CHAPTER V

ASPEN BURNS

INTRODUCTION

As explained in Chapter 1 (above), the Park Service believes that aspen has declined on the northern range, in part because lightning fires have been suppressed since Yellowstone Park was established (Christensen et al. 1989, Knight and Wallace 1989). Fire-killed aspen regenerate by root suckers at densities ranging from 10,000 to 200,000 stems per ha (Schier et al. 1985). As previously discussed (see Chapter 1 above), under "natural regulation" the Park Service believes that if burned, aspen stands will regenerate and produce stems > 2m tall even in the presence of Yellowstone's elk population. For instance, Houston (1982:127) concluded that "Data from the northern range and adjacent areas showed that aspen often reproduced successfully when burned in the presence of ungulate populations." Despain et al. (1986:107) added that "Data from some locations on the northern range have proven that aspen, when burned, has actually regenerated despite heavy elk use." Gruell and Loope (1974:19-20) and Gruell (1980a:2) also indicated that aspen stands burned in Jackson Hole were able to regenerate successfully despite heavy browsing.

However, Basile (1979) and Bartos and Mueggler (1979, 1981) reported that even though an experimental burn on Breakneck Ridge (Table 4) greatly increased the number of aspen suckers, elk browsing eliminated all incremental height growth after the first summer. They concluded that fire-induced suckering was probably not sufficient to regenerate aspen under current browsing pressures in Jackson Hole.

To determine whether burning can, in fact, regenerate aspen despite heavy utilization by elk and other ungulates, I measured burned aspen stands at 11 different locations in the Greater Yellowstone Ecosystem (Table 4, Fig. 3, see Chapter 2 above).

RESULTS AND DISCUSSION

Frequency of Stand Regeneration

As described in Chapter 2 (above), I visually scanned aspen stands to estimate whether or not those stands had successfully regenerated. I then checked my visual regeneration estimates by measuring 111 burned and 28 unburned stands. In all instances, the 139 stands were correctly classified by the visual estimation technique. On Yellowstone's northern range and in Eagle Creek, 268 out of 268 unburned stands (a 20% random sample of 1,342 stands) were correctly classified by the same method (Kay unpub. data). Thus this technique appears to be accurate for the purposes of this study.

In Jackson Hole, I visually evaluated 467 burned aspen stands and 495 adjacent unburned stands for the presence of regeneration > 2m tall (Table 22). The proportion of burned aspen stands with regeneration > 2m tall varied from 0 to 100% while the rate in unburned stands ranged from 8 to 98% (Table 22). In general, the areas with the highest regeneration rates had the lowest levels of elk use, especially winter use. Some burned areas had higher regeneration rates than their unburned counterparts while the reverse was true in other areas.

Variation in regeneration rates also was related to stand aspect. In both burned and unburned areas, aspen stands with a northeast aspect were more likely to have regeneration > 2m tall than stands with other aspects (Table 23). The prevailing southwest winds drift snow onto northeast aspects which apparently limits ungulate use on those sites. When aspect is controlled, there was no significant difference between burned and unburned stands in their ability to produce regeneration > 2m tall (Table 23).

Aspen stands burned in Eagle Creek have not been able to regenerate successfully even though fewer elk utilize that area than in the park (Kay 1985, see Chapter 2 above). Only in stands where fire-

Table 22. Proportion of aspen stands with regeneration > 2m tall in burned and adjacent unburned areas, Jackson Hole, Wyoming.

