Evaluation of tall willows (Salix spp.) within a livestock grazing allotment in southwest Montana
by Mark Edward Manoukian

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Range Science
Montana State University

Abstract:
The Long Creek Cattle Allotment has been grazed by domestic livestock from the late 1800s to the present time. For the last 28. years the 2200 ha allotment was usually grazed by 800 cow/calf pairs in a four pasture rest-rotation system from July 15 to October 15.

Concerns that historic and recent livestock management on the allotment had deteriorated Geyer (Salix geveriana Anderss.) and Booth (S. boothii Dom) willows along the three main tributaries were expressed in 1991. From the fall of 1991 to the fall of 1993, historic and current evaluations of Geyer and Booth willows were made.

Evaluations of the long-term trend of willow canopy cover along the three streams were made with the use of aerial photographs. Photographs taken of the allotment in 1942, 1965, and 1987 were compared using a dot count method. One hundred ninety-five stems were collected and aged to determine current demographics of willows within the four pastures.

Seasonal variation in the canopy volume of 380 willows was also quantified. Several environmental factors (including: beaver (Castor canadensis canadensis Kuhl), wild ungulate [moose (Alces alces shiras Nelson), elk (Cervus elaphis nelsoni Bailey), and deer (OdocoiIeus spp.)], and domestic livestock herbivory, as well as species of willow, initial willow size, and distance to surface water) were identified as potentially influencing the seasonal change in willow volume. Two ungulate exclosures were constructed to compare change in volume of willows protected from ungulate herbivory to willows not protected from ungulate herbivory. Additionally, the rate of willow development through clonal expansion was also compared inside and outside the exclosures.

Aerial photographs and stem demographics indicate that willows have and are regenerating under current management. Willow volume decreased in one exclosure and one pasture over the study period. These decreases were attributed to repeated beaver herbivory. It may take several years for these willows to return to their original size.

Clonal expansion appears to be slow inside and outside the exclosures. Historic or current domestic or wild ungulate browsing does not appear to be restricting willow growth or expansion within the Long Creek Allotment.

EVALUATION OF TALL WILLOWS (*Salix* Spp.) WITHIN A LIVESTOCK GRAZING ALLOTMENT IN SOUTHWEST MONTANA

by

Mark Edward Manoukian

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Mark Edward Manoukian

This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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Chairperson, Graduate Committee

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Date 5-6-94

Dedicated to my mother and father, Lorraine and Milt Manoukian.

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ABSTRACT

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CHAPTER 1

INTRODUCTION

The Long Creek Cattle Allotment of the Beaverhead National Forest is located on the Centennial Divide, about 71 km southeast of Dillon, Montana. The allotment encompasses approximately 2200 ha, annual precipitation averages 480 mm and elevation averages 2300 m (Montana Agricultural Potentials System (MAPS) 1994). Upland vegetation is described as Artemisia tridentata Nutt./Festuca idahoensis Elmer. habitat type (Mueggler and Stewart 1980). Riparian vegetation is dominated by Salix geyeriana Anderss. (Geyer willow), S. boothii Dorn (Booth willow)/Carex spp. and Poa pratensis L. Both species of willows normally occur as multi-stemmed shrubs, greater than 3 m tall. The allotment is divided into four grazing pastures: Pole, Jones, Long Creek, and Lone Butte. Three main streams flow through the allotment; Pole Creek flows through the Pole Creek pasture, Jones Creek flows through the Jones Creek pasture (with only a small section flowing through the Lone Butte pasture) and Long Creek flows through Lone Butte pasture with only 0.8 km of the stream flowing through the southwest corner of the Long Creek pasture (Figure 1).

