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Effect of Browsing Following Wildfire in the Missouri Breaks

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ABSTRACT

This study examined the effect of browsing on skunkbush (Rhus trilobata) *and chokecherry* (Prunus virginiana) *following two wildfires in the Missouri Breaks region of Garfield County in east-central Montana, one fire in the 2003 the other in 2006. Study objectives included: 1) Determine the potential height to which skunkbush and chokecherry can grow under local conditions, and 2) Determine if browsing will prevent young plants from attaining that potential height. Because ungulates are attracted to recently burned areas it is important to monitor browse use and regulate browsing pressure to a benign level. We documented the effect of browsing by measurement of plant height and age, browsing level, and LD Index. The most rapid growth occurred in the first two years following the fires. It is predicted that browsing will not prevent skunkbush from growing to its potential height. Three lines of evidence indicate that browsing is likely to prevent many chokecherry plants from growing to potential height. In the first few years following wildfire, the potential effect of browsing is best documented by analysis of height and age relationships and by analysis of stem growth rate. After five years browsing level and LD Index are a more-precise means of documenting the effect of browsing.*

INTRODUCTION

This study examined the effect of browsing on skunkbush (*Rhus trilobata*) and chokecherry (*Prunus virginiana*) following two wildfires in the Missouri Breaks region of Garfield County in east-central Montana. The Missouri Breaks Fire complex was ignited by lightning on July 12, 2003, and burned a total of 131,000 ac before containment on July 27. The Black Pulaski Fire complex was ignited by lightning on July 16, 2006, and was contained on July 23 after burning 60,037 ac. The area provides important habitat for mule deer (*Odocoileus hemionus*) and elk (*Cervus elaphus*). The plant communities include stands of ponderosa pine (*Pinus ponderosa*) interspersed with grassland areas used for livestock grazing. The grasslands are dominated by needle- and-thread (*Stipa comata*), blue gramma (*Bouteloua gracilis*), and western wheatgrass (*Elymus smithii*). Bluebunch wheatgrass (*Elymus spicata*) occurs in association with ponderosa pine. Skunkbush (*Rhus trilobata*) grows in association with shale outcrops; chokecherry (*Prunus virginiana*) grows on relatively moister sites. Skunkbush and chokecherry are an important component of structural diversity and are an important source of food in the form of browse and fruit.

Because post-fire vegetation is protein rich and highly palatable (Carlson and others 1993; Cook and others 1994; Hobbs and Spowart 1984; Van Dyke and Darragh 2006ab), ungulate use is often concentrated in recently burned areas (Biondini and others 1999; Fuhlindorf and Engle 2001; Lay 1967; Pearson and others 1995; Van Dyke and Darragh 2006ab; Vermeire and others 2004). Browsing by wild and domestic ungulates can prevent young plants from attaining their potential stature (Keigley and others 2005; Keigley and Frisina 1998; Ripple and Besctha 2003; White and others 1998). If ungulate use is concentrated on Missouri Breaks and Pulaski burned areas, there is the potential that some browse species could be adversely affected.

The study objectives addressed below are: 1) Determine the potential height to which skunkbush and chokecherry can grow under local conditions, and 2) Determine if browsing will prevent young plants from attaining that potential height. This paper primarily describes the analysis of data collected in 2007; some chokecherry data collected in 2008 are also described.

METHODS

Study Sites

Study sites were established in four burned areas. The Big Coulee and Germaine Coulee areas were burned by Missouri Breaks Fire in 2003 (figure 1). The Lost Creek and Lodgepole areas were burned by the Black Pulaski Fire in 2006. The Lost Creek and Big Coulee burned areas were adjacent to one another, as were the Lodgepole and Germaine Coulee burned areas. The Lodgepole / Germaine Coulee burned areas were located approximately 20 miles southwest of the Lost Creek / Big Coulee burned areas.

