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Drought and Grazing Effects on Oklahoma Phlox (Polemoniaceae, *Phlox oklahomensis*)

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ABSTRACT

Oklahoma phlox (*Phlox oklahomensis* Wherry) is endemic to Butler, Chautauqua, Comanche, Cowley, and Elk Counties of Kansas and Woods and Woodward Counties of Oklahoma. The species comprises populations of a few scattered individuals to several hundred in mixed-grass prairie sites in Oklahoma where cow-calf production is the common agricultural enterprise. It has successfully withstood periods of short-term drought (1 to 4 years) under light to moderate continuous stocking rates (41 to 52 animal unit days per hectare). Under heavy continuous stocking rates and/or prolonged drought, populations of *P. oklahomensis* tend to decrease in size and number and may disappear in some localities. Prolonged heavy stocking rates and drought will disrupt the reproductive cycle, severely limiting seed production and recruitment of new individuals to populations. During drought periods, livestock managers should use lighter stocking rates or deferred grazing to ensure rapid recovery of all prairie plants, including *P. oklahomensis*, once the drought ends. This recommendation would likely sustain prairie sites during long-term (longer than 10 years) droughts as well.

Keywords: *Phlox oklahomensis*; Drought; Grazing

1. Introduction

Oklahoma phlox (*Phlox oklahomensis* **Figure 1**) was first described by E. T. Wherry in 1944 from a specimen collected by H. C. Benke (collection # 5017) on 22 April 1929 approximately 20 km north of Mooreland, Oklahoma, USA [1]. This perennial herb was classified in the tribe Polemonieae of the family Polemoniaceae [2]. With the exception of one species that ranges into Eurasia, *Phlox* comprises approximately 70 species distributed through-out most of North America [1]. Two species are endemic to the Great Plains of North America [2]. *Phlox oklahomensis* has a limited geographical distribution, and throughout a large portion of its range it is genetically isolated from other *Phlox* species. Initially, populations were known to occur only in the northwestern Oklahoma counties of Woods and Woodward [1], but later it was found to occur also in the southern Flint Hills region of Kansas in the counties of Butler, Chautauqua, Cowley, and Elk [3,4]. Springer [5,6] extended its range into Comanche County, Kansas, a county adjacent to Woods County, Oklahoma. The currently known county distribution map of Oklahoma phlox in Kansas and Oklahoma

Figure 1. The Oklahoma phlox (*Phlox oklahomensis* Wherry). White bar equals 1 cm (photograph by Tim Springer).

is shown in **Figure 2**. Wherry [1] speculated that populations in the two states were once contiguous, but became fragmented due to farming and other agricultural practices. Because of its restricted geographical distribution, *P. oklahomensis* was initially designated as a threatened plant species by Ayensu and DeFilipps [7] under the guidelines of the 1973 Threatened and Endangered Species Act. Plants of the threatened category include taxa that are likely to become endangered within the foreseeable future throughout all or a significant portion of their range. Factors such as habitat curtailment, a fragile or restricted habitat, or small population size usually place a species in the endangered category. While Ayensu and DeFilipps' [7] listing of *P. oklahomensis* as threatened did not constitute an official or legal designation, it did indicate a need for additional research on the taxon. In 1980, the U.S. Fish & Wildlife Service's (FWS) designation for *P. oklahomensis* was Category 3C, *i.e.*, "Taxa that have proven to be more abundant or widespread than was previously believed and/or those that are not subject to any identifiable threat. Should further research or changes in land use indicate significant decline in any of these taxa, they may be re-evaluated for possible inclusion in categories 1 or 2" [8]. This FWS designation has not changed since 1980. An alternative classification to describe the global (G) and state (S) status of vulnerable species has been developed by Natural Heritage Programs and Conservation Data Centers [10]. *Phlox oklahomensis* currently has a global ranking of G3 [9,10], which means "…either vary rare and local throughout its range or found locally (even abundantly at some of its locations) in a restricted range, or because of other factors making it vulnerable to extinction throughout its range; in the range of 21 - 100 occurrences…" In Oklahoma, it has a state ranking of S1 [9,10]. The S1 rank declares that a species is "…critically imperiled in Oklahoma because of extreme rarity (5 or fewer occurrences or very few remaining individuals or acres) or because some factor of its biology makes it especially vulnerable to extinction."

