Redberry Juniper Foliage Moisture Dynamics in the Texas Rolling Plains

Rob Mitchell*
Carlton M. Britton
Department of Range, Wildlife, and Fisheries Management, Texas Tech University, Lubbock, TX 79409-2125

ABSTRACT

An important variable in the successful management of redberry juniper (Juniperus pinchotii Sudw.) with prescribed fire is foliage moisture content (FMC). Juniper canopies are readily ignited by fire when FMC falls below 70%. Our objectives were to determine seasonal changes in redberry juniper FMC, and to determine relationships with soil water content in the Texas Rolling Plains. Trees on sandy bottomland, clay flat, and shallow redland range sites were sampled at approximately 14-day intervals from September 1995 through March 1997 in Garza County. Soil samples were taken beyond the drip-line of each tree to a depth of 12 inches. The FMC followed similar trends on all sites, but was generally highest on the sandy bottomland site and lowest on the clay flat site. The FMC was below 70% on all range sites and sample dates after 24 January 1996. Soil water was highest on the clay flat site, which was due to the higher water holding capacity of the heavy clay soil. The FMC and soil water were poorly correlated on all sites, except for the first 12 months of sampling. Redberry juniper FMC appears to be more closely related to available soil water than to total soil water since foliage moisture was not significantly impacted by precipitation events. Subsoil moisture recharge may occur slowly with average precipitation, and FMC may remain low following severe drought.

KEYWORDS: Brush management, cedar, prescribed burning, soil moisture, volatile fuels

Redberry juniper (*Juniperus pinchotii* Sudw.) is an invasive shrub that occupies over 11 million acres of Texas rangeland (Soil Conservation Service, 1985). Redberry juniper is an evergreen, multi-stemmed basal sprouter that historically occurred on northwest exposures of rocky, shallow slopes in limestone and gypsum soils (Correll and Johnston, 1970). Redberry juniper is common in southwestern Oklahoma, western Texas, southeastern New Mexico, southern Arizona, and northeastern Mexico (Ueckert et al., 1994). Redberry juniper is considered an invader on most Texas range sites and has little economic value. However, redberry juniper is desirable on some range sites because it stabilizes soil and provides food and cover for wildlife (Scifres, 1980).

Fire was an important factor in the development of grassland ecosystems. Recurrent fires suppressed woody vegetation and maintained the character of grassland ecosystems (Sauer, 1950). In its original habitat, redberry juniper was historically protected from these fires by the lack of fine fuel and the topography of the steep, rocky slopes. The sup-

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pression of fire that occurred with settlement promoted the encroachment of redberry juniper from the steep, rocky slopes onto adjacent rangeland, where it has become a major problem on many range sites in the Texas Rolling Plains (Steuter and Britton, 1983).

Prescribed burning is an important tool for managing junipers in grassland ecosystems, and has been used to manage redberry juniper. However, due to the basal sprouting characteristics of redberry juniper, results have been variable. An important characteristic determining redberry juniper response to fire is the basal bud zone position. Redberry juniper with basal bud zones elevated above the soil surface had 70% mortality following fire (Steuter and Britton, 1983). Conversely, redberry juniper with basal bud zones partially below the soil surface had only 3% mortality. To maximize redberry juniper mortality with fire, the foliage must be ignited and a crown fire generated.

An important factor for the successful, rapid ignition of redberry juniper during prescribed burning is foliage moisture content (Bunting et al., 1983). Juniper foliage ignition is highly variable during prescribed burns. Junipers are readily ignited by fire when foliage moisture content falls below 70%. However, the seasonal changes in redberry juniper foliage moisture are not well understood. The objectives of this study were to determine the seasonal changes in redberry juniper foliage moisture content, and determine the relationship between foliage moisture content and soil water content on three range sites in the Texas Rolling Plains.

MATERIALS AND METHODS

This study was conducted at the Texas Tech Experimental Ranch in Garza County near Justiceburg, Texas in the Rolling Plains at a mean elevation of 2400 ft. Average annual precipitation is 19 inches, and approximately 50% of the annual precipitation occurs from April through July (Richardson et al., 1965). Annual temperatures are variable, ranging from an average daily minimum of 27°F in January to an average daily maximum of 95°F in July.

This study was conducted on three range sites: sandy bottomland, clay flat, and shallow redland. Soil on the sandy bottomland range site is a Lincoln loamy fine sand (Typic Ustifluvent). Soil on the clay flat range site is a Dalby clay (Typic Torrert). Soil on the shallow redland range site is a Vernon clay loam (Typic Ustochrept) (Richardson et al., 1965).