Domestic livestock grazing was unrestricted on the Centennial Divide with no allotment boundaries from 1911 to 1934 (Stellingwerf 1991). In 1935 the present Long Creek Allotment boundary was

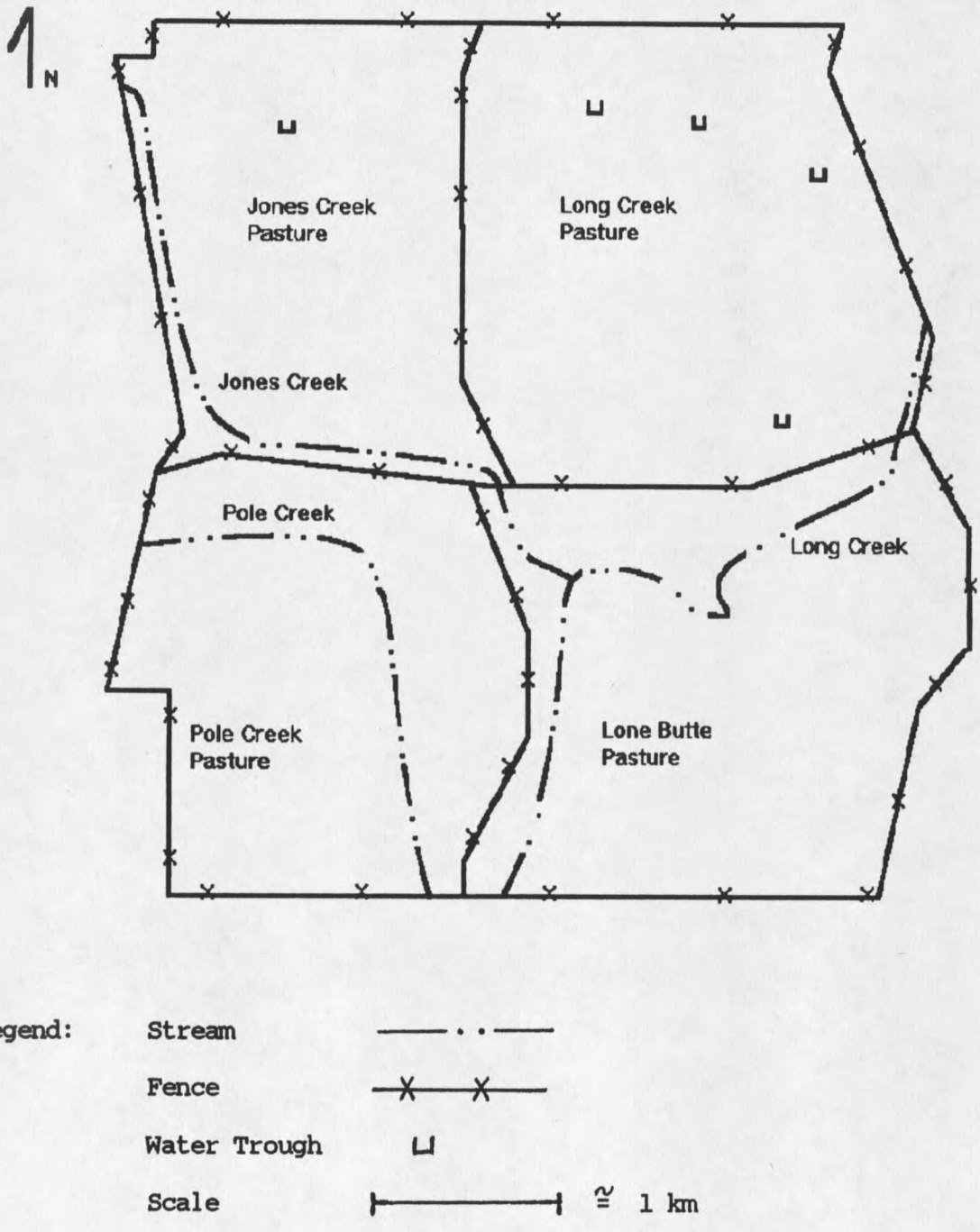

Figure 1. Location of pastures and main streams within Long Creek Allotment.

