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Effectiveness Monitoring of Aspen Regeneration on Managed Rangelands

A monitoring method for determining if management objectives are being met in aspen communities

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Acknowledgements

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Monitoring is a key part of adaptive management that gives managers an opportunity to change practices, as needed, and at a minimum make more informed decisions. On rangelands, monitoring efforts can be used to detect responses to specific management activities, such as stocking intensity, duration, class of animal, and season of use. Learning is an inherent objective of adaptive management and allows adaptation of management activities for improved success in achieving desired future conditions. The main purpose of effectiveness monitoring is to identify and quantify the direction and intensity of change for a given resource through time (Hellawell 1991) in order to evaluate changes in condition and progress towards meeting management objectives.

The objective of this protocol is to monitor the change and trend, in density, of four different size classes of aspen (*Populus tremuloides* Michx.) under current range and management practices. Aspen primarily reproduce vegetatively; therefore the desired future condition for aspen management is the establishment of successful regeneration of aspen suckers (synonymous with sprouts or ramets). Successful regeneration is defined as suckers obtaining a desired height and/or width so that the terminal leader is above the browse height of domestic and wild ungulates.

The implementation monitoring protocol, *Browsed Plant Method for Young Quaking Aspen* (USDA 2004b), also developed by the U.S. Forest Service -- Pacific Southwest Region 5, and this protocol were developed to work complementarily with one another. This effectiveness monitoring method allows repeatable measurements through time that can be directly linked to annual use data so that effects may be attributed to management causes. Both protocols have as their foundation, the concepts of repeatable measurements, simplicity of design, and understandable interpretation of on of the analysis.

a. Aspen Stand Identification. Aspen is considered a keystone species, and aspen communities are critical for maintaining biodiversity in western landscapes (Bartos and Campbell 1989). For these reasons, the Forest Service has included the restoration and conservation of aspen stands in the agency's Aquatic, Riparian, and Meadow Ecosystems management strategy (UDSA 2004a). It is appropriate to refer to individual aspen stands as critical areas if special management consideration is needed because of these biodiversity characteristics. The critical area/key area concept as found in the interagency technical references: *Utilization Studies and Residual Measurements* (USDI 1996a) *and Sampling Vegetative Attributes* (USDI 1996b), will be used to determine which aspen stands should be monitored. Where the stand is a representative sample of a larger stratum of aspen stands within a management unit, an individual stand can be described as a key area. The selected key are is monitored as a macroplot.

Note. The same aspen stands that are used for implementation monitoring (*Browsed Plant Method for Young Quaking Aspen*, USDA 2004) can also be used for effectiveness monitoring.

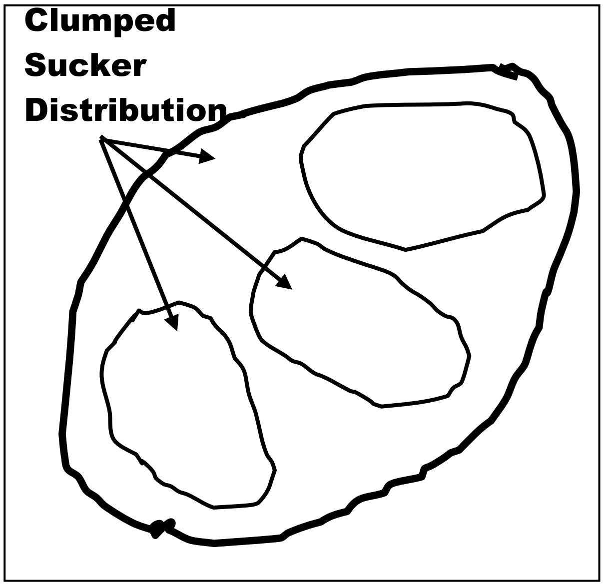
b. Permanent Quadrat Plots. The quadrat size recommended for this protocol is a 6 ft X 100 ft rectangular belt transect (Illustration 1 and illustration 2). The 600 sq. ft. quadrat size and shape can be modified depending on stand characteristics. For example, circular plots are more suitable for sampling in homogenous dense stands, whereas rectangular plots should be utilized for stands that have aggregated or clumped distributions (Elzinga, Salzer, Willoughby 1998). Using permanent monitoring plots is advantageous because (1) the power to detect change over time is much greater with permanent sampling units, and (2) spatial variability is removed from analysis (Elzinga, Salzer, Willoughby 1998). Permanent plots can be established in many different arrays (e.g., number of plots, or distribution among multiple stands), depending on the objectives for management.

c. Establishing Quadrats Plots. Permanent monitoring plots are established within an aspen stand in areas with regenerating aspen (suckers) in order to evaluate the response of aspen to management. The spatial distribution and the availability of regenerating aspen plants, within an aspen stand, must be considered to choose the appropriate plot design to establish monitoring plots throughout the stand. The following procedures are recommended based on different scenarios in aspen sucker distribution.

