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COTTONWOOD, ASPEN, AND WILLOW AT RISK: LACK OF RECRUITMENT DUE TO EXCESSIVE BROWSING

on Dixie and Fishlake National Forests

A Report and Proposal
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I. Introduction

This report summarizes a 2008 assessment by Grand Canyon Trust of browsing intensity on and recruitment of (1) riparian cottonwood, aspen, and willow (CAW); and (2) upland aspen on portions of the Dixie and Fishlake National Forests. Cottonwood, aspen, and willow are three plant groups within the willow family (Salicaceae), and they are all strongly interacting species (Lindenmayer and Joern 2006) within their watersheds. These species play a disproportionally important role in maintaining ecosystem function, because they interact particularly strongly with numerous other species as well as with the physical site, particularly riparian areas

The assessment arises out of concern for observed deficits in recruitment of cottonwood, aspen, and willow in riparian areas, and in aspen clones, not only on the Dixie and Fishlake NFs, but in the third southern Utah national forest, the Manti-La Sal NF.

The assessment does not include aspen stands overtopped by conifers, because aspen recruitment there has a more complicated relationship with browsing due to the shading of and competition with aspen by conifers. Conifer encroachment of aspen involves management not only of browsing, but also of fire and even predators, management issues not addressed in this report (but see, e.g., Halofsky, Ripple and Beschta 2008).

The diminishment of cottonwood, aspen, and willow communities due to lack of recruitment is of major concern because of the key role the willow family plays both in riparian areas (cottonwood, aspen, and willow), and on watershed slopes (aspen). Their diminishment is also preventable, through management of both livestock (cattle, but also sheep) and wild ungulates (elk, deer).

The report provides recommendations arising out of observations of both the willow family and livestock and forest management on the Dixie, Fishlake, and Manti-La Sal NFs during the past five years (2004-2008).

II. The Importance of Cottonwood, Aspen, and Willow Recruitment

Three key species of the willow family (Salicaceae) are being excessively browsed on Dixie, Fishlake, and Manti-La Sal National Forests ("Three Forests") by cattle, elk, and, less prominently in most areas, by deer and domestic sheep. The cascading ecological consequences of this excessive browsing are profound.

Cottonwood (predominantly in this assessment narrowleaf cottonwood, *Populus angustifolia)* occurs in riparian areas at 5,000'- 9,000' on all three forests.[1] It is a keystone species in the arid West, providinig structural complexity for riparian areas and therefore multiple wildlife habitat niches, temperature modulation via shading of riparian areas and creeks, deep roots for stability of creek and stream banks, and large woody debris for the creeks and streams.

The brief notes given for narrowleaf cottonwood in *A Utah Flora* (Welsh, et al. 2008) are telling:

> Narrowleaf cottonwood occupies a habitat that has received severe impact during the century and a half since colonization. Under private ownership the habitat has been heavily utilized as pasture, woodlot, and cleared for other agrarian purposes (or inundated by reservoirs). Much of the streamside forest has been cut repeatedly; little of it exists in pristine condition. Large tracts have been modified through channelization of the streams, preventing flooding and subsequent regrowth through natural seeding, and **the root sprouts are eaten by domestic livestock**. The plant is one of the favorite food and dam building plants for beaver. (Emphasis added)

In the Forest Service Rocky Mountain Research Station publication, *Responses of Plant Communities to Grazing in the Southwestern United States,* Milchunas (2006) points to some of the implications of loss of overstory species such as cottonwood, aspen, and large willows in the riparian zone, as well as their vulnerability to livestock grazing:

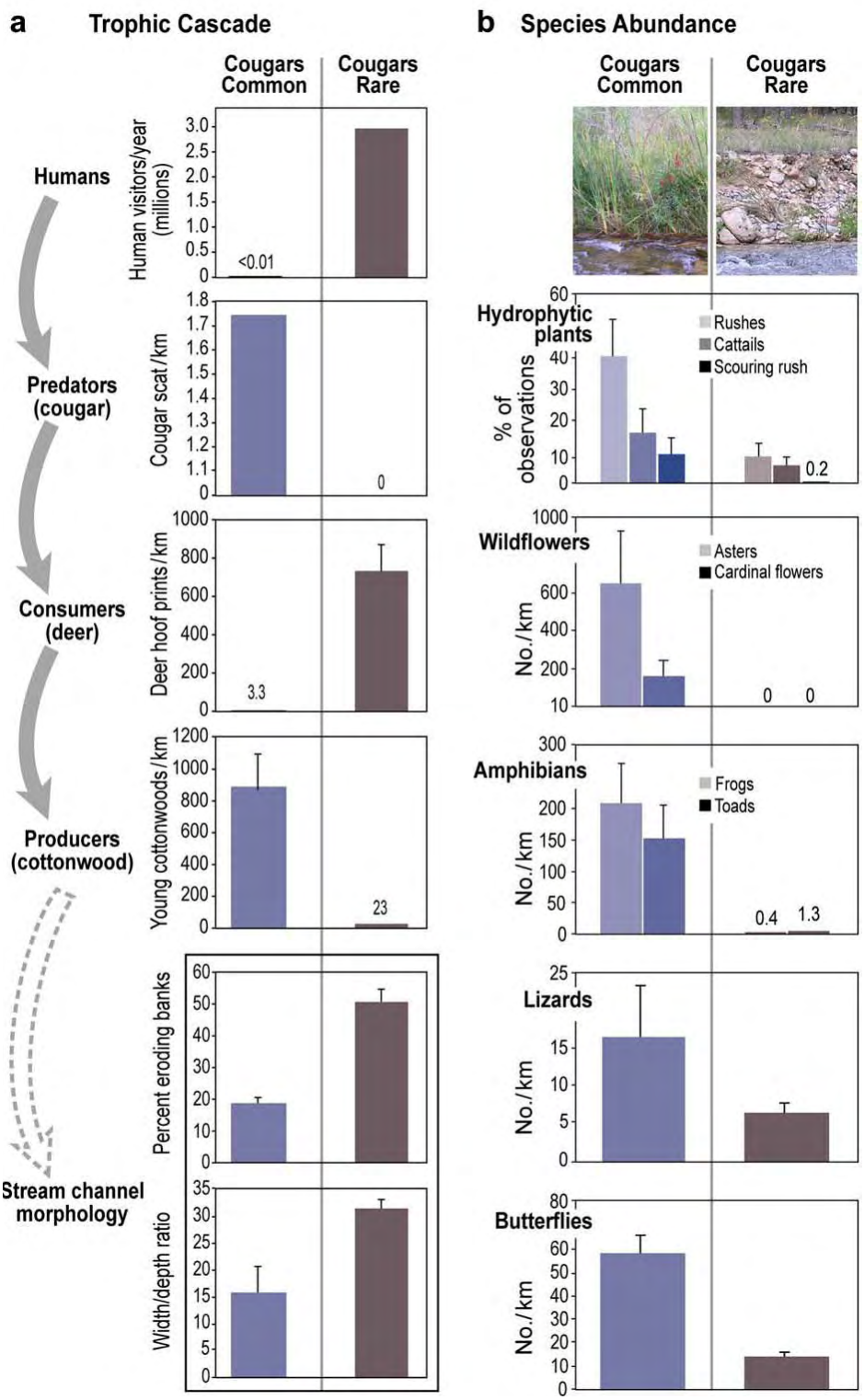
> Unlike shrub invasion problems in upland communities, **riparian zone overstories are often reduced by livestock grazing** (Kauffman and Krueger 1984), and this strata provides cover and nesting for many land vertebrates and affects water temperatures for aquatic organisms. Stream-side vegetation exerts a large influence on bank and channel morphology through effects on flow velocities, cutting during flood conditions, and erosional inputs from uplands. **There is a potential for these productive areas to be impacted by livestock to a relatively greater degree than adjacent less productive communities**, but there is also the potential for more rapid recovery from disturbance because of faster growth rates of the vegetation. (Emphases added.)

Research on the cascading species and hydrological effects of loss of riparian cottonwood galleries to excessive browsing has been starkly documented by William Ripple and Robert Beschta in Zion National Park (2006; see Fig. 5 from this article, below[2]). The consequences

[1] Southwest ReGAP estimates of acreage for Rocky Mountain Lower Montane Riparian Woodland and Shrubland are Manti-La Sal (5,964 acres, Fishlake (8,127), and Dixie (4,645)).

[2] The article is available at http://www.cof.orst.edu/leopold/papers/cougar_cascades_ripple_beschta_2006.pdf

range from stream morphology to butterflies. In the case of Zion, the overbrowsing is by mule deer in a watershed from which cougars are largely absent due to the presence of numerous Park visitors. The same consequences can follow excessive browsing by cattle, elk, or bison (e.g., see Halofsky and Ripple 2008; Beschta 2003; and Larsen and Ripple 2003).



(a)Trophic cascade indicated by inverse patterns of abundance across trophic levels and (b) observed biodiversity indicators for ‘‘cougars common’’ and ‘‘cougars rare’’ areas of Zion National Park USA. Species include Fremont cottonwood originating since 1940 (Populus fremontii), rushes (Juncus spp.), cattails (Typha sp.), scouring rush (Equisetum sp.), Welsh aster (Aster welshii), cardinal flower (Lobelia cardinalis), canyon tree frogs (Hyla arenicola), red spotted toads (Bufo punctatus). See text for a list of observed lizard species and butterfly subfamilies. Error bars represent standard errors.

Fig. 1 Figure 5 from Ripple and Beschta 2006.

Aspen (quaking aspen, *Populus tremuloides*) is a clonal species that occurs both along water courses and upland along mountainsides at 4,600'-10,500'. Aspen clones, which shelter an understory of shrubs, forbs, and grasses, are second only to riparian communities in the West for supporting biodiversity (Chong, et al. 2001) For instance, they provide soft wood for cavity nesters and secondary cavity nesters, thermal and hiding cover for wild ungulates and other mammals, and habitat for forbs and pollinators. They are vulnerable to invasion by exotic plant species (Chong, et al. 2001)

Within the Three Forests, aspen are being depleted by two major routes: overtopping by conifer in the absence of fire; and excessive browsing by domestic and wild ungulates. Pure stands are also subject, where accessible to motorized vehicles, to the impacts of large, dispersed campsites.

Willow provide riparian structural and habitat complexity, and deep roots that stabilize streambanks. Willow species occur in our transects predominantly as Geyer's (*Salix geyeriana)* and Booth's (*S. boothii)*, but also coyote (*S. exigua*)), whiplash (*S. lucida*) and graybark or yellow (*S. eriocephala*). All of these willows can attain heights above 6 feet (2 meters; Welsh et al. 2008):

Salix geyeriana	1.5-4.5m
S. boothii	2-4m
S. exigua	2-3m
S. eriocephala	3-5m
S. lucida	3-6 m

Willow are readily eaten by cattle and elk, as well as by deer and domestic sheep (e.g., Brookshire, et al. 2002; Opperman and Merenlender 2000).

III. Lack of Cottonwood, Aspen, and Willow Recruitment

During Trust field work on the Three Forests since 2004, three features common to the cottonwood, aspen, and willow (CAW) communities are frequently, and strikingly obvious:

1. Stands with a few very large, old individuals.
2. Regeneration (i.e., individuals 0.1'-2') generally present at some level.
3. Recruitment above 4'-5' often anemic or absent
4. Single- or two-tier aspen stands with little understory and no recruitment.

Specifically:

1. **Repeated Observations within Riparian Cottonwood, Aspen, and Willow Areas** (see Appendix A for GPS-linked photo examples of each of the following):
    a. Few large, old willows surrounded by Kentucky bluegrass and no willow recruitment
    b. Large, old cottonwood, with little or no cottonwood recruitment.
    c. Cottonwood root sprouts heavily browsed
    d. Old cottonwood browsed to inches.
    e. Willow on creek banks browsed to inches.
    f. Restriction of cottonwood or willow to inaccessible, steep banks
    g. Widening, incising of creeks among heavily-browsed willow
    h. Striking fenceline contrasts along riparian exclosures
    i. Entire patches of cottonwood browsed.
    j. Willow in riparian areas browsed to inches

2. **Repeated Observations Within Upland Aspen** (see Appendix B for GPS-linked photo examples of each of the following):
    a. Pure aspen stands lacking recruitment
    b. Single-tier aspen stands.
    c. Excessive browsing of conifer within conifer-encroached stands.
    d. Aspen stands experiencing recruitment only where old aspen topple, creating jack-strawed logs protecting ramets.
    e. Water developments within or near aspen stands.
    f. Browsed aspen next to unbrowsed conifer, facilitating conifer encroachment.
    g. Heavily-browsed aspen near conifer-aspen stand slated for treatment.
    h. Aspen understory heavily grazed.

IV. Problems with Forest Management of Cottonwood, Aspen, and Willow Browse

As we have tried to understand the source of the striking lack of recruitment of understory CAW individuals into overstory, i.e., a lack of 4'-6' individuals, we have observed the fundamental lack of a science-informed vision of or management for desirable cottonwood, aspen, and willow (CAW) community structure, understory, and areal extent. Some problems are specific to riparian CAW and upland aspen:

1. **Riparian Cottonwood, Aspen and Willow Browsing Management Deficiencies**
    a. Too many livestock grazing and browsing in riparian areas, particularly during the summer, when concentration in riparian areas and excessive browsing are essentially guaranteed.
    b. Annual Operating Instructions that permit livestock grazing in riparian areas where cottonwood, willow, and/or aspen recruitment is obviously lacking.
    c. Failure to rest creeks or watersheds from livestock grazing for sufficient time to allow for recruitment of willows, cottonwoods, and aspen above 6'.
    d. A focus on the greenline (i.e., within 6' of the creek or stream) rather than on the riparian area (i.e., area of current and potential hydrophytic vegetation such as cottonwood galleries and willow)
    e. Near-total lack of monitoring of CAW (a) browsing intensity; and (b) population structure, despite the key role of CAW in maintaining riparian integrity and vegetation and wildlife diversity.
    f. Lack of a rapid assessment protocol for measuring the most biologically-important browse, i.e., of leaders and subleaders (defined here, for practical purposes, as upward-trending twigs within 6 vertical inches of the tallest leader).
    g. Unscientific forest CAW utilization standards that do not lend themselves to meaningful browse monitoring
    h. Lack of enforcement of riparian graminoid utilization forest standards.
    i. Lack of a bank loss monitoring protocol to record the shearing, trampling, and loss of riparian banks, and widening and incision of creeks/streams in the absence of deep-rooted species.
    j. Failure to engage with UDWR on-ground, to set limits on excessive browsing as a result of elk or combined elk-livestock use.