established. From 1935 to 1962, class of livestock and season of use varied from 535 cows and 75 horses to as many as 1,238 cows and 115 horses or 1,351 sheep and 120 horses. Season of use was June 1 to October 31 for horses and August 1 to October 31 for cattle and sheep (Stellingwerf 1991). In the early 1950s the current permittee, Matador Cattle Company, acquired the privileges to the allotment. In 1963 and 1964, when the Forest Service aerially applied 2, 4-D to control sagebrush, the allotment was not grazed by livestock. In 1965, the allotment was fenced into four pastures and a rest-rotation management system was established. Season of use was set at 90 days, from July 16 to October 15, for 800 cow/calf pairs. The grazing program was followed until 1986, when concerns of increasing sagebrush caused the permittee to voluntarily reduce the permit by 200 cow/calf pairs (Stellingwerf 1991).

In 1991, heightened concern for riparian areas within the Long Creek Allotment led to the development of a Memorandum of Understanding between the Beaverhead National Forest, Matador Cattle Co., and Montana State University (MSU) (Memorandum of Understanding 1991). In this memorandum, MSU agreed to implement a research project which would allow a graduate student to collect baseline riparian data, evaluate the grazing management program and to complete a Masters Degree.

The primary concern within the allotment was the historic and current status of tall willows (Salix spp.) (Resource Concepts, Inc. 1991). Manning and Padgett (1991) described tall willows as willows greater than 183 cm in height at maturity and low willows as less than 183 cm in height at maturity. The focus of this thesis was to: 1)

determine the change in tall willow canopy cover over time 2) evaluate current population demographics of willow stems 3) monitor seasonal change in canopy volume of willows, and 4) monitor clonal expansion of willows.

Results of this research will assess short and long-term trend in tall willows and provide a better understanding of the environmental factors restricting willow development. This information will add to the growing knowledge of riparian management and assist land managers in making future decisions regarding management of the Long Creek Allotment and other allotments in southwest Montana.

CHAPTER 2

FIFTY-ONE YEARS OF WILLOW DYNAMICS ON LONG CREEK ALLOTMENT

Introduction

Some reaches of the three main streams in the Long Creek Allotment support tall willows, whereas other reaches do not. While historic and recent livestock management was blamed as a factor restricting distribution of tall willows (Platts 1990), there may be alternative explanations (Resource Concepts, Inc. 1991). Therefore, management options were restricted because little is known about historical willow populations.

Long-term trends in willow community can be evaluated through aerial photography taken at different time periods (Batson et al. 1987). Added information on willow population demographics can be gained through stem age structure (Kavlachek 1991). If livestock grazing was the cause of reduced willow stature, excessive browsing by domestic livestock over a long time period should decrease willow canopy cover along streams, as identified from aerial photography. Furthermore, demographics of willow stems should depict suppression by cattle browsing. The objective of this study was to improve the understanding of long-term trend of willows on Long Creek Allotment by interpreting aerial photographs, and current status of willows by analyzing population structure.

Methods

Willow Canopy Cover

Three sets of aerial photographs spanning 45 years 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 Soil Conservation Service Air Photo Field Office, Salt Lake City, Utah. Photographs were ordered at an enlarged scale of 1 cm : 121.92 m (paper size .965 m X .965 m).

The photo scale (1:121.92) was checked with a topographic map and features. Clear (.22 m X .28 m) acetate sheets were placed on individual photos, covering the length of each stream. Allotment and pasture boundaries were delineated on each set of acetate sheets. The area occupied by willows along each stream was traced onto the acetate overlays. Natural changes (breaks) in willow canopy cover were ocularly estimated and marked on the acetate sheets. A standardized dot grid template 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 cover canopy break (Tueller 1977). The total number of dots were divided into the number of dots touching willows. This approximated a percent canopy cover. To minimize sampling error, canopy cover estimates were stratified into one of the six cover classes (Daubenmire 1959) (Table 1). After calculating the percentage of the stream within a canopy cover class, the cover estimates were used to

compare canopy along streams within a given year, and to estimate canopy cover changes at the three time periods.

