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A Method for Estimating Precipitation Amounts at Remote Field Sites

Abstract

Analysis of precipitation amounts occurring on the arid sagebrush steppe of southeastern Oregon revealed significant correlation with elevation ($P < .01$). Analysis of data provided an equation for predicting precipitation at remote field sites. Predictions were subsequently compared with actual measurements at 15 newly established precipitation gauges. Regression analysis proved predictions to be significant, to highly significant, among the years. Precipitation estimates may be used to forecast vegetative response during the subsequent growing season.

Introduction

Production of vegetation on comparable sites within the semiarid rangelands of the intermountain western United States is more influenced by precipitation occurring during the Crop Year (September through June inclusive) than by any other variable. Precipitation amount increases with elevation in most instances (Helvey and Fowler 1982). Knowledge of pending vegetative growth is important for land management decisions regarding livestock and wildlife forage production, and for fuel loads for fire hazard predictions.

The sparse distribution of weather stations typical of the intermountain rangeland area does not allow site specific analysis of localized precipitation. Rangeland managers need to adjust livestock grazing intensity within fenced pastures. Similarly, big game habitat managers require information on potential browse shrub production to determine adequate harvest levels, thus reducing the likelihood of massive winter game mortality. Site specific precipitation information is generally lacking for analysis of vegetative production within localized areas.

Study Area

Southeastern Oregon is here defined as the northern half of Malheur County, an area of approximately 13,800 km^2 (Fig. 1(. Topography varies from rolling to mountainous. Elevations range from 670 m near the Snake River to 2,381 m at the summit of Ironside Mountain. The mean crop year (CY) precipitation for seven National Oceanic and Atmospheric Administration (NOAA) stations during the 17 year period of 1966 through 1982 was 26.43 cm (SD = 3.49). Station elevation averaged 1,045 m with a range of 683 m to 1,408 m (Table 1).[1]

[1]Climatological Data. E.P.S., N.O.A.A., U.S. Department of Commerce.

