# Appendix C - Browsing Thresholds and Adaptive Management Pursuant to Aspen Restoration on Monroe Mountain 15 January 2014

**Goals:**

- Establish thresholds of maximum percent browse for a given initial (post-treatment) or sustained (untreated 'stable' aspen) density of recruits that are expected to result in adequate recruitment to perpetuate the aspen stand.

- Establish timely adaptive management responses that will take place if thresholds are not met.

- Offer these recommendations fully recognizing that livestock and wildlife management decisions are made within well-established policy structures in USDA-Forest Service and Utah Division of Wildlife Resources, respectively.

**Needed:**

Detection methods that document shoot density, height progression, and browsing intensity, as they may vary independently

1) **Aspen-mixed conifer post-treatment (prescribed fire and/or mechanical) areas**
    a. Characteristic sprouting: a dense stand of similar-aged (cohort) aspen sprouts, although some stands may exhibit relatively weak sprouting initially due to depleted root systems, genetic variation, shading by conifers, or other factors.
    b. A proposed quantitative threshold: Use the chart and figure below, adapted from estimation of the maximum browsed aspen allowed that would assure the conservative outcome of at least 400-600 recruits[1]/acre (i.e. 1,000-1,500 recruits/hectare; Mueggler 1989, Campbell and Bartos 2001) (Attachment A and B).
        i. Assumptions for the probability table and figure
            1. Once a shoot is browsed (majority of top 6" [150 mm] of leaders,) the probability of it recruiting into the overstory is extremely low.
            2. A conservative minimum of 1,000 saplings[2]/acre (2,500 saplings /ha) is needed to regenerate a fully stocked aspen stand.
            3. Unbrowsed shoots will reach a relatively safe height (approximately 6' or 1.8 m) in 4-6 years.
            4. Shoots occur as a single pulse or cohort (same or similar age) of regeneration (no secondary regeneration).

[1] A recruit is defined as an aspen shoot that has successfully reached full canopy height.
[2] A sapling is an aspen shoot = 6-12' (1.8-3.7 m) height

5. There is no mortality to other causes.[3]
6. The level of browsing as defined by the percent of total shoots browsed is constant (from year to year and across spatial variation in shoot density).
7. Browsers show no preference between browsed and un-browsed shoots.

ii. The assumptions will not hold in the field but the table and figure provide an initial basis for deriving appropriate thresholds that predict success or failure for aspen recruitment after treatments (mechanical or fire) that result in a range of initial densities.

iii. Application of the table or figure will require a method to select the appropriate number of years (i.e. 4-6) for shoots to attain 'safe' heights. This can be based on site productivity, weather conditions, cumulative experience, etc.

**2)** Table 1. Suggested annual browse thresholds.

| Years after which 1,000 aspen saplings (≥6' tall)/acre will be present | 5,000 initial sprouts/ acre | 10,000 initial sprouts/ acre | 20,000 initial sprouts/ acre | 30,000 initial sprouts/ acre | 40,000 initial sprouts/ acre |
|---|---|---|---|---|---|
| | percent browse | | | | |
| 4 | 32 | 43 | 52 | 57 | 60 |
| 5 | 27 | 36 | 45 | 49 | 52 |
| 6 | 23 | 31 | 39 | 43 | 45 |

[3] It is true that at high densities (e.g. 20,000 shoots per acre), reductions in stem density through natural thinning will be substantial. This thinning will continue in the sapling stage but this is accounted for as the stand can thin from 1,000 to 400-600 stems per acre as the stand matures.