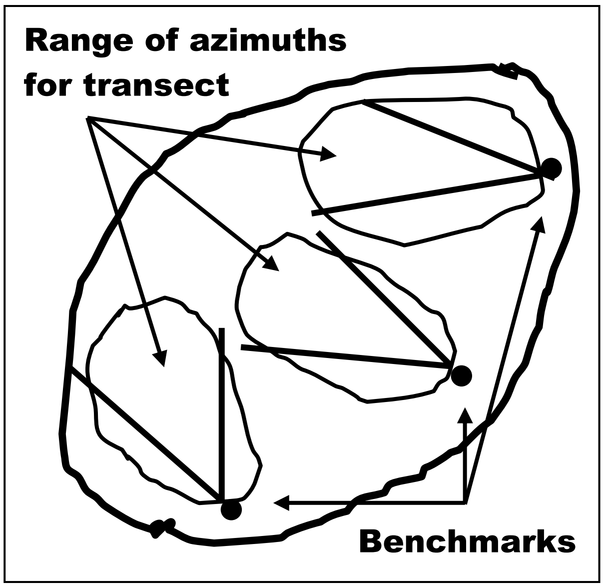
<u>Suckers Not Uniformly Distributed</u>
Plots are established in large or small aspen stands that have sparse or clumped spatial distribution of aspen regeneration using the following sampling technique: (1) identify and number all aspen clumps within a stand; (2) use a random numbers table to identify the aspen clumps where transects will be established; and (3) identify the transect direction within an aspen clump by randomly selecting an azimuth that intersects aspen suckers within the clump (Illustration 1).

<u>Suckers Uniformly Distributed</u>
In large or small aspen stands that have a uniform spatial distribution of aspen regeneration, establish transects using the following sampling technique: (1) establish a baseline through the center or along the edge of the aspen stand; (2) evenly divide the stand into equal sized sample units (sample units = *n*); (3) use a random numbers table to select the starting point within the each sample unit; and (4) place each transect perpendicular to the baseline (Illustration 2).

Note: If utilization monitoring transects were established at an earlier date using the *Browsed Plant Method for Young Quaking Aspen* (2004), also use those transects for effectiveness monitoring locations.



(1) This sampling protocol is used when sucker spacing is sparse ($\geq$ 5 ft between individual plants) or clumped (clustered plants with gaps between clusters).

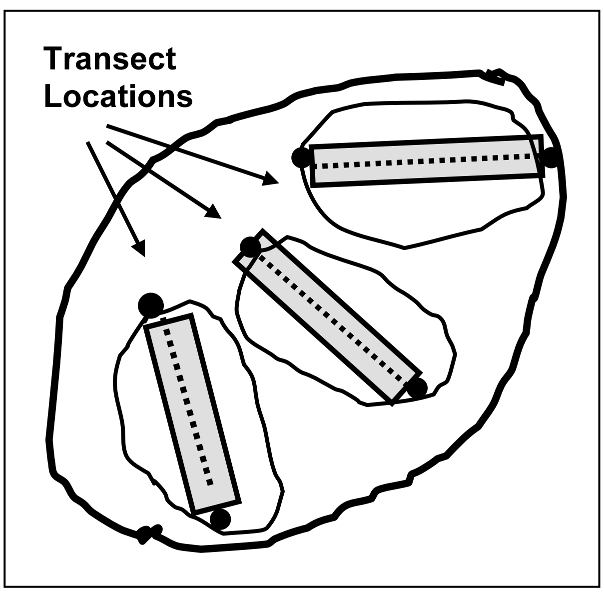


2) Choose a benchmark at one end of clumped distribution of suckers. *n* =3 in this example

(3) Set a benchmark post at that point.

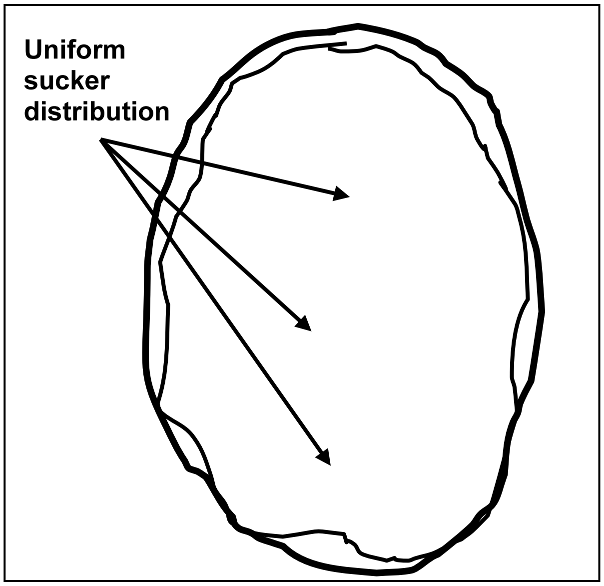
(4) Identify where transects could occur within the clumped distribution (Figure 2).

(5) Randomly choose an azimuth for the transect.

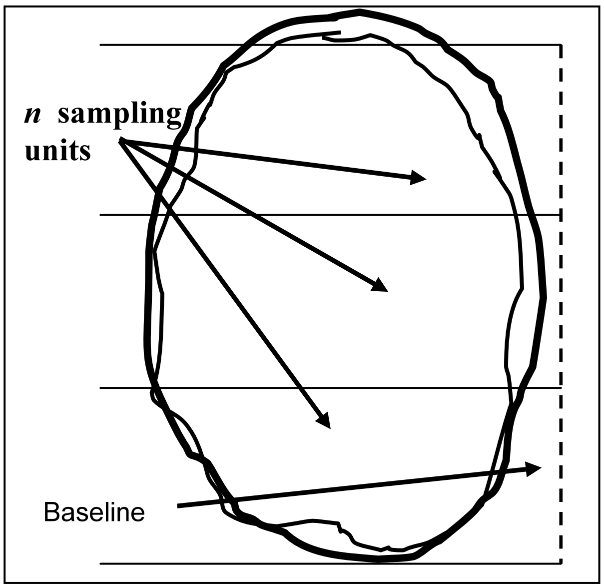


(6) Effectiveness Monitoring: Set a post at exactly 100 feet from the benchmark on the azimuth selected and collect data in a 6 ft x 100 ft transect.