2. **Upland Aspen Management Deficiencies**
    a. Annual Operating Instructions that permit livestock grazing in aspen clones obviously lacking recruitment.
    b. A focus on vegetation treatments of conifer-encroached aspen stands, to the exclusion of attention to impending death of pure, untreated aspen stands.
    c. A focus on the number of single-tier aspen ramets as a measure of aspen restoration following vegetation treatments or fire.
    d. Lack of an aspen understory monitoring protocol to determine whether an aspen community, rather than simply a dense thicket of single-tier ramets, is developing following vegetation treatments or fire.

e. Excessive browsing by livestock allowed in burned or logged aspen once an initial thicket of ramets reaches 5' or 6', guaranteeing a single-tiered stand and depleted understory of shrubs, forbs, and graminoids.
f. Water developments in or near aspen stands.
g. Failure to engage with UDWR on-ground, to set limits on excessive browsing as a result of elk or combined elk-livestock use.
h. Inaccurate claims as to when cattle browse aspen or willow. We have observed cattle browsing on aspen in June, amid verdant vegetation. We have not seen evidence that cattle will not browse willow during early season (but we are not sure of this).

3. Forest Service Browse Standard and Desired Condition Deficiencies

a. Lack of a recruitment standard or recruitment monitoring for riparian CAW communities. Desired conditions for CAW communities need to be based on height class distributions, based on willow species involved and relevant reference areas and exclosures.
b. False equation of height classes with age classes. A 2' or 3' willow or cottonwood may not be young.
c. Lack of science-based browse standards. For instance, scientific evidence is lacking that annually-repeated browse of 40% of the current year's twigs on a 2' willow will allow for recruitment and reproduction (i.e., via catkins).
d. Failure to provide for browse limits of varying heights of willow species for recruitment. Some willow species, e.g., *Salix arizonica*, do not generally grow above browse height (5'-6' tall). The intensity of browse that allows for mature height and/or reproduction of these species has not been determined.
e. Lack of distinction between browse of palatable and less-palatable woody riparian species for purposes of meeting standards, e.g., between palatable willow and less palatable water birch.
f. Focus on the greenline, as opposed to the riparian community. Often willow or aspen will be surviving on the banks of a creek if they are inaccessible to cattle, but will be extraordinarily heavily browsed on the floodplain, limiting recruitment to a few feet instead of hundreds of feet.
g. (Dixie NF) end-of-season standard of 6"graminoid stubble or regrowth as opposed to a during-season standard, insuring that few riparian areas will be monitored (i.e., to check whether pastures met utilization, all must be monitored after mid-October to be at the end of the growing season and livestock grazing).

V. Assessing Cottonwood, Aspen, and Willow Browse and Recruitment

From May through October 12, 2008, Grand Canyon Trust staff (one permanent; one temporary), two interns, and volunteers assessed cottonwood, aspen, and willow browse and upland aspen browse and stand structure at 64 sites on the Dixie and Fishlake National Forests. The purpose was to assess the browsing condition and height class structure of the riparian site or aspen stand, and note relevant conditions operative at the site (e.g., dominant plant species, location within an exclosure; see Figs. 2-3 for maps of the transect sites).

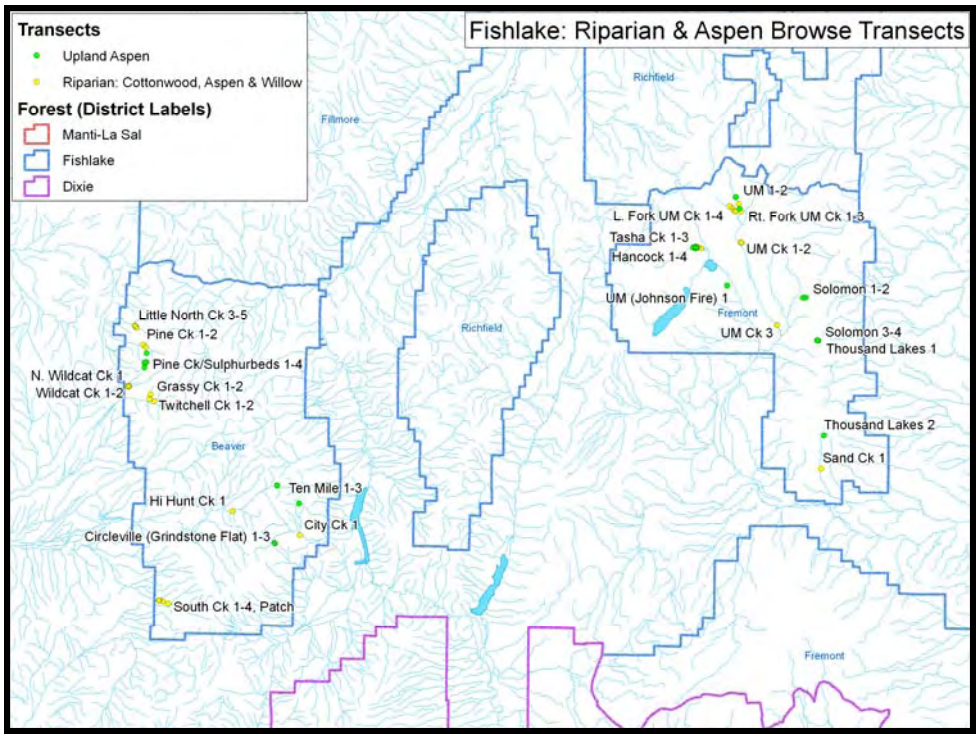


Fig. 2 Map of Fishlake NF riparian CAW and upland aspen browse transects, 2008.

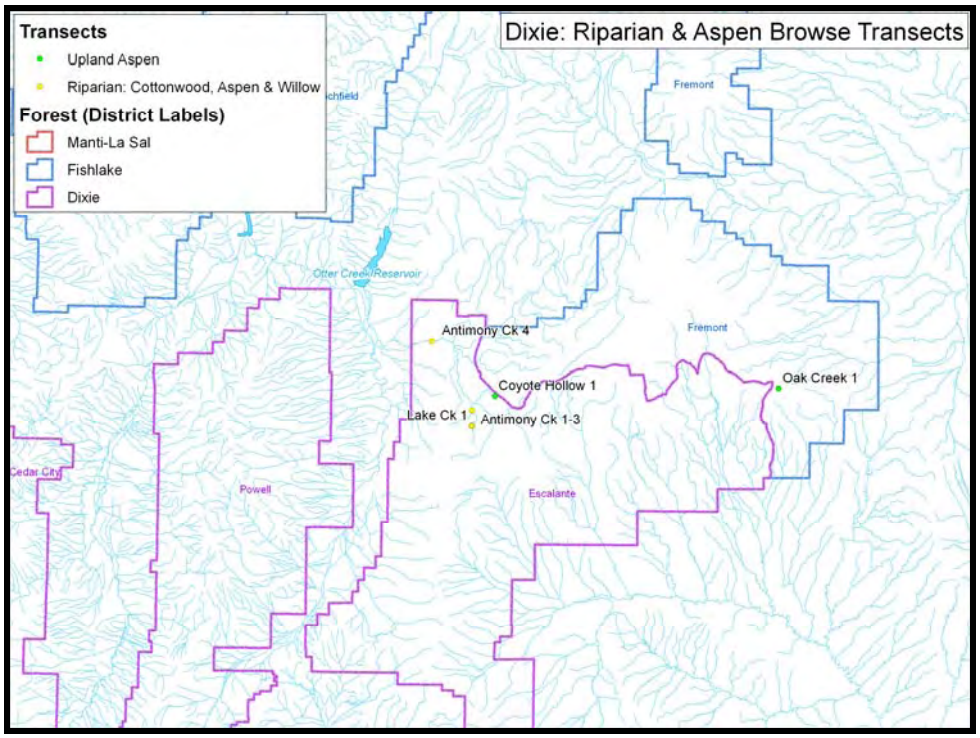


Fig. 3 Map of Dixie NF riparian CAW and upland aspen browse transects, 2008.

While the details of the browse and stand structure methods and data forms are presented in Appendices E and F, the following briefly outlines the browse and stand structure assessment methods employed:

A. Riparian cottonwood, aspen, willow browse transects

Between May 7 and October 11, riparian cottonwood, aspen, and/or willow browse transects were run at 39 sites, with repeated measurements ("second readings") later in the season than the first reading at 24 of these 39 sites.

Distinction was not made between current-season browse and browse during the previous winter (i.e., wild ungulates) or grazing season. There are three justifications for this: (1) The accuracy of such distinctions is often questionable; (2) analyzing the data would be sensitive to the precise point in the current season the assessment was made (e.g., during the time cattle are in the pasture? After cattle have left the pasture?); and, most importantly, (3) the purpose of this browse assessment is not to judge whether this year's livestock are exceeding or have exceeded a single-season browse utilization standard, but to gain a picture of the overall condition of the cottonwood, aspen, or willow plants in relation to recruitment.

When the cause of death of a particular leader or subleader is not clearly due to browsing (i.e., nipping off the leader's bud), the leader or subleader is simply recorded as "dead" and notes are made as to any possible explanation for a pattern of leaders' deaths at that site (e.g., if petioles remain after leaves are gone and some of the leaders are clearly scraped, notes would be made that many of the "dead" leaders/subleaders were apparently stripped by an ungulate).

1. Sites were selected using a variety of criteria, including
   a. **Presence of cottonwood, aspen, or willow** accessible to livestock and/or elk (or, for comparison, in an exclosure). Regeneration was present in nearly all these sites.
   b. **Pending grazing management decisions** in the allotment
   c. **Diversity of conditions** (e.g., we knew two sites were going to be entirely lacking in regeneration).
2. A form was filled out on the site (Appendix E) recording Forest, District, Allotment, aspect, elevation, dominant plant species, animal sign, adjacent developments if any, incision of creek, etc.
3. A 100-foot baseline transect was laid parallel to the creek from a permanent stake (UTM recorded), and five perpendicular 6-foot belt transects were run every 20 feet, starting from the creek's water edge, back 100' or to the last cottonwood, aspen, or willow, whichever was reached first. The first perpendicular transect was placed at a distance of 0' to 20' from the 0' of the baseline transect according to a random number table.
4. Each cottonwood or aspen encountered within the 6-foot belt transect was recorded for (a) height (within 1' increments); and (b) condition (browsed, unbrowsed, or dead) of (i) the tallest leader if below 6'; and (ii) all subleaders within 6 vertical inches of the tallest leader. If the tallest leader was >6' tall, the DBH of the cottonwood or aspen was measured.
5. Each willow encountered within the 6-foot belt transect was recorded for condition (browsed, unbrowsed, or dead) of (a) the tallest leader if below 6'; and (b) all subleaders within 6 vertical inches and 6" radius (i.e., within a 1' diameter hoop) of the tallest leader. If the tallest leader was >6' tall, the width of the base of the willow was measured.
6. A willow rooted 6" from another willow was considered a separate willow.
7. Photos were taken at the site and along transects, and each photograph was later linked to GPS tracks and labeled.

B. Aspen stand browse/structural composition assessments

Between June 22 and October 12 aspen browse transects and aspen stand structural composition plots were run (Appendix F) on 24 aspen stands (plus structural composition in one additional stand), repeating measurements early and late season in six of these stands

1. Aspen stands were selected using a variety of criteria, including

   a. Lack of major conifer presence or dominance in the stand.
   b. **Presence of aspen regeneration.**
   c. **Accessibility to livestock** (or, for comparison, in an exclosure).
   d. **In the same region of the pasture as riparian CAW transects**, but this was not always the case.
   e. **Pending management decisions** in the area, primarily grazing management decisions, but in the case of one aspen stand, a vegetation treatment decision.
2. A form was filled out on the site (see Appendix F) recording Forest, District, Allotment, aspect, elevation, dominant plant species, animal sign, adjacent developments if any, distance to a nearby creek, etc.

3. Three 100-foot 6-foot belt transects were run in each third of the stand, or, if the stand was large, within a selected portion of the stand. The three transects extended, respectively, from the left side, within the center, and from the right side of the aspen stand, at a distance from the bottom of the section chosen via a random number table.
4. Each aspen encountered within the 6-foot belt transect was recorded for (a) height (within 1' increments); and (b) condition (browsed, unbrowsed, or dead) of (i) the tallest leader if below 6'; and (ii) all subleaders within 6 vertical inches of the tallest leader. If the tallest leader was >6' tall, the DBH of the aspen was measured. If a conifer ≤6' tall was encountered, its height class was recorded; and DBH was recorded for conifers >6'.
5. Photos were taken at the site and along transects, and each photograph was later linked to GPS tracks and labeled.
6. Two circular plots of 18.4' radius were located in typical portions of the stand (though the two plots might represent different sections of the stand, e.g., a portion with regeneration, and one lacking regeneration). The percentages of overstory, recruitment, and regeneration cover were estimated, as well as the percent of overstory trees exhibiting decadence (see detailed description of the methods in Appendix F). GPS-linked photographs were taken at the center of the plot of the overstory cover; ground cover; and horizontal view into the stand.

For those sites for which repeat measurements were made, an attempt was made to take the first transect reading before or soon after cattle entered the allotments; and to take the second transect reading soon after the cattle left the allotment. This provided at least some sense of the role cattle had on browse as opposed to wild ungulates (e.g., elk).

VI. Results of Riparian Cottonwood, Aspen, and Willow Browse and Recruitment Assessment

Figs. 4-7 present data on browsing intensity of leaders and subleaders of riparian cottonwood, aspen, and willow browse. The horizontal line at 40% browsed is simply a marker in relation to the Fishlake National Forest standard for browse of "riparian/upland browse sprouts and young-aged plants", i.e., ≤40%, based on "# of current year's available twigs removed"[3] The Dixie National Forest browse utilization allows "50% use of total annual leaders available to livestock"[4] both in riparian and upland sites.

