MORTALITY OF ASPEN ON THE GROS VENTRE ELK WINTER RANGE

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CONTENTS

ABSTRACT

Stands of aspen on the Gros Ventre elk winter range of northwestern Wyoming are suffering high mortality and are not regenerating satisfactorily. If the 1970 mortality rate (3.6 percent) continues, about a two-thirds reduction in the numbers of tree-sized aspen can be expected by year 2000. Collected evidence suggests that the mortality rate is unusually high because of a combination of pathogenic fungi, injurious insects, and physiological stress that follow bark wounding of tree trunks. Elk and possibly moose are suspected of causing most of these severe trunk injuries. Sooty bark canker, Cytospora canker, and stem-boring insects were the most common pests associated with tree mortality. The prospect for aspen on the elk winter range is especially critical because of the heavy impact of browsing and pests on aspen sprouts which prohibits natural replacement of the dying aspen overstory.

INTRODUCTION

Aspen (*Populus tremuloides*) provide beautiful scenery and important wildlife habitat on the Gros Ventre elk winter range of the Teton National Forest in northwestern Wyoming. Although aspen occupies only about 4 percent of the winter range, the type usually is in a conspicuous position in the lower and middle elevations where it often forms transition zones between shrub rangelands and conifer forests. Ecological succession has not been satisfactorily documented for the Gros Ventre, but the aspen type of the general area is now mostly considered as being seral to conifers and to have been perpetuated by wildfire (Gruell 1970; and Loope 1971). Fires of the 1870's and 1880's are thought to have been particularly important in shaping the current vegetation, but more recently "...fire protection has allowed many aspen stands to be invaded by conifer species" (Gruell 1970). Some 2,000 to 5,000 elk (*Cervus canadensis nelsoni*) are thought to winter in the Gros Ventre area. Supplemental winter feed is supplied at three Gros Ventre stations, but elk also feed on native trees, shrubs, sedges, grasses, and forbs. Heavy elk use of aspen has, for several decades, been noted by the occurrence of "highlined" trees and browsed sprouts.[1] Elk and also moose (*Alces alces shirasi*) apparently contribute to the conversion of aspen stands to conifers (Beetle 1968; and Gruell 1970). These animals cause injuries (fig. 1) that presumably induce susceptibility of aspen to disease (Loope 1971) and they consume sprouts that might otherwise replace dying overstory trees. In numerous stands, aspen are obviously dying at an alarming rate (fig. 2). When conifers are absent, it appears that deteriorating aspen stands will retrogress to a treeless rangeland type (fig. 3).

The study described herein was initiated to provide an up-to-date prediction of the future of aspen in the Gros Ventre area. Emphasis was placed on determining the rate of mortality of the aspen overstory, its causes, and the likelihood of overstory replacement by natural sprouting. Hopefully, these findings will inform resource managers about the severity of the aspen deterioration problem so that they might better determine whether modifications in current management might be necessary to maintain the pleasing diversity of forest types now present in the Gros Ventre.

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[1]Inspection reports of Teton National Forest as relayed by George E. Gruell, Wildlife Biologist, Teton NF, Jackson, Wyoming.

Figure 1.--Excessive game use of aspen is especially evident in close proximity to elk feedgrounds where trees have suffered severe bark damage and sprouts are browsed down to the snow level.

