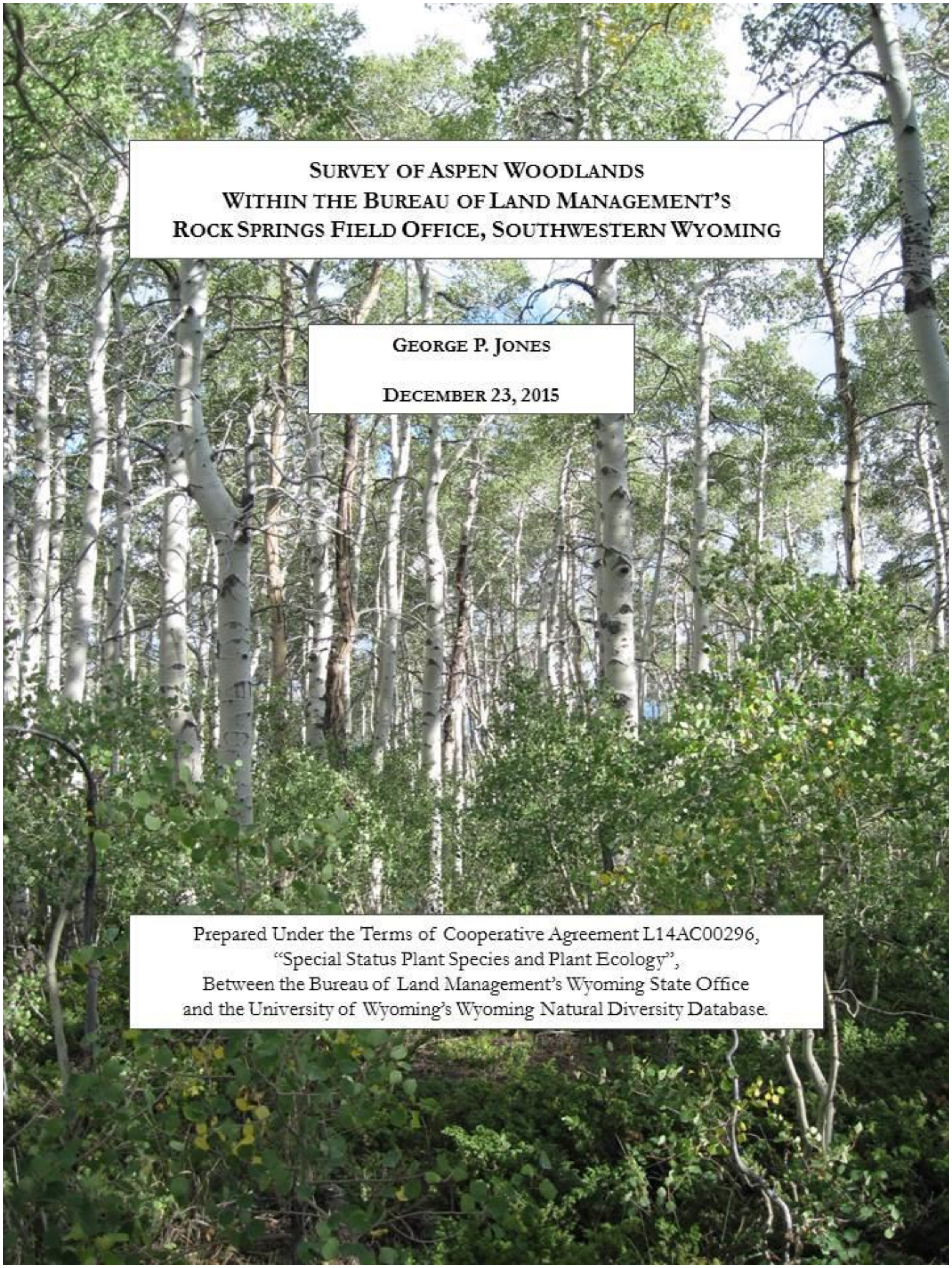

SURVEY OF ASPEN WOODLANDS WITHIN THE BUREAU OF LAND MANAGEMENT'S ROCK SPRINGS FIELD OFFICE, SOUTHWESTERN WYOMING

GEORGE P. JONES

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"Special Status Plant Species and Plant Ecology",
Between the Bureau of Land Management's Wyoming State Office
and the University of Wyoming's Wyoming Natural Diversity Database.

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ABSTRACT

Aspen woodlands are scattered across the lower-elevation parts of the Green River Basin of southwestern Wyoming and on the foothills of the surrounding mountains. Information gathered at 113 locations, and quantitative data from aspen stands at 66 of those locations, provide a general picture of the environments and vegetation of those stands. At the lower elevations, most stands are small (covering < 1 hectare, or 2.47 acres) and occur predominantly on slopes facing in northerly or easterly directions. On the foothills, stands commonly are larger and aspect has little influence on their distribution. Throughout the area, aspen stands appear to occur primarily on the upper parts of slopes.

Quaking aspen is far and away the most common species in the tree overstory, and in most stands is the only tree present. Stands with additional tree species (primarily limber pine, *Pinus flexilis*) are found mostly at higher elevations on the margins of the basin. Small aspens predominate: in many stands, trees < 4.5 feet tall are the most common aspens, and trees 1 - 4" dbh are the second-most common trees. As size increases, the numbers of trees decreases. Aspens > 8" dbh are present in stands scattered throughout the area, but trunks this large are rare.

In most stands, at least half of the aspen trees are alive, and stands with a low percentage of live aspens are rare. The proportion of live trees is greatest among the smallest trees and declines with increasing tree size. The smallest trees are the most vigorous, with over half of the smallest trees having at least 50% live canopy. Vigor generally declines with increasing tree size (percent of live canopy drops to < 50% among the larger size-classes), except in the largest trees: aspens > 8" dbh have more vigorous canopies than trees in slightly smaller size-classes. Canopy vigor appears to be unrelated to slope aspect or to elevation.

Aspen density varies enormously from stand to stand, with density determined mainly by how many aspen sprouts (trees < 4.5 feet tall) are present. In stands with abundant sprouts, densities exceed 91,000 stems/hectare (36,800 stems/acre). In the majority of stands, density is < 14,000 stems/hectare (approx. 5,700 stems/acre). Aspen density, like canopy vigor, appears to be unrelated to slope aspect or to elevation.

Few of the stands in the central part of the basin, at relatively low elevations, appear to have sufficient densities of small aspens (trees < 1" dbh) for successful stand regeneration. It appears likely that these stands will disappear, especially in the absence of management practices aimed at increasing aspen reproduction. In contrast, a high proportion of the stands near the surrounding mountains appear to have sufficient densities. Very few stands lack small aspens altogether. Browsing pressure on the small aspens is variable, but more stands have a greater proportion of small aspens showing signs of light browsing than signs of heavy browsing.

An examination of the fallen logs in aspen stands suggests that there has been no substantial change across the area in the proportion of aspens among the overstory trees: aspens have dominated the tree layers for many years. Whether the size of aspens has changed in recent years is difficult to say. If one assumes that fallen aspens of different sizes decay at the same rate, then it appears that average size of aspens has declined substantially in recent years (apparently due to a flush of sprouts in many stands). But if small stems have decayed faster than large stems, the decline in tree size has been much more modest.

In most aspen stands, the undergrowth consists of a shrub layer and a herbaceous stratum of graminoids and forbs. Shrubs generally contribute more canopy cover than do the herbaceous plants. The most widespread shrubs are *Symphoricarpos oreophilus* var. *utahensis* (Utah snowberry), *Artemisia tridentata* (big sagebrush), *Juniperus communis* (common juniper), and *Rosa* sp. (rose). Graminoids found in many stands are *Carex rossii* (Ross's sedge) and *Achnatherum* sp. (needlegrass). Forb species appear to be less widespread than graminoids and they contribute less canopy cover than do graminoids. The most common forbs are *Galium* sp. (bedstraw) and *Lupinus* spp. (lupine). Two species of dwarf-shrub, *Arctostaphylos uva-ursi* (kinnickick) and *Mahonia repens* (Oregon grape) occur in the aspen patches but are relatively uncommon.

ACKNOWLEDGEMENTS

Jim Glennon, botanist in the BLM's Rock Springs Field Office, provided a great deal of assistance in all aspects of the entire project. The late John Henderson, fisheries biologist in the Rock Springs office, provided information and advice during the 2008 field season. Valuable information about the aspen woodlands in southwestern Wyoming, and advice on sampling methods, were given by Kevin Spence of the Wyoming Game and Fish Department, and by Patrick Anderson and Tim Assal of the US Geological Survey. Paul Burke was an industrious and cheerful field assistant during the 2012 season. Mark Anderson, spatial ecologist at the Natural Diversity Database, answered many questions about GIS. The contributions of all these people helped to improve this project.

INTRODUCTION

Aspen woodlands[1] provide the only upland deciduous forest habitat in the basins and foothills of southwestern Wyoming (Merrill *et al.* 1996). Values of these woodlands are well recognized (Bowen *et al.* 2009), but the information in the extensive literature on aspen in the western U.S. (see, for example, Barnett and Stohlgren 2001, DeByle and Winokur 1985, Mueggler 1988, Shepherd *et al.* 2000) may be of limited use in characterizing these low-elevation aspen woodlands.

The Bureau of Land Management and the University of Wyoming's Natural Diversity Database have studied aspen woodlands of the BLM's Rock Springs Field Office (Figure 1) in three cooperative projects. In the first project, Database biologists used digital data layers to identify sites in the study area where aspens likely grow (Jones 2007). This GIS work resulted in the selection of potential sampling points for field work. In 2008, the Bureau of Land Management and the University entered into a second cooperative project to gather information in the field. Database biologists visited 51 sampling points in 2008, and collected data in aspen stands at 18 of them. The results of the 2008 field work are reported in Jones (2009). The field work was continued in 2012 in a third cooperative project, when Database biologists visited a second set of 62 sampling points and collected data at 48 of them. This report analyzes the information and data collected in both 2008 and 2012.

METHODS

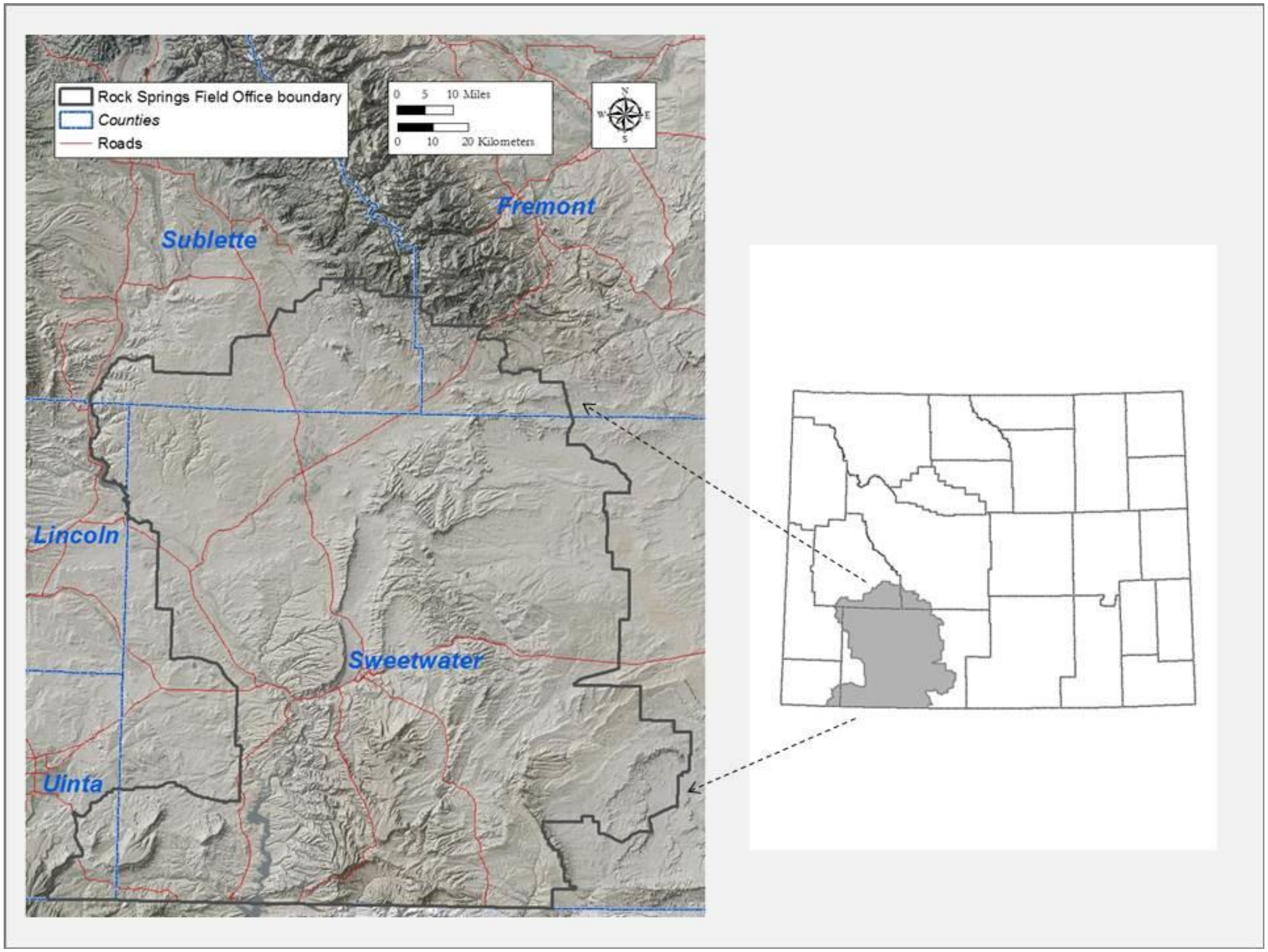
IDENTIFICATION OF POTENTIAL SAMPLING POINTS

In the 2007 project (Jones 2007), three digital vegetation layers were used to identify points where aspen likely grows on public lands in the study area. One-hundred twenty-five of those points were selected for possible field sampling, and are referred to hereafter as "known points". In 2008, the field work was concentrated on aspen stands in the central part of the study area, away from the foothills of the Wind River Mountains in the north, from Pine Mountain and Little Mountain in the south-central part, and from Cedar and Hickey mountains in the southwest. Aspen stands were found in 2008 that had not been identified during the 2007 GIS analysis; these stands are referred to as "new points", and some of them were sampled in 2008. In 2012, a second set of sampling points was selected from the set of points identified in the 2007 GIS analysis (the known points) and from the set of new points discovered in 2008. Work during this field season was conducted throughout the study area, but was concentrated on the aspen stands near the borders of the area.

In both field seasons, then, sampling was conducted at sets of points in which some points had been selected ahead of time with a partially-randomized procedure and other points had been selected subjectively in the field.

[1] Stands of trees in which *Populus tremuloides* Michx. contributes much of the tree canopy cover

Figure 1. Location of the Study Area in Wyoming (small map) and in relation to counties in southwestern Wyoming (large map).



Assessment of Potential Sampling Sites in the Field

The location coordinates of the known points had been ascertained from GIS and those of the new points with a global positioning system receiver in the field. The locations were plotted on the 1:100,000-scale BLM Surface Management Status maps of the study area. The maps and GPS receivers were used by the field crew to navigate to the points.

Upon arriving at a point, the crew used the following 3 rules to decide if the vegetation should be sampled, or the point skipped:

1. If aspen, alive or dead, were present within 50 meters of the point, then data were collected at that point.

2. If aspen were visible from the point but farther away than 50 meters, then the point was moved to the nearest visible stand of aspen and data were collected there.

3. If no aspen, alive or dead, were present within 50 meters of the point or were visible from the point, then the point was abandoned. The crew noted the kind of vegetation present and went to the next-nearest point.

Collection of Information in the Field

Information was recorded in a hierarchical manner, starting with information about the sampling point, then about the tree stand, then the sampling area within the stand (i.e., a part of the stand in which quantitative data were collected), and finally about each patch of trees within the sampling area. The data forms used for recording each type of information are shown in Appendix 1.

Sampling Point

The following information was recorded for each sampling point:

1. Location coordinates (UTM Zone 12N, NAD83) with a GPS receiver
2. Whether the sampling point had been moved from its original coordinates and, if so, why
3. Whether or not photographs were taken and, if so, a description of each photograph
4. Whether or not the vegetation was sampled; if not, why not; if so, in how many patches of trees.

If no aspen were present, or if for some other reason the vegetation at the point was not sampled, no additional information was recorded.

Stand

A stand was defined as the area of vegetation in which live aspen or dead aspen trunks (standing or fallen) were found, throughout which the species composition and the structure of the overstory were homogeneous (as judged by visual inspection). The edges of the stand were defined by a substantial change in the structure or species composition of the overstory layer. Only one stand was selected around or near each sampling point.

The following information was recorded for each stand:

1. Which one of 4 size categories included the stand: $\leq$ 0.1 ha, 0.1-1 ha, 1-5 ha, or >5 ha.

2. The number of aspen patches (defined below), up to 3, in the stand. For each patch, the crew members noted whether or not it was sampled, estimated the percentage of the stand that it contributed, and briefly described it.

3. Notes about additional salient features, if any, of the stand.

Sampling Area

Time was too short for collecting detailed data throughout the entire stand at every sampling point, so a circle of 50 meters radius (0.79 ha), centered on the sampling point, served as the sampling area. Data were collected from as many patches intersected by the sampling area as time allowed. If patches were present in the stand but not intersected by the sampling area, their presence was noted but they were not sampled.

The crew recorded this information about the sampling area:

1. aspect and the steepness of the slope (both in degrees) and the shape of the slope (straight, convex, or concave),
2. type of surface material (residual, colluvial, landslide, aeolian, or alluvial),
3. topographic position (interfluve, shoulder, backslope, footslope, toeslope, step in slope, or valley floor),
4. signs of disturbance,
5. noxious weeds present, and
6. percentage of the sampling area within the aspen stand (to the nearest 10%)

Patch

Often, a single stand of aspen includes areas with different sizes or densities of trees. For example, in a stand of medium-sized trees of nearly uniform density, aspen sprouts or saplings may form a dense understory in part of the area and be absent from the rest. Or, a single stand may comprise one area of sparse, large trees and another of denser, smaller trees. In this project, a **patch** was defined as an area of vegetation within which the layers present, tree density, and the mix of trunk sizes appeared homogeneous. The edges of the patch were marked by a change in at least one of these vegetation features, and a patch was distinguished from adjacent patches (if any) by a substantial, obvious difference in layers present, or tree density, or mix of trunk sizes.

At each sampling point, the following information was collected from as many patches that intersected the sampling area (up to 3) as time allowed:

1. Vegetation description: The vegetation layers present, the height of each layer, the amount of cover contributed by each plant growth form in each layer, and the 3 or 4 most common plant species in each layer were recorded.

2. Abundance of fallen trunks. A tape laid out through the patch and stretched tightly served as a line transect. Every fallen trunk intersected by the tape was identified to species and classified into a size-class (Table 1). Dead trunks still rooted in the ground and leaning at an angle $\leq 45^o$ to the ground were considered fallen and were counted on the line transects, but trunks leaning at an angle of $> 45^o$ to the ground were considered standing and were counted in the belt transect, as described below.

Short transects (15 to 30 meters) were used in small patches and in patches with many fallen stems, and longer transects (30 to 50 meters) were used in large patches and in patches with few fallen stems. The length of the transect was recorded for every patch.

3. Size-class composition of the tree component. The crew delineated a belt transect along the line transect through the patch, by walking along the right side of the tape with a pole held parallel to the ground and perpendicular to the tape, and with one end above the tape. Each standing tree trunk rooted in this belt transect was counted, identified to species, classified as alive (possessing twigs with the year's leaves) or dead (no sign of the year's leaves), and classified into a size-class (Table 1). Stems rooted in the ground and leaning at an angle $> 45^o$ from horizontal were considered standing, while stems leaning at an angle $\leq 45^o$ from horizontal were considered fallen and were recorded along the line transect as described above.

Table 1. Aspen size classes

Category No.	Category Name	Height	Diameter at 4.5 ' off ground
1	Sprout	< 4.5 feet (1.4 meter)	
2	Sapling	4.5 - 6.6 feet (1.4 - 2 meters)	By 2 inch (5 cm) size class
3	Small tree	> 6.6 feet (2 meters)	1 inch - 4 inches (2.5 - 10 cm)
4	Medium-size tree	> 6.6 feet (2 meters)	4 in.- 8 in. (10 - 20 cm)
5	Large tree	> 6.6 feet (2 meters)	> 8 in. (20 cm)

In patches with dense standing stems, the belt transect was 1 meter or 2 meters wide. In patches with sparse to moderately dense stems, the belt transect was 3 to 5 meters wide. In most patches, the belt transect and the line transect were the same length, but in several stands with very dense standing trees, the belt transect extended only part of the length of the line transect. The length and width of the belt transect were recorded in every case.

4. Condition of trunks. On each tree rooted in the belt transect and larger than a sprout (size class 1), the presence of wounds and signs of disease were noted, and for dead trees, the presence of bark or twigs was noted.

5. Vigor of live trees. For live trees of all sizes in the belt transects, the percentage of live canopy was recorded by category (Table 2). Branches with live leaves were considered part of the live canopy.

Table 2. Categories for percent of live canopy.

Category	Percent of potential canopy volume occupied by live canopy
1	≤ 25%
2	25% - 50%
3	50% - 75%
4	> 75%

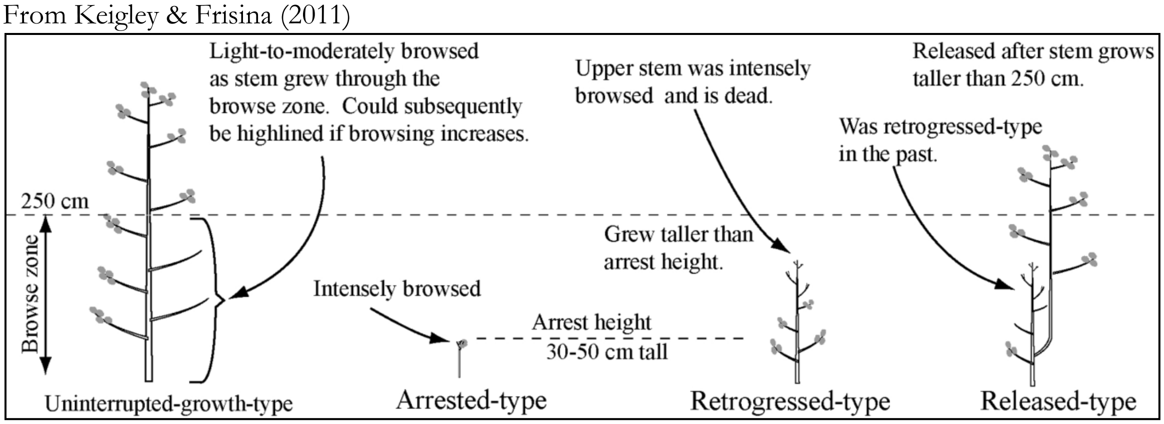
---

6. Degree of browsing.

a. 2008 field season. On every aspen in size-class 1 (the trees < 4.5 feet tall) rooted in the belt transect, the percentage of terminal buds that had been removed by browsing animals was recorded, by percentage class: 0% (no evidence of browsing on the tree), 25% - 50% of buds, 50% - 75% of buds, or >75% of buds.

b. 2012 field season. Every aspen in size-class 1 (trees < 4.5 feet tall) or size-class 2 (≥ 4.5 feet tall and < 1 inch dbh) growing in the belt transect was scored as unbrowsed (no sign that terminal buds were missing) or into one of four types of canopy architecture (Figure 2).

