address these issues.

The aim of this study was to provide data on whether rehabilitated pastures can be as sustainable and productive as native pastures which were typically present before mining began. The study extended from 2014 to 2017 at two sites. It is acknowledged that this study looks at only one of many scenarios that are possible in mine rehabilitation and hence has considerable limitations.

Methods

Two study sites were identified near Singleton and Muswellbrook where mine land rehabilitated to sown pastures could be compared with adjacent native pastures. Sites consisted of two 20 ha paddocks for each pasture type at Singleton and three 10 ha paddocks for each pasture type at Muswellbrook. Mine rehabilitation pastures had been sown to Rhodes grass (*Chloris gayana* cv. Pioneer), green panic (*Megathyrsus maximus*), lucerne (*Medicago sativa*), kikuyu (*Pennisetum clandestinus*), couch (*Cynodon dactylon*), medic (*Medicago* spp.) and white clover (*Trifolium repens*) in the 1980s (Singleton) and 1990s (Muswellbrook). Pastures persisting since the 1980s and 1990s were selected as an indicator of persistence and sustainability. All pastures had clumps of established trees which provided shade for stock.

Two groups of cattle were run at each site over three years: Group 1 from 2014–2016 and then Group 2 from 2016–2017. Initially, 10 Angus steers per pasture type were run at each site giving a stocking rate of 1 steer/4 ha at Singleton and 1 steer/3 ha at Muswellbrook. These rates were considered conservative for these areas. The number of steers on the Singleton rehabilitation pasture was increased to 15 (50% increase) in the second group in an attempt to increase pasture utilisation, which had been very low.

Grazing management was a simple rotation with cattle moved to a new paddock after being weighed every 12 weeks. At Muswellbrook, the second group of cattle were set stocked on the full 30 ha area for each pasture type due to problems with fencing and water supply. No supplementary feeding, fertiliser or mineral supplements were provided during the study.

Sustainability of the rehabilitation and native pasture systems were compared using heavy metal (arsenic, cadmium, lead) contamination of soils, plants and cattle, also species diversity and ground cover. Heavy metal contamination of soils (0–10 cm) was measured in 2016 using Analysis Systems. Heavy metal contamination of plants was measured every six weeks using inductively coupled plasma (ICP) analysis through the NSW Department of Primary Industries (DPI) Feed Quality Service laboratory. Heavy metal contamination of cattle was assessed using blood samples collected on the entry of cattle to the study sites and again on exit. These were analysed by NSW DPI Veterinary Diagnostic Laboratory and included analyses for phosphorous, selenium, copper, zinc, calcium, magnesium, sulphate, vitamin B12, arsenic, cadmium, lead and manganese. Pasture species compositions were intensively surveyed annually, with any extra species found during six weekly pasture monitoring added to the list. Ground cover percentage (%) was visually estimated in each quadrat used to estimate dry matter yield (see below).

Productivity of the rehabilitation and native pasture systems were compared using measurements of dry matter yield, percentage green (% green), growth and feed quality measurements. Dry matter yield and % green were estimated every 6-weeks using the BOTANAL relative yield method (Tothill *et al.* 1992); typically 150 or more 0.16 m^2 quadrats were used in each paddock. Pasture growth was estimated every 6 or 12-weeks using two exclusion cages per paddock: a 12-week period was used when the amount of new growth was extremely low at six weeks. Cages were placed on representative parts of each paddock and moved to a new site every 6-months: earlier if any damage to the pasture within the cages was observed. Feed quality samples were collected when undertaking BOTANAL field work: these were sorted into dead and green components and analysed by the NSW DPI Feed Quality Service laboratory. Near infrared (NIR) analysis was used for major feed quality components and ICP analysis for trace elements and heavy metals.

Results and Discussion

Sustainability

Soil, pasture and blood testing identified no heavy metal toxicities in any samples. All soil analyses were below the level of reporting for arsenic (<0.4 mg/kg), cadmium (≤0.2 mg/kg), lead (<2 mg/kg) and selenium (<4 mg/kg). Heavy metal concentrations for all pasture types were well below the maximum tolerable level for growing cattle (National Research Council 2005).