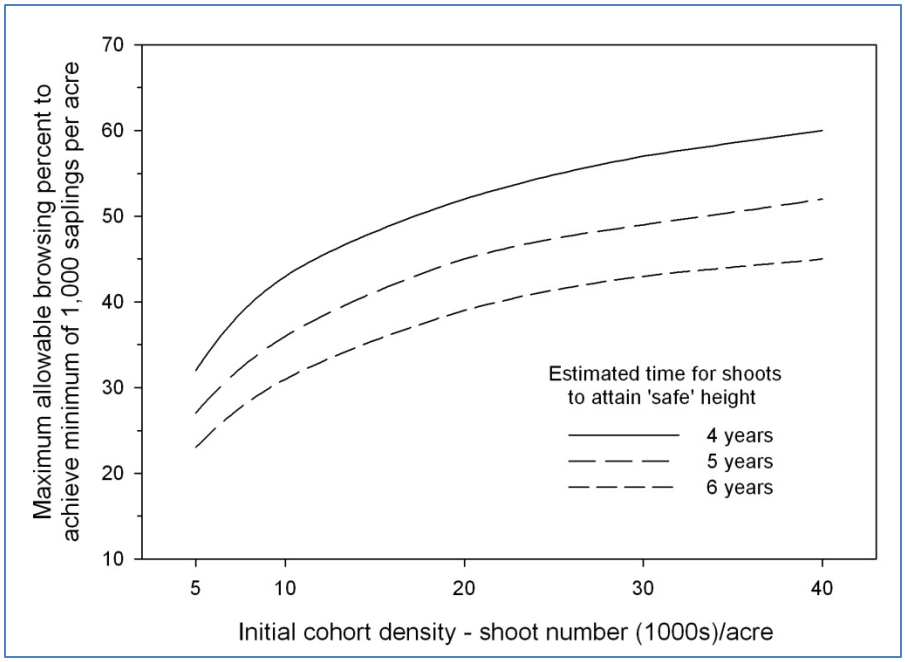



Figure 1. Projected maximum browse pressure in relation to initial aspen shoot density and time (years) needed for shoots to reach a safe height.

c. Suggested browse threshold detection
    i. Use two perpendicular belt transects (e.g., 6' x 100' or 2m x 30m) per plot, and include pellet counts for insight into use by types of ungulates.
    ii. A minimum of one plot per 300 acres (120 ha) treated, but a greater number of plots when needed to assess percent browse.
    iii. The plots should reflect the variability of the treatment area. Care should be taken to adequately represent areas of known higher use and/or vulnerability, e.g., <30% slope, <30 pre-treatment aspen stems/acre among the conifer.
    iv. Browse thresholds for a specific treatment are violated (exceeded) when:
        1. Across all plots, average plot browse percentage exceeds the maximum allowable browse threshold calculated from plot shoot density ; or
        2. At least 40% of the individual plots associated with the treatment exceed the percent browse threshold.[4]
    v. The above monitoring scheme will be adapted as necessary on the basis of experience using this scheme.
d. Browse threshold benchmarks for post-treatment aspen-mixed conifer

[4] Both elements of threshold exceedance are important to avoid outliers having determinative influence.

i. Browse = apical meristem damaged or removed on a majority of leaders within 6 vertical inches of the tallest leader.
ii. More than 20% of sprouts are browsed each year in stands with less than 5,000 initial post-treatment sprouts/acre.
iii. More than 27% of sprouts are browsed each year in plots with 5,000-10,000 initial post-treatment sprouts/acre
iv. More than 36% of sprouts are browsed each year in plots with 10,000-20,000 initial post-treatment sprouts per acre.
v. More than 45% of sprouts are browsed each year in plots with more than 20,000 initial post-treatment sprouts per acre.
vi. The above percent browse thresholds are comparable to those recommended by Olmstead (1979; 30%), Jones et al. (2005; 20%) and White and Feller (2001) while allowing for a greater range in sprout number. These values should be adapted as necessary on the basis of observed success in stand recruitment.

e. Adaptive management
i. Scale and timing of aspen restoration treatments: Recognizing that the scale and timing of treatments are likely to affect the level of impact that both wild and domestic grazers have on aspen response to treatments, consider designing treatments that would occur at the largest practical scale (neighborhood of 5,000 acres annually), while still being sensitive to other resource concerns (i.e. aquatics) for any given year. Adaptive management responses and their probability of success are expected to be highly correlated with the location, timing, and scale of treatments.
ii. Prior to treatments, recommend to the UDWR, RAC, and the Utah Wildlife Board a pre-approved antlerless hunt that could be implemented, if deemed necessary, immediately following treatments in order to reduce browse pressure adequately to facilitate greater aspen recruitment. This recommendation would be subject to the Wildlife Board and RAC approval process. If approved and following treatments, the UDWR, in coordination with the USDA Forest Service, would initiate implementation of the antlerless hunt.
iii. Post-treatment period with no livestock use: If browse thresholds are exceeded during the period of rest from livestock use (typically 2 years post-treatment), the USDA Forest Service undertakes one or more of the following adaptive management responses in order to achieve balanced livestock and wildlife use, while avoiding exceeding browse thresholds:
a. Recommend to the UDWR, RAC, and the Utah Wildlife Board a reduction of wild ungulate browsing pressure using antlerless hunts as needed at levels expected to

