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Historical Trends in Willow Cover Along Streams in a Southwestern Montana Cattle Allotment

Abstract

Concern over the apparent scarcity of tall willows prompted changes in livestock grazing management in a southwestern Montana mountain valley to avoid degradation of riparian and aquatic habitats. We assessed potential improvement in the abundance of tall willows following implementation of a new management strategy by determining the effect of historic grazing patterns on willow canopy along streams within the USDA Forest Service grazing allotment. Willow canopy cover by stream reach was measured from air photos taken in 1942, 1965, and 1987. Cover from each year was compared for change over the 46-yr record. Willow canopy cover fluctuated along the streams in the allotment, but the general trend was upward from 1942 to 1987. Willow stem population demography was evaluated to ascertain whether historic grazing patterns had affected stem replacement. Stem age classes were normally distributed with a replacement cycle similar to those reported in other areas of the western United States and Canada. These data sets suggest that extended periods of rest (> 3 yr) are not necessary for willow recovery if livestock or wildlife use is closely controlled.

Introduction

The contribution of woody vegetation to the proper function of riparian areas has been recognized since the 1970s (Meehan et al. 1977, Jahn 1979). As awareness of the importance of woody species grew the Western Division of the American Fisheries Society published a position statement calling for the immediate application of best management practices to maintain riparian stream ecosystems to perpetuate the quality of western streams for fish, wildlife, and general recreational use (Western Division of the American Fisheries Society 1980). Even though public agencies and private landowners moved to implement best management practices following published guidelines (Chaney et al. 1990, USDI Bureau of Land Management and USDA Forest Service 1994), the results have recently been criticized as inadequate (Fleischner 1994, Belsky et al. 1999). Part of the reason for the slow or limited improvements noted by these authors may be our incomplete understanding of how woody riparian species respond to livestock grazing.

Even though willows and cottonwoods are the most common woody riparian species in the western United States (Mitsch and Gosselink 1986), there was, and is, relatively little information about how much grazing these species can withstand without becoming decadent (Thomas et al. 1979). Although four of the reports published prior to 1990 (Behnke and Raleigh 1979, Knopf and Cannon 1982, Rinne 1985, Elmore and Beschta 1987) made no mention of appropriate browsing levels, they consistently recommended 3-12 yr of complete rest for the recovery of heavily grazed willows. Schulz and Leininger (1990) reported that even though willow density inside and outside of a grazing exclosure was similar, the willows protected from grazing for 29 yr had 8 times the canopy cover than those in the grazed area. This led to their recommendation of at least 5 yr of rest from grazing to initiate willow recovery. However, Kovalchik (1991) reported that certain willow species turned over or replaced portions of their stem population every 15-18 yr. This meant that a large proportion of willow stems could die at any time during a rest period, which would require extension of the nongrazing treatment to achieve management goals. Taken in total this information suggested few management options other than to exclude livestock grazing for a decade or more. Elmore and Beschta (1987) cautioned managers and landowners to avoid the temptation to relax management prescriptions at the conclusion of the rest treatment or risk the loss of improvements gained during the livestock exclusion period.

These management recommendations were met with considerable resistance by livestock producers because of the potential for substantial

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reduction in livestock grazing opportunities on public lands during the initial recovery effort. Many public land grazers felt that prolonged periods of nonuse could be avoided with more detailed information on willow or cottonwood response to intensive grazing management.

The implementation of a new allotment management plan specifically to protect and enhance willows on a USDA Forest Service (USFS) cattle allotment in the Centennial Valley of southwestern Montana provided a timely opportunity to evaluate the proposals made by livestock grazing interests and to add to the information base on woody riparian species. The intense interest in protecting both riparian woody species and public land grazing demanded field methods that could separate changes in willow cover and regeneration caused by historic grazing patterns from those produced under the new grazing prescription (Knopf and Cannon 1982, Rinne 1985). Because early USFS monitoring efforts concentrated on upland plant communities, we had to reconstruct the effect of previous livestock grazing on the willow community in the Long Creek Cattle Allotment from a series of aerial photographs. We based our analysis on the information available in 1990 when the allotment management plan was amended. We hypothesized that analysis of aerial photos would indicate that the fragmentation of willow canopy cover along the streams in 1965, when the rest rotation grazing system was implemented, would be little different from that along the same streams in 1987 because of insufficient (< 10 consecutive years) rest from grazing.

