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# USING THE PASTURE PROBE

by

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## INTRODUCTION

Estimating herbage yield is essential in many aspects of range and pasture research and management. Clipping and weighing is laborious, time consuming, and destructive, often precluding repeated measurements. Electronic capacitance is one means of nondestructive estimation of herbage yield. As interest in the pasture probe (a single probe capacitance meter) increases, a review of its operation and calibration based on three years of experience and research reports from the literature would be helpful to new probe users.

The multi-probe capacitance meter has been used for over 30 years (Angelone, Toledo and Burns 1980). The Design Electronics Pasture Probe is an earth plate capacitance meter designed by Vickery and Nicol (1982) and produced and marketed by Design Electronics of Palmerston North, New Zealand. Gallagher Power Fence, Inc. of San Antonio, TX markets the probe in the United States.

The earth plate capacitance probe (pasture probe) is about 3/4 inch in diameter and 24 inches in length. The lower 30 cm (12 in) is sensitive. Pasture probes that have 60 cm and 100 cm sensitive surfaces are being tested by a few researchers in cooperation with Design Electronics. The probe is sensitive to herbage up to 15 cm from the probe. However, the meter is most influenced by the herbage within 5 cm of the probe. The pasture probe makes use of integrated circuits and as a result is convenient to use and stable in operation. The probe is mainly responsive to the surface area of the herbage, and hence it is less sensitive to variations in moisture content of the pasture than previous capacitance meters.

A capacitor in the pasture probe is somewhat like a battery that fills up with electrical charges. There is less resistance to the flow of energy in the air than in vegetation, so after placing the probe at the base of the vegetation, it emits an electrical charge, which, depending upon the amount of vegetation present, fills the probes's capacitor. The longer it takes the meter's capacitor to fill with energy, the more vegetation is present. A measure of that difference is translated into a meter reading which has been calibrated for herbage quantity.

The air reading taken before and after data collection determines a "standard capacitance" with no herbage present that is used to "correct" meter readings (CMR). As capacitance can vary with humidity and temperature the probe automatically "standardizes" the capacitance under current operating conditions.

## OPERATING THE PROBE

Specific operating instructions come with the probe, but a general operating description is presented here for those unfamiliar with the pasture probe and to provide hints for use that are not explicit in the instructions. Herbage mass readings taken by the probe are saved in an electronic control box and can be downloaded to a microcomputer. The probe maintains the last 50 readings in memory and displays a running mean of herbage mass. Probes sold in the U.S. are programmed to report herbage mass in lb/a on a dry matter basis. The individual readings can only be retrieved by downloading the probe memory to a microcomputer. The probe also displays the number of readings taken. There is memory space for before and after grazing readings from ninety pastures. Date, time, and pasture size information can also be saved in the control box. Computer programs for downloading to a text file or spread sheet are available from the author.

The control box can be carried over the shoulder or around the waist with a belt. Readings are taken with the Pasture Probe by walking across a pasture as if the probe were a cane and taking a herbage mass reading each time the probe touches the ground. The running average of the CMR is converted to dry matter yield using a linear equation developed during calibration. The equations below estimate kg/ha, but the probe is set to convert these estimates to lbs/a. The pasture probe's electronic control box contains several equations developed in New Zealand. These equations are pre-programmed into the pasture probe so that the conversions occur instantly as you sample in the field. The following equations are programmed in the probe:

1. General use when the pasture is not moist:

   $Y\ (\text{DM kg/ha}) = -609 + 4.82\ (\text{CMR}) + 163\ \sqrt{\text{CMR}}$ (Curvilinear)

2. Early Autumn (before rains but forage is green)

   $Y\ (\text{DM kg/ha}) = 353 + 11\ (\text{CMR})$

3. Autumn (after rains)

   $Y\ (\text{DM kg/ha}) = 608 + 11.9\ (\text{CMR})$

4. Winter to Early Spring

   $Y\ (\text{DM kg/ha}) = 212 + 10.9\ (\text{CMR})$

5. Late Spring to Early Summer

   $Y\ (\text{DM kg/ha}) = 341 + 15.1\ (\text{CMR})$

6. Summer

   Y (DM kg/ha) = 854 + 19 (CMR)

7. Tropical Grasses

   Y (DM kg/ha) = 232 + 25.8 (CMR)

8. Corrected Meter Reading (CMR)

Because these equations were developed on perennial pastures dominated by perennial ryegrass and white clover, it was not clear whether any of them would work on California range and pastures. Over the last three growing seasons the Design Electronics Pasture Probe has been calibrated on annual range and irrigated pasture (George et al. 1989 and Robbins et al. 1989).

## OPERATIONAL INFLUENCES

There are three basic relationships that influence the operation of the probe:

* Corrected Meter Reading (CMR) is inversely related to capacitance.
* Capacitance increases with herbage surface area.
* Herbage surface area increases with herbage mass.

The influence of several factors on these relationships have been studied (Richardson 1984). Variations in soil surface conditions and soil water have little or no effect on capacitance. Richardson reported bare soil CMRs ranging from 10 to 18 while our tests have recorded CMRs from 45 to 55 for bare ground. This difference in CMR may be the result of changes in probe electronics since Richardson's report. Under extremely dry conditions it is possible that poor electrical conductivity results in under estimation of the surface area and consequent steepening of regression equations. The probe gives an error reading on dry soils requiring that the reading be repeated.

