Using height and density to estimate the herbage mass of different pastures in northern New South Wales

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Abstract*: The MLA Pasture Ruler for estimating pasture herbage mass was developed for a moderately dense pasture up to 14 cm high. In this paper, regression equations (r-value >0.78) between herbage mass and a herbage index (height x density) were developed for four pasture types with different structures and growth (native perennial grass pasture, lucerne, forage oats and tropical perennial grass) in northern New South Wales. Using this approach estimates can made for a wider range of pasture heights and densities than those that apply to the Pasture Ruler. By simply estimating pasture height and density the derived equations can be easily used to accurately assess pasture herbage mass.*

Key words: pasture herbage mass, herbage index, native pastures, lucerne, tropical perennial grasses, forage oats

Introduction

There is an urgent need for simple, easy-to-use tools that can assist producers to objectively assess pasture quantity (e.g. Lodge *et al.* 2011) and so make timely decision about adjusting stocking rates and matching on-farm forage resources to livestock feed requirements. One such tool that is widely available is the MLA Pasture Ruler (MLA 2004), which provides a scaled conversion of pasture height to pasture quantity for a 'moderately dense' (75% density) pasture. However, the maximum height of pasture for which the MLA Pasture Ruler can be used is only 14 centimetres (cm). In reality, many pastures on-farm are also of less than moderate density as a result of the interaction of sub-optimal grazing and/or fertiliser application with variable climates over the past few years (e.g. Lodge and McCormick 2010). Also, many pastures, such as those dominated by tussocky native perennial grass or upright tropical perennial grasses or grazed lucerne (*Medicago sativa*), have an inherently high amount of bare ground between plant crowns. This low plant density, combined with plants that are often more than 50 cm high, means that there are many situations in which the conversion factors used for the MLA Pasture Ruler are not applicable.

These situations regularly occur in northern New South Wales (NSW) where there are a range of forage options, such as C_3 and C_4 native perennial grasses, lucerne, summer-growing tropical perennial grasses and winter-growing forage oats (*Avena sativa*). The herbage mass (HM, kg dry matter (DM)/ha) of all of these potential forage sources needs to be assessed on-farm. As part of the EverGraze project in northern NSW (Lodge *et al.* 2008), estimates of HM were derived from plant height and pasture density relationships and compared with theoretical values obtained from the MLA Pasture Ruler. Similar principles to those used for the Pasture Ruler were applied to derive simple multipliers that gave more reliable and realistic estimates for a wide range of pasture types.

Methods

As part of an on-farm livestock and pasture monitoring project in northern NSW (Lodge *et al.* 2011), data were collected for plant height (cm) and density (%), plant HM and residual HM (the quantity of herbage <1 cm in height) from 2007 to 2010 for each of the four different pasture types above. Values for plant height (assessed as the height (cm) of the bulk of the vegetative plant material) and plant density [expressed as a % from 0 (low) to 100 (high)] were multiplied together to give a herbage index (HI, height x density). Herbage mass values for the different pasture types were determined over a range of seasons and growing conditions. All assessments were in quadrats (40 by 40 cm) and HM was estimated by cutting plant material to a height of 1 cm above ground level. Residual

herbage mass (0–1 cm) was estimated from 50-mm diameter cores taken from the cut area, with the herbage washed to remove any soil particles. All harvested material was dried at 80^{0}C for 48 hours before weighing. Linear regression equations for the MLA Pasture Ruler were back calculated using height values of 0–14 cm and a pasture density of 75% for each of the height values on the MLA Pasture Ruler.

For each pasture type, linear regression was applied to the values for actual HM (Y) and HI (X) and the significance ($P < 0.05$) of the relationship was assessed using the correlation coefficient (r-value). Values of R^2 were used to describe the proportion of the variation in Y that was attributed to its linear regression on X. These regression analyses were applied to two situations. The first was where the pasture height was ≤10 cm for all pasture types, except tropical perennial grasses (pasture height ≤20 cm), where $y = aX$ (equation 1) was used, since as HM approaches zero it is more appropriate to fit the data through the origin. The second situation was where pasture height was higher than these values and $Y = aX + b$ (equation 2) was applied. Given that the relationship between height and herbage mass on the MLA Pasture Ruler is not strictly linear the corresponding values for a 5 cm high, 75% density pasture calculated for equations 1 and 2 were 1238 and 1143 kg DM/ha, respectively compared with 1400 kg DM/ha for a height of 5 cm on the Pasture Ruler. For each pasture type sampled, the data shown in Table 1 indicate the mean and range of values and the number of samples used in the analyses.

Results and discussion

For the four pasture types studied, mean pasture height (Table 1) ranged from 17.8 (lucerne) to 29.4 cm (tropical perennial grass) and maximum pasture height was >49 cm. Mean density was ~35% for native pasture and forage oats and ~15% for lucerne and tropical perennial grass, but ranged from 0–100% (Table 1). Actual mean HM was <1800 kg DM/ha for native pasture and lucerne and >3200 kg DM/ha for forage oats and tropical perennial grasses (Table 1), ranging up to 11,600 kg DM/ha for the latter. Estimates of residual HM were ~250 kg DM/ha for lucerne and forage oats and >1000 kg DM/ha for native pasture and tropical grasses (Table 1), highlighting the importance of cutting height on HM estimation of different pasture types.