Five mature redberry junipers on each range site were sampled at approximately 14-day intervals from September 1995 through March 1997. Trees were randomly selected at sampling initiation and included both male and female trees. Redberry juniper foliage was hand-stripped from 1 to 4 ft above the soil surface from the terminal 4 inches of branches around the perimeter of each tree. Samples were collected from the same trees throughout the sampling period and included only leaf material. One foliage sample of approximately 3 oz. wet weight was collected for each tree from at least 5 random locations around the perimeter of the tree to eliminate potential aspect bias. During collection, foliage samples were placed in air-tight containers to prevent water loss. Following collection, all foliage samples were transported to the laboratory and wet weight determined to the nearest 0.01 oz. Samples were dried at 140°F for at least 72 h to a constant weight, weighed to the nearest 0.01 oz., and foliage moisture content determined on a dry weight basis using the formula: ((wet weight - dry weight)/dry weight) x 100 = % foliage moisture. Foliage moisture content for each range site on each sampling date was determined by the mean of the 5 trees sampled on the site.

Soil samples were taken beyond the drip-line around the perimeter of each tree to a depth of 12 inches with a 3/4 inch diameter push probe. One composite soil sample was collected around the perimeter of each tree from at least 3 random locations to eliminate potential aspect bias. During collection, soil samples were placed in air-tight containers to prevent water loss. Following collection, all soil samples were transported to the laboratory and wet weight determined to the nearest 0.01 oz. Soil samples were dried at 212°F for at least 72 h to a constant weight, weighed to the nearest 0.01 oz., and soil water content determined on a dry weight basis using the formula: ((wet weight - dry weight)/dry weight) x 100 = % soil water. Soil water content for each range site on each sampling date was determined by the mean of the composite soil samples collected around the 5 trees on the site. A running mean was calculated for foliage moisture and soil water content between adjacent sampling dates to smooth the data transition between sampling dates.

The experiment was a completely random design with 5 replicates (trees) at each sampling date and range site. The data between range sites were compared with analysis of variance. Sampling date means within a range site that displayed significant differences were separated using Fisher's protected least-significant-difference at $\alpha = 0.05$. Relationships between foliage moisture and soil water content were determined by evaluating the coefficients of determination for the regression of foliage moisture content against soil water content.

RESULTS AND DISCUSSION

Drought conditions persisted during 1993 and 1994, with 11.7 and 13.3 inches of precipitation recorded, respectively. Precipitation during the sampling period from September 1995 to March 1997 was 22.2 inches, which was 7.6 inches below normal (Fig. 1). In 1995, the period from 1 January to sampling initiation received a total of 17.3 inches of precipitation, approximately 4 inches above the long-term average for this period. Only 7 days during the sampling period (September 1995 to March 1997) received >0.5 inches of precipitation.

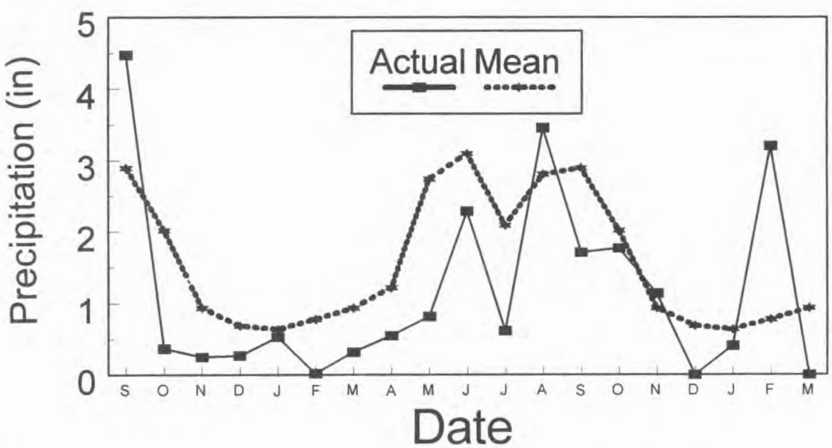

Fig. 1. Precipitation from September 1995 through March 1997 and long-term average annual precipitation at the Texas Tech Experimental Ranch near Justiceburg, Texas.

Tree height on the 3 range sites ranged from 5 to 12 ft. Canopy diameter of the trees ranged from 3 to 12 ft, which included both male and female trees. Tree height and sex had no impact on foliage moisture content.

Redberry juniper foliage moisture content was not different (P=0.625) between range sites on common sampling dates. Redberry juniper foliage moisture content on all range sites followed similar trends (Fig. 2). Foliage moisture content was generally highest on the sandy bottomland site and lowest on the clay flat site. Redberry juniper foliage moisture content was below 70% on all range sites and for all sampling dates after 24 January 1996. Foliage moisture content in June and July 1996 represent the lowest values ever observed at Texas Tech University, and are significantly lower than data reported in the literature for Juniperus species (Ortmann et al., 1995; Bunting et al., 1983).