Study Area

The Long Creek Cattle Allotment of the Beaverhead National Forest is located on the Centennial Divide, ~71 km southeast of Dillon, Montana (Figure 1). The allotment encompasses nearly 2200 ha, annual precipitation averages 480 mm, and elevation is ~2300 m (Caprio et al., 1994). Upland vegetation is within the big sagebrush/Idaho fescue (*Artemisia tridentata/Festuca idahoensis*) habitat type (Mueggler and Stewart 1980). Riparian vegetation is dominated by Geyer willow (*Salix geyeriana*), Booth willow (*S. boothii*), sedges (*Carex* spp.), and Kentucky bluegrass (*Poa pratensis*). Mature plants of both willows in the study area normally occur as multi-stemmed shrubs > 3 m tall.

The area has a record of combined sheep, horse, and cattle grazing since the turn of the century. Unrestricted grazing prior to 1935, coupled with custodial management until 1962, necessitated rangeland renovation and the implementation of

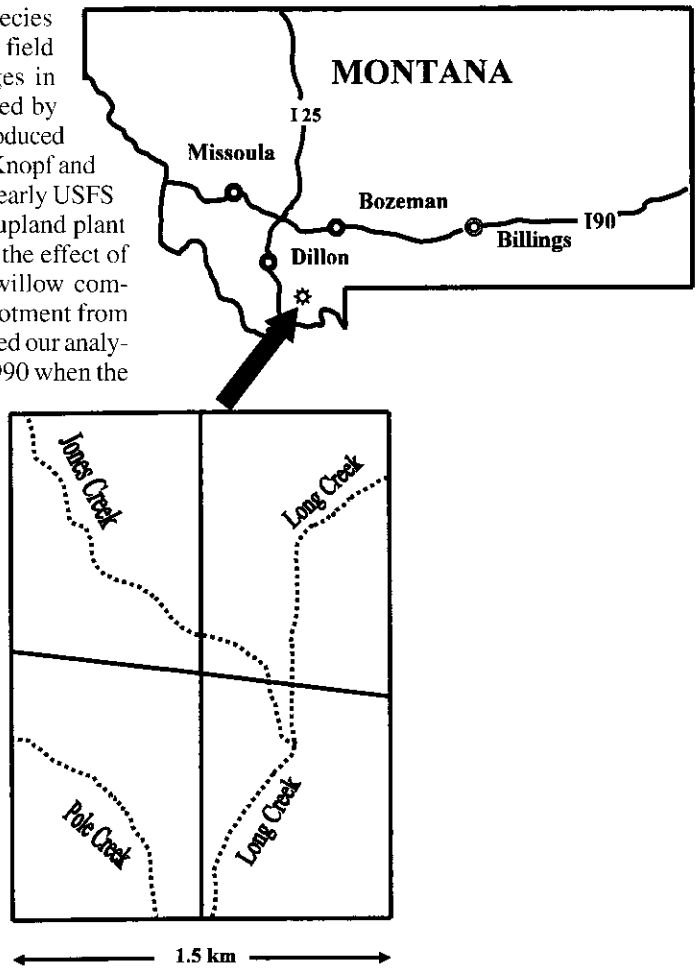

Figure 1. The location of the USDA Forest Service Long Creek cattle allotment in southwestern Montana. Pastures served as replicates in analysis of changes in willow canopy cover from 1942 to 1987.

grazing control practices to reverse an apparent downward trend in ecological condition of the uplands. As part of the renovation effort herbicide was applied in 1963 and 1964 to reduce the abundance of mountain big sagebrush (*Artemisia tridentata vaseyana*). This action was followed by extensive cross fencing to facilitate the implementation of a rest-rotation grazing system. The allotment was divided into four grazing pastures to allow one pasture to be left ungrazed (rested) each year to promote recovery of upland plant communities (Figure 1). To provide water for livestock, the fencing design incorporated reaches of Pole Creek, Jones Creek, and Long Creek. Consequently, each of the four pastures in the Long Creek Cattle Allotment had stream reaches with similar riparian vegetation composition (Figure 1).

