Discussion

Initially, I will discuss the results on a treatment area by treatment area basis: suggesting the reasons for what was observed. Next, I will discuss the patterns observed along with land management issues that could be contributing to the observed patterns..

Fishlake Plateau Subsection

Briggs Hollow

According to my hypothesis, there should have been significant differences in the number of aspen suckers produced inside the fenced sites versus outside the sites, however that was not what happened. It is important to note that all sites were sampled early in the grazing season (July 16-18, 2001), except outside the cattle exclosure on unit 2 (BH2cout-AC), which was sampled at the end of the grazing season (October 11, 2001). BH2cout-AC also received the highest percentage of animal damage. Additionally, all the other sites had more wildlife sign (pellet groups or scat) in them than cow sign (cow paddies). Thus, the most probable explanation is that the cattle had not yet reached the sites by the time we sampled them, except for BH2cout-AC.

Even though the number of stems produced did not vary statistically, herbivory was impacting stem height in all the units that had been sampled in July. The most likely reason for stems outside unit 2 to be taller than inside the cattle exclosure would be the time lag in sampling, since inside the exclosure was sampled in July, outside the exclosure in October, giving those stems more time to grow.

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Farnsworth

Similar to Briggs Hollow, there was no significant difference in the production of aspen stems between the fenced and unfenced Farnsworth units, but they did vary in their stem heights. Unexpectedly, the unfenced unit's stems were taller. The stand that was one year younger was the taller of the two. There are two possible reasons for this. One, there is clonal variation being observed, since the sites were separated by almost 0.9 miles. The other, there are physical differences between the sites.

When the unfenced unit was sampled, we noted that it had a 20% slope and there were boulders as large as 1.5 meters (~ 5 feet) in diameter throughout the site, whereas the fenced unit was quite flat with very thick undergrowth and it was much wetter. In spite of the greater percentage of damage attributable to animals on the steeper site, it had no deer, elk or cow sign, whereas the flat, fenced site did have either moose or elk sign. The steep, stony site was more difficult to move around in, with footing being much more treacherous, and it didn't have the same thick, grassy undergrowth that the fenced unit had. It is likely that instead of browsing on the aspen, wildlife were grazing the grasses.

Monroe Mountain Subsection

Burnt Flat

As mentioned earlier, the wildlife excluded site produced significantly more stems per acre than either of the two unfenced sites. The same was true of stem height. It is interesting to note that BFS16ufd-C received about the same amount of animal damage as the tall-fenced unit (BF2win-Q); however, BF2wout-P received more animal damage than the other two. As mentioned, the fenced unit was quite small, and the plastic fencing material was quite pliable.

These qualities made the fencing easy for cattle and wildlife to push into and still browse the perimeter of the stems inside the fence, but it was strong enough to limit browsing damage to the periphery. The plot had originally been fenced with the plastic netting to test the utility of the material for protective exclosures. There was one section of the fence that had been torn leaving a hole large enough for an animal's head. In this area, as well as all along the fence, sample plots had been surveyed, which explains the amount of animal damage noted.

Dry Creek

The two Dry Creek units sampled were about 0.6 miles apart. The unfenced unit was sloped 17%, was nearest to the road and there was a depression were water collected or seeped. The other unit (fenced) had not been fenced until late-July, only about two weeks prior to sampling, so the data should be interpreted as if it weren't fenced. In any event, the units were statistically different in the number of stems produced and in dominant stem heights, with the fenced unit producing more and taller stems. The fenced unit had also received more animal damage. According to the forester who had initiated the fencing, cattle had to be driven or shooed out of the fenced area, which was much flatter with only a 5% slope. In spite of the greater percentage of animal damage that the fenced unit received, the stems there were a year older and taller than the unfenced sloped unit nearer the water source. In all likelihood, the water source tended to congregate animals at a less desirable foraging site, which had been very nearly browsed clean. The animals probably didn't move to the flatter site until the nearby sloped site, nearer to water had been utilized to the point of no longer being worth the effort.