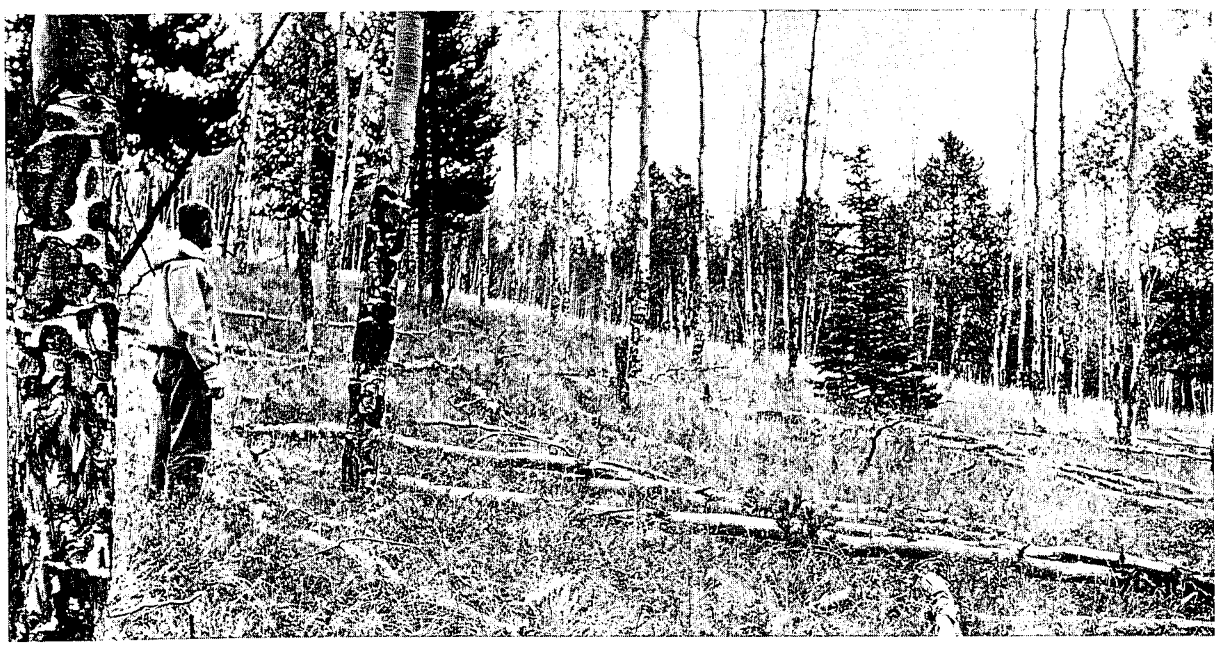


Figure 2.--Late stages of aspen deterioration in a stand south of Upper Slide Lake. Areas such as this are currently changing from an aspen type to a grass-forb parkland with scattered conifers. Many other deteriorating stands succeed more rapidly toward a conifer type, but some culminate in shrub, grass, and forb communities.