Table 1. Daubenmire Cover Classes

Cover Class	Range of Coverage, %	Midpoint of Coverage Class, %
I	0-5	2.5
II	5-25	15.0
III	25-50	37.5
IV	50-75	62.5
V	75-95	85.0
VI	95-100	97.5

Another clean set of acetate sheets was placed over the photos. The stream channel, breaks in the canopy cover, and the associated cover classes were marked onto these clean acetate sheets. The length of stream within each pasture was measured from these stream channel acetate sheets with the use of a digitizer.

The digitizer used 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 each of the three years. 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.

Stem Age

Five locations in each pasture, systematically distributed along the stream reaches, were selected as collection sites for willow stems.

Two average size willows, one each of Geyer (Salix geyeriana Anderss.) and Booth (S. boothii Dorn) were selected for stem aging at each location (willows were selected based on ocular size compared with other willows at the location).

The base of each willow was measured with a two meter ruler along a north-south axis. Five stems equally spaced along the axis were selected for removal. Prior to removal, height of individual stems was measured in centimeters and recorded. Each stem was cut at ground level. The narrowest diameter of each stem was measured to the nearest millimeter and recorded. Stems were shortened to 20 cm in length, permanently tagged, and transferred to Montana State University.

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 help accentuate growth rings. Annual growth rings were counted under a 1 X 10 binocular microscope. One hundred fifty stems were collected and analyzed from Long Creek, Jones Creek, and Lone Butte pastures. Fifty stems were also collected from Pole Creek pasture however, due to lost data, only 45 stems were analyzed for Pole Creek pasture. Therefore, a total of 195 stems were analyzed.

Analysis

Willow Canopy Cover

Because canopy cover of the entire willow population along the three main streams was inventoried, the pasture canopy cover class estimates per stream reach were population statistics, rather than samples. No further analysis was required.

Stem Age

Multiple regression analyses were used to determine the correlation of species, stem height, and diameter on stem age by pasture. Also, linear regression analysis was used to determine the correlation between stem diameter and stem age for all 195 stems.

Results

Willow Canopy Cover

Canopy cover was less than 75% along all three streams. Therefore, canopy classes V and VI were omitted from the discussion.

The percentage of stream occupied by cover classes I and II in the Lone Butte and Pole Creek pastures decreased from 1942 to 1987 (Figure 2). These decreases have been off-set by an increase of cover class III in both pastures. Cover class IV in Lone Butte pasture varied from 21% in 1942, to 0% in 1965, to 18% by 1987. Cover class IV was never encountered in the Pole Creek pasture.

Cover class I in the Jones Creek pasture increased 7% during the 45 year period (Figure 2). Cover classes II and III remained relatively constant from 1942 to 1965 but changed considerably from 1965-87. During the later period, cover class II decreased while cover class III increased.

From 1942 to 1965 the percentage of stream occupied by cover class IV in the Long Creek pasture decreased from 90% to 0% (Figure 2). However, increases in cover classes II and III maintained the amount of willow cover. From 1965 to 1987 cover class II declined while class III occupied the entire stream reach.

Stem Age

Willow stem ages averaged 8, 9, 9, and 10 years for Lone Butte, Pole, Jones, and Long Creek pastures, respectively (Figures 3). Stem diameters from each pasture were correlated ($p < 0.0001$) to stem age (Table 2). Additionally, the linear regression of stem diameter and stem age for all 195 stems was correlated ($p < 0.0001$) and explained 67% of the variation (Table 2).

Table 2. Diameter and stem age regression equations by pasture.

Pasture	n	R^2	Equation
Lone Butte	50	66	Stem Age = 0.76 + 4.87 * Diameter
Pole Creek	45	57	Stem Age = 1.57 + 3.78 * Diameter
Jones Creek	50	60	Stem Age = 2.06 + 3.37 * Diameter
Long Creek	50	77	Stem Age = 2.59 + 3.37 * Diameter
All	195	63	Stem Age = 2.18 + 3.84 * Diameter

Discussion

Although photographs from 1942 did not precede introduction of domestic livestock to the Long Creek Allotment, they provided a quantifiable baseline of willow canopy cover along the main streams on the allotment. For purposes of research and management, this provided 45 years of trend data.

