SUITABILITY OF ASPEN TREES AS LIVESTOCK FEED

Phase I

Demonstration of the Suitability of Aspen For Use As Livestock Feed

THE OLD WEST REGIONAL COMMISSION
May 1977

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May 1977

Prepared for the Old West Regional Commission
by
The South Dakota State Division of Forestry
Department of Game, Fish and Parks
Pierre, South Dakota 57501

The Old West Regional Commission is a Federal-State partnership designed to solve regional economic problems and stimulate orderly economic growth in the states of Montana, Nebraska, North Dakota, South Dakota and Wyoming. Established in 1972 under the Public Works and Economic Development Act of 1965, it is one of seven identical Commissions throughout the country engaged in formulating and carrying out coordinated action plans for regional economic development.

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FOREWORD

This report deals with a well-publicized demonstration of the utilization of ground aspen, an abundant little-used tree found in parts of the Old West Region, for cattle feed. The Commission is grateful to Dr. L. D. Kamstra of the College of Agriculture and Biological Science at South Dakota State University and his staff for their conduct of the project on behalf of the South Dakota Department of Game, Fish and Parks.

Warren C. Wood
Federal Cochairman

Project Completion Report

RUFFED GROUSE ECOLOGY STUDY

Pre-Operational Phase
Task 1

Contributing to

The South Dakota Department of
Game, Fish and Parks Project

Submitted by

Jon Sharps
and
Jeremiah Kranz

May 31, 1977

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INTRODUCTION

Aspen, (Populus tremuloides Michx.) is the most widespread tree species in North America. Estimates exceed 6 million acres of aspen-type commercial forest land in the areas including the Black Hills, Rocky Mountain States and the Great Lake States. The need to manage this very important fiber source has long been recognized by personnel of the South Dakota Department of Game, Fish and Parks and the Forest Services. In addition to providing a vast relatively untapped source of fiber, aspen management would be beneficial to wildlife habitat, watershed improvement, soil building, scenic beauty and public recreation.

In the fall of 1974, South Dakota Game Fish and Parks personnel discussed the lack of aspen management in South Dakota with Gordon Gullion from the Agricultural Experiment Station, University of Minnesota. Dr. Gullion relying on 18 years of studies relating aspen management to ruffed grouse (Bonasa umbellus) and wildlife habitat, suggested a great potential for aspen management for improving wildlife habitat in the Black Hills. Grouse particularly would benefit since ruffed grouse chicks depend on sucker regeneration of managed aspen during early life. In South Dakota as well as other areas in the region vast areas of aspen have been allowed to mature and become marginal for wildlife habitat or industrial uses. Since no market existed in the Black Hills, harvesting of aspen in a management program could not proceed without a

use for wood material being generated.

The Agricultural Experiment Station of South Dakota State University, Brookings, South Dakota agreed to begin ruminant feeding trials to determine the feasibility of utilizing aspen material as major feed component. In retrospect, Phase I of this study served as a feasibility study on aspen utilization by the cooperating agencies each with specific objectives. Phase II, considered in this report, presumes that the objectives of Phase I were accomplished and were adequately reported in the termination report submitted by the Game, Fish & Parks Department in 1975. In Phase II, feeding of aspen will be extended to growing and finishing rations with ruminants to determine its competitive status with traditional feeds in similar rations. The Game, Fish and Parks Department accepted the responsibility for determining the most economical means of harvesting aspen material and preparing it for ration formulation.

Problem Definition

In excess of 30,000 acres of pure aspen (Popules Tremuloides) stands exist in the Black Hills, most of which is composed of mature aspen having marginal value for wildlife food and cover. Feasibility for use of whole aspen tree material corrected for nutrient deficiencies was established for ruminant foods in Phase I of this research using maintenance-type rations with cattle. In order to effectively utilize the potential volume of aspen material presently available the use of aspen in growing and finishing rations must be established. The competitive position of aspen material with traditional fibrous feeds must also be established to develop markets for its use.

Objectives

1. To determine the value of aspen in growing rations in replacing conventional roughages.
2. To determine the value of aspen as the roughage portion of high concentrate finishing rations.
3. To determine the most economical method of supplementation of aspen material to correct nutrient deficiencies.
4. To determine the most economical means to harvest and process aspen material prior to ration formulation.

Project Methodology

Approximately 50 tons of green aspen material was harvested as chips and transported to South Dakota University, Brookings, South Dakota. The chips were subjected to drying in The Foundation

seed house driers to a moisture level suitable for grinding and encorporation into a complete mixed ration. Growing-finishing trials using 550-600 lb. steers were used to determine the value of aspen material as a component of a high energy ration replacing alfalfa as the roughage portion, as a component of a growing ration in which soybean oil meal was used to correct the protein deficiency, and as a component of a growing ration in which soybean oil meal as well as chicken manure was used to correct the protein deficiency of aspen material. The feeding data was used to determine the value of aspen material in finishing and growing rations, as compared to traditional forages.

Specifically, 60 Hereford steers weighing approximately 550-600 lbs. were randomly alloted to 12 pens with 5 animals per pen, providing replication for each of the six treatments. Trials were terminated when animals reached approximately 1,100 lbs. All rations were offered as a meal.

Project Impacts Upon the Region

If aspen material can successfully compete with traditional roughages as a major ruminant animal ration component, some of the benefits which could be expected are as follows:

A. Increased use of feed material such as aspen grown on marginal farm land with creation of additional cattle feeding opportunities in low-income rural areas.

B. Producing an additional income source for the lumber industry.

C. Increasing recreational opportunities by improvement of wildlife habitat for grouse and deer.

D. Information gained from cattle experiments could apply equally as well to development of diets for ruminant zoo animals or for emergency feeding of ruminants in the wild such as elk.

Pre-Operational Phase
June - July 1976

Task 1

Mark and sample the two acre stand of aspen selected for cutting to determine site quality, density, average diameter at breast height, and volume of merchantable material scheduled for removal.

INTRODUCTION

This is the second phase of cooperative investigation between the South Dakota Game, Fish and Parks and South Dakota State University College of Agriculture and Biological Sciences, regarding the improvement of aspen, Populus tremuloides, in the Black Hills for the benefit of wildlife through commercial harvest and use of aspen trees as a ruminant feed.

The long term results of this study hopefully will be to perpetuate a diversity of mixed age class in the aspen biomes of the Black Hills and stimulate interest in the commercial aspects of aspen.

Ruffed grouse, Bonasa umbellus, particularly would benefit from aspen management because of the resultant sucker regeneration which would provide the crucial brood habitat needed by ruffed grouse chicks in their first few weeks of life.

OBJECTIVES

1. Select a suitable stand of aspen to determine site quality, tree density, average diameter at breast height and volume of merchantable material;

2. Transport approximately fifty tons of green weight aspen chips to the feed lot test site or wherever specified;

3. Provide a cost value of dried aspen wood chips, suitable for reconstituting into a feed ration product, at the point of pelleting; but not including the pelleting process produced by different systems for harvesting, chipping and drying.

STUDY AREA

Study Site "A" is located in the Black Hills National Forest, Spearfish District, Lawrence County, Township 5 North, Range 1 East, Sections 13 and 14 (Figure 1). The topography of the Spearfish site extends over an area roughly one third mile long by one eighth mile wide and is oriented east to west. The elevation is 5400 feet with the soil being a rich clay-loam type.

