J. Double-Weight Sampling

1. *General Description* This technique has been referred to by some as the Calibrated Weight Estimate method. The objective of this method is to determine the amount of current-year above-ground vegetation production on a defined area. The following vegetation attributes are monitored:

   - Peak standing crop, which is the above-ground annual production of each plant species
   - Species composition by weight

   It is important to establish a photo plot (see Section V.A) and take both close-up and general view photographs. This allows the portrayal of resource values and conditions and furnishes visual evidence of vegetation and soil changes over time.

2. *Areas of Use* This method can be used in a wide variety of vegetation types. It is best suited to grasslands and desert shrubs. It can also be used in large shrub and tree communities, but the difficulties increase.

3. *Advantages and Limitations*

   a Double-weight sampling measures the attribute historically used to determine capabilities of an ecosystem.

   b It provides the basic data currently used for determining ecological status.

   c Seasonal and annual fluctuations in climate can influence plant biomass.

   d Measurements can be time-consuming.

   e Current year's growth can be hard to separate from previous years' growth.

   f Accurate measurements require collecting production data at peak production periods, which are usually short, or using utilization and phenology adjustment factors.

   g Green weights require conversion to air-dry weights.

   h In most areas, the variability in production between quadrats and the accuracy of estimating production within individual quadrats requires the sampling of large numbers of quadrats in order to detect reasonable levels of change.

4. *Equipment* The following equipment is needed (see also the equipment listed in Section V.A, page 31, for the establishment of the photo plot):

   - Study Location and Documentation Data form (see Appendix A)
   - Production form (Illustration 22)
   - Sampling frames or hoops
   - One stake: 3/4- or 1-inch angle iron not less than 16 inches long

- Herbage Yield Tables for Trees by Height, DBH, or Canopy
- Clippers
- Paper bags
- Kilogram and gram spring-loaded scales with clip
- Tree diameter measuring tape
- Steel post & driver
- Oven for drying vegetation
- Air-dry weight conversion tables
- Rubber bands
- Pin flags
- Compass

5. *Training* The accuracy of the data depends on the training and ability of the examiners. Examiners must be able to identify plant species and determine current year's growth.

6. *Establishing Studies* Careful establishment of studies is a critical element in obtaining meaningful data (see Section III).

   a **Site Selection** The most important factor in obtaining usable data is selecting representative areas (critical or key areas) in which to run the study (see Section II.D). Study sites should be located within a single plant community within a single ecological site. Transects and sampling points need to be randomly located within the critical or key areas (see Section III).

      (1) The number of quadrats selected depends on the purpose for which the estimates are to be used, uniformity of the vegetation, and other factors (see Section III.B for Statistical Considerations).

      (2) The size and shape of quadrats must be adapted to the vegetation community to be sampled (see Section III.B.6).

   b **Pilot Studies** Collect data on several pilot studies to determine the number of samples (transects or observation points) and the number and size of quadrats needed to collect a statistically valid sample (see Section III.B.8).

   c **Study Layout** Production data can be collected using either the baseline, macroplot or linear study designs described in Section III.A.2 beginning on page 8. The linear technique is the one most often used.

   d **Number of Transects** Establish the minimum number of transects to achieve the desired level of precision for the key species in each study site (see Section III.B).

   e **Reference Post or Point** Permanently mark the location of each study with a reference post and a study location stake (see beginning of Section III).

   f **Study Identification** Number studies for proper identification to ensure that the data collected can be positively associated with specific sites on the ground (see Appendix B).

g Study and Documentation Document pertinent information concerning the study on the Study Location and Documentation Data form (see beginning of Section III and Appendix A).

7. *Taking Photographs* The directions for establishing photo plots and for taking close-up and general view photographs are given in Section V.A.

8. *Weight Units* Double sampling requires the establishment of a weight unit for each species occurring in the area to be sampled. All weight units are based on current year's growth.

a Procedures For Establishing Weight Units:

(1) Decide on a weight unit that is appropriate for each species. A weight unit could be an entire plant, a group of plants, or an easily identifiable portion of a plant, and can be measured in either pounds or grams.

(2) Visually select a representative weight unit.

(3) Harvest and weigh the plant material to determine the actual weight of the weight unit.

(4) Maintain proficiency in estimating by periodically harvesting and weighing to check estimates of production.

b Estimating Production of a Single Quadrat:

(1) Estimate production by counting the weight units of each species in the quadrat.

(2) Convert weight units for each species to grams or pounds.

(3) Harvest and weigh each species to check estimate of production.