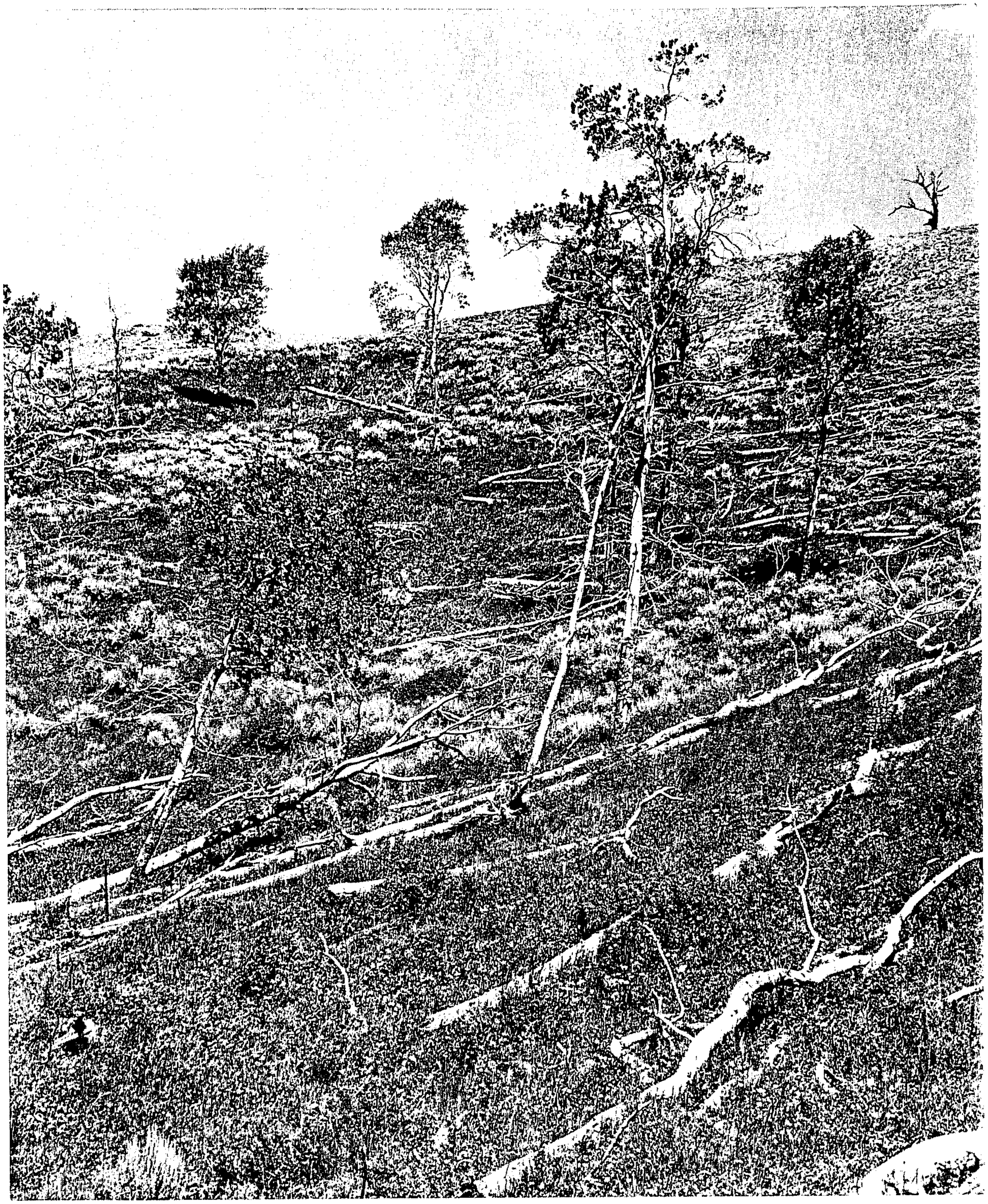


Figure 3.--Deteriorated stand of aspen on Breakneck Ridge east of Upper Slide Lake. Although it once supported a nearly continuous aspen crown canopy over several acres, this site has reverted to a rangeland dominated by shrubs, forbs, grasses, and decaying aspen remnants.

METHODS

The 84,000 acres of the middle Gros Ventre drainage selected for this study contained most of the aspen stands influenced by wintering elk (fig. 4). Within this area 100 sample plots were located by a method in which one plot occurred at random within each 33.3 acres of the 3,330 acres of aspen type delineated on the Forest Service 1956 Timber Type Map. Each plot was circular and 1/20 acre in size. Aspen ages were estimated by increment cores extracted at the 10-inch height from two trees containing wood sound enough for ring analysis and located nearest the plot centers. Ring counts were made in the laboratory with the aid of the acid-phloroglucinol staining technique of Patterson (1959). All aspen trees (individual stems taller than 10 feet) within plots were tallied by 6-inch d.b.h. size classes and condition classes: i.e., live, died in the current season, or died before the current season. Trees were assigned to current year mortality if unweathered dead leaves still remained in the crown. Dead trees that had fallen to the ground were not included in the sample unless they were windfall of the current season.

Sampling began in August 1970 and was completed in September, before fall coloration. This short time span insured a fairly comparable estimation of current mortality on all plots. Special efforts were made to record indicators that might suggest the cause of mortality in both classes of dead trees and the presence of injury or disease on all trees. Aspen sprouts within the plots were tallied, their heights determined, and any evidence of injury from browsing, insects, or diseases was recorded. The presence and ground coverage provided by young conifers, conspicuous shrubs, grasses, and forbs were also noted since understory vegetation can provide clues as to the degree of inherent stand stability and disturbance.