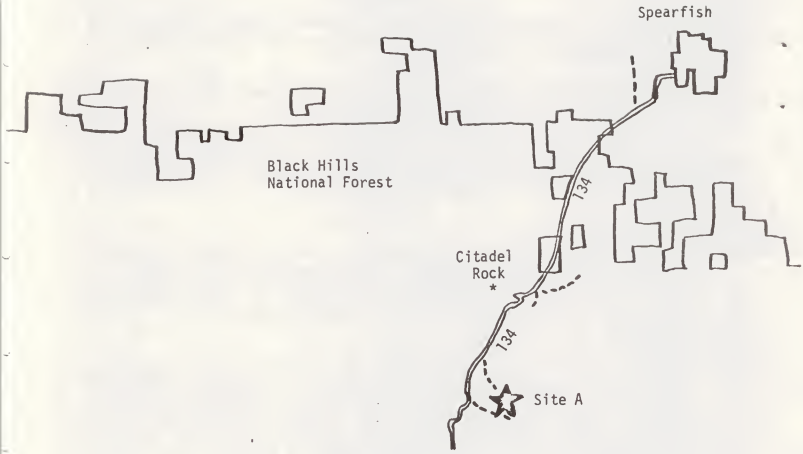
Study Site "B" is located in the Black Hills National Forest, Nemo District, Meade County, Township 4 North, Range 5 East, Sections 16 and 17 (Figure 2). The Nemo site covers an area roughly one half mile long by an eighth mile wide and is oriented east to west. The elevation is 4600 feet with the soil being a sandy-clay-loam type. The site is situated next to Elk Creek and is characterized by an over-mature stand of aspen approximately 75 to 100 years of age.

Study Site "B" is included here only for the purpose of reporting results of last year's clearcutting. No aspen chips were utilized in this year's feeding trials from this site.

METHODS

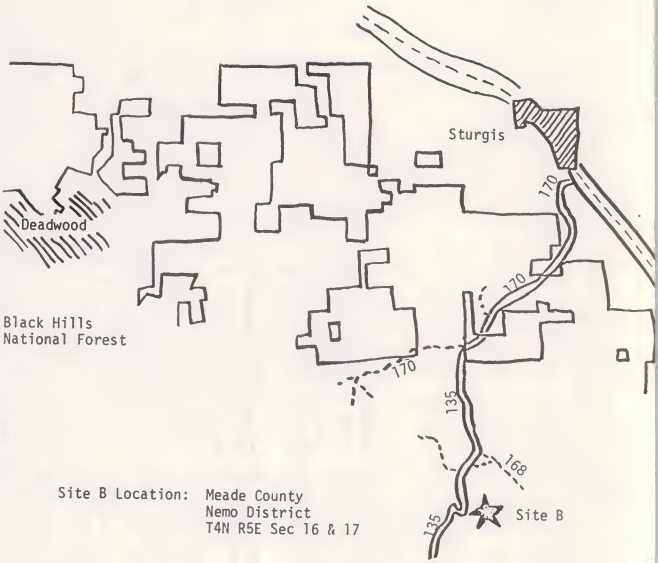
Site Description

Site "A". Six acres in Site "A" were treated as follows: One acre was clearcut the fifteenth of each month starting in May and continuing through September with the last acre cut in November. Cutting was done with chain saws. Each acre was fenced immediately after cutting with a four strand barb wire fence to exclude cattle and ten by twenty foot woven wire exclosure seven to nine feet high to exclude deer and elk (Figure 3). Approximately one and one half acres of aspen trees were used in the Phase II feeding trials by South Dakota State University as a replacement of traditional roughage in fishing and growing rations.



Site A location: Lawrence County, Spearfish District,
T5N R1E Sec 13 & 14

Figure 1.



Site B Location: Meade County
Nemo District
T4N R5E Sec 16 & 17

Figure 2.

Site A Plot Description

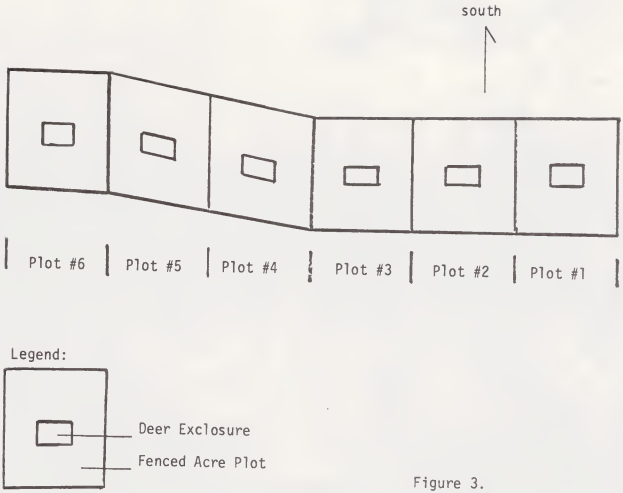


Figure 3.

Site "B". Eight acres were treated in Site "B" as follows: Plots one and two were clearcut with removal of firewood-size slash, leaving small limbs and debris; plots three and four were clearcut with removal of all slash and debris; plots five and six were clearcut with no slash or debris removed; plots seven and eight were used as a control and were not clearcut (Figure 4). Cutting was done with chain saws. Clearcutting started the seventeenth of June, 1975, and continued intermittently until the twenty-first of November, 1975. Plots one, three, five and seven were fenced in July 1976. Fencing was conventional four strand barb wire using wooden posts and five foot aspen tree stumps as posts where feasible.

Woven deer exclosures measuring ten by twenty feet by seven feet high were put inside fenced acre plots.

A permanent centerstake was established in each plot of both Study Sites "A" and "B". Ten circular subplots were established per plot to determine aspen regeneration numbers and height. Subplots were established randomly using distance and magnetic direction from plot centerstake.

Following the initial survey, data were analyzed to determine means and standard errors. In subsequent years additional subplots will be established until mean data are estimated to be within 10 percent of the true mean at the 95 percent confidence level.

Overstory

Tree numbers (stems/acre) and basal areas (sq. ft./acre) were estimated from stumps following clearcutting. Ten circular subplots (1/100 acre) were established per plot. Stumps within subplots were counted and diameters measured. Tree numbers were projected by multiplying average number of stumps per subplot by 100.

Basal areas (breast height) were calculated using the following formula for each stump:

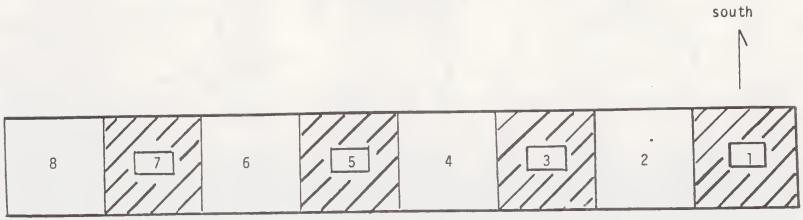
$$X = \frac{\pi}{144} \frac{(.821Y)^2}{2} \frac{43560}{Z}$$

wherein: "X" equals basal area in square feet per acre, "π" equals 3.14, "Y" equals stump diameter in inches, and "Z" equals area of subplot in square feet. Stump diameters were multiplied by 0.821 to give breast diameter. The figure 0.821 was obtained by measuring stump and breast high diameters of 87 nearby trees. For our subplots the formula in shortened version is $X = 0.368\ (Y)^2$.

Reproduction

Sucker sprouting of aspen and crown sprouting of birch were calculated from subplots used to measure overstory; however, subplot size was decreased to 1/1000 acre. All sprouts were counted and grouped by 6 inch height classes. Browsed sprouts were also recorded. Stems per acre were calculated by multiplying stems per subplot by 1000.

Site B Plot Description



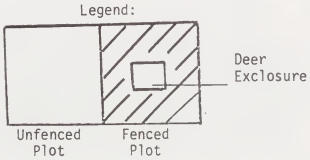


Figure 4.

FINDINGS

Overstory

Tree numbers. Aspen was the most abundant overstory species averaging 504 stems/acre for both sites (Table 1). Birch was next in abundance averaging 211 stems/acre. Other species including oak, pine and spruce averaged 30 stems/acre.

Table 1. Stems per acre of aspen, birch and other species, Aspen Study Sites "A" and "B", Black Hill's, South Dakota, 1976.