In 2007 a total of 11 study sites were established in the Big Coulee (5 sites) and Germaine Coulee burned areas (6 sites). Measurements of chokecherry and skunkbush were taken at each site. The additional study site in the Germaine Coulee burned area was established to document the unusually robust growth of chokecherry that occurred in one area. A total of 17 study sites were established in the Lost Creek and Lodegpole burned areas. In the Lost Creek burned area, chokecherry and skunkbush were examined at seven sites, one of which was inside a big game exclosure, one inside a livestock exclosure, and five that were not protected from browsing. In each burned area, one of the sites exposed to browsing was located in the immediate

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vicinity of the exclosures. In the Lodgepole burned area, separate big game and livestock exclosures were constructed for skunkbush and chokecherry.

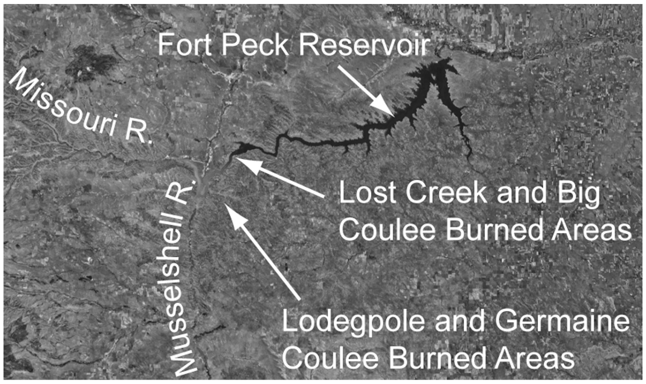


Figure 1—Location of study areas. The Lost Creek / Big Coulee burned areas are approximately 35 miles northwest of Jordan, MT.

Selection of Plants for Sampling

At each site, 20 plants of both species were selected for measurement by walking a transect line and stopping at equal intervals. The pace interval varied depending on the size of the stand. The closest live plant that was fully exposed to potential browsing was selected for measurement.

Measurements in Missouri Breaks Burned Areas

The height of live plants was measured to the base of current-year-growth (H_{BCYG}). In the case of skunkbush, the tallest stem of the shrub (as determined by height to the base of current-year-growth) was selected for measurement. If the sprouts originated from a plant that was not consumed by fire (in other words, terminal buds were present on the dead stem), the height of the parent plant was measured. The height of dead plants was measured to the tip of the stem. In cases where the parent plants were consumed by fire a separate search was conducted to complete the sample of 20 plants; at some sites 20 suitable plants were not present.

Browsing was classified into two levels by examining annual growth increments on vertically oriented stems. The length of annual growth increments was determined by inspection of bud scars. A stem was classified as intensely browsed if one ore more vertically-oriented, complete annual growth increments were browsed and were dead. If no complete annual increment was browsed and dead, the stem was classified as light-to-moderately browsed. A skunkbush plant was classified as intensely browsed if any stem in the shrub was intensely browsed. A chokecherry plant was classified on the basis of its single stem. The browsing level of the site was calculated as the percent of the 20 plants that were intensely browsed.

Live / Dead Index (LD Index) was used to assess the effect of browsing on intensely browsed plants. The index was calculated as: LD Index = $H_{BCYG} - H_D$, where H_D is the height to the tip of the tallest dead, complete annual increment (figure 2). An LD Index of about zero would indicate that a plant was being browsed to the zone of mechanical protection (browsed, dead twig clusters often deter browsing in the interior of the plant). A highly negative LD Index would indicate that a plant was dying to ground level. A highly positive LD Index would indicate that a plant was gaining height after past intense browsing.

