A Field Test of the Relative-Weight-Estimate Method for Determining Herbage Production[1]

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Highlight

Reliable estimates of total herbage yield can be made by the relative-weight-estimate method. The method is based on the concept that it is easier and more accurate to estimate herbage yield as a percent of yield from a base plot than it is to estimate yields directly in grams or pounds. Estimates of total herbage are reasonably accurate, but they are less accurate for vegetation classes of grasses, forbs, and shrubs and for individual species. This method generally contains an inherent bias that cannot be detected unless a double-sampling procedure is used to check and correct field estimates.

Weight estimates of herbage production proposed by Pechanec and Pickford (1937) have been widely used to measure and compare herbage yields on native ranges. Several difficulties are inherent when making direct estimates of herbage as follow:

1. Extensive training periods are required before observers can estimate accurately, and frequent checking of estimates against actual weights is necessary during the inventory period.

2. Estimates probably are always somewhat biased; consequently, it is often advisable to apply a double-sampling procedure in which estimates are checked against actual weights from a series of clipped plots. This provides a correction factor for estimated plots.

3. The observer must develop and maintain a constant mental image of the weight units for the various species. The tendency is to try to remember the weight units for too long a period.

4. Estimates are affected by changes in light conditions and observer fatigue or attitude.

The relative-weight-estimate method is one we believe will minimize or eliminate some of these difficulties. This method generally contains some personal bias, which cannot be corrected unless double sampling is applied to provide correction factors. However, in the field tests reported in this paper, bias was considered to be minimal and the estimates on most sites were suitable.

The relative-weight-estimate method is based upon the assumption it is easier to make comparisons than it is to estimate actual yields. That is, it is easier to estimate production in a plot as a percentage of that in a nearby base plot than it is to estimate production in grams or other units of weight. Since absolute yields are not estimated, no mental image of a weight unit is required.

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Areas Sampled and Methods

The three areas selected for sampling represent different levels of production. Area 1, Montana Power Park, is a relatively dry, mixed grass-forb type under a sparse overstory of mature ponderosa pine. Production is low, averaging about 720 lb per acre. Grasses make up about 75% of the vegetation. Major grasses are *Festuca idahoensis, Danthonia unispicata, Koeleria cristata,* and *Agropyron spicatum.* Forbs are not uniformly distributed; in some areas few or none are found. Principal forbs encountered are *Antennaria luzuloides, A. rosea, Solidago missouriensis,* and *Achillea millefolium.*

Area 2, Vigilante, is a moderately dry range in fair condition, producing about 1,000 lb herbage per acre: 55% grasses, 17% forbs, and 28% shrubs. Principal grasses are *Festuca idahoensis, Koeleria cristata,* and *Agropyron spicatum.* Important forbs are *Phlox canescens, Perideridia gairdneri, Geum triflorum,* and *Comandra pallida.* The major shrub, often the only one, is *Chrysothamnus viscidiflorus.*

Area 3, Modesty Creek, is a high-producing grass-forb range in good condition. This area produces approximately 2,500 lb per acre, green weight. Grasses make up 68% of the herbage produced and forbs the rest. The important grasses are *Festuca idahoensis, F. scabrella, Stipa columbiana, Agropyron spicatum,* and *Koeleria cristata.* The rich mixture of forb species present includes *Viola nuttallii, Achillea millefolium, Geranium viscossimum, Solidago missouriensis, Antennaria rosea,* and *Erigeron spp.*

Clusters of five 1- by 2-ft plots were located randomly within the three ranges. Ten clusters were located in Area 1 and two clusters in each of Areas 2 and 3. The five plots in a cluster were located in a pattern similar to the five spots on the face of a die, with plot centers 3 to 4 feet apart.

Production in each of the four corner plots was estimated as a percentage of that in the base plot. Only the herbage within the vertical projection of the plot boundary was included in the estimates.

Total production was estimated first; then production by vegetation classes—grasses, forbs, and shrubs. Finally, production of individual species was estimated as percentages of the total herbage produced in the base plot. Weight of herbage was computed by multiplying percent production by clipped weight of the base plot.

