Plant Life-form Classification and its Use in Evaluating Range Conditions and Trend[1]

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Ranchers and range technicians need to understand how plants respond to grazing and other land-use pressures in order to determine management practices which will help maintain a high level of range productivity. This article presents a system of plant classification, based on life form, that should help fill this need.

Plant life form may be defined as the structural form a plant assumes under the conditions of its habitat. Structural form reflects a plant's adaptation to its environment and indicates its response to disturbance such as grazing.

Historically, the concept of life form is not new. Clements (1920) gives a detailed summary of several classification systems by Humboldt, Grisebach, Warming, Drude, Raunkiaer, and others. Recent publications by Watt (1947), Cain (1950), Gimingham (1951), Dansereau (1951) and others represent a renewed interest in plant life forms.

In the ponderosa pine zone in northern Arizona, plants can be conveniently classified into the following life-form groupings: (1) long-lived trees and shrubs, (2) perennial tall grasses, (3) perennial midgrasses, (4) perennial short grasses, (5) perennial tall, mid-, and short forbs, (6) perennial prostrate forbs, (7) short-lived half-shrubs, and (8) annuals (Fig. 1). Life span and stature are the two most important life-form characteristics in this classification. Life span decreases from long-lived woody perennials (trees and shrubs) to annuals. Stature decreases from tall trees to prostrate herbaceous plants. There are such other life-form characteristics as propagation, seasonal growth habits and protective devices which need to be considered in addition to life span and stature.

The life-form classification provides a systematized grouping of plants that reflects deterioration or recovery in response to management treatments. In this respect the classification is similar to the "decreaser-increaser-invader" (Weaver and Hansen 1941, Dyksterhuis 1949, Voigt and Weaver 1951, Weaver and Tomanek 1951, Branson and Weaver 1953, and Tomanek and Albertson 1953) and the "desirable-intermediate-undesirable" (Chohlis 1946, Gilbert 1948, Parker 1951 and 1954) systems of classification. The life-form classification has the added advantages of (1) employing life-form characteristics as an objective basis for constructing the classification, (2) using terminology that is neutral in its implied meaning with regard to deterioration and recovery, and (3) using terminology that encourages a careful distinction between economic and ecological standards of evaluation.

Life Forms and Ecological Processes

Ecological dominance and subordination is largely determined by the combinations of life-form characteristics. Trees and shrubs exert dominance over all other species in natural forest communities largely because of their superiority in life span and stature. Tall grasses dominate in undeteriorated mountain meadows and midgrasses dominate in undeteriorated bunchgrass openings. Thus, trees and shrubs, tall grasses and midgrasses are superior life forms of undeteriorated forest communities, meadows and pine-bunchgrass openings, respectively. All other plants possess ecologically inferior life forms.

The control exerted by superior life forms over inferior life forms is greatly reduced when natural communities are disturbed by land-use pressures. Heavy logging, for example, reduces the control of trees over forest communities and consequently releases inferior herbaceous life forms. Plowing of pine-bunchgrass openings unsuited to farming denudes these sites of perennial life forms. When unsuccessful farming is abandoned, annual life forms are released. Overgrazing by cattle reduces tall grasses in meadows and midgrasses in pine-bunchgrass openings. Tall grasses and midgrasses are successively replaced by short grasses, perennial prostrate forbs, short-lived half-shrubs and annuals, which consequently indicate successive stages of range deterioration.

A reduction in the intensity of disturbance or a complete removal of the disturbance favors recovery through secondary succession. The prevailing life forms of a range area indicate stages of recovery or secondary succession just as they indicate stages of deterioration.