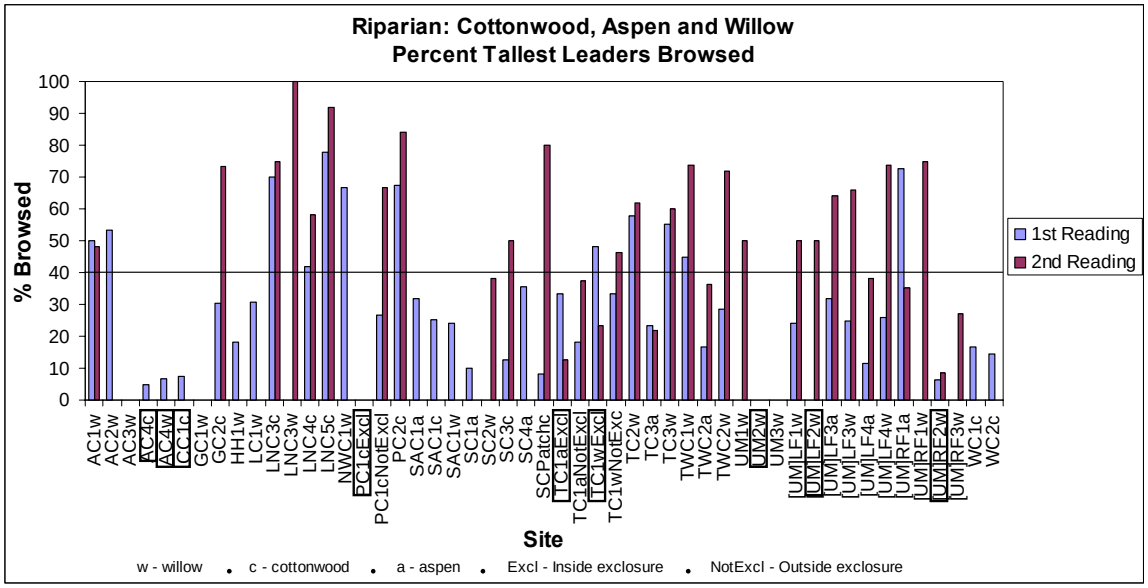


Fig. 4 Percent tallest leaders browsed on riparian cottonwood, aspen, and willow ≤6' tall.
▭ = sites with little or no cattle presence

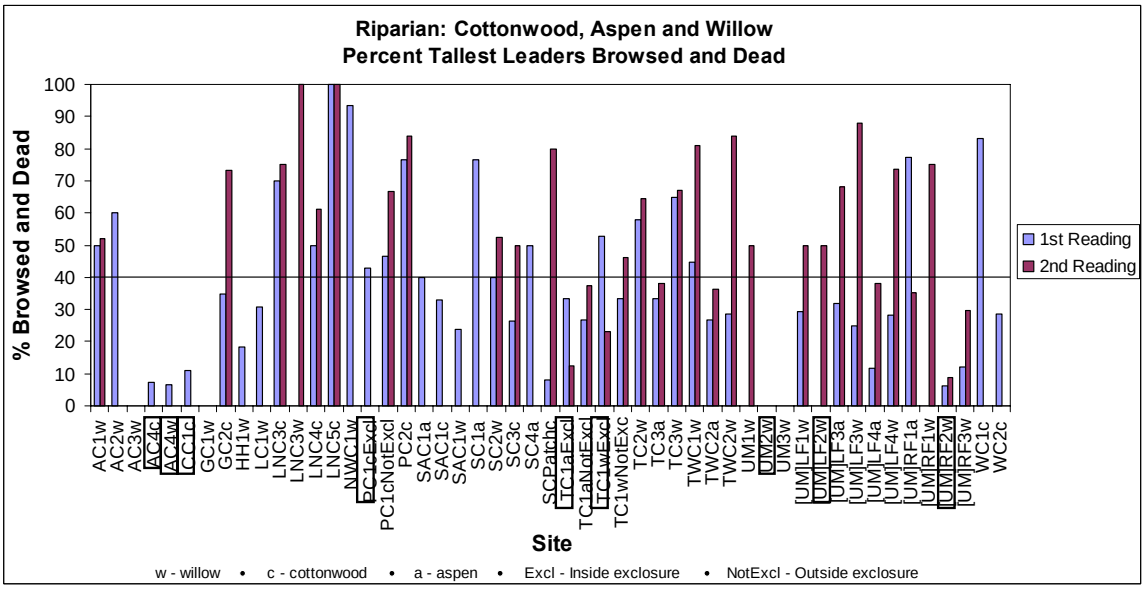


Fig. 5 Percent tallest leaders browsed and dead on cottonwood, aspen, and willow ≤6' tall.
▭ =sites with little or no cattle presence

[3] Cited in Beaver Ranger District 2008 Annual Operating Instructions. The allowable browse of "riparian/upland mature browse" is ≤50%. It is not clear what is considered a "mature" plant and a "young" plant.
[4] Cited in Bowery Allotment 2008 Annual Operating Instructions.

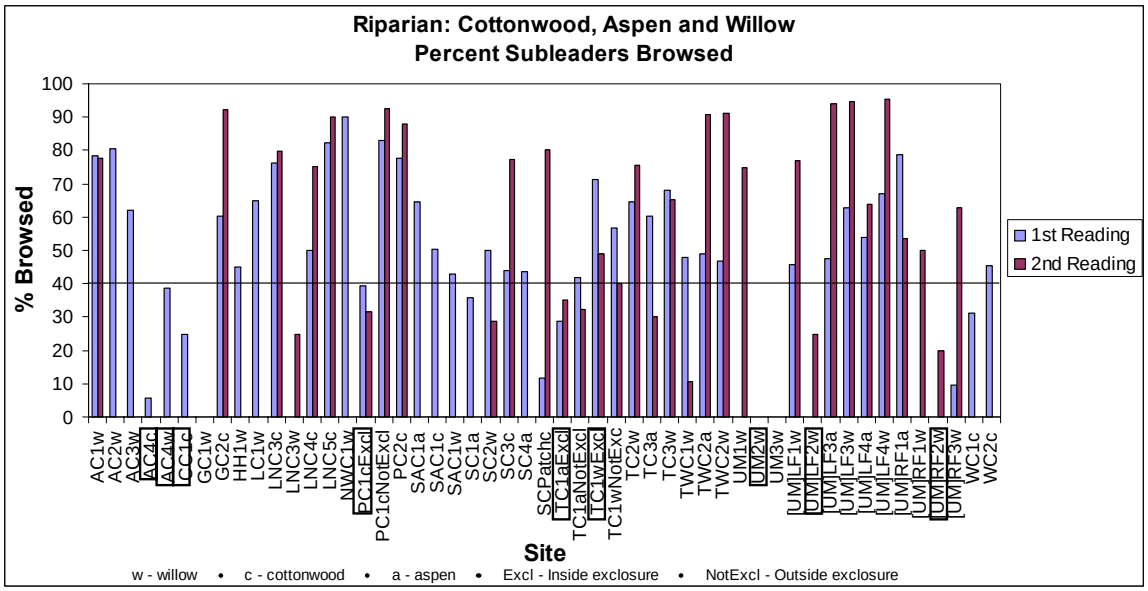


Fig. 6 Percent subleaders browsed on riparian cottonwood, aspen, and willow ≤6' tall.
▭ = sites with little or no cattle presence

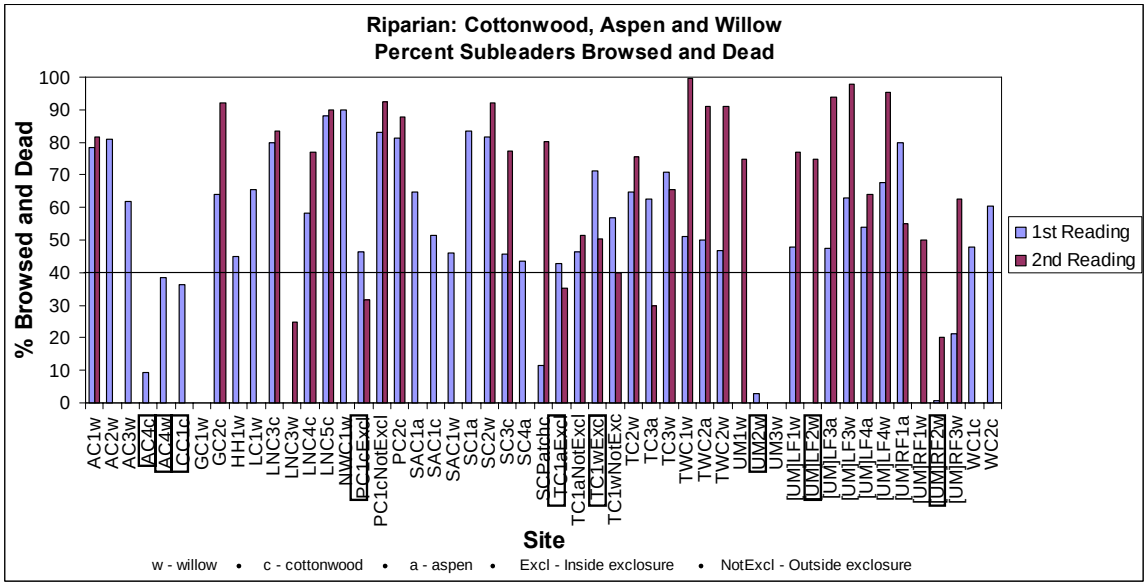


Fig. 7 Percent subleaders browsed and dead on riparian cottonwood, aspen, and willow ≤6' tall. ▭ = sites with little or no cattle presence

General Notes - Several have sites had little browsing due to a variety of reasons:

Antimony Creek #3 (AC3) has zero percent of the tallest leaders browsed (Fig.4), but there were only 3 willows <6' tall. Even though the tallest leaders were not browsed, over 60% of the subleaders were browsed (Fig. 6).

Antimony Creek #4 (AC4) has very little browsing due to its location. It is surrounded by cliffs to the north and south and a narrow, relatively impassable canyon to the west. Therefore there is very little ungulate use (Fig. 4-7).

City Creek #1 (CC1); **UM Creek #2** (UM2) and **Right Fork UM Creek #2** ([UM]RF2) are all in cattle exclosures, have very little browsing on the leaders and subleaders (Fig. 4-7).

Grassy Creek #1 (GC1) and **UM Creek #3** (UM3) have no browsing, but there were no willow <6' tall (Fig. 4-7).

Tasha Creek #1 (TC1) was surveyed the first time (June 29) while the exclosure was being built, therefore the exclosure was only functional for the second reading. For both the aspen and willow, the percent browse inside the exclosure was lower on the second reading (Sept. 29). Outside the exclosure the percent browse was higher on the second reading. The willows and aspen outside the exclosure demonstrate the same pattern as most of the sites – more browse later in the season. The willows inside the exclosure, however, were able to recover and many subleaders were able to grow to the height of the previously browsed leaders, resulting in a lower browse percentage than had been recorded at the first reading (Fig. 4-7).

Fig. 8 shows the height class distribution of aspen, cottonwood, and willow within each riparian site, and the average DBH for aspen and cottonwood >6' and average width at the base of willow >6' tall. The average DBH of cottonwood over >6' is 8.5", indicating a large break in age between overstory and recruitment. Aspen >6' average 2.3" in diameter; this average is a mixture of sites with smaller diameter overstory and larger diameter overstory (see individual site reports in Appendix C). Willow average 4.9' at their base, indicating very old willows; while only 5.3% of the site's willows are 4.1'-6'

Overall Percent Aspen Present in Each Height Class and Ave. DBH					
	0' - 2'	2.1' - 4'	4.1' - 6'	>6'	Ave. DBH or Width
Aspen	22.1%	27.8%	12.8%	37.2%	2.3" (111)
Cottonwood	41.6%	33.3%	12.2%	12.9%	8.5" (143)
Willow	41.2%	27.7%	5.3%	25.8%	4.9' (318)

Fig. 8 Percent aspen, cottonwood, and willow present in each height class, and ave. DBH. (Number of individual plants in parentheses; sites with little or no cattle presence are boxed)

Fig. 9 shows the height class distribution of cottonwood, aspen, and willow as well as the average DBH (aspen, cottonwood) or width (willow) of those plants >6'. The black portion of the bar represents the percent of the transects' cottonwood, aspen, or willow which were in the height class of 4.1'-6'. This is a height class that is generally quite small in relation to the regeneration below, which is particularly vulnerable to excessive browsing (i.e., 0.1'-2'; 2.1'-3; and 3.1'-4').

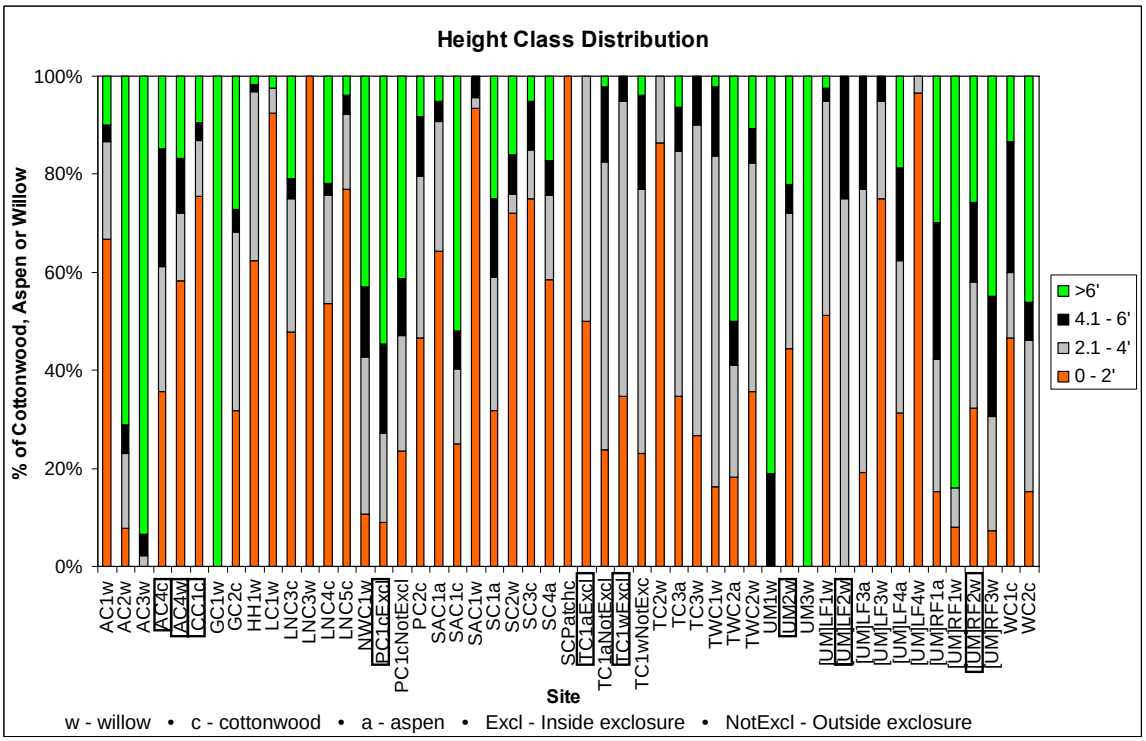


Fig. 9. Height class distribution of cottonwood, aspen, and willow at each riparian site. Fig. 10 shows average DBH of the cottonwood or aspen over >6' or average width at base of the willow >6'. = sites with little or no cattle presence

Site ID	Aspen Ave. DBH (in)	Cottonwood Ave. DBH (in)	Willow Ave. Width (ft)	Site ID	Aspen Ave. DBH (in)	Cottonwood Ave. DBH (in)	Willow Ave. Width (ft)
AC1w			6.5	TC1aExcl			
AC2w			5.4	TC1aNotExcl	2.5		
AC3w			3.0	TC1wExcl			
AC4c		2.3		TC1wNotExcl			3.0
AC4w			1.2	TC2w			
CC1c		6.6		TC3a	2.9		
GC1w		3.2		TC3w			
GC2c		20.8		TWC1w			2.0
HH1w			32.0	TWC2a	4.1		
LC1w			1.0	TWC2w			2.5
LNC3c		10.8		UM1w			5.2
LNC3w				UM2w			3.4
LNC4c		1.0		UM3w			3.3
LNC5c		17.0		[UM]LF1w			5.3
NWC1w			24.0	[UM]LF2w			4.4

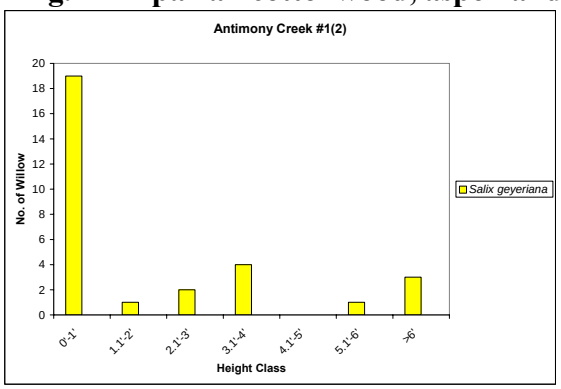
PC1cExcl		0.8		[UM]LF3a			
PC1cNotExcl		9.2		[UM]LF3w			
PC2c		6.5		[UM]LF4a	6.0		
SAC1a	3.0			[UM]LF4w			
SAC1c		4.0		[UM]RF1a	1.0		
SAC1w				[UM]RF1w			3.5
SC1a	3.2			[UM]RF2w			2.9
SC2w			2.4	[UM]RF3w			3.6
SC3c		16.5		WC1c		9.6	
SC4a	2.8			WC2c		18.4	
SCPatchc							

Fig. 10. Average DBH of cottonwood or aspen >6', or average width of willow >6' tall.