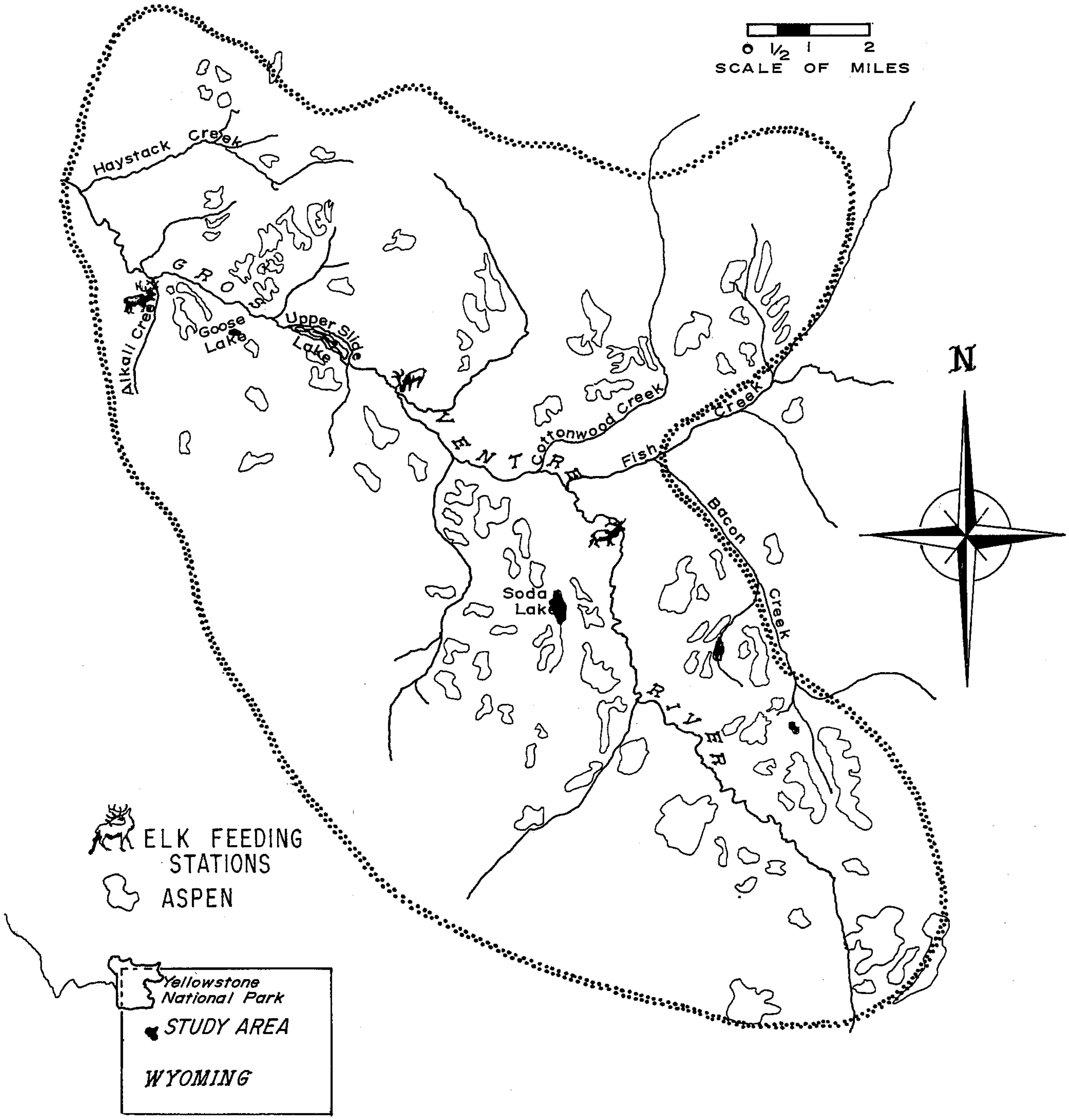


Figure 4.--Boundaries of the Gros Ventre study area, Teton National Forest, Teton County, Wyoming.

RESULTS

Age of Overstory Trees

As determined by ring counts, the trees sampled in the Gros Ventre were relatively old; none were less than 40 years of age, and the majority were between 81 and 120 years. The following tabulation shows the age distribution of sample trees:

Age class *Years*	*Frequency* *Percent*
<40	0
41-80	21
81-120	71
121-160	6
>160	2

Mortality of Overstory Trees

The combined sample from all plots totaled 2,332 live trees and 1,684 dead trees, of which 86 had apparently died during the 1970 season. These data are transformed to a per-acre basis (mean number of trees per acre) and presented in greater detail in the following tabulation:

Size class, in. d.b.h.	*Live trees*	*Dead trees*	*Died in 1970*
0.1- 6.0	196.6	290.6	11.2
6.1-12.0	258.8	44.6	5.8
12.1-18.0	11.0	1.6	.2
Combined	466.4	336.8	17.2

Wind breakage, sooty bark canker, and "barking" complemented by weak parasites and stem-boring insects accounted for most of the aspen mortality on the sample plots, as shown in the following tabulation:

Size class in. d.b.h.	*Wind breakage*	*Sooty bark canker*	*"Barking," weak parasites, pests, etc.*
	Percent	*Percent*	*Percent*
0.1-6.0	1	28	71
6.1-12.0	8	73	19
12.1-18.0	25	75	0
Combined	2	35	63

Death resulting from wind breakage or windfall was infrequent in small trees but rather common in the larger tree classes. *Cenangium singulare*, cause of sooty bark canker, was the single most injurious pathogen found on dead trees (fig. 5), and it too was especially prevalent in the larger tree classes. The third group was composed of trees that seemed to have died from a mixture of the following: bark wounding by elk or moose; infestation by stem-boring insects (probably species of *Agrilus*) (fig. 6); infection by bark fungi (including *Cytospora* sp.); suppression; and occasionally, sunscald. Mortality caused by this mixed category was especially prominent among the smaller trees.

