Range weather: A comparison at three California range research stations

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Knowing when to expect the first rain in the fall and the length of winter can reduce risk in livestock operations

Variations in the timing and duration of the seasons influence the forage base of California's annual rangelands, creating a high degree of risk and uncertainty for range livestock operations.

The productive potential of these ranges primarily depends on the date of germination-causing rains, onset of cold winter temperatures, onset of warm spring temperatures, and ending date of effective spring rains. The expected date of soil moisture depletion after spring rains end would influence the decision to market or move livestock. Much of this is known by experienced ranchers, but is less apparent to new managers.

Fall forage growth starts after sufficient rainfall for germination. Based on past research at the San Joaquin Experimental Range, germination requires 0.5 to 1 inch of rainfall. If a prolonged dry period follows germinating rains, a second germination may occur with later rains. Sometimes late rains result in germination after the onset of cold winter weather.

Fall forage grows rapidly until winter temperatures become too cold. Rapid growth resumes when temperatures begin to rise in the spring, and usually continues until late April or early May when soil moisture sufficient for plant growth has been depleted. This depletion occurs sooner on south-facing slopes or shallow soils, and it can be later on north-facing slopes or deeper soils with high moisture-holding capacity. After maturing, forage plants dry but remain standing through the summer and into the fall. The forage gradually decreases in quantity and quality but is available as dry feed for livestock and can compensate for poor fall forage growth. In the fall, the rains begin again and the cycle is repeated.

This report compares the fall, winter, and spring phases of the growing season, their variation in length, and the probability of their occurrence at given dates at three range locations in California: UC Hopland Field Station (HFS) south of Ukiah, UC Sierra Foothill Range Field Station (SFRFS) east of Marysville, and San Joaquin Experimental Range (SJER) northeast of Fresno.

Methods

We estimated the beginning dates for germinating rains, cooling winter temperatures, warming spring temperatures, and soil moisture depletion using the criteria in table 1 and 31, 23, and 51 years of weather data from HFS, SFRFS, and SJER, respectively. Dates meeting these criteria were selected by means of a computer program that analyzes daily minimum and maximum temperatures and precipitation.

Criteria based on precipitation were used to select the beginning (fall) and end (summer) of the growing season. Temperature criteria (degree-day accumulations) were used to determine the beginning of the cold winter and warm spring phases of the growing season. A sustained period when an average of five degree-days or less is accumulated each day was determined to be a good indicator of winter conditions. Degree-day accumulations were begun on the first day of the growing season. As the cold winter season approaches, daily degree-day increments decline until the criterion in table 1 is met. Likewise, as warming spring conditions approach, daily degree-day increments increase until the criterion for the spring growth phase is met.

For a broad selection of cool-season forages, growth begins at about 41°F. A mean daily temperature of 42°F would be 1 degree-day above the critical temperature. Of the several methods available for calculating degree-days (*California Agriculture*, January-February 1983), we used the single sine curve method.

For each season, we determined the beginning day, accumulated degree-days, and total precipitation. The starting dates for each season, based on weather data from the three sites, were analyzed to determine the weekly probability for the start of fall, winter, spring, and summer.

Each season was classified as cold, average, or warm and dry, average, or wet. Conditions considered average are those that happen 50 percent of the time. Statistically, average conditions are defined as those that fall within 68 percent of the standard deviation of the mean for all years. Seasons that had accumulated degree-days or rainfall below the average were classified as cold or dry, respectively. Those seasons above the average range were classified as warm or wet.

Results

Computer-selected average beginning dates for fall, winter, spring, and summer for SJER, SFRFS, and HFS are summarized in table 2.

SFRFS and HFS have the earliest average starting dates for fall, beginning on October 12 and 15, respectively, while SJER is about two weeks later. The average date for the onset of winter at HFS is three days before SJER and eight days before SFRFS. SJER has the shortest average fall season (26 days). HFS and SFRFS have average falls of 35 and 46 days.

SJER has the earliest spring starting date, which is about one week earlier than at SFRFS and HFS. HFS has the

TABLE 1. Criteria for fall, winter, spring, and summer phases of the growing season

FALL (Germination): We defined the germination date to occur 7 days after the first rainy day in a week where 0.5 inch of rainfall occurred.

WINTER (Cold): The winter season began on the first cold day in the first cold period of 7 days that averaged less than 5 degree days accumulated per day.

SPRING (Warm): The spring season began on the first warm day in the first warm period of 14 days that averaged greater than 5 degree days accumulated per day.

SUMMER (Dry): Peak forage crop ended with the onset of the dry season which, on the average, began 21 days after the last rainy day in a week where 1 inch of rain occurred.