Oldroyd Private Property

On the Oldroyd private property units, harvests were conducted in 1996. The selective harvest's (OPPufd-U) median stem age was three years, and the clearcut aspen harvest's was one

year. Quaking aspen is not a shade tolerant tree (Jones & DeByle 1985b), thus by selectively removing the shade tolerant spruce and fir species, thereby opening up the canopy, aspen was able to regenerate on the site, even though the mature aspen were left. The remaining cover on OPPufd-U probably gave the aspen suckers protection from foraging wildlife. However, both sites produced very few stems, with the aspen harvest (OPPah-AG) site producing only 350 stems per acre. The clearcut aspen harvest looked very much like the unfenced White Ledge unit, but the acreage clearcut on the Oldroyd property was much smaller. When the aspen clearcut (OPPah-AG) was sampled, we noted that 18 of the 20 plots contained elk sign, in comparison to the selective harvest unit (OPPufd-U), with 3 of the 20 having elk sign. These sites demonstrate that treatment type can have an important impact on the success of aspen restoration projects.

White Ledge

When comparing the cattle excluded (WL2cin-W) and unfenced (WL16ufd-V) units of the White Ledge treatment area, one can see that over-utilization is a very real problem. There are just too many animals foraging in this treatment. At the time of sampling, some cattle were seen in the area, but only four plots contained cow sign. In contrast, only eight of the twenty plots surveyed were without animal sign, with elk sign, in half of the plots, being most common. Clearly, elk have as much or more impact on the treatment area as cattle. Sadly, unless something is done immediately to protect this site from further herbivory, the treatment will have failed in its purpose to restore the aspen.

Oldroyd Fire

When the number of stems per acre of the moderate burn intensity areas was compared to the fenced Dry Creek and Briggs Hollow units, there was only a possible statistical significance

found (P = 0.0538). However, the bulk of the fenced samples were from the Briggs Hollow units (n=80, vs. n=10 from DC2cin-Y). Briggs Hollow is located on the Fishlake Plateau, and the site was much drier, with much of the surrounding vegetation being a sagebrush (*Artemisia sp.*) type. In contrast, the moderate burn sites were in a mixed conifer/aspen type. Additionally, since aspen is a clonal species, there could also be differences related to clonal variation that are confounding the results. So, had it been possible to compare the moderate intensity sites with nearby successfully regenerating sites, then the significance would probably have been stronger.

It would be useful to compare a wide variety of clearcut sites with a wide variety of moderate burn sites, so that site characteristics and clonal variation could be masked. That said, there was an effect of fire intensity on stem heights (P = 0.0018), since the moderate burn sites weren't statistically different from the clearcut sites. Thus, with the almost significant number of stems produced and the significance of stem height noted, clearcutting a site has about the same restorative use or value as a moderate burn intensity. Schier et. al. (1985) noted that the greatest number of suckers was produced following clearcutting versus partial cutting.

Since, fire is such an important component of Rocky Mountain forests, and many researchers (Bartos & Campbell 1988b, Campbell & Bartos 2001, Clark & Sampson 1995, Chappell 1997, Gifford et. al. 1984, Malespin & Kingston 1986, Mueggler 1985, White et. al. 1998 and White 2001) note that changes in fire intervals are causing a conversion from an aspen to mixed conifer ecotype and a build up of forest fuels. Clearcutting aspen to restore the ecosystem type could be a useful tool in situations where burning is unsafe or otherwise problematic. Burning is an inexpensive and effective way to naturally regenerate aspen forests (Schier et. al. 1985), making it an important management tool for its efficiency. My data showed that if fire intensities can be kept in the moderate range, then aspen could be economically

restored to the landscape. But as Chappell (1997) determined Monroe Mountain's fire intervals are more than 100 years overdue. The accumulation of forest fuels over that long of a time frame means that fire intensities will tend toward the high end, rather than the pre-settlement trend of frequent, low-intensity fires.

Tushar Mountains Subsection

Grindstone Flat

As noted earlier, there was no significant difference found on the number of stems produced, nor on the heights of the stems between the three treatments (wildlife exclosure, cattle exclosure, outside the exclosures). This was not what was expected. Clearly, animals were differentially impacting the three treatments, as can be seen by the very different percentages of animal damage noted (GSwin-Z = 0%, GScin-A = 11%, GSout-AA = 74%), but herbivory must not be having a significant impact on the area. This is also interesting, since the area is quite flat; only about 7% slope. However, the area of the Grindstone exclosures is quite small in relation to the surrounding flat, which was also burned in the 1996 fire. As mentioned by (Campbell & Bartos 2001), if treatments are large, herbivory may be effectively distributed across the treated landscape.