Illustration 1. Stratified Random Sampling



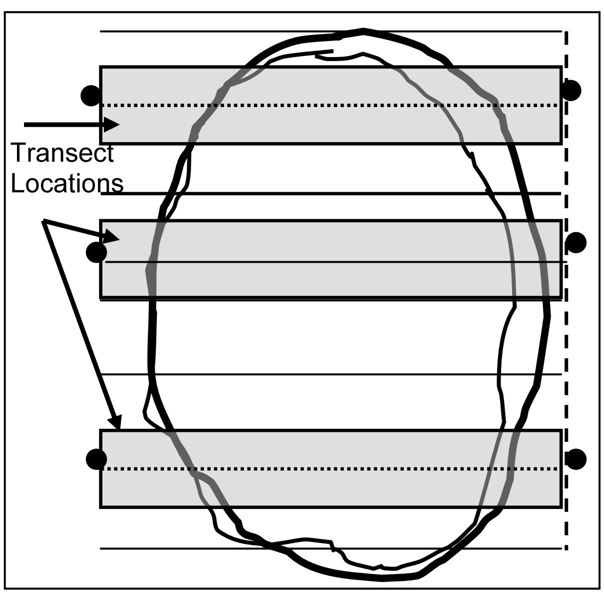
(1) This sampling protocol is used when individual sucker spacing is relatively is uniform (≤ 5 ft between individual plants).



2) Establish a baseline parallel to the stand (Figure 2).

(3). Determine the number of sampling units, *n*. *n* = 3 in this illustration.

(4) Divide the stand into *n* equal-sized segments.



(5) Trend Monitoring: Within each of these segments, following the protocol, a single sampling unit is randomly located and benchmarked. Collect data in a 6 ft x 100 ft sampling unit.

Illustration 2. Restricted Random Sampling

d. Equipment.

Establishing Plots

- ✓ GPS – global positioning system receiver
- ✓ Metal T-posts (two for each transect, and one for each photo point)
- ✓ Post pounder
- ✓ Aluminum tags and rebar wire
- ✓ Fluorescent spray paint
- ✓ Compass

Data Colleciton

- ✓ 100 ft tape measure
- ✓ Chaining pins
- ✓ Diameter "dbh" tape
- ✓ Camera
- ✓ Dry erase board or note cards for photos
- ✓ Distance measuring pole (6 feet long, marked in half foot increments) for use in measuring both distance from the tape and the height of aspen, and establishing height relationships in photo point images.

e. Sampling Process.

Monitoring Plots:
A minimum of three 6 ft X 100 ft permanent quadrat plots are established using a belt transect in an aspen stand using the protocol described in *Section c.* A minimum of three transects are recommended in order to calculate standard deviation. In instances where a high level of change detection is desirable more quadrat plots should be established (e.g., large or diverse stands).

Monument Permanent Plots:
At each plot, place a metal T-post at each end of the transect to permanently mark and allow future re-establishment of the quadrat. The distance between each T-post is exactly 100 feet apart and can be measured using a distance tape that is stretched straight and tight. Attach an aluminum survey tag to each fence post to identify the plot number and azimuth. Record the coordinates of the transect ends using a GPS receiver. In addition, select a conifer witness tree, nail an aluminum tag identifying the plot number and paint a yellow circle around it. If the only available witness tree is an aspen, use paint only; to prevent tree infection or girdling do not nails, wire or wrap flagging around aspen stems. For aspen witness trees, place the tag on a loose wire loop around the base of the tree. Record the distance and azimuth from the witness tree to each fencepost in case any T-post is accidentally removed. Spray paint each T-post to aid visual relocation of the posts when the quadrats are re-established in the future.

Data Collection for Aspen Density by Size Class:
All aspen stems within 3 ft of each side of 100 ft distance tape are counted and recorded in the following size classes:

a. Size Class I = less than or equal to 1.5 feet (18 inches). This class size represents the annual or recent recruitment of suckers due to suckering at root buds.
b. Size Class II = greater than 1.5 feet to 5 feet. This class size represents the survival of suckers and the progression of recruitment of existing suckers that are vulnerable to browsing of the terminal leader.

c. Size Class III = greater than 5 feet and up to 1 inch dbh. This class size represents the aspen regeneration grown above the height range that is vulnerable to browsing; the minimum height for size class III represents the maximum browse line height for herbivores present[4].

d. Size Class IV = greater than 1 inch dbh. DBH measurements are recorded for all stems in this class. Class IV captures information for all remaining cohorts in the plot.

Use a measuring pole at ground level to determine if an aspen stem is in or out of the belt transect. If any part of the aspen's stem is within 3 feet of the tape or the pole touches the base of the stem, it is counted. Do not count overhanging branches when stems base is outside of the belt transect. To reduce error in counting aspen stems, divide the transect into 10-foot segments to record the number of stems by size class (Illustration 3 and Illustration 4). To assure consistency, when aspen stems are joined/branched above ground, they are counted as a single individual; conversely, if they are joined/branched below the surface (e.g., duff surface) they are counted separately DBH measurements are recorded for all trees over 1 inch dbh.