Figure 5.--Sooty bark canker, caused by the fungus Cenangium singulare *in game-wounded portion of the aspen trunk on the left. The tree on the right was also scarred by game, but otherwise has remained healthy. Note the advanced degree of stand deterioration and the absence of visible sprouts.*

Figure 6.--Galleries of stem-boring insects, presumably Agrilus *sp., in cambial zone as seen when dead bark is stripped from aspen trunk.*

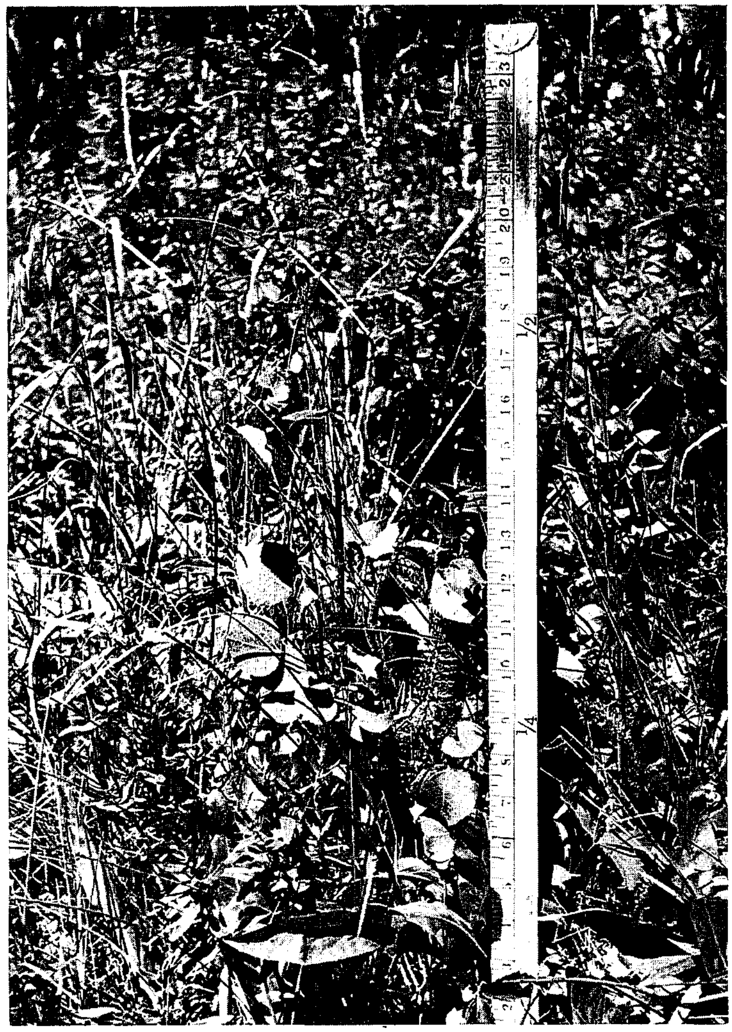
Aspen Sprouts

Even though generally hidden by grasses, forbs, and shrubs (fig. 7), aspen sprouts were found in 96 of the 100 plots. Expanded to a per-acre basis and expressed at the 0.05 confidence interval, the mean number of aspen sprouts ranges from 463 to 843 per acre, but 20 plots had less than 100 aspen sprouts per acre. Sprouts of 84 plots showed indications of having been browsed down annually to less than 2 feet in height. Sprouts survived and grew beyond a height of 3 feet in only three plots.

Miscellaneous Information on Injury, Pathogens, and Insects

Although diagnosis of mortality was emphasized during field evaluation of plots, the more obvious injuries, pathogens, and insects were noted and recorded. The

Figure 7.--Aspen sprout browsed off to about 14 inches high. There were an average of 653 sprouts per acre on sample plots, but most were overtopped by forbs as is shown in this photo. Although aspen sprouts were present on 96 plots, they were actually replacing dying trees on only three plots; all other aspen sprouts were held in check by browsing and pest damage.



incidence of disease and insect problems in stems expressed as a percentage of the aspen tree sample (n=4,016) is shown in the following tabulation:

Problem	*Causal organism*	*Plot incidence*
Bark wounds	Big game and rodents	90.0
Stem-boring insects	*Agrilus* spp.[2]	27.0
Cytospora canker	*Cytospora chrysosperma*	25.0
Sooty bark canker	*Cenangium singulare*	14.7
Cryptosphaeria canker	*Cryptosphaeria populina*	2.0
Heartrot	*Fomes igniarius*	1.2
Ceratocystis canker	*Ceratocystis fimbriata*	.6
Rough stem galls	*Diplodia tumefaciens*[2]	.3
Roundheaded borer galls	*Saperda* sp.[2]	.2
Buttrot	*Fomes applanatus*	.1
do.	*Pholiota squarrosa*	.1

[2]Identified by symptoms only.