	Stands visually evaluated				Measured stands					
	Number		Percent of stands with regeneration > 2m tall		Number		Percent of stands with regeneration > 2m tall		Level of elk use*	
Area	Burned	Unburned	Burned	Unburned	Burned	Unburned	Burned	Unburned	Winter	Summer
Burro Hill	71	50	100	98	14	10	100	100	Low	Low
Russold Hill	19	26	68	38	19	5	68	40	Low-High	None
Coal Mine Draw	51	58	27	38	10	11	40	45	Low-Mod.	Mod.
Lightning Creek	98	62	48	16	20	--	50	--	Mod.-High	None
Breakneck	80	48**	5	19	16	--	0	--	High	None
Dry Cottonwood	54	48**	13	19	10	--	10	--	High	None
Dry Dallas	90	186	17	19	18	--	22	--	High	None
Elk Refuge	4	65	0	8	4	2	0	0	High	Mod.
Totals	467	495			111	28				

* Unpub. data in Wyoming Department of Game and Fish files, Jackson, WY and pers. commun. Garvice Roby, Wyo. G&F. A few moose also utilize these areas in winter and summer. Mule deer are rare.

** The stands in these two areas are the same because Breakneck Ridge is located between Dry Cottonwood and Cottonwood Creeks.

Table 23: Effect of aspect on the ability of burned and unburned aspen stands to produce regeneration > 2m tall in the Gros Ventre Valley, Wyoming.

	Percent of Stands with Regeneration > 2m*	
Aspect	Burned (n = 323)	Unburned (n = 302)
N	5	0
NE	56	59
E	7	11
SE	14	15
S	4	2
SW	5	2
W	0	0
NW	8	11

$x^2 = 4.95$, *df* = 4, *p* > .25

* Based on visual evaluations of each stand; see Chapter 2.

Table 24: Aspen regeneration in stands burned in the Eagle Creek drainage north of Gardiner, Montana. Sampled during 1986. Additional photographs taken in 1987, 1988, and 1989.

Stand no.	Date burned	Elevation (m)	Aspect	Stand size (m)	Number of stems per ha <2m	Number of stems per ha >2m but <5cm DBH
1.	Spring 1980	2073	E	40 x 40	20,256	2,564*
2.	Spring 1980	2075	E	21 x 25	19,762	0
3.	Spring 1978	2042	E	6 x 9	40,000	2,778*
4.	Spring 1978	2027	S	7 x 15	38,667	0

* Stems > 2m tall only occur in the portion of the stand where fire-killed, jack-strawed aspen physically excluded ungulate browsing. All other stems have been repeatedly browsed and are < 1m tall.

killed aspen fell, jackstrawed, and physically excluded elk were any regenerating stems able to grow > 2m tall (Table 24). This occurred in only small portions of two out of four stands. However, during the winter of 1988-89, food-stressed elk (Lemke 1989, Lemke and Singer 1989) forced their way into these areas, high-lined all the aspen regeneration, and severely damaged most stems by stripping and eating the bark (Kay unpub. photos).

Stem Densities

The burns in Jackson Hole with the lowest levels of elk use had the highest densities of regenerated stems > 2m tall (Table 25). All stands apparently had sufficient initial sucker growth after burning (Bartos 1979, 1981) and many still have large numbers of stems < 2m tall (Table 25). However, repeated elk browsing apparently prevents those stems from growing > 1m tall. One stand in Coal Mine Draw had initial post-fire sucker densities > 100,000/ha (Bartos 1979, 1981) while 11 years later it still had stem densities > 50,000/ha, but they were all < 1m tall. On Breakneck Ridge, none of the burned aspen stands has been able to produce any stems > 2m tall (Table 25). Aspen stands in the Breakneck Ridge Burn also have low densities of stems < 2m tall. I was unable to locate live aspen stems in several of those stands. Apparently, burning plus repeated elk use (Bartos and Mueggler 1979, 1981) has led to the elimination of some clones.

As noted in Chapter 4 (above), various studies have demonstrated that elk avoid areas of human disturbance and especially open roads (Ward 1973; Ward et al. 1976; Lyon 1979a, 1979b, 1980,1983, 1984a, 1984b; Gruell 1980a:7; Leege 1984; Edge and Marcum 1985; Edge et al. 1985; Lyon et al. 1985; Witmer and De Calesta 1985). The Russold Hill burn extends from the Gros Ventre road (USFS 015) upslope to the north. Thus, burned and unburned aspen stands are located at varying distances from the road. This road is not plowed during winter, but is open to

Table 25. Aspen regeneration in burned and adjacent unburned areas in Jackson Hole, Wyoming. Number of stems per ha.