Figure 2. Four types of canopy architecture.
From Keigley & Frisina (2011)



RESULTS AND DISCUSSION

SAMPLE POINTS

Fifty-one potential sample points were visited in the 2008 field season, and aspen trees were found at 18 of them (Table 3). In 2012, 62 additional points were visited, and aspen was found at 57 of them. In the two years combined, 113 points were visited and aspen trees were found at 75 of them (66% of the points). Data were collected at 66 of those points.

Table 3. Numbers of potential sampling points visited each year at which aspen was found or not, and that were sampled or not.

	Aspen Present		Aspen Absent	
Year	Sampled	Not Sampled	Not Sampled	All Points
2008	18	0	33	51
2012	48	9	5	62
Both Years	66	9	38	113

The potential sampling points were distributed throughout the rougher topography of the Rock Spring Field Office area (Figure 3). Aspen stands were found at points throughout the Field Office area, but the points in the northern part of the area and along its southern boundary had the highest likelihood of supporting aspen. The 66 points at which aspen patches were sampled also were widely distributed throughout the Field Office area.

Quantitative data on the vegetation were collected in 1 patch at each of 61 of the sampling points, in 2 patches at each of 4 points, and in 3 patches at one 1 point. Thus the quantitative data were collected in 72 aspen patches.

The set of potential sample points suggests that aspect exerts a strong influence on where aspens grow. Of the 75 points where aspen was found, 56 of them (75%) were on sites with whose aspects have a northerly or easterly component (NW through SE), and 19 of them (25%) were on sites with southerly or westerly aspects (from SE through NW) (Figure 4). The 38 points without aspen were more evenly distributed, with 22 points (58%) on slopes with northerly or easterly aspects, and 16 points (42%) on slopes with southerly or westerly aspects (Figure 5). Aspect exerted a stronger influence at relatively low elevation than at higher elevations (Figure 6): at the lower elevations, aspen was found at points within a narrow range in aspect, tending toward the northeast; while at higher elevations, aspens occurred across a much broader range in aspect. The position on the slope was recorded only for 65 of the 66 aspen stands that were sampled, and most were located on the upper parts of slopes (Figure 7).

Figure 3. Map of 113 potential sample points, showing points with aspen and points where no aspen was found.

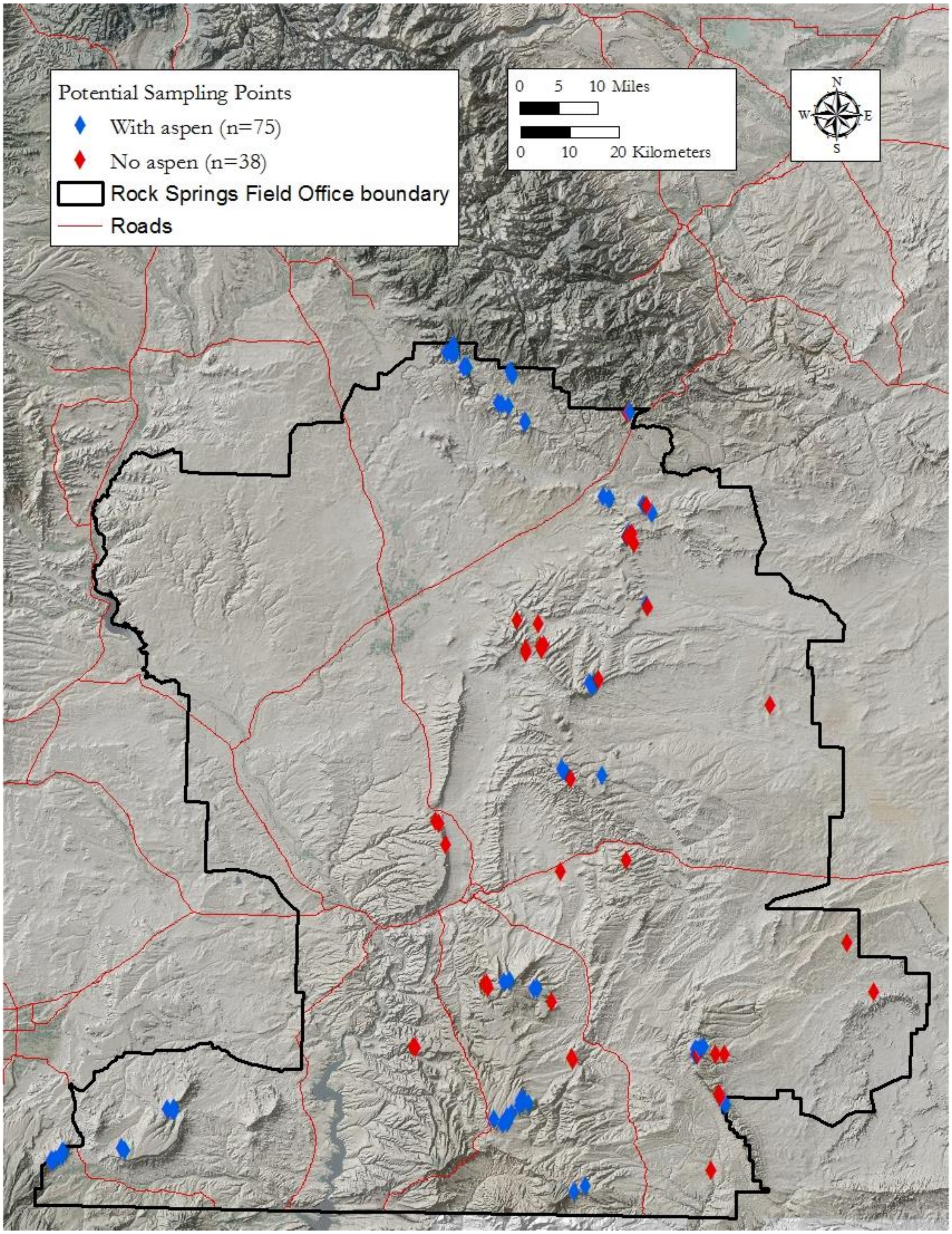


Figure 4. Aspects of 75 points at which aspen were found in either year.
Letters show cardinal directions. Numerals and circles indicate numbers of points. Each heavy line shows the number of points (length of line) on approximately the same slope aspect (direction of line). E.g., 8 points had aspects of approximately 360°, 3 had aspects of approximately 90°.

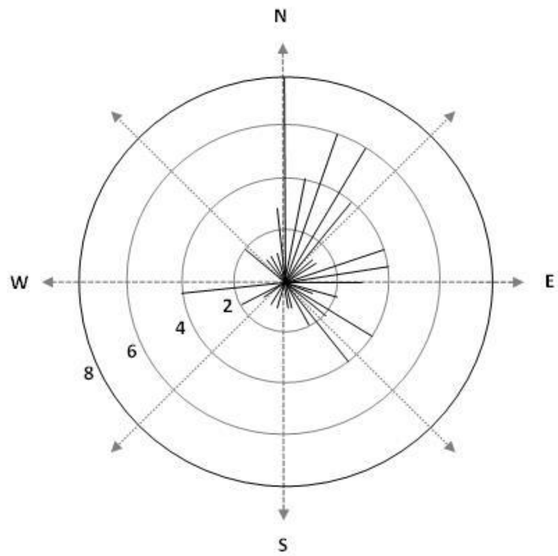


Figure 5. Aspects of 38 points at which no aspen were found in either year.
Letters show cardinal directions. Numerals and circles indicate numbers of points. Each heavy line shows the number of points (length of line) on approximately the same slope aspect (direction of line). E.g., 6 points had aspects of approximately 75°, 3 had aspects of approximately 200°.

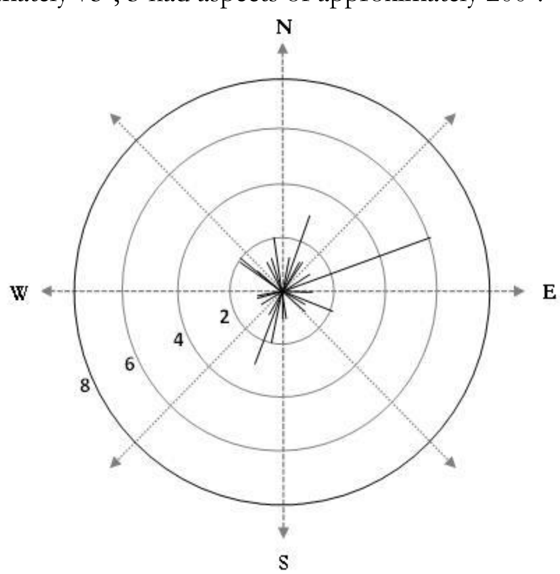


Figure 6. Aspect (transformed) versus elevation for 113 sample points.
Aspect has been transformed so that 0 on the Y axis = 225° (southwest) and 2 = 45° (northeast).

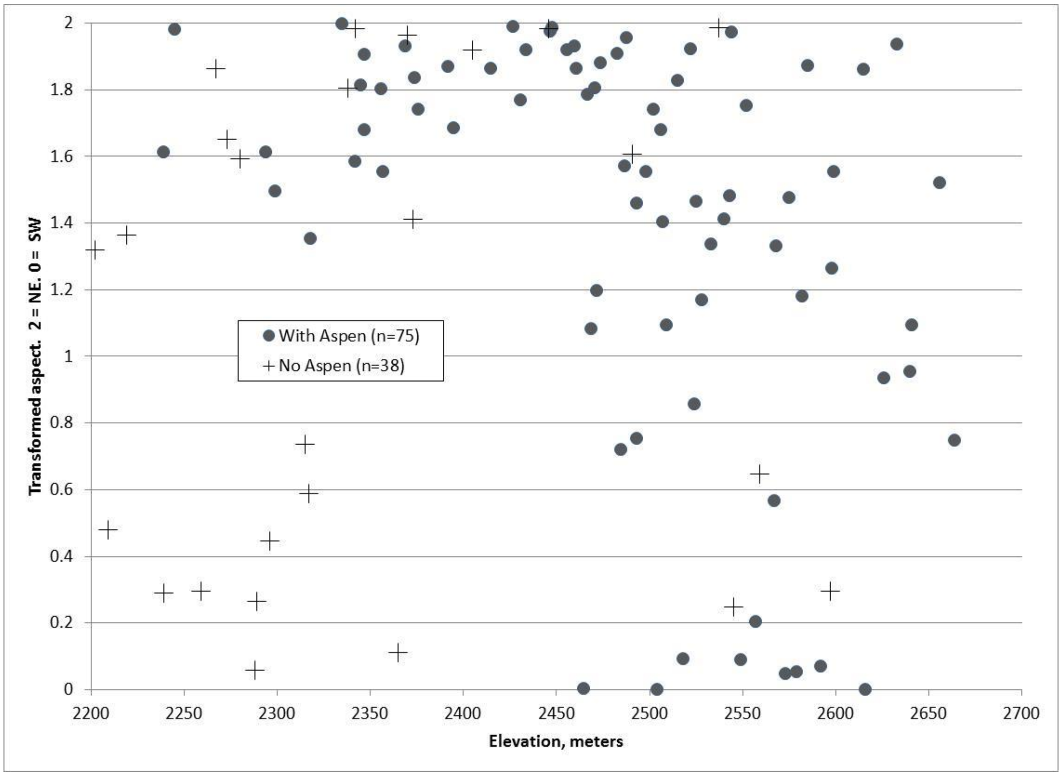
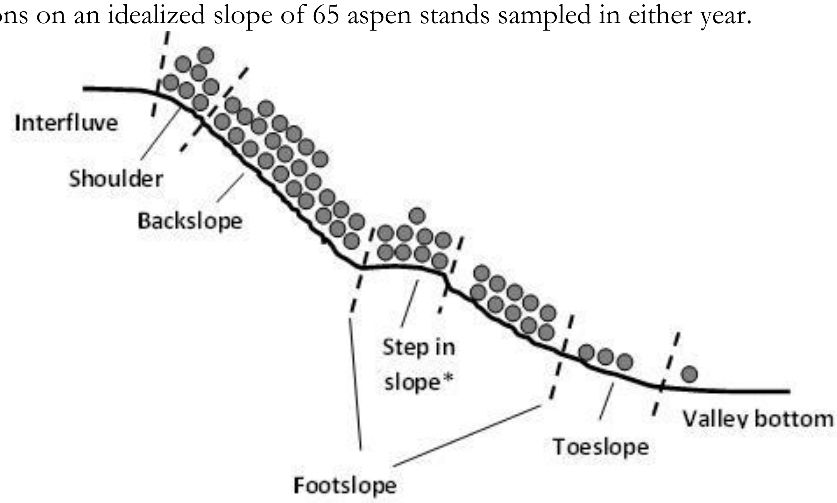


Figure 7. Positions on an idealized slope of 65 aspen stands sampled in either year.



* A step may be found in the shoulder, backslope, footslope, or toeslope regions.

TREE SPECIES

Abundance of All Species

Eight species of trees (including tree-sized shrubs, *Juniperus* spp. and *Salix scouleriana*) were recorded in the 72 sampled aspen patches (Table 4). Aspens accounted for 93% of the trees. Limber pine (*Pinus flexilis*) was the only other species that contributed > 1% of the trees. The other six species together accounted for < 1% of the trees. The preponderance of aspens extended down to the individual aspen patches: within the 72 patches, aspen was the sole tree species present or the very strong dominant in 70 of them (Figure 8). Patches in which the tree stratum was composed entirely of aspen were located throughout the study area, but the patches with other trees (primarily limber pine) were concentrated at the northern end and the southwestern corner of the study area (Figure 9).

Seventy-two percent of all trees, and 71% of the aspens, were alive (Table 4). Among the 72 sampled patches, live trees predominated in a large percentage: in each of 37 patches, at least 75% of the trees were alive; and in each of 60 patches, at least 50% of the trees were alive. In only 4 aspen patches were < 25% of the trees alive.

Table 4. Numbers of trees, living (L) or dead (D), counted in each size-class in 72 aspen patches. Number in parentheses in the *Populus tremuloides* and the All Species columns are proportions of live trees in the size-class.

Size		*Populus tremuloides*	*Pinus flexilis*	*Juniperus osteosperma*	*Juniperus scopulorum*	*Picea engelmannii*	*Pinus contorta*	*Pseudotsuga menziesii*	*Salix scouleriana*	All Species
Size-class 1, < 4.5 ft. tall	L	1,304 (0.82)	97			1	4	5	1	1,412 (0.83)
	D	278	2							280
	All	1,582	99			1	4	5	1	1,692
Size-class 2, 4.5 - 6.6 ft. tall	L	369 (0.72)	31	1	2		2	2		407 (0.74)
	D	145	1							146
	All	514	32	1	2		2	2	0	553
Size-class 3, 1" - 4" dbh	L	400 (0.52)	51		2		6	6		465 (0.56)
	D	362	2							364
	All	762	53		2		6	6	0	829
Size-class 4, 4" - 8" dbh	L	234 (0.57)	11				1	1		247 (0.58)
	D	176	1							177
	All	410	12				1	1	0	424
Size-class 5, > 8" dbh	L	90 (0.73)	2					1		93 (0.72)
	D	33	3						1	37
	All	123	5					1	1	130
All Sizes	L	2,397 (0.71)	192	1	4	1	13	15	1	2,624 (0.72)
	D	994	9	0	0	0	0	0	1	1,004
	All	3,391	201	1	4	1	13	15	2	3,628

Figure 8. Density (trees/hectare) of trees (alive and dead) of different species in 72 aspen patches. Vertical dashed lines show densities for quartiles of patches.

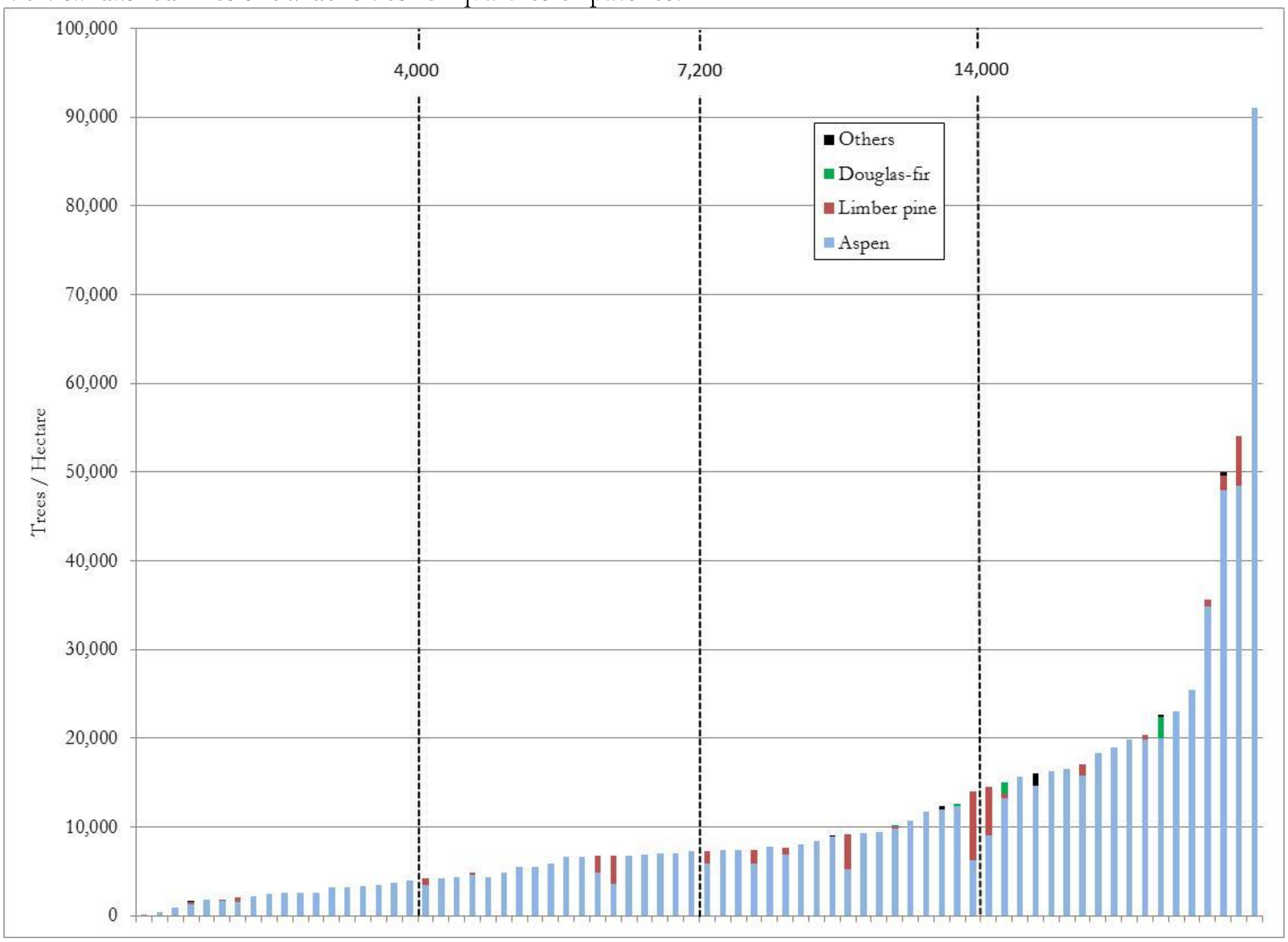
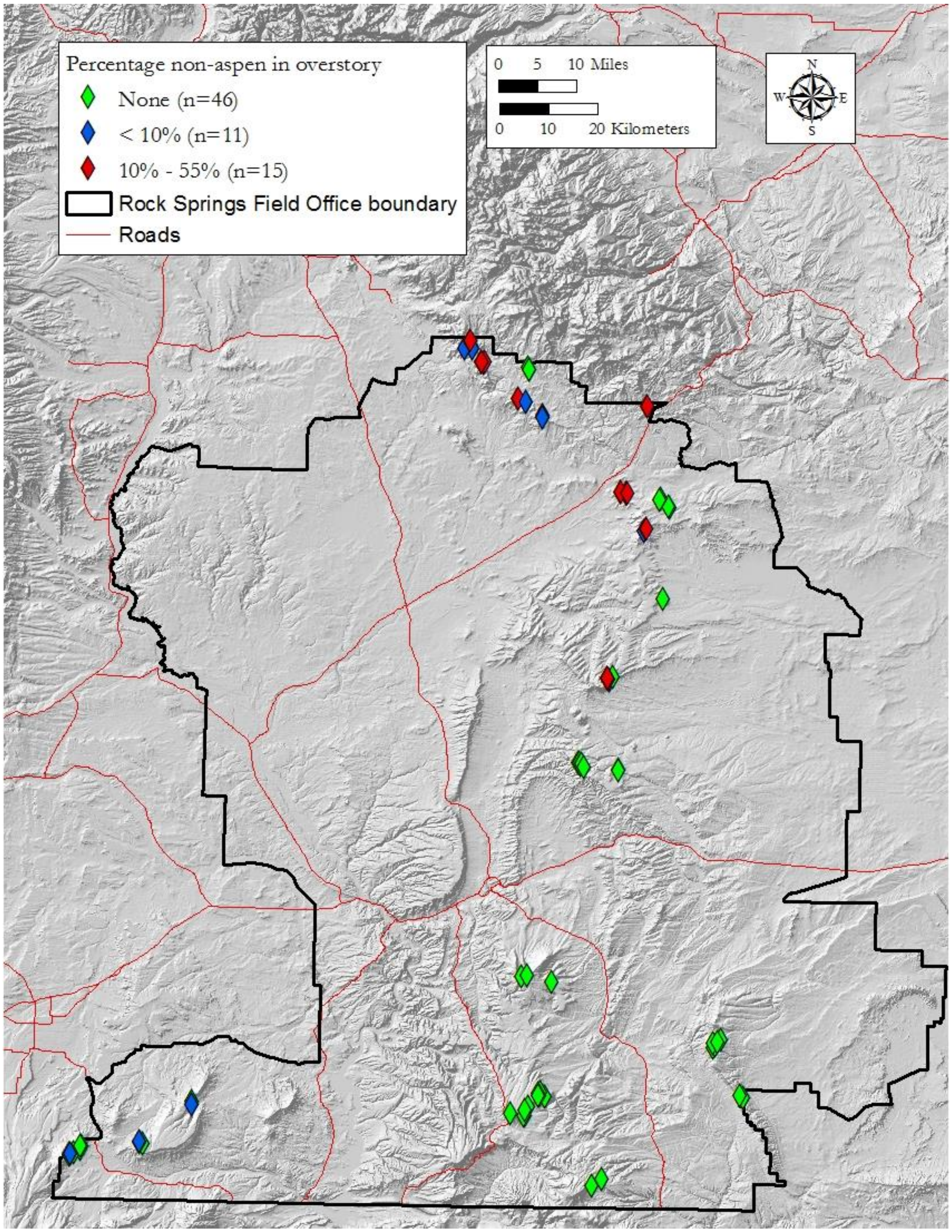


Figure 9. 72 aspen patches showing percentages of overstory trees other than aspens.



