Phenology of the Aerial Portions of Shadscale and Winterfat in Curlew Valley, Utah

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Highlight: Phenological development of aboveground portions of shadscale and winterfat was observed for 7 years in Curlew Valley, Utah, and graphically related to patterns of precipitation and temperature. The considerable variation in year-to-year phenology should be noted by those taking data in other basic and applied studies. Preset dates for livestock management actions that ignore yearly phenological differences could result, in some years, in the plants being used during phenological states that are susceptible to damage by browsing. Seed set cannot be counted on every year, complicating one of the assumptions of rest-rotation grazing.

Explanations of various rangeland plant phenomena often require an understanding of the phenological course of development of the organisms under study. For example, transpiration rates of desert plants are only partially explained by soil moisture depletion. Loss of ephemeral leaves sharply cuts transpiration losses by cold-winter desert shrubs during summer drought (Moore et al. 1972). Productivities are often inferred from what are thought to be peak standing crops (Holmgren and Brewster 1972). However, if the periods of growth were better defined, one could more accurately gauge when peak standing crop occurs. Nutritive values also vary with phenological stages. Sampling of materials on a preset date for several years may result in collection of materials in radically different phenological stages.

Management plans are dependent on plant development. Desert ranges are best suited for livestock utilization during the dormant periods. Although desert plants commonly provide more palatable and nutritious forage during their periods of growth, the plants can withstand much less grazing pressure and have high mortality rates if grazed at that time (Cook 1971). If phenological patterns and their likely variations due to climatic differences were more completely known, we could better adjust livestock use to avoid excessive damage by grazing.

Although some data are available on the phenology of the aboveground growth of cold winter desert and semidesert species, particularly sagebrushes, (Morton and Hull 1975) only Wein and West (1972), Wallace and Romney (1972), Tueller et al. (1972), and Ackerman and Bamberg (1974) have included phenology of perennial chenopods in published reports. These prior studies have all been located in drier and warmer environments than the northern Great Basin and conducted over only 1 to 3 years. Characterization of phenological variation over longer periods was needed for a variety of basic and applied research projects being conducted in the northwestern Great Basin.

Since the data we collected in response to these needs are of possible direct use by others and illustrate some principles applicable elsewhere, we present here the results of our phenological monitoring of shadscale [*Atriplex confertifolia* Torr. and Frem. (S. Wats.)] and winterfat [*Ceratoides lanata* (Pursh) J. T. Howell] between 1966 and 1973 in Curlew Valley, northwestern Utah.

The climate, vegetation, and soils at the study location near the north end of the Great Salt Lake have been described by Mitchell et al. (1966). Fernandez and Caldwell (1975) provided further descriptions of the study area and have reported on belowground phenology of the same species at the same site during 1972 and 1973.

Methods

Twenty individuals of each species were randomly selected from pure stands and permanently marked for observation. Sample plants were located within exclosures that have excluded livestock and rabbit grazing since 1967.

Phenological observations were made at least once every 2 weeks from March through October. Observations were more frequent during periods of rapid change. Three different sets of plants in close proximity to each other on the same site were used to minimize the possible effects of accumulated observer disturbance. The first set was observed from 1966 to 1968. A second set was selected and observed in 1969 and 1970. Data were not taken in 1971, but a third set of 10 plants of each of the two species was observed during 1972–1973.

A random set of 10 twigs in all possible portions of each plant's crown was selected and marked with colored plastic tape using coding techniques previously described by West and Wein (1971). Phenophases and numerical codes used to denote them are given in Table 1. Graphs of phenological progression were drawn using the methods described by West and Wein (1971). Since the phenological status was recorded on an ordinal scale, as discrete, noncontinuous variables, only graphical comparisons of averages were made because parametric statistical analysis was inadvisable.

Meteorological data were collected continuously at the study site. Data missing due to malfunction or disturbance of equipment were obtained by the Thiessen polygon method, using the nearest three U.S. Weather Service stations (Wisler and Brater 1959). Mean weekly air

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Table 1. Phenophases and the numerical codes used to denote them.

Score	Phenophase
1	Winter dormancy
2	Leaves regreening, apical leaf buds swelling
3	Twigs elongating
4	Floral buds developing
5	Flowers opening
6	Fruit developing (male flowers dying)
7	Fruit disseminating
8	Summer dormancy beginning, leaves turning grey-green
9	Leaf buds swelling after late summer or early fall rains
10	Twig elongation after late summer or early fall rains

temperatures (at 1.5 meters above the ground in a standard shelter) and annual cumulative precipitation values were graphed from October 1, preceding the growing period.

Results

The phenological progressions observed in each of the years are graphically summarized in Figure 1. The concomitant weekly average air temperatures and cumulative precipitation values are given immediately below. Average temperatures and cumulative precipitation data (over the 8-year sequence) are indicated by the thinner, identical line within each year's graph. The current year's values are highlighted by shading below the thicker line.