The incidence of diseases and insects in aspen foliage in 1970 expressed in terms of presence in all plots (n=100) is shown in the following tabulation:

Problem	*Causal organism*	*Plot incidence*
Aspen leaf miner	*Phyllocnistis populiella*	53
Aspen leaf blight	*Marssonina populi*	13
Aspen shoot blight	*Pollaccia radiosa*	8

Inasmuch as only the more obvious injuries and pests were recorded, the frequency and various types of tree damage problems probably are underestimated in these tabulations. For example, conks (used to indicate incidence of heart and buttrot) were evident on less than 2 percent of the trees sampled, but heartrot was present in 33 percent of the increment cores examined for age data. Furthermore, some types of aspen damage in the Gros Ventre were not included because they occurred outside the 100 sample plots. For example, beaver (*Castor canadensis*) had damaged trees immediately adjacent to one plot but there was no beaver damage in any of the plots.

Many of the problems listed in the tabulations on pages 9 and 10 are combined in the mortality figures shown in the tabulation on page 7. For instance, *Fomes applanatus* had rotted the roots of at least three trees that succumbed to windfall. Likewise, heartrot was present in many other trees that were included in "wind breakage," and at least one tree broke off at a Ceratocystis canker.

In addition to the direct effects of bark injury caused by game and rodents, it was also noted that 90 percent of the sooty bark cankers occurred in the lower part of trees where the trunks had been scarred by animals. Elk were responsible for most of these bark scars, but moose, mice, and hares also contributed.

Of the foliage pests, shoot blight was limited to sprouts, but leaf blight and the aspen leaf miner occurred both on sprouts and on overstory leaves. Aspen leaf hoppers were rare, but occurred on sprouts in at least one plot.

Associated Understory Vegetation

The mean understory vegetation was composed of about 49 percent forbs, 36 percent grasses and occasional sedges, 12 percent shrubs, and 3 percent conifer saplings. Each of these groups contained a diversity of species. The frequency of occurrence of the more conspicuous trees, shrubs, and forbs are presented in table 1. Grasses and sedges were not identified except for pinegrass (*Calamagrostis rubescens*), which on an average occupied 66 percent of the ground cover in the eight plots in which it occurred. Although forbs were present in all plots and grasses or sedges were found in all but one plot, shrubs were absent from 10 plots and conifer saplings were missing in 27 plots.

Table 1.--*Constancy of trees, shrubs, and forbs commonly found in the 100 sample plots*[1]

Trees	No. of plots	Shrubs	No. of plots	Forbs	No. of plots
Picea engelmannii	39	*Rosa* spp.	54	*Geranium richardsonii*	85
Pinus flexilis	35	*Shepherdia canadensis*	53	*Lupinus argenteus*	80
Pinus contorta	16	*Symphoricarpos oreophilus*	41	*Thalictrum occidentale*	65
Abies lasiocarpa	16	*Berberis repens*	7	*Galium boreale*	49
Pseudotsuga menziesii	2	*Artemisia tridentata*	7	*Fragaria* sp.	46
		Potentilla fruticosa	7	*Achillea millefolium*	38
		Juniperus communis	5	*Senecio* spp.	34
		Arctostaphylos uva-ursi	5	*Aster* spp.	32
				Epilobium angustifolium	30
				Lathyrus sp. and *Astragalus* sp.	23
				Potentilla gracilis	22
				Pedicularis bracteosa	14
				Castilleja sulphurea	14
				Helianthella uniflora	14

[1]The shrubs *Lonicera involucrata, Prunus virginiana, Salix scouleriana, Ribes* spp., *Amelanchier alnifolia, Sambucus* sp., and *Pachistima myrsinites* were present in fewer than five of the plots. Also, there were 16 species of forbs not listed because they were noted in fewer than 10 plots. This included possible indicator species such as *Frasera speciosa, Balsamorhiza sagittata, Perideridia gairdneri,* and *Pyrola secunda*. There were some forbs in this group (such as *Allium* sp., *Taraxacum* sp., and *Agoseris glauca*) that probably were more frequent but were inadvertently overlooked because of their decadent condition at the time of sampling.

DISCUSSION AND CONCLUSION

Since aspen generally are known to be short-lived trees (Strothmann and Zasada 1957), it is natural that some aspen stands are becoming decadent in the Gros Ventre. Meinecke (1929) noted for nearby Utah that senility occurs with aspen at about 120 years of age and that the "wild aspen forest as a whole does not reach much beyond 130 years." If this is true for the Gros Ventre, we can expect a marked change in much of the aspen type within the next few decades since about two-thirds of the sampled trees are already in the 81- to 120-year age class. Furthermore, a drastic decline in the aspen type is eminent if game browsing continues to prohibit replacement of dying overstory trees and if exclusion of fire continues to allow invasion by conifers.