To test the accuracy of estimates of relative production, vegetation in the base plot and in the four corner plots was clipped and weighed by species. These clippings were recorded as green weights.

Five men made the estimates: men 1, 4, and 5 at Montana Power Park, and men 1, 2, 3, and 4 at Vigilante and Modesty Creek. None had any training in the relative-weight-estimate method. Three men had little, if any, experience in estimating herbage production by any method, but the other two had used weight estimates extensively in other studies.

Table 1. Mean yields (grams per plot).

Area	Actual means	Estimated means by men				
		1	2	3	4	5
Montana Power Park	14.76 ± 6.64	14.19 ± 6.46	—	—	14.44 ± 7.07	14.14 ± 6.51
Vigilante	21.33 ± 11.74	16.34 ± 8.32	16.74 ± 9.70	17.73 ± 8.02	20.73 ± 10.72	—
Modesty Creek	83.33 ± 23.26	88.40 ± 24.88	83.55 ± 13.08	85.78 ± 22.43	135.44 ± 53.46	—

Accuracy of Estimates

Estimates of total production of all species combined were more accurate and consistent than estimates of production for the three forage classes —grasses, forbs, and shrubs—or for individual plant species.

Total herbage production.—In general, the men's estimates of total herbage production were reasonably accurate and consistent. All were within 20% of the actual mean, except on Modesty Creek (Table 1).

At Montana Power Park, estimates of average total production for the 40 plots were remarkably close to the actual average yields; these varied from the actual mean by only a fraction of a gram. At Vigilante, all estimates of average yields from eight plots, though low, also were close to the actual mean. At Modesty Creek, the estimates of three men for the average yields from eight plots also were close to the actual mean. However, the fourth man markedly overestimated the yield on each plot; his estimate of mean production was more than 60% greater (135 g) than the actual (83 g).

Although the estimates of mean production were fairly close to the actual, the estimates of individual plot yields varied widely, especially on the high-yielding Modesty Creek area. Analysis of variance of the differences between actual and estimated yields shows the estimates of individual plots were significantly different at the 1% level at Montana Power Park and Vigilante (Table 2). However, the differences were not considered to be of practical importance.

Prediction equations for estimating total herbage yield vary from area to area. Regression coefficients were below 1.0 for all men on the dry Montana Power Park area, and they were greater than 1.0 for the intermediate Vigilante area. At Modesty Creek, where yields were high, two men's regression coefficients were below 1.0 and two men's above. The ideal would be to have all regression coefficients equal to unity.

Relations between the actual and estimated values are shown graphically in Figures 1–3. On the dry fescue range at Montana Power Park area, all men underestimated low-yielding plots and overestimated high-yielding plots. At Vigilante, all men tended to underestimate all plots, and at Modesty Creek three men overestimated all plots; but one man overestimated the low-yielding plots and underestimated the high-yielding ones.

Vegetation classes.—Estimates of yields for the grasses, forbs, and shrubs were more variable and less accurate than estimates of total herbage production. Shrubs were not abundant enough in Montana Power Park or Modesty Creek to furnish reliable data. On the Vigilante area, correlations between the actual and estimated shrub yield were very high for the four men ($r = 0.99$). Although these correlations were high, the mean yields for the men's estimates varied from 80 to 116% of the actual.

All men estimated grass yields at less than actual on low-yielding plots but more than actual on high-yielding plots on the two dry sites, Montana Power Park and Vigilante. On the high-yielding

Table 2. Analysis of variance of differences between actual and estimated total yields.