Analysis of aerial photographs indicated fluctuations in willow canopy cover along the three main streams within the Long Creek Allotment over 45 years. From 1942 to 1965 the majority of the stream reach of Long Creek within the Long Creek pasture changed from cover class IV to cover class II and III. Herbivory (by beaver, wild ungulates, domestic livestock), harsh climatic conditions, or herbicide drift from sagebrush control efforts in the early 1960s, or other

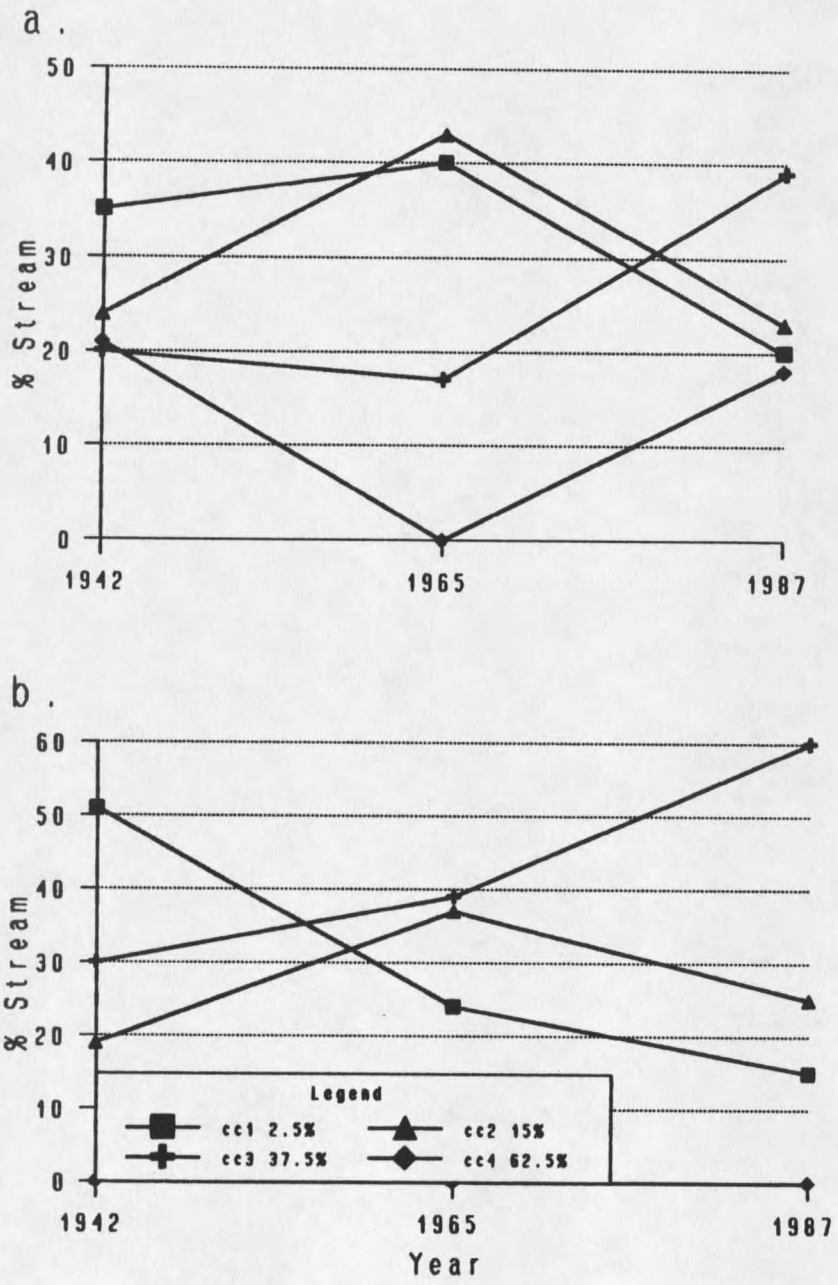

Figure 2. Percent of stream occupied by different canopy classes at three time periods for a. Lone Butte pasture and b. Pole Creek pasture