Initial measurements and repeated measurements should be taken in both the treated and control stands at the same sampling time. See *Section h* (**Analysis and Interpretation**) for discussion of the relationship between treatment stand and control stand data.

f. Additional Data. To aid in assessing how rangeland management practices affect the change of aspen density by size class through time, record animal class, animal type, number of animals, date animals introduced, date animals removed, and utilization percentage. Also, note the presence of browse by wildlife prior to each transect recording.

g. Photo Documentation. Establish photo points at both ends of each transect using the guidelines provided in the Interagency Technical Guide (USDI 1996b). It is essential for consistency to use a use a standard lens camera without a zoom feature so that repeat photos are not distorted. Two photos are taken at each transect. Each photo is taken at one T-post looking towards the opposite end of the transect. Place the 6-foot height measuring staff, in the center of each photo at a distance of two paces. The photo identification label is held in the immediate foreground (within one pace) and lower corner of the frame. Label the photograph with survey date, area name, transect number, and azimuth direction. Size your hand print so that it will be legible when digitized images are downloaded or when film images are developed. Establish at least two photo points far enough outside the stand to get the "big picture". Mark these photo points with T-post stakes and follow the same labeling procedure at these photo points as used for taking photos at transects.

h. Analysis and Interpretation. Appropriate analysis and interpretation of trend data is required to make conclusions about changes in aspen density, within a stand, through time. In this section we will focus on simple graphical analysis techniques to evaluate trend in aspen density which can be conducted on commonly available spreadsheet or graphing software. For illustrative purposes we will use several <u>hypothetical</u> datasets examining aspen density changes over time. If the desired level of confidence in evaluating trend is high, and/or there is a specific need to evaluate cause and effect between management, annual weather, etc. and trend in aspen density, then we recommend that a statistician be consulted at the outset of the planning process. The desired level of certainty for conclusions drawn from trend monitoring must be a factor in determining sample size (e.g., number of plots per stand),

[4] Note: The following browse line heights are recommended for the presence of the following herbivores: sheep (3 ft), cattle and deer (5 ft) and elk and horse (6 ft in height and >1 in diameter at breast height)

sampling frequency (e.g., annually, 2-year interval), and analysis approach (e.g., graphical analysis, statistical analysis, comparison to a control stand).

Example 1: Evaluation of Change through Time

Question: Is aspen density within Stand A increasing or decreasing through time? To address this question, a manager established three permanent plots within Stand A. The plots are annually measured for aspen density, by size class, at the end of summer. This stand had historically been heavily browsed by livestock in excess of 50% annual utilization of terminal leaders on aspen suckers. Management adherence to a 20% utilization standard commenced in 1999. Aspen recruitment monitoring was established in 1998 to evaluate the effectiveness of this management change. Figure 1 displays annual mean densities (n=3/year) for size classes 1, 2, and 3 from 1998 through 2003. Figure 1 clearly illustrates that an increase in the density of all three size classes occurred over the time period from 1998 through 2003. The upward trend for size classes 2 and 3 indicates there is recruitment of larger size classes into the stand, an important indication of population sustainability.

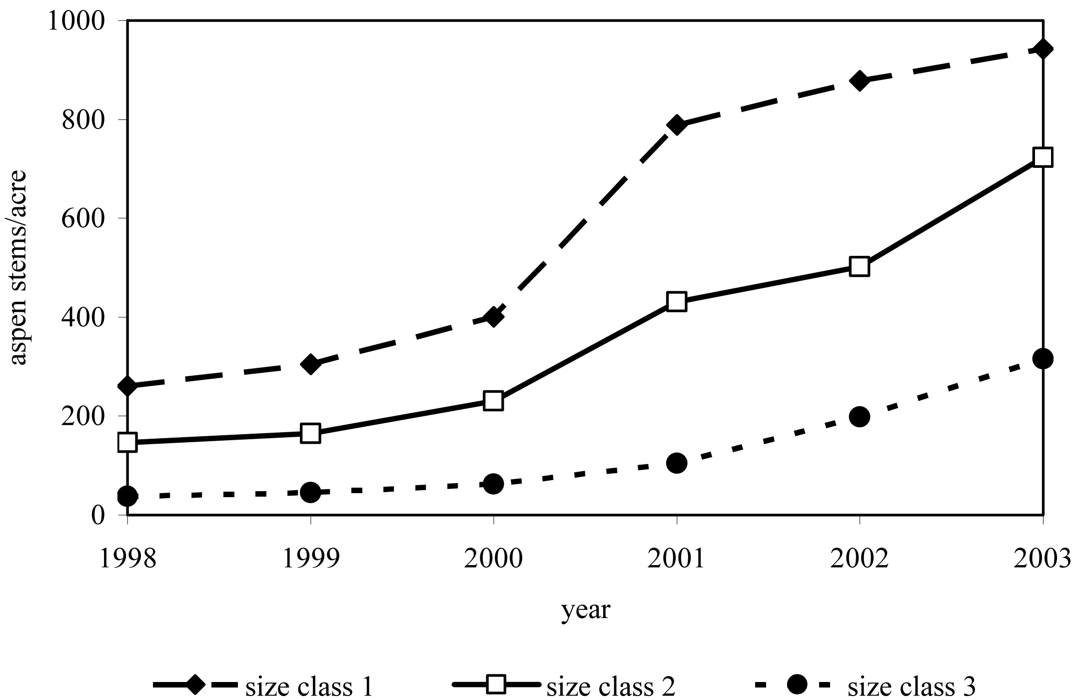


Figure 1. Mean annual aspen stem density for size class 1, 2, and 3 within Stand A from 1998 through 2003.