TABLE 2. Average beginning date for each season

Station	Fall	Winter	Spring	Summer
	Starting date			
SJER	Oct 27	Nov 22	Feb 21	Apr 23
SFRFS	Oct 12	Nov 27	Feb 28	May 9
HFS	Oct 15	Nov 19	Mar 1	May 12

TABLE 3. Accumulated degree days and rainfall for fall, winter, spring,and growing season (year)

Station	Fall	Winter	Spring	Summer
	Accumulated degree days			
SJER	100	374	847	1609
SFRFS	778	383	981	2109
HFS	609	451	722	1704
	Rainfall (inches)			
SJER	1.80	9.34	6.33	16.94
SFRFS	5.60	14.47	6.41	26.23
HFS	6.13	21.36	8.08	34.78

longest average winter season (103 days), while SJER and SFRFS have average winters of 91 and 93 days.

The average starting date for the summer dry season is earliest at SJER—16 to 19 days before SFRFS and HFS, respectively. The average length of spring is about 10 days more at SFRFS and HFS than at SJER.

SFRFS and HFS have average growing seasons of 210 days, compared with SJER's season of 179 days.

In the 1930s and '40s, researchers at SJER described three seasons: inadequate green season, adequate green season, and inadequate dry season. The average fall starting date determined by the criteria in table 1 agrees with the late October beginning of the inadequate green season described in the 1930s and '40s at SJER. The spring and summer starting dates, however, do not correspond closely to the average dates for the beginning of the adequate green season and the inadequate dry season, because those dates were based on cattle weight gains and not on plant growth criteria.

On the average, SFRFS receives more degree-days of heat in the fall and spring than do the other two stations (table 3). HFS receives more degree-days than the others in the winter. On an annual basis, SFRFS receives the most degree-days during the growing season, followed by HFS and then SJER. The variation in annual accumulated degree-days is greatest at SJER. Differences between stations are due to differences in growing season length and temperatures. A long cool growing season may have as many degree-days of heat accumulation as a short warm growing season. HFS and SFRFS have longer growing seasons than SJER and therefore are likely to have greater heat accumulations within the growing season. HFS and SFRFS have similar growing season lengths, but SFRFS has greater degree-day accumulations because of the longer average fall season and shorter winter season.

Average growing season precipitation is highest at HFS, followed by SFRFS and SJER (table 3). Average fall precipitation is substantially lower at SJER than at the other two stations. Winter and spring average precipitation is greatest at HFS.

Figure 1 illustrates the probabilities, at weekly intervals, of each season starting date. Based on the criteria in table 1, all three stations can have a germinating rain as early as the second week in September. There is a high probability of fall beginning between October 5 and October 12 at SFRFS. The period during which fall can occur is longer at SJER than at the other stations, indicating that the date of fall germination and beginning of the forage growing season is less dependable there than at the more northerly stations.