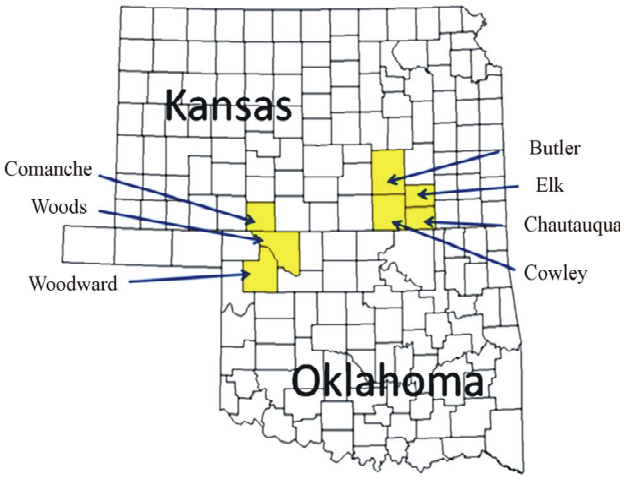

Figure 2. County distribution map for *Phlox oklahomensis* (Wherry) in Kansas and Oklahoma, USA.

Drought is a common feature of every landscape and in the Great Plains, including the mixed-grass prairie sites occupied by *P. oklahomensis*, can last from a few months to several years [11]. On the Great Plains over the last 1000 years there have been 10 droughts that lasted longer than 10 years with the longest estimated to have been over 60 years [11]. According to the Federal Emergency Management Agency (FEMA), droughts are the most costly natural hazard affecting the United States, costing 6 to 8 billion dollars annually [12]. Mitigating the impacts of drought through planning and preparedness could save billions of dollars. When drought and overgrazing of rangeland are combined, several effects can and possibly will occur to plant communities. First, the biomass of the plant root system is reduced as roots die. Second, the biomass of the shoot system is reduced because of limited water supply. Third, plants that are not drought tolerant will die, and fourth, plants that are drought tolerant will increase in number shifting, species composition and possibly decreasing diversity. It is the shift in species composition due to drought and grazing that could have an effect on the long-term survival of endangered, threatened, and vulnerable plant species. Our intentions in this paper are to describe the effects of short-duration drought and grazing on plant population stability, and to speculate on the effects of drought and grazing on the long-term survival of *Phlox oklahomensis* in northwestern Oklahoma.

2. Livestock Grazing and Precipitation on Species Composition in Northwestern Oklahoma

A 20-year continuous stocking rate experiment was conducted at the USDA, ARS, Southern Plains Experimental Range located approximately 27 km northwest of Woodward, Oklahoma (lat 36˚37'N, long 99˚35'W, elevation 610 - 640 m) [13]. The research was initiated in 1940 and ended in 1961 to determine the stocking rates for a sand sagebrush (*Artemisia filifolia* Torr.) dominated mixed-grass prairie of the southern Great Plains that would sustain beef cattle while maintaining plant and wildlife resources. The long-term annual precipitation (1915 to 2012) was 576 mm with approximately 77% of the precipitation occurring during the April to October growing season. Before 1940, the rangeland was extremely overgrazed and was emerging from the 10-year drought of the 1930s. Details of methodology and results of this experiment have been reported in several journal articles [13-18]. In summary, stocking rates of 41, 53, and 82 animal-unit-days per hectare were used from 1941 to