Tree Density

Density of trees varied over 600% among patches, from 140 trees/ha to 91,000 trees/ha (Figure 10). Four patches had extremely dense trees (> 30,000/ha, or 3/sq m), and when those patches are removed from consideration, variation among patches is 180%. In most of the patches, live trees greatly outnumbered dead trees; the proportion of live trees ranged from 1.0 down to 0.1, and 51 of the 72 patches had at least 70% live trees (Table 5). The densest patches were sampled on the edges of the study area, but otherwise both sparse and dense patches appear to be distributed throughout the area (Figure 11).

Aspens constitute the great majority of trees, both among all of the trees counted (Table 4) and in individual patches (Table 6) and are the species of primary interest. Scatter diagrams (Figure 11) suggest that the density of aspen trees (either live and dead trees, or only live trees) has no relationship to elevation or slope aspect; apparently, the density of aspens is determined by other factors.

Figure 10. Density (trees/hectare) of live trees and dead trees of all species and all size-classes in 72 aspen patches.
Vertical dashed lines show densities for quartiles of patches.

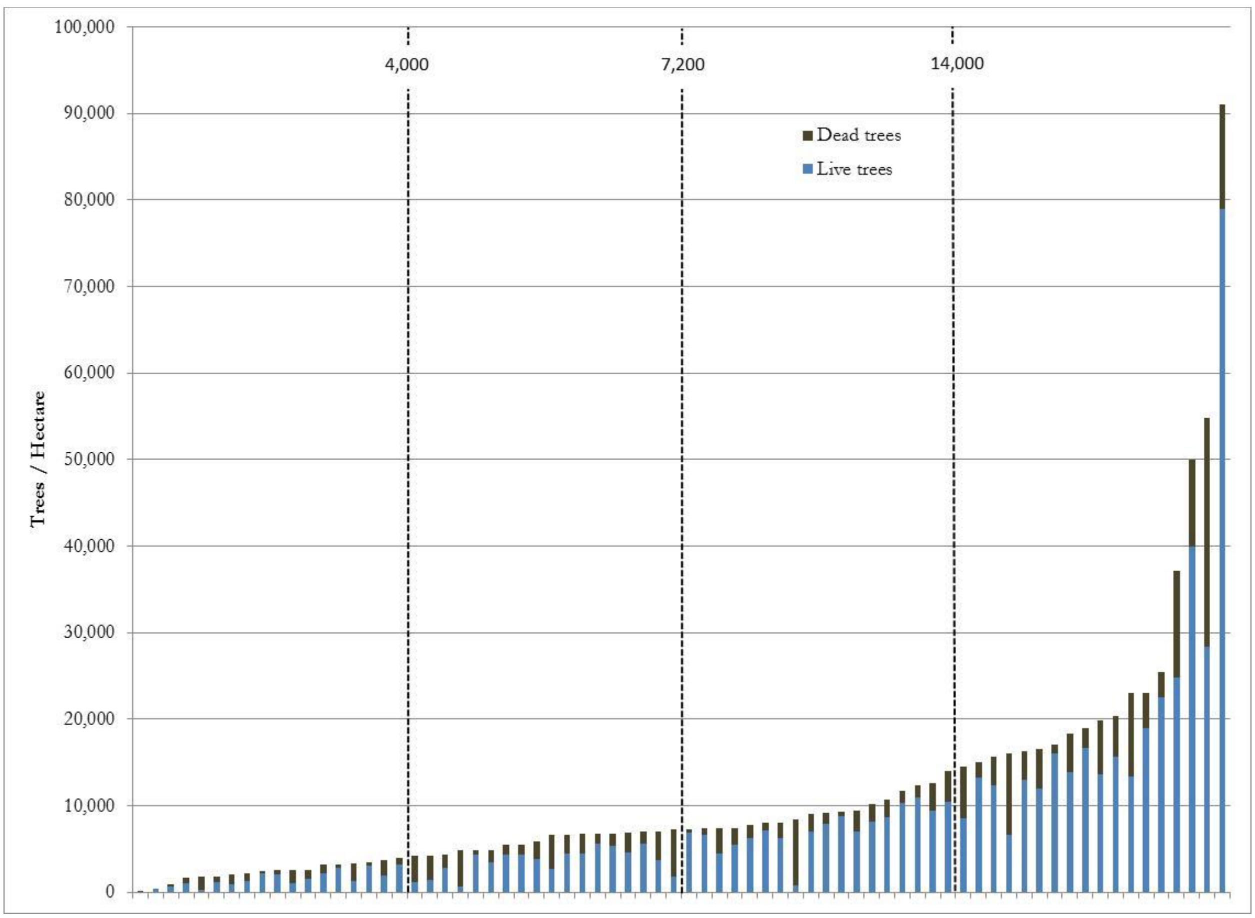


Table 5. Proportion of live trees (all species, all sizes) in 72 aspen patches.
Proportions have been rounded to the nearest tenth.

Proportion of Trees Alive	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
Number of Patches	4	0	3	5	3	6	13	21	16	1

Table 6. Proportion of the trees (alive and dead) that are aspens, in 72 patches.
Proportions have been rounded to the nearest tenth. No patches had < 40% aspens.

Proportion of Aspens	0.4	0.5	0.6	0.7	0.8	0.9	1
Number of Patches	1	1	2	2	4	10	52

Figure 11. Maps of 72 aspen patches showing densities of overstory trees, alive and dead, of all species in all size-classes.

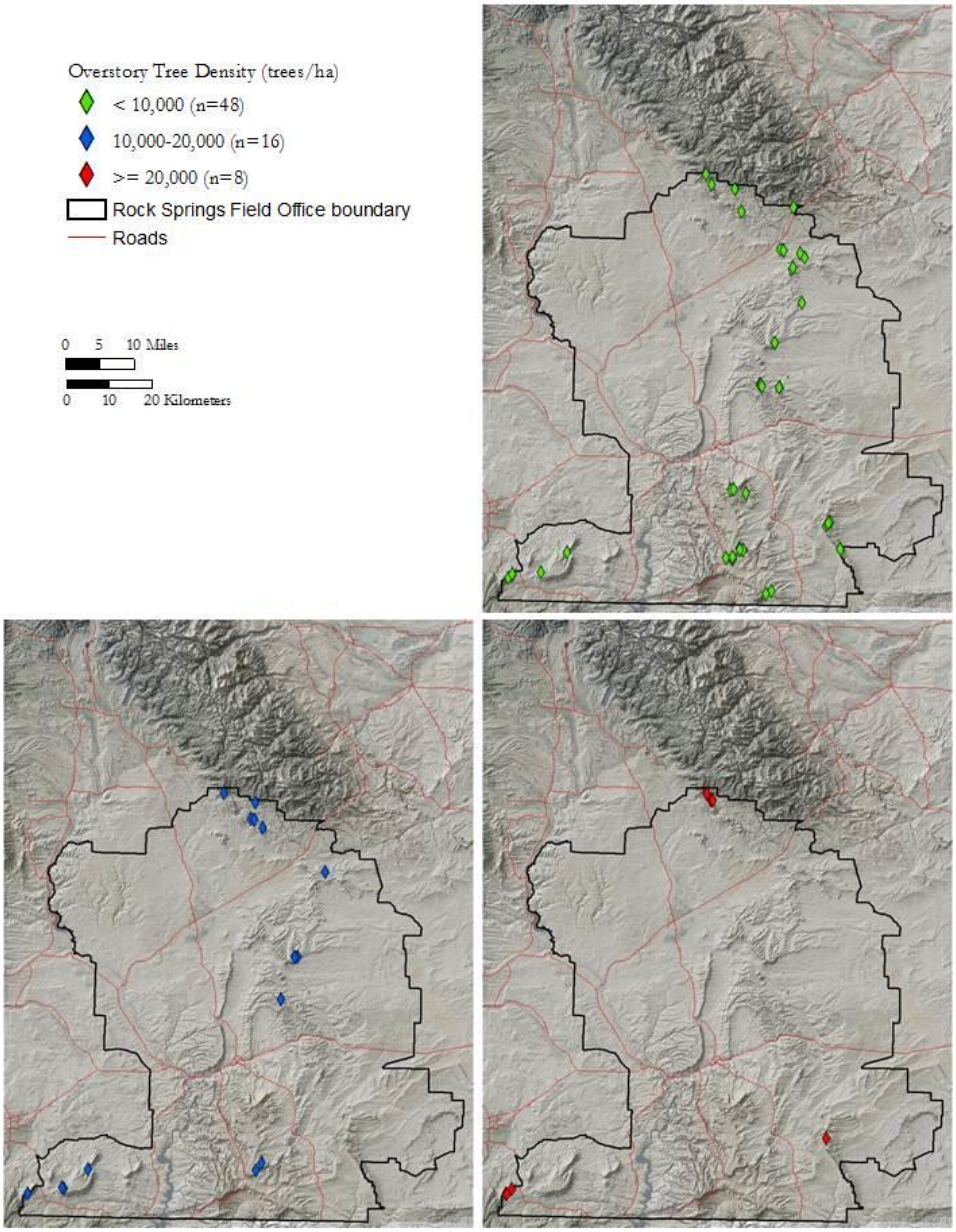


Figure 12a. Densities of all aspens in 72 patches related to elevation and slope aspect.

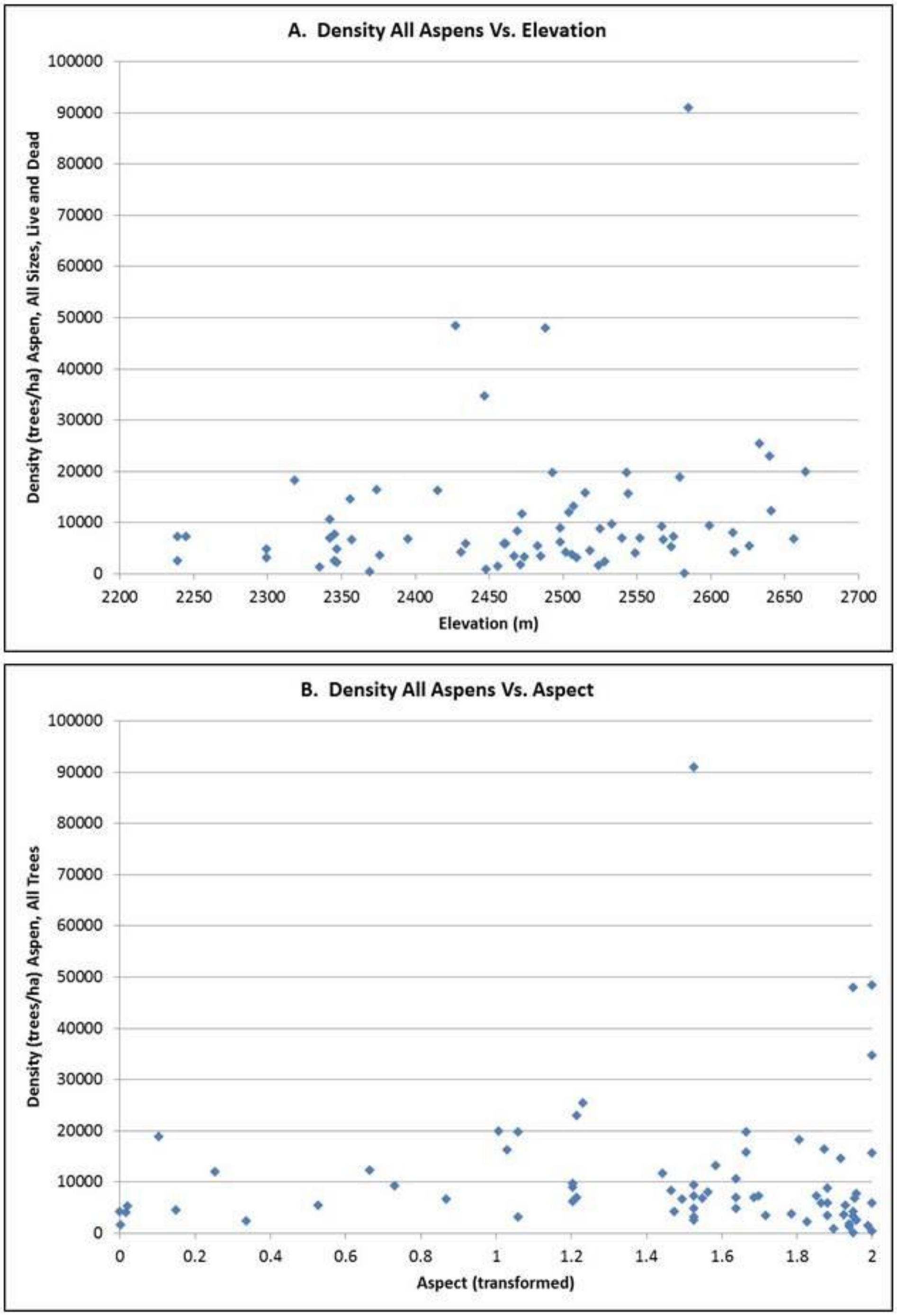
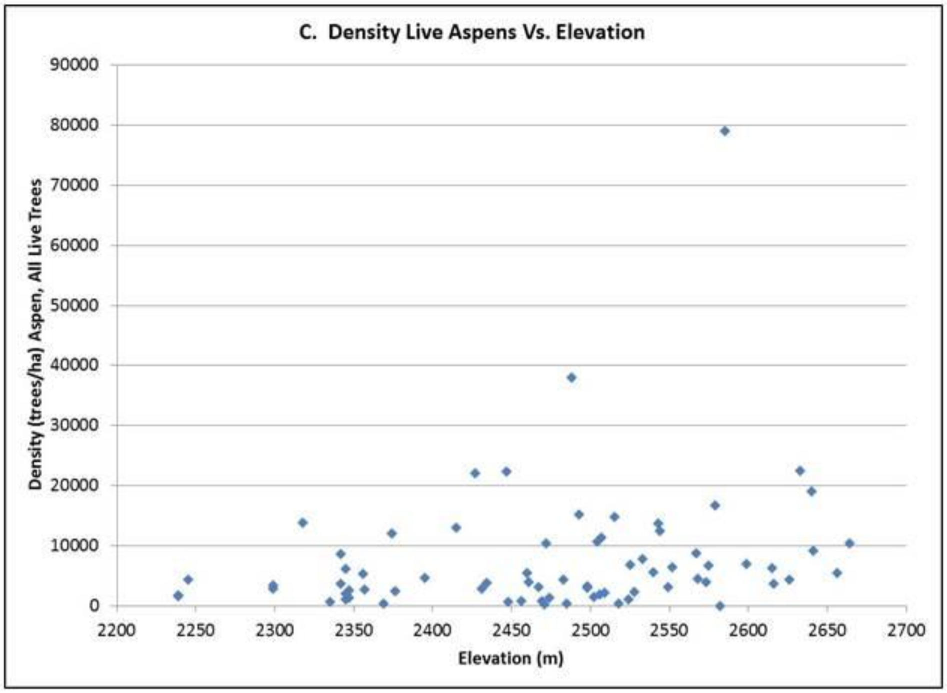
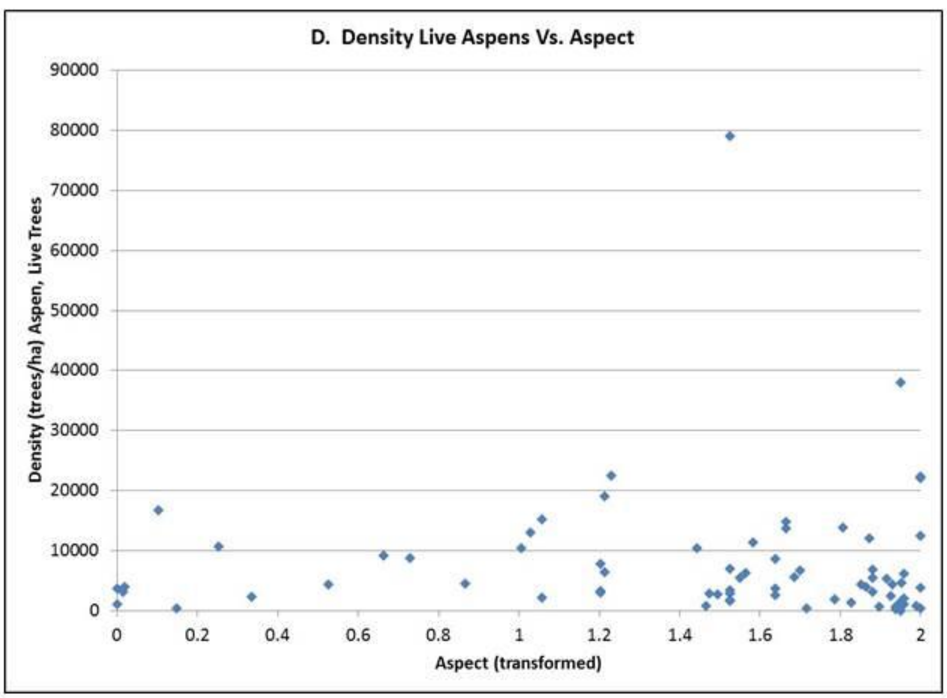


Figure 12b. Density of live aspens in 72 patches related to elevation and slope aspect.





Tree Size

Small trees predominate in the aspen stands. Nearly half (47%) of the 3,628 trees counted in the 72 sampled aspen patches were < 4.5 feet tall (Table 4). This plurality of very small trees is due almost entirely to the abundance of aspen sprouts (44% of the 3,628 total trees are aspens of size-class 1, <4.5' tall) or of aspen saplings (14% of the 3,268 total trees are aspens of size-class 2, 4.5'-6.6' tall). Limber pine, the second-most common species, also was represented strongly by very small trees (97 of the 192 live limber pines are in size-class 1). Among individual aspen patches, the representation of very small trees varied considerably (Figure 13). The smallest trees (< 4.5' tall) were absent from only 5 of the 72 patches, constituted 20% of the trees in 56 of the patches and were the most common trees in over half of the patches (Table 7).

Trees 1" to 4" dbh (size-class 3) were the second-most common, accounting for 23% of all trees counted (Table 4). They were present in 68 of the patches and were the most common of trees in 25 patches (Table 7). The largest trees, > 8 inches dbh, contributed the smallest percentage of all trees counted (<4%; Table 4) and constituted a very small percentage of the trees in nearly all patches (Table 7). But they were present in half of the patches.

The proportion of trees alive declined with increasing tree size-class from size-class 1 through size-class 4, but increased for the largest trees (size-class 5). This trend was observed among all trees and among aspens (Table 4).

Figure 13. Density of trees (all species, alive or dead) in each size-class, in 72 aspen patches.
Vertical dashed lines show densities for quartiles of patches.

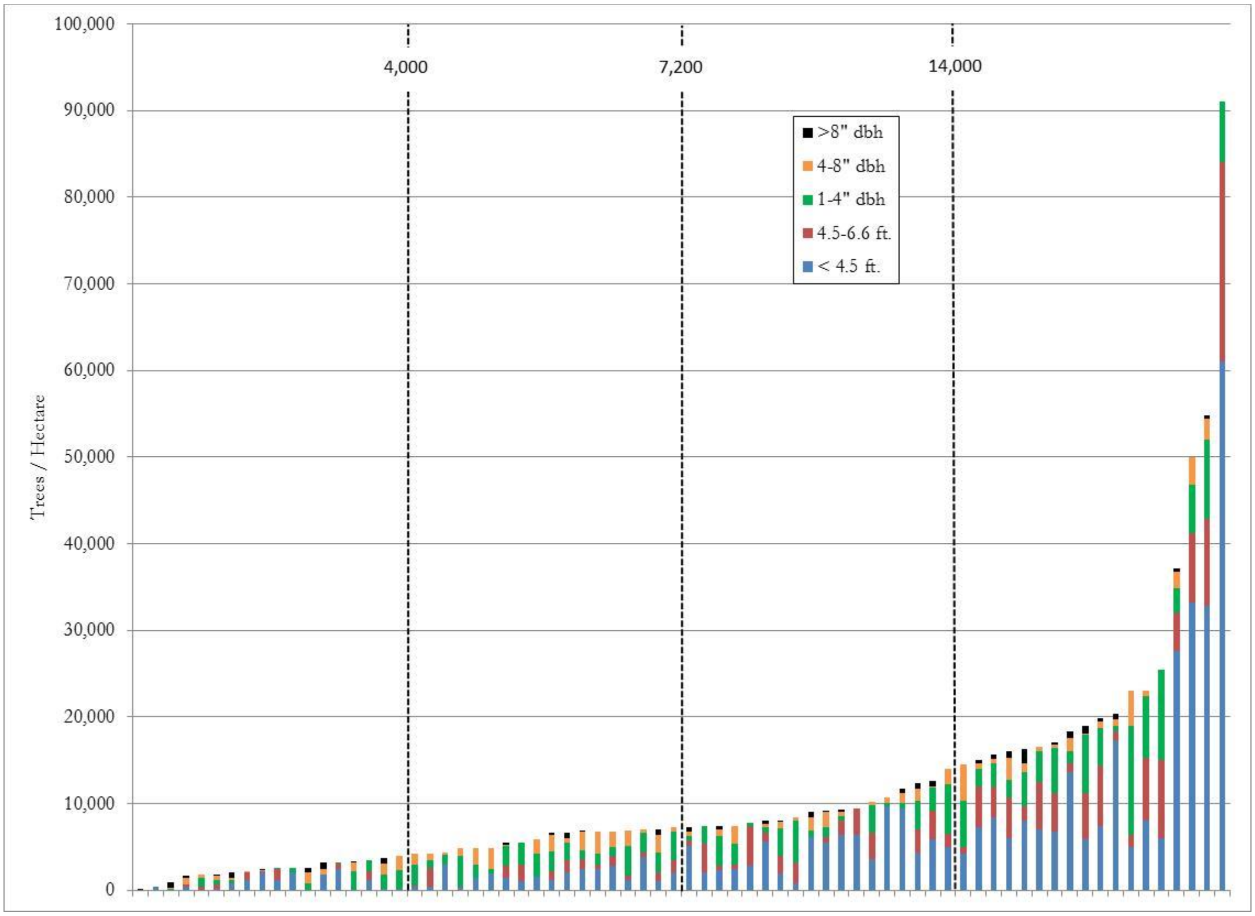


Table 7. Abundance of trees (all species, alive or dead) in 5 size-classes in 72 patches.
Columns show the numbers of patches in which trees of the size-class were present; or constituted 20%, 50%, or 75% of the trees counted; or constituted the largest percentage of trees among all size-classes.

Size-class	Present	20% of trees	50% of trees	75% of trees	Max. % of trees
1 (< 4.5' tall)	67	56	41	7	39
2 (4.5'-6.6' tall)	56	28	9	0	5
3 (1"-4" dbh)	68	39	22	1	25
4 (4"-8" dbh)	61	20	7	0	6
5 (>8" dbh)	36	5	3	0	2

ASPEN VIGOR

Canopies of small aspens generally are more vigorous than canopies of the larger trees (Figure 14). Among the trees < 1" dbh (i.e., size-classes 1 and 2), at least half of the trees had canopies 50% or more alive. For trees in size-classes 3 and 4, less than half of the trees had canopies > 50% alive. The proportion of dead trees also generally increases with increasing trees size across these four size-classes. (See also Table 4.) The largest trees (size-class 5) do not fit the trend, though: well over half of those aspens had canopies > 50% alive, and the proportion of dead trees was relatively small.