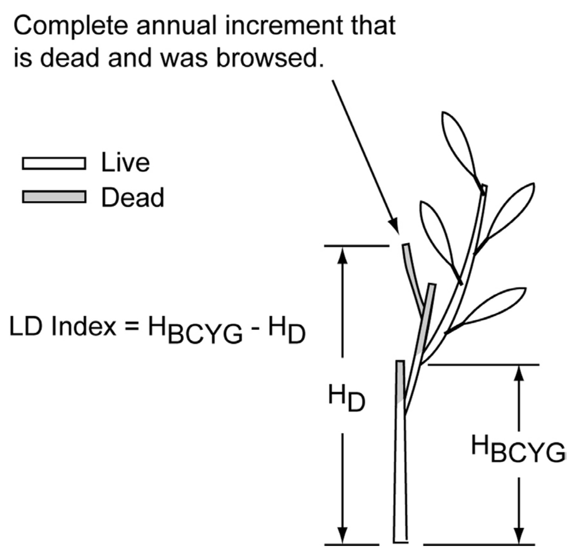
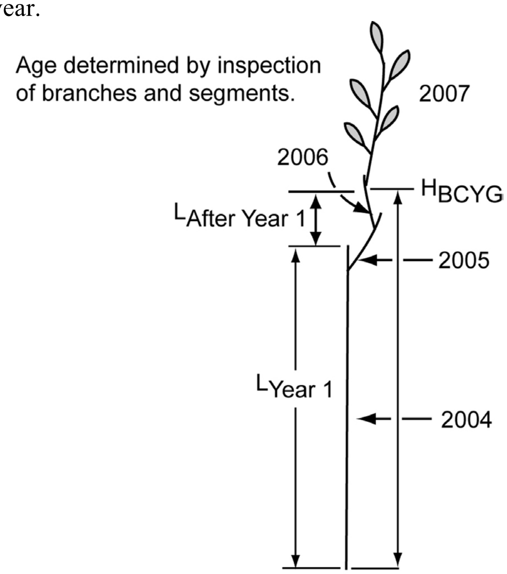


Figure 2—Measurements taken on intensely browsed plants. The measurements are used to calculate LD Index.

Over the long term, percent intensely browsed and LD Index will be used to document the effect of browsing. However, because most plants established in the Missouri Breaks burned areas were only four years old in 2007, there was concern that the plants had not been exposed to browsing long enough to develop the characteristics of intense browsing. LD Index measurements were taken in 2007 and 2008 to assess when LD Index could be used after wildfire. In the short-term, an analysis of stem growth rate was used to gain a perspective on the effect of browsing on chokecherry. The measurements on which the growth rates were based are described in figure 3.

Because skunkbush was seldom browsed, it was possible to measure the net length of stem that elongated each year after the fire. The annual increments were measured on the stem that was selected for height measurement. Annual increments were measured from the base of the increment to the point where the higher (younger) increment developed from the older stem segment. These data were used to assess the rate at which plants grew to potential stature.

For skunkbush and chokecherry the incidence of browsing during the growing season of 2007 was determined from inspection of the tallest terminal leader. For chokecherry the incidence of browsing for 2004 through 2006 was determined from inspection of the respective segments; if any of the segments that elongated in a given year was browsed, the plant was recorded as having been browsed that year.



$GR_{Year\ 1} = L_{Year\ 1}$

$GR_{After\ Year\ 1} = (H_{BCYG} - L_{Year\ 1}) / (Age - 2)$

Figure 3—Measurements used to calculate stem growth rate. Height was measured to the base of current year growth. These data were used to calculate the number of years required for a plant to grow from its height in 2007 to 3.5 m tall.

Measurements in Black Pulaski Burned Areas

The length of 2007 current-year-growth was measured. If present, the length of the segment that elongated the year of the fire (2006) was measured. Current-year-growth was examined for evidence of browsing. The height of plants killed by the fire was measured using the protocol followed in the Missouri Breaks burned areas. The plants killed by fire were examined for morphologic evidence of browsing.

In the future, plants growing inside the big game exclosures will document the height to which plants can grow in the absence of browsing. A temporary estimate of that potential height was made from measurements of plants that were protected from browsing by topography.

RESULTS AND DISCUSSION

Skunkbush

Potential Height

The mean height of skunkbush killed by the Missouri Breaks Fire was 51 ± 3 cm (n = 81; ± SE); the mean height of skunkbush killed by the Black Pulaski Fire was 58 ± 1 cm (n = 195). These heights include the stem segment that was current-year-growth at the time of the respective fires. The maximum height of a skunkbush killed by fire was 122 cm. In a search for taller skunkbush growing in areas protected from browsing, none were found.