Control of grazing was enhanced by coupling a lower stocking rate (number of cattle for a specific period) and a shift in grazing season (from 1 June - 31 October to 16 July - 15 October) to the construction of the four pastures. These actions appeared to arrest the downward trend in ecologic condition until 1986 when the livestock permittee voluntarily reduced livestock numbers from 800 cow/calf pairs to 600 because of an increase in sagebrush cover. Shortly after that decision was made, USFS personnel concluded that the tall-willow (plants greater than 1.8 m in height) component of the allotment's riparian zone had declined. The perceived decline heightened management concerns because fragmented willow canopy cover could lead to decreased streambank stability, higher water temperature, and degraded riparian and aquatic habitats (Platts 1991, Fleischner 1994). To reverse the perceived fragmentation of the tall willow community and thereby avoid potential riparian and aquatic degradation, the USFS proposed that the recent livestock reduction become permanent. The permittee opposed the long-term reduction, but was willing to work with USFS to amend the existing grazing management plan to extend the scheduled rest period for each pasture to 2 yr. In return the permittee requested that an outside party, the Montana Agricultural Experimentation Station, monitor the response of the willow community to the longer rest period. This provided the opportunity to contrast the extent of willow cover along streams under custodial livestock management (1942 to 1965) to that under rest rotation grazing management (1965 to 1987).

Methods

Willow Canopy Cover

Three sets of aerial photographs spanning a 46-yr period were used to determine the change in willow canopy cover along the three main streams in the Long Creek Allotment. Aerial photographs from 1942 were purchased from the National Photographic Archives, Atlanta, Georgia and photographs taken in 1965 and 1987 were purchased from the Natural Resource Conservation Service Air Photo Field Office, Salt Lake City, Utah. Photographs were ordered at an enlarged scale of 1 cm = 121.92 m.

The photo scale was checked with a topographic map and recognizable landscape features. Clear 22 x 28 cm acetate sheets were placed on individual photos, covering the length of each stream within a pasture. Because each of the four allotment pastures had a stream, tall willow communities, and received a common treatment (rested one year in four), the pastures were treated as replicates for statistical analyses. This necessitated delineation of pasture boundaries on each set of acetate sheets. The area occupied by willows along each stream reach was traced onto the acetate sheets. Apparent breaks in willow canopy cover were identified and marked on the acetate sheets. A standardized dot grid template, 100 dots per 1.2 cm^2, was then placed over the acetate sheets. The number of dots within the outlined willow area and number of dots touching willows were totaled for each canopy cover break (Tueller 1977). The total number of dots was divided into the number of dots touching willows to approximate percent canopy cover. However, because a single canopy measure for each pasture would provide little information on fragmentation of the tall willow community cover, estimates were then stratified into five cover classes (Daubenmire 1959). Stratifying the canopy cover measures into cover classes allowed us to approximate willow canopy cover fragmentation over the period the allotment was under rest rotation grazing management. Because none of the canopy cover breaks measured on the aerial photographs had $\geq$ 75% canopy only cover classes 1 (0-5%), 2 (5-25%), 3 (25-50%), and 4 (50-75%) were used.