There is substantial variation among aspen patches in the vigor of the aspen trees (Figure 15). The proportion of dead aspens and of live trees in different vigor-classes in a patch appears to be unrelated to the density of trees. Comparisons of aspen vigor to elevation, aspect, and slope steepness indicate that these site variables also have no influence on vigor. Figure 16 and Figure 17 show typical examples.

Figure 14. Numbers of dead aspens and of live aspens in each canopy-vigor class counted in all 72 aspen patches.
Numbers beside bars are proportions of trees in each vigor-class.

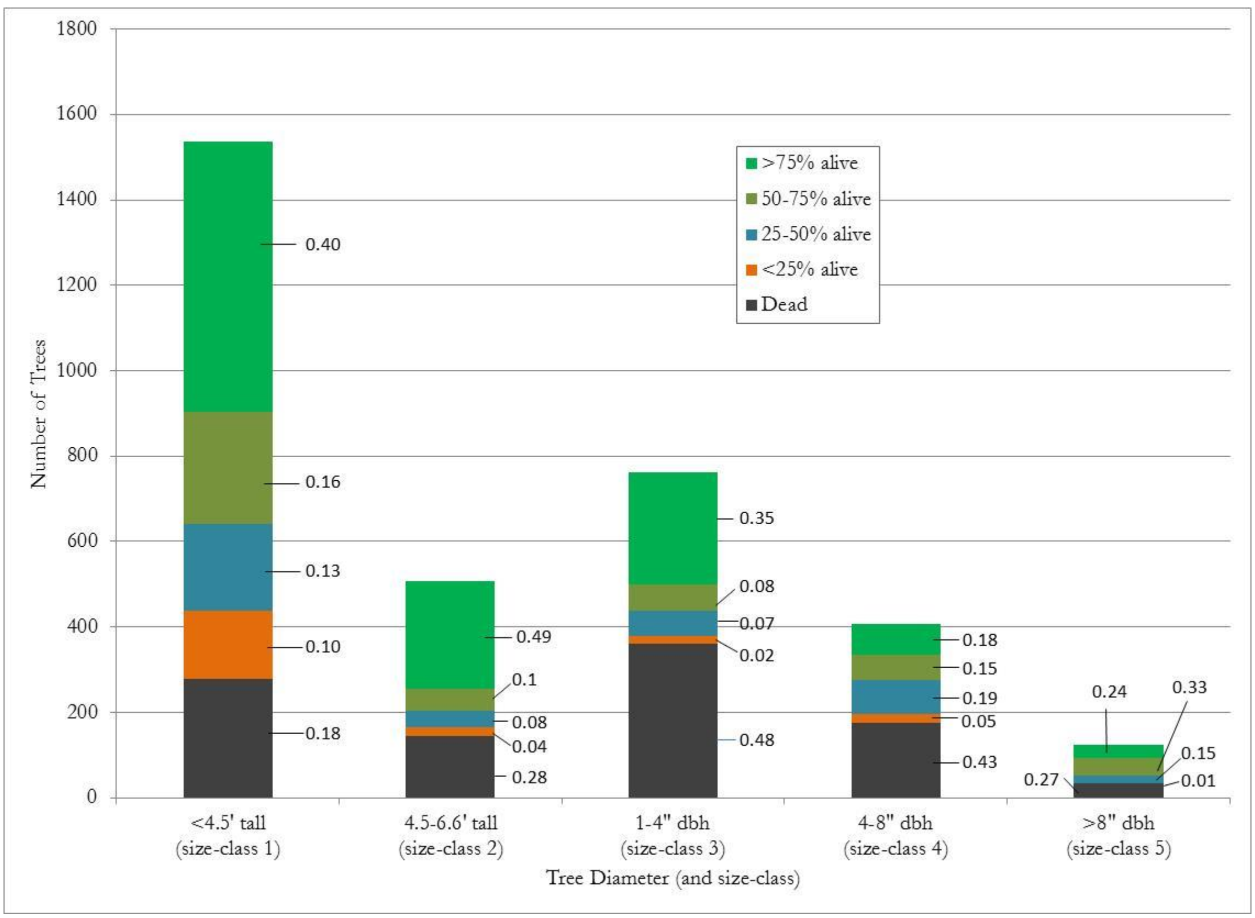


Figure 15. Density of dead aspens and of live aspens in different canopy-vigor classes in each of 72 aspen patches.
Vertical dashed lines indicate quartiles of patches.

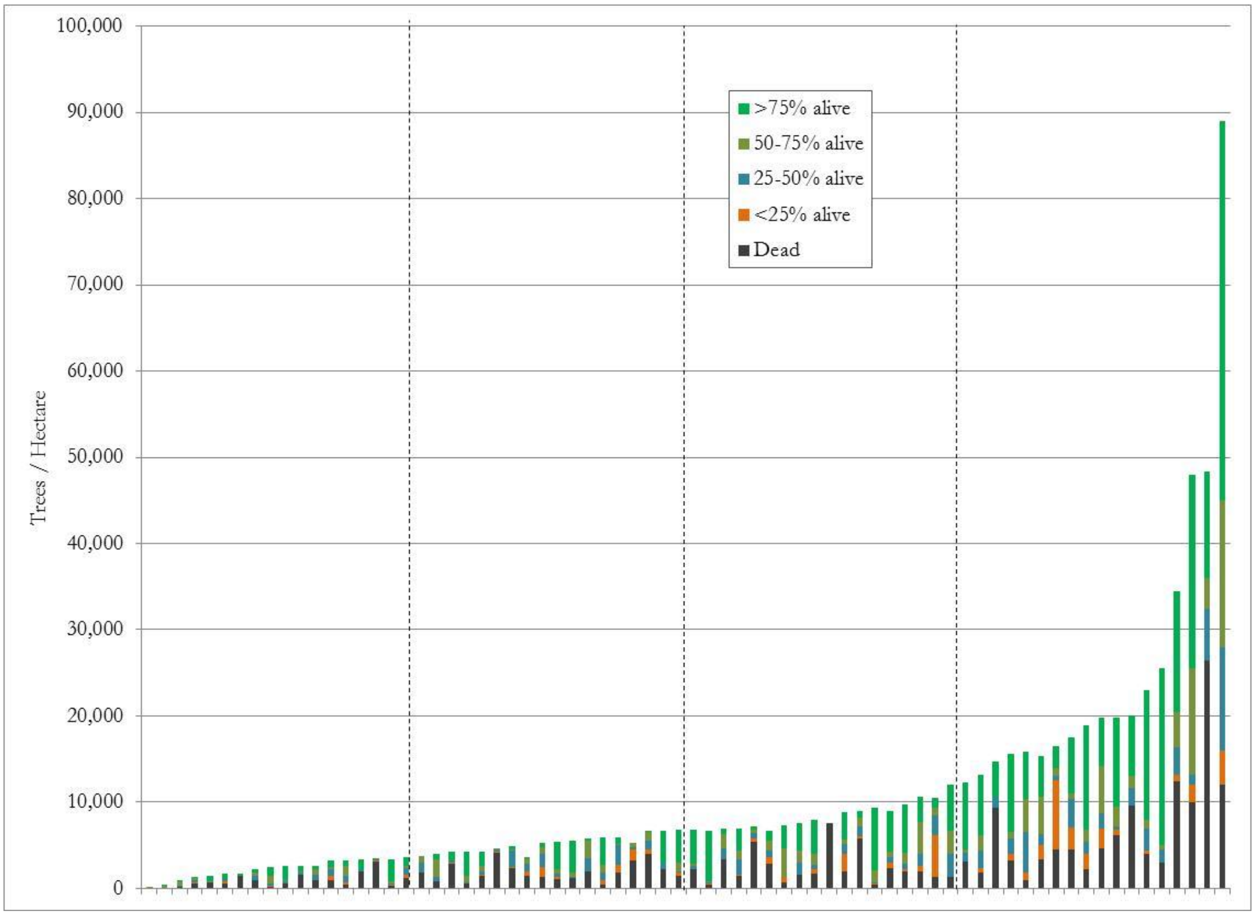


Figure 16. Aspen canopy vigor in 72 patches vs. elevation.

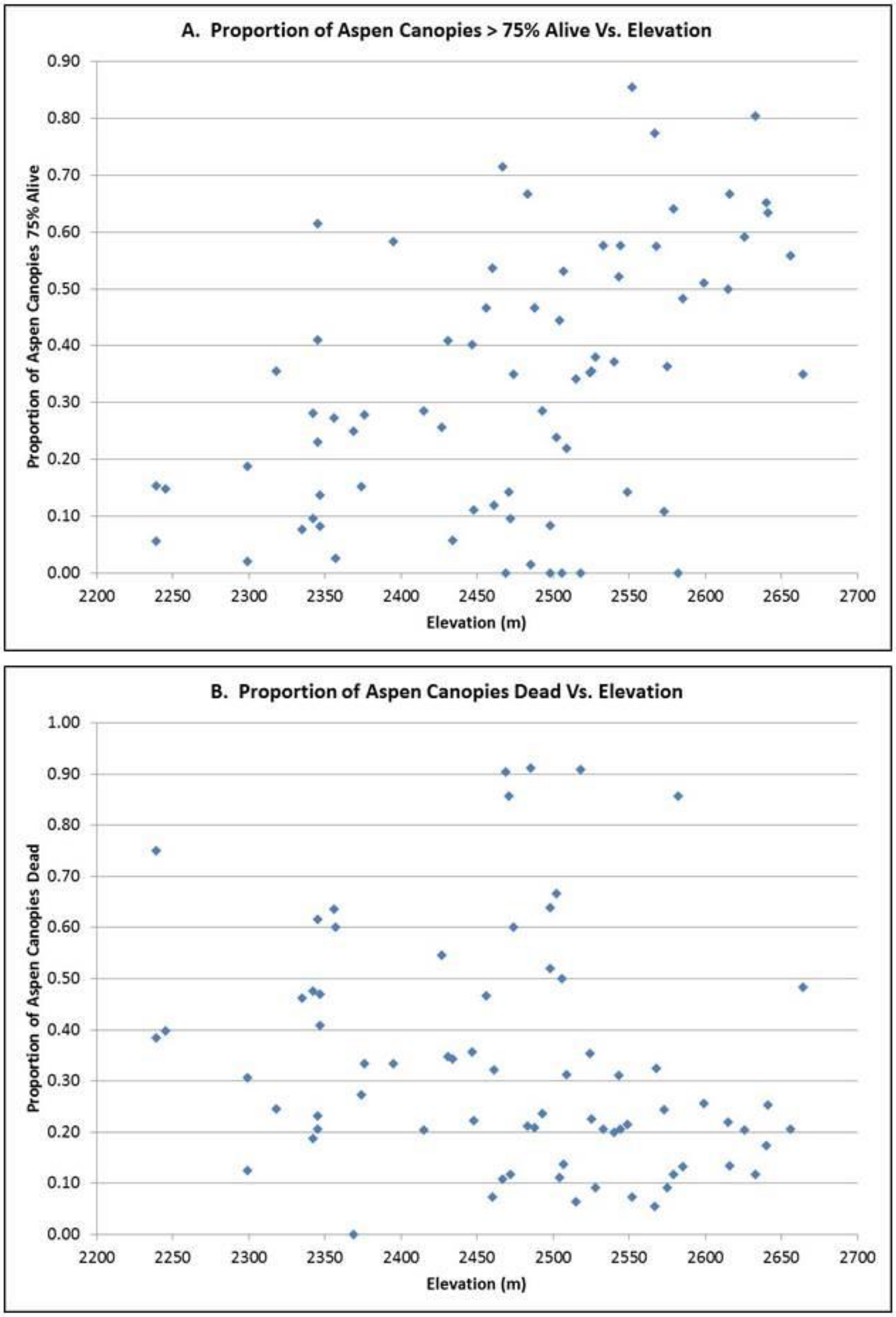
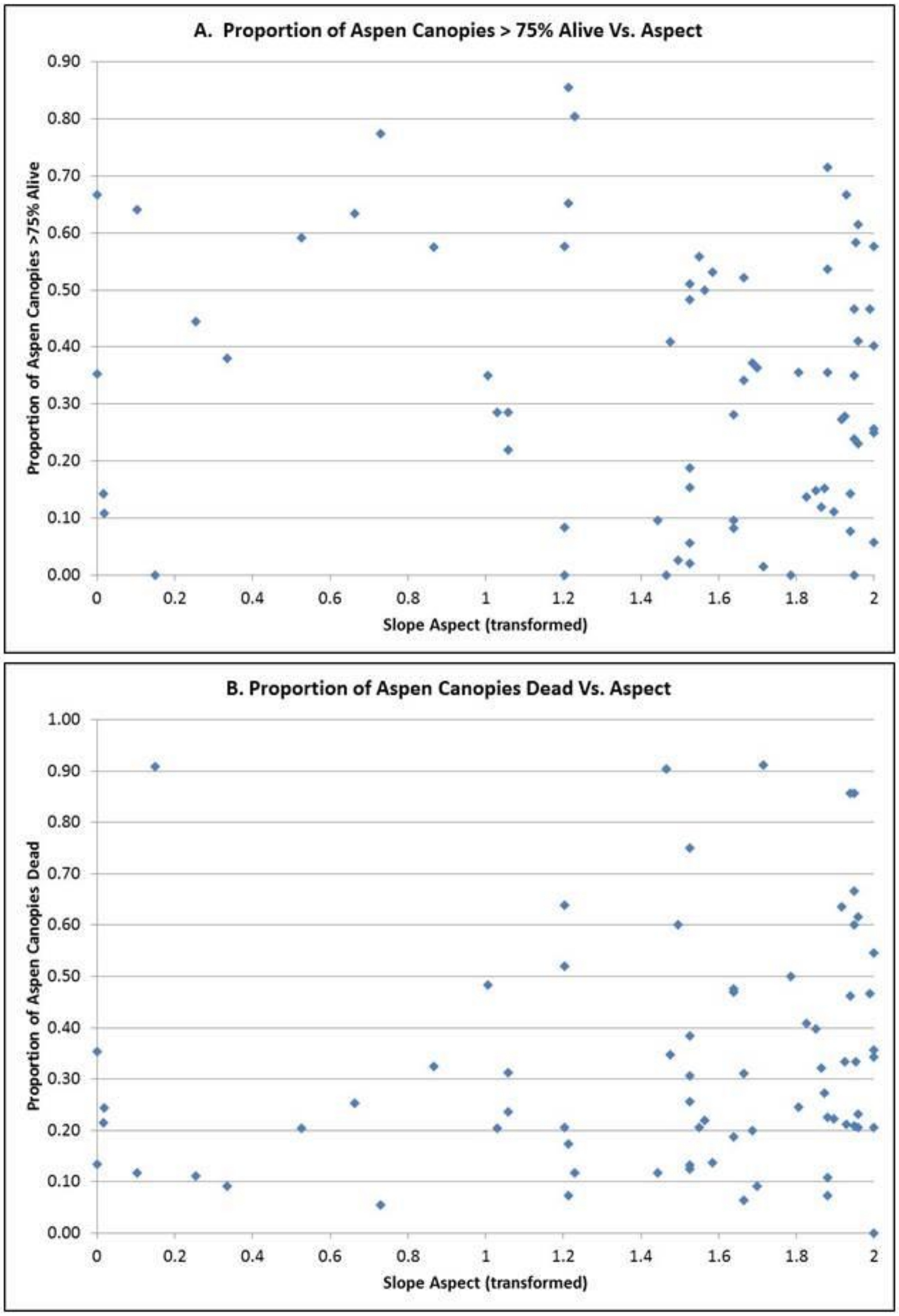


Figure 17. Aspen canopy vigor in 72 patches vs. slope aspect.



ASPEN STAND REGENERATION

The presence of aspen trees < 1" dbh in densities > 1,000 trees/acre (2,470 trees/ha) has been considered a necessity for successful regeneration of aspen stands in the Intermountain Region (Eastern Idaho Aspen Working Group 2008). Two size-classes of trees measured in this project, size-class 1 (sprouts, < 4.5' tall) and size-class 2 (saplings, 4.5-6.6' tall and < 1" dbh), include trees < 1" dbh. The threshold density of those trees was exceeded in half of the 72 patches sampled in this project (Figure 18). Among the 36 patches with densities below the threshold, aspens < 4.5' tall were absent from 8 patches, and aspens 4.5-6.6' tall were absent from 24. Eight of the patches had no aspens in either size-class (i.e., < 1" dbh).

The patches in which density of aspens < 1" dbh exceeded the threshold for stand regeneration and those in which the density was below the threshold were scattered throughout the study area, but their distributions were not uniform (Figure 19). The patches with potentially successful regeneration were relatively common near the edges of the study area (especially on the northern edge, at the foot of the Wind River Mountains) and rare in the center. In contrast, the patches with densities below the threshold needed for successful regeneration were common in the central and the south-central parts of the area. The cause of this general pattern is unclear, as density of aspens < 1" dbh appears to bear no relationship to either elevation or slope aspect (Figure 20).

Figure 18. Density of live aspen trees in the two size-classes < 1 inch dbh in 72 patches.
Vertical dashed line separates patches with insufficient density for regeneration (<2,470 trees/ha or 1,000 trees/acre) from those with sufficient density (≥ 2,470 trees/ha or 1,000 trees/acre).

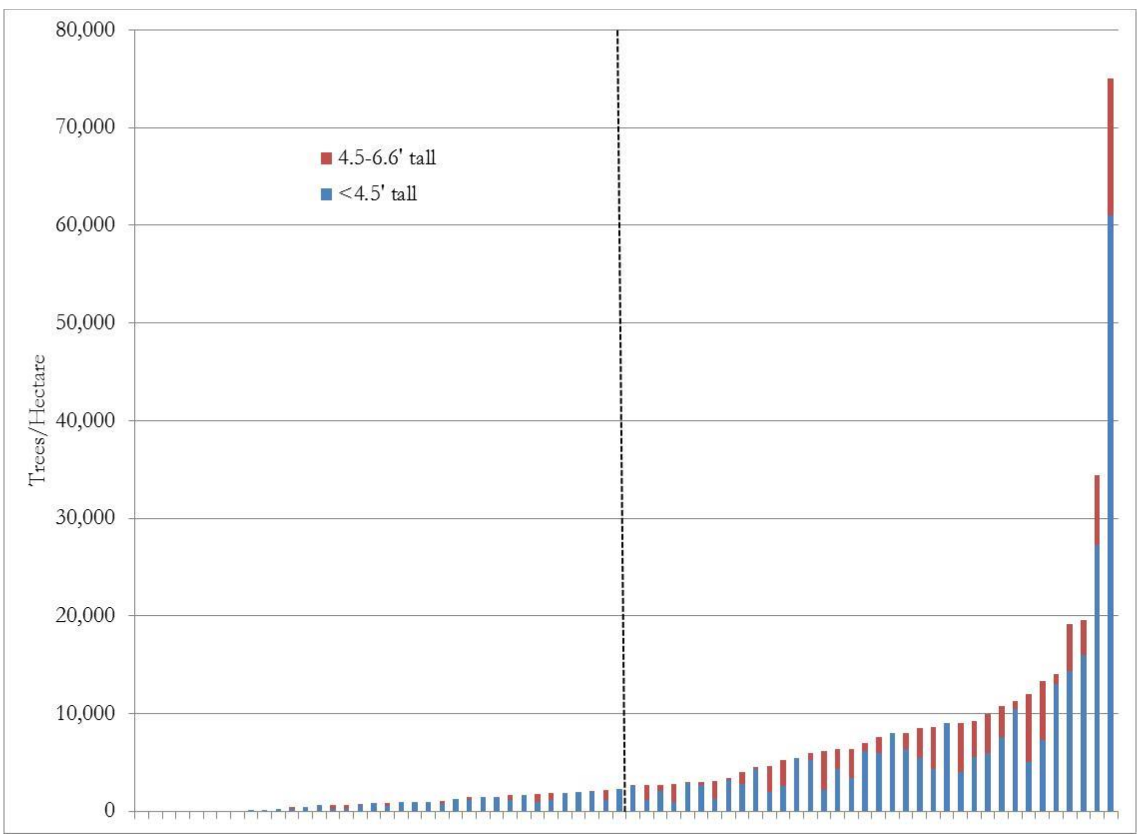


Figure 19. Map of aspen patches with or without potentially successful aspen reproduction. Criterion for reproduction is ≥ 2,470 aspens < 1" dbh / ha.