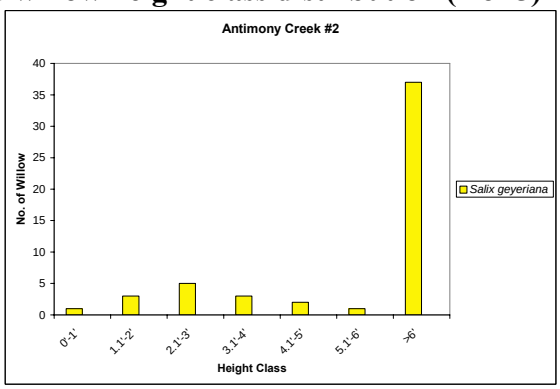
On the following five pages, the charts of Fig. 11 (A through AL) provide a visual picture of the height class distribution at specific riparian sites, arranged in the same alphabetical order as in Figs. 4-7 and 9-10 above. It is striking that despite the variety of conditions and species at the various sites, most of the riparian cottonwood, aspen and willow surveyed have a deficit of individuals making it into the 4'-6' class. This is the height class that then can achieve a height beyond which their tallest leaders and subleaders will not be browsed. That is, the main age classes in the stands are 0.1'-4' and/or >6', while the 4-6' age class is either completely absent or relatively low in number.

Notes following the five pages of charts provide some explanation for individual sites, which may vary from general trends. A detailed report for each site, with maps, site descriptions, photographs and additional data, are found in Appendix C.

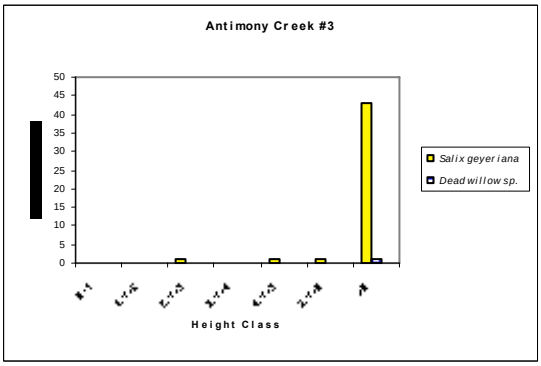
Fig. 11 Riparian cottonwood, aspen and willow height class distribution (1 of 5)



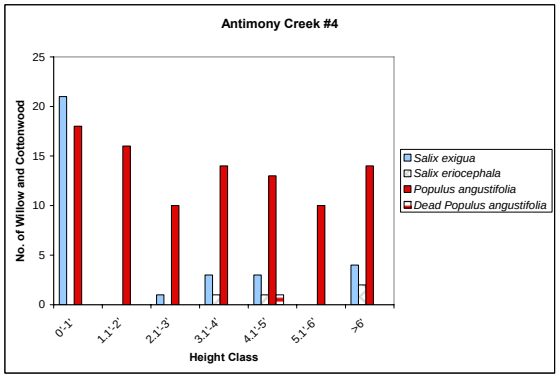
A - Antimony Creek #1



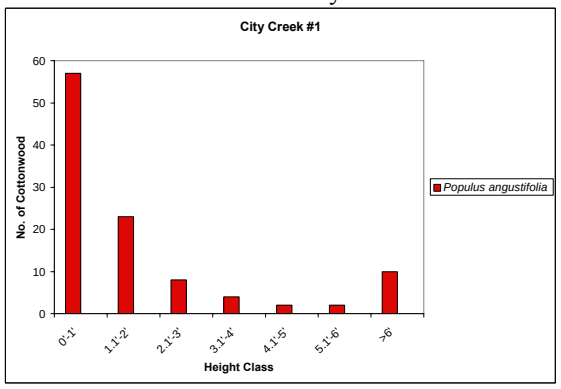
B - Antimony Creek #2



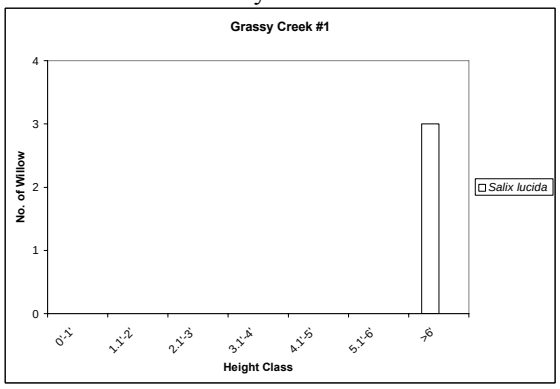
C – Antimony Creek #3



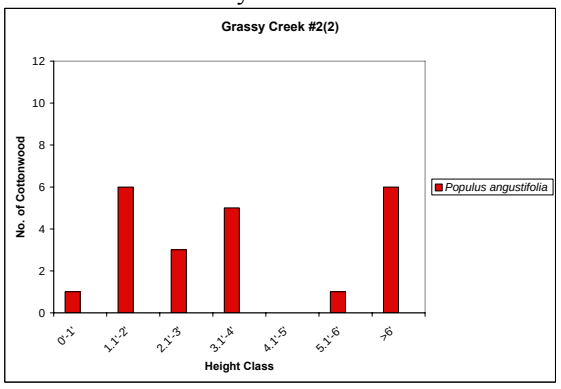
D – Antimony Creek #4



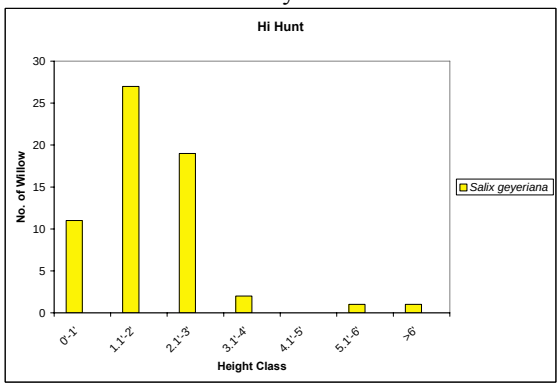
E – City Creek #1



F – Grassy Creek #1

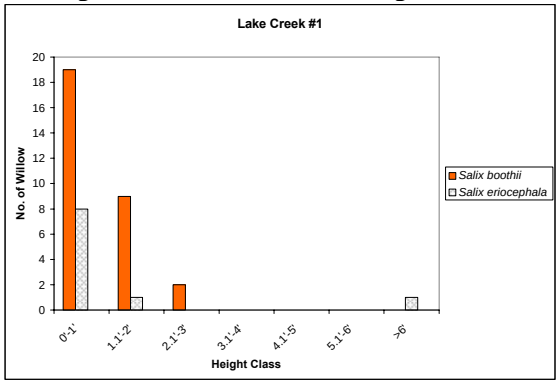


G – Grassy Creek #2

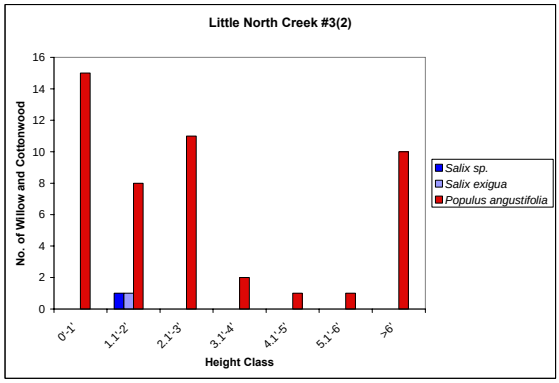


H – Hi Hunt Creek

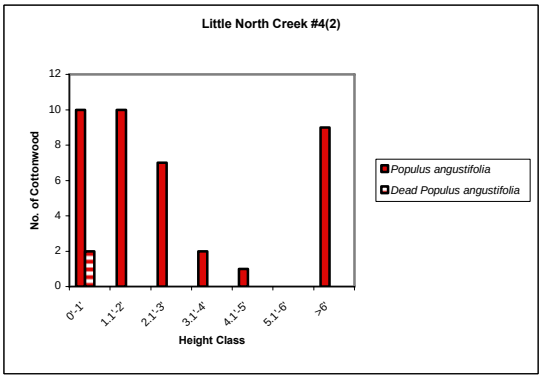
Riparian Cottonwood, Aspen and Willow Height Class Distribution (2 of 5)



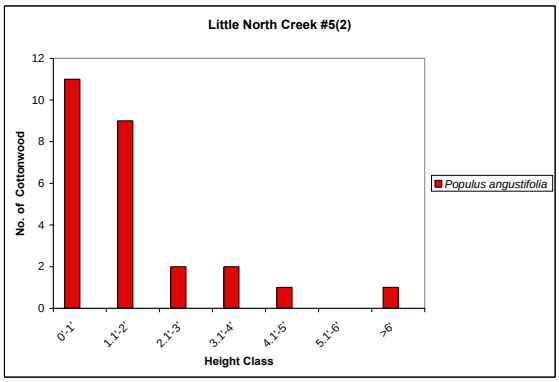
I – Lake Creek #1



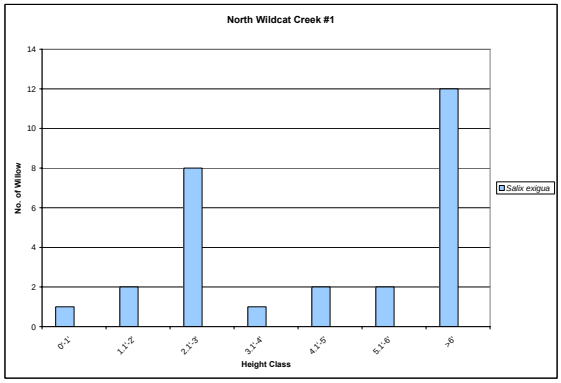
J – Little North Creek #3



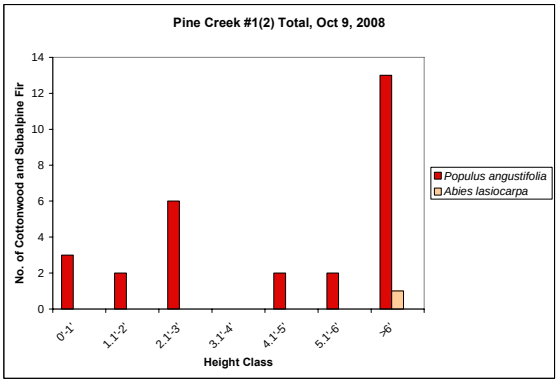
K – Little North Creek #4



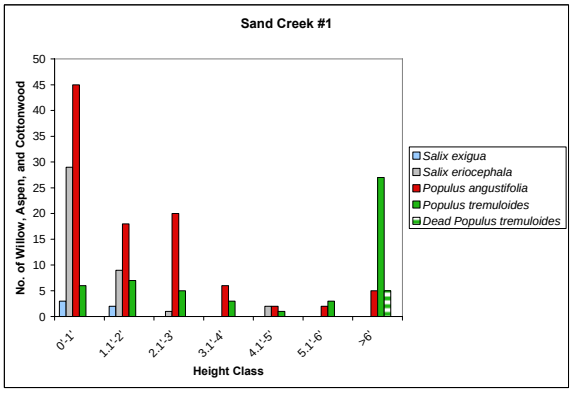
L – Little North Creek #5



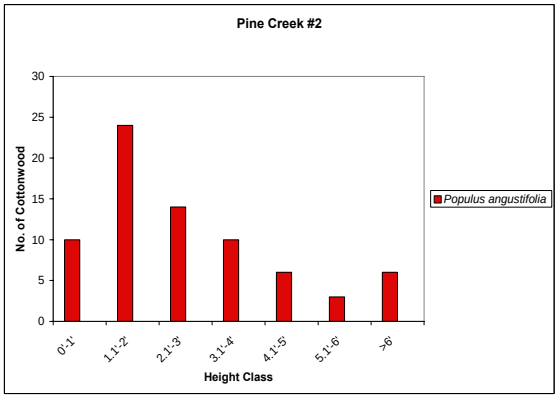
M – North Wildcat Creek #1



N – Pine Creek #1

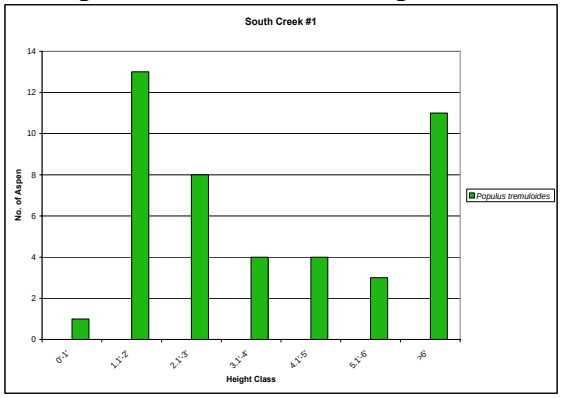


O – Pine Creek #2

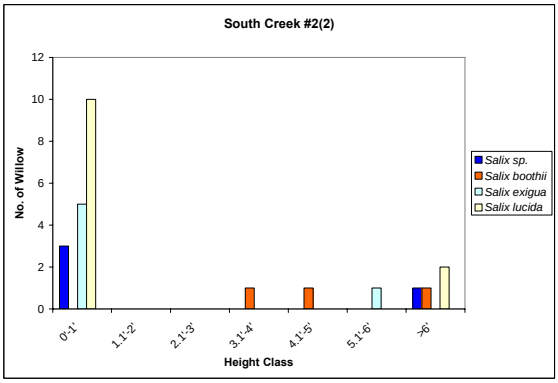


P – Sand Creek #1

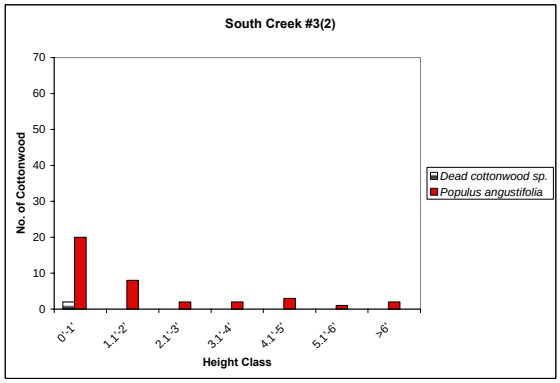
Riparian Cottonwood, Aspen and Willow Height Class Distribution (3 of 5)