Area and source of variation	Degrees of freedom	Sums of Squares	Mean square	F
Montana Power Park:				
Clusters	9	556.73	62.97	3.39**
Plots (P/C)	30	558.10	18.60	2.29**
Men	2	37.75	18.88	.83
Clusters X men	18	408.29	22.68	2.79**
Error	60	487.49	8.12	
Total	119	2,058.36		
Vigilante:				
Clusters	1	7.90	7.90	0.13
Plots (P/C)	6	366.50	61.08	13.57**
Men	3	73.67	24.56	4.66
Clusters X men	3	14.82	5.27	1.17
Error	18	81.01	4.50	
Total	31	544.90		
Modesty Creek:				
Clusters	1	22.95	22.95	0.18
Plots (P/C)	6	754.65	125.76	.29
Men	3	11,902.84	3,967.61	4.73
Clusters X men	3	2,516.86	838.95	1.93
Error	18	7,809.09	433.84	
Total	31	23,006.39		

** Significant at 1% level.

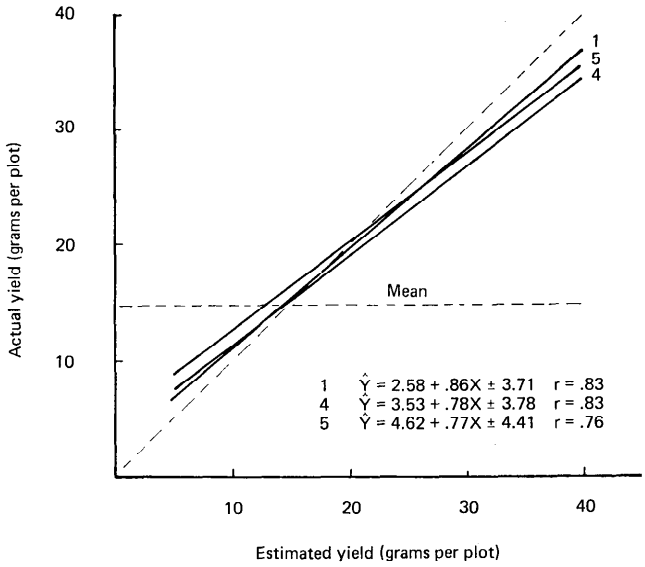

FIG. 1. Comparison of herbage yield estimates by individual men (1, 4, 5) with actual yield at Montana Power Park. Dashed line shows 1 : 1 ratio.

grass-forb range at Modesty Creek, two men's estimates were high for all plots. The third man's estimates were very close to actual yield; the fourth man's were fairly accurate on low-yielding plots but extremely high on high-yielding plots. Correlations between actual and estimated yields on all sites ranged from 0.42 to 0.93. Estimates by three

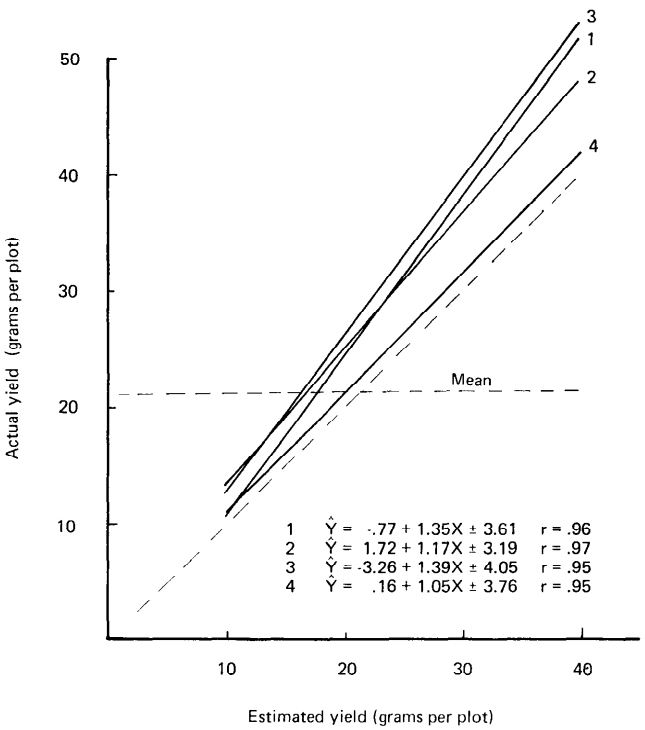

FIG. 2. Comparison of herbage yield estimates by individual men (1, 2, 3, 4) with actual yields at Vigilante. Dashed line shows 1 : 1 ratio.