Example 2: Determining if an Apparent Trend is Significant

Question: Is the upward trend observed in Figure 1 a statistically significant increase in aspen density from 1998 through 2003? We can determine if the apparent increase in density for Stand A, over a period of years, is statistically significant by using a simple linear regression (trend line) as illustrated in Figure 2 for size class 2. In this linear regression analysis the "y" variable is density (stems/acre) of size class 2 and "x" variable is time. The trend line in Figure 2 indicates that there is a significant change in density over time ($P<0.05$,

R^2=0.94). The value of the coefficient for year (+114) indicates that, on average, 114 additional size class 2 stems/acre were recruited by the stand each year.

Figures 1 and 2 provide compelling evidence that density for all 3 size classes within Stand A are in a significant upward trend. What this data does not provide, is insight to how annual grazing management was implemented over this time period, or what factors are causing this upward trend (e.g., reduced grazing pressure, consecutive high annual precipitation).

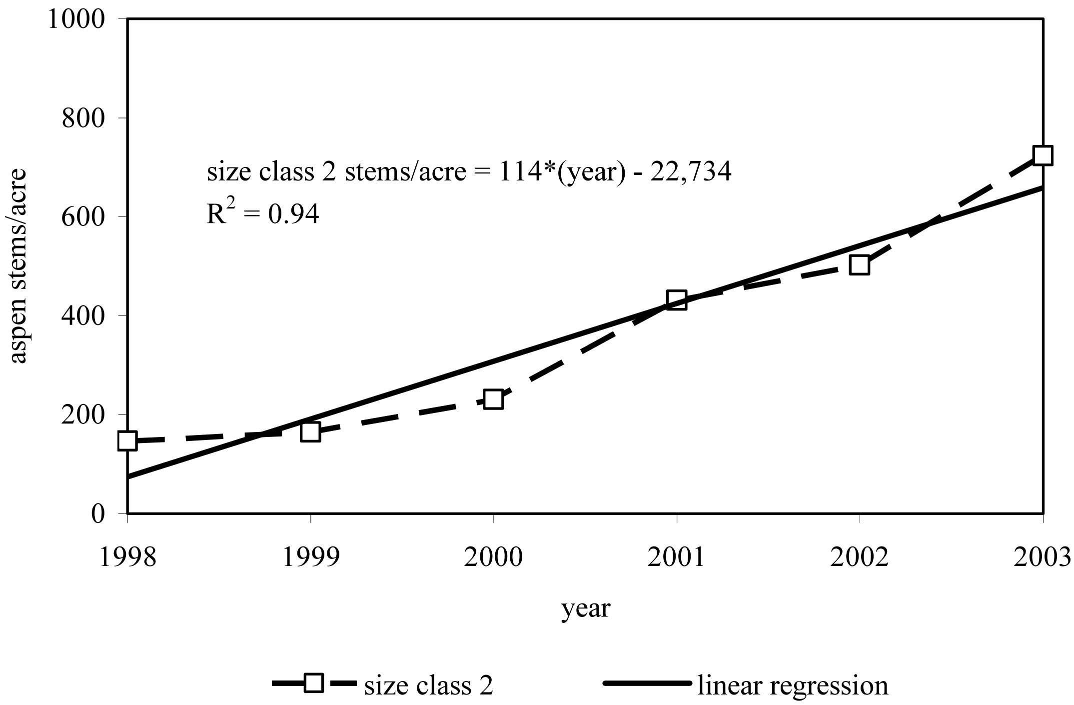


Figure 2. Mean annual size class 2 aspen stem density within Stand A from 1998 through 2003 with a simple linear regression line (trend line) fit to the data to determine significance of density trend over years.

Example 3: Evaluation of Trend and Annual Utilization of Terminal Leaders

Question: <u>How does trend in aspen density compare with annual utilization of terminal leaders over this time period</u>? To start addressing this question, we must first collect annual utilization data from Stand A following methods described in *Browsed Plant Method for Young Quaking Aspen* (USDA 2004b). If annual utilization and annual trend data are both collected for Stand A in the same years we can begin to examine if possible relationships exist between annual utilization and long term trends in aspen density. As it turns out, the manager of Stand A collected annual utilization of terminal leader data at end of the growing season for each year from 1998 through 2003. Figure 3 reports mean annual aspen density and mean annual utilization in Stand A from 1998 through 2003. From this macroplot it appears that the significant upward trend in aspen density may be due to a reduction in annual utilization of 45% in 1998 down to ~20% in 2000 through 2003 which resulted from adherence to the 20% utilization standard for aspen starting in 1999.