Area*	No. Stands	Number of Stems < 2m per ha		Number of Stems > 2m but < 5cm DBH per ha		Level of elk use	
		Mean	SEM	Mean	SEM	Winter	Summer
4. Burro Hill							
Burned	14	1,512	228	13,727	1,115	Low	Low
Unburned	10	2,584	584	4,917	816		
5. Russold Hill							
Burned	19	4,571	959	5,089	1,822	Low-High	None
Unburned	5	4,101	1,440	3,234	2,142		
6. Coal Mine Draw							
Burned	10	7,085	2,677	5,201	2,617	Low-Mod.	Mod.
Unburned	11	1,515	434	3,758	1,556		
7. Lightning Creek							
Burned	20	8,335	1,572	3,051	1,030	Mod.-High	None
8. Breakneck Ridge							
Burned	16	1,125	424	0	0	High	None
9. Dry Cottonwood							
Burned	10	6,601	2,167	1,317	1,317	High	None
10. Dry Dallas							
Burned	18	5,066	1,718	2,917	1,587	High	None
11. Elk Refuge							
Burned	4	3,209	1,667	0	0	High	Mod.
Unburned	2	3,334	2,000	0	0		

* Burn numbers correspond to those given in Table 4 and Fig. 3.

snow machine use. In recent years, snowmobile travel over this road has increased approximately 300-400% (G. Roby, pers. commun. 1987).

For unburned stands near the road, 90% produced regeneration > 2m tall while at distances more than 800m from the road, no stands successfully regenerated (Table 26). This same pattern occurred in burned aspen stands. Those nearest the road had over 11,000 stems > 2m tall per ha but that dropped to only 1,000 stems per ha at distances > 800m from the road (Table 26). This pattern cannot be attributed to site or climatic differences since the stands farthest from the road are also at increasing elevations and if anything, receive more precipitation. Apparently, human disturbance limits elk use close to the road which allowed nearby aspen stands to produce more stems > 2m tall. Gruell and Loope (1974:21) reported a similar pattern of aspen regeneration near roads in Jackson Hole.

In Yellowstone Park, burning caused a 10-fold increase in aspen sucker density outside the Junction Butte Exclosure (Table 27). Inside, stem density increased more than 25-fold. After burning, suckers were three times more common inside the exclosure than outside. Three growing seasons after the fire, aspen outside the exclosure had not increased in height while those protected from browsing did (Table 27). Outside the exclosure, elk browsed all of the aspen suckers to within a few cm's of the ground each winter (Kay unpub. photos). This stand and other stands experimentally burned by the Park Service on Yellowstone's northern range (Kay unpub. photos) have not been able to produce stems > 2m tall due to repeated elk browsing.

Yankee Jim Canyon Burn

Houston (1982:111) stated that at the Yankee Jim Canyon burn "over 95% of the aspen and chokecherry sprouts were browsed during the winter of 1977-78 and again in 1979. Despite intense browsing many aspen stems over 2m tall and chokecherry 1-2m tall occurred in dense stands when

Table 26. Aspen stands with regeneration > 2m tall at three distances from the road, at Russold Hill, Gros Ventre Valley, Wyoming.

	Percent of stands regenerating at three distances from road		
Stand condition	Stands < 400m	400m < stands < 800m	Stands > 800m
Unburned*	90% (n=10)	25% (n=4)	0% (n=11)
Burned**	100% (n=7)	40% (n=5)	57% (n=7)
	Mean number of Stems > 2m but < 5cm DBH per ha		
Burned			
All stands	11,086	767	595
Only stands with regeneration > 2m	11,086	1,917	1,042

* Based on visual evaluation of each stand; see Chapter 2.

** All burned stands were measured; see text.

Table 27. Aspen regeneration inside and outside the Junction Butte exclosure on Yellowstone's northern range. Burned after 1986 growing season.