The linear regression equations given in Table 2 were all significant ($P < 0.05$) and as shown by the R^2-value more than 61% of the variation in estimated HM was accounted for by its linear regression on the herbage index (HI). The advantage of using the equations for the four pasture types (Table 2) is that they apply to all pasture heights and densities, whereas the MLA Pasture Ruler regressions apply only to pasture heights of 1–14 cm and a density of 75%. Sufficient variation was also apparent in both the slope and intercept values in Table 2 to justify using different linear regression values for different pasture types and heights.

Use of the equations in Table 2 is best shown by two examples. In the first example, to estimate the HM of a native pasture with a height of 10 cm and a density of 20%, use equation 1 in Table 2 since pasture height is ≤10 cm. Using this equation the HM estimate would be 3.23 x (10 x 20) = 646 kg DM/ha. In the second example, the native pasture has a height of 50 cm and a density of 30%, so equation 2 in Table 2 is used since pasture height is >10 cm. Using this equation the HM estimate would be 2 x (50 x 30) + 692 = 3692 kg DM/ha. In practice, since only estimates of pasture quantity are required, the calculated values could be rounded to the nearest 50 or 100 kg DM/ha.

Finally, the HM estimates that would be obtained using equations 1 and 2 for the MLA Pasture Ruler and the four pasture types were compared at a pasture density of 75% (Table 3). Using equation 1 for pastures ≤10 cm high, for a pasture height of 5 cm the MLA Pasture Ruler approximated the value calculated for the native pasture (1143 *v.* 1211 kg DM/ha), but markedly under estimated the HM of the other pasture types by 600–2000 kg DM/ha (Table 3). Applying equation 2 to a 5 cm high pasture the MLA Pasture Ruler HM estimate approximated the value for lucerne (1270 *vs.* 1263 kg DM/ha), under estimated the value for native pasture

Table 1. Mean pasture height (cm), density (%) and actual herbage mass (kg DM/ha) with the range in measured values given in parentheses for four different pasture types. Mean values are also presented for the residual herbage mass (kg DM/ha) and *n* indicates the number of samples used to calculate the mean.

Pasture type	Height (cm)	Density (%)	Herbage mass (kg DM/ha)[A]	*n*	Residual herbage mass (kg DM/ha)[B]	*n*
Native pasture	18.3 (0–74)	33 (1–100)	1770 (0–8590)	1160	1300	427
Lucerne	17.8 (0–60)	16 (0–60)	1110 (0–4795)	408	245	89
Forage oats	21.3 (2–49)	35 (4–67)	3220 (160–8085)	75	255	25
Tropical perennial grass	29.4 (0–58)	15 (0–55)	3230 (0–11600)	55	1010	20

[A]Above ground herbage mass >1 cm above ground level for all pasture types. [B]Above ground herbage mass from ground level to a height of 1 cm.

Table 2. Linear regression equations and R^2-values for the MLA Pasture Ruler and four different pasture types for equation 1 (pasture heights ≤10 cm for all pasture types, except tropical perennial grasses which were ≤20 cm) and equation 2 (all pasture heights).

Method/pasture type	Equation 1	Equation 2
MLA Pasture Ruler[A]	$HM = 3.05HI$ $R^2 = 0.94$	$HM = 2.62HI + 287$ $R^2 = 0.98$
Native pasture	$HM = 3.23HI$ $R^2 = 0.66$	$HM = 2.00HI + 692$ $R^2 = 0.70$
Lucerne	$HM = 5.44HI$ $R^2 = 0.75$	$HM = 2.01HI + 509$ $R^2 = 0.73$
Forage oats	$HM = 8.33HI$ $R^2 = 0.62$	$HM = 2.23HI + 1388$ $R^2 = 0.62$
Tropical perennial grass	$HM = 8.76HI$ $R^2 = 0.75$	$HM = 5.05HI + 947$ $R^2 = 0.86$

[A]Assumes a pasture density of 75% (moderately dense) with pasture heights ranging from 0–14 cm.

Table 3. Estimated herbage mass (kg DM/ha) for the MLA Pasture Ruler and four different pasture types using equation 1 for a pasture height of 5 cm and equation 2 for pasture heights of 5 and 20 cm. For all calculations a pasture density of 75% was used.

Method/pasture type	Pasture height (cm)		
	5	5	20
	Equation 1	Equation 2	
	kg DM/ha		
MLA Pasture Ruler	1143	1270	4217
Native pasture	1211	1442	3692
Lucerne	2040	1263	3524
Forage oats	3124	2224	4733
Tropical perennial grass	3285	2841	8522

(1270 *vs.* 1442 kg DM/ha) and markedly under estimated the HM values for forage oats and tropical grass by >1000 kg DM/ha (Table 3). When applying equation 2 to a 20 cm high pasture the MLA Pasture Ruler over estimated the HM of native pasture and lucerne (4217 *vs.* 3692 and 3524 kg DM/ha, respectively) and under estimated forage oats HM and tropical perennial grass HM by ~500 and ~4300 kg DM/ha, respectively.

Obviously, in the present study the use of a herbage index for different pasture types has only been considered in the context of estimating total HM. For animal production, green HM is of primary interest and to estimate this, the total HM estimates would need to be adjusted for the proportion of green material. When estimating percent green it is important to remember that the estimate is on a dry-weight basis and adjustments for green material with water contents of up to 80% of dry-weight and dead material with as low as 10% moisture will need to be made.

Using the equations specifically derived for the four different pasture types in this study had the advantage of being able to estimate HM for pastures of any height and density and to take into account the modifying effect of pastures with different structures and growth habits (e.g. upright *vs.* prostrate and bunched *vs.* non-bunched grasses).

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