Rehabilitation pastures at Singleton and Muswellbrook contained a lower diversity of plant species (87 and 107 respectively) than the native pastures (144 and 174 respectively), but species numbers were still high and there was also a high percentage (43–49%) of native species in the sown areas. The abundance of native species in the rehabilitation areas may be due to survival of seed in the seedbank of the re-laid topsoil, transport by wind or animals from other areas and/or unrecorded sowing of native species in the forested areas. A broad diversity of plant species can be important for supplying diverse food sources and habitats for native animals, including soil fauna (Dorrough *et al.* 2008; Ruiz and Lavelle 2008). Whether the differences in plant species numbers and composition had an impact on the native fauna was outside the scope of this study, but may form a useful area for future investigation. It should also be noted that experience from other areas suggest that the diversity of native plant species may well increase over time with good pasture management and in the absence of fertiliser application (Leech and Keys 2003).

Ground cover was similar in both rehabilitation and native pastures and was maintained at desirable levels of ≥90% (Lang and McDonald 2005) throughout the year. This is even though stocking rates were 50% higher on the Singleton sown pasture in the latter part of the study. Adequate levels of ground cover are important as it minimises run-off, reduces erosion, increases plant growth, aids soil health, assists in weed control and improves the quality of water entering dams, streams and rivers (Lang and McDonald 2005; Graham 2017). Pasture cover is the preferred indicator of sustainability and stability on mine rehabilitated land as the soils are often very prone to erosion (Carroll *et al.* 2001; Grigg *et al.* 2000). Carroll *et al.* (2001) reported that >80% pasture cover is required to reduce erosion rates on steep slopes to negligible levels.

Productivity

Dry matter yields and % green were higher in the Singleton rehabilitation pastures than the native pasture throughout the study (Fig. 1). However, the rehabilitation pastures initially had higher yield and % green. Dry matter yields tended to increase over time in the rehabilitation pasture, but remain relatively steady in the native pastures. By comparison, there was no obvious difference in total dry matter yields or % green between sown and native areas at Muswellbrook. The carrying capacity at Muswellbrook of both the rehabilitation and native areas was very similar when based on pasture quantity alone.

Although not shown here, growth rates and the distribution of growth through the year in rehabilitation pastures was generally equal to or superior to the native pastures at both sites. This may be partly due to the greater growth rate potential of the introduced pasture species and partly due to better soil fertility in the Singleton rehabilitation pasture. Soil Colwell phosphorous was greater than 30 mg/kg in the Singleton rehabilitation pastures and less than 10 mg/kg in all other pastures. Sulfur was also low in all pastures. This indicates that production was potentially limited by low phosphorous in three pastures and low sulfur in all pastures.

It is likely that rehabilitation pasture production could also have been higher if the pastures had been actively managed prior to the study to reduce the sizeable build-up of dead material. Silcock (1991) noted that only a small proportion of Rhodes grass pastures in ungrazed rehabilitation areas were actively growing. In part this is typically due to the build-up in dead material and consequent nitrogen immobilisation (Robbins *et al.* 1989; Robertson *et al.* 1993). Even with the introduction of cattle sizeable areas, especially at Singleton, retained a large dead biomass.

The message on pasture quality or feed value was more nuanced. Metabolisable energy of Singleton rehabilitation pastures declined during the study as biomass accumulated and plants