	Outside exclosure			Inside exclosure		
		Height (m)			Height (m)	
	Stems per ha	Mean	SEM	Stems per ha	Mean	SEM
Pre-Burn						
1986	4,947	0.21	0.02	6,402	4.73	0.52
Post-Burn						
1987	52,200	0.30	0.01	154,860	0.33*	0.01
1988	51,620	0.30	0.01	165,010	0.55**	0.01
1989	35,591	0.21	0.01	116,821	0.83***	0.02

* $t = 2.44$, $p < .02$

** $t = 13.04$, $p < .001$

*** $t = 20.99$, $p < .001$

examined 18 September 1980." However, Houston provided no data on browse utilization or ungulate use at this site nor in Yellowstone Parkto determine if the two areas were comparable. Moreover, Superintendent Barbee (1984) stated that the Park Service did not have "any data on browse utilization and/or ungulate use for this area."

As previously discussed (see Chapter 2 above), because the Yankee Jim Canyon burn is located at the extreme northern end of the Yellowstone winter range as defined by Houston (1982) it receives proportionately less elk use than more central portions of the elk winter range in Yellowstone Park or even Eagle Creek. Gallatin National Forest records show that prior to the fire, Yankee Jim Canyon was used by an estimated 50 elk in 1976, by only one bull elk in 1977, and by approximately 15 mule deer during both those years. Forest Service and Montana Department of Fish, Wildlife and Parks records indicate that Yankee Jim Canyon receives relatively little ungulate use in most years.

From 1983 to 1988, I observed few elk pellet groups in this area. Within Yellowstone Park, nearly all of the conifers have been high-lined to a height of 2-3m by elk (see Chapter 8 below). Few conifers adjacent to the Yankee Jim Canyon burn show any signs of ungulate utilization and none are high-lined (Kay unpub. photos). In 1989, I measured regenerating aspen in this burn on 3-2x30m belt transects using the methods described in Chapter 2 (above).

Aspen within the burn averaged 25,122 (SEM=3,696) stems > 2m tall but < 5 cm DBH per ha. This was the maximum density I recorded for any burned aspen stand measured during my study and is not characteristic of the densities I recorded at other burned stands with moderate to high elk use (Table 25). Furthermore, this stand's understory contained 45% chokecherry and 74% total shrub canopy-coverage. Measurements on 194 randomly selected stands in Yellowstone Park failed to locate any stand which remotely approached this understory species composition (Kay unpub. data; see Chapters 3 and 4 herein). In the park, elk have reduced or eliminated the highly palatable chokecherry and other deciduous shrubs (see Chapters 3, 4, and 7 herein).

The available information indicates that few elk or other ungulates commonly frequent Yankee Jim Canyon. The area certainly is not representive of the level of ungulate utilization which exists or has existed in the park. Thus, the Yankee Jim Canyon burn is not an example of a fire-killed aspen stand which was able to regenerate despite intense browsing.

During the winter of 1988-89, several thousand elk from the northern herd died from a lack of food (Lemke 1989, Lemke and Singer 1989). Thousands of elk were forced from the park despite a late season hunter-kill of over 2,200 animals outside the park. For the first time since the fire, large numbers of elk utilized Yankee Jim Canyon. Their impact was readily apparent and dramatic. Nearly all of the aspen regeneration which could be physically reached by elk was high-lined and bark wounding was common (Kay unpub. photos). Prior to this time, the regenerating aspen had not been utilized in this manner.

PROBABILITY OF LIGHTNING FIRES

Flammability of Aspen Stands

Though aspen is often thought of as a seral community which needs to burn at frequent intervals if it is to maintain its dominance or presence at a site, experience and research have shown that aspen is extremely difficult to burn (Fechner and Barrows 1976, Brown and DeByle 1982, Jones and DeByle 1985c, Brown and Simmerman 1986, DeByle et al. 1987). Terms such as "asbestos type" and "firebreak" are often used to describe aspen (DeByle et al. 1987:75). Crown fires in conifers drop to the ground when they reach aspen communities and, prior to autumn leaf fall, spread only a short distance into aspen stands (Fechner and Barrows 1976:15). DeByle et al. (1987) noted that "Wild fires that had burned thousands of acres of shrubland or conifer types during extreme burning conditions usually penetrated less than 100 ft into pure aspen stands."