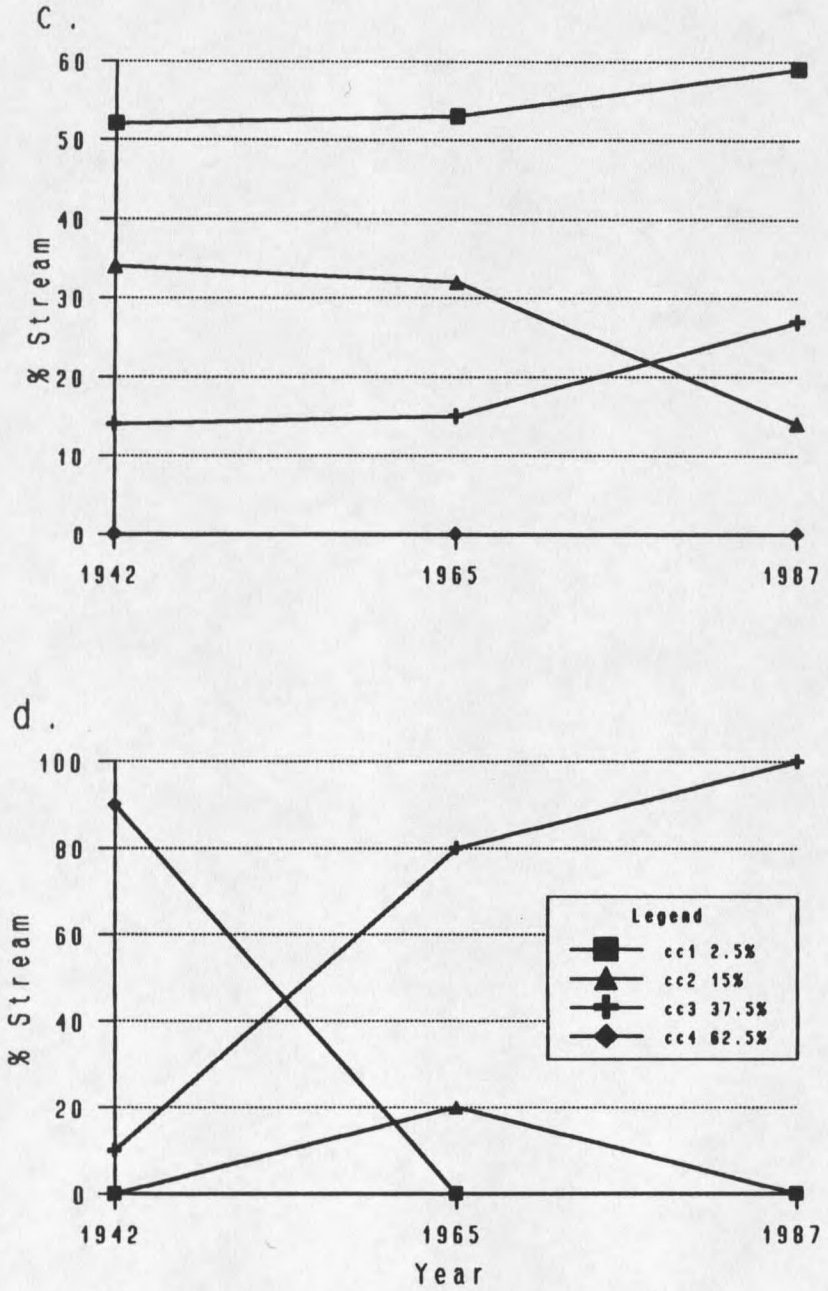

Figure 2. (Contd) Percentage of stream occupied by the different canopy classes at three time periods for c. Jones Creek pasture and d. Long Creek pasture