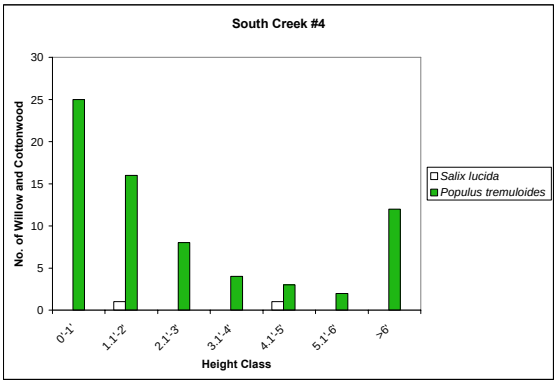
Q – South Creek #1



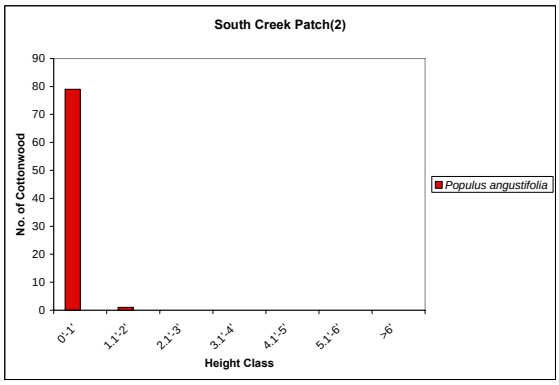
R – South Creek #2



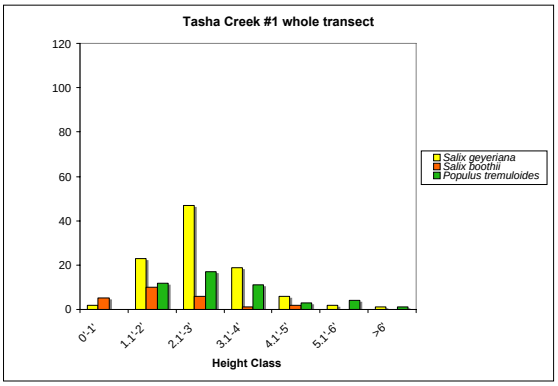
S – South Creek #3



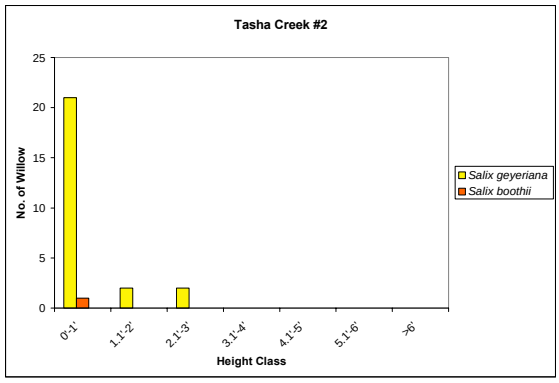
T – South Creek #4



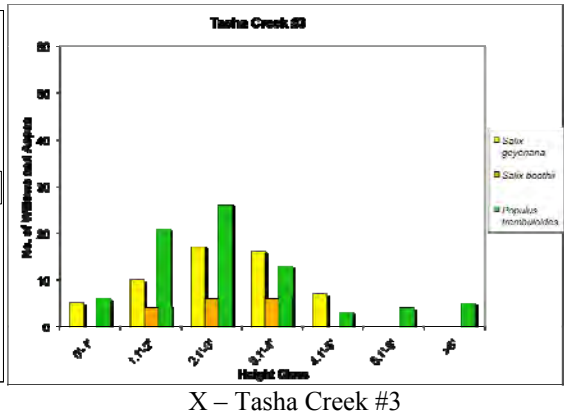
U – South Creek Patch



V – Tasha Creek #1

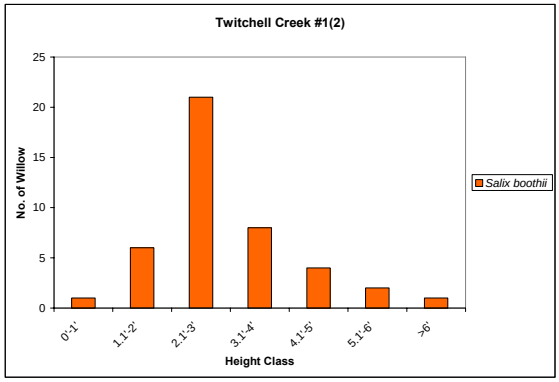


W – Tasha Creek #2

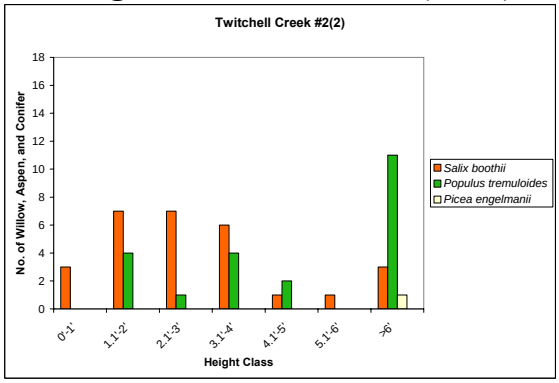


X – Tasha Creek #3

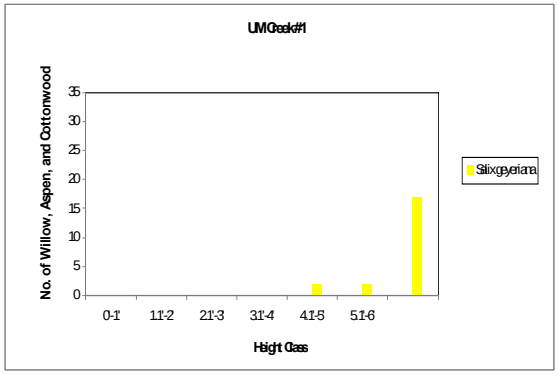
Riparian Cottonwood, Aspen and Willow Height Class Distribution (4 of 5)



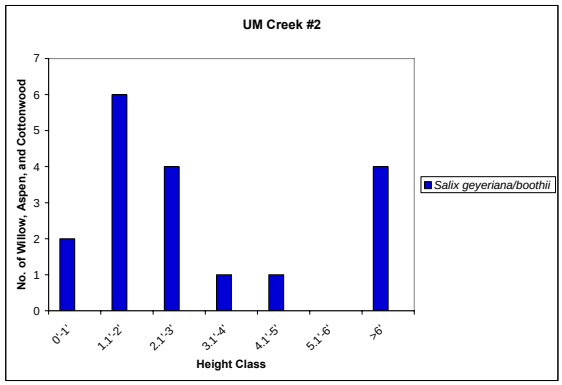
Y – Twitchell Creek #1



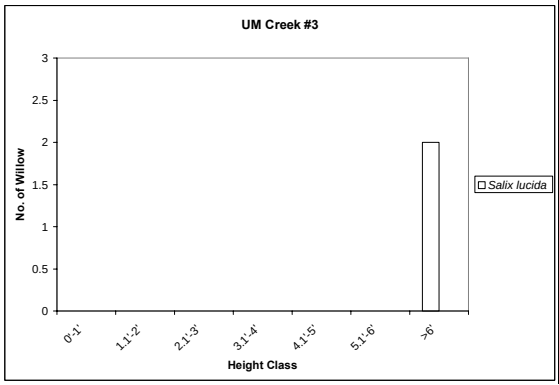
Z – Twitchell Creek #2



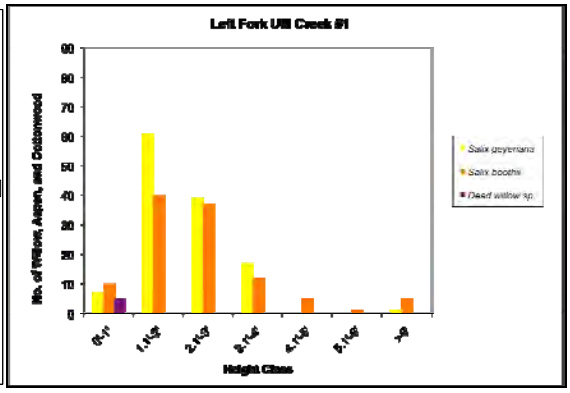
AA – UM Creek #1



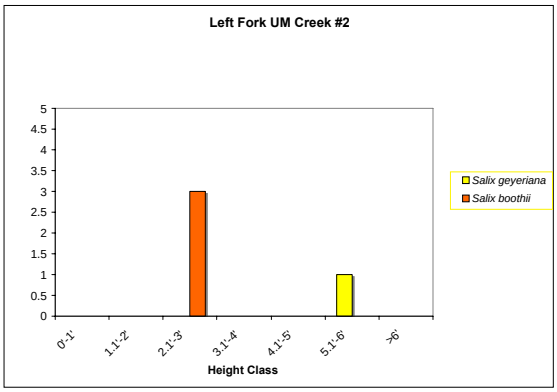
AB – UM Creek #2



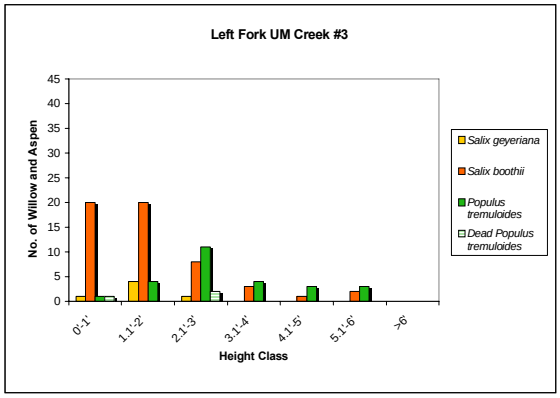
AC – UM Creek #3



AD – Left Fork UM Creek #1

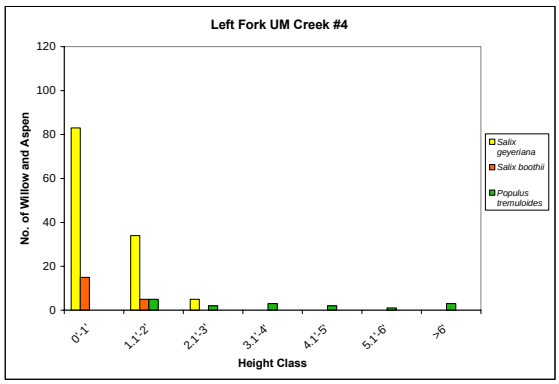


AE – Left Fork UM Creek #2

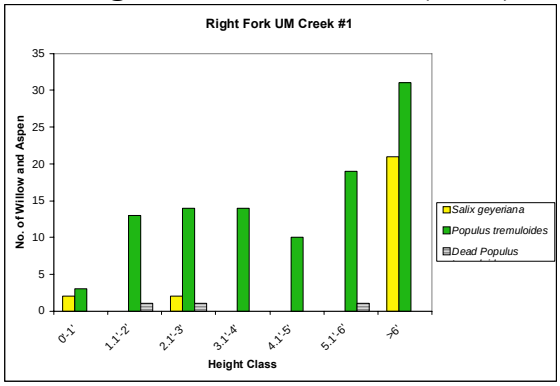


AF – Left Fork UM Creek #3

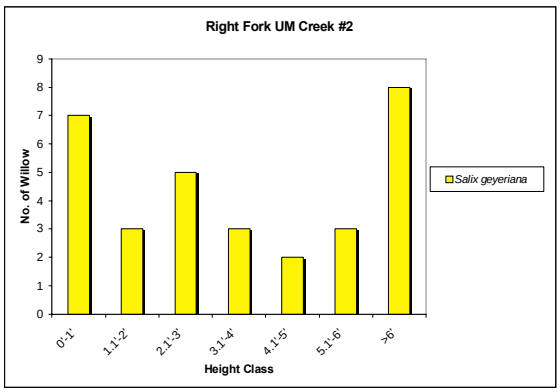
Riparian Cottonwood, Aspen and Willow Height Class Distribution (5 of 5)



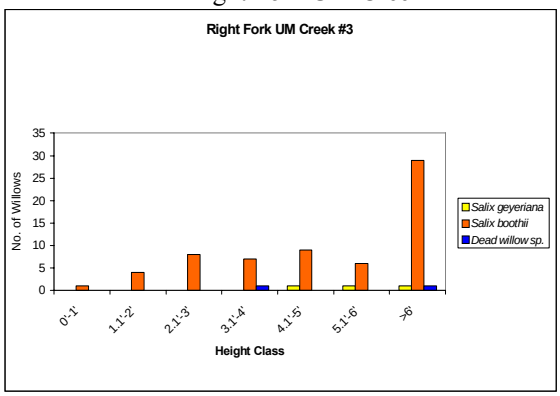
AG – Left Fork UM Creek #4



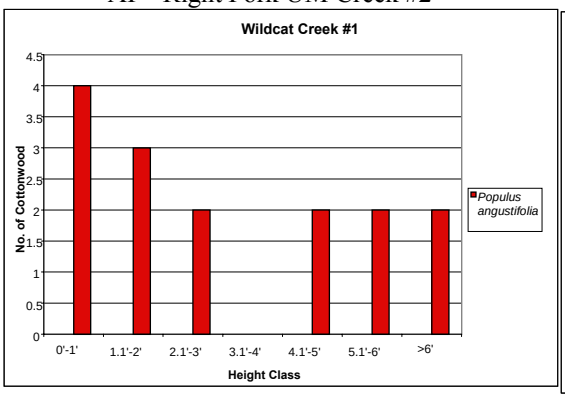
AH – Right Fork UM Creek #1



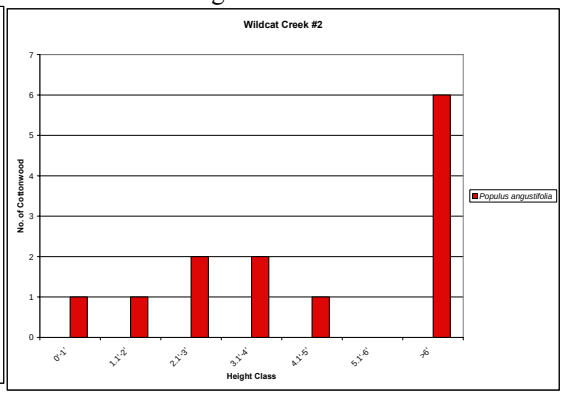
AI – Right Fork UM Creek #2



AJ – Right Fork UM Creek #3



AK – Wildcat Creek #1



AL – Wildcat Creek #2

General Notes:

Most charts show a similar pattern of the missing 4.1'-6' height class. The trends spans communities of different sizes (e.g., W includes 158 willow and aspen, while AG only has 2 cottonwood); as well as different vegetation types (e.g., AF consists of cottonwood, while AD is willow, and U is a combination of willow and aspen). Exceptions to this trend are discussed below.