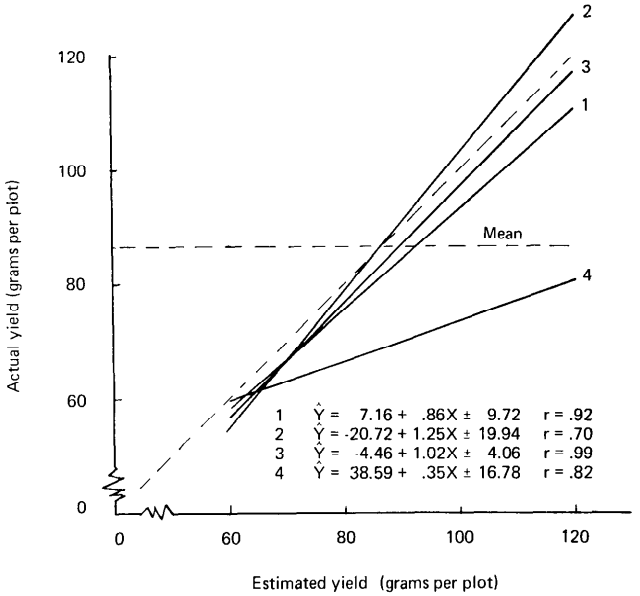

FIG. 3. Comparison of herbage yield estimates by individual men (1, 2, 3, 4) with actual yields at Modesty Creek. Dashed line shows 1 : 1 ratio.

men of total grass at Montana Power Park were exceptionally close; correlations ranged from 0.73 to 0.81, and means of the estimated weights ranged from 9.44 to 9.98 g, as compared to the actual yield of 10.59 g per plot.

All estimates were low for forb production at Montana Power Park. At Vigilante, all estimates of forb production were fairly accurate on low-yielding plots; however, on high-yielding plots, the estimates of two men were extremely high, while the estimates of the remaining two men were extremely low. At Modesty Creek, one man overestimated all plots, while the remaining three men underestimated on low-yielding plots and overestimated on high-yielding plots.

Individual Species.—Estimates of yield for individual species were much more erratic than estimates for total herbage or for the three vegetation classes. Estimates of yields for *Festuca idahoensis* and *Erigeron* spp. were very accurate. Correlations between actual and estimated yields for *Festuca idahoensis* ranged from 0.83 to 0.90, and the means were within 21% of the actual. Correlations between the estimated and actual yields of *Erigeron* ranged from 0.92 to 0.99 and the means were within 15% of the actual. Estimates of *Artemisia frigida, Chrysothamnus viscidiflorus, Achillea millefolium, Agropyron dasystachyum,* and *Agropyron spicatum* were extremely varied and often inaccurate.

Discussion and Summary

The men participating in the test obtained reliable estimates of total herbage yield quite consistently using the relative-weight-estimate method.

However, their estimates of yield by vegetation class or by species were less reliable. Apparently this was due chiefly to their inability to see or to recognize all individuals of a species, especially of grasses. As many as 15 species, eight of which were grasses, were encountered on some plots. Frequently, the smaller grasses and forbs were hidden underneath taller vegetation. On some plots, it was difficult to distinguish between old growth and new growth; this added to the variation in estimates.

Therefore, this method seems appropriate only for studies requiring estimates of total production, or where compositions are not complex. It seems especially adaptable for use on ranges where vegetation is monospecific and growth is uniform.

Estimates of yields by vegetation classes and by species probably would be improved by estimating them as percentages of the same vegetation class in the base plot instead of the total yield. In this procedure the base plot would have to be clipped by vegetation classes. The base plot would not be selected arbitrarily. Rather it would be selected to contain all the vegetation classes present in the other four plots in the sample cluster. Grouping or lumping minor species into a single estimate should also improve the yield estimates. Also, it would be desirable to include a double-sampling procedure so that personal bias could be corrected. This could be done by harvesting some estimated plots as well as the base plot at randomly selected clusters.

LITERATURE CITED

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