Richardson (1984) found that correlations were generally better between probe readings and dry weight than probe readings and fresh weight. This is one of the major advantages that the single earth plate meter has over its predecessors. The probe also functions reliably when surface water clings to the surface of the herbage as long as the probe tip is kept free of continuous surface water. Waxing the probe tip keeps it free of surface water. He also reported that dry herbage can be a source of error, but much of that error can be removed by separating the dry dead material and calibrating with the green herbage only. Surface contamination of the probe is a potential source of error that can be removed by frequent cleaning and waxing of the probe. The probe should be disconnected from the control box when it is wiped clean or waxed to prevent static electricity from damaging the electronics in the control box.

Sward structure also influences probe operation. The probe works best on short, upright, moderately open pastures as it is under these conditions that surface area can be most effectively measured. The probe works poorly or requires a great deal of calibration on very open pastures (e.g., pastures with patches of bare ground). Herbage mass may be underestimated where turf mats prevent proper contact between the soil and the earth plate. Lodged or trampled pastures also may inhibit contact with the ground resulting in underestimation of the herbage mass.

Sward structure is also influenced by the structure of individual plants. Grass or clover leaves produce greater CMR than stems and petioles. Therefore a pasture with a high proportion of leaf will have a higher herbage mass than a pasture with a high component of stems, petioles, or culms (Richardson 1984).

Each individual probe reading is likely to be based on a different reading/herbage mass relationship due to the inherent variability in pasture structure and composition. Therefore, effective mean herbage mass estimates must be based on high sample numbers.

Operator error also influences pasture probe operation. The probe spike must be firmly in contact with the ground and perpendicular to it. It takes a 1/2 second to complete a reading once the trigger is squeezed and the probe should remain in correct position for at least that long. If the operator moves too quickly or places the probe in dry soil on a rock or the toe of his boot, the probe will give an audible squeal (error warning) instead of the expected beep, and the measurement must be repeated. As with other sampling methods the probe must be placed randomly without introducing operator bias.

Our experiences generally agree with Richardson's (1984). However, we have found that the probe is sensitive to our high summer temperatures. Therefore, we limit most of our data collection to periods when the air temperature is less than 90 F. One Oregon researcher believes that the probe is also sensitive to temperatures near freezing, but we have not experienced this in California. Vichery and Nicols (1982) determined that there was little temperature dependence between 4 and 24 C.

During calibration and use we have encountered occasional problems getting an air reading and are uncertain of the reason. It has occurred on several occasions when the wind was blowing. We have found that the probe overestimates herbage mass when readings are taken in standing water on recently irrigated pastures.

## RECOMMENDATIONS

The probe is a sensitive electronic device that must be treated with care, especially when being transported in a vehicle. It should be kept in a padded box. The box it comes in serves this purpose well. It should be secured so that it cannot be tossed about in the trunk or pick-up bed.

The probe is powered by a rechargeable nicad battery. It should be recharged every 10 to 14 days. The probe displays a warning when batteries are low.

The first 12 in. (30 cm) of the probe should be waxed with parafin or hard ski wax prior to use, especially when the pasture is damp. The probe should be disconnected from the control box when it is wiped clean or waxed to prevent static electricity from damaging the electronics.

Take at least 50 to 100 probe readings along a walk (transect) in each pasture. If the running average herbage mass changes little it is a sign of an adequate sample size.

Probe and clip at least 20 paired samples on each date or every two weeks if sampling frequently. These can be used to check calibrations and to refine equation selection. Take care to collect paired samples over the range of herbage masses present in the pasture.

Pastures containing large variation in composition or phenology should be stratified and probed separately.

On annual range equation 4 should be used from the time herbage mass reaches 700 lb/a until most plants are flowering (April). Equation 5 should be used from flowering until the forage is too dry to measure (May). Probe readings will become more erratic as sward variation increases due to different plant maturity dates and associated plant moisture changes. The following conversion equation has been developed to estimate annual range herbage mass from germination until 700 lb/a (George et al. 1989): $Y = 231 + 6.3\ (CMR)$.

Equation 4 should be used on irrigated pasture from fall until April. Equation 5 should be used in late spring and early summer (April until hot weather usually in late June). Equation 6 should be used from the onset of hot weather (June) until fall. Equation 7 is usually reserved for warm season pastures, although it may have use on very stemmy or fibrous cool season pastures (Robbins et al. 1989).

The recommended timing for changing equations is based on experience over the past three years. However these recommendations are subject to continued study and refinement.

Table 1. Equations used to convert corrected meter readings (CMR) to herbage mass (kg/ha).

| Equation No. | Conversion Equation | Season of Use |
|---|---|---|
| 1 | $Y = -609 + 4.82\ CMR + 163\sqrt{CMR}$ | Winter-Spring Use |
| 2 | $Y = 353 + 11\ CMR$ | Early Autumn (before rains, forage green |
| 3 | $Y = 608 + 11.9\ CMR$ | Autumn (after rains) |
| 4 | $Y = 212 + 10.9\ CMR$ | Winter to Early Spring |
| 5 | $Y = 341 + 15.1\ CMR$ | Late Spring to Early Summer |
| 6 | $Y = 854 + 19\ CMR$ | Summer |
| 7 | $Y = 232 + 25.8\ CMR$ | Tropical Grasses |
| 8 | Corrected Meter Reading (CMR) | |

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