Even if the aspen senility and decadence situations of Utah do not apply directly to the study area, the Gros Ventre mortality data (see page 6, second tabulation) provide a dismal view. Using those data we can estimate that in 1970 there were approximately 1,500,000 aspen trees in the 3,330 acres of aspen type in the Gros Ventre sample area. If the 3.6 percent mortality rate of 1970 remains stable in the future, aspen would decline to about 500,000 trees by year 2000, and to only 40,000 by year 2070. Although the 3.6 percent rate was a fair estimate[3] based on the criteria used to estimate current year mortality, it probably was conservative since it could not have included trees which died in 1970 during winter dormancy. Certainly, these data indicate that unless there is replacement of overstory trees, the aspen overstory is due for a marked decline.

Although few comparative data are available, aspen mortality appears to be somewhat greater on the Gros Ventre than in other aspen areas. For instance, Hinds (1964) found that only 9 percent of the standing trees were dead in sample plots scattered over a wide area of Colorado, whereas almost 42 percent in the Gros Ventre sample were dead. Assuming that most aspen trees remain standing for about 10 years after death (which approximates the measured 1970 Gros Ventre mortality rate), there appears to be less

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[3]The confidence interval at the 0.05 level was only 2.6 to 4.6 percent as determined from a standard error computed as described by Freese (1962) for attributes from unequal-sized clusters.

than 1 percent annual mortality in Colorado as compared to the 3.6 percent rate in the Gros Ventre. Furthermore, the Gros Ventre rate is perhaps two to four times greater than reported recently by Manion and Valentine (1971) in New York. Also, in Ephraim Canyon of central Utah, Dr. K. T. Harper[4] found about 2.7 percent annual mortality in a sample of 2,091 aspen larger than 4 inches d.b.h. Harper's technique involved reexamination in 1970 of trees originally examined and tagged as being dead in 1969. When examining Harper's sample trees in autumn of 1970, we found that many would not have been tallied as 1970 mortality by the criterion used in the Gros Ventre study; these were trees that had not maintained dead leaves and were assumed to have succumbed during the 1969-1970 dormant season. From this we conclude that the 3.6 percent annual mortality measured in the Gros Ventre probably is an underestimate of actual mortality.

In the Gros Ventre, it appears that increased mortality has been caused by big game "barking" combined with pathogens and injurious insects that invade the wounded trees. Most of the 1,061 trees included in the "Barking, weak parasites, pests, etc." category of the tabulation on page 7 had scars resulting from big game chewing and some had been completely girdled. "Barking" damage was most injurious to the smaller trees; this partially accounts for the especially high rate of mortality in the 0- to 6-inch class. Probably though, the higher mortality in smaller trees was caused mostly by partial suppression which reduced their resistance to weak pathogens and stem-boring insects that characteristically follow "barking." *Cytospora chrysosperma* probably is a primary contributer to the demise of such trees. This fungus was thought to be a major factor in the aspen dieback associated with similar elk wounding of trees in Rocky Mountain National Park (Packard 1942), and "...it is generally considered a weak parasite on declining or dying trees" (Hinds 1964). Although encountered infrequently, *Cryptosphaeria populina* seemed to replace Cytospora as an invader of wounded bark in the dead aspen trees encountered in some of the Gros Ventre plots. It is not known whether this fungus is parasitic on aspen, but these observations suggest that it may be a weak parasite on this species and similar in aggressiveness to Cytospora.

The sooty bark fungus *(Cenangium singulare)* is an aggressive pathogen that can enter wounded tissues and girdle and kill aspen trees within 2 to 4 years (Hinds 1962). In the Gros Ventre, this fungus appears to be frequently aided by *Agrilus* beetles. Although Hinds (1964) found that elk wounds on aspen in Colorado seldom served as entrance points for canker organisms, the sooty bark fungus in the Gros Ventre was more frequently associated with big game wounds than would be expected by mere coincidence. Perhaps this results from more severe wounding in the Gros Ventre, or possibly wounding occurs at a more favorable time for fungus infection. In this respect, it should not be overlooked that moose are abundant in the Gros Ventre and might be "barking" some aspen trees during the growing season. In this study, a few fresh "barking" wounds were found in late September (fig. 8) in an area where only moose sign was fresh. In contrast, other observations in the Gros Ventre sample area suggest that most of the elk "barking" occurs in winter between December and May.

Harmful fungi and insects were not particularly severe on aspen foliage during 1970, but it is suspected that in years when they are epidemic they might complement the aggressiveness of other pathogens, or as Mielke (1957) suggested for *Marssonina*, some aspens might even die from heavy attacks. In spite of the appeal of this logic the Gros Ventre data failed to support a role by *Marssonina* in aspen mortality; the 13 plots showing leaf blight had similar mean numbers of live and dead trees (20.5 and 14.8, respectively) as did plots without *Marssonina* (23.7 and 17.1, respectively). The hypothesis might better be tested during and after epidemic conditions.