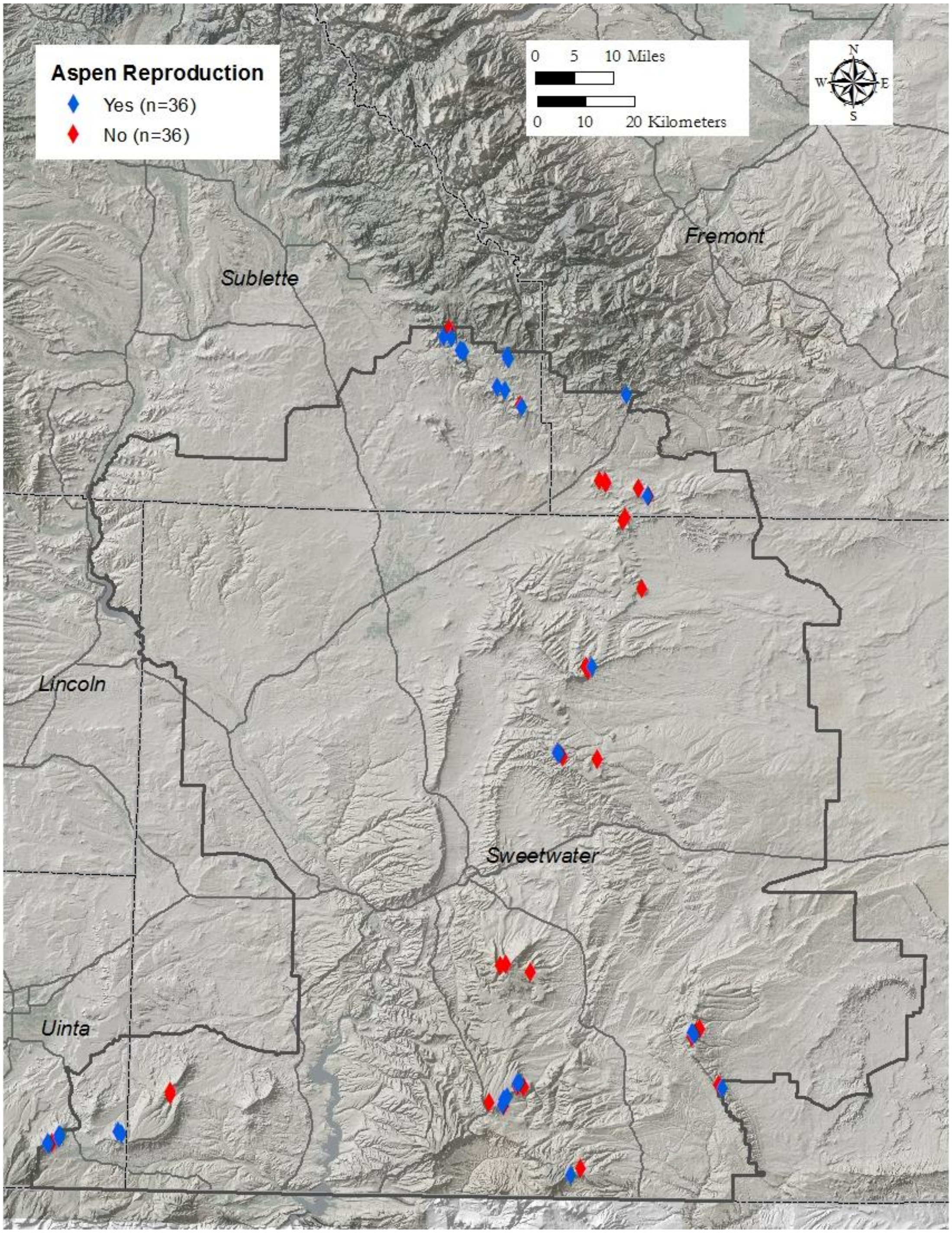
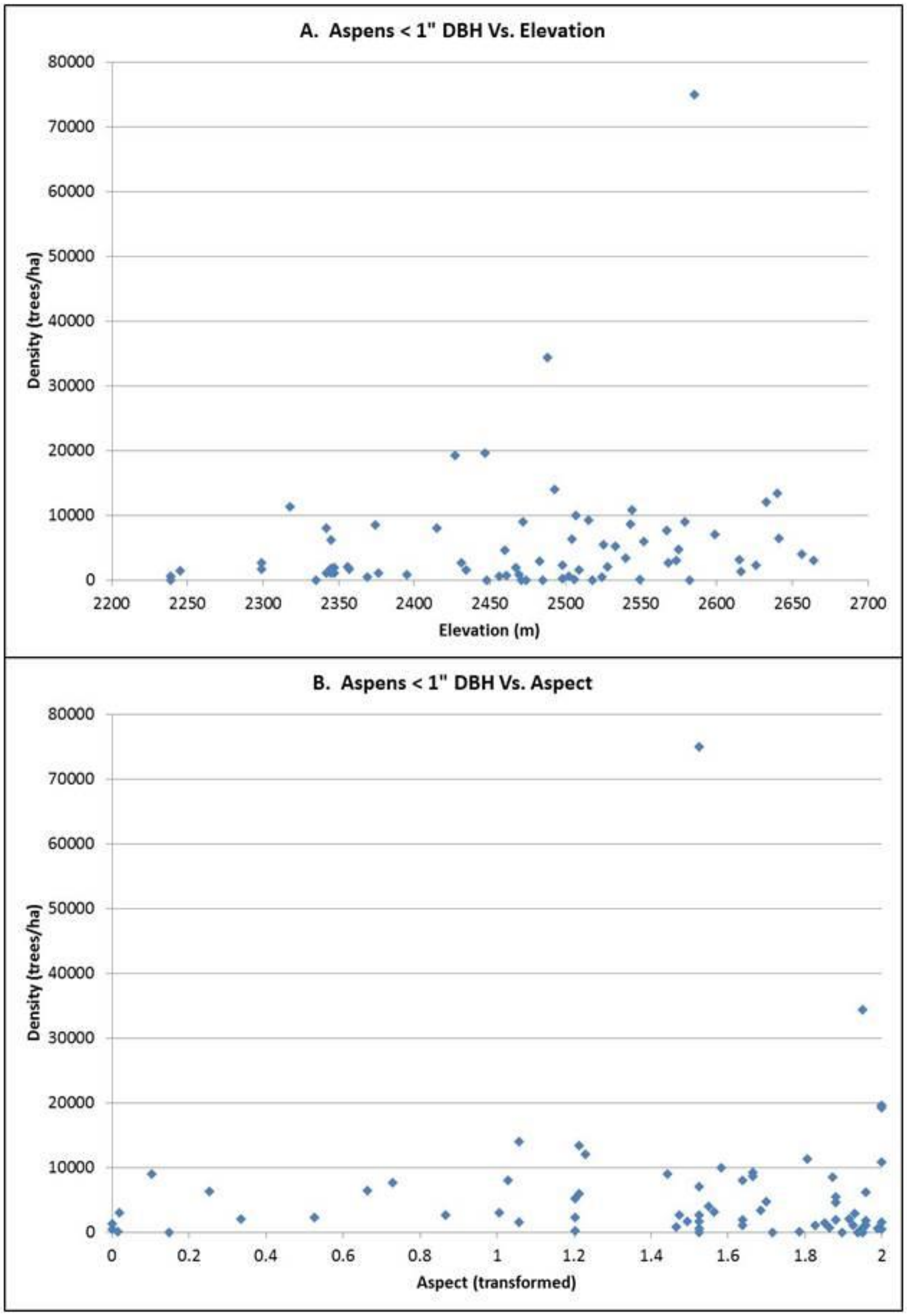


Figure 20. Density of aspen reproduction (trees < 1" DBH) related to elevation and to slope aspect.



BROWSING ON ASPEN REPRODUCTION

Browsing on young aspens can suppress regeneration of aspen stands. Two methods of assessing the amount of browsing pressure on small aspens were used in this project. The method of Keigley and Frisina (2011), the more rigorous of the two, was used in 2012. The architecture-class from Keigley and Frisina was recorded for each of 1,270 of the 1,473 aspens in size-classes 1 and 2 (i.e., trees < 1" dbh) encountered in 47 aspen patches. Over half of those trees showed no signs of browsing or were in the uninterrupted architecture-class (Figure 21), which indicates light-to-moderate browsing (Keigley and Frisina 2011). Nearly a third of the trees were in the arrested architecture class, which is produced by chronic, intense browsing. Very few trees were in the retrogressed class (which indicates a change from light-to-moderate browsing to intense browsing) or the released class (which indicates a change from intense browsing to light-to-moderate browsing).

Figure 22 shows the numbers of aspen patches in which the different architecture-classes contributed different proportions of the small aspens. As expected from the small numbers of trees in the retrogressed and the released classes, almost all of the patches had no aspens in those classes. In contrast, unbrowsed and uninterrupted-class aspens spanned the range of proportions of trees in a patch, from none of the trees in 7 patches to all of the trees in 4 patches. Aspens in the arrested class showed a similar pattern, although more of the patches had small proportions of these trees and fewer patches had proportions $\geq$ 0.8 of the trees.

Patches with light-to-moderate browsing and patches with heavy browsing both were well distributed throughout the study area (Figure 23).

Figure 21. Proportions of 1,473 live aspens in size-classes 1 and 2 (trees < 1" dbh) counted in 2012 in each browse-architecture class.

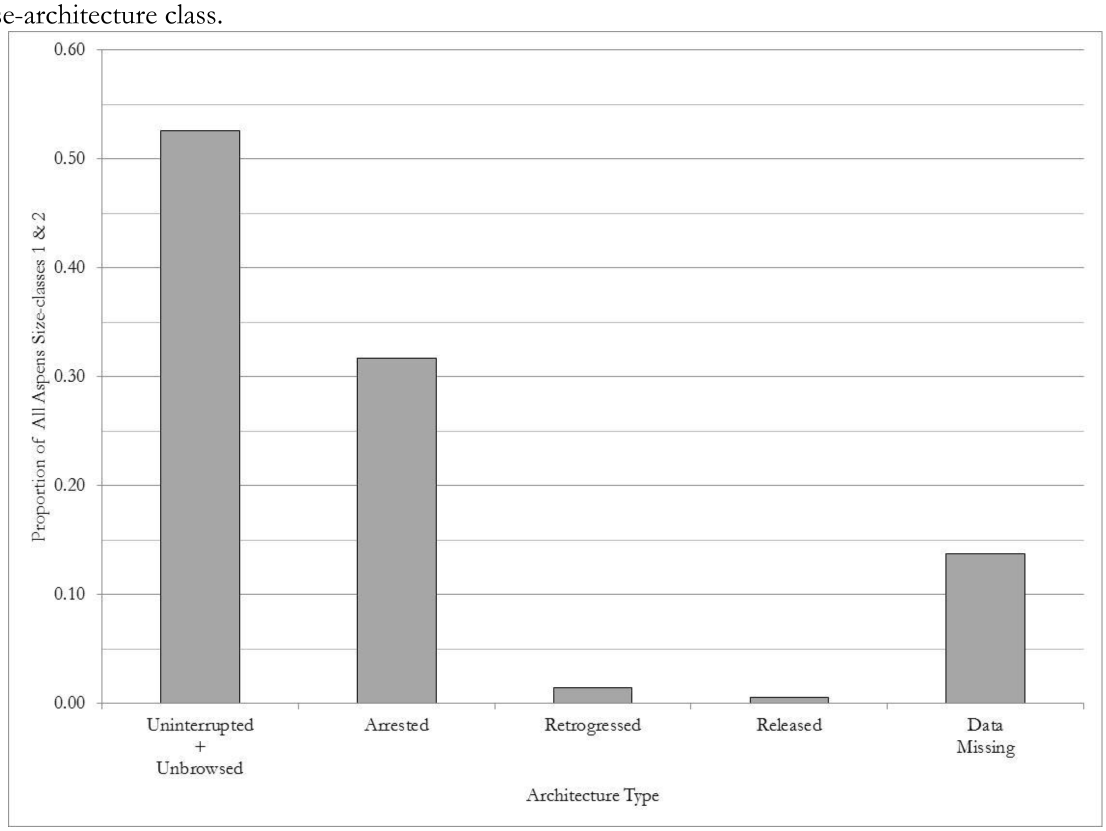


Figure 22. Relative abundances of aspens in size-classes 1 and 2 (trees <1" dbh) in each architecture-class in 47 aspen patches sampled in 2012.

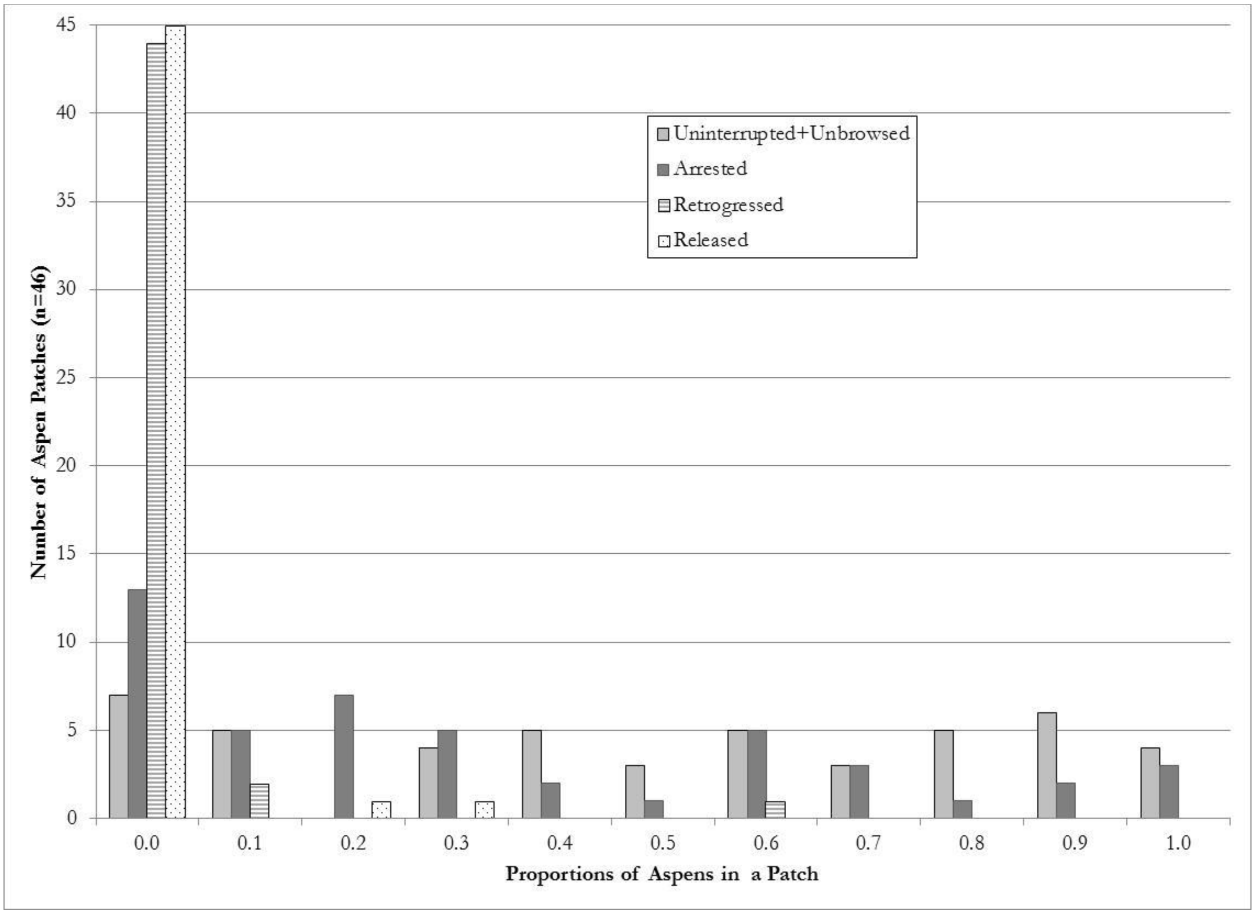
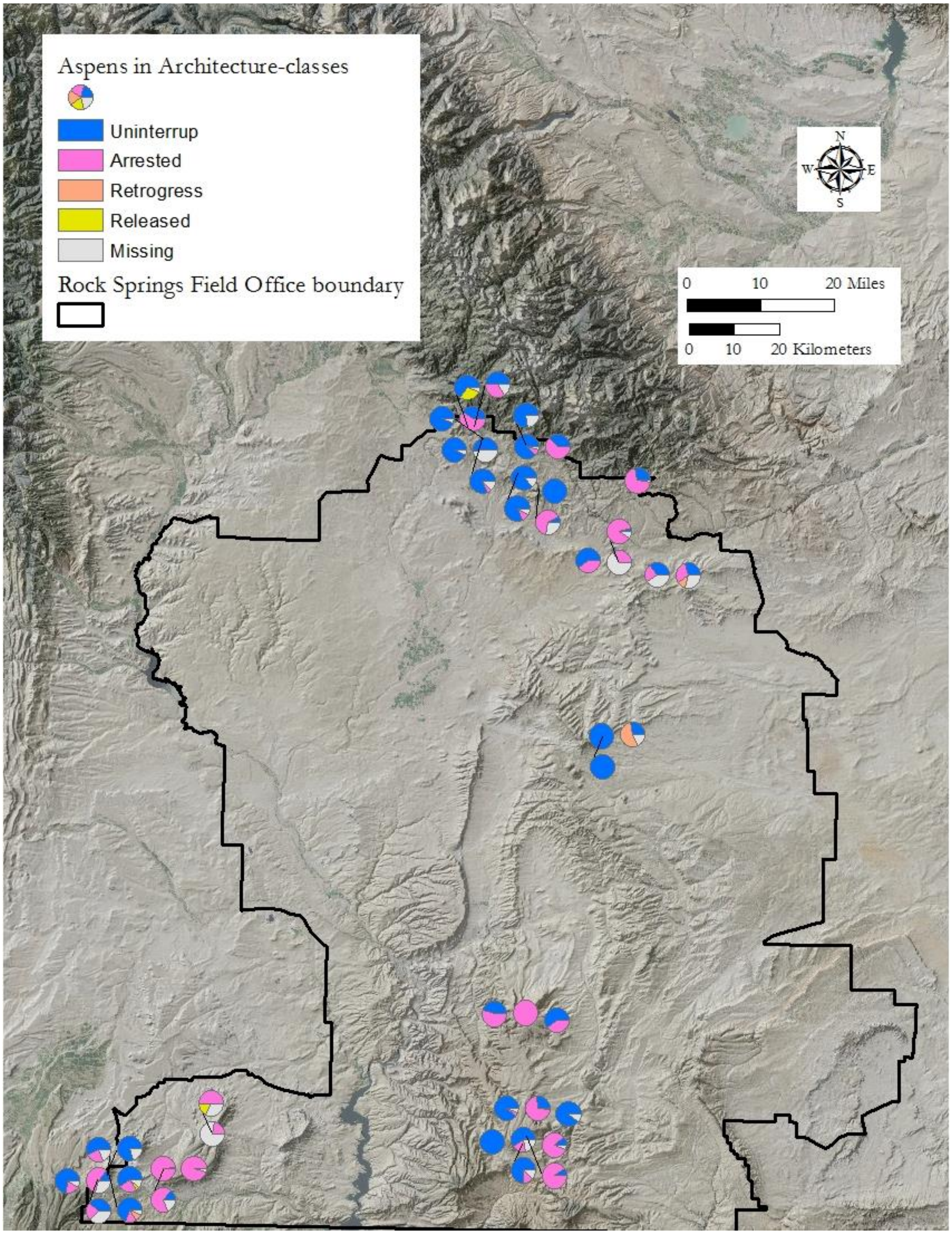


Figure 23. Map showing proportions of aspens < 1" dbh in each browse-architecture class, in patches sampled in 2012.
The Uninterrupted class includes unbrowsed trees.



In 2008, a less-rigorous method was used in an attempt to measure the degree of browsing on small aspens (size-classes 1 and 2, i.e., trees < 1" dbh): for each small aspen, the percentage of buds that had been browsed was recorded in one of 3 broad categories (none, <50%, ≥ 50%). Four hundred thirty-one aspens of this size were encountered and estimates were recorded for 419 of them. On over half of the small aspens, no sign of browsing was noted (Figure 24). On approximately 10% of the trees, fewer than 50% of the buds had been browsed. On about one-quarter of the trees, 50% of more of the buds had been browsed.

Unbrowsed aspen were found in many of the patches, and the proportion of unbrowsed trees in a patch ranged from none (in 4 patches) to all of the trees (in three patches) (Figure 25). Lightly-to-moderately browsed trees (<50% of buds) were found in 10 patches, and in most of those they accounted for only a fifth (or less) of the trees. More heavily browsed aspens (≥ 50% of buds per tree) were documented in 9 patches, in most of which they accounted for 70% or less of the trees. In only 1 patch did all of the small aspens have at least half of their buds browsed.

Figure 24. Proportions of 431 live aspens in size-classes 1 and 2 (trees <1" dbh) counted in 2008 in each category of percentage of terminal buds browsed.