Rigger Park

The only post-fire salvage treatment was found in the Rigger Park area. For the most part, the area is bowl shaped and gently slopes (10-26%) towards the bowl. The salvaged sites had statistically fewer stems than the unharvested, sloped site. Additionally, salvaging overall had statistical impact on stem height to the detriment of the salvaged units. Thus, salvaging

areas that have regenerating aspen following a fire appears to adversely impact the young aspen stems. How salvaging impacts the long-term health and possible restoration of aspen to these sites still needs to be studied. But many of the stems found in the salvaged units had oozing, diseased wounds, which cannot bode well for those infected stems.

Patterns and Management Issues

Overall, restoring aspen to the landscape on Monroe Mountain appears to be the most challenging subsection of the three studied. Aspen restoration treatments on the Fishlake Plateau and Tushar Mountain Ecological Subsections appear to be regenerating without much impact from herbivory, as was seen by the lack of significance noted on the number of stems produced in combination with the significance noted on the stem height of regenerating aspen. By comparison, Monroe Mountain treatments are receiving enough herbivory impact to not just inhibit stem height, but to also reduce the number of stems produced following treatments.

This study also determined that clearcut treatments appear to mimic the effects of moderate burn intensity. It is disturbing, however, that efforts to restore aspen on Monroe Mountain are having limited to unacceptable success, since only the Burnt Flat units appear to be successful. Without knowing the movement patterns of elk, deer and cattle on and near this area, one cannot accurately determine what is happening here; whether the physical characteristics are unsatisfactory, the area is relatively isolated, the clones are unpalatable, or some other reason that reduces the density of animals on that part of the mountain.

Jones & DeByle (1985a) observed that "moderate intensity fire that kills most or all the overstory will stimulate very adequate suckering and will have the least effect on subsequent sucker growth. From 12,100 to 60,700 suckers per acre were produced after burning several

sites in western Wyoming (Bartos 1979), certainly enough to adequately regenerate aspen to those sites." The Briggs Hollow, Farnsworth, Burnt Flat, Dry Creek fenced unit, Oldroyd Fire moderate and moderate-high burn intensities, Grindstone Flat, and all but one Rigger Park unit produced between 10,000 and 90,000 stems per acre. The sites that didn't were either experiencing setbacks from herbivory pressure or mechanical damage from salvaging operations. Clearly, the most extreme cases of unsuccessful aspen restoration were found at White Ledge, Dry Creek near the water source, and the Oldroyd Private Property aspen harvest, which were all due to over-utilization.

White (2001) pointed out that, "Disturbance reduces tree cover, the more open cover conditions favour increased elk use, and elk browse off all young aspen suckers before reaching sapling size (2-4 m tall)." White et. al. (1998) used <1 elk per square kilometer (Km^2) as a low elk density, but then revised that in 2001 (White 2001) to <2 elk / Km^2. In either case, elk density within Utah DWR's Monroe Mountain Wildlife Management Unit (WMU), which completely encompasses the Fishlake NF boundary of Monroe Mountain, is considered low (1800 elk / 443,629 acres (1795.27 Km^2) = 1.00 elk / Km^2). Moderate elk density would be 2 to 4 elk / Km^2, and high elk density would be >4 elk / Km^2 (White 2001). In White's study, cattle grazing was not a factor, since his work was limited to Canadian and United States National Parks found in the Rocky Mountains, which have not permitted cattle grazing since the parks were established. In 1999 through 2001, the Fishlake NF grazed 906 to 1046 cattle within three of the twelve grazing allotments on Monroe Mountain. In 1996, Mrowka & Campbell reported that 3500 domestic cattle and 5000 sheep grazed the mountain. According to DeByle (1985), "Cattle and elk compete because they both graze and both prefer grasses when succulent forbs are not available. The summer ranges of cattle and elk overlap, although the elk commonly

retreat to steeper, higher, and more inaccessible areas." DeByle (1985) goes on to say that generally, this is a problem on winter ranges when cattle are grazed in the summer where elk will congregate in the winter.

