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Response of Grass Species to Tree Harvesting in Singleleaf Pinyon-Utah Juniper Stands

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RESEARCH SUMMARY

Cover, yield, and nutrient concentrations of grasses were sampled on tree-harvested and nonharvested plots on north, west, and south aspects of a singleleaf pinyon (*Pinus monophylla*)-Utah juniper (*Juniperus osteosperma*) stand. Grass cover increased rapidly the first 2 years following tree harvest, but the rate of increase declined over the next 2 years. Grass yield varied among aspects and soil microsites on tree-harvested plots but not on the nonharvested plots where tree competition masked aspect and microsite effects. All grass species had greater yield and greater percentage nitrogen and phosphorus on harvested than on nonharvested plots. Low digestibility of some species may reduce potential livestock gains. On tree-harvested plots, the tree-associated microsites (duff and transition) had higher grass yield per unit area than the interspace microsites between trees. Tree harvesting decreased the area required per animal unit month from 27 to 7 acres (11 to 3 ha) (north) and 42 to 5 acres (17 to 2 ha) (west), but had no effect on the south aspect (40 acres, or 16 ha). Protein levels were adequate for livestock on tree-harvested plots (north and west) but below levels recommended for deer.

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INTRODUCTION

An inverse relationship between tree cover and forage production is well established for several forest systems including the pinyon-juniper woodlands of the West (Jameson 1967; Clary 1969). Thinning or clearcutting small patches of trees has been suggested to increase production and quality of forage for wildlife and livestock (Patton 1974), but cutting must be balanced with the appropriate management of the wood resource. Currently little is known about understory response following tree harvest in the pinyon-juniper woodlands of the Great Basin. Understory production has increased following removal of juniper species in the Southwest, but there are large variations due to soils and climate (Jameson and Dodd 1969; Clary 1974).

Understory species composition and cover vary among soil microsites found within pinyon-juniper stands (Harner and Harper 1976; Everett and Koniak 1981). Understory composition and distribution patterns are closely tied to tree cover and associated soil characteristics (Everett and others 1984). Barth (1980) demonstrated nutrient enrichment in soil microsites under the tree crown of pinyon (*Pinus edulis* Engelm.) and the depletion of nutrients from the interspace microsites among tree stems.

Understory production, protein levels, and mineral concentrations may increase under the crowns of semiarid shrubs in response to increased soil nutrients and shading effects (Rickard and others 1973). Under mesic forest conditions, forage production and digestibility may decline with increasing overstory cover, but protein concentrations may increase (Laycock and Price 1970). Climate of the singleleaf pinyon (*Pinus monophylla* Torr. and Frem.)-Utah juniper (*Juniperus osteosperma* [Torr.] Little) woodland is intermediate between these two vegetation types, and forage quality and quantity differences among soil microsites are unknown.

Microsites that produce more nutritious forage are particularly important to selective feeders like deer (*Odocoileus* sp.) that must depend on high quality forage because of their limited rumen capacity (Hanley 1982). Utilization of forage by livestock and wildlife is directly related to nitrogen and phosphorus levels in plants and soils (Van Soest 1982). Increases in nutrient concentrations of forage among soil microsites may increase intake and animal gains.

Protein, phosphorus, and energy usually limit animal nutrition on western ranges (Halls 1970; Cook and Harris 1977). Ruminants feed until energy requirements are met or their rumen is full. Consequently nitrogen and phosphorus uptake depends on their concentrations in consumed forage.

Grass yield from woodland sites is a hierarchial phenomenon: (1) individual species yield, (2) composite species yield by soil microsite, and (3) composite microsite yield by site. This study assessed forage quality differences of grass species on tree-harvested and nonharvested plots and among soil microsites that occur on those plots. We chose to sample yield at plant maturity and forage quality at the anthesis phenologic stage. We asked: (1) What effect does tree harvesting have on individual species yield and nutritional quality? (2) What changes in grass yield and quality occur on individual soil microsites? (3) What is the total nonharvested and harvested plot yield available to cow/calf pairs and wildlife that use the sites?

Change in forage quality over time has been adequately documented for many of the grass species in this study (Murray and others 1978). Although exact timing of nutrient changes may differ between study areas, decline in forage quality over time has been sufficiently established in the literature to have already been made into a basic range management concept (Vavra and Raleigh 1976), and therefore these trends need not be restudied here.

METHODS

Study Site

We chose a study area with a simple floristic composition and sufficient grass understory to demonstrate a response to tree release. The study area was a singleleaf pinyon-Utah juniper woodland approximately 2.5 mi (4 km) northeast of Ione in the Shoshone Mountain range of west-central Nevada. Similar areas occur on several mountain ranges in western Nevada.

Basalt-andesitic derived soils were classified as clayey, skeletal, mixed, frigid, Lithic Xerollic Haplargids (USDA 1975). These soils are depleted of nutrients in the interspace between trees and are enriched under the tree crowns (Everett 1984). Precipitation during the study was:

Year	Inches	(mm)
1979	9.5	240
1980	12.6	320
1981	11.8	300
1982	13.0	330
1983	17.3	439

These are estimates from the mean of the two closest official weather stations in the same vegetation type (Reese River Valley and Austin).