1951 for beef steers, and stocking rates of 45, 60, and 87 animal-unit-days per hectare were used from 1952 to 1961 for cow-calf pairs. These stocking rates did not affect canopy cover of sand sagebrush. Average basal cover percentage of grasses did not respond to stocking rate, but fluctuated over years in relation to precipitation and aspect of pasture slope gradient. Perennial forbs were found to follow the same trend as the perennial grasses and varied year to year depending upon precipitation (**Figure 3**). Following adequate precipitation, differences in stocking rates occurred in 1949, 1951, 1958, and 1961, but a short-term drought occurred from 1953 to 1957 where stocking rate effects were significantly diminished. During years of favorable precipitation, a moderate stocking rate favored perennial forb basal cover, and following drought the moderate and light stocking rates recovered rapidly and eventually stabilized at pre-drought levels. Species richness, as measured by the number of plants encountered along a 10 m belt-transect, followed the same pattern as percentage basal cover in **Figure 3**. Moderate and light stocking rates had significantly higher levels of species richness compared to a heavy stocking rate. Similarly, species richness was greater in years following drought and was lowest during drought. Consequently, precipitation is a major driving force of species composition on rangeland sites on the southern Great Plains.

3. Threats to the Long-Term Health and Survival of *Phlox oklahomensis*

Oklahoma phlox in northwestern Oklahoma and adjacent Kansas occurs in mixed-grass prairie sites where cow-calf production is the common agricultural enterprise and a significant contributor to the rural economies. Although the long-term annual precipitation of this region ranges 620 to 690 mm, seasonal, short-term, and long-term droughts are common [11]. Plants in this region have become adapted to the extremes of temperature and precipitation, and *P. oklahomensis* is no exception. Throughout its geographic range the topography of the area is dissected with many small canyons and drainage basins where plants are associated with big bluestem (*Andropogon gerardii* Vit.), little bluestem (*Schizachyrium scoparium* [Michx.] Nash), sideoats grama (*Bouteloua curtipendula* [Michx.] Torr.), blue grama (*B. gracilis* [Willd. ex Kunth] Lag. ex Griffiths), and hairy grama (*B. hirsuta* Lag.).

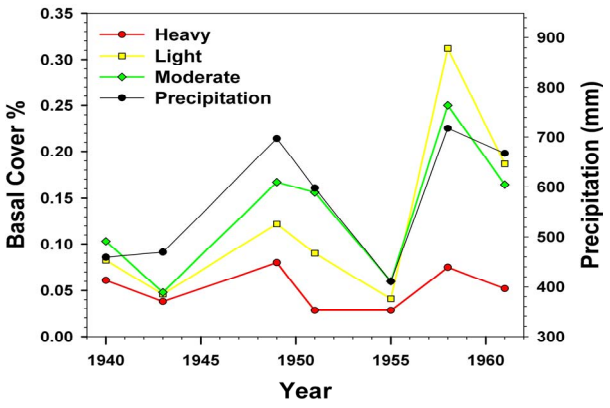

Figure 3. Effect of stocking rate and precipitation on cover of perennial forbs at the USDA, ARS, Southern Plains Experimental Range in northwestern Oklahoma (1940-1961). Stocking rates of 41 (light), 53 (moderate), and 82 (heavy) animal-unit-days per hectare were used from 1941 to 1951 for beef steers, and stocking rates of 45 (light), 60 (moderate), and 87 (heavy) animal-unit-days per hectare were used from 1952 to 1961 for cow-calf pairs.

In 1982, 2002, and 2003 surveys were conducted to determine the geographic range of *P. oklahomensis* in northwestern Oklahoma and adjacent Kansas [5,6,19]. These surveys consisted of systematically examining public land survey sections (a section equals 1.6 square kilometers) to determine whether populations of the species were present. The census criterion was the occurrence of at least one population per section. As might be expected, several populations were found in some sections. The relative abundance of *P. oklahomensis* plants was noted, but not quantified. In 1982, *P. oklahomensis* occurred in 79 sections in northwestern Oklahoma and adjacent Kansas, in 2002 it occurred in 52 sections, and in 2003 it occurred in 114 sections. The variation in the number of sections found among years appeared to be associated with accumulated September through March precipitation. The correlation of accumulated September through March precipitation in centimeters and number of sections found each year was 0.98 ($P \leq 0.12$). Abundant fall and winter precipitation is important in the life cycle of *P. oklahomensis*.