result in sufficient reduction in browse to avoid surpassing browse thresholds. This recommendation would be subject to the Wildlife Board and RAC approval process.

b. Co-ordinate with the UDWR to hire/contract adequate number of seasonal employees and/or coordinate the use of volunteers (i.e. Dedicated Hunter Program) to spend time in treatment areas hazing wildlife at levels expected to result in sufficient reduction in browse to avoid surpassing browse thresholds.
c. Treatment areas be fenced for protection.
d. Restrict livestock use until aspen recovery objectives are met.

iv. Post-treatment period after return of livestock to treatment area(s): If percent browse threshold is exceeded in a treatment area(s) grazed by both wild ungulates and livestock (typically after 2 years post-treatment), the USDA Forest Service undertakes one or more of the following adaptive management responses in order to achieve balanced livestock and wildlife use, while avoiding exceeding browse thresholds:

a. Recommend to the UDWR, RAC, and the Utah Wildlife Board a reduction of wild ungulate browsing pressure using antlerless hunts as needed at levels expected to result in sufficient reduction in browse to avoid surpassing browse thresholds for combined livestock and wildlife use. This recommendation would be subject to the Wildlife Board and RAC approval process.
b. Co-ordinate with the UDWR to hire/contract adequate number of seasonal employees and/or coordinate the use of volunteers (i.e. Dedicated Hunter Program) to spend time in treatment areas hazing wildlife at levels expected to result in sufficient reduction in browse to avoid surpassing browse thresholds.
c. Fence treatment areas.
d. Improve time, timing, and intensity of livestock grazing.
e. Recommend to the UDWR utilize the Grass Bank Program on state Wildlife Management Areas to help offset temporary loss of livestock opportunities.

v. The above-mentioned adaptive management responses are not intended to be all-inclusive. Additional or alternative adaptive management responses that are proposed, and which have been shown to be effective, should also be considered.

vi. After overstory aspen trees are removed or killed (i.e., mechanical or burn treatment), healthy roots systems typically are able to sustain vigorous shoot growth for a limited time (2-3 years,) providing a brief opportunity to modify management when browse pressure exceeds threshold levels. Therefore, the above-mentioned potential adaptive management responses have been identified for consideration as timely management responses as each treatment phase is implemented.

vii. Although management changes that reduce wild or domestic ungulate numbers may be necessary to restore healthy aspen communities on Monroe Mountain, such changes will be viewed as temporary and will not be interpreted as support for permanent or long-term reductions in stocking levels or population objectives. The Forest Service should be actively engaged in the UDWR's elk management plan revision process in order to promote understanding and consideration of resource conditions on objectives.

viii. If adaptive management responses are needed, the number and type of responses are anticipated to vary depending on location and timing of treatments. Considering the location, size, and timing of treatments, adaptive management responses and the probability of success are expected to vary. Decision authorities for the adaptive management responses also vary. For these reasons, continued and close communication between USDA Forest Service, UDWR, RAC, Utah Wildlife Board, and all other interested stakeholders is critical. The adaptive management responses are intended to avoid surpassing browse thresholds and to achieve a 1,000 saplings/acre.

**3) Stable aspen stand response to changed management of ungulates and of fire and mechanical treatments in aspen-mixed conifer**

a. Long-term monitoring plots: Sixty long-term monitoring plots will be established to represent the range of conditions thought to occur in stable aspen stands on Monroe Mountain. Aspen stands will be classified as stable when all of the following criteria are met.

i. Mature conifer stem counts per unit of area (acre) < 20% of total mature tree stem count (surrogate for BA [basal area] or cover)

ii. Total conifer stems (all sizes) < 40/acre (100/ha)

iii. Judgment will be used when required. For example, apparent intermixing of stable and seral conditions across uniform topography may require moving the plot to where stable conditions prevail. In addition, the age/size structure of conifer populations might be used supplementally to infer stand stability.