D: In Antimony Creek #4 the height class distribution is evenly distributed for both the willow and cottonwood community. The site is surrounded by cliffs and is downstream of a narrow gorge that is relatively inaccessible to cattle and no recent ungulate sign was noted in the area.

Y: Twitchell Creek #1 shows more willows in the 4'-6' height class than in any other height class. This site is located on a point bar inside an incised stream that has recently been re-colonized by willows.

AH: Right Fork UM Creek #1 shows an even distribution of aspen, but the 4'-6' height class is missing in the willow community. The site is located in a narrow floodplain with an adjacent hill. An upland aspen stand is present on top of the hill and its regeneration/recruitment apron covers the hillside and part of the floodplain. The riparian transects reached part of the way up the slope, but didn't fully characterize the structure of the aspen stand. Many of the aspen >6' tall in this apron had a DBH of <1', which is small compared to the observed larger diameter trees throughout the rest of the stand.

For explanations of additional results that differ from the general trends, see the individual site reports in Appendix C.

VII. Results of Upland Aspen Browse and Recruitment Assessment

Figs. 12-15 present data on browsing intensity of leaders and subleaders of upland aspen. As with Figs. 4-7 for riparian cottonwood, aspen, and willow, the horizontal line at 40% browsed is simply a marker in relation to the Fishlake National Forest standard for browse of "riparian/upland browse sprouts and young-aged plants", i.e., ≤40%, based on "# of current year's available twigs removed"[5]. The Dixie National Forest browse utilization allows "50% use of total annual leaders available to livestock"[6] both in riparian and upland sites.

[5] Cited in Beaver Ranger District 2008 Annual Operating Instructions. The allowable browse of "riparian/upland mature browse" is ≤50%. It is not clear what is considered a "mature" plant and a "young" plant.
[6] Cited in Bowery Allotment 2008 Annual Operating Instructions.

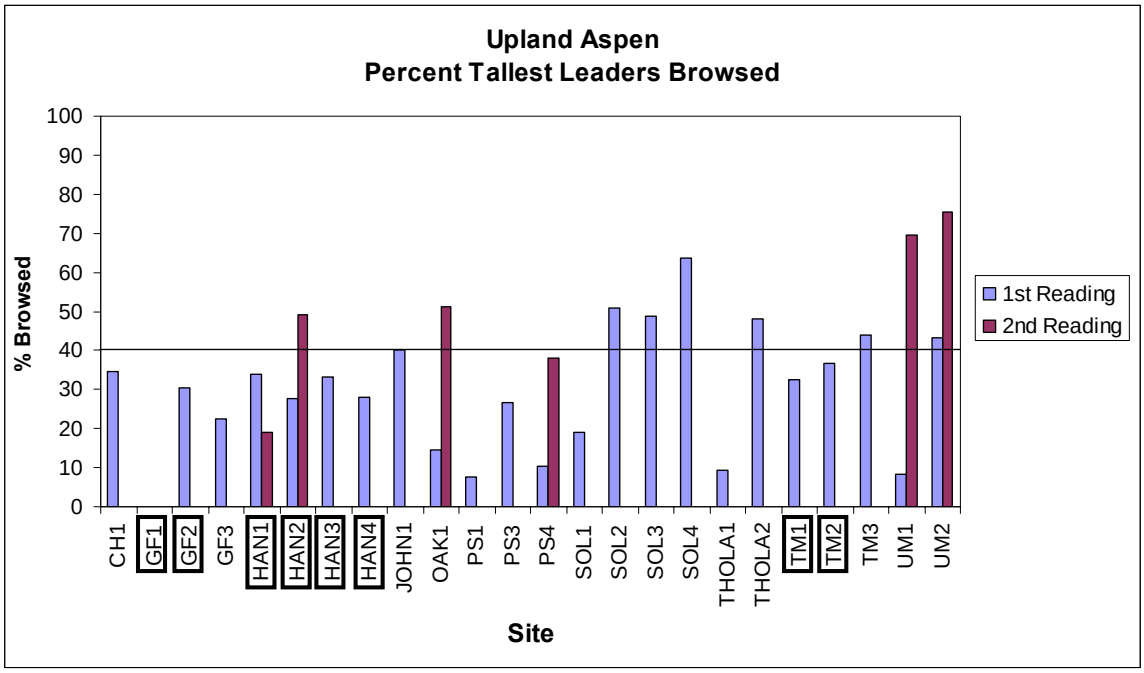


Fig. 12. Percent tallest leaders browsed on upland aspen ≤6' tall. ▭ = sites with little or no cattle presence

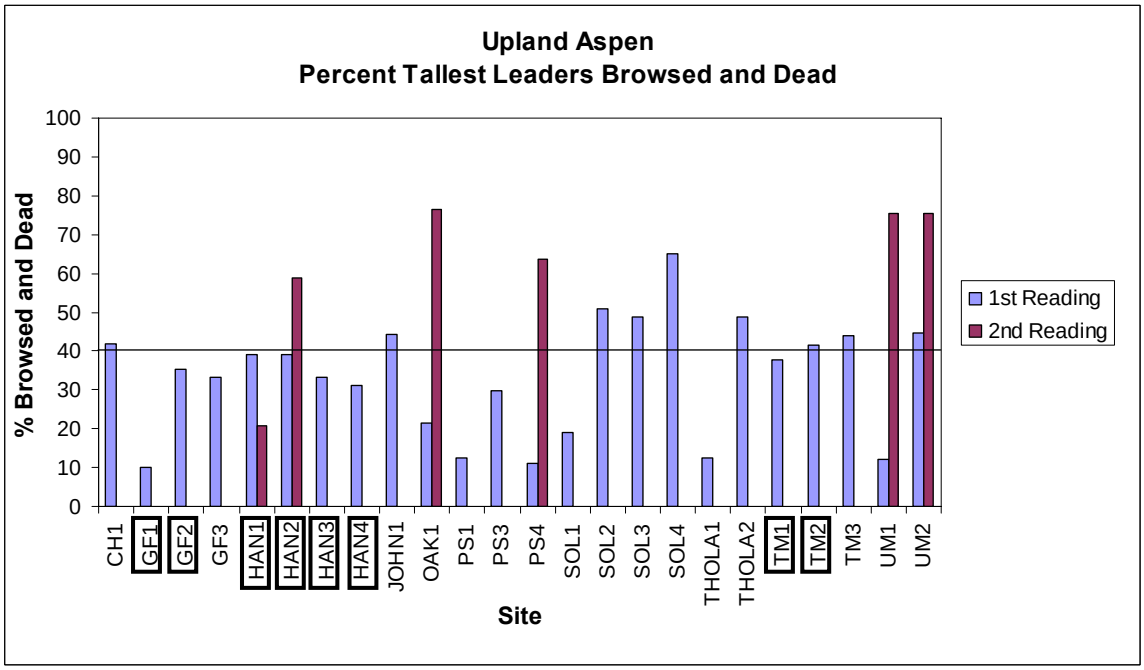


Fig. 13. Percent tallest leaders browsed and dead on upland aspen ≤6' tall. ▭ = sites with little or no cattle presence

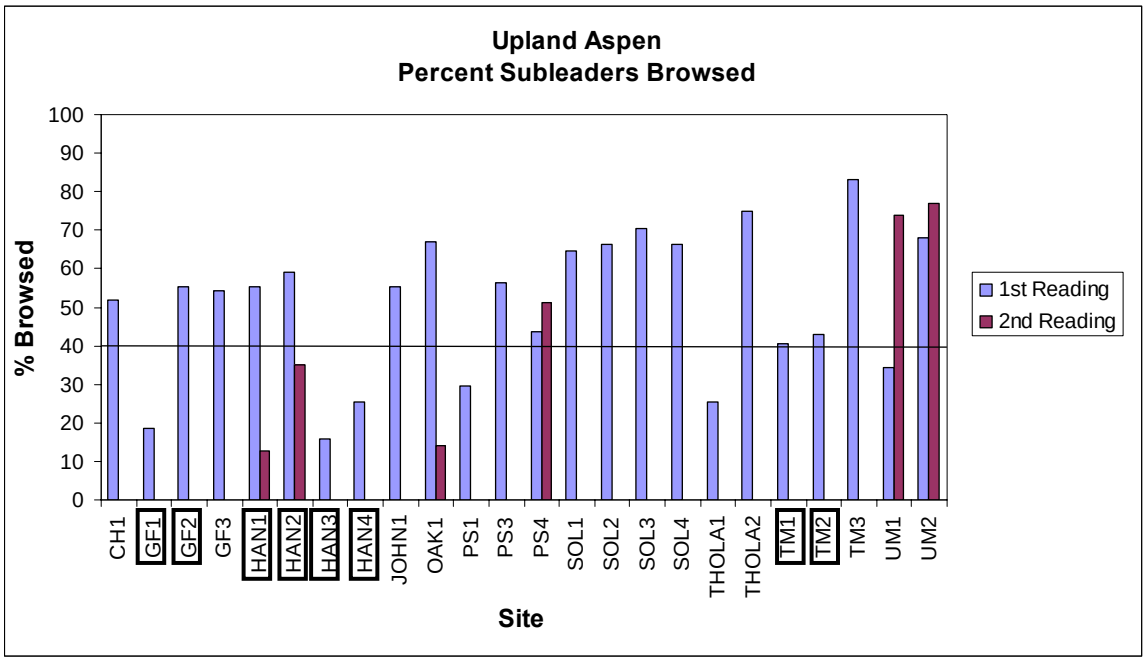


Fig. 14. Percent subleaders browsed on upland aspen ≤6' tall. . ▭ = sites with little or no cattle presence

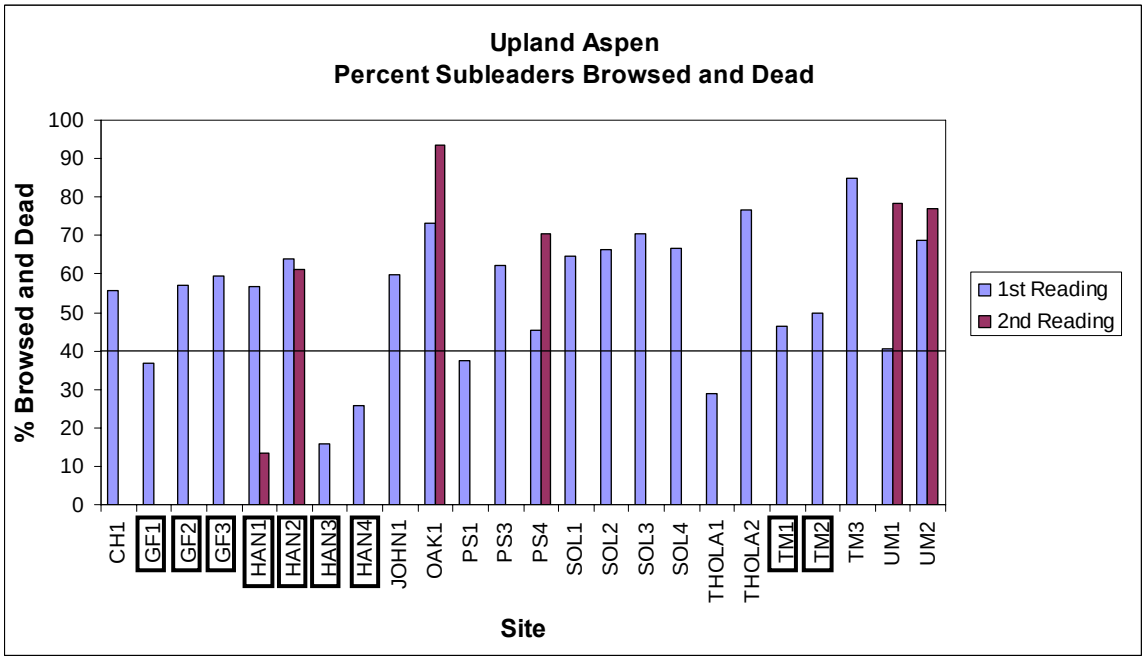


Fig. 15. Percent subleaders browsed and dead on upland aspen ≤6' tall. ▭ = sites with little or no cattle presence

Grindstone Flat #1 (GF1) is located inside an elk exclosure, thus experiencing no browse (Fig. 12).

Hancock #1 (HAN 1) has less browsing on the second reading due to its location in a sheep allotment, where few unauthorized cattle browsed in 2008. Thus the initial reading will reflect elk browsing prior to the 2008 livestock season, plus browsing from the previous (2007) livestock season. The second reading reflects the growth of unbrowsed leaders, one of which may have become a new "tallest" leader (Fig. 12-15).

Pine Creek / Sulphurbeds #1 (PS1) is located high on a steep slope, little used by cattle (Fig. 12-15).

Thousand Lakes #1 (THOLA1) with little browsing, is a stand with dense underbrush and downed logs, and is located on a steep rocky slope. Therefore it is not readily accessible to cattle (Fig. 12-15).