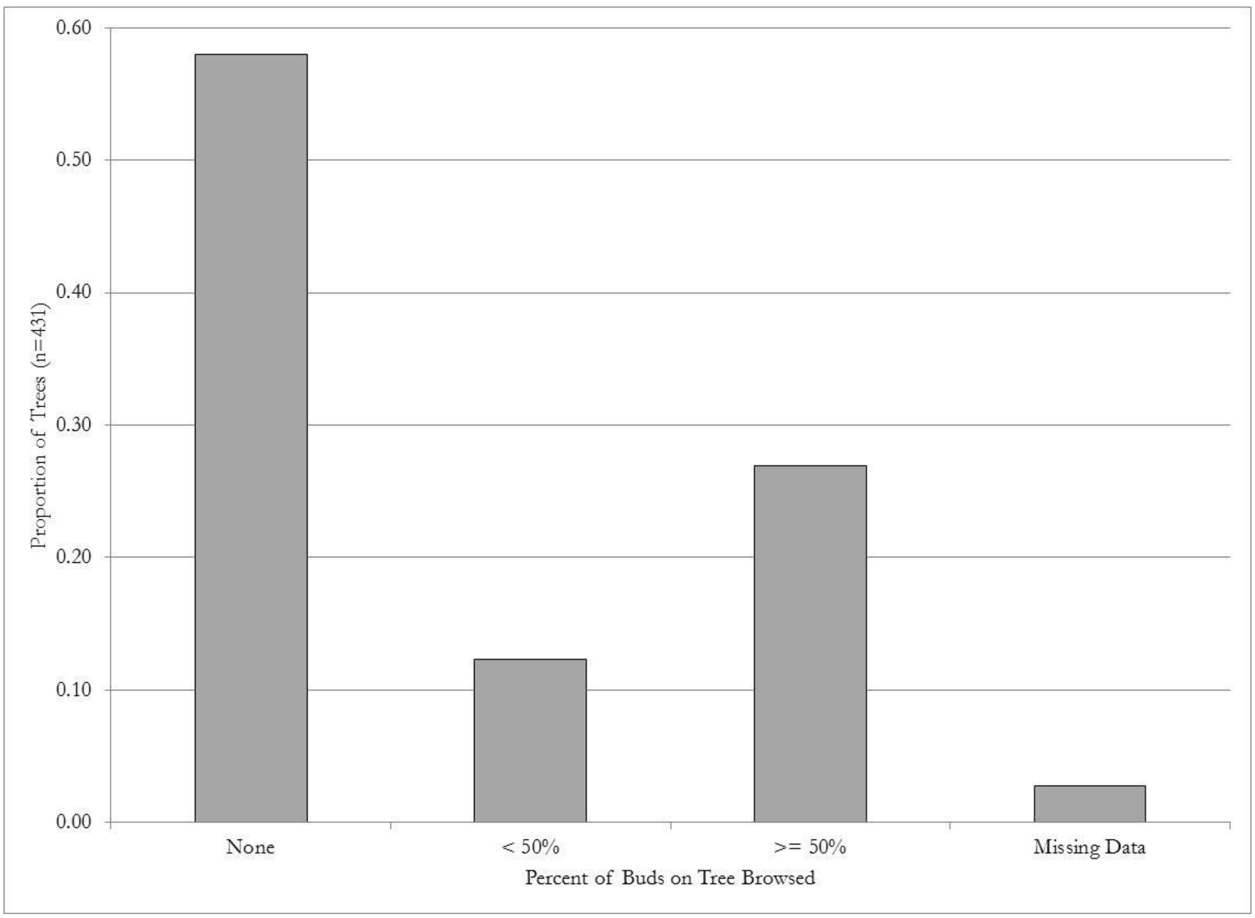
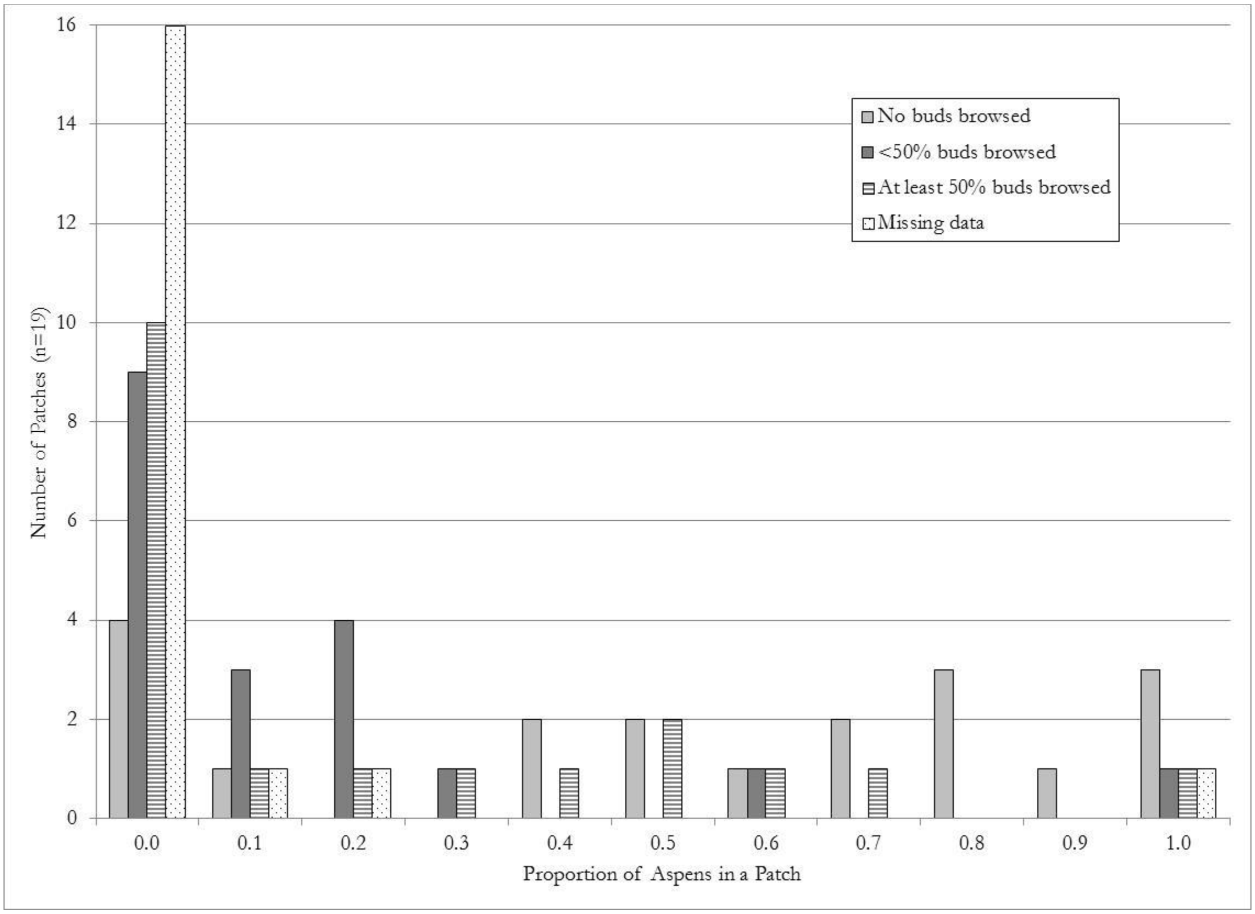
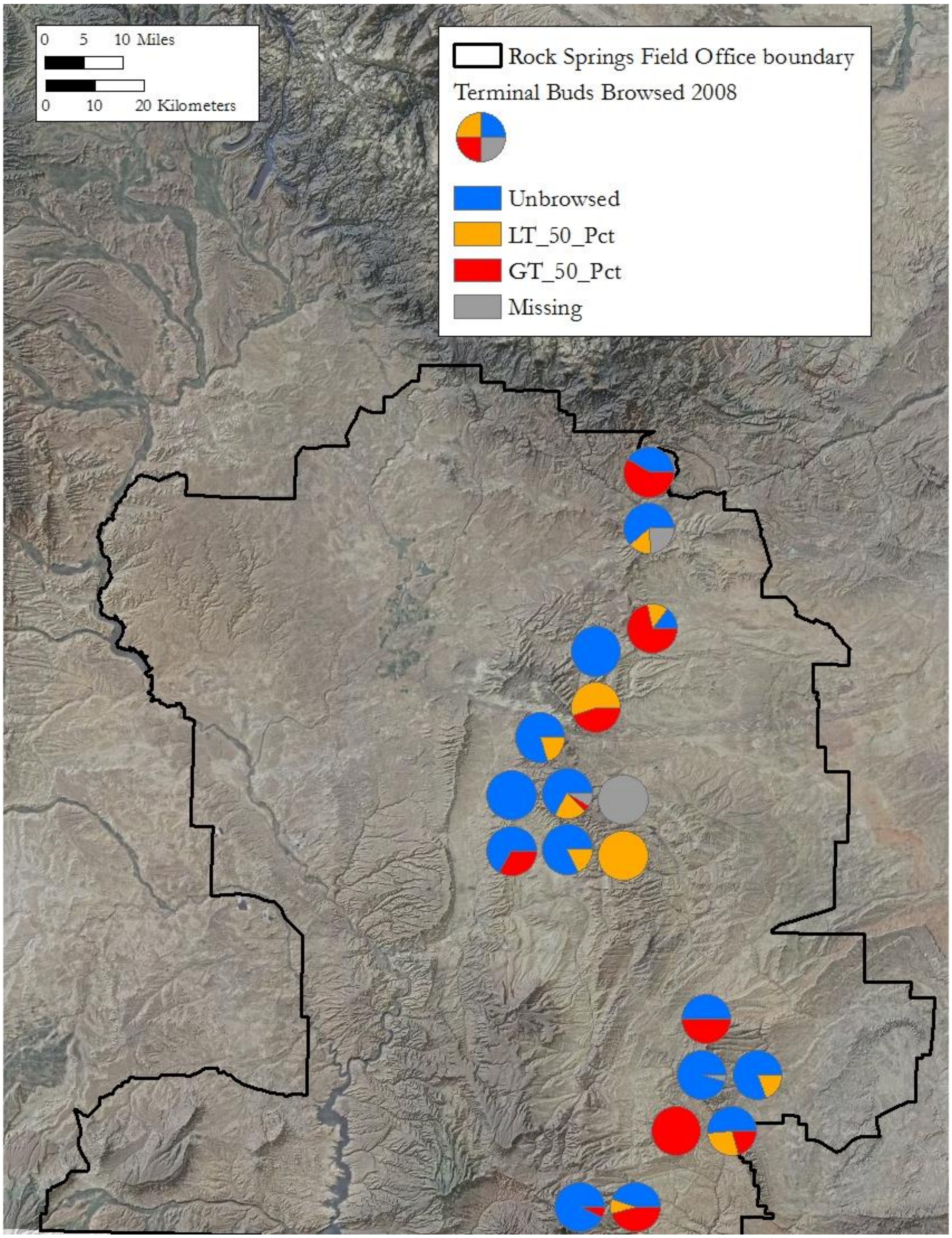


Figure 25. Relative abundances of aspens in size-classes 1 and 2 (trees < 1" dbh) in categories of percentage of terminal buds browed, in 19 aspen patches sampled in 2008.



Patches with little or no browsing on small aspens (i.e., patches with high proportions of small aspens unbrowsed or with <50% of buds browsed) were distributed throughout the study area (Figure 26). The patches with heavier browsing were less numerous but also were well distributed throughout the study area.

Figure 26. Map showing proportions of aspens < 1" dbh tall in each percentage-category of terminal buds browsed, in patches sampled in 2008.
Each category is the percentage of terminal buds on a tree that have been browsed.



FALLEN LOGS VERSUS STANDING TREES

Aspens account for at least 80% of the fallen logs in all but 6 of the 72 patches sampled, and for all of the fallen logs in 60 of the patches (Figure 27). A comparison of the proportion of aspen trunks among the fallen logs with the proportion among the standing trees would suggest whether the relative amount of aspens in a stand has changed markedly or remained nearly constant. Figure 27 shows that, in 44 of the 72 patches sampled, the proportion of aspens among fallen logs is the same as the proportion among standing trees. In 20 patches, aspens account for more of the fallen logs than they do of the standing trees; and in the remaining 8 patches, aspens account for a higher proportion of the standing trees than they do of the fallen logs. In most of the latter 28 stands, the difference in proportions is modest. Consequently, it appears that the representation of aspens among the trees has not changed substantially in recent years.

A comparison of the sizes of fallen logs with that of standing trees in a patch could suggest whether or not the size of aspen trees composing the patch has changed recently. If, for example, the proportions of trunks in the larger size-classes were greater for the fallen logs than for the standing trees, one could hypothesize that larger trees are now less common in the patch than they used to be. The distribution of standing trees among size-classes cannot be compared directly to the distribution of fallen logs among size-classes, because trees were counted in a plot and their abundance is expressed in number of trees per unit area, while logs were counted along a line and their abundance is expressed in number of logs per unit length.

The two can be compared indirectly, using the weighted averages of tree size-class and of log size-class. Even this comparison is complicated, though, because the small aspen logs may decay faster than the larger logs. (Information in the literature is unclear: Harmon *et al.* 1986 report that branches and smaller logs of other species decay faster, but Johnson *et al.* 2014 report no effect of trunk size on rate of mass loss). So the comparison was done twice, once including trees and logs in all size-classes and again excluding the trees and logs in the smallest size-class (trees < 4.5' tall, logs < 4.5' long).

In the first comparison, the weighted averages of the size-classes were calculated using the formula

$$\text{Weighted ave.} = \sum_{\text{Class 1}}^{\text{Class5}} (\text{Number of trunks X Size-class integer value})/\text{Number of trunks in all size-classes.}$$

Logs in the smallest size-class (<4.5' long) were rare in the sampled patches, so this comparison shows that the average log size-class exceeds the average tree size-class in a large majority of the patches (64 of the 72 patches; Figure 28). The differences in average size-class were substantial: in almost three-quarters (73%) of the patches, the averages differed by at least 20% (Figure 29).

In the second comparison, the weighted averages of the size-classes were calculated using the formula

$$\text{Weighted ave.} = \sum_{\text{Class 2}}^{\text{Class5}} (\text{Number of trunks X Size-class integer value})/\text{Number of trunks in all size-classes.}$$

In this comparison, too, the weighted-average log size-exceeded the weighted-average tree size-class in a majority of the aspen patches (44 of the 72 patches; Figure 30). The differences were more modest, with only one-third of the patches having differences of 20% or more (Figure 31).

The data do not permit a firm conclusion about change in size of aspens over recent years. If all of the downed aspen logs have been decaying at approximately the same rate, then the smallest size-classes of trees and logs should be included in the analysis, and it appears that the average size of aspen trees has declined substantially because (apparently) of a recent flush of new aspen sprouts. If we assume, though, that the smallest downed aspen decayed relatively rapidly and have largely disappeared, then leaving the smallest size-class of trees and logs out of the analysis is appropriate, and the data suggest a more modest decrease in size of aspens.

Figure 27. Proportion of aspens (all size-classes) among standing trees vs. proportion among fallen logs (all size classes) in 72 aspen patches.

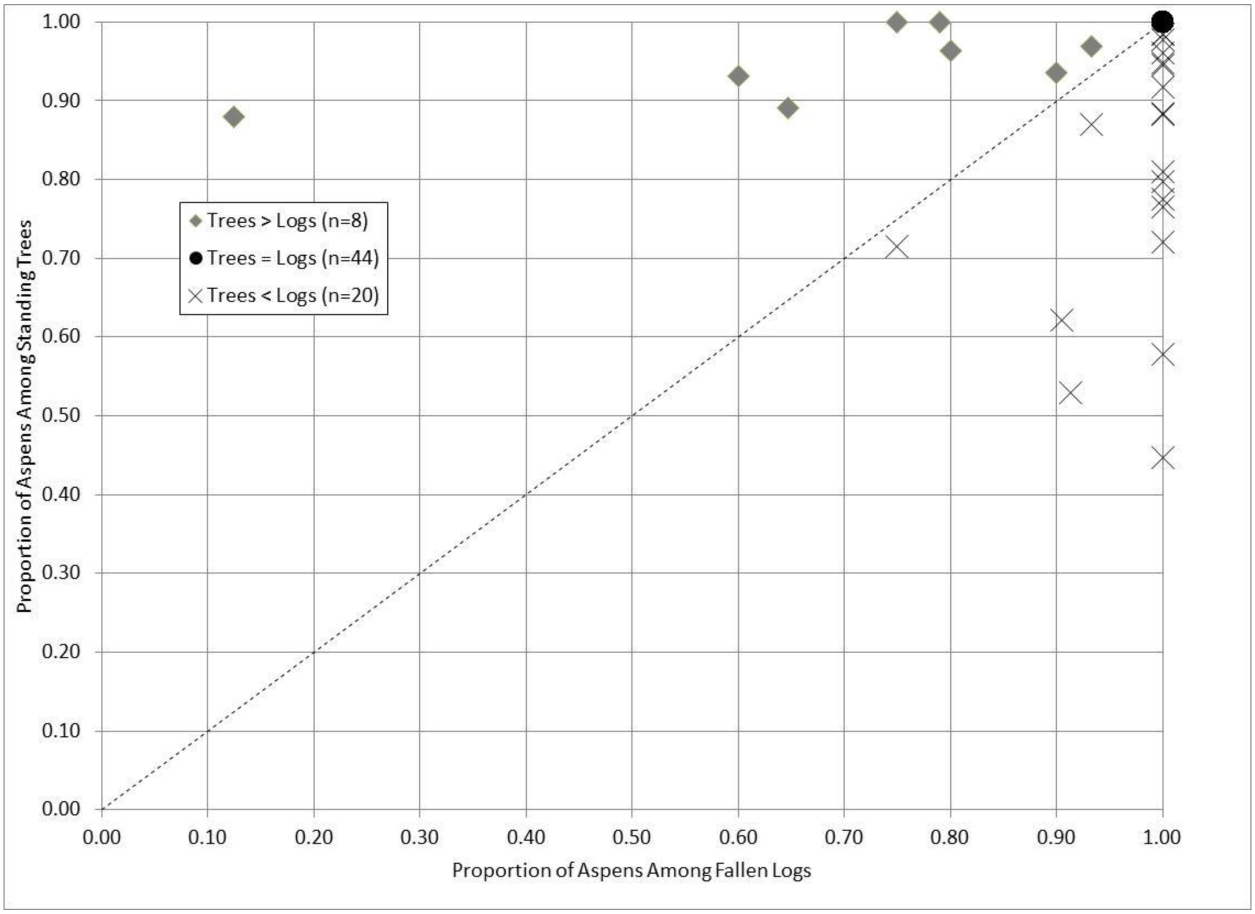


Figure 28. Weighted average size-class of standing aspen trees in all size-classes vs. weighted average size-class of fallen logs in all size-classes in 72 sampled patches.

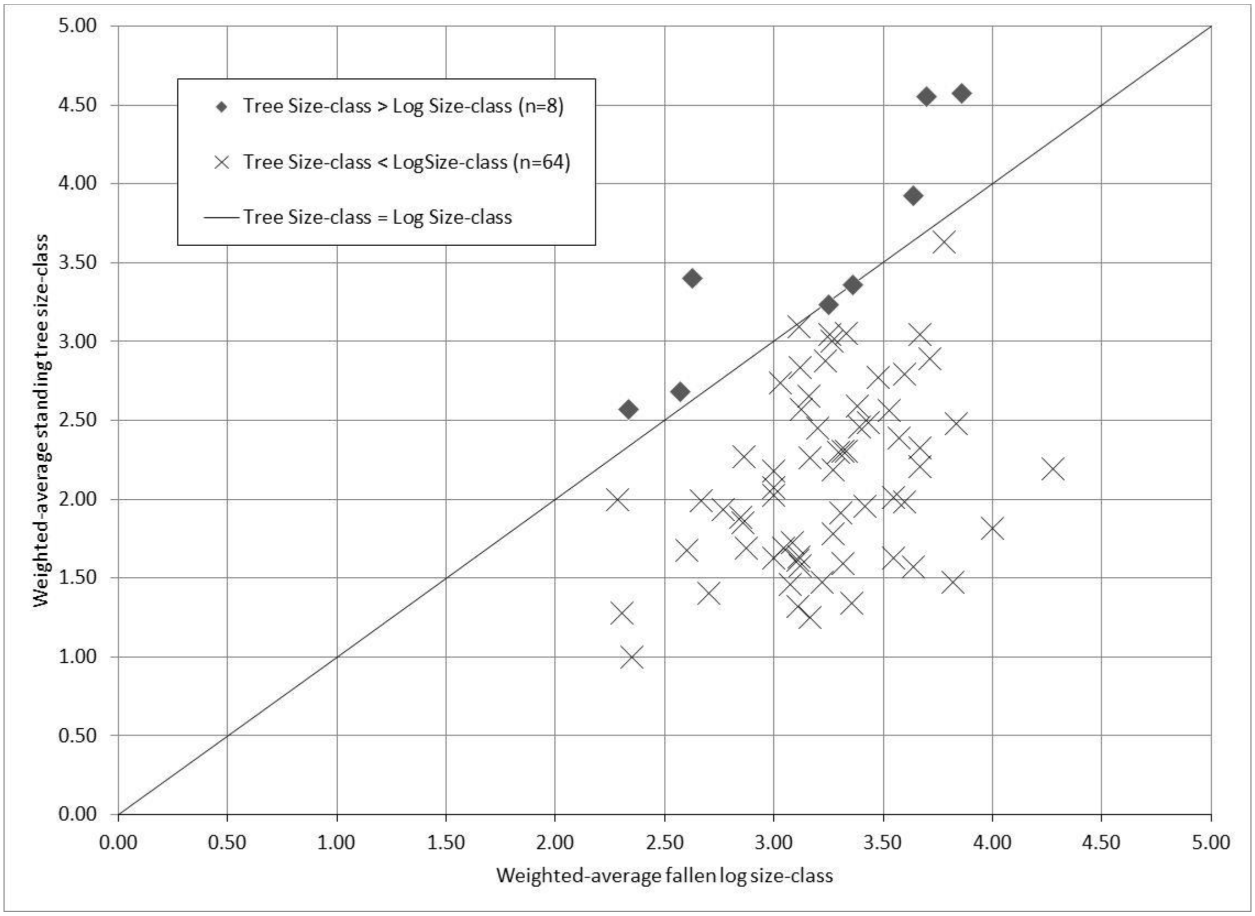


Figure 29. Difference between weighted-average size-class of aspen trees (in all size-classes) and weighted-average size-class of aspen logs (in all size-classes) in 72 aspen patches as a percentage of the larger average in the patch.

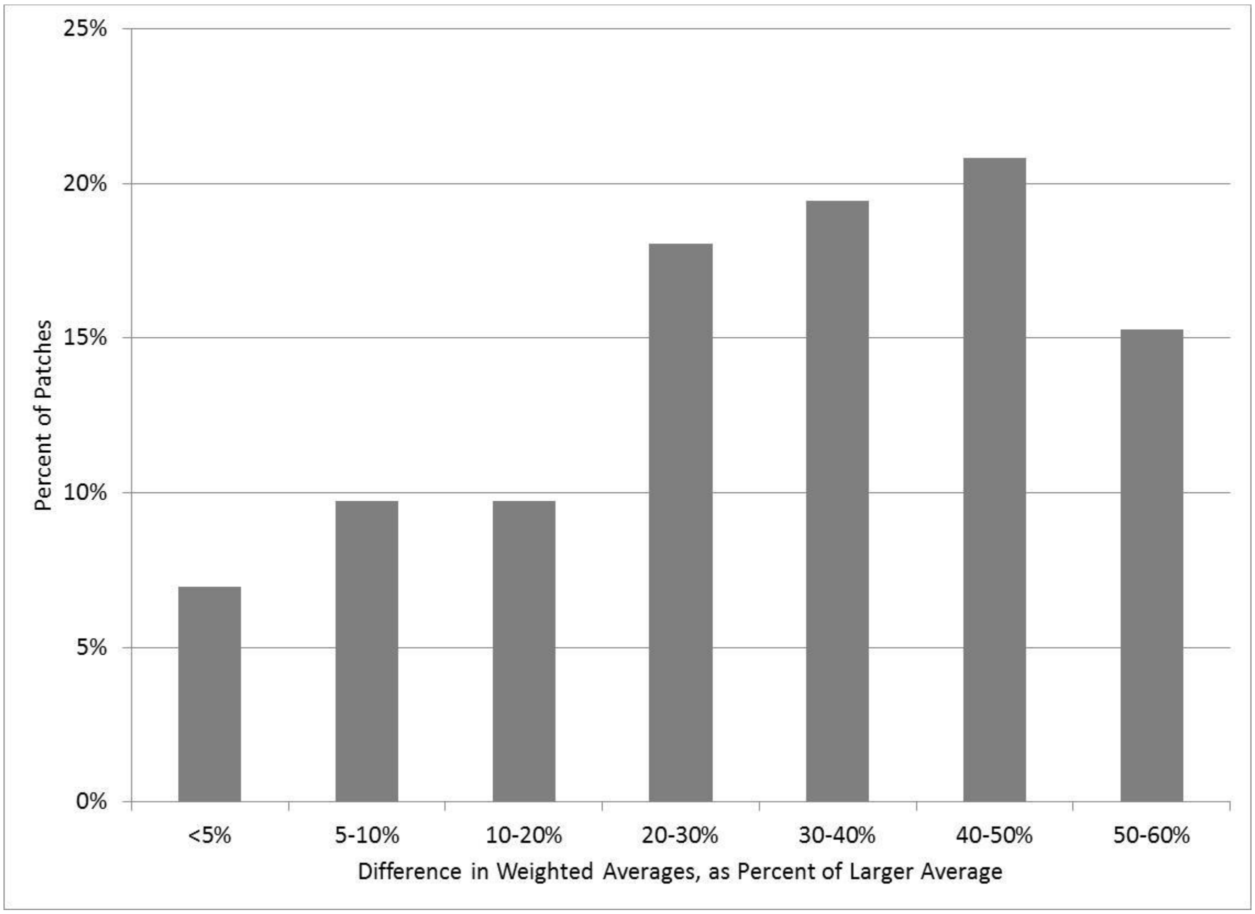


Figure 30. Weighted average size-class of standing aspen trees > 4.5' tall vs. weighted average size-class of fallen logs > 4.5' long in 72 sampled patches.