Data will be collected on overstory condition, aspen regeneration and recruitment (including browse use), fecal pellets and cow pies and understory for these plots starting in 2013. These data will provide a baseline dataset from

which to detect change in subsequent years. Data for aspen shoot density, height, and percent browse will continue to be collected on an annual basis. Overstory and understory data will be collected at longer intervals (3-5 years).

b. Stable aspen stand type classification: Although it is well recognized that in many areas stable aspen is not recruiting, it should be assumed that some plots would be located in stands that are appropriately described as self-replacing. Self-replacing stands may be classified into three basic conceptual types with intermediate conditions expected. These stand types are: 1) stands of dense, even-aged stems that have successfully recruited following recent (10-30+ yrs.) disturbance (e.g. fire or mechanical) to heights that they are now safe from ungulate browse pressure and generally exhibit little or no new regeneration; 2) stands with depleted overstories but with vigorous regeneration and ample stems in the sapling to sub-canopy size classes; or 3) multi-aged stands with stratified canopies (long time since last disturbance). It is essential that we be able to characterize all types of self-replacing, stable aspen stands using reasonable metrics to in turn be able to quantify the variables that will be used in their classification.

    i. **Stable Aspen stand type 1 (SA1)** will have a minimum of 1,000 live stems/ acre (2,470 stems/ha). This is approximately double the density of a fully stocked aspen stand (Mueggler 1989, Guidelines for Aspen Restoration 2010). Subsequently, additional natural thinning is expected. Aspen stands with densities greater than 1,000 live stems/acre are common when vigorous suckering follows disturbance (e.g., fire) in healthy aspen stands and browse impacts remain low. Consequently, tree density is high enough that the absence of active shoot generation in SA1 stands should not be considered a disqualifier for self-replacing status.

    ii. **Stable Aspen stand type 2 (SA2)** is what might be expected when stands with depleted overstories exhibit sufficient recruitment that full recovery is expected as stems mature. In general, recruitment synchrony for self-replacing SA2 stands is intermediate between that of the disturbance-initiated SA1 stands and that of the more continuous stable aspen type 3 (SA3) stands described below. The upper density limit for live canopy trees is arbitrarily set at 200/acre for the SA2 stand type, or less than half that of a fully stocked aspen stand. SA2 stands are further sub-divided into four levels based upon the combined density of sapling and sub-canopy trees[5] relative to the density of live canopy trees. The levels are defined as follows: **full self-replacing (SA2-**

[5] Sub-canopy trees are >12' (3.65 m) in height with crowns clearly below the dominant canopy structure which will vary in height for mature stands with microsite conditions and genotype.

**F)** when the combined density of saplings and sub-canopy trees is ≥ 200% of the density of live canopy trees; **transitional self-replacing (SA2-T)** when the combined density of sapling and sub-canopy trees is ≥ 100% but < 200% of the live canopy-tree density; **marginal self-replacing (SA2-M)** when the combined density of sapling and sub-canopy trees is ≥ 50% but < 100% of the live canopy-tree density; and **non-self-replacing (SA2-N)** when the combined density of sapling and sub-canopy trees is < 50% of the live canopy-tree density.

Table 2. Threshold benchmarks for Full, Transitional, and Marginal self-replacing levels of Class 2 stable aspen (SA2).