Fig. 16 shows that across all aspen stands, 16 percent of all aspen are within the 4.1'-6' height class, while 52% are in the two height classes (0'-2' and 2.1'-4') most vulnerable to browsing. Thirty-three percent are above 6'.

Overall Percent Aspen Present in Each Height Class and Ave. DBH						
	0' - 2'	**2.1' - 4'**	**4.1' - 6'**	**>6'**	**Ave. DBH 0"-3"**	**Ave. DBH ≥3.1 "**
Aspen	25.7%	25.5%	15.6%	33.2%	1.4" (984)	6.4" (389)

Fig. 16. Overall percent of aspen individuals in each height class ≤6', and ave. DBH of aspen >6' (# of individuals in parentheses)

Fig.17 shows the height class distribution within these same aspen stands, as well as the average DBH of trees >6'. The black portion of the bar represents the percent of the aspen in the transect of each stand which were in the height class of 4.1'-6'. This height class is generally quite small in relation to the regeneration height classes (i.e., 0.1'-2'; 2.1'-4'), which are particularly vulnerable to excessive browsing.

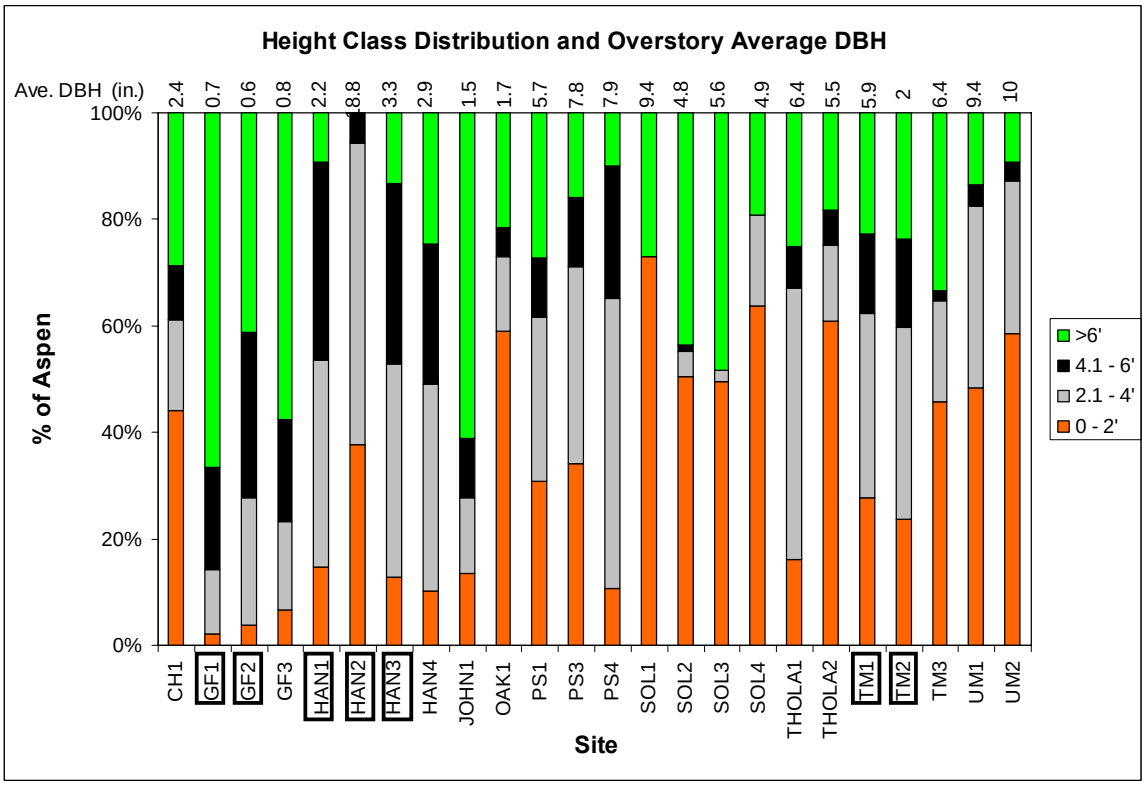
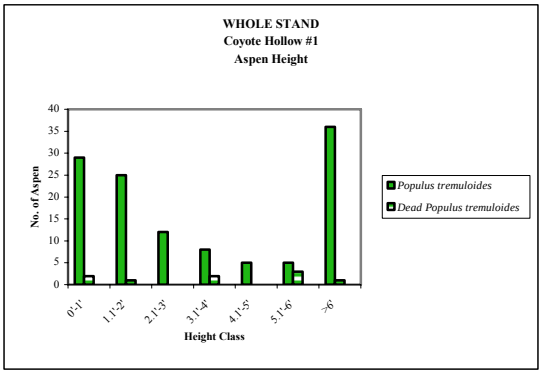


Fig. 17. Height class distribution of aspen and average DBH of aspen >6'. . ▭ = sites with little or no cattle presence

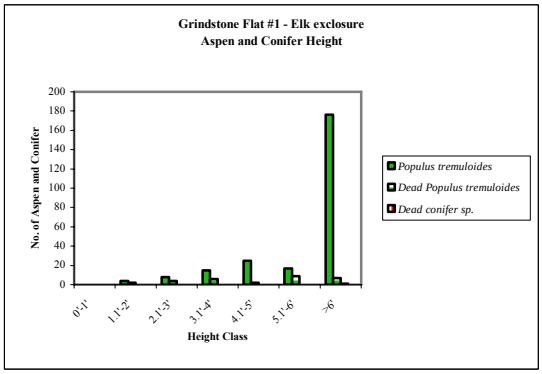
Grindstone Flat #1-2 (GF1, GF2) have a relatively large 4.1 -6' height class. They are in elk and livestock exclosures, respectively.

Hancock #1, #3, and #4 (HAN1, HAN3, HAN4) have a more evenly-distributed height class than most others. They are all located in a sheep allotment that receives only some unauthorized cattle use, and are therefore subject to less browsing pressure. The 4.1'-6' height class in **Hancock #2** (HAN 2), however, is deficient.

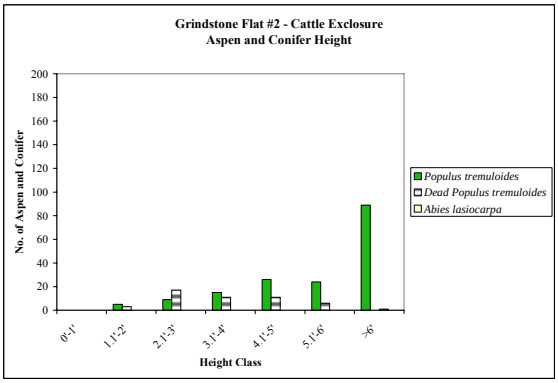
Fig. 18. Upland aspen height class distribution (1 of 3)



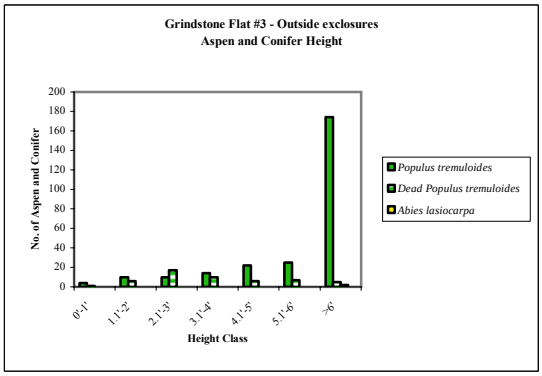
A – Coyote Hollow #1



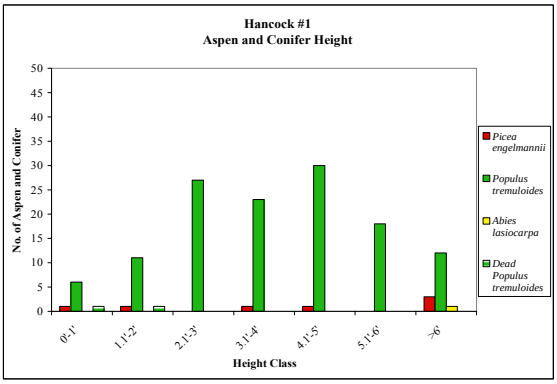
B – Grindstone Flat - #1



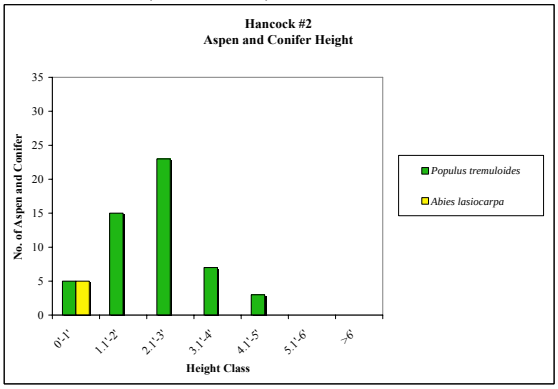
C – (Circleville) Grindstone Flat #2



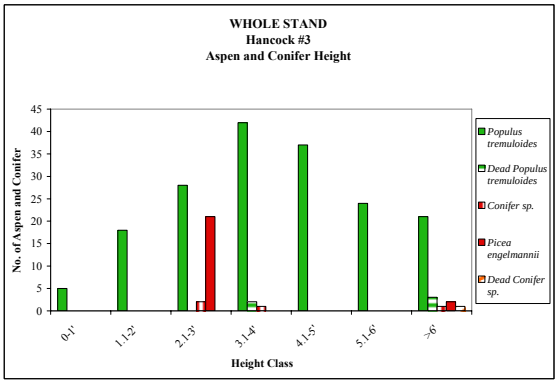
D – (Circleville) Grindstone Flat #3



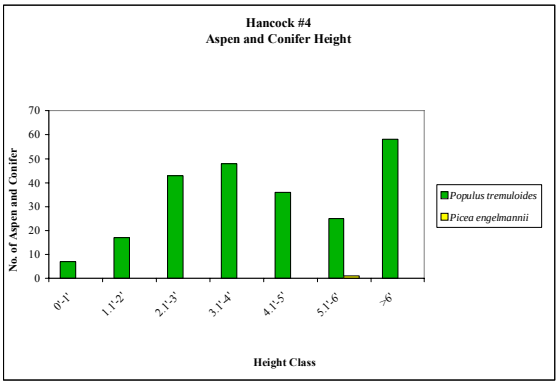
E – Hancock #1



F – Hancock #2

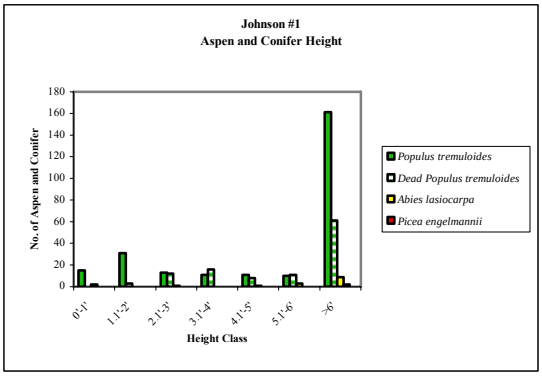


G – Hancock #3

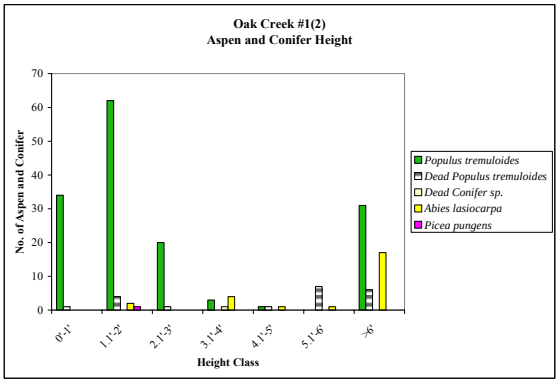


H – Hancock #4

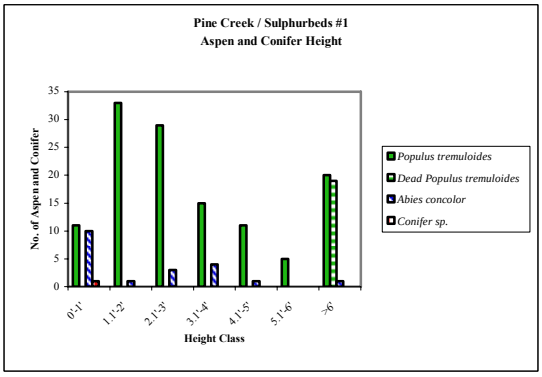
Upland Aspen height class distribution (2 of 3)