Although there was morphologic evidence that skunkbush was browsed prior to the fires, the stems were not hedged. This suggests that prior to fire, browsing had a minimal influence on skunkbush height growth, and that plants likely grew to their potential stature given local site conditions. Depending on site conditions, the potential height of skunkbush likely ranges from 50 cm to somewhat over 1 m.

Effect of Browsing Following Wildfire

The percent of current-year-growth leaders that were browsed at the Lost Creek and Lodgepole burned areas was 0.7 and 1.8 percent respectively. The percent of current-year-growth leaders that were browsed at the Big Coulee and Germaine Coulee burned areas was 1.0 and 23.0 percent, respectively. At Germaine Coulee Site 5 all current-year-growth leaders were nipped. If Site 5 is excluded, 3.8 percent of leaders at Germaine Coulee were nipped. The incidence of browsing suggests that skunkbush browse use was greater at the southwestern end of the study area.

With the exception of Germaine Coulee Site 5, all Missouri Breaks burned area sites were zero percent intensely browsed. At Germaine Coulee Site 5, 65 percent of the plants were intensely browsed; the mean LD Index of those plants was –2 cm. Based on incidence of browsing and browsing level, browse use at Germaine Coulee Site 5 differed from all other sites.

Plant height and growth rate data indicate that growth to potential stature occurs within a few years. The mean height (H_{BCYG}) of skunkbush established after the Missouri Fire was 43 ± 1 cm. To compare this height to the height of plants that were killed by fire, the mean length of current-year growth (8 ± 0 cm) was added, resulting in a total height of 51 cm. After four full growing seasons, skunkbush established after the Missouri Breaks Fire attained a height similar to that of plants killed by the fire (51 cm).

The length of stem segments produced in each year following the Missouri Breaks fire indicates that growth rate declines with age (figure 4). This conclusion is based on lengths produced during the complete growing seasons of 2004 through 2007. Only 10 of the 200 sampled plants included segments that elongated in 2003. These segments completed their growth to a mean height of 12 ± 2 cm within a truncated season that began in late-July. Seventy three percent of the total stem growth in Missouri Breaks burned area occurred during the first two full growing seasons.

In the Black Pulaski burned areas, sprouts were observed in the Fall of 2006, however no segments produced in 2006 were encountered in 2007; all sampled plants consisted solely of current-year-growth. The mean height of current-year growth was 57 ± 1 cm, a height similar to the mean height of mature plants killed by the fire (58 cm).

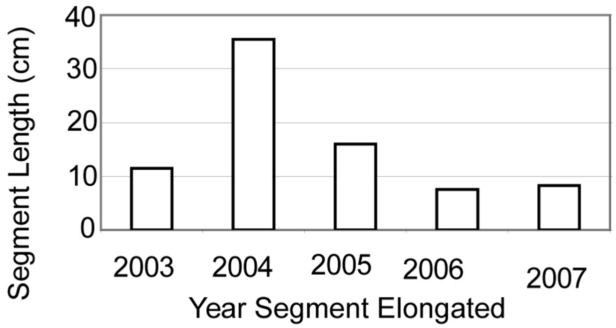


Figure 4—Much of the growth to a plant's potential height occurs during the first two years after fire. The most rapid growth occurred during the first full growing season. Growing conditions during these initial years likely plays an important role in determining a plant's ultimate stature.

In a comparison of pooled data by ANOVA, the 2007 current-year-growth of the Black Pulaski plants was significantly greater than the stem segments that elongated for the first time in 2004 in the Missouri Breaks burned areas (57 ± 1 cm and 35 ± 1 cm, respectively; $P < 0.001$). Both of these segments were in their initial growing season and could be expected to be similar in length. Figure 5 describes the mean length of the segments by year at each of the burned areas. The difference in first-season segment length may be due to differences in 2004 and 2007 precipitation.