Site	Plot	Aspen	Birch	Other	Total
A	1	360	0	0	360
	2	480	20	0	500
	3	400	10	0	410
	4	480	60	0	540
	5	460	100	0	560
	6*	--	--	--	--
	Avg.	436	38	0	474
B	1	500	240	30	770
	2	500	560	10	1070
	3	480	400	50	930
	4	850	410	20	1280
	5	400	280	120	800
	6	620	210	60	890
	7	610	270	130	1010
	8	620	700	60	1380
	Avg.	572	384	60	1016
Grand Avg.		504	211	30	745

*Not cut at time of sampling.

Study Site "A" was nearly a pure stand of aspen with only minor numbers of birch present, whereas Site "B" was more of a mixed community.

Standard error of the aspen mean for Site "A" (436) was 43.31, and the 95 percent Confidence Interval was $\pm$ 87.5 trees or 20 percent of the mean. Standard error of the aspen mean for Site "B" (572) was 35.62, and the 95 percent Confidence Interval was $\pm$ 71.24 or 12.5 percent of the mean. To achieve means accurate to within 10 percent of the true mean at the 95 percent confidence level, approximately 200 sampling subplots are needed in Site "A" and 125 in Site "B".

Basal area. Aspen constituted the major part (83%) of the combined basal areas averaging 58.3 square feet per acre compared to 6.3 for birch and 4.0 for oak, pine and spruce combined (Table 2). Aspen basal areas for the two Study Sites were similar.

In general the Study Sites were similar; however, Site "A" was a more pure stand with fewer but larger aspen and birch trees. Site "B" contained a few large oak, pine and spruce trees.

The standard error of the aspen basal area mean for Site "A" (59.2) was 5.40, and the 95 percent Confidence Interval was ± 10.9 or 18 percent of the mean. Standard error of the mean for Site "B" (57.4) was 3.75, and the 95 percent Confidence Interval was ± 7.6 or 13 percent of the mean. Approximately 150 sampling subplots are needed in each Site to achieve a mean accurate to within 10 percent of the true mean at the 95 percent confidence level.

Table 2. Basal area (sq. ft./acre) at breast height for aspen, birch and other species, Aspen Study Sites "A" and "B", Black Hills, South Dakota, 1976.

Site	Plot	Aspen	Birch	Other	Total
A	1	63.6	0	0	63.6
	2	67.4	1.9	0	69.3
	3	49.2	0.7	0	49.9
	4	63.4	7.3	0	70.7
	5	52.3	9.0	0	61.3
	6*	--	--	--	--
	Avg.	59.2	3.8	0.0	63.0
B	1	55.8	1.9	3.4	61.1
	2	67.9	8.3	0.7	76.9
	3	53.7	16.5	2.0	72.2
	4	84.7	8.3	1.6	94.6
	5	39.4	9.8	20.3	69.5
	6	59.4	4.4	10.6	74.4
	7	58.9	4.6	20.2	83.7
	8	39.6	16.0	4.0	59.6
	Avg.	57.4	8.7	7.9	74.0
Grand Avg.		58.3	6.3	4.0	68.5

*Not cut at time of sampling.

Reproduction

Suckering rate. Aspen suckers accounted for the majority (93%) of the suckering, although birch crown-sprouted prolifically (Table 3). Those plots in Site "A" cut early in 1976 gave excellent first year suckering.

Additional suckering probably will occur in most plots, especially Site "A" plots cut late summer, 1976. Site "B" suckering rate was generally lower than the "anticipated" 50,000 stems per acre. Since suckering obviously was not complete, average stems per acre figures are misleadingly low. Rate of suckering should be more informative after the second year.

Rate of suckering appeared higher in cattle grazed plots (2, 4 and 6) than in cattle exclosure plots (1, 3 and 5) of Site "B". However, this difference (38,887 versus 21,633) was not significant ($P > 0.05$) and may be sampling error.

Rate of suckering was affected by slash removal. Slash left laying on the ground significantly ($P < 0.05$) depressed rate of regeneration.

An average standard error of aspen sucker mean for plots 1 through 6 of Site "B" was calculated to determine sample size estimates. The average standard error of the mean (35,250) was 5,067 and the 95 percent Confidence Interval was $\pm$ 11,461 or 32 percent of the mean. Approximately 100 sampling subplots are needed in each plot to achieve a mean accurate to within 10 percent of the true mean at the 95 percent confidence level.

Table 3. Suckering rate (stems/acre) for aspen and birch, Aspen Study Sites "A" and "B", Black Hills, South Dakota, 1976.

Site	Plot	Aspen	Birch[1]	Total
A	1	95,600	0	95,600
	2	73,700	0	73,700
	3	17,800	1,000	18,800
	4	4,100	0	4,100
	5	0	0	0
	6	--	--	--
	Avg.	38,240	200	38,440
B	1	32,900	300	33,200
	2	35,300	0	35,300
	3	41,300	7,500	48,800
	4	54,800	4,000	58,800
	5	20,700	10,000	30,700
	6	26,500	10,300	36,800
	7	700	0	700
	8	1,100	0	1,100
	Avg.[2]	35,250	5,350	40,600
Grand Avg.[2]		36,745	2,775	39,520

[1]Crown sprouts estimated - not counted.
[2]Average figures do not include uncut plots #7 and #8.

Suckering growth. Aspen sucker height after one summer's growth for all cut plots in Site "B" averaged 16.7 inches (Table 4). Suckers in cattle exclosure plots of Site "B" (plots 1, 3 and 5) averaged 19.1 inches, significantly greater ($P < 0.05$) than the 14.4 inches in grazed plots (2, 4 and 6). Aspen sucker height was not significantly ($P > 0.05$) affected by slash removal.

Table 4. Aspen sucker height and percent browsed, Aspen Study Sites "A" and "B", Black Hills, South Dakota, 1976.

Site	Plot	Suckers Observed	Height (")	Browsed (%)
A	1	956	11.6	4.7
	2	737	8.1	18.2
	3	178	5.6	32.6
	4	41	5.1	4.8
	5	0	--	--
	6	--	--	--
	Avg.	382	7.6	15.1
B	1	329	17.5	1.8
	2	353	14.2	17.8
	3	413	17.7	9.0
	4	548	14.0	10.6
	5	207	22.0	10.1
	6	265	14.9	18.9
	7	7	15.0	28.6
	8	11	7.4	--
	Avg.[1]	352	16.7	11.4
Grand Avg.[1]		367	12.2	13.2

[1]Average figures do not include uncut plots #7 and #8.

In Site "B" 15.8 percent of the aspen suckers were browsed in cattle grazing plots compared to 7.0 percent browsed by deer in cattle exclosure plots. This difference is not sufficient to explain the growth rate differential of 14.4 inches in cattle grazed plots versus 19.1 inches in cattle exclosure plots. Possibly cattle grazing had other detrimental effects such as ground compaction and sucker trampling.

RECOMMENDATIONS

Continue to monitor aspen regeneration response for an additional three years. Burning should be tried in five to ten acre blocks as a method by which to monitor aspen sucker regeneration.

The relationship of ruffed grouse to selected aspen treatment should be studied. Future aspen regeneration studies should continue, sites should be placed in locations where substantial populations of ruffed grouse are known to exist and should be five to ten acres in size.

Project Completion Report

RUFFED GROUSE ECOLOGY STUDY

Pre-Operational Phase
Task 2

Contributing to

The South Dakota Department of
Game, Fish and Parks Project

Submitted by

Jon Sharps
and
Jeremiah Kranz

May 31, 1977

TASK 2

Harvesting and hauling aspen material.

Pre-Operational Phase
June - July 1976

Task 2

The Braden Forest Services, Inc. and personnel of the Game, Fish and Parks Department harvested and chipped the aspen tree material (total tree). The Les Holben trucking firm of Spearfish transported the raw aspen chips to Brookings. Three loads of aspen chips were received at Brookings by June 23, 1976 to total 48 tons of raw aspen material.