Life Forms and Range Conditions

Proportional densities of superior life forms to inferior life forms are directly related to ecological range conditions as shown by measurements of meadow, and pine-bunchgrass openings in northern Arizona (Table 1). High densities of tall grasses in mountain meadows and high densities of midgrasses in pine-bunchgrass openings indicate good to excellent range conditions. Densities of inferior life forms are naturally low when the densities of superior life forms are high. Fair

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range conditions are generally characterized by low to intermediate densities of tall grasses or midgrasses with high densities of short grasses. Poor range conditions are characterized by low densities of tall grasses or midgrasses with fairly high densities of short grasses in combination with perennial prostrate forbs. Very poor range conditions are indicated by low densities of tall grasses or midgrasses with high or low densities of perennial prostrate forbs, short-lived half-shrubs and annuals in pure or mixed stands.

Herbage yields of forage plants are related most directly to the densities of superior life forms (Table 1). High densities of tall grasses in mountain meadows and high densities of midgrasses in pine-bunchgrass openings produce high herbage yields. Yields decrease as densities of superior tall grasses or midgrasses decrease. Yields are inversely related to densities of inferior life forms and show no positive relationships to total herbaceous densities.

In the types studied, amounts of organic mulch that protect the soil against erosion are also related to the densities of the superior life forms. Tall grasses and midgrasses, by producing the greatest herbage yields, produce the most organic mulch. Amounts of organic mulch decrease as tall grasses or midgrasses decrease and are progressively replaced by perennial short grasses, perennial prostrate forbs, short-lived half-shrubs and annuals. Organic mulches may decompose more rapidly on good condition ranges where the soil surface is shaded and micro-organisms are active than on poor condition ranges where the surface is exposed and subject to rapid drying. Organic mulch, therefore, is not always related to range condition since the amounts of organic materials that disappear through decomposition are not easily separated from the amounts removed by grazing.

High densities of superior tall grasses and midgrasses indicate vigorous growing conditions in