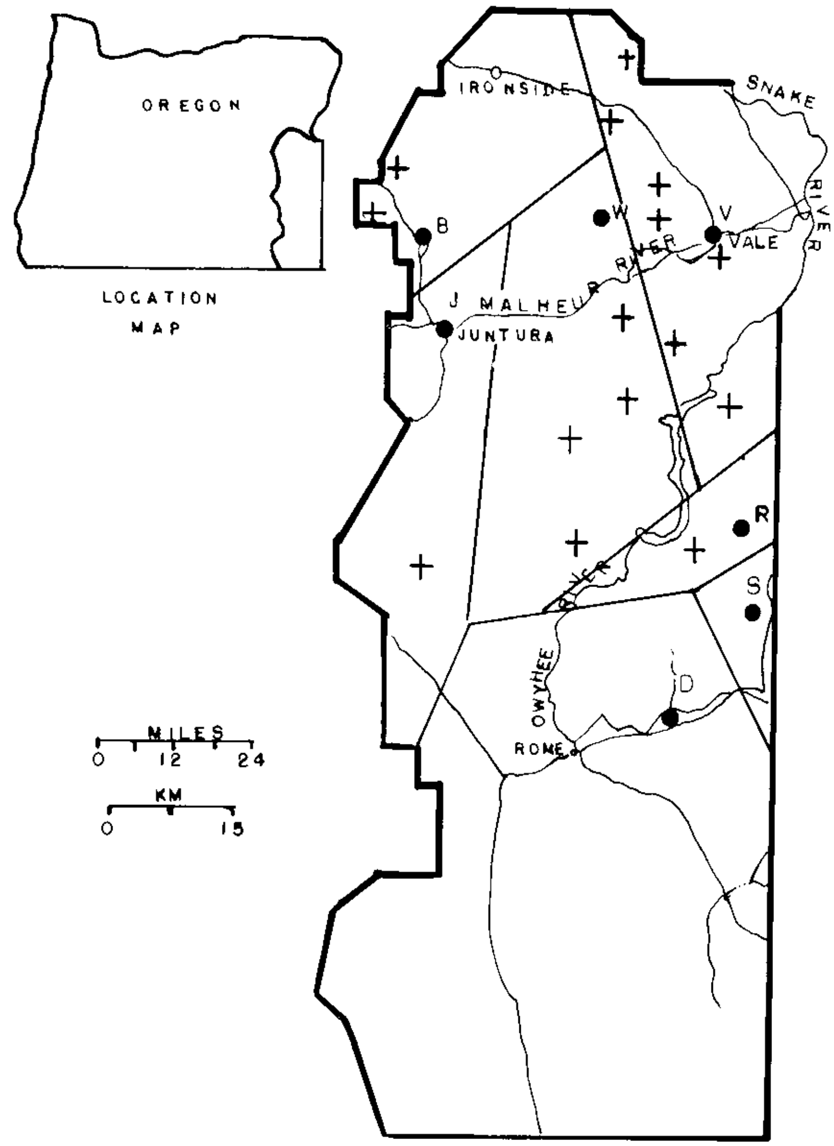

Figure 1. Study area in southeastern Oregon. ● = NOAA stations, + = BLM remote gauges, ⋊ = NOAA station polygon.

TABLE 1. Elevations and 17 year arithmetic mean CY precipitation of 7 NOAA weather stations within northern Malheur County, Oregon.

NOAA Station	Elevation (m)	Mean CY Precipitation (cm)
Beulah	997	24.7
Danner	1,288	27.4
Juntura	863	22.7
Rockville	1,119	25.5
Sheaville	1,408	29.0
Vale	683	21.1
Westfall	957	21.2

Previous Work

A positive correlation between increases in elevation and increased precipitation in middle and high latitudes has been recognized (Henry 1919, Lull and Ellison 1950). Helvey and Fowler (1982) described the variation in annual precipitation in the Columbia Basin of Washington. Sneva and Calvin (1978) developed an improved Thiessen polygon grid for eastern Oregon utilizing data from long term weather stations. Although past workers have documented that correlation coefficients between stations decreased as horizontal distance between stations increased they found higher correlations for stations oriented in a SW-NE direction than for other bearings.

Sneva and Hyder (1962a) developed a method of forecasting production of rangeland grasses for a given year when present CY precipitation was expressed as a percentage of the median CY precipitation for a related weather monitoring station. The CY avoids the two summer months of July and August when typically scant or isolated precipitation has little effect on vegetative production. Kindschy (1982) developed a somewhat similar method, for forecasting the production of forage shrubs in southeastern Oregon, based upon the ratio of the present CY precipitation to the accumulative mean CY precipitation. The accumulative mean was calculated through the inclusion of present CY precipitation data each year. Prior means were not dropped with the addition of new means. The influence of short-term wet or dry cycles was thus smoothed.

Methods and Results

Crop year precipitation data for seven permanent recording stations in Malheur County, Oregon, were analyzed for the 13 year period 1966-78. Elevation above sea level for each station was compared to precipitation received during the CY through linear regression analysis. A strong correlation ($r = 0.938$, $P < .01$) was found between station elevations and precipitation received during the crop year. The resultant equation was:

$$Y = 0.0115\ X + 12.532$$

. . . where Y is crop year precipitation in centimeters and X is station elevation in meters.

Sneva and Hyder (1962) calculated current CY precipitation as a percentage of the median CY precipitation in order to forecast perennial grass production during the subsequent growing season. I employed a similar calculation for adjustment of the regression equation to the present crop year. Comparison of the median CY precipitation data with that of the mean for the period showed nearly identical values (± 3.6 percent). I selected the accumulative mean due to its ease of calculation and familiarity to users (Table 2).