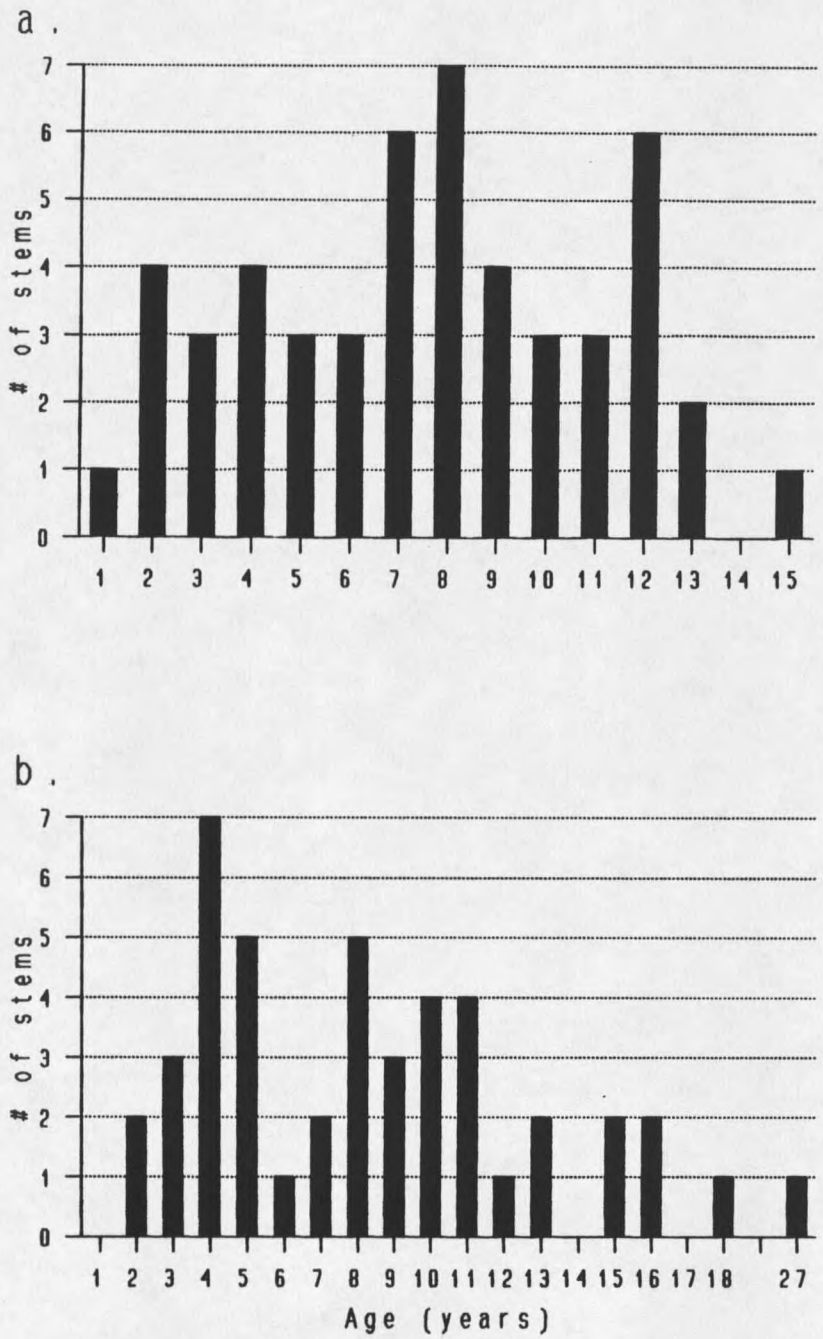

Figure 3. Population demographics of willow stems within a. Lone Butte pasture (n=50) and b. Pole Creek pasture (n=45)