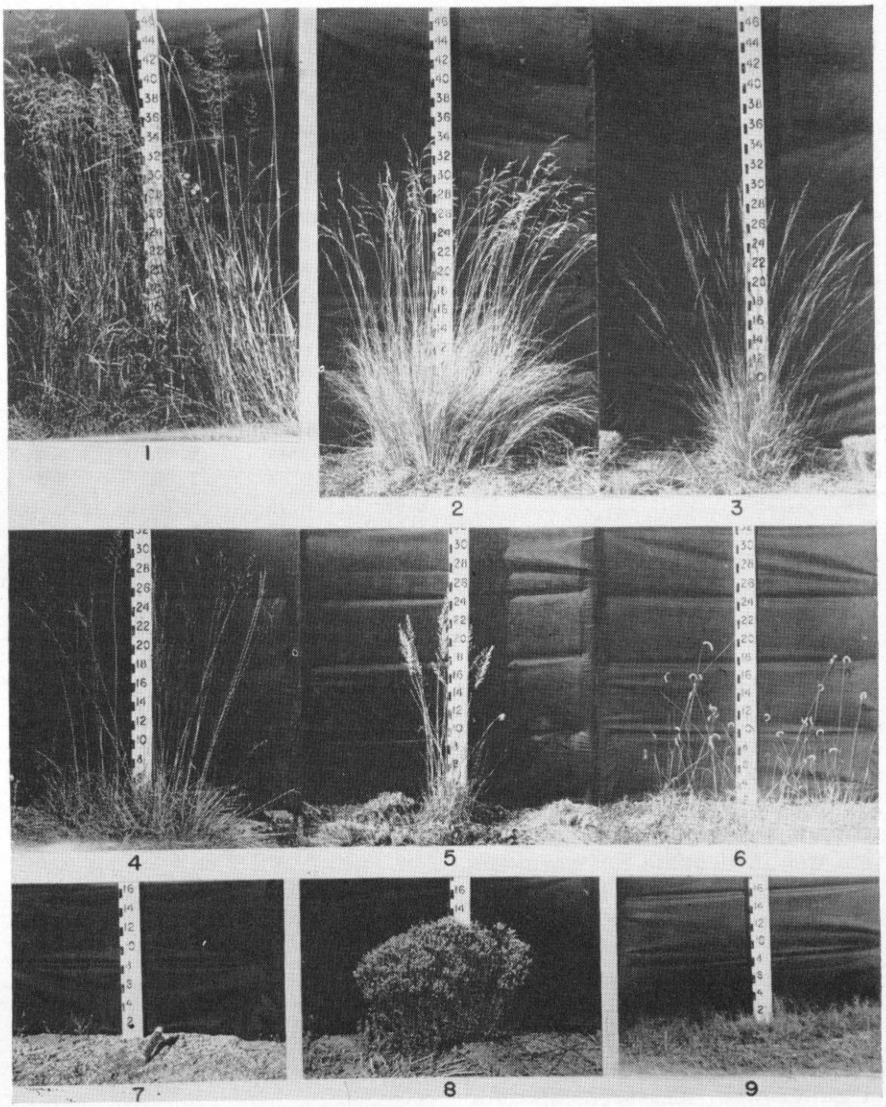

FIGURE 1. Illustrations of several important life forms: **perennial tall meadow grasses,** (1) redtop *(Agrostis alba)* and timothy *(Phleum pratense)*; **perennial midgrasses of bunchgrass openings and timbered ranges,** (2) Arizona fescue *(Festuca arizonica)* and (3) mountain muhly *(Muhlenbergia montana)*; **perennial short grasses** (4) black dropseed *(Sporobolus interruptus)*, (5) pine dropseed *(Blepharoneuron tricholepis)* and (6) blue grama *(Bouteloua gracilis)*; **perennial prostrate forbs,** (7) pussytoes *(Antennaria spp.)* and sandworts *(Arenaria fendleri)*; **short-lived unpalatable half-shrubs,** (8) snakeweed *(Gutierrezia sarothrae)*; **annuals,** (9) annual dropseed *(Sporobolus microspermus)*.

meadows and pine-bunchgrass communities. Growing conditions of each community as a whole decline as superior life forms are replaced by inferior species. The vigor of a community may be indicated by height-growth measurements of a few key indicators if the selected species are superior life forms. Height-growth measurements of inferior life forms may give misleading indications of the growing conditions for the community as a whole, because the vigor of inferior species such as short grasses may often be affected very little by degrees of grazing that reduce the vitality of superior tall and midgrasses (Fig. 2). Even where superior life forms are used, the influence of grazing on plant vigor may not be easily isolated from natural influences. For example, leaf measurements may indicate

Table 1. Relationships between plant densities of superior and inferior life forms and mean herbage yields of forage plants by ecological range condition classes.

Condition	Density (percent of basal line intercept)			Mean air-dry herbage yields
	Superior life forms	Inferior life forms	Total	
		Percent		*Lbs. per acre*
		Mountain Meadows		
Excellent	10.59	2.87	13.46	6,351
Good	7.16	3.50	10.66	4,116
Fair	4.04	4.88	8.92	2,850
Poor	1.19	6.56	7.75	1,692
Very poor	.02	6.64	6.66	1,374
Abandoned cropland	0	10.70	10.70	[1]
		Pine-bunchgrass openings		
Excellent	8.17	1.34	9.51	1,452
Good	5.45	2.53	7.58	988
Fair	2.48	6.25	8.73	699
Poor	1.35	7.77	9.12	518
Abandoned cropland	.02	2.52	2.54	[1]

[1]Not sampled because areas were grazed at the time of observation.

good vigor for Arizona fescue in a year like 1928 when adequate winter moisture favored the growth of cool-season species. In the same year the vigor of mountain muhly was low because summer precipitation was inadequate for warm-season grasses (Fig. 3). The influence of grazing on the vigor of Arizona fescue and mountain muhly is confounded by seasonal variations in precipitation. Thus, proportional densities of superior and inferior life forms are more accurate than height-growth measurements for indicating the effect of grazing management on the vigor of growth for a community as a whole.

