A New Approach to Estimating Herbage Moisture Content[1]

GEORGE T. TURNER

Range Scientist, Rocky Mountain Forest and Range Experiment Station,[2] Fort Collins, Colorado.

Highlight

Moisture contents of different species of range plants growing under generally similar conditions are closely related during the period of peak herbage development. From regression equations that express those relationships, moisture content of several species can be predicted within reasonable limits from the content of one or more associated species.

Moisture content is an important but generally neglected attribute of range vegetation. It commonly influences or relates to palatability, nutrient content, and flammability of herbage; to susceptibility of plants to damage from frost and trampling; and to droughtiness of range sites. It influences water and salt consumption by range animals, their grazing habits, and patterns of range use. It must be measured or eliminated before herbage production can be expressed in terms of dry weight. If production is used in computing grazing capacities, important variations in herbage moisture content should be recognized (Sharif and West, 1968).

Although several methods for measuring herbage moisture content are available (Magee and Kalbfleisch, 1952; Henderson, 1953), most are cumbersome and time consuming. A more expedient means is needed to increase sampling efficiency and extend the usefulness of moisture determinations. This Note provides evidence that moisture content of plants growing under generally similar conditions is closely interrelated, and may be predicted from the content of one or more associated species.

Study Area and Methods

Herbage samples for moisture determination were obtained from grasslands on Black Mesa, 30 miles west of Gunnison in southwestern Colorado at an elevation of 9,800 feet (Fig. 1). The rolling terrain provides good drainage and a variety of exposures. Most of the 25- to 30-inch annual precipitation falls as snow. Upon melting, it provides abundant moisture for plant growth.

FIG. 1. Herbage samples for moisture determination were obtained from Black Mesa grasslands in southwestern Colorado.

Most plants are in bloom by mid-July. When rainfall is abundant and well distributed, they remain green and relatively succulent throughout the summer. More commonly, however, moisture content declines and plant color fades with advance of the season. The more common plants, along with records to illustrate typical moisture contents at a given time and place, are listed in Table 1.

Herbage samples of several of the more productive species —3 grasses, 7 forbs, and 1 shrub—were collected on 44 occasions over a 4-year period. The 484 samples (44 for each species) provided a basis for determining how moisture content of one species varies with respect to that of another. Correlation coefficients, regression equations, and standard errors of estimate were computed for all possible paired combinations of records for the 11 species.

A total of 149 herbage samples collected on 16 subsequent occasions over another 4-year period provided a basis for testing the predicting reliability of the regressions. Moisture content of those samples was predicted independently on the basis of the measured content of Idaho fescue and aspen fleabane.

On each sampling occasion, the current growth of several plants of each species was harvested. Herbage was bagged, weighed immediately, air dried for 1 to 3 months at room temperature, and reweighed. Moisture content was computed as a percentage of net fresh weight. Collection dates varied from July 23 to August 27, and stages of plant development from preflowering to seed ripening. A sample of each species was obtained from each of 19 sites, most of which were about 1 acre in size.

In a separate study, five composite samples of Idaho

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[2] Forest Service, U. S. Department of Agriculture, with headquarters at Fort Collins, Colorado, in cooperation with Colorado State University.

Table 1. Moisture content (%) of herbage samples, all collected on the same day, from a grassland site on Black Mesa. Most plants were fully grown.

Species	Moisture content
Grasses and Sedge	
Idaho fescue (*Festuca idahoensis*)	44
Letterman needlegrass (*Stipa lettermani*)	46
Thurber fescue (*Festuca thurberi*)	47
Slender wheatgrass (*Agropyron trachycaulum*)	49
Subalpine needlegrass (*Stipa columbiana*)	50
Mountain brome (*Bromus carinatus*)	54
Prairie Junegrass (*Koeleria cristata*)	54
Nodding brome (*Bromus anomalus*)	56
Elk sedge (*Carex geyeri*)	58
Forbs	
Ballhead sandwort (*Arenaria congesta*)	50
Subalpine eriogonum (*Eriogonum subalpinum*)	53
Western yarrow (*Achillea lanulosa*)	60
Beauty cinquefoil (*Potentilla pulcherrima*)	60
Goldenrod (*Solidago ciliosa*)	60
Aspen fleabane (*Erigeron macranthus*)	60
Hairy goldaster (*Chrysopsis villosa*)	62
American vetch (*Vicia americana*)	63
Skyrocket gilia (*Gilia aggregata*)	65
Orange sneezeweed (*Helenium hoopesii*)	66
Sharpleaf valerian (*Valeriana acutiloba*)	66
Bluebell (*Campanula rotundifolia*)	68
Fremont geranium (*Geranium fremontii*)	68
Littleleaf alumroot (*Heuchera parvifolia*)	68
Lupine (*Lupinus amplus*)	68
Aspen peavine (*Lathyrus leucanthus*)	70
Common dandelion (*Taraxacum officinale*)	72
Pale agoseris (*Agoseris glauca*)	78
Shrubs	
Falsetarragon sagebrush (*Artemisia dracunculoides*)	62
Parry rabbitbrush (*Chrysothamnus parryi*)	66

fescue were harvested at weekly intervals during July and August over a 2-year period. Those samples, each of which contained 10 plants from a relatively uniform site, provided a record of the variation in herbage moisture content at a given time and place.

