Managing the Consequences of Drought: A Need for Clarity in Emphasis and Expectation

Tom Thurow
Department of Renewable Resources
University of Wyoming

Last year I wrote an article for this newsletter which discussed the difficulty of having a shared understanding of drought and the management problems that can arise because of this difficulty. The definition of "drought" is ambiguous because it depends upon expectation and emphasis, which tends to differ between individuals. There are four broad categories of drought perception. A ***meteorological drought perspective*** focuses on how much precipitation occurs within a given time period; generally a drought is designated when less than 75% of average precipitation is received over the course of a season. An ***agricultural drought perspective*** focuses on conditions that cause water stress in plants that significantly reduces grain and/or forage yield. A ***hydrologic drought perspective*** focuses on when surface water and groundwater availability is inadequate to supply established uses. A ***socio-economic drought perspective*** focuses on when water shortage affects peoples' lives in terms of their behavior and options (e.g., increased prices, depressed income).

These four perspectives are frequently out of phase; therefore, it is not surprising that people with different interests disagree about when a drought begins and when it ends. For example, a series of well-timed light showers in the spring may result in lush plant growth, but do little to recharge streams and aquifers. Conversely a large mountain snowpack and rapid melt in the spring may fill reservoirs, but if it is hot and dry during the critical period of growth initiation of range grasses it will be a poor year for forage production. A long-term water shortage may force ranchers to sell their livestock. Once the livestock are sold, it may take several years to build herds back to their original pre-drought level, thus the socio-economic consequences of drought may extend many years past the period of water shortage. If the drought is severe enough it may lead to the financial demise of some enterprises which may never return.

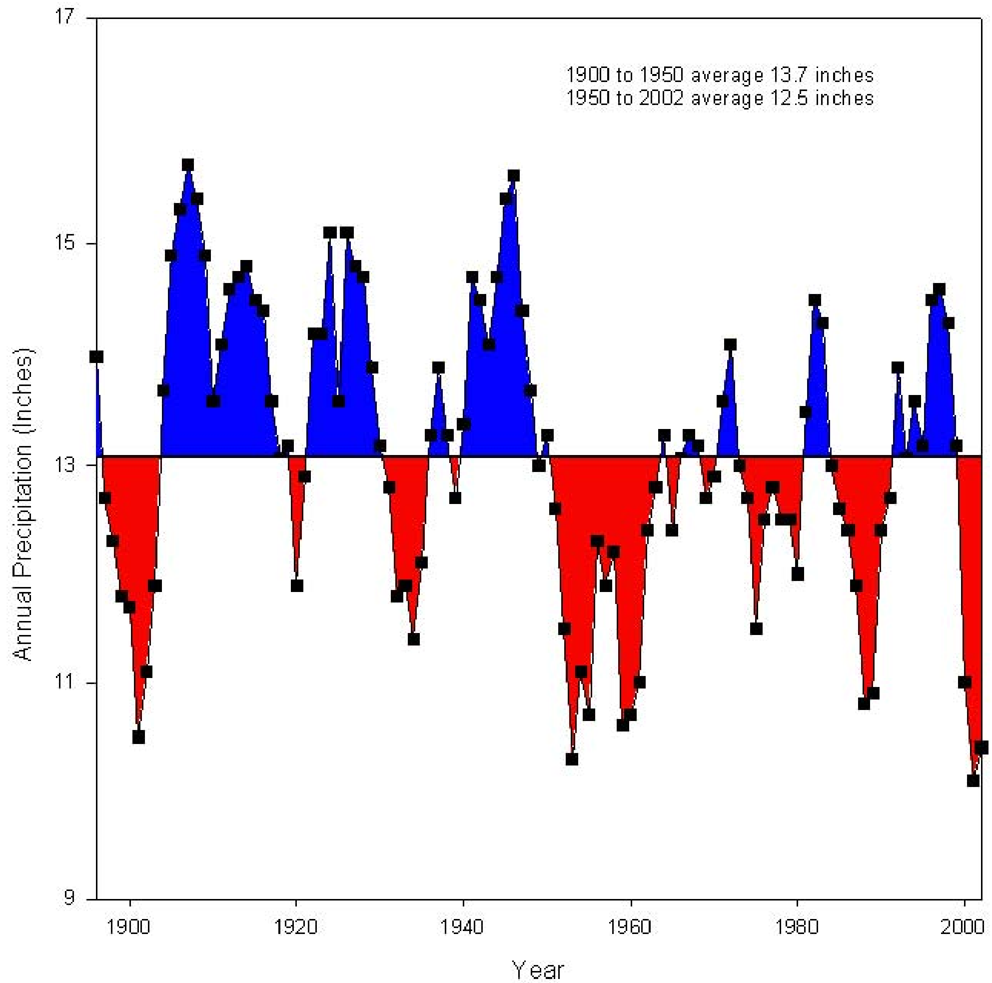
It should be clear from the above discussion that the word "drought" means different things to different people. To use the term without clarifying which type (or types) of drought characteristics are being discussed tends to result in confusion and sometimes even conflict. Often the media discuss drought in the context of a meteorological perspective. This is unfortunate because fixating on the amount of precipitation is often too simplistic to understand how the things most people care about relative to drought are likely to respond. Two examples of the complications of characterizing drought, when it begins and when it ends, are discussed below.