TABLE 2. Ratio of CY precipitation for the years 1979-1982 at NOAA weather stations in northern Malheur County, Oregon. Present CY precipitation ÷ accumuative mean CY precipitation of each station.

NOAA Station	Elevation (m)	1979	1980	1981	1982
Sheaville	1,408	1.05	1.26	1.39	2.00
Beulah	997	.90	1.36	1.25	1.65
Vale	683	.94	1.25	1.29	1.48
Westfall	957	.97	1.34	1.38	1.58
Danner	1,288	.96	1.00	1.31	1.41
Rockville	1,119	.95	1.31	1.50	1.23
Juntura	863	.92	1.49	1.18	1.47

Combining the CY adjustment factor with the regression equation provided the following formula for forecasting the amount of CY precipitation at sites of known elevation within the polygon of influence of a NOAA station:

Metric data:

$$\text{CY Precip.} = [(0.0115 \times \text{Elev (m)}) + 12.532] \times \frac{\text{Present CY Precip (cm)}}{\text{Mean CY Precip (cm)}}$$

English data:

$$\text{CY Precip.} = [(0.0014 \times \text{Elev (ft)}) \times 4.941] + \frac{\text{Present CY Precip (in)}}{\text{Mean CY Precip (in)}}$$

(where the present CY precipitation and the mean CY precipitation pertain to the NOAA station within the polygon.)

During 1978, the Bureau of Land Management placed 15 additional precipitation gauges in remote sites within the study area (Fig. 1). It was felt that the distribution of existing NOAA stations was too sparse and non-uniform to allow adequate forecasting of CY precipitation required by Sneva's method of predicting production of perennial grass forage. Information on the correlation of the newly gathered precipitation data to

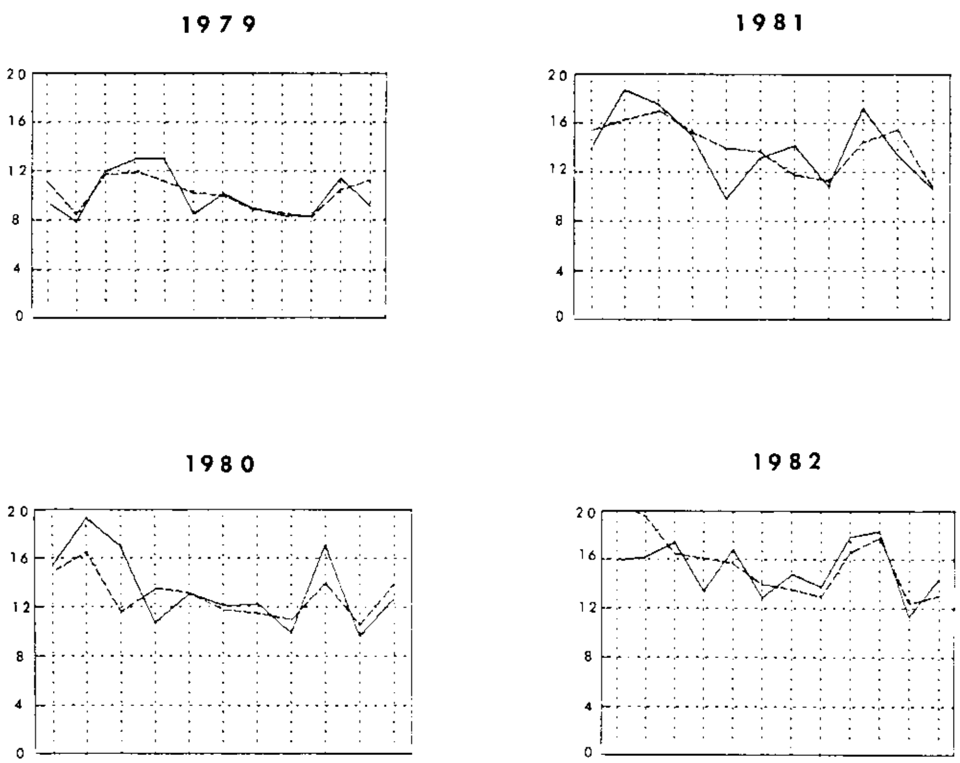

Figure 2. Comparison of the amount of CY precipitation received (solid line) with amount predicted. Horizontal axis represents individual BLM gauging sites.