Results and Discussion

Moisture relationships

Moisture contents of the 11 species included in the study (Table 2) were highly correlated ($P < .01$). Most correlation coefficients were larger than 0.70 although they ranged from 0.40 to 0.92. Those for aspen fleabane averaged the highest (0.80), and those for Parry rabbitbrush the lowest (0.56). Standard errors of estimate for the 110 regressions averaged 4.1 percent. Standard errors for paired samples of alfalfa hay and alfalfa-brome hay taken about 1 ft apart in the swath averaged 3.4 and 4.5%, respectively (Isaacs and Wiant, 1959).

Table 2. Estimated linear regression parameters depicting relationships between herbage moisture content of each of two predictor species and that of associated species. Basis: N = 44 for each species.

	Predictor species							
	Idaho fescue				Aspen fleabane			
Associated species	a	b	$S_{y \cdot x}$	r	a	b	$S_{y \cdot x}$	r
Idaho fescue	–	–	–	–	–22.2	1.12	5.4	0.84
Aspen fleabane	32.7	0.62	4.1	0.84	–	–	–	–
Western yarrow	30.9	0.68	3.8	0.87	3.2	0.96	3.0	0.92
Thurber fescue	21.3	0.58	3.5	0.85	1.3	0.76	3.7	0.84
Hairy goldaster	36.0	0.54	3.9	0.81	13.6	0.78	3.3	0.86
Pale agoseris	62.8	0.31	2.4	0.79	50.9	0.42	2.2	0.81
Fremont geranium	57.2	0.26	4.0	0.55	39.3	0.49	3.1	0.76
Common dandelion	54.2	0.44	3.4	0.79	38.2	0.59	3.4	0.79
Parry rabbitbrush	57.6	0.18	4.0	0.40	42.3	0.38	3.4	0.64
Letterman needlegrass	30.4	0.33	4.4	0.59	10.9	0.56	3.6	0.77
Aspen peavine	47.9	0.38	3.6	0.72	31.1	0.56	3.1	0.80

Herbage moisture relationships are expressed through the equation $\hat{Y} = a + bX$. From Table 2, the estimated moisture content ($\hat{Y}$) of western yarrow, for example, would be 65% if the measured content (X) of Idaho fescue were 50% [$\hat{Y} = 30.9 + 0.68(50) = 65\%$].

Moisture contents of Idaho fescue, aspen fleabane, western yarrow, Thurber fescue, and hairy goldaster covered a wider range than that of other species during the period of peak herbage development. Pale agoseris, Fremont geranium, common dandelion, and Parry rabbitbrush were relatively succulent whenever harvested. Idaho fescue usually contained more moisture than Thurber fescue and Letterman needlegrass at the higher moisture levels, but less at lower levels. Aspen fleabane, hairy goldaster, and western yarrow had practically the same moisture content within the observed range of 48 to 78%.

Moisture content of all samples used in determining herbage moisture relationships ranged from 26 to 87%. Values for pale agoseris differed as little as 15 (71–86)%, and those for Idaho fescue as much as 40 (26–66)%.

Moisture prediction

Four-fifths (111) of the 133 values predicted from Idaho fescue, and nine-tenths (122) of those from aspen fleabane, were within 5% of measured values. The samples for which fleabane failed to predict moisture content within 5% were among those that fescue also failed to predict within that limit. Only six estimated values—three from each species—differed from measured values by more than 7%. On the average, predicted values differed from measured values by 2.8 and 2.5%, respectively. Moisture content of Idaho fescue samples from which predictions were made ranged from 38 to 65%, and that of aspen fleabane from 52 to 76%.

Moisture content of Fremont geranium, which tends to mature nonuniformly, was predicted least accurately. Observed values differed by 3.5 and 4.4%, on the average, from those predicted from fleabane and Idaho fescue. The content of rabbitbrush also was estimated somewhat less accurately than that of other species.

Moisture variability

Moisture content of Idaho fescue samples collected weekly during July and August over a 2-year period ranged from 22 to 68%. Differences between the highest and lowest content of samples collected at a given time averaged 3.3%. Coefficients of variation averaged 2.9%. Moisture content became slightly more variable as herbage matured. Even so, no value differed by more than 5% from the average for its group. One representative sample was generally adequate for prediction purposes at any one time during the 2-month period. Required intensity of sampling will vary, of course, with variability in moisture content of the herbage sampled.

Conclusions

Moisture contents of range plants growing under generally similar conditions are related. By means of regression equations that express those relationships, the moisture content of numerous species in a complex flora can be estimated from the measured content of one or more associated species. Species from which predictions are made should be relatively abundant and widely distributed on the site sampled; their moisture content should be sensitive to changes in growing conditions and plant maturity. One representative sample of the predictor species may be adequate, depending on moisture variability.

Whether or not prediction equations developed for one locality, such as Black Mesa, can be used for another is not known. A new equation must be derived, of course, for each additional species for which information is desired. Capabilities and limitations of the method will become better known as it is further tested. Available evidence indicates, however, that plant moisture relationships, once determined, can be used for prediction purposes year after year. Where precise measurements are not required, they offer a promising means for estimating quickly and efficiently the moisture content of numerous herbaceous plant species.

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