Lightning-fire ignition rates for aspen communities are the lowest of any forest type and overall ignition rates are less than half that for all other cover types, including brush or grass (Fechner and Barrows 1976). DeByle et al. (1987:73) reported that at current rates of burning "it would require about 12,000 years to burn the entire aspen type in the West."

Since litter seldom accumulates in aspen stands, due to relatively rapid decomposition, fires usually are carried through those communities by the current year's growth of understory species and any accumulated shrub biomass (Brown and Simmerman 1986). Moreover, understory plants must have a low moisture content if fire is to be carried through the stand. This usually occurs only after aspen leaf fall and after the understory plants have dried out following a killing frost (Brown and DeByle 1982, Brown and Simmerman 1986).

These conditions usually exist in the Greater Yellowstone area only after the latter half of September or later (Brown and DeByle 1982). However, precipitation during this period can curtail burning. Based on historic precipitation, relative humidity, and temperature data, Brown and DeByle (1982) reported cumulative frequency curves of estimated dates before the first major interruption in the aspen burning season, as well as the last date of the burning season for a portion of the Bridger-Teton National Forest south of Jackson Hole. By the third week in September, there is a 60% probability that at least one precipitation event will interrupt the aspen burning season. After November 1st, there is virtually no chance to burn aspen.

Thus at best there is only a 6-week window from September 15th to November 1st when aspen communities can normally be burned. Due to precipitation events and especially early snowfall, it is often virtually impossible to burn aspen. In some years, it is possible to burn western aspen stands in early spring, if weather conditions are right prior to understory growth (Jones and DeByle 1985c).

Ignition Sources

Based on analysis of fire-scarred Douglas fir trees from Yellowstone's northern range, Houston (1973, 1982) concluded that fires swept over that area with "mean intervals of about 20-25 years between fires" prior to modern suppression efforts. Houston (1973:1115) noted that "It seems probable that aboriginal man contributed to the frequency of fires on the area, but a quantitative assessment of this contribution is not possible." Nonetheless, he clearly implied that most of the "natural," pre-European fires had been started by lightning. Houston (1973:1115) also indicated that aspen on the northern range "had formerly been subjected to frequent burning."

In Jackson Hole, Gruell and Loope (1974:3) noted that "Aboriginal populations undoubtedly were an ignition source, but the incidence of lightning fires was sufficient to insure recurrent periodic burning and restoration of early stages of plant succession." Loope and Gruell (1973:434) added "Aboriginal man probably started fires, intentionally or inadvertently, but sufficient lightning fires have been ignited by late-summer storms to assure the existence of fire-influenced forests with periodic cyclic disturbances without human ignitions."

Since the early 1970s, the Park Service has had a policy of letting many lightning fires in Yellowstone burn. Under a 20-25 year fire frequency, about half the northern range should have burned in recent years. Prior to the summer of 1988, few fires began on the north range, and those which did burned only small areas and no aspen stands. Agency biologists have attributed this lack of fires to the fact that "lightning has chosen not to strike very often on the northern range" (Despain et al. 1986:109), but they provided no supporting evidence.

This assertion is not supported by data from BLM's Automatic

Lightning Strike Detection System (ALDS). From April through October 1985, lightning struck 680 times on Yellowstone's northern range. During the same period in 1986, 1987, and 1988 lightning struck 1,355, 598, and 917 times respectively. Thus, in 4 years, the northern range was struck by lightning at least 3,550 times. For a larger area in Jackson Hole, lightning struck 3,057, 5,162, 2,606, and 2,037 times in 1985-88; a total of 12,863 times. During this period, lightning struck at a rate of approximately 4 times per km^2/year on Yellowstone's northern range and around 4.5 times per km^2/year in Jackson Hole.