| **Density of live canopy trees** | **Minimum sapling + sub-canopy tree density for SA2-F level** | **Minimum sapling + sub-canopy tree density for SA2-T level** | **Minimum sapling + sub-canopy tree density for SA2-M level** |
|---|---|---|---|
| **(trees/acre)** | | | |
| **200** | 400 | 200 | 100 |
| **150** | 300 | 150 | 75 |
| **100** | 200 | 100 | 50 |
| **50** | 100 | 50 | 25 |
| **25** | 50 | 25 | 13 |

iii. All self-replacing, stable aspen stands not classified as type SA1 or SA2 will by default be classified as **stand type 3 (SA3)**; multi-aged stands with densities that are greater than 200 and less than 1000 live trees/acre. Stratified canopies of continuous or pulsed recruitment and a basal level of new shoot production are descriptive of SA3 stands. In reality, SA2 and SA3 stand types represent different segments on a single continuum of overstory condition; however, the corresponding recruitment effort may differ substantially between the two types as a function of overstory live-tree density and corresponding differences in apical dominance. Specifically, as canopy tree density increases for SA2, a corresponding 2-fold increase in recruitment-size stems is required to qualify for the fully self-replacing status. However, for SA3 stands, sapling/sub-canopy tree density is expected to decrease with increasing canopy density (Figure 2). Thus at the low end of the SA3 spectrum (200 live canopy trees/acre), a minimum of 400 saplings/sub-canopy trees per acre are required for full self-replacing (SA3-F) status while at the high end (999 live canopy trees/acre) none are required for the same. More specifically, SA3 stands will be assigned to the **SA3-F (full self-replacing)** level based upon the following equation where (a) =

density of live canopy trees and (b) = combined density of saplings and sub-canopy trees.

$b \geq a\ (-0.5) + 500$

Stands will be assigned to the **SA3-T (transitional self-replacing)** level if the sapling + sub-canopy density is at least ½ of the minimum threshold for F-SR status as indicated by the equation:

$a\ (-0.5) + 500 > b \geq a\ (-0.25) + 250$

Stands will be assigned to the **M-SR (marginal self-replacing)** level if sapling + sub-canopy density is at least ¼ of the minimum threshold for F-SR status as indicated by the equation:

$a\ (-0.25) + 250 > b \geq a\ (-0.125) + 125$

SA3 stands are assigned to the **N-SR (non-self-replacing)** level when recruiting stem densities are below the M-SR minimum threshold:

$$b \geq a\ (-0.125) + 125$$

Table 3. Threshold benchmarks for Full, Transitional, and Marginal self-replacing levels of Class 3 stable aspen (SA3).

| **Density of live canopy trees** | **Minimum sapling + sub-canopy tree density for SA3-F level** | **Minimum sapling + sub-canopy tree density for SA3-T level** | **Minimum sapling + sub-canopy tree density for SA3-M level** |
|---|---|---|---|
| **(trees/acre)** | | | |
| **200** | 400 | 200 | 100 |
| **400** | 300 | 150 | 75 |
| **600** | 200 | 100 | 50 |
| **800** | 100 | 50 | 25 |
| **1000** | 0 | 0 | 0 |

c. Stable aspen improvement thresholds: Using 2013 (and possibly 2014) monitoring data, each of the 60 stable aspen plots will be classified into the appropriate class and level based upon live canopy tree and recruitment (saplings + sub-canopy trees) densities as described above. Although monitoring will continue on all plots, those plots initially classified as SA1 or SA2/SA3 level F (fully self-replacing), will not be used to determine treatment-related improvement in stable aspen because it is assumed that these plots are already fully self-replacing.

Improvement for the subset of plots initially classified in levels T (transitional), M (marginal), and N (non-self-replacing) will be recognized and documented when plots move upward from one level to another (N to M, M to T, T to F). Similarly, degradation will be acknowledged if plots drop a level.

i. A minimum benchmark of success in restoring stable aspen on Monroe Mountain will be that average improvement for all eligible plots (SA2 and SA3 levels T, M, and N) must be equal to one full level increase as a benefit of the project. Thus, for every plot that fails to move up a level, another will have to move up two levels. Plot degradation (drop in levels) will also be factored in.

ii. It is not acceptable to have to wait 10-15 years until the entire Monroe Mountain project is completed to determine the degree to which it has been successful. A process must be adopted to incrementally assess whether management actions are leading to the desired outcome and, if not, additional management actions on the mountain will be warranted.

iii. Aspen response (including stable aspen) should be proportional to the area treated (as a percent of the total area planned for treatment) across the duration of the project. It may not be possible to accurately predict how browse relief will be distributed spatially. Therefore, stable aspen improvement should be interpreted at the broadest spatial scale (all 60 plots). For example, one scenario might allow that 10% of the area planned for treatment, be treated. Assuming in the same scenario that 50 of the 60 stable aspen plots are classified as being eligible for improvement (as defined above) then an expectation for reclassification to at least one level higher might be expected for a minimum of 5 (10%) of the 50 eligible plots, with no plots being downgraded in response to this first year of treatment. It is anticipated that level changes may be detectable within 3 years of treatment.