Proportional densities of superior life forms to inferior life forms generally reflect the degree of soil erosion or deterioration caused by livestock trampling. The superior life forms of tall grasses and midgrasses provide greater and more lasting protection against soil erosion and deterioration than inferior life forms. Protection against erosion and soil deterioration decreases as tall grasses or midgrasses decrease and are progressively replaced by the inferior plant life forms (Osborn 1950).

For example, in the excellent mountain meadows examined in northern and central Arizona, there were no gullies. Two of the 13 meadows classed as good had shallow gullies less than 2 feet deep. Five of 11 fair condition meadows had shallow gullies. Of 10 poor condition meadows, 7 had shallow gullies and 2 had gullies more than 2 feet deep. Of 14 very poor condition meadows, 10 had deep gullies and 2 had shallow gullies. Pine-bunchgrass openings showed a similar relation between their condition and the degree of soil deterioration and the extent of gully erosion.

The life-form approach to judging range condition requires the construction of locally adaptable life-form classifications by qualified range technicians. After a classification is made, it is only a matter of comparing densities of superior and inferior life forms of grazed ranges with those of remnant climax range communities to judge range conditions. The analysis can be applied to any of the accepted methods of measuring vegetation that record densities by individual plant species. This life-form method of evaluating range condition is more reliable because life-form characteristics, which distinguish between ecologically superior and inferior plants, can be visually observed.

Importance of Life Form in Evaluating Range Trend

In evaluating range trend it is important to distinguish the plant

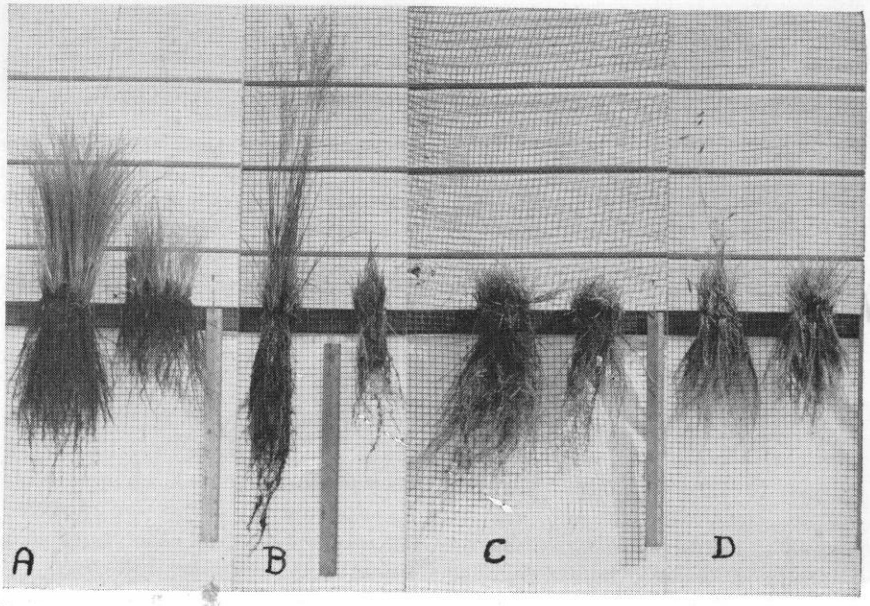

FIGURE 2. The effect of grazing use on individual plant vigor varies among the different life forms according to their capacities to withstand grazing. As indicated by root development and top growth of ungrazed (left) and grazed specimens (right), superior midgrasses like Arizona fescue *(A)* and mountain muhly *(B)* are more highly vulnerable to grazing injury than inferior short grasses like black dropseed *(C)* and blue grama *(D)*.