COST ANALYSIS FOR ASPEN CHIP PRODUCTION IN THE BLACK HILLS

Task 3

Prepared for

South Dakota Department of Game, Fish and Parks under contract with South Dakota State University and the Old West Regional Commission.

Submitted by

Braden Forestry Services, Inc.
Box 327
Deadwood, South Dakota 57732

May 31, 1977

TASK 3

Undertake and complete cost analysis of harvesting and chipping phase of aspen material.

TASK 3

UNDERTAKE AND COMPLETE COST ANALYSIS OF HARVESTING AND CHIPPING PHASE OF ASPEN MATERIAL

Submitted by

Braden Forestry Services, Inc.
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ABSTRACT

The model operation for production of aspen chips in the Black Hills consists of harvesting the aspen trees by conventional Black Hills forest industry methods of cutting and bucking with chain saws and bunching the logs with rubber-tire skidders. The logs would then be transported to a stationary plant facility for chipping and drying. The practical level of production to realize the greatest return on investment would be 8660 tons of dried chips per year. Unit cost-value for the dried aspen chip product at the plant would be $35.00 per ton.

SCOPE AND METHOD OF STUDY

OBJECTIVE

The objective of this study was to determine the average cost-value of dried aspen wood chips produced in the Black Hills, suitable for re-constituting into a livestock feed product, at the point of pelleting, but not including the pelleting process, produced by different systems for harvesting, chipping and drying.

METHOD OF STUDY

The production of dried aspen wood chips involves five basic operations which must be performed in some form or another regardless of the methods used.

1. Timber acquisition and purchase.
2. Falling and bunching of the trees.
3. Chipping.
4. Drying of chips.
5. Transportation of product from the woods.

There are no present existing operations in the Black Hills utilizing aspen where aspen wood might be acquired as a by-product from another operation. Thus, production of this product necessitates the total process of procurring and harvesting the aspen timber.

To properly analyze the costs for production of this product, a model operation was developed, whereby each of the above mentioned five phases of processing could be examined and compared with similar operations, common to the area, for the production of other products from other species. Cost information for production in ponderosa pine species throughout the Black Hills is commonly available. In addition, different alternatives for performing the respective phases of operation were considered.

SUMMARY AND CONCLUSIONS

STUDY MODEL

The model operation conceived for this cost study envisions a firm that specializes in the production of this product. Such a firm may also engage in other aspects of the timber harvesting and processing business, but the aspen production would have to be separate and identifiable for a practical business operation. This model firm engages in all phases of the production, including timber procurrment, harvesting, chipping, drying and transportation. Such a firm may well contract with other parties for performance of some steps in the operation and thereby reduce it's initial investment costs in capital equipment, however, the resultant unit production costs would not be significantly altered from what is presented here.

This model consists of harvesting the timber by conventional chain saws and rubber-tired skidders, and hauling the rough logs, or bolts, to a stationary chipping and drying plant. This method was found to be most practical and resulted in the lowest unit production costs. In addition, it provides some opportunities for expanded production volume if the market dictates.

The production level for this model would be approximately 7500 cords, or 8660 tons of dried chips at 18% moisture content, per year (250 working days per year, 2310 pounds of 18% moisture content dried chips per cord of green wood). This production level is established by the productive capacity of the single-line harvesting, chipping and drying equipment found to be most practical for Black Hills conditions when all factors are considered.

Unit production costs could be expected to be reduced by 8% to 15% by increasing the production of the chipping and drying equipment through double or triple shifts. Additional harvesting equipment would have to be added in the timber operation to supply the increased raw material volume needed for the double or triple shift at the plant. The added cost for this significantly reduces the savings in costs resulting from double or triple shifts.

UNIT PRODUCTION COSTS FOR MODEL OPERATION

	Dollars per ton dried chips
1. Timber purchase and acquisitions, including road building and maintenance	1.73
2. Falling and bunching of trees	9.70
3. Transportation of rough logs to central chipping and drying plant	6.93
4. Chipping process (including handling of chips to drying process)	7.36
5. Drying process (including handling of chips to storage area or loading for distribution to pelleting plant)	4.50
6. Business administration, overhead, and profit margin. (Profit margin computed here is 12% return on inventment of capital, equipment, labor and management.)	5.29
Total unit production costs (Unit = ton of dried chips)	$35.51

NOTE: Ammortization and depreciation of capital equipment is included within cost figure for each operational phase.

ANALYSIS OF COSTS AND DISCUSSION OF ALTERNATIVES

TIMBER PURCHASE AND ACQUISITION

The majority of the aspen stands (78%) suitable for harvesting are located on federal lands under the administration of the US Forest Service. Federal laws governing that agency's authorities for sale of forest products does not permit it to give the product away, but instead, requires that it be appraised and sold competitively, at fair market value. Since there is no present marketing and utilization of aspen in the Black Hills, there are no values of comparable sales and end product values to determine a timber appraisal. Under these circumstances, the Forest Service could be expected to establish the standard wood product salvage value of .50 cord. This figure can be expected to prevail until such time as effective timber appraisal information suitable for the Forest Service timber appraisal process can be developed.

The stumpage value for aspen procurred from private lands would no doubt follow closely the values established by the US Forest Service and could be expected to be about .50 per cord. There may be cases where a landowner might give the stumpage value to the logger for the removal of the trees where unwanted. In either case, the .50 per cord stumpage cost is not a significant element in the overall unit cost of production.

Another element in the overall cost of production which is treated in this report under the heading of timber acquisition, is the costs of road building, maintenance and winter-time snow removal in the logging area. This is a highly variable item and difficult to relate to unit production costs. Figures for this activity in other Black Hills roundwood logging operations range from .25 per cord to $3.00 per cord. The biggest factor affecting this is the volume of material removed from an area in relation to the input of road building, maintenance and snow removal costs. The median figure between the .25 per cord and $3.00 per cord, could be used here, however, judgment dictates that the figure used here should be higher for two reasons: 1. the volume of aspen removed per logging area would be lower than pine roundwood stands and the unit production cost would be higher; 2. the more productive aspen sites are located in the higher Hills where snow removal from haul roads would be necessary a greater portion of the year. The value for road building and maintenance used in this analysis is established at $2.00 per cord of production.

HARVESTING AND PROCESSING

The process of converting the standing aspen trees to useable chips involves four basic operations which must be carried out in one form or another: 1. falling and bunching of the trees; 2. chipping the wood to desired chip size; 3. drying of the chips to desired moisture level; and, 4. transportation of the product from the woods. Each of these operations is examined separately along with the different methods for performing each.

1. Falling and bunching of trees:

The most commonly accepted means for performing this operation throughout the Black Hills forest industry is by falling the trees with chain saws and rentralizing them at the woods landing with rubber-tired tree skidders. An operation of this nature in aspen can be easily compared with similar roundwood logging operations in the Black Hills and costs can be readily predicted.

Falling and bucking ----------	$ 6.00 per cord
Skidding ----------	$ 5.20 per cord
Total for falling and bunching ---	$11.20 per cord

The other possibility for the falling and bunching process is with the use of a machine commonly called the "feller-buncher". The principle of this machine is that it is driven to the base of the tree where it grips the tree and shears it off at the stump with hydraulic shears and then it is driven to the landing while carrying the tree in an upright position. At the landing, it lays the tree down along side others and has completed the falling and bunching operation.

The cost per cord can be reduced by as much as 40% when using a feller-buncher instead of the chain-saw-skidder method, however, it is severely limited by terrain and snow-cover conditions. In addition, it's high initial investment cost ($40,000.00 to $80,000.00) requires a high level of production at all times. Feller-buncher manufacturers recommend that the machine operate in timber averaging 10 inches diameter breast height. Black Hills aspen stands average DBH falls considerably below that. Feller-bunchers are not in popular use in Black Hills timber operations primarily because of their high initial cost and limited useability.