Two Remote Automated Weather Stations documented a period of substantial precipitation in late-May of 2007; the corresponding period in 2004 was relatively dry (figure 6). In the vicinity of the Lost Creek burned area, 18 cm (7.08 in) of precipitation fell between May 20 and May 31, 2007. Over that same period in 2004, the precipitation was 4.3 cm (1.7 in). Over the same period in the vicinity of the Lodgepole burned area, 13 cm (5.13 in) of precipitation fell in 2007, compared to 5 cm (1.98 in) in 2004. The late-May precipitation in 2007 occurred immediately prior to the intense summer heat typical of the area, and may have extended the 2007 growing season.

The difference in precipitation may also explain why the 57-cm -height of the one-season old plants in the Black Pulaski burned areas was greater than the total 51-cm height of the four-season-old plants in the Missouri Breaks burned areas ($P < 0.01$; the total height of Missouri Breaks plants includes current-year-growth). Being in their initial growing season, the Black Pulaski plants were growing at a high rate; an extension of the growing season would add a correspondingly long length of stem. In contrast, most of the Missouri Breaks plants were in their fourth growing season, and growing at a reduced rate (see figure 3). Because their rate of growth was relatively slow, an extension of the growing season would produce a correspondingly shorter length of stem. Growing conditions during the initial year of growth may be a significant factor that determines the potential height of skunkbush at a site.

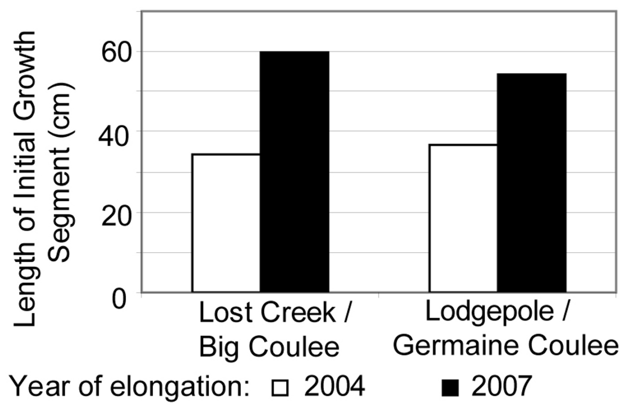


Figure 5—Skunkbush stems that elongated for the first time in 2007 grew longer than stems that elongated for the first time in 2004. A similar effect occurred with chokecherry (68 versus 56 cm). The between year difference in growth could be due to differences in precipitation described in figure 5.

Chokecherry

Potential Height

At a few locations, chokecherry plants killed by fire had grown to at least 4-m tall. The site conditions where they grew appeared to be similar to those that existed close-by where chokecherry plants were shorter. The shorter plants were hedged by browsing, while the tall plants were not. It appears that, if protected from browsing, chokecherry has the potential to grow to 3-to-4-m tall in the study area. Growth within big game exclosures will be used to reexamine this conclusion in the future.

Effect of Browsing Following Wildfire

The stems killed by fire were often hedged, suggesting that browsing had affected height growth in the past. In the Black Pulaski burned areas, 20 percent of the current-year-growth was browsed; in the Missouri Breaks burned areas 26 percent of the current-year-growth was browsed. Because measurements were taken in late-August and early-September, these data reflect browsing that occurred during the 2007 growing season. From 2004 through 2006, the incidence of browsing was 77, 86, and 80 percent, respectively. The incidence of browse use approximately triples during the late-fall and winter.

Three lines of evidence indicate that browsing will be a dominant influence on chokecherry height growth: 1) height and age relationships, 2) browsing level and LD Index, and 3) stem growth rate.

The mean height of chokecherry killed by the Missouri Breaks Fire was 69 ± 6 cm (*n* = 24; ± SE); the mean height of chokecherry killed by the Black Pulaski Fire was 73 ± 2 cm (*n* = 228). The mean height (H_{BCYG}) of chokecherry established after the Missouri Fire (excluding Germaine Coulee Site 3b) was 71 ± 1 cm (*n* = 200). After four full growing seasons, chokecherry plants established after the Missouri Breaks Fire were approximately the same height as the plants killed by fire. The mean length of current-year-growth in the Black Pulaski burned areas was 68 ± 1 cm, a height slightly shorter than the mean height of plants killed by the Black Pulaski Fire. The similarity of heights among different age classes indicates that after the initial growing season, height growth ceases. The presence of hedging indicates that browsing is a factor.