We encountered a variety of climatically different years. Phenological patterns were correspondingly unique. Visual inspection of the graphs and consideration of the original data support the following generalizations.

Winterfat generally undergoes a slower progression of phenophases than does shadscale. When the full sequence of phenophases was truncated due to adverse conditions, then winterfat phenology was more arrested than that of shadscale. Both species evidenced accelerated development during warmer than average spring periods, whereas colder than average spring conditions were associated with delayed progression of phenophases. Drier than average years truncated phenological development, with noncompletion of reproductive phases. Low or zero seed set was noticeable during such years.

Total winter precipitation was apparently of major importance in influencing a full progression of phenophases, although warmer and/or drier than average spring or summer conditions were seen to cancel some of the effects of above average winter precipitation. Rainfall after June did little to either prolong or fulfill the potential course of phenophases. One warmer, wetter than average August-September period (1968) was associated with a pattern of some individuals beginning to grow and flower a second time.

The date of first appearance of given phenological stages varied considerably (Table 2). For instance, the average date of initial twig growth in the spring had a range of 35 days for shadscale and 47 days for winterfat over the 7 years observed. The average date of first flowering (phase 5) had a range of 44 days for shadscale and 29 days for winterfat. The respective standard deviations were 20 days for shadscale and 15 days for winterfat. Shadscale dispersed seed (phase 7) in 6 out of 7 years, winterfat in 5 out of 7 years.

Root growth in these shrubs begins slightly before aboveground morphological developments appear and continues after there is visible change in the aerial portions of these plants (Fernandez and Caldwell 1975). This more prolonged belowground activity is understandable because of the more moderate microenvironment of the soil compared to the atmosphere and the connection of root growth with the near year-round transpiration and photosynthesis carried on by these species (Caldwell et al. 1978).

These species in Curlew Valley began their aboveground phenological development later and had their phenophases

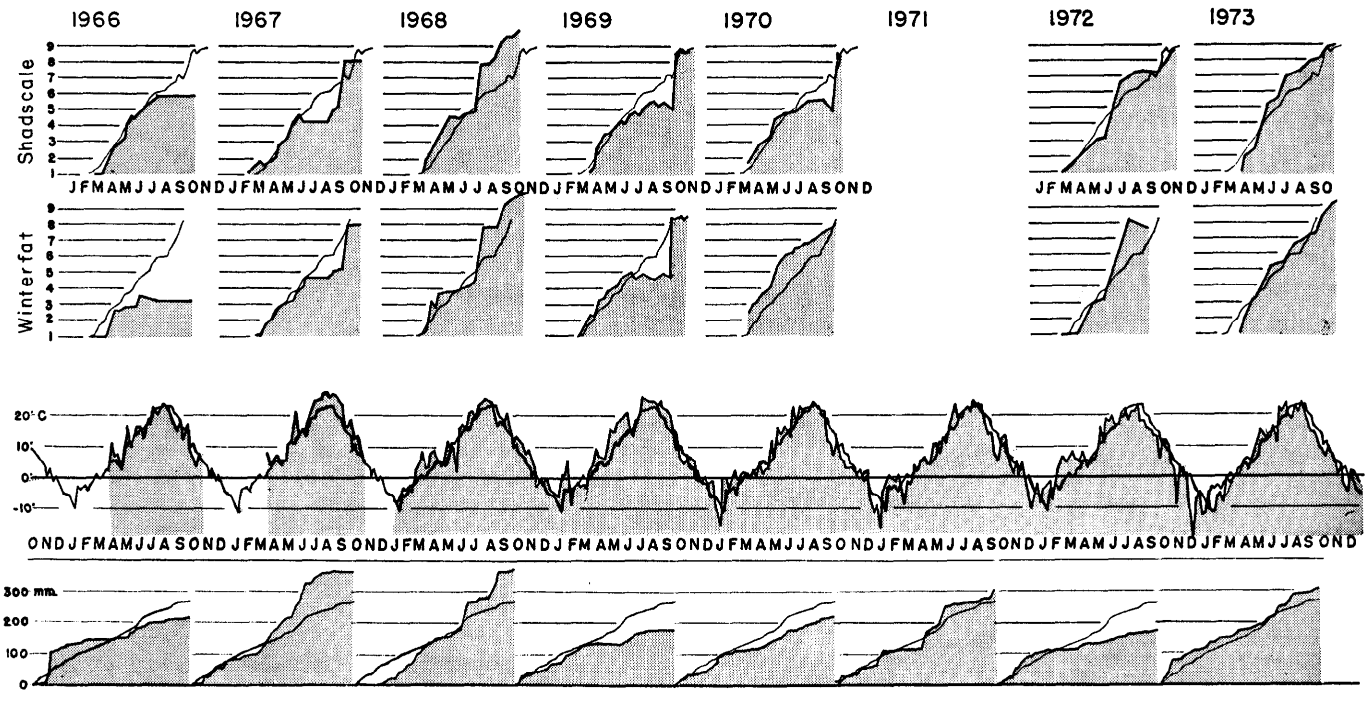

Fig. 1. *Population averages for phenological progressions by shadscale and winterfat in Curlew Valley, Utah, for the years indicated. Description of phenophases and coding are given in Table 1. Next to bottom row of graphs indicates average weekly temperatures (°C) for each year (thick line and shading) and 8-year average (thin line). Unshaded areas lack temperature data. Bottom row of graphs indicates cumulative precipitation (mm) for each year beginning Oct. 1 (thick line and shading) and 8-year average (thin line).*

Table 2. Mean date (± days standard deviation) of first observed occurrence of each phenophase each year and over the 7 years for each species. (Phenophases described in Table 1.)