characteristics that fluctuate erratically with seasonal and annual variations in weather from those characteristics that change more slowly with changes in management. Leaf growth fluctuates very erratically in the short run with seasonal variations of temperature and precipitation (Fig. 3). Maximum leaf development occurs when favorable temperatures and precipitation coincide with seasonal growth habits of different life forms. Muttongrass (*Poa fendleriana*), an early maturing cool-season grass, shows maximum leaf development in years such as 1935 when monthly means for both precipitation and temperature were above normal during January, February and March. Peak years in leaf development for Arizona fescue (*Festuca arizonica*), a late maturing cool-season grass, coincide with above-normal temperatures and precipitation during April, May and June, as occurred in 1928 and 1931. Maximum leaf development for pine dropseed (*Blepharoneuron tricholepis*), an early maturing warm-season grass, occurred in years such as 1929 when precipitation greatly exceeded the normal monthly mean for July and August and when temperatures were slightly above normal. Leaf development for mountain muhly (*Muhlenbergia montana*) reached a maximum in 1933, when temperatures exceeded the normal monthly means for July, August and September, while precipitation was normal during August and above normal during July and September. Minimum leaf development of these four species occurred when temperatures and precipitation were least favorable to their seasonal growth habits.

Cool season and warm season grasses may be segregated into early maturing, intermediate and late-maturing grasses on the basis of seasonal growth habits. Leaf development may thus vary widely among different species in any one year. Maximum leaf development for one or two cool-season species may occur in the same year that a warm-season species shows minimum leaf development. In another year, precipitation and temperatures may favor the reverse situation. Only when drought extends through the entire year do all of the species show suppressed leaf development, and only in years with continuing periods of favorable moisture do all species show maximum leaf growth. Seasonal and annual variations in leaf development cause measurements of herbage yields, vigor and mulch to fluctuate in the short run with seasonal and annual variations of weather.

Slower changes in plant life forms, such as the replacement of one species by another, represent long-run trends in response to changes in management practices. A change from midgrasses to short grasses progresses slowly in response to overuse. Similarly, a change from short grasses to midgrasses progresses slowly in response to management treatments like protection, or a change from dual use to sheep use (Fig. 4). Replacement of one life form by another represents a long-run change which is influenced very little by the usual seasonal and annual fluctuations in climate.

Annual herbage yields fluctuate in the short run mainly as yearly climatic conditions cause seasonal and annual variations in plant growth (Fig. 3). Range productivity, on the other hand, changes more slowly in the long run as shifts in management stimulate changes in plant life forms. A short-run trend in annual yields over a period of only a few years may or may not reflect long-run trends in range productivity. Slow, gradual changes in range productivity resulting from changes in management are often obscured by extreme fluctuations in annual yields. Current investigations indicate that influences of management treatments may be isolated in part from climatic influences by expressing annual yields in terms of pounds per acre per inch of precipitation. Yields per acre per

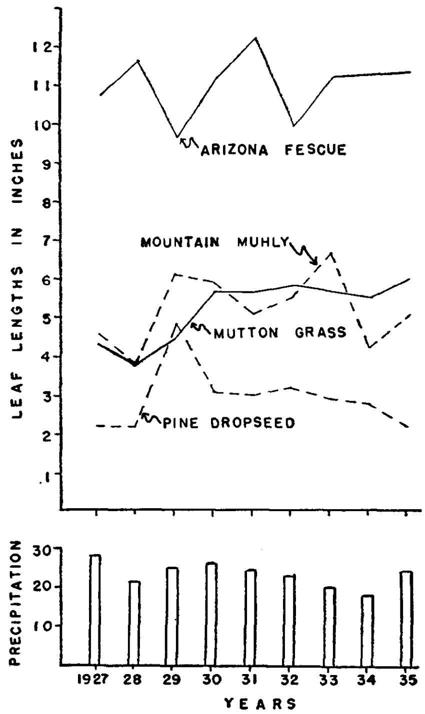

FIGURE 3. Annual fluctuations in leaf lengths at the end of the summer growing periods for four bunchgrass species as related to annual precipitation.

inch of precipitation indicate long-run trends in range productivity that may otherwise be unapparent over brief periods of 4 or 5 years because of extreme fluctuations in annual yields.