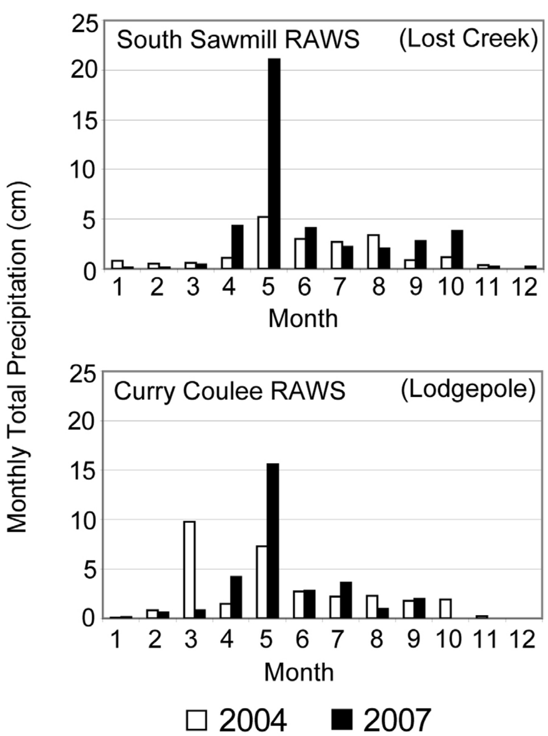


Figure 6—Precipitation in late-May of 2007 was substantially greater than that occurring in 2004. At that time of year, hot dry conditions could potentially slow growth rate. The precipitation in 2007 may have had the effect of extending the growing season. Weather conditions during the initial season of elongation could an important determinant of potential stature.

Browsing level and LD Index is the second line of evidence suggesting that browsing will influence height growth at some sites. Data collected in 2007 and 2008 are plotted in figure 7. In 2007 three sites were 0 percent intensely browsed. Because no LD Index can be calculated for light-to-moderately browsed plants, these sites are not depicted on the graph. The position of a point on the graph indicates the potential severity of browsing at a site. A severe browsing effect would be indicated by a clustering of points in the upper-center and upper-left of the graph. The browsing level and LD Index data collected in 2007 after the fire do not indicate a severe browsing effect.

Because most of the plants established after the Missouri Breaks Fire were four years old in 2007, it seems possible that they had not been exposed to browsing long enough to develop the characteristics of intense browsing. The data collected in 2008 corroborate this interpretation. By 2008 only a single site (GC03-2) was 0 percent intensely browsed. One site was 100 percent intensely browsed, and three sites were 95 percent intensely browsed. It is our interpretation that these changes reflect cumulative stress on plants rather than an increase in browsing pressure.

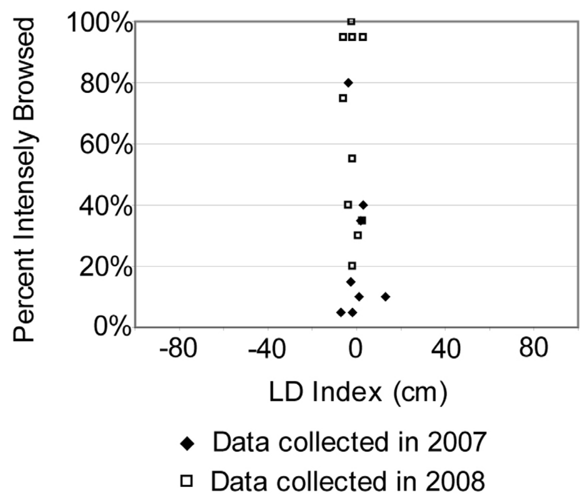


Figure 7—The relationship between percent intensely browsed and LD Index can be used to describe how the effects of browsing change over time. The earliest stage of decline would be indicated by a point at the bottom center of the graph. As a higher percentage of plants in the sample are intensely browsed, the point would move to the upper center. If browsing pressure remains high, the point would move from the upper center to the upper left. If browsing pressure diminishes, the point would move from the upper center to the upper right; as the number of light-to-moderately browsed plants increases, the point would move from the upper right to the lower right.