Species	Year	Phenophase code								
		2	3	4	5	6	7	8	9***	10***
Shadscale	1966	18 Apr. ± 2	5 May ± 3	22 May ± 18	30 June ± 23	25 July ± 8	**	**		
	1967	*	30 Apr. ± 4	29 May ± 10	15 June ± 9	26 June ± 12	6 Sept. ± 5	18 Sept. ± 0		
	1968	2 Apr. ± 8	16 Apr. ± 10	15 May ± 7	15 June ± 6	3 July ± 5	18 Sept. ± 0	27 July ± 0		
	1969	5 Apr. ± 0	21 Apr. ± 4	21 May ± 6	1 June ± 9	5 July ± 22	29 Aug. ± 6	21 Sept. ± 0	31 Aug. ± 4	18 Sept. ± 0
	1970	10 Apr. ± 9	30 Apr. ± 13	8 May ± 7	18 May ± 6	28 June ± 5	5 Aug. ± 11	7 Oct. ± 5		
	1972	20 Apr. ± 17	20 May ± 25	24 May ± 16	17 June ± 14	21 Aug. ± 47	16 Sept. ± 21	5 Aug. ± 56		
	1973	19 Apr. ± 0	11 May ± 0	22 May ± 5	1 June ± 9	17 June ± 20	6 Oct. ± 15	2 Oct. ± 47		
	Mean	11 Apr. ± 10	20 Apr. ± 14	19 May ± 12	11 June ± 20	7 July ± 22	1 Sept. ± 21	11 Sept. ± 36		
Winterfat	1966	17 Apr. ± 0	25 May ± 19	17 June ± 38	**	**	**	**		
	1967	7 Apr. ± 6	1 May ± 4	9 June ± 4	21 June ± 5	20 July ± 0	5 Sept. ± 4	18 Sept. ± 0		
	1968	28 Mar. ± 3	8 Apr. ± 11	14 June ± 6	21 June ± 9	11 July ± 11	10 Oct. ± 0	26 July ± 0	29 Aug. ± 0	18 Sept. ± 0
	1969	*	20 Apr. ± 2	26 May ± 13	5 June ± 8	23 June ± 11	6 Aug. ± 3	24 Sept. ± 20		
	1970	28 Mar. ± 0	18 Apr. ± 0	2 May ± 0	24 May ± 9	10 June ± 10	14 Aug. ± 0	12 Oct. ± 0		
	1972	22 Apr. ± 9	14 May ± 14	3 June ± 0	2 July ± 0	31 July ± 0	**	31 July ± 0		
	1973	19 Apr. ± 0	2 May ± 0	28 May ± 6	9 June ± 8	15 July ± 16	3 Oct. ± 0	2 Sept. ± 32		
	Mean	8 Apr. ± 10	29 Apr. ± 18	28 May ± 21	7 June ± 15	38 June ± 20	27 Aug. ± 23	10 Sept. ± 31		

* Some plants already in phase 2 when sampling began.
** Not observed.
*** Regreening after summer dormancy was only observed in nonfruiting individuals in 1968.

spread out over a longer period than populations observed elsewhere (Wallace and Romney 1972; Wein and West 1972; Tueller et al. 1972; Ackerman and Bamberg 1974). The other sites were warmer and drier than Curlew Valley, however. Sites with greater amounts of and more consistent late summer-early fall precipitation probably have second periods of reproductive activity occurring more routinely (Wein and West 1972).

The practical implication of this study for other researchers is that to ignore phenology when plant data are gathered for other purposes, is to confound the results seriously. The range manager should also be alert to yearly differences in phenological patterns. For instance, if livestock were turned in or gathered up at prescribed calendar dates, variable vegetation responses should be expected since time of range readiness varies considerably among years.

Seed production cannot be counted on every year. Rest-rotation grazing plans assume that seed will develop during the rest year. Under desert conditions seed production is not dependable. Thus, if the "rest" year is dry and hot, no seed production is likely and no reproductive benefits from rest will occur.

Studies such as this can yield insights into the effects of climatic conditions on phenological development. Many years of data collection from various sites will be necessary, however, before we can begin to predict phenological consequences of antecedent climatic conditions on salt desert shrubs, such as Blaisdell (1958) has done for major species on a sagebrush-grass range.

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