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[4]Personal communication, Dr. K. T. Harper, University of Utah, Salt Lake City, based on research while employed by Intermountain Station.

Figure 8.--Big game scars on a 9-inch-diameter aspen trunk. The fresh toothmarks near the center and lower right of this late-summer photo are suspected to have been made by a moose. The scar on the upper left likely was from elk chewing of the previous winter and that on the right from elk a year earlier.

Unfortunately, mortality tends to open the crown canopy which can initiate a chain of events that result in rapid stand deterioration. Graham, Harrison, and Westell (1963) noted that deterioration following the opening of aspen crown canopies can sometimes render "...within a 5- or 10-year period a valuable stand...to a worthless condition." Presumably, increased exposure to sunlight and associated sunscald that results from opening the canopy increases the susceptibility of remaining trees to harmful insects and diseases. This is an alarming hypothesis for the Gros Ventre elk winter range where most stands of aspen are already in at least the early stages of deterioration. It also seems reasonable to suspect, as Beetle (1968) suggested, that remaining trees become more "vulnerable to wind" as stands are opened up through overstory mortality.

It should not be overlooked that some mortality in a relatively dense aspen overstory might improve wildlife habitat by increasing forage production in the understory. Concerning the Coconino National Forest, Reynolds (1969) reported that thinning aspen from 229 sq.ft. basal area per acre to 42 sq.ft. per acre significantly increased the production of forbs, perennial grasses, and aspen sprouts. In the Gros Ventre, live aspens averaged only about 138 sq.ft. per acre in the 1970 plots, but 16 percent of the plots had less than half that amount. Natural mortality seldom resulted in fallen trees in numbers sufficient to create barriers to animal movement such as Reynolds had noted and it is assumed that increased forage is readily available to big game.

In most Gros Ventre plots there were numerous aspen sprouts ($\overline{X}$ = 653 per acre), but far too few escaped browsing and pests for successful replacement of overstory mortality. In fact, replacement was occurring on only three of the 100 sample plots. Insects and diseases were injurious to sprouts in addition to the detrimental effect of browsing by elk, moose, deer, cattle, and rodents. The aspen leaf miner was prevalent and *Marssonina* leaf blight and leaf hoppers were observed. On some of the wetter sites, *Pollaccia* shoot blight was devastating. Sprouts that were stripped of leaves by moose late in the growing season were particularly sensitive to frost injury, which may partially account for the severe impact of browsing.

A study of the associated vegetation in the aspen sample plots reinforces the conclusion that much of the Gros Ventre aspen is changing. Of the 100 sample plots, only 13 plots showed a species composition that was essentially identical to the stable *Populus tremuloides-Symphoricarpos oreophilus* habitat type described by Reed (1971). Nevertheless, there is some encouragement from these 13 plots because their 1970 mortality rate was only about two-thirds of that in the remaining 87 plots. Also, these plots contained a greater proportion of trees in the smallest size class, in which mortality was only about one-third that of the remaining 87 plots. This supports general observations suggesting that some stands of aspen will persist much longer than others. Forty-seven of the 100 plots had spruce or fir saplings in their understory; this, and the abundance of plants such as buffaloberry (*Shepherdia canadensis*), indicate that perhaps half of the aspen in the Gros Ventre occupy sites that are somewhat like the *Abies lasiocarpa-Pyrola secunda* habitat type of Reed (1969). It could also be argued, however, that the occurrence of plants such as pinegrass, balsamroot (*Balsamorhiza sagittata*), and sagebrush (*Artemisia tridentata*), along with the presence of conifer saplings in 73 plots, is indicative of a state of browsing disclimax (in the sense of Beetle 1968) in otherwise stable aspen. In either case, it is evident that if the current trends continue, perhaps one-half to three-fourths of the area now in aspen will succeed to conifers. Some of the remaining will go to shrub, grass, and forb communities, and at best, only a token amount will remain as a dominant aspen type.

The high rate of mortality in the aspen overstory on the Gros Ventre elk winter range appears to be caused mostly by a mixture of pathogenic fungi and insects which invade trees wounded by big game. The situation is critical because the combination of heavy browsing and pests prevents aspen sprouts from replacing dead trees. If current trends continue, most of the aspen type will ultimately be eliminated from the Gros Ventre winter range. Additional data about the potential for regenerating these aspen stands are needed before an aggressive and intensive management program can be initiated to preserve both the aspen type and the big game herds.

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