The analysis of stem growth rate is the third line of evidence pointing to a browsing-related effect on height growth. The goal of this analysis is to determine if a chokecherry plant will grow at a rate that will allow it to attain potential stature before it dies. The analysis was conducted separately for the Big Coulee, Germaine Coulee (excluding Site 3b), and Germaine Coulee Site 3b. Chokecherry at Germaine Coulee Site 3b was sampled because plants growing there were visibly more robust and more lightly browsed compared to plants at other sites where site conditions were similar. For undetermined reasons, chokecherry plants in this small patch (approximately 5-by-20 m) grew to an unusual height and may demonstrate the growth potential for the area.

The mean length of the stem segments that elongated in 2004 was 56 ± 1 cm (n = 199) (excluding Germaine Coulee Site 3b). After that initial growing season, stem growth rate diminished with mean values ranging from 16 cm / year at Big Coulee Site 4, to –0.1 cm / year at Germaine Coulee Site 5. Thirty-six plants had a negative growth rate; after initial elongation, these plants were growing shorter. Based on each plant's growth rate, we calculated the total age at which the plant would grow from its height in 2007 to a height of 3.5 m. A frequency distribution of those ages is shown in figure 8. Plants having negative growth rates were included in the ">49 year" class.

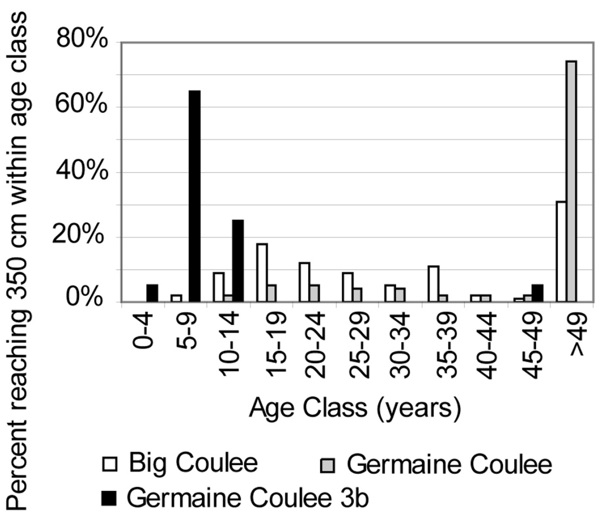


Figure 8—Frequency at which plants are predicted to grow from their height in 2007 to 2.5 m tall within a given period of years. A relatively large percentage of plants at Germaine Coulee Site 3b are predicted to grow to that height by 15 years of age; the browsing level at this site was 0 percent intensely browsed. Relatively few plants at other sites are predicted to attain 3.5 m by 15 years of age; at these areas browsing will likely prevent many plants from growing to their potential stature.

At Germaine Coulee Site 3b 95 percent of the stems are predicted to grow to 3.5 m by the time they are 15 years old. Unless conditions change, we predict that many of these plants will attain their potential stature. At Big Coulee and Germaine Coulee a respective 11 and 2 percent are predicted to grow to that height by the same age. Because growth rate diminishes with age and because browsing often shortens the lifespan of stems (as evidenced by mortality observed in 2008), it seems likely that few Big Coulee and Germaine Coulee plants will attain potential stature.

Conditions during the first few years following wildfire are critically important to the development of the future structure of the plant community. Browsing pressure must be monitored and regulated if browsing is to be limited to levels that do not adversely affect the future structure of the plant community. During the initial years of growth, many plants may not have developed the morphologic characteristics of intense browsing; the measurement of browsing level and LD Index may not detect an adverse effect of browsing. The analysis of stem growth rate may provide an alternate means of assessing the effect of browsing during the early period. The age of young plants can easily be determined by inspection, and used to calculate growth rate. After a few years, the determination of age by inspection is problematic. At this point, browsing level and LD Index provide a better means of measuring the effect of browsing.

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