To compare canopy cover fragmentation along streams within a given year, and to estimate canopy cover changes over the 46-yr period, we determined

the percentage of the stream reach within each pasture that was occupied by each canopy cover class. The percentage of stream falling within each of the four cover classes was determined by placing a new set of acetate sheets over each set of aerial photographs. The stream channel, breaks in the canopy cover, and the associated cover classes were marked onto these acetate sheets. The length of stream within each cover class was measured by a digitizer, using the Sigma Scan 3.10 program. Sigma Scan was calibrated to the scale of the photographs by tracing a known distance with an electronic pointer on an electronic pad. The pointer and pad were used to measure total length of each stream from the stream channel acetate sheets. Stream channels were re-measured on photos from 1942, 1965, and 1987. The total length of individual cover classes was also measured from stream channel acetates. Stream length occupied by individual cover classes was divided by the total stream length. This calculation represented the percentage of stream occupied by the individual cover classes. Changes in the percent of stream reach occupied by each cover class over time were used as the primary indicator of willow canopy cover fragmentation.

Stem Age

In 1991, we selected five locations, evenly distributed along the length of streams in each of the four pastures, as collection sites for willow stems. Two average size willows, one each of Geyer and Booth, were collected for stem aging at each location. Individual willows were chosen based on comparable height and diameter with other willow clumps at the location.

The base of each willow was measured with a 2-m ruler along a north-south axis. Five stems equally spaced along each axis were selected for removal. Each stem was cut at ground level. Stems were shortened to 20 cm, permanently tagged, and transferred to the lab. The narrowest diameter of each stem was measured to the nearest millimeter.

The end of the stem closest to the ground was shaved with a sharp knife to produce a smooth surface and dipped in water to accentuate growth rings. Annual growth rings were counted under a 1 x 10 binocular microscope. We analyzed 195 stems, 50 each from Long Creek, Jones Creek, and Lone Butte Pastures. Fifty stems were also collected from Pole Creek Pasture, however, five stems were lost resulting in only 45 for Pole Creek Pasture. Due to the turnover rate of willow stems within a willow clump, these data do not indicate the age of the original root crown but rather the clonal stem. For this reason, cross dating was not required. Multiple regression analyses were used to determine the correlation of species and diameter on stem age by pasture. Correlation analysis ($P = 0.05$) was then used to determine the relation between stem diameter and stem age for all 195 stems.

Data Analysis

A one-way ANOVA was used to test differences between the four canopy cover classes within each year (n = 4). The same statistical procedure was also used to test for differences in each cover class among years (n = 3). Pastures were used as replicates with $P = 0.05$ set for determining significance. Mean separation was performed with a least significant difference test.

Results

Willow Canopy Cover

In 1942, the distribution of the various willow canopy cover classes along the three streams flowing through the allotment appeared to be relatively uniform (Table 1). After 23 yr of custodial management (1942-1965) the percent of stream reaches occupied by the smallest and largest cover classes had declined while those reaches covered by willow canopies of 5-25% and 25-50% had increased. In 1965 the difference in stream reaches with more than 50% willow canopy cover and those with lesser amounts was not significant ($P = 0.07$)(Table 1).

TABLE 1. The percent of stream reach within the Long Creek allotment covered by various willow canopy cover classes in 1942 (custodial management-no rest from grazing), 1965 (initiation of rest-rotation grazing management) and 1987 (22 years of rest rotation grazing management). Values with the same superscript letters in 1987 are not significantly different at P=0.05.

	Percent Willow Canopy Cover			
Year	<5	5-25	25-50	50-75
1942	35	24	16	28
1965	29	33	38	1
1987	24[a]	15[a]	57[b]	6[a]

After 22 yr of rest rotation grazing management (1965-1987) there were significantly more ($P = 0.02$) stream reaches with a willow canopy cover of 25-50% than any other cover class (Table 1). When the percent of stream reaches covered by each cover class in 1942 was compared with the same measure in 1987, reaches with 25-50% canopy had increased but not to a significant level ($P = 0.06$), while none of the other cover classes changed significantly during the same period.