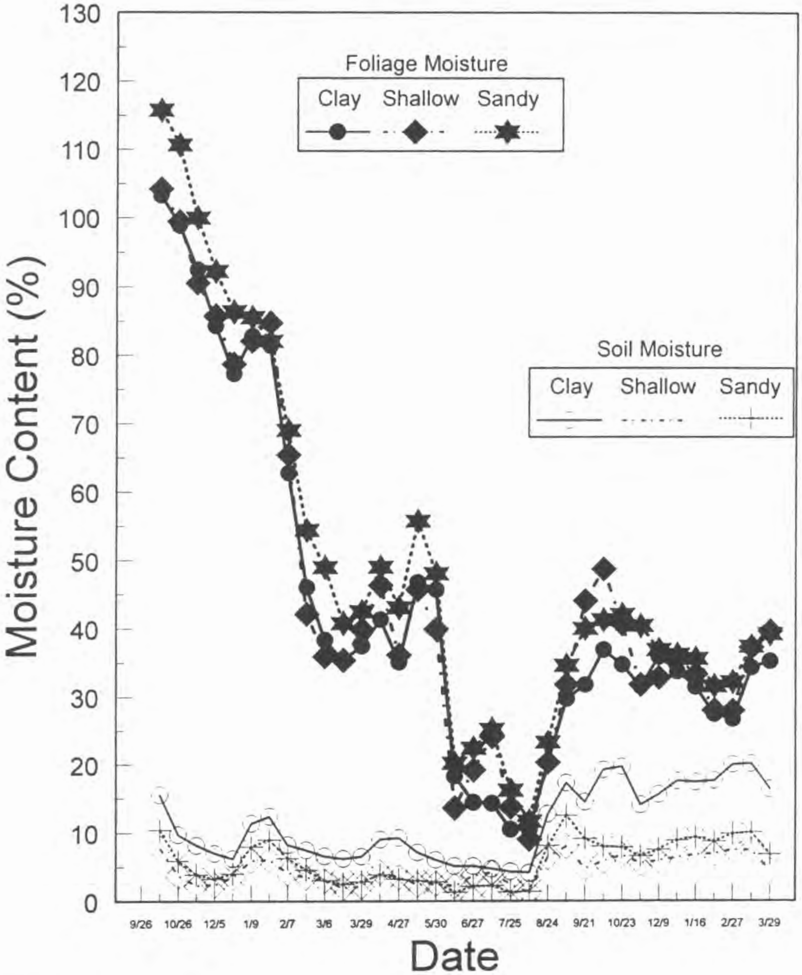

Fig. 2. Redberry juniper foliage moisture content calculated on a wet weight basis and soil water content on three range sites in the Texas Rolling Plains from September 1995 through March 1997. Data represent running averages between sampling periods.

Soil water content was always highest on the clay flat site, which was due to the higher water holding capacity of the heavy clay soil (Fig. 2). The coarse-textured nature of the soils on the sandy bottomland and shallow redland sites promoted the relatively rapid deep percolation of soil water, which resulted in lower soil water content. Precipitation in August 1996 was 3.5 inches and resulted in an elevation of soil water content on all sites (Fig. 2).

The relationship between foliage water content and soil water content was compared on the three sites for all data during the sampling period, resulting in a maximum $r^2 = 0.14$ on the sandy bottomland site (data not shown). Following initial evaluation of data from all sites, we determined precipitation events in August 1996 resulted in atypical foliage water content responses, and data were removed from analysis. Consequently, the correlation between foliage moisture content and soil water content was compared for the first 21 sampling periods during drought conditions.

Soil water content accounted for 58% of the variation in foliage moisture content on the clay flat site (Fig. 3), 32% on the shallow redland site (Fig. 4), and 59% on the sandy bottomland site (Fig. 5). Slopes were similar for all sites ($F=0.34$, $P=0.71$). The high water holding capacity of the clay soil shifted the data on the clay flat site away from the origin on the x-axis, resulting in a negative constant in the regression equation (Fig. 3). Soil water content explains a majority of the variation in redberry juniper foliage moisture content, and is a reasonable predictor of foliage moisture content on sites with high clay content and on sites with sandy soils.

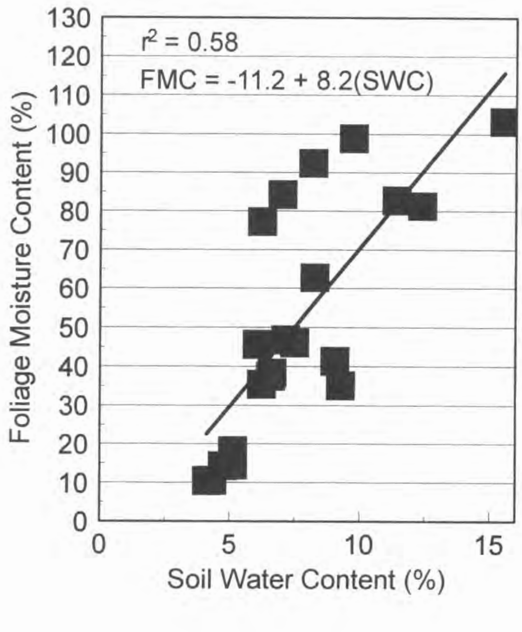

Fig. 3. Foliage moisture content and soil water content relationship on a clay flat range site in the Texas Rolling Plains. Points represent the running averages between sampling periods from September 1995 through August 1996 (n=21).