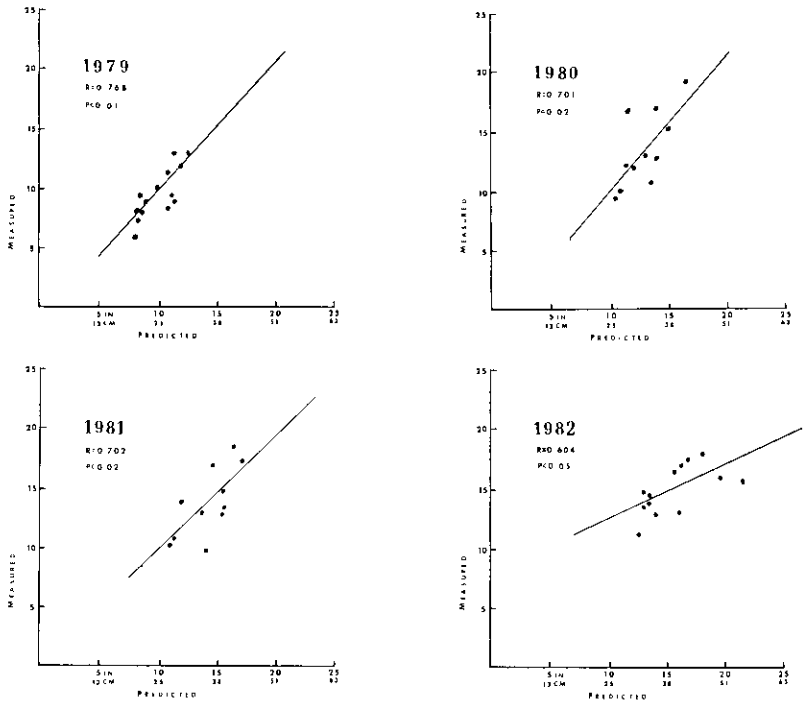

Figure 3. Correlation of predicted to measured CY precipitation.

that from existing NOAA stations would enable refinement of local Thiessen polygon boundaries (Sneva and Calvin 1978). If correlations were sufficiently strong, the new BLM gauges could be abandoned and NOAA data used to forecast subsequent vegetative production.

Crop year precipitation for 1979, 1980, 1981, and 1982 were obtained from these new sites. Each year one or more of the new gauges suffered vandalism or other disruption causing a loss of data. Valid information was obtained for 14 gauges in 1979, 11 during 1980, 11 during 1981, and 13 during 1982. These data were compared to precipitation predicted by the modified regression equation (Fig. 2).

Individual gauge measurements were plotted for each year for comparison with CY precipitation amounts predicted through application of the modified regression equation. Figure 3 illustrates the relationship of measured precipitation to predicted precipitation.

Field Application

A rangeland manager wishes to determine the approximate crop year precipitation for a newly seeded experimental plot at 1,300 m elevation. The plot is located within the polygon of the Vale NOAA station. The accumuative mean CY precipitation for Vale is 22.48 cm. During the 1982 CY (September 1981 through June 1982) the Vale station measured 33.30 cm of precipitation. Thus the adjustment factor for 1982 at Vale is 33.30 ÷ 22.48 = 1.48. Applying the equation:

$$\text{CY Precip.} = [(0.0115 \times \text{Elev.}) + 12.532] \times \text{CY Adjustment Factor}$$
$$= [0.0115 \times 1300) + 12.532] \times 1.48$$
$$= 40.7 \text{ cm precipitation}$$

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Received, May 3, 1983

Accepted for publication, February 28, 1984