Importance of Life Forms to Grazing Use

Range productivity in the long run is dependent upon the prevalent plant life forms. High productivity is maintained where proper management maintains high densities of superior tall grasses in mountain meadows and superior midgrasses in pine-bunchgrass openings. Productivity is progressively lowered when superior life forms are successively replaced by inferior short grasses, perennial prostrate forbs, short-lived unpalatable half-shrubs and annuals. To keep a range at a high level of range productivity, management must aim at maintaining as high a density of the superior life forms as is practical.

To judge proper stocking, one must take into account the response of the various life forms to grazing. Tall grasses and midgrasses are most highly susceptible to injury from improper cattle grazing. Short grasses, perennial prostrate forbs, short-lived unpalatable half-shrubs and annuals are successively less susceptible. It is highly important, therefore, that grazing be kept within the susceptibility limits of the superior herbaceous life forms.

Palatability, or the attractiveness of plants to grazing animals, is variously affected by certain life-form characteristics. Stature often determines, in part, the attractiveness of plants for grazing because among species that are more or less equally palatable, cattle will generally graze tall grasses and midgrasses in preference to short and prostrate life forms. Protective devices such as external awns and spines and internal oils, saps and milky juices often exempt some species from being normally eaten by livestock. Attractiveness often varies with the life-form characteristic of seasonal growth (Johnson 1953). For example, livestock show greater preferences for cool-season species during spring than during the summer. Their preferences for warm-season species, on the other hand, are generally greatest during the summer season.

Seasonal range use is practiced where grazing is largely adjusted to the seasonal growth habits of the prevailing plant life forms. In general, the peak of nutrition in the growth stages of cool-season grasses occur during spring or early summer. Regrowth of cool-season grasses may provide nutritious forage during a second period in fall. Warm-season grasses provide their most nutritious forage during the summer months (Johnson 1953). Seasonal grazing use, therefore, provides a means of utilizing the grasses according to their seasonal growth habits.

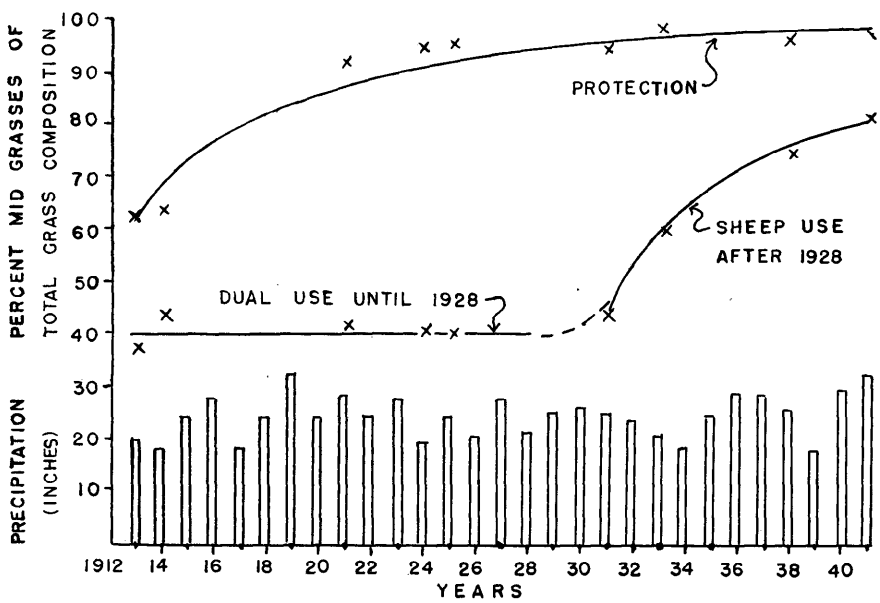

FIGURE 4. Long-run trends of midgrasses as expressed in percent of total grass composition are affected by such management treatments as protection, dual use and sheep use. The trends are unrelated to the annual precipitation pattern.