The onset of winter is clustered around early November to early December at all

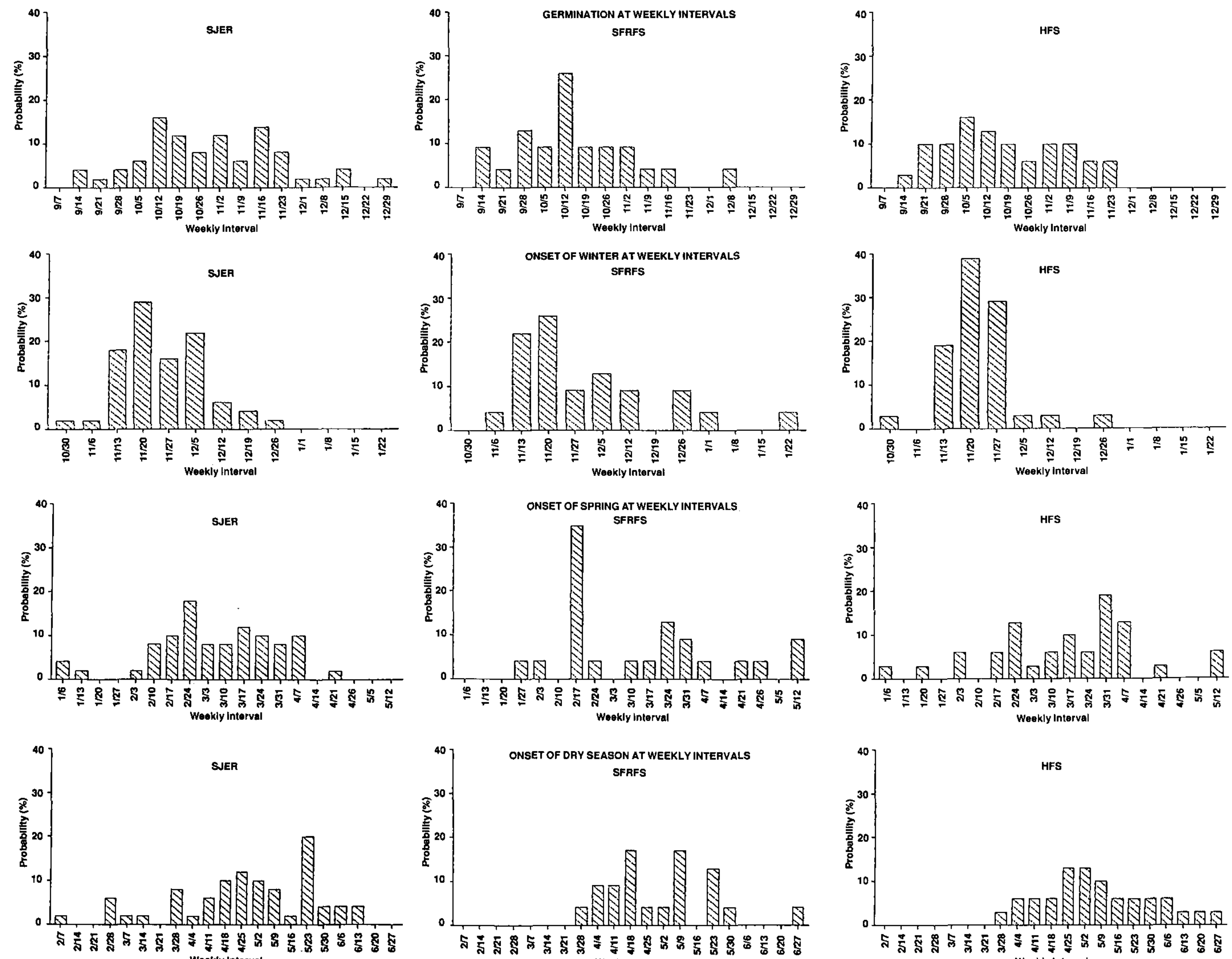

Fig. 1. Probability of fall germination and the onset of winter, spring, and the summer dry season at weekly intervals at the San Joaquin Experimental Range, Sierra Foothill Range Field Station, and Hopland Field Station.

Cattle on Sierra foothill range

Range weather analysis *continued*

three stations. HFS has a high probability of turning cold between November 13 and December 5. Because forage growth rates are very slow during winter, the amount of forage at the beginning of winter is unlikely to increase substantially until warming spring temperatures begin. The winter forage supply is the most critical level for ranchers. Its low level creates a bottleneck for increasing the cow herd and results in major costs for supplemental feeding.

TABLE 4. Historical probabilities of dry, average and wet, cold, average and dry conditions for each season

Condition	Fall	Winter	Spring
		SJER	
Dry	22	20	25
Average	51	61	49
Wet	12	20	22
No Season	16	0	4
Cold	24	27	22
Average	47	47	49
Warm	14	25	25
No Season	16	0	4
		SFRFS	
Dry	30	26	26
Average	43	52	52
Wet	22	22	22
No Season	4	0	0
Cold	17	22	26
Average	65	57	52
Warm	13	22	22
No Season	4	0	0
		HFS	
Dry	23	26	23
Average	48	45	61
Wet	16	29	16
No Season	13	0	0
Cold	26	32	29
Average	35	45	45
Warm	26	23	26
No Season	13	0	0

The beginning of warming conditions is widely spread from early January to early May, but the starting dates are clustered in the period from mid-February to early April. At SFRFS, spring has an extremely high probability of starting between February 10 and 17. The length of the spring forage season is heavily influenced by the timing of spring rains. Mid-April rains can prolong the green season well into May. Later rains are often less effective, because the forage has matured and is less likely to respond to additional moisture with more production.

The dry season begins as early as the first week in February at SJER but is generally clustered in the mid-April to mid-May period at the stations. There is a small probability of the green season lasting well into June.

The probabilities of receiving a wet, average, or dry and a warm, average, or cold season are presented in table 4. When a season is cold or dry, plant growth can be expected to be below average. When warm conditions coincide with average or above-average moisture, plant growth can be expected to be average or above average. These judgments are based on experience and common sense. They have not been tested, because collection of long-term seasonal forage production data has been inadequate. Investigations in progress, however, suggest that there is a strong relationship between degree-day accumulations and forage production.

Conclusion

This report illustrates the use of weather analysis as a tool for determining expected timing of weather and plant growth events. Such analyses can be used to assess risk. Knowing when to expect the first germinating rain in the fall can help to determine average dates for range seeding as well as the expected date of fall green-up. Knowing the length of winter and recognizing deviations from normal may influence short-term animal stocking and supplementation decisions.

Weaknesses in the criteria (table 1) suggest the need for more research. The criteria for estimating the timing of soil moisture depletion are particularly weak because there have been no long-term studies of seasonal soil moisture levels. The criteria for the onset of germination were developed at SJER and may not be adequate for all annual range locations in the state.

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