(4) Repeat the process until proficiency is attained.

(5) Periodically repeat the process to maintain proficiency in estimating.

(6) Keep the harvested material, when necessary, for air-drying and weighing to convert from green weights to air-dry weights.

c Alternate Method of Establishing Weight Units:

(1) Decide on a weight unit that is appropriate for each species. A weight unit could be an entire plant, a group of plants, or an easily identifiable portion of a plant, and can be measured in either pounds or grams.

(2) Visually select a representative weight unit.

(3) Instead of weighing the material, save it by securing it with rubber bands so portions are not lost.

(4) Use this as a visual model for comparison at each quadrat in the transect. Record on the proper forms only the number of weight units. Do not record the estimated weights.

(5) Weigh each weight unit at the conclusion of the transect. Weighing the weight unit before the conclusion of the transect might influence the weight estimates.

(6) Convert the weight units on the form to actual weight by multiplying the number of units by the weight of the unit.

(7) Harvested weight unit material is *not* saved for determining air-dry weight conversion. Air-dry conversions are determined from clipped quadrats.

9. *Sampling Process* In addition to collecting the specific studies data, general observations should be made of the study sites (see Section II.F).

a Transect Bearing Determine the transect bearing and select a prominent distant landmark such as a peak, rocky point, etc., that can be used as the transect bearing point.

b Double Sampling

(1) Randomly select the starting point along the transect bearing. Take the specified number of paces and read the first quadrat.

(2) Temporarily mark the quadrat by placing a pin flag next to the quadrat so that it can be relocated later if this quadrat is selected for clipping. Be sure to flag every quadrat.

(3) Estimate and record the weight of each species in the quadrat by means of the weight-unit method.

When estimating or harvesting plants, include all parts of all plants *within* the quadrat. Exclude *all* parts of herbaceous plants and shrubs outside the vertical projection of the quadrat, even though the base is within the quadrat (see Illustration 23).

(4) Continue the transect by establishing additional quadrats at specified pace intervals. To change the length of the transect, adjust the number of paces between quadrats.

(5) After weights have been estimated on all quadrats, select the quadrats to be harvested.

(a) The quadrats selected should include all or most of the species in the estimated quadrats. If an important species occurs on some of the estimated quadrats but not on the harvested quadrats, it can be clipped *individually* on one or more other quadrats.

(b) The number of quadrats harvested depends on the number estimated. At least one quadrat should be harvested for each seven estimated to adequately correct the estimates (see table 3).

Table 3

Number of quadrats Estimated	Minimum Number of Quadrats to be Weighed
1 - 7	1
8 - 14	2
14 - 21	3
22 - 28	4
29 - 35	5
36 - 42	6

(6) Harvest, weigh, and record the weight of each species in the quadrats selected for harvesting. Harvest all herbaceous plants originating in the quadrat at ground level. On rangeland, harvest *all* of the current leaf, twig, and fruit production of woody plants located in the quadrats. On native pasture and grazable woodland, harvest the current leaf, twig, and fruit production of woody plants within the plot up to a height of 4 1/2 feet above the ground. For further clarification see Illustration 23.

(7) Correct estimated weights by dividing the harvested weight of *each species* by the estimated weight for the corresponding species on the harvested quadrats. This factor is used to correct the estimates for that species in each quadrat. A factor of more than 1.0 indicates that the estimate is too low. A factor lower than 1.0 indicates that the estimate is too high.

After quadrats are estimated and harvested and correction factors for estimates are computed, air-dry percentages are determined by air-drying the harvested materials or by selecting the appropriate factor from an air-dry percentage table. Values for each species are then converted to air-dry pound per acre or kilograms per hectare for all quadrats. Average weight and percentage composition can then be computed for the sample area.

10. Calculations The weights collected for each species per quadrat placement are recorded on the Production form (see Illustration 22).

a Record estimated weights for each species occurring in each quadrat in the appropriate column (Estimated or Clipped Weight sections of the form.)

b Quadrats that were harvested are circled. The estimate weights for these quadrats are totaled and shown in column 4. The total harvested weights are shown in column 5. Harvested weights for each quadrat for each species are not shown on the form, only the total for each species.

c Column 6 is the actual dry weight for each species from the quadrats that were clipped.

d The Quadrat Correction Factor (QCF)column 7 is calculated by dividing column 5 by column 4.

f Column 8 is determined by dividing the dry weight by the green weight. In the example shown on Illustration 22, the clipped weights were not air dried; the percent dry weights shown in column 8 were taken from the dry weight conversion table.