Stem Age

No significant correlation existed between species and stem age, and between pasture and stem age. Therefore, all stem data were pooled and are presented as an allotment average. The individual willows sampled contained a wide distribution of stem ages (Figure 2). While certain age classes were absent from some pastures, the sampled population within the allotment was represented in all age classes from 1 yr to 19+ yr. Only Jones Creek had two consecutive years with no apparent stem production. Stem age averaged 9.5 yr on the allotment and fewer than 13% of the collections were >14 yr old. Additionally, the correlation between stem diameter and stem age for all 195 stems was significant ($P < 0.0001$, $r^2 = 0.63$), indicating that larger diameter stems were older than smaller stems.

Discussion

According to the extensive review of riparian literature by Fleischner (1994) and Belsky et al. (1999) the willow canopy along the streams in the Long Creek allotment should have declined and become fragmented because of the allotment's long history of livestock use. However, analysis of a series of aerial photographs of the allotment from 1942 to 1987 did not reveal the expected fragmentation of the willow community. The nearly uniform distribution of willow canopy classes along the allotment's three streams in 1942 served as an effective baseline for establishing the trend in

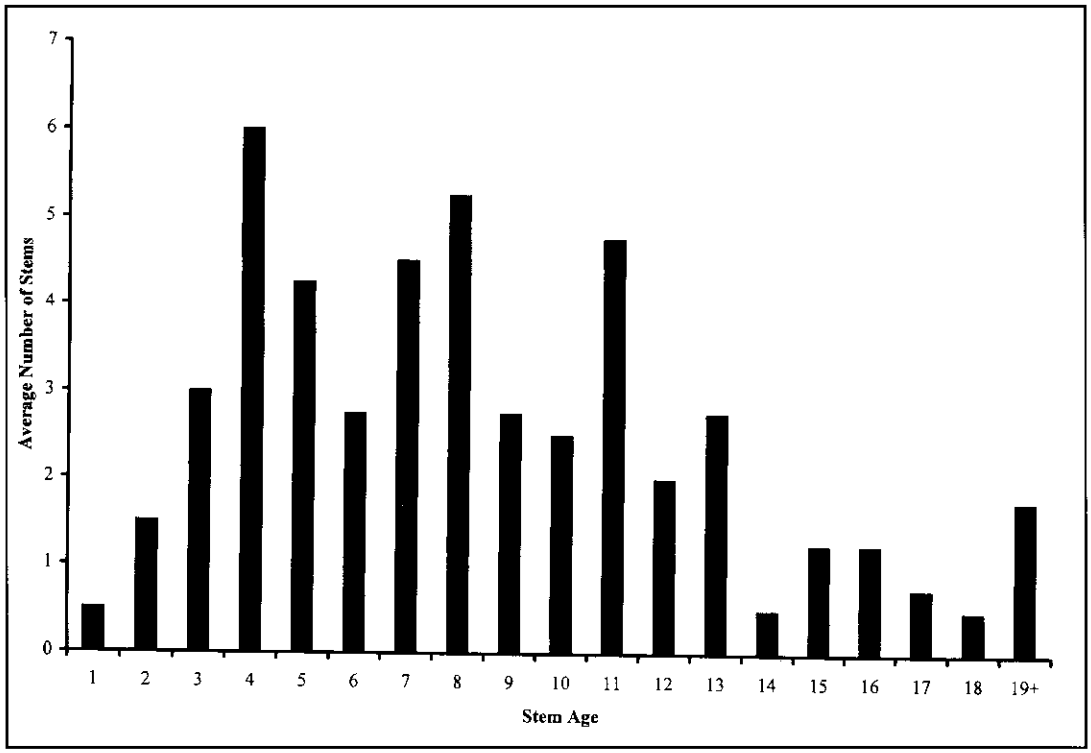

Figure 2. The stem age class distribution developed from collections made from randomly selected willows in the USDA Forest Service Long Creek allotment.