When ALDS data are tabulated by 2-week intervals, only 2.9% of the total lightning strikes on Yellowstone's northern range occurred prior to May 15th and only 0.3% after September 15th (Table 28). In Jackson Hole, 2% struck before May 15th and only 1% after September 15th (Table 28). When aspen communities are normally dry enough to burn in early spring or late fall, there are practically no lightning strikes. The only way aspen could be burned by a lightning-caused fire would be for the fire to have started in late summer in coniferous forests, have burned slowly, and then have been blown down onto the northern range late in the fall when the aspen stands were dry enough to burn.

This series of events is plausible, but unlikely to have occurred often enough to have produced the 20-25 year fire interval recorded on the northern range prior to European intervention. Yellowstone's 1988 fires were driven onto the northern range by exceptionally high winds, but those fires are thought to be a 100-300-year event (Singer et al. 1988b; Jeffery 1989; Romme and Despain 1989a, 1989b; Schullery 1989a, 1989b; Singer and Schullery 1989; Williams 1989) and certainly could not produce the 20-25-year interval reported prior to European arrival. Moreover, despite what were considered the worst burning conditions in the park's history, many aspen stands were still not overly susceptible to fire during the 1988 season (Kay unpub. data).

The only other ignition source for fires on the northern range

Table 28. Frequency of lightning strikes on Yellowstone's northern range and in Jackson Hole by 2-week periods 1985-1988. ALDS data; Yellowstone n = 3,550 and Jackson Hole n = 12,863.

2-week periods		Percent of total lightning strikes: Yellowstone	Jackson Hole
April	1	0.2	0.2
	2	1.6	1.1
May	1	0.7	0.8
	2	5.7	9.6
June	1	7.7	7.1
	2	23.9	8.5
July	1	15.9	9.9
	2	13.8	18.2
August	1	8.0	12.7
	2	11.6	23.9
September	1	10.5	6.8
	2	0.2	0.3
October	1	0.0	0.3
	2	0.1	0.4

would have been Native Americans. Recent studies have concluded that aboriginal burning was widespread and that native peoples had a sophisticated ecological understanding of fire (Lewis 1973, 1977, 1980, 1982a, 1982b; Arno 1976, 1980; Wright 1979; Barrett 1980a, 1980b, 1981; Lewis and Ferguson 1988). If aspen did burn at frequent intervals in Yellowstone and Jackson Hole prior to European influence, the vast majority of those fires would probably have been started by Native Americans. The scarcity of fires in recent times, during which lightning did "choose" to strike frequently, provides circumstantial evidence for this native burning hypothesis. Even if this was the case, burned aspen stands would probably not have been able to regenerate successfully if large herds of elk were present in prehistoric times.

CONCLUSIONS

1. Aspen suckering is stimulated by burning.

2. Even when burned, most aspen stands failed to produce stems greater than 2m tall when ungulate use was moderate or heavy. There is no evidence that burned aspen stands in Yellowstone will regenerate successfully despite intense browsing as claimed by the Park Service.

3. Evidence suggests that a combination of fire and continued heavy elk use may eliminate some aspen clones.

4. Aspen is a fire-resistant vegetation type which will readily burn only after autumn leaf fall and after the understory vegetation has dried-out. Because of these factors, aspen in the Greater Yellowstone area, under normal weather conditions, usually burns only after September 15th.

5. Lightning strikes at an average rate of 4-4.5 times/km^2/year on Yellowstone's northern range and in Jackson Hole mostly from June 1st to September 15th. Throughout the Greater Yellowstone ecosystem, few lightning strikes occur, on average, when aspen is physically able to carry a fire.

6. The 20-25-year fire frequency recorded for pre-Columbian times on Yellowstone's northern range is more likely to have been the result of aboriginal burning than lightning ignitions.

7. It is unlikely that fire suppression during Yellowstone Park's existence is primarily responsible for the decline of aspen in the park (see Chapter 8 below) especially since aspen continues to flourish in the absence of fire inside exclosures (see Chapter 4 above) and outside the park in Eagle Creek (see Chapter 3 above).