For purpose of aspen logging in the Black Hills, the chain-saw and rubber-tired skidder is the most practical means for the tree falling and bunching operation.

2. Chipping process:

There are two possibilities for performing the chipping process which are examined here: 1. portable chipping equipment that is operated in the woods at the log landing and the chips are conveyed directly to a van-type truck for hauling from the woods; and, 2. stationary central-plant chipping facility, whereby the aspen logs are hauled from the woods to the central plant.

An examination of these two possibilities shows little, if any, difference between the two in performing the chipping process. The per unit operating cost is essentially the same between the two. Chipping equipment most suitable for the average size stand diameter of aspen in the Black Hills (and operating portably) would require an initial investment of about $12,000.00 and would be limited to about 30 cords of wood per day, or 7500 cords per year on a 250 day per year operating schedule. The operating cost per cord of wood for this type of portable equipment would average $8.50 per cord. This includes ammortization of investment, maintenance and operation, and labor for in-feed of material.

NOTE: There is on the market some rather highly mechanized and sophisticated portable chipping equipment including the whole-tree chipper machine. Because of it's high investment cost ($80,000.00 to $100,000.00) the manufacturers recommend that it is operated in conditions where the average stand diameter of the harvested timber exceeds that for Black Hills aspen, in order to realize the fair rate of return on investment.

A stationary central-plant chipping operation, utilizing the portable equipment first described above, would result in greater efficiency in the chipping process, however, would have the added cost of land and plant investment. The resultant cost per cord would nearly equal that of having the chipping operation portable.

3. Chip drying process:

The most practical equipment for the chip drying process, consistent with the most practical level of chip production, is the standard corn or alfalfa dryer. The portable farm operated dryer would provide the level of production consistent with the balance of the operation. This too could be a portable "in woods" operation or could be operated at a stationary-central-plant facility. In either case, the initial investment and operating costs will be about the same. Capital investment for this type of equipment is about $8,000.00 for new equipment. The cost per cord of wood for the drying process will average $5.20.

4. Transportation of product from the woods:

The two alternatives of transportation include hauling the rough logs, or hauling the finished chips. Hauling of rough logs from the woods to a central plant will cost about $8.00 per cord or roughly $4.00 per ton of green wood. Hauling of green chips will average close to $4.00 per ton, or, nearly equal to the cost for rough logs. The hauling of dried chips can be expected to reduce the cost to about $2.75 per ton.

5. Portable chipping and drying versus stationary plant facility:

An examination of the equipment most suitable for the average size of Black Hills aspen trees show little overall difference in unit production costs between a portable operation for the chipping and drying and a stationary plant facility for that purpose. There are other factors which should cause an investor to favor the stationary plant alternative. These factors provide the opportunity for less per unit production costs in the future.

a. The portable operation must have a steady flow of the product through all phases of the processing chain from the standing tree to the marketing of the finished products. There is little opportunity to build or hold inventory at various stages of the production process. For example, a stationary plant could build an inventory of logs to carry the operation through a period when trucks could not haul in the woods because of "spring breakup" season, or, deep snow conditions.

b. The "level ground" space necessary for chip handling equipment and for the chipping and drying equipment is many times not readily available at the logging site. In addition, the agencies administering the federal lands of the Black Hills would be reluctant to accommodate such an operation by allowing larger wood landings.

c. A stationary plant provides much more opportunity for increased efficiency, and increased volume, through better mechanization of product handling equipment, and through double or triple shifting of plant operations all of this provides the opportunity for lowering of unit production costs which is not as readily possible with a portable facility.

CAPITAL INVESTMENT COSTS

Capital investment costs can vary considerably with type of equipment, manufacturer, plant location, etc. A rough average is presented here:

1.	Land and buildings for plant	$ 25,000.00
2.	Chipping equipment	$ 12,000.00
3.	Drying equipment	$ 8,000.00
4.	* Trucks	$ 50,000.00
5.	* Rubber-tire skidder	$ 30,000.00
6.	Power saws	$ 1,000.00
7.	Miscellaneous items	$ 5,000.00
		$131,000.00

* These items and services can readily be contracted for, thus significantly reducing the initial investment costs.

GENERAL COMMENTS

The purpose of this study is not to determine the feasibility of producing aspen chips for processing into a livestock feed ration. The economic feasibility will have to be viewed from the overall scope of the entire project. The purpose here is to determine a cost-value of the aspen chips produced in the Black Hills by the most practical means and providing a fair and reasonable return on investment in producing them.

The greatest per unit costs incurred in the production of aspen chips is in the harvesting and the chipping of the trees. By far the major factor affecting the harvesting and chipping costs is the average diameter at breast height of the standing trees. The per unit production costs will go down significantly with only a few inches increase in average stand diameter. Unfortunately, the Black Hills aspen stands have an average stand diameter of only 6" to 7". Only in rare cases will the average stand diameter exceed this.

ADDENDUM TO REPORT ON COST ANALYSIS FOR ASPEN CHIP PRODUCTION IN THE BLACK HILLS

June-August 1976

This addendum to the main report addresses itself to the cost effect of portable chipping utilizing a somewhat more sophisticated piece of chipping equipment that envisioned in the original model. This piece of equipment consists of a chipper mounted on a trailer and having a boon-grapple for loading and in-feeding. It's initial cost delivered is about $30,000. In the study model used in the report, it would be substituted in place of the stationary chipping plant. Unit production costs for each phase of the operation is then examined.

Unit Production Costs for Model Operation
Substituting Portable Chipping

	Dollars per ton dried chips
1. Timber purchase and acquisition including road building and maintenance. This item will remain constant.	1.73
2. Falling and bunching of trees. This item will remain constant.	9.70
3. Chipping process - done in the woods at log landing site. This figure can be reduced because of lower initial investment.	5.90
4. Drying process - under this model situation the drying would be done in the woods in conjunction with the chipping because of the elimination of stationary plant facilities, however, costs could be expected to remain about constant.	4.50
5. Transportation - this phase of the process would be altered in that rough logs would not be hauled from the woods to a stationary plant, but instead, dried chips would be hauled directly to the market, thus eliminating one stage of handling.	4.80
6. Administration, overhead, and profit - this item should remain constant.	5.29
Total unit production costs (Unit = ton of dried chips)	$31.92

Discussion

In summary, the stationary plant operation would produce chips at a cost-value of about $35.00 per ton, whereas the portable operation would produce the chips at a cost-value of about $32.00 per ton. This could be a significant difference in the margin of profit for the operator and in making this product competitive with other products available for cattle feed. A discussion of the stationary versus portable operation is made in the main report pointing out why the stationary operation should be considered over the portable when making an investment in this type of business.

It is further pointed out that the cost-value results shown in this report are by no means cast in concrete. The management element of any type of operation can have an effect good or bad on costs which cannot be accurately measured. Different operators with different management techniques and different innovativeness can have drastically different results. This study is based on the envisioned prudent operator using existing area industry standards. These standards are generally what has developed thru trial and error over a period of time by those in the closely related forest industry and are compared against this envisioned operation.

Task 4

Determine a suitable drying and storage method for aspen chips.

TASK 4

DETERMINE A SUITABLE DRYING AND STORAGE METHOD FOR ASPEN CHIPS

Submitted By

Leslie D. Kamstra, Professor of Animal Science
Department of Animal Science
Agricultural Experiment Station
South Dakota State University
Brookings, South Dakota 57007

Task 4

Determine a suitable drying and storage method for aspen chips.