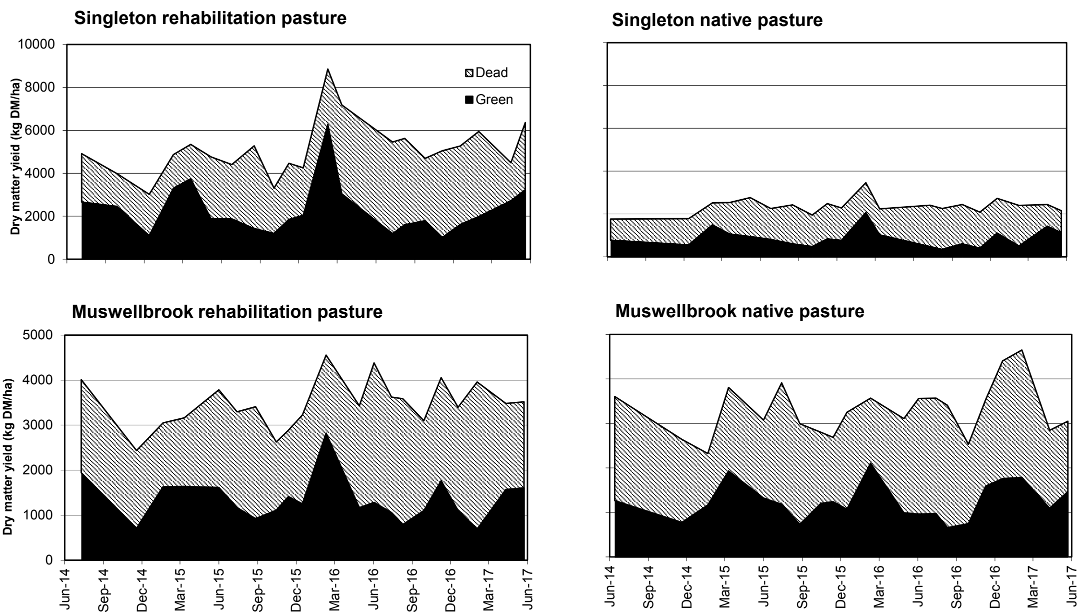

Figure 1. Green and dead pasture dry matter yields (kg DM/ha) for rehabilitation and native pastures at Singleton and Muswellbrook. Figures are averaged across paddocks within each area.

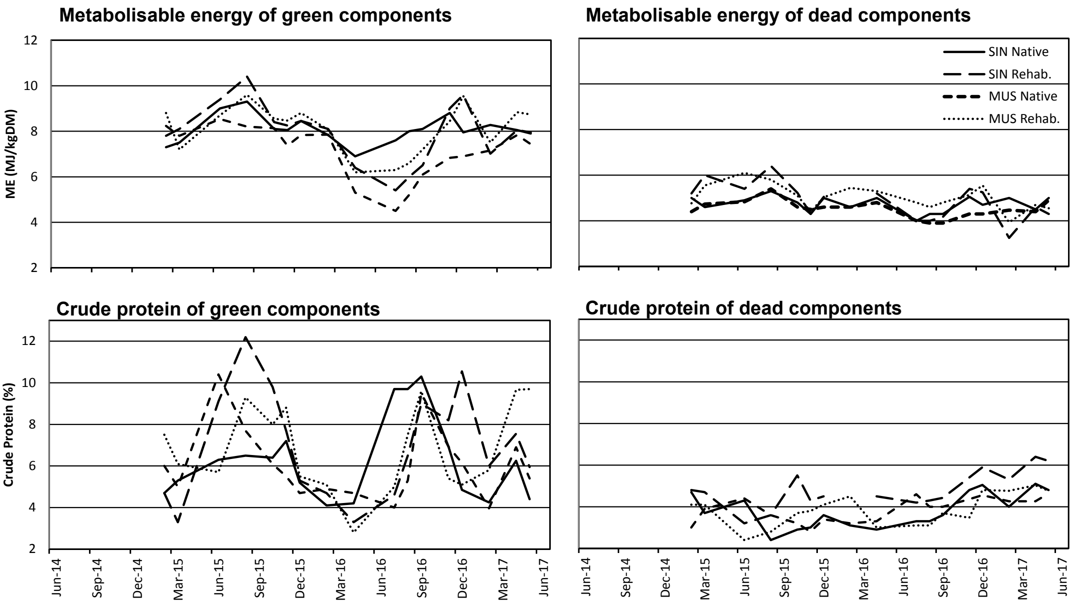

Figure 2. Metabolisable energy (ME, MJ/kg DM) and crude protein (%) of green and dead pasture components for rehabilitation and native pastures at Singleton (SIN) and Muswellbrook (MUS). Figures are averaged across paddocks within each pasture type.

became rank due to pasture growth exceeding cattle consumption (Fig. 2). Huxtable (1997) also noted that unless appropriate stocking rates are used Rhodes grass tends towards a monoculture and is of fairly low nutritive value to stock. The quality of Singleton native pastures appeared to improve as consumption exceeded pasture growth and a greater proportion of the pasture was of high feed value. In this case, lower green feed availability (often ≤1000 kg DM/ha) limited cattle weight gain.

Conclusion

Over the three years of this study, the rehabilitation and native pastures were found to have similar levels of ground cover and no toxic levels of heavy metals in the soils, plants and livestock. However, species diversity was much lower in the rehabilitation pastures. Dry matter yields, percentage green and growth rates of rehabilitation pastures were all equal to or higher than for native pastures. The data from this study suggest that many measures of sustainability and production of rehabilitation pastures can be equal to or better than the original native pastures of the area. However, to confidently make generalisations further comparisons and work are warranted to boost the biodiversity of rehabilitation pastures if high biodiversity is regarded as a desirable feature of these pastures. Further information is available from the final report for Project C32053 'A study of sustainability and profitability of grazing land in the Upper Hunter NSW' (Griffiths and Rose 2018)

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