willow canopy with and without rest from grazing. There is little evidence that the Long Creek allotment received any rest from grazing from 1942 to 1965, yet willow canopy cover remained relatively static (Table 1). This pattern would be expected if the willow community had been in high ecological condition (Knopf and Cannon 1982), but historic livestock records suggest that willow condition in the Long Creek allotment in 1942 should have been relatively low. The relative increase in stream reaches with 5-25% cover and 25-50% cover from 1942 to 1965 (Table 1) suggests that the lower stocking rates implemented under custodial management maintained willow canopy cover. However, this increase stands in stark contrast to the decline in the relative amount of stream reach with 50-75% willow cover (Table 1). While the apparent break up of the heavier willow cover could be attributed to livestock use, USFS records indicate that aerial spraying was conducted in 1962 and 1963 to control sagebrush in the uplands. The lack of riparian monitoring data from that period complicates efforts to determine whether livestock use or herbicide drift was responsible for the dramatic decline in proportion of stream reaches with > 50% willow cover. Nonetheless, the lack of a significant difference between stream reaches with cover classes 1, 2, and 3 at the beginning of the rest rotation grazing management system in 1965 compared to the significant difference (Table 1) between the same cover class distributions in 1987 indicate that year long rest was sufficient to initiate willow recovery. The change in the amount of stream reach with 50-75% willow canopy between 1965 and 1987 further suggests that willow recovery was unhindered under rest rotation grazing management. Further support for rejecting the study hypothesis arises from closer examination of the willow stem data.

Three lines of evidence indicate that rest rotation grazing management promoted willow stem recruitment. First, the stem-age population curve was fairly uniform with fewer than 13% of the stems older than 14 yr (Fig. 2). Second, skewed stem age groups indicative of heavy browsing use were absent. Third; the mean stem age (9.5 yr) was nearly identical to willows protected from grazing for 29 yr (Schulz and Leininger 1990).

The turnover rate of individual stems in the Long Creek allotment appears rapid, because 87% of the samples were <14 yr. Therefore, willow stem populations may have completely turned over three times during 1942 to 1991. A complete turnover of stems every 15 yr on the Long Creek Allotment is similar to stem senescence in Geyer and Booth willow at 15-20 yr in central Oregon (Kovalchik 1991). Begin and Payette (1991) suggested turnover occurred from 10-14 yr for planeleaf willow (*S. planifolia*) along a Quebec lakeshore. Consequently, it appears that cattle grazing during 1942 to 1987 did not affect natural turnover patterns and that individual willows could continue to produce replacement stems at a sufficient rate under rest rotation grazing to expand willow canopy cover.

While aerial photographs and willow stem age data did not provide information about the density or generation of new tall willow clumps within the Long Creek Allotment, streamside willow canopy cover generally increased (Table 1) and willow stem recruitment was similar to records from other areas in the west and northeast (Begin and Payette 1991, Kovalchik 1991). At first glance, the results of this study contradict the findings of Knopf and Cannon (1982) and recommendations that willows need extended rest periods to recover from overuse (Behnke and Raleigh 1979, Rinne 1985, and Elmore and Beschta 1987). However, in contrast to these management recommendations, the grazing management implemented on the Long Creek allotment included rest, reduced stocking rate, a shorter grazing season delayed until mid July, and sagebrush control. This management action follows the recommendation that careful control of the season and intensity of livestock use fostered improved riparian function (Elmore and Beschta 1987). Thus, our results corroborate rather than contradict the earlier grazing studies. Short rest periods (< 3 yr) are probably inadequate for willow recovery without concurrent changes in season and intensity of use.

Even though several authors (Kay and Chadde 1991, Kovalchik 1991, Singer 1996, and Belsky et al.1999) suggest that willows require extended rest periods to recover from heavy use by livestock or wildlife, the 46-yr photographic record of Long Creek indicates that long periods of nonuse can be avoided through close control of season and intensity of ungulate use. The photo record also supports the recommendation of Clary et al. (1996) that grazing practices might have to be in place for several decades before degraded riparian vegetation begins to improve.

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