The Animal Science Department of SDSU received permission from the Foundation Seed House on SDSU campus, to use the seed drying bins to dry the aspen chips, (Propane and Electric Drying Bins). Following a three-day drying period, the dried aspen chips were removed and ground through a portable hammer mill (Van Hoepen's Feed Service, Volga, South Dakota) using a 3/8 in. screen. The ground material was stored in steel storage bins adjacent the SDSU Feed Unit for later ration preparation.

Task 5

Analysis of Aspen Material.

TASK 5

ANALYSIS OF ASPEN MATERIAL

Submitted by

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South Dakota State University
Brookings, South Dakota 57007

OPERATIONAL PHASE

August 1, 1976 to May 30, 1977

Tasks 1 through 3

Submitted by

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Brookings, South Dakota 57007

TASK 1

ASPEN RATION PREPARATION - PREPARE SUFFICIENT QUANTITIES OF RATIONS TO FEED 600 HEAD OF STEERS FROM AN INITIAL WEIGHT OF 600-700 LBS. TO A FINAL WEIGHT OF APPROXIMATELY 1,100 LBS.

Submitted by

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Agricultural Experiment Station
South Dakota State University
Brookings, South Dakota 57007

Task 5

Analysis of Aspen Material

	Load No. 1	Load No. 2	Load No. 3
Moisture (as arrived in Brookings)	46.25	38.73	37.50
	Analysis on Dry Basis Percent		
Ash	3.2	3.6	2.8
Calcium	0.87	1.22	0.87
Phosphorus	0.04	0.04	0.03
Acid Detergent Fiber	63.2	62.0	69.4
Acid Detergent Lignin	12.8	11.3	10.2
Crampton & Maynard Cellulose	45.6	46.4	50.0
Crude Protein	1.2	1.4	0.9

Carotene (Vitamin A potential) Less than .3 mg/lb. for all samples analyzed.

<u>In Vitro Digestibility</u> - (Pooled load samples) 30.1% - dry matter disappearance.

TASK 1

Aspen Ration-preparation - prepare sufficient quantities of rations to feed 600 head of steers from an initial weight of 600-700 lbs. to a final weight of approximately 1,100 lbs.

Ration Composition and Treatments

The rations formulated for 60 head of Hereford steers appears in the attached table.

The six treatments indicated in Table I are the Concentrate Control with no roughage, the Roughage Control composed of 93% alfalfa, a Concentrate-Alfalfa ration having 15% alfalfa as roughage, a Concentrate-Aspen ration having 15% aspen as roughage, and 48% Aspen ration with added 32% soybean oil meal as a protein supplement, and a 48% Aspen ration with added 16% soybean oil meal and 16% chicken manure as protein supplements. All rations were prepared as a meal at the SDSU Feed Mill in Brookings in 3000 lb. lots and stored at the Feed Unit.

Table 1.
Ration Composition and Treatments

Ingredients

	1	2	3	4	5	6
Corn	86		73.5	67.0		
Aspen				15.0	48.0	48.0
Alfalfa		93	15.0		13.0	13.0
Soybean Oil Meal (44% C.P.)	13		10.0	17.0	32.0	16.0
Chicken Manure (26% C.P.)						16.0
Molasses		5.0			5.0	5.0
Trace Mineral	0.5	1.0	0.5	0.5	1.0	1.0
Limestone	0.5		0.5			
Dicalcium Phosphate		1.0	0.5	0.5	1.0	1.0
Vitamin A*						
Estimated C.P.	12.60	13.95	12.53	12.84	16.00	13.15

*Vitamin A 67g/ton of ration of vitamin A

Suppl. added (30,000 I.U. of vitamin A/g)

Calculated to supply 2,000 I.U. vitamin A/kg of ration

Task 2

Aspen Feeding Phase.

TASK 2

ASPEN FEEDING PHASE

Submitted by

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TASK 2

Aspen Feeding Phase. Sixty Hereford steers weighing approximately 700 lbs. were randomly alloted into 12 lots of 5 animals each. Following allotment, initial fill and shrunk weight was obtained prior to feeding of experimental rations. Each of the six rations were fed to two lots or 10 animals. Animals were brought up to full feed over a two-week period starting with an initial feeding of 10 lbs. per animal and increasing the feed level daily. Animals were fed an libitum once full feed was achieved. All animals received free choice trace mineral salt and water. All experimental rations were readily consumed but some difficulty was encountered with the alfalfa control ration. One animal was lost to bloat and others showed distention. It was decided to feed a portion of the ration as long hay in an attempt to alleviate the bloat problem. No problem with bloat occurred after long hay was included in the ration. Chicken manure rations attracted a large fly population and animals are somewhat disturbed during ration consumption. Large aspen chips were discovered to have been inadvertently included in the 48% aspen rations during the preparation of one 3000 lb. feed preparation. The effect on gain and consumption is not known. Normal feeding operations were disturbed during a three-day period during the second 30-day period when the automatic water system failed. Animals were watered in the same pen and not fed. The effect on weight gains for that period cannot be estimated.

Task 3

Aspen Feeding Trial Evaluation.

TASK 3

ASPEN FEEDING TRIAL EVALUATION

Submitted By

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South Dakota State University
Brookings, South Dakota 57007

TASK 3

Aspen Feeding Trial Evaluation. Animals in general performed according to expectations on the various rations. Feeding rations as a meal rather than as pellets usually will decrease consumption. No sorting of components or feed refusal were noted. Since animals were somewhat heavier than anticipated at the beginning of the trials, many animals reached 1,100 lbs. by the October 19, 1976 weigh day and were sent to slaughter.

On October 19, 1976, 35 animals which had reached the desired slaughter weight of 1,100 lbs. were slaughtered. This included the following treatments (10 animals per treatment):

Treatment 1 - Concentrate control - corn with no roughage.

Treatment 3 - Concentrate - corn and 15% alfalfa as roughage.

Treatment 4 - Concentrate - corn and 15% aspen as roughage.

Treatment 5 - Roughage ration - 48% aspen supplemented with SBM (only 1 of the 2 lots sold 5 animals).

Only one lot of the 48% aspen-SBM treatment were sold with the concentrate fed animals to make it possible to compare between roughage and concentrate cattle fed the same length of time. Animals within this lot were near the 1,100 lb. selling weight imposed by the experimental proposal. At this point the animals had been on feed for 126 days. A summary of feedlot performance is shown in Table 1A and the slaughter data in Tables 1B and 1C.

Little difference in average daily gain can be noted between

Table 1A. Feedlot Performance as Affected by Different Rations (Aspen Project 1976)**

	Control Conc.	Control Alfalfa	Conc. Alfalfa	Conc. Aspen	48% Aspen SBM	48% Aspen SBM Chicken Manure
	1	2	3	4	5	6
Number of animals	10	10	10	10	10	10
Number of days fed	126	126	126	126	126	126
Ave. initial filled wt., lb.	718	722	720	722	722	718
Ave. final filled wt., lb.	1176	1012	1166	1177	1030	952
Ave. initial shrunk wt., lb.	707	717	710	710	708	709
Ave. final shrunk wt., lb.	1148	---	1135	1140	---	---
Ave. daily gain, lb.						
(filled) 31 days	3.42	1.71	3.48	4.10	3.45*	1.90
(filled) 63 days	3.78	2.05	3.57	3.96	2.74	1.53
(filled) 94 days	3.66	2.37	3.51	3.66	2.51	1.88
(filled) 126 days	3.64	2.29	3.55	3.61	2.44	1.86
(shrunk) 126 days	3.50	--	3.37	3.42	--	--
Ave. daily ration, lb.						
(consumption) 31 days	14.91	18.36	17.99	19.59	21.33	16.94
63 days	17.60	23.37	19.00	22.32	22.58	19.75
94 days	18.60	25.74	19.86	23.38	22.61	21.26
126 days	19.91	28.24	21.25	24.63	23.82	23.04
Feed/lb. gain, lb.						
31 days	4.49	10.78	5.17	4.78	6.26*	8.97*
63 days	4.67	11.47	5.32	5.63	8.24*	13.25
94 days	5.10	10.95	6.50	6.39	9.01	11.44
(filled) 126 days	5.47	12.43	6.00	6.83	9.82*	12.42
(shrunk) 126 days	5.72	---	6.34	7.24	--	---

** Ration 3 (conc. alfalfa) and Ration 4 (conc. aspen) are compared with concentrate control, and Ration 5 (48% aspen-SBM) and Ration 6 (48% aspen-manure) against alfalfa control (at P=0.05.