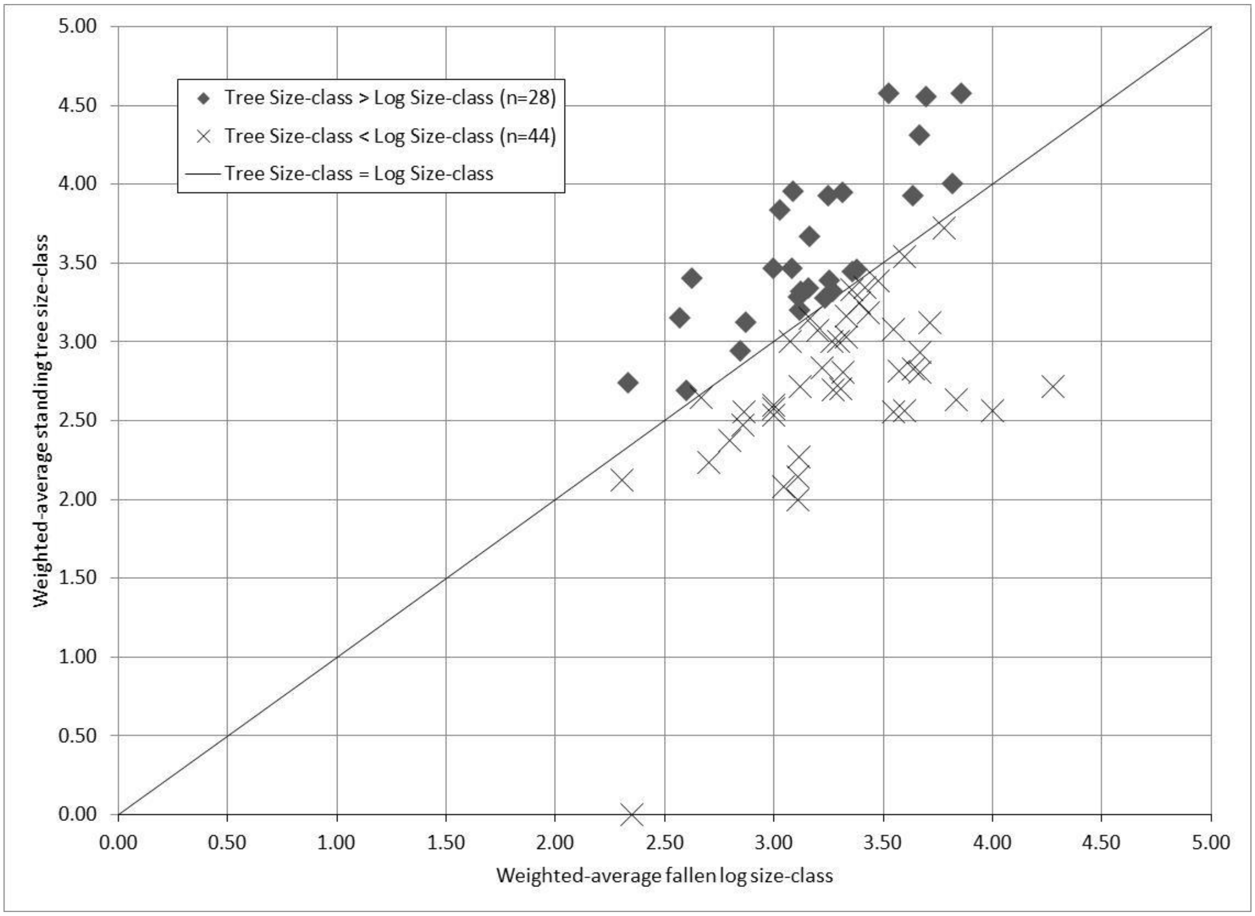
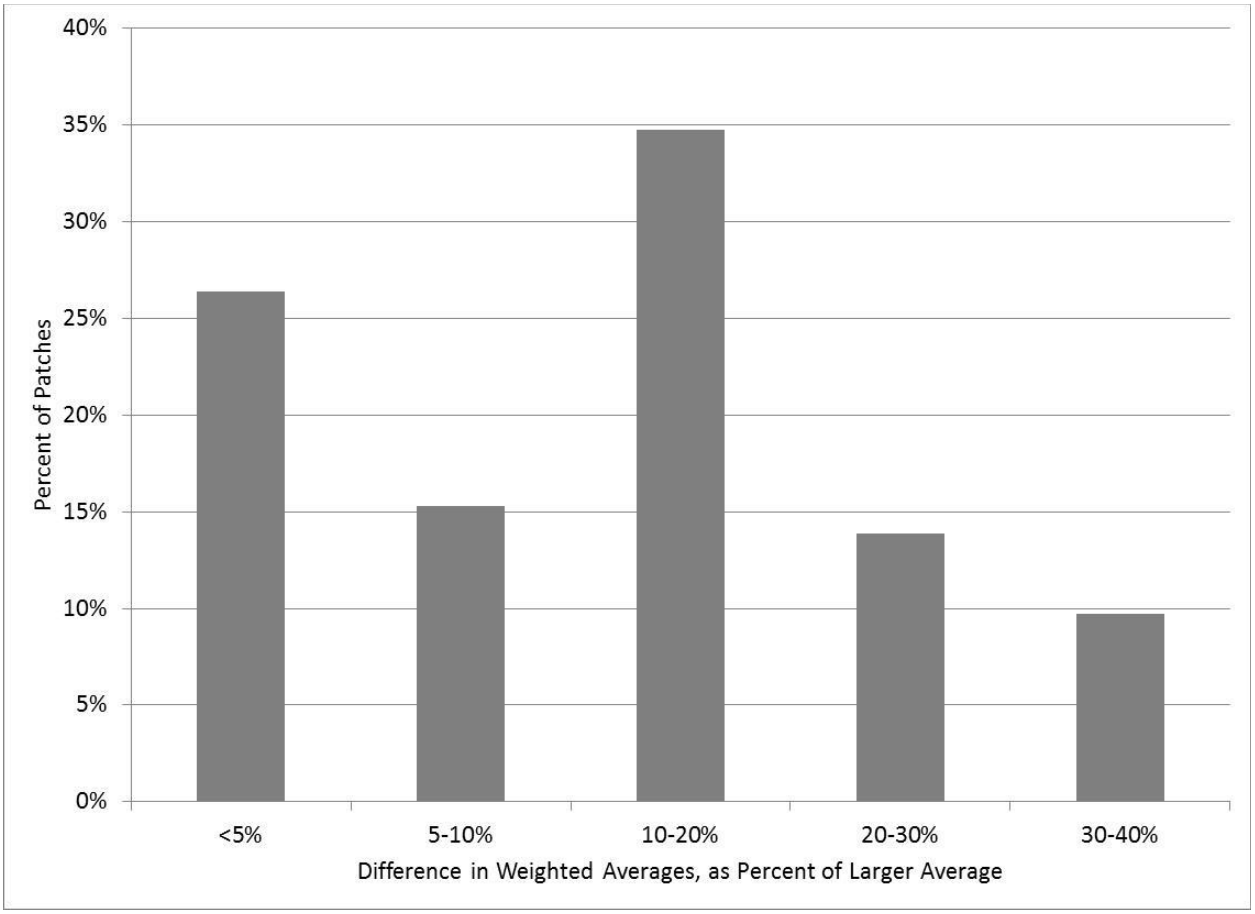


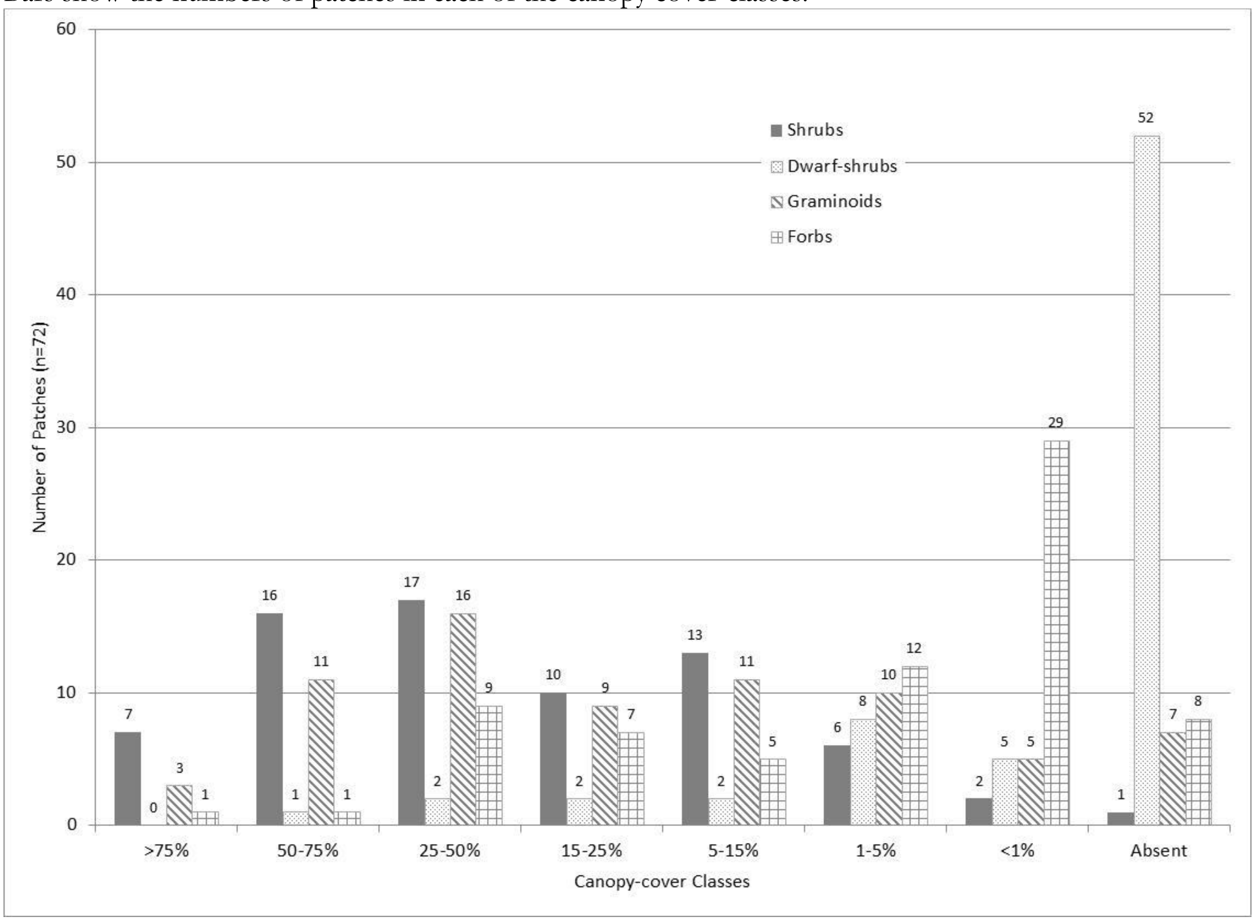
Figure 31. Difference between weighted-average size-class of aspen trees >4.5' tall and weighted-average size-class of aspen logs >4.5' long, in 72 aspen patches as a percentage of the larger average in the patch.



UNDERGROWTH VEGETATION

The undergrowth in most of the 72 aspen patches consists of a shrub stratum above a herbaceous stratum (Figure 32). Shrubs were documented in all but one of the patches, and in 40 of the 72 patches, their canopy cover was estimated to be at least 25%. Graminoids were present in 65 of the patches, and they contributed slightly less canopy-cover than did shrubs. Forbs were documented in nearly as many patches as were graminoids, but in most patches they accounted for less cover. Dwarf-shrubs were present in only 20 of the patches and they contributed little canopy cover in most patches.

Figure 32. Canopy-cover of plant growth-forms in undergrowths of 72 aspen patches.
Bars show the numbers of patches in each of the canopy cover-classes.



Common taxa in each growth-form are shown in Table 8. Only six taxa were found in at least one-third (24) of the patches. Four of those were shrubs: *Symphoricarpos oreophilus* (snowberry), *Artemisia tridentata*, (big sagebrush [mostly var. *vaseyana*, mountain big sagebrush]), *Juniperus communis* (common juniper), and *Rosa* sp. (rose). The other two were graminoids: *Carex rossii* (Ross's sedge) and *Achnatherum* sp. (needlegrass [probably mostly *A. lettermannii*, Letterman's needlegrass]). Non-native plant species seem to be minor components of the flora of the aspen patches: *Poa pratensis* (Kentucky bluegrass) was documented in 17 patches, and the two exotic forbs noted during the surveys, *Taraxacum* sp. (dandelion, which may have included native species) and *Cirsium arvense* (Canada thistle) were recorded from only 5 and 3 patches, respectively. *Phleum pratense* (meadow timothy) was noted in one patch.

Table 8. Common plant species in each growth form recorded in 72 aspen patches. Taxa in shaded rows are exotics. Scientific names are from Dorn (2001).

Species	**Number of Patches**
SHRUBS	
Symphoricarpos oreophilus var. *utahensis*	63
Artemisia tridentata (mostly var. *vaseyana*)	38
Juniperus communis	31
Rosa sp.	24
Amelanchier sp.	17
Prunus virginiana	15
Ribes cereum	14
Ribes sp. (prickly)	7
Purshia tridentata	7
DWARF-SHRUBS	
Mahonia repens	20
Arctostaphylos uva-ursi	8
GRAMINOIDS	
Carex rossii	27
Achnatherum sp. (mainly *A. lettermannii*?)	24
Elymus spp. (mainly *E. virginicus*?)	17
Poa pratensis	17
Elymus trachycaulus	14
Festuca idahoensis	14
Leucopoa kingii	12
Bromus spp. (tall natives)	15
Elymus cinereus	12
Elymus smithii	7
FORBS	
Galium sp. (primarily *G. boreale*)	18
Lupinus sp.	18
Antennaria sp.	11
Thalictrum sp.	9
Achillea millefolium	8
Maianthemum stellatum	7
Osmorhiza sp.	7
Taraxacum sp. (may include native species)	5
Cirsium arvense	3

ASPEN COMMUNITY-TYPES

The classification of aspen community-types in the U.S. Forest Service's Intermountain Region (Mueggler 1988) is a framework for understanding the relationships between vegetation and environment and the values that different types of aspen stands provide. The methods used in this project were not designed to classify the aspen stands into types with a high degree of resolution, but the information about species composition of the understory does allow for their tentative placement into types from the Intermountain Region classification.

The majority of the aspen patches appear to fall within *P. tremuloides* types with low-shrub undergrowths (Table 9). The most common of those are types in the *P. tremuloides/Symphoricarpos oreophilus* Low Shrub Undergrowth Type (25 patches). The *P. tremuloides/Artemisia tridentata* community-type is represented by 15 patches, and *P. tremuloides/Juniperus communis* types by 11 patches. Ten patches appear to represent *P. tremuloides* Herb Undergrowth community-types. Because of the way that potential sampling points were selected for this project, only 8 of the 52 patches belong to *P. tremuloides* - conifer cover-types.

Assigning the aspen patches to Intermountain Region aspen types may guide managers to information useful in the management of aspen woodlands in the Green River Basin. The information collected in this project about these patches (and stands) may also increase the understanding of the distribution and environmental niches of those types. Both should be done only after the relationships of these aspen patches to the Intermountain Region types are clearer, and that clarity will require more-detailed data on composition of the understories.

Table 9. Numbers of the 72 Aspen Patches Tentatively Placed Into Cover-types, Undergrowth-types, and Community-types of the U.S. Forest Service Intermountain Region Aspen Community-type Classification.

Community-Types	Number of Patches
P. tremuloides **Tall Shrub Undergrowth Types (3 patches total)**	**3**
P. tremuloides/Amelanchier alnifolia Tall Shrub Undergrowth Type	1
P. tremuloides/Amelanchier alnifolia/Symphoricarpos oreophilus/Bromus carinatus Community-Type	1
P. tremuloides-Salix scouleriana Community-Type	1
P. tremuloides **Low Shrub Undergrowth Types (51 patches total)**	**51**
P. tremuloides/Artemisia tridentata Community-Type	15
P. tremuloides/Juniperus communis Low Shrub Undergrowth Type (community-type unknown)	6
P. tremuloides/Juniperus communis/Lupinus argenteus Community-Type	5
P. tremuloides/Symphoricarpos oreophilus Low Shrub Undergrowth Type (community-type unknown)	6
P. tremuloides/Symphoricarpos oreophilus/Bromus carinatus Community-Type	8
P. tremuloides/Symphoricarpos oreophilus/Calamagrostis rubescens Community-Type	1
P. tremuloides/Symphoricarpos oreophilus/Carex rossii Community-Type	5
P. tremuloides/Symphoricarpos oreophilus/Poa pratensis Community-Type	2
P. tremuloides/Symphoricarpos oreophilus/Thalictrum fendleri Community-Type	3
P. tremuloides **Herb Undergrowth Types (10 patches total)**	**10**
P. tremuloides/Bromus carinatus Community-Type	2
P. tremuloides/Carex rossii Community-Type	6
P. tremuloides/Stipa comata Community-Type	2
P. tremuloides-Pinus contorta **Cover-Types (3 patches total)**	**3**
P. tremuloides-Pinus contorta Cover-Type (community-type unknown)	1
P. tremuloides-Pinus contorta/Juniperus communis Community-Type	2
P. tremuloides-Pinus flexilis **Cover-Type (3 patches total)**	**3**
P. tremuloides-Pseudotsuga menziesii **Cover-Types (2 patches total)**	**2**
P. tremuloides-Pseudotsuga menziesii/Calamagrostis rubescens Community-Type	1
P. tremuloides-Pseudotsuga menziesii/Juniperus communis Community-Type	1

SUMMARY

This study provides a general picture of the species composition, stand structure, and condition of the aspen stands in the central part of the Green River Basin, and of the amount of variation in the stands. Small aspens (<4.5' tall) are, by far, the most common trees, and are present in nearly every aspen patch. The larger the trees, the less abundant they are, except for the largest aspens (≥ 8" dbh), which are slightly more numerous than trees in the next-smaller size-class. These large trees are uncommon but are scattered throughout the area. In most stands, the majority of the aspens are alive, and the canopies of these live trees generally are vigorous (judging by the percent of the canopy alive). The proportion of vigorous canopies is greatest among the small trees and generally declines with increasing tree size, although a surprising proportion of the largest trees appear to have healthy canopies

In almost every stand examined, the overstory and the understory are composed entirely, or nearly so, of aspens. Density of trees in different size-classes, and the resulting stand structure, vary widely among stands. Some stands are thickets of aspen sprouts and saplings with few overstory trees, some are groves of larger overstory trees with few small understory trees, and many stands are intermediate between these structural types. Conifers (*Pinus flexilis*, *Pinus contorta*, *Pseudotsuga menziesii*) are present in a small proportion of stands, almost always in low numbers compared to the aspens. There seems to be no cause for concern that conifer stands will replace these aspen stands. Judging from the proportion of aspens among the standing trees, compared to the proportion among the fallen logs, the tree strata in these stands have been composed of aspens for a very long time (and perhaps for the entire history of the stands). Whether the size of the aspens in these stands has changed in recent times is less clear; at best, there is only a suggestion that aspens used to be, on average, slightly larger than they are now.

A more serious potential problem is that small aspens stands in the central part of the study area will disappear as the overstory trees die. Very few aspen patches there have small aspens in densities thought to be necessary for stand regeneration. Topography exerts a strong control on those stands, which occur (with few exceptions) on the upper parts of northerly and easterly slopes. These are sites where windblown snow is likely to form drifts, and the occurrence of these stands may well depend on the soil water provided by melting snow. Successful regeneration seems to be more common in stands around the margins of the study area, which are less closely tied to slopes with northerly or easterly aspects. Whatever the reason for this pattern of potential regeneration, it appears to not be a simple response to elevation or slope aspect.

Browsing may prevent stand regeneration even where small aspens are present in sufficient densities, but stands with a high proportion of small aspens showing signs of light browsing are more common than stands with a high proportion showing signs of heavy browsing. Hence browsing does not appear to be a chronic problem throughout the study area.

While the information from this project provides managers with a general picture of the aspen stands in the area, it does not (by its design) give them information they need to prescribe management practices for individual stands. That information must come from more-detailed examination of structure and condition.

LITERATURE CITED

Barnett, David T. and Thomas J. Stohlgren. 2001. Aspen Persistence Near the National Elk Refuge and Gros Ventre Valley Elk Feedgrounds of Wyoming., USA. Landscape Ecology 16: 569-580.

Beers, T.W., P.E. Dress, and L.C. Wensel. 1966. Aspect Transformation in Site Productivity Research. J. Forestry 4:691-692.

Bowen, Z.H., C.L. Aldridge, P.J. Anderson, G.W. Chong, M.A. Drummond, C. Homer, R.C. Johnson, M.J. Kauffman, S.T. Knick, J.J. Kosovich, K.A. Miller, T. Owens, S. Shafer, and M.J. Sweat 2009. U.S. Geological Survey Science Strategy for the Wyoming Landscape Conservation Initiative: U.S. Geological Survey Scientific Investigations Report 2008-5195, 26 p.

DeByle, Norbert V. and Robert P. Winokur (editors). 1985. Aspen: Ecology and Management in the Western United States. USDA Forest Service General Technical Report RM-119. Rocky Mountain Forest and Range Experiment Station, Fort Collins CO.

Dorn, Robert D. 2001. Vascular Plants of Wyoming. Third Edition. Mountain West Publishing, Cheyenne WY.

Eastern Idaho Aspen Working Group. 16 December 2008. Aspen Stand Risk Assessment Protocol. http://www.eiawg.org/uploads/ASPEN_STAND_RISK_ASSESMENT_PROTOCOL_3-12-14.pdf

Grove, Simon J., Lee Stamm, and Christopher Barry. 2009. Log Decomposition Rates in Tasmanian *Eucalyptus obliqua* Determined Using An Indirect Chronosequence Approach. Forest Ecology and Management 258: 389–397.

Harmon, M.E., J.F. Franklin, F.J. Swanson, P. Sollins, S.V. Gregory, J.D. Lattin, N.H. Anderson, S.P. Cline, N.G. Aumen, J.R. Sedell, G.W. Lienkamper, K. Cromack, Jr., and K.W. Cummins. 1986. Ecology of Coarse Woody Debris in Temperate Ecosystems. Advances in Ecological Research 15: 133-302.

Johnson, Chris E., Thomas G. Siccama, Ellen G. Denny, Mary Margaret Koppers, and Daniel J. Vogt. 2014. In situ decomposition of northern hardwood tree boles: decay rates and nutrient dynamics in wood and bark. Canadian Journal of Forest Research 44(12): 1515-1524, 10.1139/cjfr-2014-0221.

Jones, George P. 2007. Distribution of Aspen Woodlands in the Bureau of Land Management's Rock Springs (Wyoming) Field Office, and a Proposal for Field Study of Their Nature and Condition. Final Report for Assistance Agreement KAA041040 between the BLM Rock Springs Field Office and the University of Wyoming, Wyoming Natural Diversity Database. 32 pp. Unpublished. Available on line at http://www.uwyo.edu/wyndd/reports-and-publications/

Jones, George . 2009. Final Report for the 2008 Aspen Woodland Study in the BLM's Rock Springs Field Office, Southwestern Wyoming. University of Wyoming - Bureau of Land Management Cooperative Agreement KAA089014. 56 pp. + 2 appendices. Available on line at http://www.uwyo.edu/wyndd/reports-and-publications/

Keigley, Richard B. & Michael R. Frisina. 2011. Process to Monitor and Manage Ungulate Browsing Pressure. Natural Resources and Environmental Issues Vol. 16, Article 29. Available at: http://digitalcommons.usu.edu/nrei/vol16/iss1/29.

MacMillan, Paul. C. 1981. Log Decomposition in Donaldson's Woods, Spring Mill State Park, Indiana. American Midland Naturalist 106 (2): 335-344.

Merrill, Evelyn H., Thomas W. Kohley, Margo E. Herdendorf, William A. Reiners, Kenneth L. Driese, Ronald W. Marrs, and Stanley H. Anderson. 1996. The Wyoming Gap Analysis Project Final Report. University of Wyoming, Laramie WY. 109 pp. + appendices.

Mueggler, W.F. 1988. Aspen Community Types of the Intermountain Region. USDA Forest Service General Technical Report INT-250. Intermountain Research Station, Ogden UT.

Mueggler, W.F. 1989. Age Distribution and Reproduction of Intermountain Aspen Stands. Western Journal of Applied Forestry, Volume 4, Number 2, 1 April 1989, pp. 41-45(5). Abstract only.

Shepperd, Wayne D., Dan Binkley, Dale L. Bartos, Thomas J. Stohlgren, and Lane G. Eskew (compilers). 2000. Sustaining Aspen in Western Landscapes: Symposium Proceedings; 13-15 June 2000; Grand Junction, CO. Proceedings RMRS-P-18, USDA Forest Service, Rocky Mountain Research Station, Fort Collins CO.

APPENDIX 1. FIELD SAMPLING INSTRUCTION MANUAL AND FORMS

ROCK SPRINGS FIELD OFFICE ASPEN SURVEY

FIELD SAMPLING MANUAL, 2012

I. WHAT QUESTIONS DO WE WANT TO ANSWER?

A. ARE THE LOW-ELEVATION ASPEN STANDS ON THE BLM ROCK SPRINGS FIELD OFFICE LANDS HEALTHY?

1. Are the individual trees vigorous?
2. Are signs of successful aspen reproduction common or rare in the aspen stands?
3. Are the aspen being replaced by conifers?