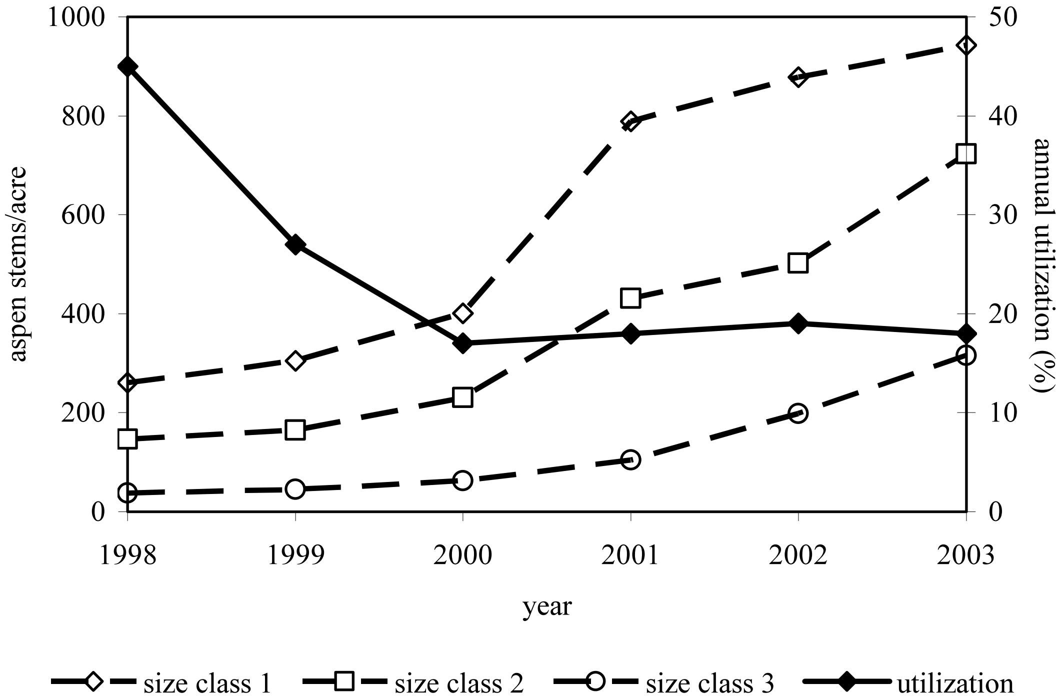


Figure 3. Mean annual aspen stem density for size class 1, 2, and 3 within Stand A from 1998 through 2003 with mean annual aspen terminal leader utilization at end of summer for Stand A.

Figure 3 indicates that the increase in aspen density during that period of time coincides with compliance to the lowered annual browse standards and improved control of livestock. This is often sufficient information to make management decisions, such as to continued implementation of the 20% utilization standard within Stand A. However, this data does not establish clear cause and effect between annual management and long term trend. For instance, the upward trend may be in part or entirely due to other factors such as a favorable weather conditions during the time period.

Example 4: Evaluation of Cause and Effect Relationship between Compliance with the Annual Utilization Standard and Aspen Density through Time

Question: Did the reduction in annual utilization due to standard implementation starting in 1999 within Stand A result in the change in aspen density observed during the time period, or is the increase in density at Stand A simply due to a series of high precipitation years with favorable growing conditions? To address this question we can first examine patterns of annual precipitation over the time period relative to mean annual aspen density (Figure 4). The long-term mean annual precipitation for Stand A is 22 inches. Evaluation of the pattern of precipitation relative to aspen density over the time period does not indicate that the upward trend in aspen within Stand A is due to a series of above average precipitation years. Note that 2000 through 2003 were all below average precipitation years. This graphical evaluation provides evidence to make a stronger conclusion that the upward trend in Stand A is due to controlled management of livestock and adherence to the annual utilization standard.