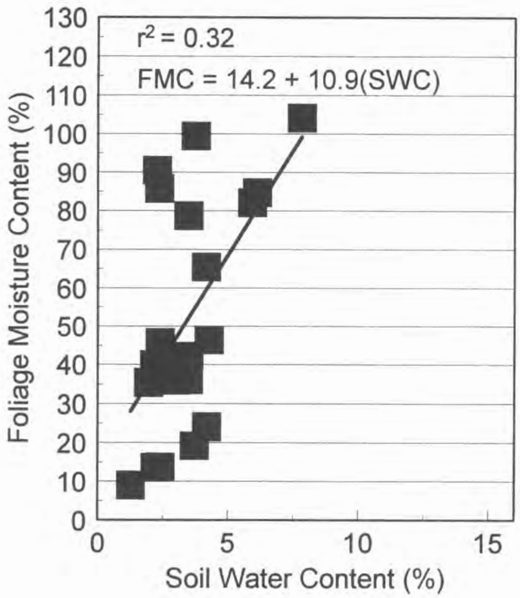

Fig. 4. Foliage moisture content and soil water content relationship on a shallow redland range site in the Texas Rolling Plains. Points represent the running averages between sampling periods from September 1995 through August 1996 (n=21).

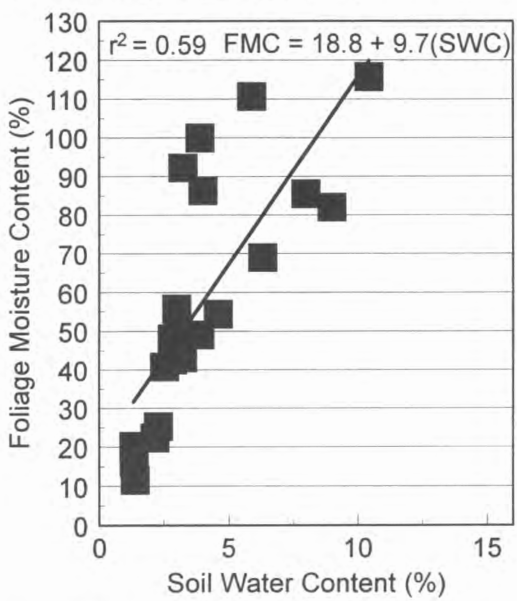

Fig. 5. Foliage moisture content and soil water content relationship on a sandy bottomland range site in the Texas Rolling Plains. Points represent the running averages between sampling periods from September 1995 through August 1996 (n=21).

Redberry juniper foliage moisture content appears to be more closely related to available soil water than to total soil water content. The lack of response in foliage moisture to rainfall events in August 1996 were likely due to inadequate subsoil moisture or lack of infiltration of precipitation (Fig. 2). The drought conditions that persisted during 1993 and 1994 in this area probably caused soil water depletion below the sampling depth. Depletion of the subsoil moisture may explain the minimal response of foliage moisture to precipitation events in mid April and mid August 1996. These precipitation events likely provided only adequate water for the soil surface and water did not sufficiently percolate to the lower portion of the redberry juniper root zone. Subsoil moisture recharge may not occur until several consecutive years of average precipitation have been received with significant fall and winter precipitation events. The occurrence of low intensity, long duration precipitation events during the fall and winter resulting in high quantity precipitation with little surface flow will provide the best opportunity for subsoil moisture recharge. Consequently, redberry juniper foliage moisture may recover slowly following drought conditions in the Texas Rolling Plains. However, redberry juniper foliage moisture content apparently responded to the above average precipitation that occurred prior to sampling in 1995 following drought conditions in 1993 and 1994.

SUMMARY

Redberry juniper is a severe problem on Texas rangeland. Understanding the seasonal dynamics of redberry juniper foliage moisture content will indicate when prescribed fire may be most effective for managing redberry juniper. Additionally, understanding the volatile nature of junipers, especially at very low foliage moisture contents, provides information for safety considerations during juniper burning. Soil water content can be used to predict redberry juniper foliage moisture content, but the predictions appear to be site-specific. These data indicate that juniper foliage moisture content may remain dangerously low during and shortly after the conclusion of severe drought. Prescribed burning of juniper communities during or shortly after drought conditions must include the monitoring of foliage moisture content prior to burning, and necessary precautions must be taken during the planning process.

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