g The total estimated weights for each species for the entire transect are shown in column 9.

h The average yield (column 10) is determined by multiplying the Total Estimated Weight of each species (column 9) times the Quadrat Correction Factor (column 7) to adjust for the error in estimating weights and then multiplying that times the percent dry weight (column 8) to determine the adjusted dry weight or the Average Yield (column 10).

i The Average Yield for each species (column 10) is totaled at the bottom of the form for the composition totals.

j Percent Composition (column 11) is calculated by dividing the average yield for each species (column 10) by the composition totals.

k If peak standing crop is collected in grams, it can be easily converted to pounds per acres if the total area sampled is a multiple of 9.6 ft^2.

Use table 4 to convert grams to pounds per acre:

Table 4

(# of plots x size = total area)						
(10 x 0.96	=	9.6 ft^2)	multiply grams times	10.0	=	pounds per acre
(10 x 1.92	=	19.2 ft^2)	multiply grams times	5.0	=	pounds per acre
(10 x 2.40	=	24.0 ft^2)	multiply grams times	4.0	=	pounds per acre
(10 x 4.80	=	48.0 ft^2)	multiply grams times	2.0	=	pounds per acre
(10 x 9.60	=	96.0 ft^2)	multiply grams times	1.0	=	pounds per acre
(10 x 96.0	=	960.0 ft^2)	multiply grams times	0.1	=	pounds per acre

11. Data Analysis

This technique involves destructive sampling (clipped plots), so permanent transects or quadrats are not recommended. Since the transects are not permanently marked, use the appropriate nonpaired test. When comparing more than two sampling periods, use ANOVA.

12. References

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Production

Study Number	Date	Examiner	Allotment Name & Number	Pasture

Transect Location	Quadrat Size	Transect Bearing

	Plant	Estimated or Clipped Weight Per Species										Wt Clipped Plots			QCF	%Dry	Wt All	Avg	Pct
Plant Name	Symbol	(Circle Plots that are Clipped) (3)										Est	Clip	Dry		Wt	Plots	Yield	Comp
(1)	(2)	P-1	P-2	P-3	P-4	P-5	P-6	P-7	P-8	P-9	P-10	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Totals																			

Notes (use other side or another page)

Production

Study Number 13N-41E-27-04	Date 9/30/95	Examiner Rex Johnson	Allotment Name & Number Round Mtn 11078	Pasture Ridge
Transect Location 2 miles north of Jack's well on the left hand side of the road.		Quadrat Size 9.6 sq. ft.		Transect Bearing 225°

	Plant	Estimated or Clipped Weight Per Species (Circle Plots that are Clipped) (3)										Wt Clipped Plots			QCF	%Dry	Wt All	Avg	Pct
Plant Name	Symbol											Est	Clip	Dry		Wt	Plots	Yield	Comp
(1)	(2)	P-1	P-2	(P-3)	P-4	P-5	P-6	P-7	P-8	P-9	(P-10)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Black Grama	BOER2	12	16	5		16	8		3	8	3	8	9		1.12	55	71	43.7	12
Curly Mesquite	HIbe	7		12	7		4	9		3		12	13		1.08	60	42	27.2	8
Blue Grama	BOGR2	3	4	3	7	4		1	8		5	8	7		.87	60	35	18.3	5
Sideoats Grama	BOCU		8		1		12	5		7	3	3	4		1.33	55	36	26.3	7
Bush Muhly	MUPO2					(3)						3	3		1.00	55	3	1.6	1
Sixweeks Grama	BOBA			1					6	2	6	7	8		1.14	60	15	10.3	3
3-AWN	ARIST			10				5			8	18	16		.88	60	23	12.1	3
	VUOC					3	1			3	3	3	2		.66	55	10	3.6	1
	Gilia	3		5	8		1		2	12	1	6	7		1.16	40	32	14.8	4
Lotus		2	1		3	5		1	5		6	6	7		1.16	40	23	10.7	3
Lupin			3	2		6	1	7		2	1	3	4		1.33	40	22	11.7	3
Pepperweed					2		2		3	4	3	3	4		1.33	40	14	7.4	2
Burroweed	HAGR	25		18	12			30		7		18	20		1.11	65	92	66.4	18
Mesquite	PRJU		32			20	45		15		28	28	31		1.10	50	140	77	21
Wolfberry	Lyph			20				12		15		20	22		1.10	65	47	33.6	9
Totals																		364.7	100

Notes (use other side or another page)