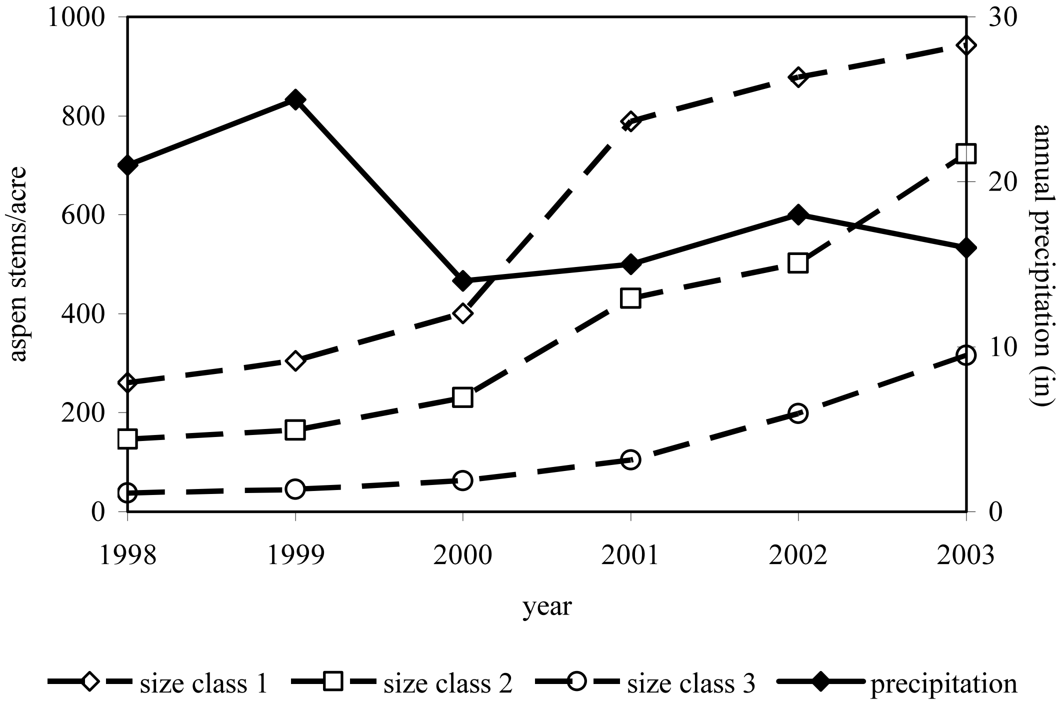


Figure 4. Mean annual aspen stem density for size class 1, 2, and 3 within Stand A from 1998 through 2003 with mean annual precipitation for Stand A.

Question: <u>How can we get the clearest indication of the potential effect of the change in annual utilization on aspen density trend</u>? We can get the clearest indication of the potential effect of the change in annual utilization on aspen density trend by simultaneously monitoring annual aspen density in a control stand (Stand B). A control stand is a stand which is relatively similar to Stand A (e.g., similar soils, elevation, precipitation, stand condition) which has consistent management across all years of the monitoring project. Stand B is located near stand A, has similar conditions, and received relatively constant annual utilization over the time period (Figure 5). Figure 5 indicates that aspen density has been relatively static within Stand B during the time period and under an average annual utilization of ~ 40%.

Question: <u>How can we provide credibility of the argument that a 20% utilization standard produces positive results</u>? Figure 6 shows plots size class 2 density for Stands A and B from 1998 through 2003, and provides substantial credibility to the argument that adherence to a 20% annual utilization standard for Stand A beginning 1999 has resulted in an upward trend in aspen density within Stand A.

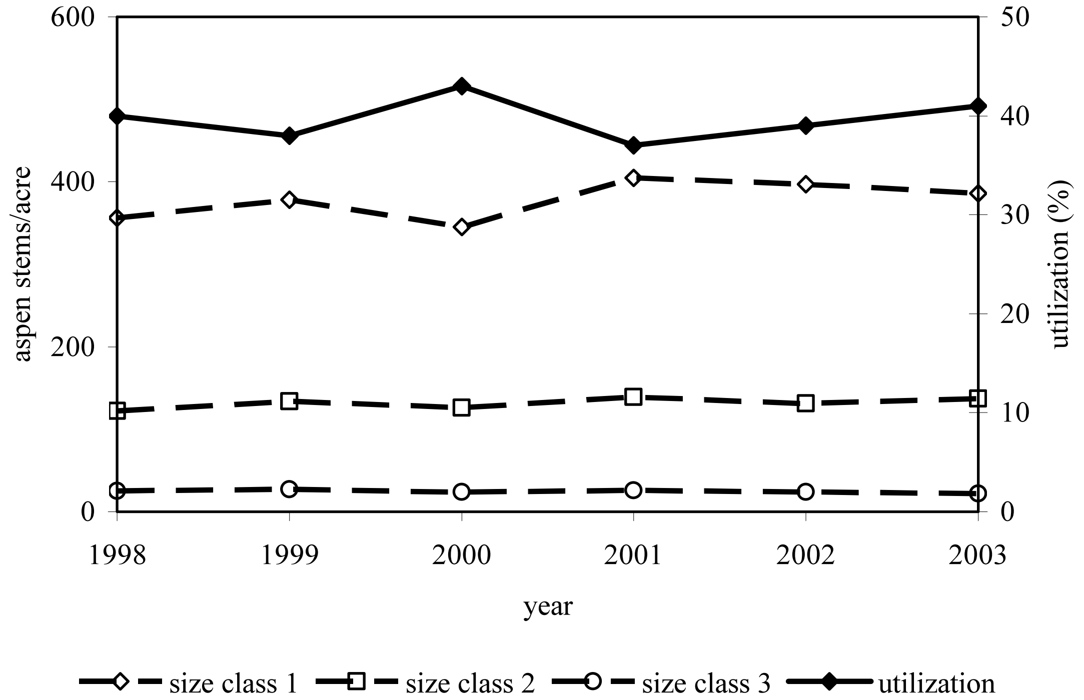


Figure 5. Mean annual aspen stem density for size class 1, 2, and 3 within Stand B from 1998 through 2003 with mean annual aspen terminal leader utilization at end of summer for Stand B.