* Significantly different (at P=.05).

Table 1B. The Carcass Characteristics and Taste Panel Evaluation as Affected by Different Rations (Aspen Project 1976, for 126 days)

	Conc. Control Corn 1	Conc. Alfalfa 15% 3	Conc. Aspen 15% 4	48% Aspen 32% SBM* 5
Hot carcass wt.	700.8	694.2	687.4	546.4
Dressing, %	59.5	59.6	58.4	51.2
Carcass grade	choice-	good+	good+	standard+
Marbling score	4.7	4.3	4.9	3.0
Abscessed livers	4	4	3	--
Number of livers condemned	3	2	2	--
Rib eye area, cm^2	73.5	78.1	73.3	69.7
$inch^2$	11.4	12.1	11.4	10.8
Maturity	24	24	24	24
Color	5.1	5.1	5.5	4.8
Firmness	4.7	4.4	4.8	4.2
Kidney Fat, %	3.0	2.8	2.8	1.6
Taste Panel Evaluation**				
Tenderness	3.9	3.7	3.3	2.7
Flavor	3.0	3.1	2.9	2.9
Juiciness	4.0	3.9	3.7	3.4

*Five animals only
**Scored on a scale of 1 to 8 with lower values being more desirable

Table 1C. Evaluation of Aspen Meat Products - 1976.

	Conc. Control 1	Alfalfa Control 2	Conc. Alfalfa 3	Conc. Aspen 4	48% Aspen-SBM 5	48% Aspen DPM-SBM 6
% Vol. Gas Loss	22.4	25.1	24.6	22.0	20.3	22.7
% Cooking Loss	27.1	29.6	28.4	26.4	25.1	29.4
Shear (lbs/1 in sec.)	16.0	13.8	14.6	12.9	11.4	14.3

animals receiving high concentrate feeds. Efficiency appeared to be in favor of animals receiving no roughage and the no roughage animals received a slightly higher grade even though the marbling score was the highest for animals on concentrate-aspen. Low marbling and lighter weight of the high aspen fed cattle probably resulted in the lower grade received by these animals. This was also true with the 1975 cattle. Cattle fed aspen supplemented with soybean meal to a protein level similar to the alfalfa appear to have gained better and are more efficiently then the alfalfa control roughage ration (93% alfalfa). The alfalfa control and the 48% aspen-soybean ration are similar to the rations fed in 1975 feeding experiments except the rations were fed as a meal in the 1976 feeding experiments. The cattle were sold at 93 days with the 1975 trial. Comparing the two rations on different years at the similar feeding time is as follows:

	Control Alfalfa Ration 93% Alfalfa		48% Aspen-Soybean Ration	
	Ave Daily Gain	Feed lb/Gain	Ave Daily Gain	Feed/lb Gain
1975 (93 da) (filled wt)	1.55	15.93	2.72	10.25
1976 (94 da) (filled wt)	2.29	12.43	2.44	9.82

Alfalfa control animals did better in 1976 on the meal except that one animal was lost to bloat and other animals were suffering from bloat. Long hay feedings was supplemented with the meal and continued throughout the feeding period. We also found that with certain batches of feed, corn was inadvertently added to the alfalfa ration (as much as 1/3 corn). This probably occurred from making the concentrate ration just ahead of the alfalfa ration and the mill does not clean well between batches (mill error). The 1975 rations were prepared at the Egan Mill, the 1976 rations were prepared at the University Mill.

The 48% aspen-soybean ration showed similar gains, both years, except one lot did poorly in 1976 which reduced the average gain of the treatment throughout the trial. We had some difficulty with large chips in the meal being fed.

On December 14, 1976, the final lots of animals were slaughtered after 182 days of feeding. This was a group of 25 animals from the following treatments:

Treatment 2 - Roughage control ration - 93% alfalfa

Treatment 5 - Roughage ration - 48% aspen supplemented with SBM (remaining lot, 5 animals)

Treatment 6 - Roughage ration - 48% aspen supplemented with SBM and chicken manure

The animals had not reached the final 1,100 lb. weight but aspen ration components were nearly depleted at this time. Tables 3 and 4 indicate feedlot performance and slaughter data summary

Table 3. Feedlot Performance as Affected by Different Rations (Aspen Project 1976). Continued after 182 days for Ration # 2,5 (Lot #5) and 6.

	Control Alfalfa 2	48% Aspen SBM 5	48% Aspen SBM, Chicken Manure 6
Number of animals	10	5	10
Number of days fed	182	182	182
Ave. initial filled wt., lb.	722	722	718
Ave. final filled, wt., lb.	1091	1041	975
Ave. initial shrunk wt., lb.	717	708	709
Ave. final shrunk wt., lb.	1054	1022	959
Ave. daily gain, lb.			
(filled) 154 days	2.11	1.88	1.67
(filled) 182 days	2.02	1.76	1.41
(shrunk) 182 days	1.89	1.73	1.37
Ave. daily ration, lb.			
(consumption) 154 days	30.09	22.81	24.19
182 days	31.15	23.14	24.94
Feed/lb. gain, lb.			
(filled) 154 days	14.25	12.13	14.55
(filled) 182 days	15.50	13.17	17.77
(shrunk) 182 days	16.55	13.43	18.32

Table 4. The Carcass Characteristics and Taste Panel Evaluation as Affected by Different Rations (Aspen Project 1976, for 182 days).

	Control* Alfalfa 2	48% Aspen** 32% SBM 5	48% Aspen, SBM Chicken Manure 6
Hot carcass wt.	591.1	552.4	504.3
Dressing %	54.17	53.08	51.74
Carcass grade	good-	good-	standard
Marbling score	3.6	3.8	3.05
Abscessed livers	2	--	--
Number of livers condemned	2	--	--
Rib eye area, cm^2	65.61	66.69	67.01
$inch^2$	10.17	10.34	10.38
Maturity	23.7	24.0	23.8
Color	5	5	4.8
Firmness	6	6	5.8
Kidney, fat %	1.9	1.6	1.4
Taste Panel Evaluation***			
Tenderness	3.7	2.6	3.6
Flavor	3.2	2.9	3.0
Juiciness	3.9	3.5	4.0

* Ten animals
** Five animals only
*** Scored on a scale of 1 to 8 with lower values being more desirable

for 182 days. Animals in all treatments, including controls, did poorly during this period even though consumption appeared normal. The final gain and efficiency reflect this trend. Marbling score also reflects the lower grade for the roughage rations which ranged from standard to good-. Slaughtering half of the 48% aspen-soybean cattle at each date enabled slaughter data comparison of the highest aspen ration with both concentrates and roughages in taste panels.

Economic Considerations of Aspen Harvest and Feeding

Aspen Harvest.

The cost analysis for aspen chip production in the Black Hills of South Dakota by Braden Forestry Services, Inc., Box 327, Deadwood, SD 57732, is included earlier in this report. It must be mentioned that at this time aspen harvest in the Black Hills is much more expensive than commercial production costs of chips in Minnesota. Total Tree Inc., Burnsville, Minnesota, for example, estimates the production cost of chips is approximately $8.50/ton wet weight as compared to $20.00 or more in the Black Hills. The difference in cost is largely due to lack of mechanization of harvest and lack of other markets, such as paper production, in the Black Hills area.

Aspen Feeding.

