ACCUMULATED GROWING DEGREE DAYS: HOW TO USE THEM TO UNDERSTAND NATURAL PATTERNS AND THEIR EFFECTS ON RANGELAND PLANTS

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Rangeland management activities such as rotational grazing, herbicide application, and seeding require specific timing to be successful. However, due to changes in climate regimes, timing of plant development can differ significantly from one year to the next. By utilizing different monitoring methods, as opposed to calendar dates, land managers can make more informed decisions and better time key management practices, which will benefit both forage and livestock. The objective of this document is to explain how accumulated growing degree days can be used to track the development of plants on rangelands, which can facilitate timing and adoption of adaptive management plans.

Growing degree days (GDD) are defined as the number of heat or thermal units required to reach different stages of growth and development. For example, grasses need a specific number of thermal units to develop leaves and grow beyond a point where grazing can cause detrimental effects. Pastures can receive that number of thermal units at different times each year, depending on climate conditions. Recognizing these patterns each year can aid in optimal timing for several management practices. The number of GDDs for any given day can be calculated by taking the average of the hourly minimum and hourly maximum temperature in the same 24-hour period minus the base temperature (Equation 1). The base temperature, which is the lowest temperature under which plants initiate development, is 32°F for cool season grasses and 50°F for warm season grasses (see below).

Equation 1: Calculating GDD

$$\boldsymbol{GDD = \left(\frac{T_{max} + T_{min}}{2}\right) - \ T_{base}}$$

Where GDD = Growing Degree Days

T_{max}= Daily maximum temperature

T_{min} = Daily minimum temperature

T_{base} = 32°F for cool season grasses and 50°F for warm season grasses

Beginning on January 1st each year, the GDD is calculated – if that number is larger than zero, it is assumed that plants received enough thermal energy that day to grow. Values greater than zero can be added up to provide the **accumulated growing degree days (AGDD)** for that year. It is important to note that for many locations, temperatures will not exceed the base temperature until late Winter or early Spring.

Examples of Warm and Cool season grasses

Base temperature differs for each plant species and is dependent on that plant's **photosynthetic pathway**.

(1) **C3 (*cool season*)**: plants that require less thermal energy and thus reach development stages earlier in the growing season and senesce earlier as well. These species also tend to require higher amounts of water. In Net Mexico these species are typically found in northern portions of the state, in mountainous areas or during wet periods in the southern part of the state. Common cool season grasses in New Mexico are western wheatgrass (*Agropyron smithii*), Arizona fescue (*Festuca arizonica*), and New Mexico feathergrass (*Stipa neomexicana*). The base temperature used for these grasses is typically **32°F**.

(2) **C4 (*warm season):*** plants that require more thermal energy compared to cool season. These species typically thrive in warm and dry environments and are prevalent throughout New Mexico. Examples include: grama species (*Bouteloua spp*.), cane bluestem (*Bothriochloa barbinodis*), galleta (*Hilaria jamesii*). The base temperature for these grasses is typically **50°F**.

Summary of Steps:

Step 1: Record the daily maximum and minimum temperatures and calculate the daily GDDs. Temperatures can be obtained by weather stations, weather reports, and the New Mexico State University weather data website: https://weather.nmsu.edu/

Step 2: Determine the starting date for calculating GDDs. If the average daily temperature is below 32°F no GDDs are accumulated for that day.

Step 3: Add up the GDDs for each day from the starting date.

Step 4: Use Table 1 provided below to determine the number of AGDD needed for the desired grass species to reach specific growth stages.

Scientists have determined how many GDDs that key rangeland grass species need to reach certain development stages. The table below provides values for some common grasses in New Mexico. Notice that the warm season grasses, such as blue grama, require more GDD to initiate growth and reach grazing readiness compared to cool season grasses.

Grass	Photosynthetic Pathway	Base Temperature	AGDD	
			Initiation of growth	Optimal grazing
Blue grama (*Bouteloua gracilis*)	C4	50°F	423	1296
Western Wheatgrass (*Agropyron smithii*)	C3	32°F	297	1170
Prairie June Grass (*Koeleria macrantha*)	C3	32°F	216	756
NM Needle-and-thread (*Stipa comata*)	C3	32°F	290	1014

Table 1. Number of accumulated growing degree days needed to reach certain growth stages for common NM grasses.

The GGD on a specific calendar date will vary year to year. Growing degree days are a more reliable method of predicting plant development than calendar days. By simple daily monitoring, landowners will be able to calculate the number of GDDs each pasture has received and make management decisions accordingly. Below is a graph displaying GDD data from a weather station near Las Vegas, New Mexico. Each line represents the number of GDDs for each year from the period of 1890-2018. The gray area is the range of historic that that weather station should normally receive. Values outside of that range are significantly different from average (and deviate from temperatures to which the ecosystem is adapted) and will drastically affect the rate of growth and development of plants. Land managers should change the timing of management practices accordingly.