The Fishlake NF is unique however, because cattle, elk and deer all utilize the same summer range on Monroe Mountain with winter ranges being used only by wildlife. Monroe Mountain's top is relatively flat (Davis 1998) and weather conditions observed were quite mild during the summer, which makes cattle grazing possible at elevations above 9000 feet. This is also true of the Tushar Mountains and Fishlake Plateau Ecological Subsections. Davis (1998) also states that, "winter range is still considered the limiting factor for the unit's elk and deer herds", and as a result Utah DWR only monitors range trends on the winter ranges. However, without having range trend data for the summer range, which lies fully within Forest Service boundaries, no assessment can be made as to the validity of this statement. This is important, because, if cattle are utilizing the same amount of forage as the elk, then their density on the mountain could be comparable, and the number of animals on the mountain would fall into the moderate or high density range, even without figuring in the approximately 7500 deer that are utilizing the same summer range. Further, Monroe Mountain's elk population is managed by the Utah DWR as a trophy bull elk unit. According to DeBloois (2001b), Utah DWR's Beaver (Pole Creek Fire) and Plateau (Briggs Hollow) WMUs are larger (4656.23 Km2, 8534.22 Km^2 respectively), but their wildlife management objectives set elk densities much lower (0.2 elk / Km^2, and 0.003 elk / Km^2 respectively) than Monroe Mountain's 1.00 elk / Km^2. Similarly, Monroe Mountain's deer density (4.18 deer / Km^2) is much higher that either the Beaver (2.36 deer / Km^2) or Plateau (2.93 deer / Km^2) WMUs.

Other researchers have found that elk or deer alone can effectively prevent aspen regeneration in untreated areas as well as following prescribed fires (Krebill 1972, DeByle 1985, White et. al. 1998, White 2001). So it is safe to assume that a combination of low cattle, elk, and deer densities may produce enough cumulative herbivory to effectively undermine aspen restoration efforts. Thus, aspen restoration efforts on Monroe Mountain may be doomed to failure, if relief from herbivory cannot be guaranteed. As can be seen by comparing the Oldroyd Private Property aspen harvest (wildlife only), and the unfenced White Ledge unit (cattle and wildlife), wildlife herbivory on Monroe Mountain, may be enough to keep aspen suckers cropped to the ground, thereby starving the underlying root system of nutrients derived from photosynthesis, which would ultimately kill the clone itself. Unfortunately, no studies could be found that studied the combinations of cattle, deer and elk densities that would be low enough to regenerate aspen without relief from herbivory.

White (2001) studied the functional response of elk herbivory to aspen sapling (2 - 4 m tall) density, and determined that elk density in the Canadian Rockies was probably kept low through predation by wolves (*Canis lupis*), mountain lions (*Felis concolor*), bears (*Ursus sp.*)), and native peoples. Further, he found that, "Increasing elk herbivory results in a relatively rapid transition from a regenerating aspen state to a declining state, where few stems survive beyond the sapling age class. In this state, high herbivory levels combined with disturbances such as fire will not create increased densities of young aspen, and may even kill long-lived aspen clones (Kay and Wagner 1996, White et. al. 1998a)." Monroe Mountain has few bears or mountain lions, and no wolves. According to the Fishlake NF (2000a), Monroe Mountain received limited use by prehistoric people. As a result, one would hypothesize that if native elk did occur on

Monroe Mountain prior to European settlement, then elk densities were probably kept low, by higher densities of predators than there are now.

Presently, Utah DWR administers annual limited entry bull elk, general buck deer and general antlerless (does or yearling deer) deer hunts on Monroe Mountain. Elk populations have increased from about 600 in 1992 to about 1800 in 2001. Over that time, an average of 20 bull elk per year have been harvested from an average of 23 permits. Antlerless (cow elk or yearling elk) elk hunts are not held annually, but when held are considered control hunts. In 2000, Utah DWR sold 200 of these control hunt permits, with 157 antlerless animals being harvested, and in 2001 DWR sold another 200 control permits, but data regarding the harvest are not yet available. Prior to the 2000 and 2001 control hunts, antlerless elk hunts were held in 1993 yielding 23, in 1994 yielding 15, and in 1996 when 50 were removed. It remains to be studied, whether removing 157 to 357 antlerless elk over two years will bring elk numbers down low enough to permit aspen regeneration on treated areas without providing relief from herbivory; however it is doubtful that harvesting 16 to 27 bull elk will have much, if any effect on elk densities or herbivory impacts.