As described earlier, grazing can affect the density of plants in a population as well as population size of *P. oklahomensis*. In years of abundant precipitation, the frequency and size of perennial forbs thrived under light to moderate stocking rates but diminished under heavy stocking rates (**Figure 3**). During seasonal and short-term drought periods, however, there were no differences among stocking rates for perennial forb frequency and size. Furthermore, these data indicated a rapid forb recovery following drought under light to moderate stocking rates, but virtually no recovery under a heavy stocking rate. Observations have shown that *P. oklahomensis* is grazed by livestock. Springer and Tyrl [19] stated that, "Plants were abundant where livestock grazing intensity was light to moderate, but absent where heavy grazing had occurred." *Phlox oklahomensis* is encountered also in areas where cattle do not graze. These protected areas are created when roadways deviate to bypass deep canyons or rugged outcrops of bedrock resulting in prairie

areas inaccessible to grazing cattle. When extremely heavy grazing occurs under severe drought, these inaccessible areas may likely insure the survival of the species. The prairies in these areas of Oklahoma and Kansas normally burn by natural wildfires every 4 to 6 years [20]. In the absence of wildfires, prescribed burning once or twice a decade would likely maintain suitable habitat for *P. oklahomensis*.

Energy exploration and development may also impact *P. oklahomensis*. Over the last 40 years, plant populations in two sections were destroyed due to pipeline construction [19]. Although this threat is minimal, increased energy development needs to be monitored to minimize its impact on *P. oklahomensis*.

4. The Future of *Phlox oklahomensis*

Phlox oklahomensis flowers from late March to early May and peaks in mid-April. The corolla opens usually at night and, once opened, it remains open. The anthers dehisce longitudinally the morning after the corolla opens. Three to four weeks after self-pollination and fertilization, the capsules mature. Upon drying each capsule quickly separates along three sutures and catapults its seed up to 2 meters away, completing its reproductive cycle. As the seeds age and are heated on the soil surface during the summer they become dormant. They remain dormant until subjected to a moist soil temperature of 0 to 5˚C for two weeks accompanied by an average soil temperature of 20˚C [5,6].

Phlox oklahomensis has successfully withstood periods of short-term drought (1 to 4 years) under light to moderate continuous stocking rates. Under heavy continuous stocking rates and/or prolonged drought, populations of *P. oklahomensis* tend to decrease in size and number and may disappear in some localities. Prolonged heavy stocking rates and drought disrupt the reproductive cycle, severely limiting seed production and recruitment of new individuals to the population. During severe drought periods, livestock managers should use lighter stocking rates or defer grazing to ensure rapid recovery of prairie plants, including *P. oklahomensis*, once the drought has ended [21]. Below moderate stocking rates benefits all species on the prairie site and will help to minimize the effects of soil erosion by wind and water [15,22,23]. These recommendations would likely sustain prairie sites during long-term (longer than 10 years) droughts as well.

Populations of *P. oklahomensis* should be closely monitored to describe the effects of increased energy production from oil and natural gas production and wind energy. Increased vehicle traffic and the development of oil and gas well sites, pipelines, and concrete bases for wind turbines would destroy prairie habitat that sustains *P. oklahomensis*. In order to protect known populations, minimal inhibition to energy exploration operations would be needed to avoid their destruction.

Currently, populations of *P. oklahomensis* in northwestern Oklahoma and adjacent Kansas are stable and constitute reproductively mature and immature plants. In 2003, Springer and Tyrl [19] recommended an Oklahoma Natural Heritage Inventory listing of S2S3. The S2 ranking denotes that the species is "imperiled in Oklahoma because of extreme rarity (6 to 20 occurrences or few remaining individuals or acres) or because of other factors making it very vulnerable to extinction throughout its range," and the S3 ranking denotes that the species is "rare and local in Oklahoma (though it may be abundant at some of its locations); in the range of 21 - 100 occurrences," [10]. In 2003, the Oklahoma Natural Heritage Inventory listing of *P. oklahomensis* was S1S2. Based on more than 20 years of visual observations, the authors recommend a State ranking of S2S3 and continued monitoring of populations in northwestern Oklahoma and adjacent Kansas. The authors would further recommend that federal, state, and local government action agencies become aware of the existence of *P. oklahomensis* and its value as a component to the rangeland ecosystems of northwestern Oklahoma and adjacent Kansas.

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