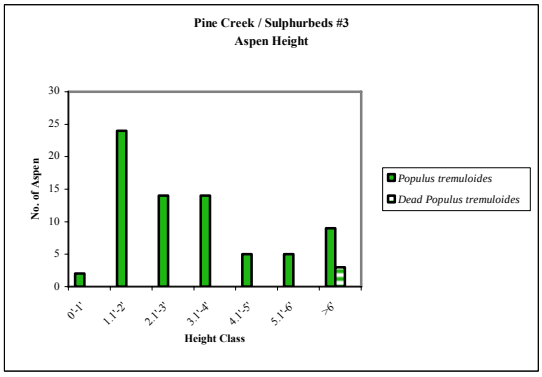
I – Johnson #1



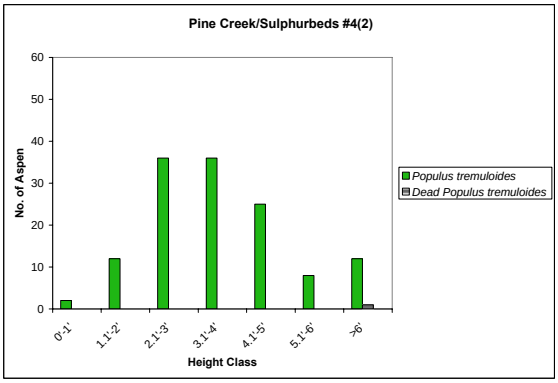
J – Oak Creek #1



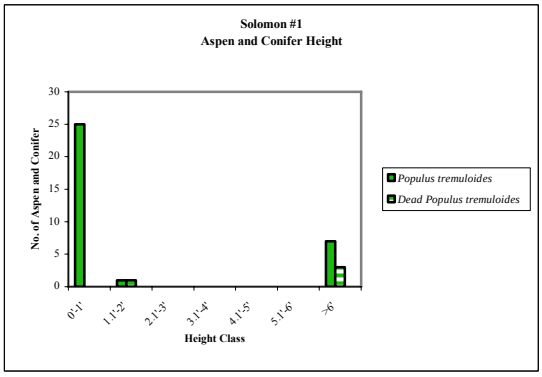
K – Pine Creek / Sulphurbeds #1



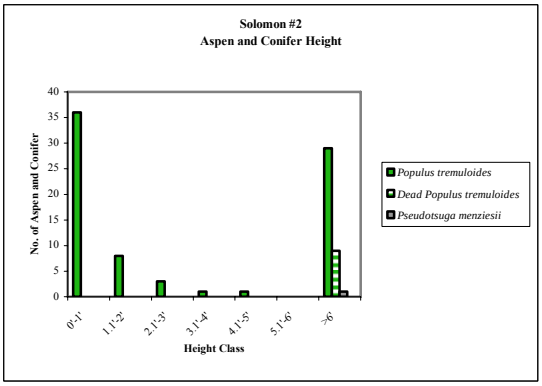
L – Pine Creek / Sulphurbeds #3



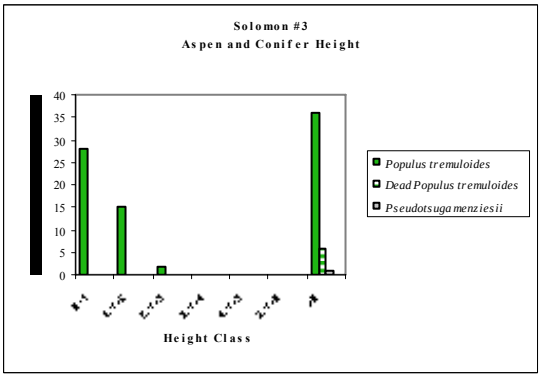
M – Pine Creek / Sulphurbeds #4



N – Solomon #1

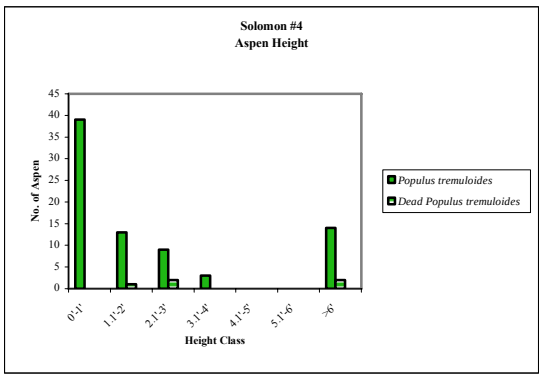


O – Solomon #2

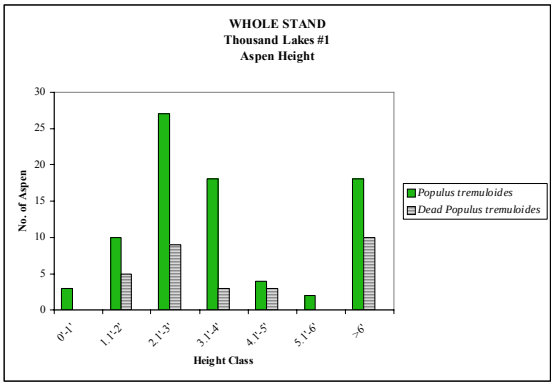


P – Solomon #3

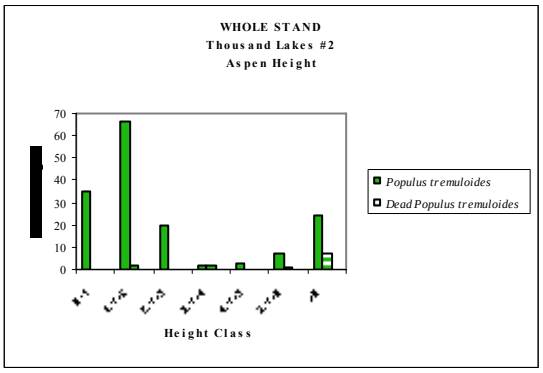
Upland aspen height class distribution (3 of 3)



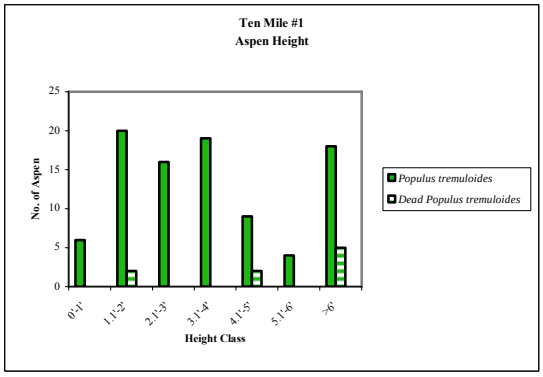
Q – Solomon #4



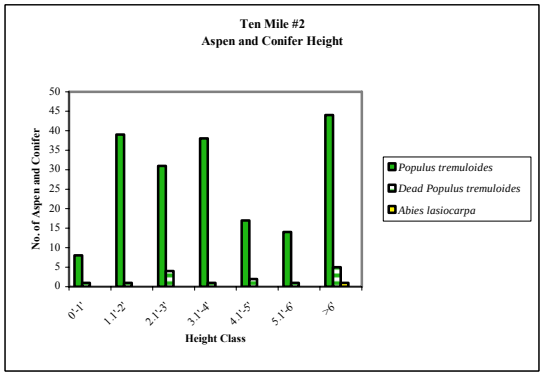
R – Thousand Lakes #1



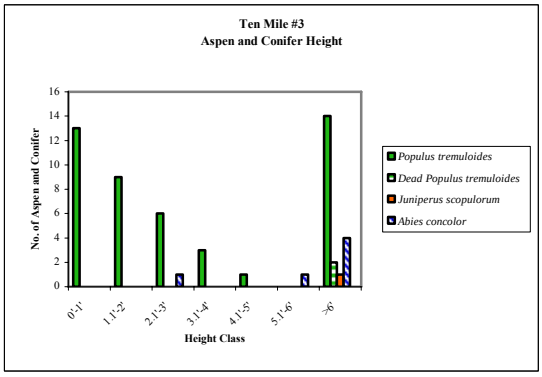
S – Thousand Lakes #2



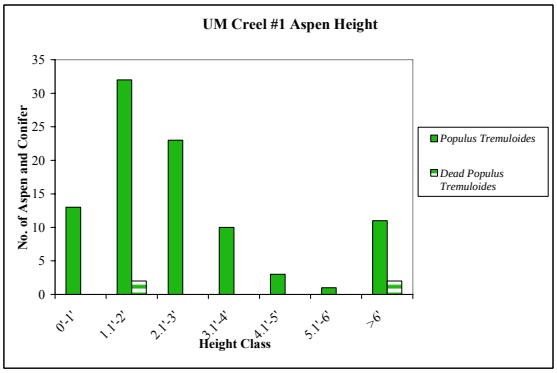
T – Ten Mile #1



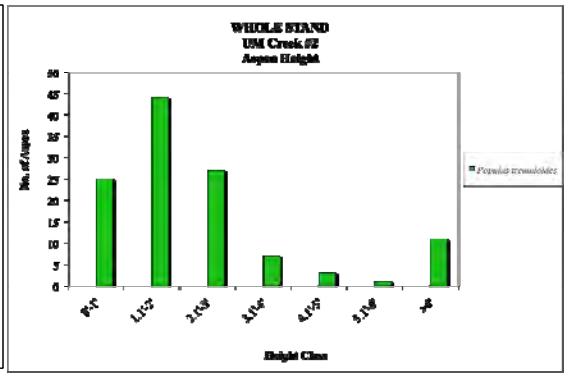
U – Ten Mile # 2



V – Ten Mile #3



W – UM Creek #1



X – UM Creek #2

General Notes:

Despite the variety of sites in Fig. 18, most of the upland aspen surveyed have similar deficits in the 4.1'-6' height class. The main age classes in the stands are 0.1'-4' and/or >6', while the 4-6' age class is either completely absent or relatively low in number. The trend spans different sizes of stands (e.g. K containing 37 aspen and B containing 275 aspen). Exceptions to the pattern are discussed below.

E,G,H: Show less of a deficit in the 4.1'-6' height class. These sites are in a sheep allotment, in which unauthorized cattle use is present, but not heavy. The fourth of these sheep allotment sites, F, Hancock #2 (HAN2), has been browsed more heavily, and cattle sign is present at the site.

For explanations of additional results that differ from the general trends, see the individual site reports in Appendix D.

VI. Discussion of Browse and Recruitment Assessment

Across the 64 sites of cottonwood, aspen, and the various species of tall willow assessed in this study, (and with the exception of exclosures and one sheep allotment) there is a striking lack of individuals recruiting into the overstory, to eventually replace large, old individuals as they die. This is accompanied by high percentages of leaders and subleaders being browsed, with the percentages browsed generally above 50% and often 70% or higher, particularly by the end of the season.

Nearly all sites examined in these assessments are grazed by cattle; only one set of transects (Hancock Allotment, along and near Tasha Creek) is a sheep allotment, and sheep presence is not heavy in the Tasha Creek portion of the allotment.

VII. Recommendations for browsing management of cottonwood, aspen, and willow

The most important management consideration is to actually restore and maintain adequate recruitment of cottonwood, aspen, and willow. Management changes should be (a) based on a track record of such changes providing for restoration and ongoing recruitment of cottonwood, aspen, and willow; (b) monitored for their effectiveness and altered accordingly.

We do not believe that lack of cottonwood, aspen, and willow recruitment can be remedied within grazing systems that allow for annual grazing/browsing of riparian areas and upland aspen at the current numbers of livestock. If there is evidence, on a general basis, to the contrary, we are interested in learning of it.

We also do not believe that "browsing utilization standards" in the tradition of graminoid utilization standards (e.g., percent utilization) will be effective or feasible, in particular because of the presence of excessive browsing by wild ungulates in addition to livestock browsing. Instead, we estimate that multi-year periods of rest will be an essential response to willow family recruitment deficits.

We have examined the monitoring protocol for riparian woody species regeneration and use in the 2007 version of the riparian indicators manual being recommended by Region 4 for use by the national forests in Utah, i.e., pp. 23-27 in *Monitoring Stream Channels and Riparian Vegetation - Multiple Indicators* (Burton, et al. 2007). The monitoring protocol captures neither the biologically-relevant leader/subleader browse condition, nor height-class structure of cottonwood, aspen, and willow in riparian woody communities. For instance, to characterize riparian woody species regeneration, a cottonwood stem <4.5' tall is placed in the "Seedling" age class, as is a 3' tall aspen, and yet many cottonwood and aspen plants of multiple years of age are browsed back below 3'-4.5'. They are definitely not seedlings. Further, the method is a greenline method, extending only 3 feet into the floodplain, thus ignoring browse or recruitment deficits in much of most riparian areas.[7]

Fig. 19 presents our recommendations for management of browse for restoration and maintenance of cottonwood, aspen, and willow recruitment.

[7] We have conveyed our thoughts to the MIM revision committee via Rick Hopson, Region 4 Hydrologist on this matter in 2008. Communications available on request to Mary O'Brien.

Recommendations for Restoration and Ongoing Maintenance of Cottonwood, Aspen, and Willow Recruitment

1. **Convene a 1-year, multi-stakeholder working group on management for cottonwood, aspen, and willow recruitment** to examine the scientific evidence for management that provides for restoration and maintenance of ongoing recruitment of the willow family (cottonwood, aspen, and willow).
2. **Provide for cottonwood, aspen, and willow rest from livestock browsing.**
    a. Prioritize particular creeks, streams, pastures, or watersheds exhibiting severe lack of cottonwood, aspen, and/or willow recruitment for 2-4 years of rest in order to achieve recruitment. Establish key transects to document wild ungulate browse during livestock rest.
    b. Place pastures, particular creeks, and/or watersheds that have exhibited cottonwood, aspen, and/or willow recruitment deficits on a once-every-three years grazing rotation, in order to provide, on a continuing basis, for recruitment of cottonwood, aspen, willow
3. **Measure browse on leaders and subleaders.** Utilize a browsing protocol that focuses on leaders and subleaders.
4. **Measure the distribution of height classes in CAW and upland aspen communities.** Utilize a browsing protocol that records height classes in the cottonwood, aspen, and/or willow communities. Avoid referring to these height classes as age classes, e.g., individuals shorter than 2' may not be young.
5. **Establish standards based on (a) height class distribution and (b) browse of leaders and subleaders.**
6. **Establish browse standards of leaders and subleaders on the basis of scientific evidence** that the standard will allow for (a) recruitment; and, in the case of willows, (b) catkins and seed production.
7. **Establish height class requirements for grazing of pastures.** Where recruitment is failing, do not permit the grazing of livestock. Even if some of the browsing is due to elk, the cumulative impact of livestock browsing must be considered.
8. **Require documentation of understory condition in upland aspen clones.** Develop a simple protocol that records dominant plant species (distinguishing between native and non-native species), reproductive condition (e.g., are seedheads present?) and other condition of understory forbs, grasses, and shrubs; as well as estimations of bare ground.
9. **Assess the correlation of 4" riparian graminoid stubble height with browsing intensity on riparian woody species at particular seasons.** Determine whether browse standards are exceeded before 4" stubble height is reached.
10. **Respond to quality evidence by independent observers re: browse and height class conditions.** Collaboration will be required to regain and maintain recruitment of cottonwood, aspen, and willow on these national public lands.

Fig. 19. Recommendation for restoration and ongoing maintenance of cottonwood, aspen and willow recruitment.

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Appendix A

Photos: Examples of Repeated Observations within Riparian Cottonwood, Aspen, and Willow Areas

(See III.1. Repeated Observations within Riparian Cottonwood, Aspen and Willow Areas in *CAW At Risk* Report)

a. Few large, old willows surrounded by Kentucky bluegrass and no willow recruitment

b. Large, old cottonwood, with little or no cottonwood recruitment.

c. Cottonwood root sprouts heavily browsed

d. Old cottonwood browsed to inches.

e. Willow on creek banks browsed to inches.

f. Restriction of cottonwood or willow to inaccessible, steep banks

g. Widening, incising of creeks among heavily-browsed willow

h. Striking fenceline contrasts along riparian exclosure

i. Entire patches of cottonwood browse

j. willow on floodplain browsed to inches (yellow tab is 4” tall)

Appendix B

Photos: Examples of Repeated Observations within Upland Aspen Stands

(See III.2. Repeated Observations within Upland Aspen in *CAW At Risk* Report)

a. Pure aspen stands lacking recruitment

b. Single-tier aspen stands

c. Excessive browsing of aspen within conifer-encroached stand

d. Aspen stands lacking structural layering or vegetative diversity (FLNF)

e. Aspen stands experiencing recruitment only where old aspen topple, creating jack-strawed logs protecting ramets

f. Water development within or near aspen stands

g. Browsed aspen next to unbrowsed conifer, facilitating conifer encroachment.

h. Heavily-browsed aspen near conifer-aspen stand slated for treatment.

i. Aspen understory heavily grazed