One tree-harvested and one nonharvested plot were established adjacent to each other on north (N. 20° E.), west (S. 84° W.), and south (S. 16° E.) aspects. Square tree-harvested plots (0.25 acre [0.1 ha] in size) were cleared of all trees 3.3 ft (l m) in height. Cut trees, including slash, were removed from the plot. Adjacent nonharvested plots (0.1 ha in size) were left undisturbed, and both tree-harvested and nonharvested plots were fenced to exclude livestock. Sampled aspects were within 1.29 mi (2 km) of each other on 14 to 18 percent slopes at a mean elevation of 7,580 ± 100 ft (2 310 ± 30 m).

The soil surface in the woodland was a mosaic of soil microsites. Tree litter (duff) greater than 0.3 inch (0.5 cm) in depth occurred under the tree crown. A transition zone of light needle cover (less than 0.5 cm in depth) formed a halo at the crown edge. And bare mineral soil occurred in the interspaces between trees (Everett and Sharrow 1983). Microsites with needle cover (duff and transition) occupied 50, 72, and 70 percent of the ground surface of north, west, and south aspects, respectively.

The three plant assemblages sampled were: *Pinus monophylla*/*Purshia tridentata* (Pursh) D.C. (antelope bitterbrush)/*Festuca idahoensis* Elmer (Idaho fescue)/*Lupinus caudatus* Kellogg (tailcup lupine) on the north aspect; *Pinus monophylla*/*Artemisia arbuscula* Nutt. (low sagebrush)/*Poa sandbergii* [Steud.] Vasey (Sandberg bluegrass)/*Trifolium gymnocarpon* Nutt. (hollyleaf clover) on the west aspect; and *Pinus monophylla*/*Artemisia tridentata* ssp. *wyomingensis* Nutt. (Wyoming big sagebrush)/*Poa sandbergii*/*Microsteris gracilis* (Hook.) Greene (microsteris) on the south aspect (Everett and others 1984). At the time of tree harvest the ratio of tree to grass cover was 28/3 percent, 61/2 percent, and 54/1 percent on north, west, and south aspects, respectively.

Cover, Density, and Biomass

In 1979 species cover and plant density of Sandberg bluegrass, squirreltail (*Sitanion hystrix* [Nutt.] J. G. Smith), Idaho fescue, and junegrass (*Koelaria cristata* [L.] Pers.) were estimated on harvested plots immediately before trees were removed. Sampling was repeated on both tree-harvested and nonharvested plots in 1981 and 1983. Crown cover and number of plants for each grass species were estimated with 20- by 20-inch (50- by 50-cm) frames laid at every meter mark on five permanent parallel transects of 66 ft (20 m) in length and 16 ft (5 m) apart in each tree-harvested and nonharvested plot. In 1981 grass yield was estimated on these permanent transects in nonharvested and tree-harvested plots. Leaf weight estimates were made separately for each grass species in each frame using the weight estimate double sample method (Pechanec and Pickford 1937; Wilm and others 1944). Of each grass species, 20 samples were clipped at maturity, seed heads discarded, and estimates made of dry weight. Samples were oven-dried, weighed, and regression equations derived (r^2 = 0.81 to 0.96). Yield (ovendry weight) was calculated from the regression of weight estimates made in the field.

Forage Quality

In June 1980 we collected at random 20 plants of each species in each tree-harvested and nonharvested plot where they occurred in abundance. All species were sampled at the anthesis stage of development. Sampling was refined in 1981, and eight plants of each species (anthesis stage) were harvested from each of the soil microsites, duff, transition, and interspace, on each tree-harvested and nonharvested plot. Grass samples were clipped at 0.4 inch (1 cm) height and seed heads were removed. Leaves were ovendried at 117 °F (47 °C) and ground to pass through a 0.5-mm sieve.

Plant materials collected in 1980 were run in duplicate through in vitro digestibility trials (Tilley and Terry 1963) using rumen inoculum from heifers maintained on a grass hay diet. Plant materials for 1981 were analyzed in duplicate for in vitro digestibility, total Kjeldahl nitrogen-salicylic acid modification (Eastin 1976), and phosphorus (sulfuric acid digest-colorimetric procedure using ascorbic acid indicator: Watanabe and Olsen 1965). Duplicate samples not within 10 percent of their mean value were rerun. A standard forage sample was included in each run and each run was adjusted to every other run via the common standard. Gross energy of each species was determined from four composite subsamples with a Parr adiabatic bomb calorimeter. Digestible energy (DE) was computed by microsite and whole plots using the formula DE = Production (i) * Gross Energy (i) * Dry Matter Digestibility (i) for each (i) species, as suggested by Conroy and others (1982).

Analysis

The experimental unit was the individual plant (20-24 replicates) when we tested for differences in in vitro digestibility, percentage of phosphorus, and percentage of nitrogen between harvested and nonharvested plots. In comparisons of the above parameters among soil microsites there were eight replicates per harvested and nonharvested plot. Belt transects (five replicates) were subdivided into individual soil microsite components, duff, transition, and interspace. Microsite area per transect served as the experimental unit. Differences in yield and forage quality among microsites were evaluated on a per-unit-area basis. The three replicates of paired harvested and nonharvested plots served as the experimental units in the comparison of the composite microsite change in forage yield and quality following tree harvest.