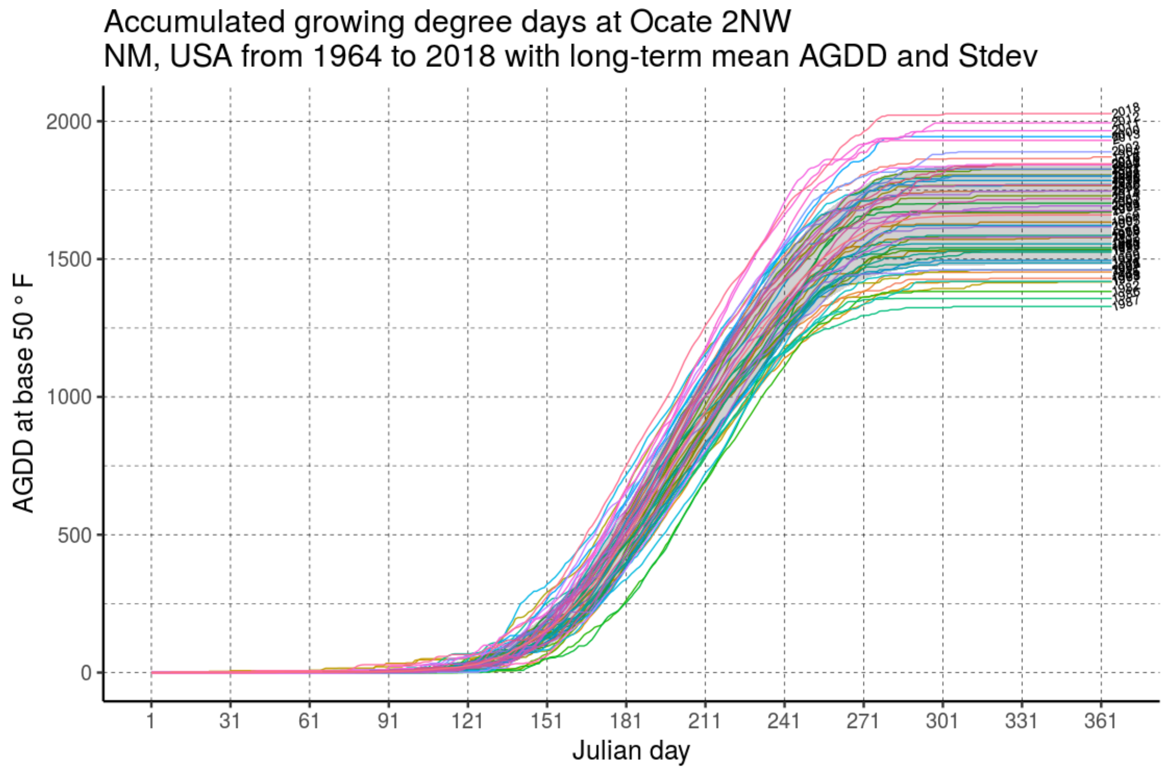

Figure 1. Accumulated growing degree days (base 50) from Ocate 2NW weather station near Las Vegas, NM.

Accumulated growing degree days were developed for and have been used extensively on croplands, aiding farmers in optimal timing for planting and harvesting. However, they have not been extensively used on rangelands, despite the similarities of the plant characteristics used to develop them. Monitoring GDD is an effective management tool to help managers adapt to the changing climate because it helps identify major fluctuations in air temperature. By simply recording daily temperature and making simple calculations, land managers can take back the reins and adjust management to fit constantly changing climatic conditions.

Resources available to you:

(1) *Climate Visualization Tool* from New Mexico State University, data visualization tool that provides (1) Climate data from NOAA (National Oceanic and Atmospheric Administration) weather stations across New Mexico and (2) platform for users to upload their own daily temperature and precipitation data and outputs visual graphs to aid in interpretation. Users can compare their weather data to historical climate data nearest to them with ease. https://aridclim2020.shinyapps.io/climate_visual_demo/

(2) *New Mexico Range Plants* from New Mexico State University to help identify rangeland plants and determine the type of photosynthetic pathway and base temperature to use for calculations. https://aces.nmsu.edu/pubs/_circulars/CR374/

(3) *Evaluating Grass Development for Grazing Management, Frank, A. B. (1996)* for more information about utilizing AGDD when developing a rotational grazing plan.