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A New Electronic Meter for Measuring Herbage Yield

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ABSTRACT: A new electronic instrument, called the Heterodyne Vegetation Meter to measure herbage yield and utilization was built and tested. The instrument proved to be reliable and rapid. Further testing will be conducted.

Ever since scientists first began measuring vegetation, they have felt a need for a quick and accurate method of sampling production or utilization, or both. Many methods currently available are accurate or quick, but few even come close to having both attributes. Instruments using the principle of capacitance measurement show promise of filling this need.

Since the 1930's, the principle of measuring capacitance--the ability to store electrical energy--has been used as an index to moisture content. Instruments have been built to measure the moisture of cereal grains, cotton bales, and soil. Probably the first application of this principle to herbage yield measurement was made by Fletcher and Robinson[1] in 1956. Since then several "capacitance meters" have been built. Although they all used similar principles, each one was different.

In 1962, Campbell, Phillips, and O'Reilly reported on a new instrument.[2] Although still measuring capacitance, their meter uses two principles that contribute greatly to its accuracy. A sensing head uses an array of insulated probes instead of the usual bare metal plates, and a telemetering system allows readings to be made from a remote point. Using these two developments and several of our own, we designed and built an electronic instrument for measuring herbage yield. We called it the Heterodyne Vegetation Meter.[3]

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[1] Fletcher, Joel E., and Robinson, Max E. A capacitance meter for estimating forage weight. Jour. Range Mangt. 9(2):96-97. 1956.

[2] Campbell, A.G., Phillips, D.S.M., and O'Reilly, E.D. An electronic instrument for pasture yield estimation. Jour. British Grassland Soc. 17(2):89-100. 1962.

[3] Mention of trade names and commercial enterprises or products is solely for necessary information. No endorsement by the U.S. Department of Agriculture is implied.

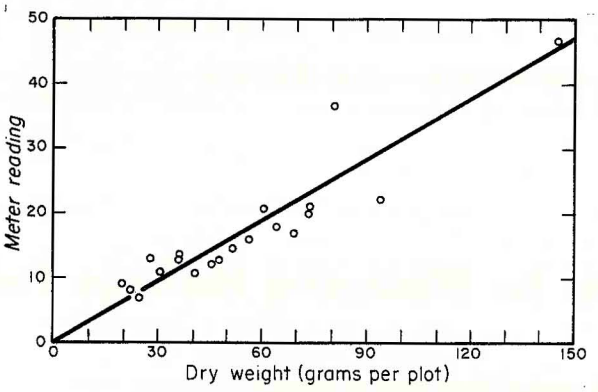

Figure 1.--Observed values of Heterodyne Vegetation Meter readings on green annual range plots, by dry weights of plots, and regression line.

Figure 2.--Range technician operates the Heterodyne Vegetation Meter.

SAMPLING RESULTS

We made preliminary tests of the meter during the summer of 1963 on a green annual grass range and a drying perennial range. It performed with excellent results. We measured plots with the meter, hand clipped and oven dried the vegetation, and conducted regression and correlation analyses (fig. 1). All correlation coefficients ranged from r = 0.94 to r = 0.98. These results meant that the readings accounted for 88 to 96 percent of the variation in yield. Correlation coefficients were even higher using green weights.

We have sampled without any problem grass from 1/2 to 40 inches tall. Using a remote reading unit, the operator can make his readings at a distance of 6 feet and prevent the effects of body capacitance from influencing the readings (fig. 2). The probes cause a minimum disturbance of the vegetation.

At present, a double sampling system seems best adapted to this instrument. Each sampling job requires a few extra plots to be read first with the meter and then hand clipped. The clipped sample should be weighed and used to create a regression line by which the meter readings are converted to weight. We found that major

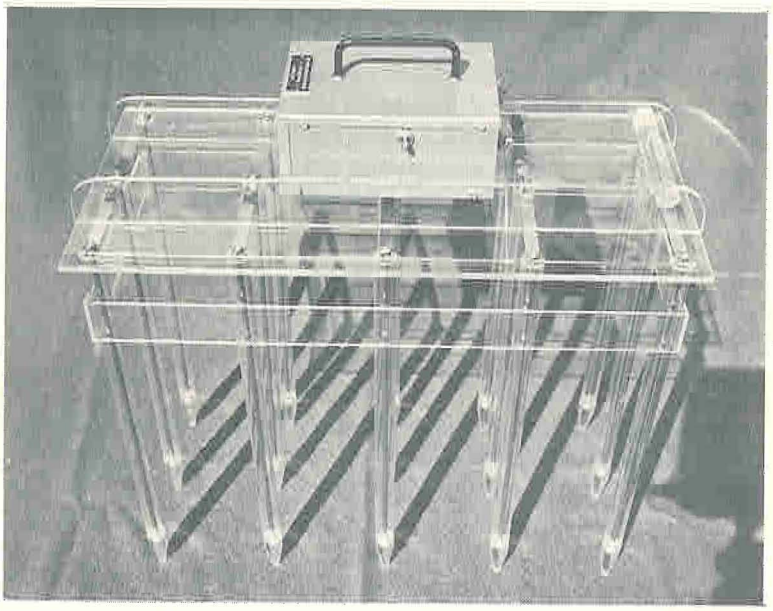

Figure 3.--Sensing head of the test model of the Heterodyne Vegetation Meter, with transmitter-oscillator attached.

Figure 4.--Receiver-reading unit of the meter.

changes in phenological stage or vegetation type require a new double sample and regression line.

The meter compares favorably with hand clipping in accuracy. It is, however, much faster; reading a plot takes about 10 seconds. Many more plots can be taken in a given amount of time. Use of the meter reduces considerably the work of drying and weighing clippings.

HOW THE METER WORKS

The sensing head is an array of fifteen 18-inch probes arranged in a 1-by 2-foot grid (fig. 3). Attached to the sensing head is a transmitter-oscillator which sets up a radio frequency field within the array of probes. The mass between the probes has a capacity to store energy from this field. The energy is an alternating current which reverses polarity. Polarity is reversed when the capacity of the mass is reached. The time required to "fill" the capacity of a given mass controls the rate of polarity reversal and thereby controls the frequency of the transmitter-oscillator. This frequency is transmitted to a receiver-reading unit containing an adjustable heterodyning oscillator (fig. 4).

Before he begins sampling, the operator "zeros" the reading unit by matching its oscillator to the frequency of the sensing head's transmitter-oscillator when the probes are in air. When he inserts the probes into the vegetation on the sample plots, the frequency shifts because the vegetation has a capacitance greater than air. The receiver's heterodyning-oscillator is adjusted to match the new frequency. The difference between the "zero frequency" and the new frequency is registered on a dial. Since the shift in frequency is proportional to the capacity, which is proportional to the mass, the reading provides a reliable index to mass and therefore the amount of or weight, of vegetation.

We plan to continue to test the Heterodyne Vegetation Meter and compare its efficiency with that of hand clipping. Statistical analyses will be made to determine the proper number of meter readings and hand clipped samples necessary to do a given sampling job. We plan to investigate the influence of nearby shrubs and trees on plot readings and the practicality of sampling browse production of woody species. The relative influence of moisture and dry matter on meter readings will be explored.

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