B. WHAT IS THE PHYSICAL HABITAT STRUCTURE IN THESE ASPEN STANDS?

1 What vegetation layers are present?
2 How tall and dense are those layers?
3 What growth-forms of plants make up those layers?

C. HOW DO THESE LOW-ELEVATION STANDS DIFFER FROM ASPEN STANDS IN THE NEARBY MOUNTAINS AND IN THE INTERMOUNTAIN REGION?

1. Are there obvious differences in vegetation structure and plant species dominance?
2. Do these stands represent different plant associations or dominance types?

D. HOW HAVE THE ASPEN STANDS CHANGED IN THE PAST YEARS?

1 How common are sites where aspen stands have been replaced by other types of vegetation? What types of vegetation?
2 Did these aspen stands used to be more dense, or larger?

II. WHAT KINDS OF INFORMATION (OR DATA) WILL BE COLLECTED, AND HOW?

A. THE STAND

We will collect information in stands of vegetation where aspen grows now, or where it used to grow but only dead aspens (either standing or fallen) are now present. For our purposes, the **stand** of vegetation of interest is defined as the area of vegetation in which we find live aspen or dead aspen trunks (standing or fallen), and throughout which the same overstory vegetation layer is present and the same plant species contribute the most canopy cover. The edges of the stand are marked by change in the nature of the overstory layer or in dominant species. We assume that we will find only one stand of interest at each sampling point.

A single stand of vegetation (especially woodland), though, may contain more than one patch. A **patch** is an area of vegetation within which the vegetation layers present, the sapling and tree density, and the mix of tree stem sizes do not differ obviously or substantially. At the edge of a patch, at least one of these vegetation features does change, and one patch is distinguished from adjacent patches by a substantial, obvious difference in layers present, or tree density, or mix of tree stem sizes.

We will briefly describe the stand of vegetation that we encounter at each sampling point, and describe in more detail the patches in those stands.

B. THE SAMPLING AREA

The sampling area is a circle of 50 meters radius (0.79 ha area) centered on the sampling point. We will use the sampling area to select the vegetation patches from which we will collect information, and will sample only the patches that intersect the sampling area. If the vegetation stand at a point contains patches outside the sampling area, we will note their presence but not sample them.

C. EACH PATCH IN THE SAMPLING AREA.

The following information will be collected for each patch *that covers at least 10% of the circular sampling area (i.e., at least 800 square meters)*. If the sampling area includes a patch that covers less than 800 square meters, simply note the presence of that patch, but don't sample it. (See Form 2, part A).

1. Vegetation description. This will be semi-quantitative information on the vegetation layers present, the height of each layer, the amount of cover contributed by each plant growth form in each layer, and the 3 or 4 most common plant species in each layer. The description will be made for each patch of vegetation that intersects the sampling area, and will be based on observation of the entire patch.

2. Size-class composition of the tree component. These will be quantitative data, collected in belt transects of various sizes, depending on the density of trees in the patch. Every tree rooted in a belt transect will be counted, classified as alive or dead, and classified into a size-class category.

3. Health of individual trees. This information will be quantitative and categorical, and will be collected from the belt transects. Every tree rooted in a belt transect will be examined. On trees larger than reproduction (>6.6 ft. tall), the presence of trunk wounds and conks will be noted and the percent of live canopy estimated. For sprouts (<4.5 ft. tall) and reproduction (4.5-6.6 ft. tall), each will be classified as alive or dead, the percent of live canopy will be estimated, the type of architecture (Keigley & Frisina 2011) will be noted, and the height above the ground of the base of the tallest leader will be recorded.

4 Abundance of fallen stems. These will be quantitative data, collected from line transects. Every fallen trunk intersected by the line transect will be counted, identified to species, and classified into a size-class.

5. Extent of stand and possible changes in extent. The perimeter of the stand of live trees will be recorded with a GPS receiver. If the perimeter of the area of fallen trees is different from that of the area of live trees, then the perimeter of the area of dead trunks also will be recorded with the GPS receiver.

III. INSTRUCTIONS

A. GO TO THE POTENTIAL SAMPLING POINT

1. Use the GPS receiver to navigate to the potential sampling point.
2. Complete an aspen sampling point description form (Form 1).

B. DECIDE WHETHER TO SAMPLE AT THE POINT OR NOT

1. If you find aspen, alive or dead, within 50 meters of the sampling point (that is, within the sampling area), sample there.

2. If you find no aspen, alive or dead, within 50 meters of the point, skip the sampling.
   a. If aspen is present within sight of the point, go to that aspen stand and sample.
   b. If no aspen is present within sight of the point, go to the nearest potential sampling point on the list.

C. SAMPLING

1. Characterize the aspen stand.

Use the aspen stand description form (Form 2, part A). Base your description on what you can see of the stand from the point or nearby. There is no time to thoroughly investigate large stands.

Note the following:

- the patches of vegetation present in the stand;

- for each patch, indicate whether or not you sampled the vegetation (sample only those patches that are intersected by the sampling area), estimate the percentage of the stand that is accounted for by the patch, and briefly describe the patch;
- other salient features about the stand.

2. Use the GPS receiver to record the perimeter of the stand of live trees, by walking around the outermost trees in the stand while recording positions. Exclude isolated trunks growing $\geq$ 10 m away from other trunks (but watch for sprouts between the trunks). If the area of fallen logs is different than the area of live trees (suggesting that the stand has contracted, expanded, or moved), record the perimeter of the two areas separately.

3. Delineate the limits of the sampling area.

a. Flag the sampling point.

b. By pacing or (when necessary) measuring with a tape, identify the circumference of the 50-m radius circle that constitutes the sampling area. If necessary, flag some points along the circumference of the circle.

4. Characterize the sampling area.

Use the aspen sampling area description form (Form 2, part B). Base your description on a fairly quick examination of the area, but one thorough enough to show you what patches occur in it and must be sampled.

Record the following information:
- aspect, steepness, and shape of the predominant slope (use a sighting compass and clinometer);
- type of geological material underlying the area;
- predominant topographic position;
- signs of disturbance;
- presence of noxious weeds (Table 1);
- and percent of the sampling area that is within aspen vegetation or vegetation that used to contain aspen.

5. Characterize each aspen patch within the sampling area.

This will require both a semi-quantitative description of the vegetation in the patch (Form 3) and the collection of quantitative data on the aspen component (Forms 4 and 5). The point is to get a moderately detailed description of the structure of the vegetation, but only a rough description of the plant species composition.

a. Describe the vegetation (Form 3)

Base your description on observations of the patch that you can make in a 10-minute walk through it. Record only the common plant species in each stratum of the vegetation. Don't try to list all of the plant species.

b. Collect the quantitative data.

These data are collected along a line transect and in a belt transect located along that line transect.

(1) Line transect for fallen trees (Form 4). *A fallen tree is one that (1) is no longer is held up by its roots, so that the trunk rests on the ground, or is held off the ground by the tree's own branches or by other fallen trees; or (2) that is held up by its own roots, but the angle between the trunk and the ground is < 15°.*

(a) Locate one line transect in the patch, so that it passes through vegetation typical of most of the patch. (Pay attention especially to stem density.) Orient the line transect randomly unless there is some reason to do otherwise

The length of the line transect will depend on the size of the patch and the density of trees in it. In a sparse patch, use a transect 20 m or 25 m long (or maybe even longer). In a dense patch, use a transect 10 m long. Always note the length of the transect.

If you find an area of fallen aspen trunks outside the patches with standing aspen, either extend the line transect from the nearest patch into that area, or lay out a separate line transect in that area. (We want to collect data on those fallen trunks because they may indicate that the aspen stand used to be larger.)

(b) For every fallen tree trunk that intersects the line, record:

- the species and
- the diameter class. Measure the diameter at the point that would have been breast height (4.5 ft. above the ground) when the trunk was standing, if you can determine that point. Otherwise, measure the greatest diameter.

(2) Belt transect for standing trees (Form 5). *A standing tree is held off of the ground by its own roots. Dead standing trees are at an angle of $\geq 15^o$ from the ground. Live standing trees may be at $< 15^o$ from the ground if they are held up by their own roots.*

(a) Decide whether to use a belt transect 1 m wide (where trees grow close together) or 2 meters wide (where trees are sparse). Note the width of the belt.

(b) You don't mark the belt transect out on the ground. Instead, you walk along the right side of the line transect (looking from its 0 end), holding the stick of the chosen length with one end over the line and the stick extending 90^o to the right of the line.

(c) For every standing tree trunk that you encounter between the line and the end of the stick, record

- the species,
- whether it is alive or dead,
- the size-class (Table 2),
- the presence of wounds or conks on the trunk, and
- the estimated percent live canopy (Figure 1), by category (Table 3),

(d) **ONLY FOR SPROUTS (trees < 4.5 feet tall) AND REGENERATION (trees 4.5-6.6 feet tall)**, also record the type of architecture and the height above the ground of the base of the terminal leader. There are 5 types of architecture:

Type 1 -- Uninterrupted: the main stem is $\geq$ 250 cm tall. Buds on lateral branches may be browsed. See Figure 2.

Type 2 – Arrested: the plant is < 250 cm tall and has no lateral branches (or only short lateral branches) because the terminal buds on the main stem and lateral branches have been browsed off. See Figure 2.

Type 3 – Retrogressed: the plant is < 250 cm tall because the terminal bud on the main stem has been browsed off, but lateral branches have not been heavily browsed. See Figure 2.

Type 4 – Released: the plant is $\geq$ 250 cm tall, because a lateral branch has grown up. A released plant was at one time retrogressed, when the main stem was stunted by browsing, but later release of the browsing pressure has allowed a lateral branch to grow up. See Figure 2.

Type 5 – Unbrowsed. The plant is < 250 cm tall simply because it has had insufficient time to grow taller, not because browsing is keeping it shorter. Few of the terminal buds (on the main stem or on lateral branches) appear to have been browsed. Not illustrated.

Table 1. Plant species listed as noxious weeds in Wyoming[1]

Common Name	Scientific Name
Canada thistle	*Cirsium arvense*
Scotch thistle	*Onopordum acanthium*
Musk thistle	*Carduus nutans*
Plumeless thistle	*Carduus acanthoides*
Common tansy	*Tanacetum vulgare*
Common burdock	*Arctium minus*
Perennial sowthistle	*Sonchus arvensis*
Skeletonleaf bursage	*Franseria discolor*
Ox-eye daisy	*Chrysathemum leucanthemum*
Russian knapweed	*Centaurea repens*
Spotted knapweed	*Centaurea maculosa*
Diffuse knapweed	*Centaurea diffusa*
Hoary cress (whitetop)	*Cardaria draba & C. pubescens*
Perennial pepperweed (giant whitetop)	*Lepidium latifolium*
Dyer's woad	*Isatis tinctoria*
Yellow toadflax	*Linaria vulgaris*
Dalmatian toadflax	*Linaria dalmatica*
Field bindweed	*Convolvulus arvensis*
Leafy spurge	*Euphorbia esula*
Houndstongue	*Cynoglossum officinale*
Purple loosestrife	*Lythrum salicaria*
Saltcedar	*Tamarix sp.*
Common St. Johnswort	*Hypericum perforatum*
Quackgrass	*Agropyron repens*

1. Re-arranged from: WYOMING WEED & PEST CONTROL ACT DESIGNATED LIST, Designated Noxious Weeds W.S. 11-5-102 (a)(xi) and Prohibited Noxious Weeds W.S. 11-12-104. Obtained August 28, 2008 from http://agriculture.wy.gov/divisions/techserv/sections/weedpest.htm.

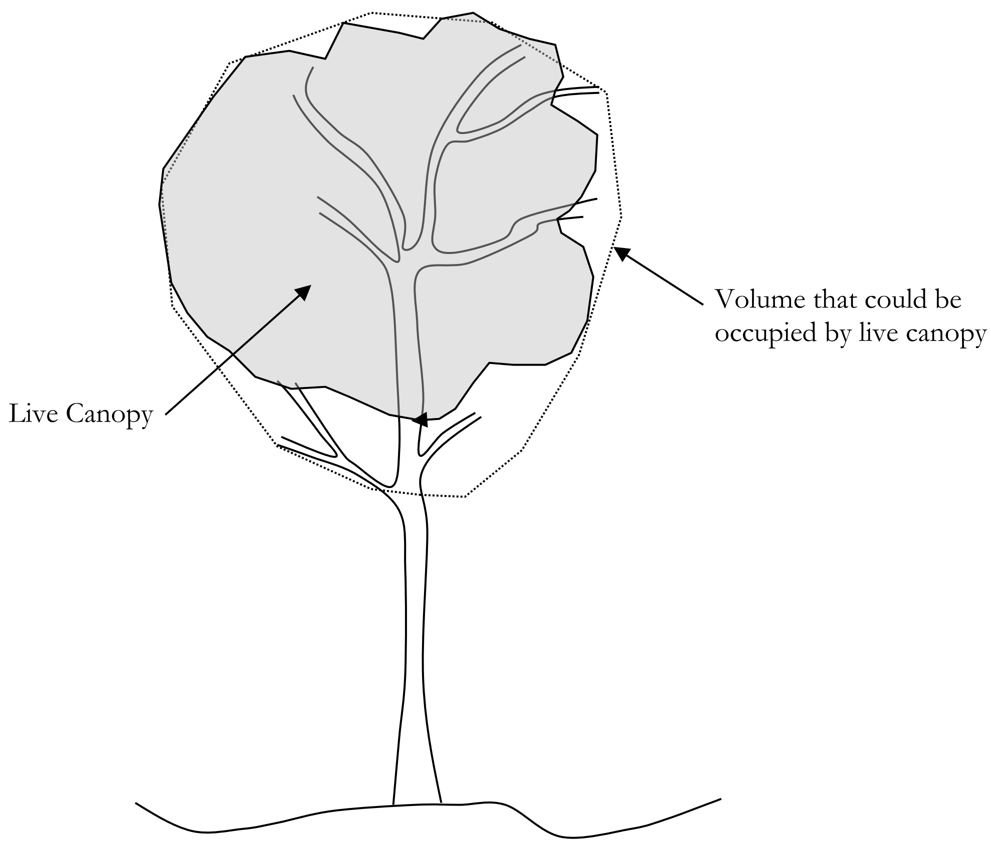
Table 2. Aspen size classes

Category No.	Category Name	Height	Diameter at 4.5 ' off ground
1	Sprout	< 4.5 feet (1.4 meter)	
2	Regeneration	4.5 - 6.6 feet (1.4 - 2 meters)	By 2 inch (5 cm) size class
3	Small tree	> 6.6 feet (2 meters)	1 inch - 4 inches (2.5 - 10 cm)
4	Medium-size tree	> 6.6 feet (2 meters)	4 in.- 8 in. (10 - 20 cm)
5	Large tree	> 6.6 feet (2 meters)	> 8 in. (20 cm)

Table 3. Categories for percent of live canopy. See Figure 1.

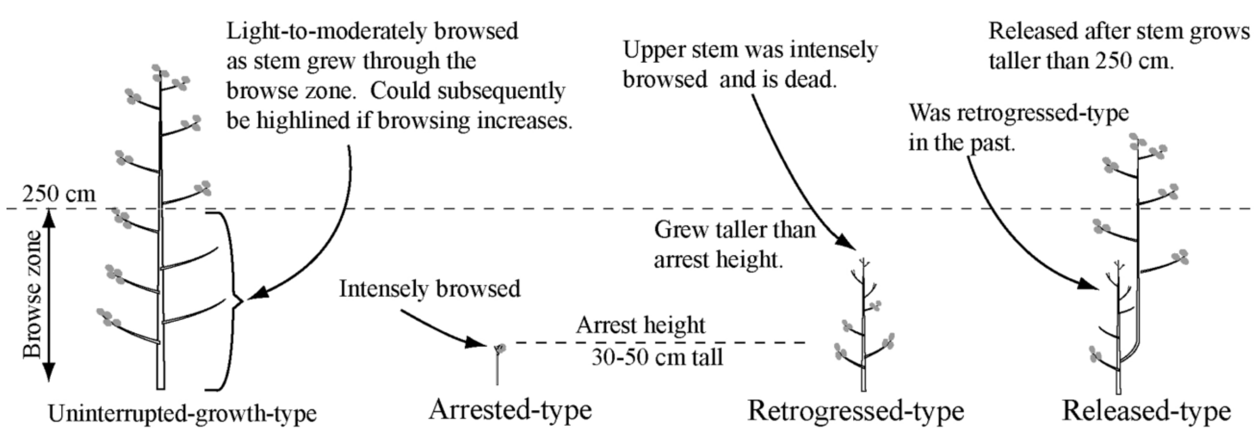
Category	Percent of potential canopy volume occupied by live canopy
1	≤ 25%
2	25% - 50%
3	50% - 75%
4	> 75%

Figure 1. Basis for estimating percent live canopy of an aspen tree.



Percent live canopy is estimated as the volume of the potential tree canopy (the volume between the lowest and highest branches, and the widest branches) that is actually occupied by live canopy. In this case, the percent live canopy is ca. 80%.

Figure 2. Plant architecture types 1, 2, 3, and 4.



From Keigley & Frisina. 2011. Process to Monitor and Manage Ungulate Browsing Pressure. Natural Resources and Environmental Issues Vol. 16, Article 29

Sampling point number ____________________________________

Surveyor____ Date______________________

A. LOCATION

Geographic coordinates (UTM Zone 12N, NAD83):

northing 4_______________________mN, easting___________________________mE

Was sampling point moved in field from its original coordinates? No_____ Yes_____

Explain:____

____

1:100,000 Map Name_________________________________.

1:24,000 Map Name (optional_________________________________

Township_____N, Range_____W, Section_______

B. PHOTOGRAPHS (OPTIONAL)

Taken? No_____ Yes_____ Photographer____________________ Camera____________________

Photo # (e.g., 08CW0812.01)	Focal length	Description
______________	F______	____
______________	F______	____
______________	F______	____

C. WERE SAMPLES TAKEN?

No_____ Why not? ____

____

Yes_____ What samples?

Plot number	Patch number	Description
______________	__________	____
______________	__________	____
______________	__________	____
______________	__________	____

STOP HERE IF NO SAMPLES WERE TAKEN.

CONTINUE ON BACK IF SAMPLES WERE TAKEN.

A. STAND DESCRIPTION

Size of stand (circle): ≤ 0.1 ha 0.1-1 ha 1-5 ha >5 ha

Patches present

Number	Sampled?	% of stand	Describe
________	Y N	__________	______________________________
________	Y N	__________	______________________________
________	Y N	__________	______________________________

Notes:

B. STAND PERIMETER

Label of GPS track, stand of live trees ______________________________

Label of GPS track, area of fallen trunks ______________________________

Notes about GPS data:

C. SAMPLING AREA DESCRIPTION

Aspect (degrees)_____ Slope: steepness (deg)_____. Slope shape (circle) flat convex concave

Surface deposit (circle): Residual Colluvial Landslide Aeolian Alluvial Glacial

Topo Position (circle) Interfluve, Shoulder, Backslope, Footslope, Toeslope, Step in slope, Valley Floor

Disturbance Signs:______________________________

____

____

____

List the noxious weeds present:______________________________

____

Rock Springs FO Aspen Survey, 2012 **FORM 3: PATCH VEGETATION DESCRIPTION**

Sampling Point Number____ Patch Number__________________________________

Surveyors____ Date ____

GROWTH-FORMS: TBD=Tree, Broadleaf, Deciduous; TN=Tree, Needleleaf; SBD=Shrub, Broadleaf, Deciduous; SBE=Shrub, Broadleaf, Evergreen; SM=Shrub, Dwarf; HF=Herb, Forb; HG=Herb, Graminoid; NV=Non-vascular

CANOPY COVER CATEGORIES								
	Percent Canopy Cover	<1	1-5	5-15	15-25	25-50	50-75	75-100
	Code for recording	1	2	3	4	5	6	7

Layer (Live / Dead)	Growth-form (Live / Dead)	Common Plant Species (Height; Live Cover / Dead Cover)
TREE – **Overstory:** Height ____ m Cover ___/___	TBD Cover ____/____	
	TN Cover ____/____	
	Epiphyte: Cover ____/____	
	Vine: Cover ____/____	
TREE – **Understory:** Height ____ m Cover ___/___	TBD Cover ____/____	
	TN Cover ____/____	
	Epiphyte: Cover ____/____	
	Vine: Cover ____/____	
TREE – **Regeneration:** Height ____ m Cover ___/___	TBD Cover ____/____	
	TN Cover ____/____	
	Epiphyte: Cover ____/____	
	Vine: Cover ____/____	
SHRUB Heith_______m Cover ____/____	TBD Cover ____/____	
	TN Cover ____/____	
	SBD Cover____/____	
	SBE Cover____/____	
	SM Cover____/____	
	Epiphyte: Cover ____/____	
	Vine: Cover ____/____	
FIELD Herbs & sub-shrubs Height_______m Cover ____/____	TBD Cover ____/____	
	TN Cover ____/____	
	SBD Ht _____ cm Cover ____/____	
	SBE Ht _____ cm Cover ____/____	
	SM Ht _____ cm Cover ____/____	
	HG: Ht _____ cm Cover ____/____	
	HF: Ht _____ cm Cover ____/____	
NON_VASCULAR Cover____/____	Moss Cover_____	
	Lichen Cover_____	
	Club-moss Cover_____	
Total Canopy Cover Estimate cover of all vegetation. This is NOT simply the sum of values for separate layers ____/____		

Sampling Point Number______________________________ Patch Number____________

Surveyor____ Date____________________

Transect Length __________ meters

Orientation of Transect____

Enter information for one fallen log per line.

No.	Species	Dia. Class	Check if DBH	No.	Species	Dia. Class	Check if DBH

Diameter Classes

Category No.	Height	Diameter at 4.5 ' off ground
1	< 4.5 feet (1.4 meter)	
2	4.5 - 6.6 feet (1.4 - 2 meters)	By 2 inch (5 cm) size class
3	> 6.6 feet (2 meters)	1 inch - 4 inches (2.5 - 10 cm)
4	> 6.6 feet (2 meters)	4 - 8 inches (10 - 20 cm)
5	> 6.6 feet (2 meters)	> 8" (20 cm)

Rock Springs FO Aspen Survey, 2012 **FORM 5: BELT TRANSECT FOR STANDING TREES**

Sampling Point Number____________________________ Patch Number___________

Surveyor______________________________________ Date____________________

Transect Length __________ meters Width of Belt (circle): 1 meter 2 meters

Orientation of Transect____

Enter Information for One Stem Per Line

No.	Species	Alive or Dead	Size-class	Wounds & Conks	Live Canopy Category	*SIZE 1 & 2 Architect. Type*

Size-classes		
Cat. No	**Ht. (ft)**	**DBH**
1	< 4..5’ < 1.4 m	
2	4.5’ - 6.6’ 1.4-2 m	By 2” cat. By 5 cm
3	> 6.6’ > 2 m	1” - 4” 2.5-10 cm
4	> 6.6’ > 2 m	4” - 8” 10-20 cm
5	> 6.6’ > 2 m	> 8” > 20 cm

% Live Canopy Categories	
Cat. No.	**% Vol. Occupied**
1	≤ 25%
2	25% - 50%
3	50% - 75%
4	> 75%

SIZE CLASSES 1 & 2 Architecture Types	
Type No.	**Type**
1	Uninterrupted
2	Arrested
3	Retrogressed
4	Released
5	Unbrowsed