The importance of plant life form in practical range management is indicated by the questions a rancher may raise in evaluating the economic justification for reseeding a depleted range. Replacement costs for restoring a depleted range lead a rancher to consider the life-form characteristics of the species recommended for reseeding. He shows an interest in (1) life span, (2) stature, (3) susceptibility to grazing injury, (4) propagation, and (5) seasonal growth habits, when he asks such questions about a species recommended for reseeding as: (1) How long does it live? (2) How tall does it grow and how much forage will it produce? (3) How does it stand up under grazing? (4) Does it reproduce itself naturally and will it keep out other undesirable plants? (5) At what time of year does it make most of its growth? Thus, life-form characteristics often determine whether or not a rancher is willing to risk replacement costs of reseeding a deteriorated range.

Summary

Plant life form provides a convenient basis for visually evaluating (1) ecological dominance and subordination in natural communities, (2) the susceptibilities of different plants to grazing injury and to injury from other land-use disturbances, and (3) stages of secondary succession and recovery that result when disturbances are reduced or removed.

Plant life form provides a visual means of evaluating ecological range condition because the life forms that prevail on a given range unit indicate conditions with respect to herbage yields, organic mulch, range vigor and soil erosion.

Trends in leaf development and in annual yields fluctuate erratically in the short run with seasonal and annual variations in climate. Trends in plant life forms and range productivity change slowly in the long run in response to changes in management practices.

The recognition of plant life forms helps: (1) to evaluate range productivity, (2) to establish the goals for proper stocking, (3) to distinguish differences in grazing preferences, (4) to establish the needs for seasonal use and other systems of grazing, and (5) to estimate the economic justification for restoring depleted ranges by artificial reseeding.

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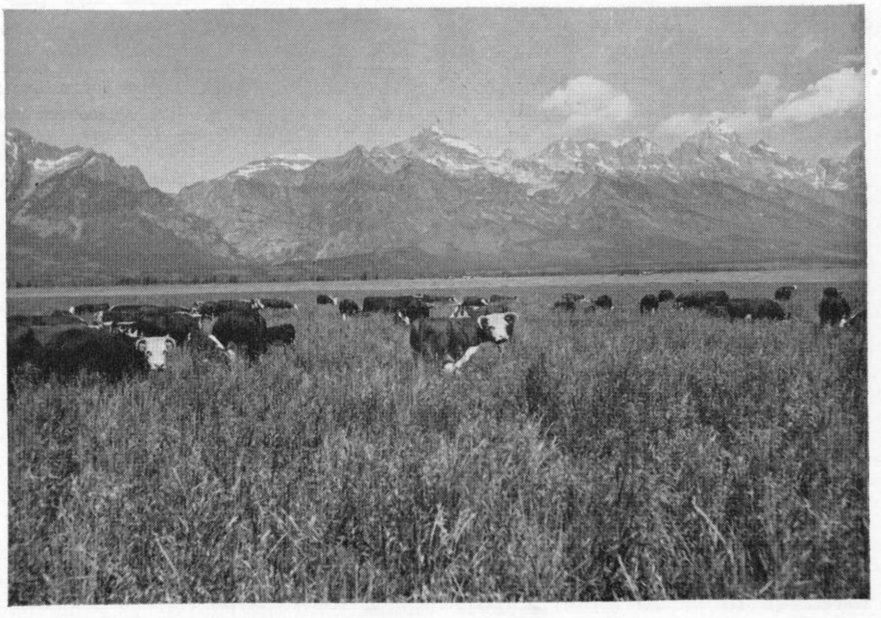

Purebred Herefords on reseeded range on the James Ranch in Jackson Hole, Wyoming. Seeding mixture of Manchar smooth brome, intermediate wheatgrass and Ladak alfalfa. Photograph by HAROLD W. COOPER, Soil Conservation service, Lincoln, Nebraska. Grand Prize Winner and First Place, Grazing Scenes, Photograph Contest at San Jose, California annual meeting.

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