<u>Water Supply for Irrigation, Livestock, and Municipal Needs</u>

If the reservoirs and aquifers are full when a period of precipitation deficit begins it may take several years before their levels drop to a point where water access is imperiled. Conversely, there may be very little recovery in stream flow or reservoir and aquifer storage during the first year or two after a precipitation deficit has ended because the soil and rock fractures will need to be recharged before a increase in water yield will be manifest. **Is the drought over if normal rainfall has resumed but the stream flow or reservoir and aquifer storage have not yet recovered?** If I depend on the stream or reservoir or aquifer, I would say no!

The lagged response between precipitation and level of water in streams, aquifers, and reservoirs makes it useful to consider annual precipitation in the context of a running average of several years. In Figure 1 the precipitation average for Wyoming is expressed as a three-year running average. The line through the middle of the graph is the median (half of the points are above the line and half are below the line). Many of our reservoirs were planned and built relying on precipitation data from the first half of the 20th century. During the second half of the 20th century water demand dramatically increased in association with expanding irrigation acreage and human population, but the precipitation pattern has been conspicuously lower. This has prompted some scientists to question whether there has perhaps been a historic miscalculation of expectation (demand) relative to sustainable supply, with unmet expectations (whether realistic or not) being perceived by the public as drought. The graph also illustrates that extended periods of precipitation deficit are a normal characteristic of the region! It is therefore not unreasonable to expect that policy makers and managers should plan for these certain, albeit unpredictable, periods of low precipitation.

Figure 1. Long-term running three-year average of Wyoming precipitation.



Rangeland Forage Production

Forage production is complicated because the topsoil moisture available for plant growth is not only a function of the amount of precipitation, it is also influenced by the timing of precipitation and by evaporative water demand affected by climatic factors such as temperature and wind. Annual precipitation for many locations in Wyoming is skewed (with more dry years than wet years). Combined with the fact that the timing of precipitation or the climatic evaporative demand is also less than optimal, this creates a skewed forage production data set with a few years of very high production and many years of low production. This is an important phenomenon to acknowledge because the calculation of proper stocking rate depends on the estimate of annual forage production. Unrealistic expectation of "average" forage production leads many people to perceive that they are in a forage drought more often than is really the case.

Three long-term data sets collected in Casper, Cheyenne, and Saratoga (under the respective guidance of Mr. C. Fifield of the U.S. Bureau of Land Management, Dr. R. Hart of the USDA-Agriculture Research Service and Dr. M. Smith of the University of Wyoming) illustrate that how the "average" is calculated will dramatically affect expectation (Table 1). The arithmetic mean (i.e., summing annual precipitation data and dividing by the number of years) is commonly used to characterize average forage production or annual precipitation – this is an ***incorrect*** statistical procedure for skewed data sets since a few high years inflate the average. It is appropriate to use either the median (i.e., mid-point of the data set) or mode (i.e., the most frequently encountered data class) to characterize such data sets and thereby base stocking rate on a realistic long-term average of expected forage production.

Table 1. Averages of the annual growing season peak forage standing crop for three rangeland locations in Wyoming.

Location	Casper	Cheyenne	Saratoga
Years of data	18	22	18
Mean (lbs/acre)	409	1105	310
Median (lbs/acre)	382	1037	283
Mode (lbs/acre)	350 ± 25	1000 ± 50	250 ± 25

Numerous studies have illustrated that rangeland forage is adapted to cope with normal climatic fluctuation when moderately stocked. Therefore, if stocking rates are responsive to fluctuations in forage production the native grasses are ecophysiologically able to cope with several years of dry weather that result in abnormally low forage production (generally identified to be when forage production is less than 75% of the median forage production). A protracted forage drought is rare in Wyoming – for the three data sets cited above only the years of 1992-1994 in Cheyenne represent a period where forage production was less than 75% of the median for three years in a row. Since grass root reserves would be exhausted after about two years of forage drought it would desirable to defer livestock grazing if precipitation is not satisfactory for resumption of normal growth in the third year and beyond of a forage drought. Damage to rangeland ecosystems is usually associated with long-term poor control of stocking rate in response to annual fluctuation of forage production and/or poor distribution of livestock (which may be exacerbated by a hydrologic drought when secondary water sources dry up). A grazing plan that has a serious strategy developed for responding to variations in water and forage supply is the best way to avoid the long-term ecological and socio-economic disruptions that drought can trigger.