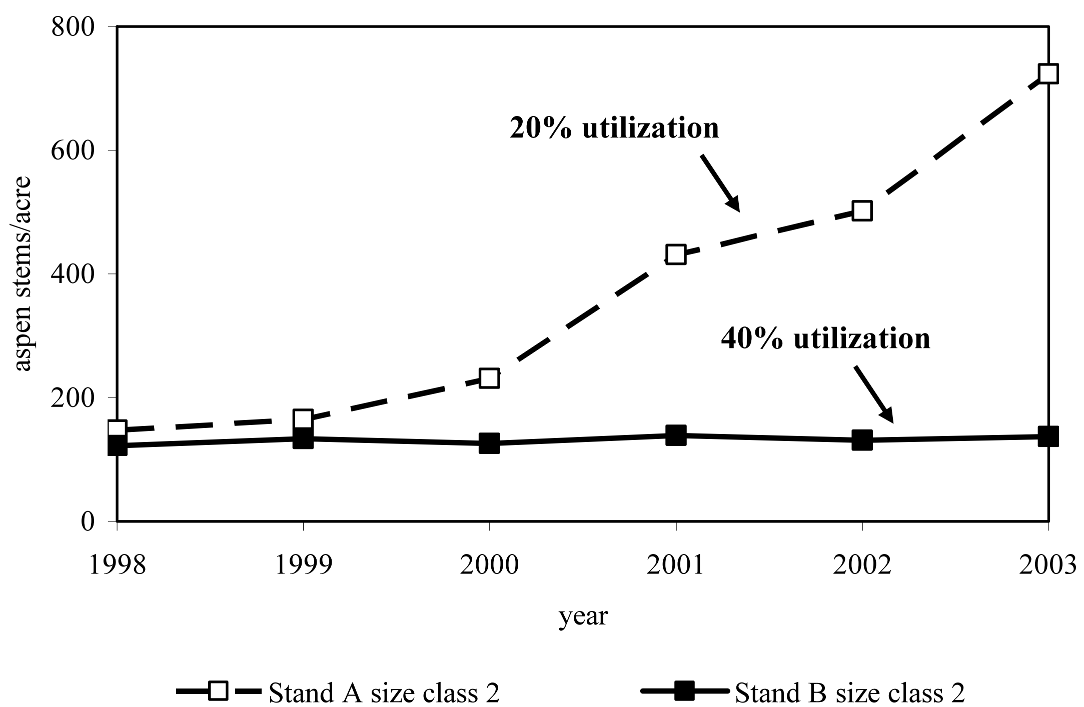


Figure 6. Mean annual size class 2 aspen stem density within stand A and B from 1998 through 2003.

Glossary of Terms

Critical Area – An area which must be treated with special consideration because of inherent site factors, size, location, conditions, values, or significant potential conflicts among users.

Key Area – A relatively small portion of a range selected because of its location, use or grazing value as a monitoring point for grazing use. It is assumed that key areas, if properly selected, will reflect the overall acceptability of current grazing management over the range. The macroplot is placed within the key area

Key Species – Those species which must, because of their importance, be considered in the management program.

Ramet – An individual member of a clone.

Suckers – A shoot springing from the base of a tree or other plant, especially one arising from the root below ground level as some distance from the main stem or trunk.

Terminal Leader – The current year's growth at the tip of a primary stem. Trees typically have a single terminal leader, whereas shrubs typically have many.

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Notes

Appendix 1. Effectiveness Monitoring Field Form
Version 2.2—July 12, 2005

Effectiveness Monitoring Field Form

Date of Sampling:______________________________
Examiner(s)::_________________________________
Monitoring Site Code: _________________________

Allotment:___________________________________
Pasture (Key Area):___________________________

Azimuth : ____________________________________
GPS Coordinates--Benchmark 1: _______________
____

Azimuth : ____________________________________
GPS Coordinates--Benchmark 2:________________
____

Livestock Type: ______________________________
Class of Animals:_____________________________

Number of Animals: __________________________
Date Livestock Introduced: ___________________
Date Livestock Removed: _____________________

Distance	cs1: <18"	<18" Total	cs2: 18"-5'	18"-5' Total	cs3: >5'-1"dbh	>5'-1"dbh Total	cs4: >1"dbh	>1"dbh-Total	Can. Cov.
0-10									0-
10-20									10'-
20-30									20'-
30-40									30'-
40-50									40'-
50-60									50'-
60-70									60'-
70-80									70'-
80-90									80'-
90-100									90'-
Totals									%-

Comments and Notes____
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Appendix 2. Sample Field Form
Filled Out Example

Effectiveness Monitoring Field Form

Date of Sampling: *July 12, 2005*
Examiner(s):: *Sam Smith*
Monitoring Site Code: *AH-01-01*

Allotment: *Big Ravine*
Pasture (Key Area): *Aspen Hollow*

Azimuth : *125 degrees*
GPS Coordinates--Benchmark 1: *0234567* *4356678*

Azimuth : *305 degrees*
GPS Coordinates--Benchmark 2: *0234590* *4356801*

Livestock Type: *Cattle*
Class of Animals: *Cow Calf*

Number of Animals: *120*
Date Livestock Introduced: *6/15/05*
Date Livestock Removed: ____________________

Distance	CS1: <18"	<18" Total	CS2: 18"-5'	18"-5' Total	CS3: >5'-1"dbh	>5'-1"dbh Total	CS4: >1"dbh	>1"dbh-Total	Can. Cov.
0-10	:: :: .	9	::	4	-	-	1-2"	1	0-
10-20	:	2	-	-	-	-	-		10'-
20-30	:: :: :: :	14	:: ::	8	:	2	-		20'-
30-40	:: .	5	-	-	-	-	-		30'-
40-50	:: :: .	9	.	1	:.	3	-		40'-
50-60	:: ::	8	:	2	::	4	-		50'-
60-70	-	-	-	-	-	-	1-2", 3-4"	4	60'-
70-80	:: :: :: ::	16	.	1	-	-	-		70'-
80-90	:	2	:: ::	4	-	-	-		80'-
90-100	:: :: :: :: ::	20	-	-	:: :	6	-		90'-
Totals		86		20		15		5	%-

Comments and Notes ____