Summaries of estimates of ration costs and cost/lb of gain are shown in tables 5 through 12. The cost of supplementation

to correct the deficiency of aspen for protein is the most critical to all aspen rations. This is true in using either alfalfa or soybean oil meal because of the high cost of these components at the present time. Chicken manure as a protein supplement did cheapen the ration but not the cost of gain since the rate of gain was depressed by addition of manure.

Table 5. Summary of Cost of Rations and Cost/lb. Gain (Aspen Project 1976 - 126 days)

	Corn 1	Alfalfa 2	Conc. Alfalfa 3	15% Aspen 4	48% Aspen SBM 5	48% Aspen, SBM Chicken Manure 6
Cost/ton	130.25	104.60	125.45	118.67	96.02	76.82
Cost/lb. gain	0.36	0.65	0.38	0.40	0.47	0.47

Table 6. Cost/lb. Gain (Aspen Project 1976 - 126 days)

Ration #	Feed/lb. gain	Cost/lb. ration	Cost/lb. gain
1 (control corn)	5.47	0.065	0.36
2 (alfalfa)	12.43	0.052	0.65
3 (conc. - alfalfa)	6.00	0.063	0.38
4 (conc. - aspen)	6.83	0.059	0.40
5 (48% aspen - S3M)	9.82	0.048	0.47
6 (48% aspen - S3M chicken manure)	12.42	0.038	0.47

Table 7. Cost of Rations - Ration # 1 Corn (Aspen Project 1976)

Ingredients	Amt/ton	Cost/ton	Total cost
1. Corn	1720	120.00	103.20
2. Aspen	--	15.46	---
3. Alfalfa	--	100.00	---
4. SBM	260	200.00	26.00
5. Manure	--	80.00	---
6. Molasses	--	160.00	---
7. Trace mineral	10	90.00	0.45
8. Limestone	10	60.00	0.30
9. Dical	--	240.00	---
10. Vitamin A	$\frac{67 \text{ g}}{2{,}000}$	0.30/67 g	0.30
		TOTAL COST	130.25

Table 8. Cost of Rations - Ration # 2 Alfalfa (Aspen Project 1976)

Ingredients	Amt/ton	Cost/ton	Total cost
1. Corn	--	--	--
2. Aspen	--	--	--
3. Alfalfa	1860	100	93.00
4. SBM	--	--	--
5. Manure	--	--	--
6. Molasses	100	160	8.00
7. Trace mineral	20	90	0.90
8. Limestone	--	--	--
9. Dical	20	240	2.40
10. Vitamin A	67 g / 2,000	0.30/67 g	0.30
		TOTAL COST	104.60

Table 9. Cost of Ration - Ration # 3 Concentrate Alfalfa (Aspen Project 1976).

Ingredients	Amt/ton	Cost/ton	Total cost
1. Corn	1470	120	88.20
2. Aspen	--	--	--
3. Alfalfa	300	100	15.00
4. SBM	200	200	20.00
5. Manure	--	--	--
6. Molasses	--	--	--
7. Trace mineral	10	90	0.45
8. Limestone	10	60	0.30
9. Dical	10	240	1.20
10. Vitamin A	67 g / 2,000	0.30/67 g	0.30
		TOTAL COST	125.45

Table 10. Cost of Ration - Ration # 4 Concentrate Aspen (Aspen Project 1976)

Ingredients	Amt/ton	Cost/ton	Total Cost
1. Corn	1340	120	80.40
2. Aspen	300	15.46*	2.32
3. Alfalfa	--	--	--
4. SBM	340	200	34.00
5. Manure	--	--	--
6. Molasses	--	--	--
7. Trace mineral	10	90	0.45
8. Limestone	--	--	--
9. Dical	10	240	1.20
10. Vitamin A	$\frac{67\ g}{2{,}000}$	0.30/67 g	0.30
		TOTAL COST	118.67

* Aspen cost only. Charges for transporting aspen are not included. Delivery charges for feed ingredients are approximately $4.50 per 100 miles.

Table 11. Cost of Ration - Ration # 5 48% Aspen - SBM (Aspen Project 1976)

Ingredients	Amt/ton	Cost/ton	Total cost
1. Corn	--	--	--
2. Aspen	960.00	15.46	7.42
3. Alfalfa	260	100.00	13.00
4. SBM	640	200	64.00
5. Manure	--	--	--
6. Molasses	100	160	8.00
7. Trace mineral	20	90	0.90
8. Limestone	--	--	--
9. Dical	20	240	2.40
10. Vitamin A	$\frac{67 \text{ g}}{2{,}000}$	0.30/67 g	0.30
		TOTAL COST	96.02

* Aspen cost only. Charges for transporting aspen are not included. Delivery charges for feed ingredients are approximately $4.50 per 100 miles.

Table 12. Cost of Ration - Ration # 6 48% Aspen - Chicken Manure (Aspen Project 1976)

Ingredients	Amt/ton	Cost/ton	Total cost
1. Corn	--	--	--
2. Aspen	960	15.46*	7.42
3. Alfalfa	260	100	13.00
4. SBM	320	200	32.00
5. Manure	320	80	12.80
6. Molasses	100	160	8.00
7. Trace mineral	20	90	0.90
8. Limestone	--	--	--
9. Dical	20	240	2.40
10. Vitamin A	67 g / 2,000	0.30/67 g	0.30
		TOTAL COST	76.82

* Aspen cost only. Charges for transporting aspen are not included. Delivery charges for feed ingredients are approximately $4.50 per 100 miles.

Summary of Feeding Trial Evaluation

Almost without exception aspen fed animals performed as well or better than control animals. Since numbers of animals on each treatment were limited, differences had to be quite large to be significant. Some differences were significant, however, and can be noted, for example:

1. Gain for 48% aspen-SBM was significantly greater than the roughage control at the first weigh period and efficiency in feed conversion favored the 48% aspen ration after 126 days on feed.
2. Carcass characteristics also showed some differences in that dressing percent was greater for the alfalfa control than the two highest aspen containing rations. Aspen rations 5 & 6 had less kidney fat than the roughage control. Ration 5 meat had less cooking loss than the control ration. Ration 5 meat was more tender than either corn or alfalfa ration meat. Mechanical shear confirmed that the ration 5 meat was more tender than meat from the corn control ration.

No significant differences were noted between marbling scores, dressing percent, rib eye area, color, maturity, flavor, juiciness, dip loss or volatile gas loss. It can be noted with some confidence that including aspen in cattle finishing and growing rations does not adversely affect the expected animal efficiency or value of the meat product produced. It must be realized that aspen has certain nutrient deficiencies which must be corrected

when formulating any type of ration in which it is to serve as a major component. Aspen's most serious nutritional deficiency is shown to be protein, vitamin A and perhaps phosphorus. If nutritional deficiencies can be corrected without excessive costs, aspen rations should become competitive with similar traditional rations.

O.W.R.C. ASPEN FEEDING STUDY
PHASE II
GRANT NO. 1070230

Statement of Expenditures
June 1, 1976 through May 31, 1977

TOTAL FUNDS RECEIVED FROM O.W.R.C.			$ 26,250.00
Administrative			
Travel	$ 226.55		
Telephone & Postage	340.25		
SUB TOTAL		$ 566.80	
Operations			
Harvesting & Transportation	4,500.00		
Food preparation, Animal management yardage	2,619.24		
Expendables & Equipment depreciation	3,000.00		
SUB TOTAL		10,119.24	
Research and Testing			
Labor			
Hourly Labor	4,886.76		
Secretarial	1,158.40		
Student Assistantship	4,269.72		
Supplies & Equipment leasing	3,913.52		
Travel	521.36		
SUB TOTAL		14,749.76	
GRAND TOTAL EXPENDITURES			$ 25,435.80
Balance of Funds Returned to O.W.R.C.			$ 814.20