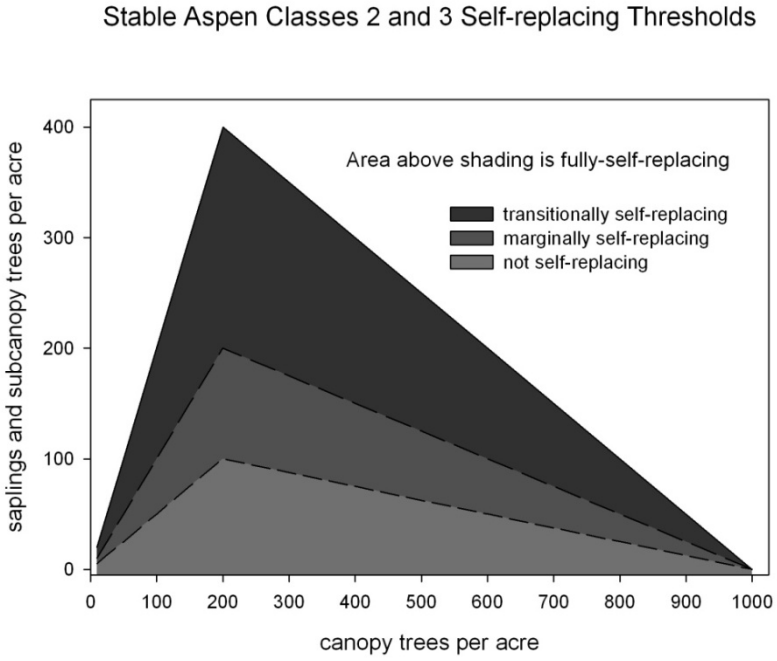
d. Adaptive management: A failure to detect sufficient improvement after an appropriate lag time (allowing some flexibility for unknowns such as extreme weather events) will trigger a recommendation for an appropriate adaptive management response(s) (selecting from the adaptive management responses listed above) to temporarily reduce browse pressure by domestic and/or wild ungulates sufficient to allow for stable aspen recovery. These recommendations will not be interpreted as endorsement of permanent changes in livestock or wildlife management. As additional area is treated, a proportionate increase will be expected in the number of plots that improve sufficiently to warrant reclassification to a higher level. A lag period of approximately 3 years will continue to be employed for each treatment. Hypothetically, this could result in a recommendation to reduce browse pressure after treatment of seral aspen stands even when aspen recovery

within the treatment area is satisfactory but where there is no corresponding improvement in stable aspen monitoring plots. The opposite is also possible, that is we could have improvement in stable aspen but unsatisfactory results in the treated area. Either way, under these conditions management actions designed to reduce browse pressure would be desirable.

e. Boundaries described herein between stable aspen classes and levels of recruitment, though somewhat artificial, are based upon expert opinion and best science available. These boundaries are subject to modification if site-specific data from stable aspen plots and/or exclosures provide clear rationale for doing so. The lag period (3 years) between treatment and time of expected recruitment enhancement may also be adjusted with experience. In such cases, proposed changes and supporting rationale will be documented and subject to review prior to implementation. For this reason, continued and close communication between USDA Forest Service, UDWR, RAC, Utah Wildlife Board, and all other interested stakeholders is critical.

f. Stable aspen classes and recruitment levels are based directly upon the densities of stems that reach relatively safe heights and will not initially take into account the browse intensity values that will clearly influence those densities. Patterns in annual browse data will be analyzed over time with the objective of determining how they might be incorporated to improve assessments of stable aspen condition and trajectory on Monroe Mountain.

Figure 2.

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