Analysis of variance and Hartley's sequential method of testing (Snedecor 1956) were used collectively to test for differences in total grass cover among years and individual species differences in yield, percentage nitrogen and phosphorus, in vitro digestibility, and plant density. Orthogonal contrasts were used to test for differences in forage quality (digestible dry matter, digestible energy, protein [6.25 × %N] and phosphorus) among microsites and tree-harvested treatments.

RESULTS AND DISCUSSION

Species Yield and Plant Density

All plant species examined showed a numerical increase in yield on tree-harvested plots, although differences were not always statistically significant (table 1). Except for squirreltail (west) and Idaho fescue (north), the greater yield on tree-harvested plots was the result of increased growth per plant and not increased plant density.

Squirreltail biomass and plant density increased on the tree-harvested plot of the west aspect. The species was barely represented on nonharvested plots but rapidly occupied the duff microsite following tree removal (Everett and others 1984). Robust growth of squirreltail following tree felling was previously reported by Clary and Morrison (1973) for alligator juniper (*Juniperus deppeana* Steud.) woodlands. Idaho fescue dominated the understory of the north aspect on nonharvested and tree-harvested plots.

Table 1.—Grass yield and plant density on tree–harvested and nonharvested singleleaf pinyon–Utah juniper plots by aspect

	Yield		Density	
Grass	Nonharvest	Harvest	Nonharvest	Harvest
	----------Lb/acre----------		--------Plants/ft^{2}--------	
	South			
Sandberg bluegrass	24.9	26.7	0.8	0.6
	West			
Sandberg bluegrass	14.3	59.8*[1]	2.1	1.5
Squirreltail	0	274.8*	.1	.4 +
Idaho fescue[2]	8.9	10.7	.1	.1
	North			
Sandberg bluegrass	4.5	32.1*	1.4	1.3
Squirreltail	12.5	13.4	.1	.1
Idaho fescue	39.3	151.7*	.4	.8 +

[1](+,*) significantly (p = 0.1, p = 0.05) greater yield or plant density on tree–harvested than nonharvested plots.

[2]Junegrass plants were present but in too few numbers for statistical analysis.

Species Forage Quality

In vitro digestibility of grass on tree-harvested plots was greater or equal to that on nonharvested plots for Sandberg bluegrass and Idaho fescue (north). Digestibility of squirreltail, junegrass, and Idaho fescue (west) was similar or lower on tree-harvested than on nonharvested plots (table 2). Apparent contradictory reports of digestibility increasing (Duvall 1970), remaining unchanged (Conroy and others 1982), or declining (Laycock and Price 1970) following tree harvest appear justified. We found digestibility increased and decreased among species growing on the same site. A general decline in digestibility of grasses on our sites occurred from 1980 to 1981.

Based on averages of data, species digestibility was in the general order of Sandberg bluegrass = junegrass > squirreltail > Idaho fescue (table 2). Wallace and others

Table 2.—Percentage in vitro digestibility of grass species on tree–harvested and nonharvested plots for 1980 and 1981 by aspect

	1980		1981	
Grass	Nonharvest	Harvest	Nonharvest	Harvest
	----------------Percent digestibility----------------			
	South			
Sandberg bluegrass	63[b][1]	76[a]	62[c]	66[b]
	West			
Sandberg bluegrass	72[a]	72[a]	68[b]	67[b]
Squirreltail	57[a]	—[2]	66[a]	56[a]
Junegrass	67[a]	—	72[a]	59[b]
Idaho fescue	57[a]	—	52[a]	46[a]
	North			
Sandberg bluegrass	72	72	—	—
Idaho fescue	60[a]	64[a]	47[b]	52[b]

[1]Dissimilar superscripts denote significant (p = 0.05) differences in in vitro digestibility between harvested and nonharvested plots in 1980 and 1981 for a given species (same row).

[2]Inadequate plant materials available for sampling.

(1961) reported a similar order for junegrass (67-69 percent) > squirreltail (64-65 percent) > Idaho fescue (54-55 percent) in eastern Oregon. Gross energy estimates derived from the bomb calorimeter followed a different species order: squirreltail ($4,150 \pm 50$ cal/g) > junegrass ($4,030 \pm 90$ cal/g) > Sandberg bluegrass ($3,840 \pm 40$ cal/g) > Idaho fescue ($3,640 \pm 270$ cal/g). Idaho fescue on our sites was low in both digestibility and gross energy. If carrying capacity were estimated from yield data alone, the estimate would be too high.

Percentage nitrogen (N) was numerically greater for all species on tree-harvested plots (table 3) and significantly so for Sandberg bluegrass (all aspects), squirreltail (west aspect), and Idaho fescue (west aspect). Minimum nitrogen (N) requirements for maintenance of a 1,100-lb (500-kg) lactating cow (9.2 percent protein $\cong$ 1.47 percent N: National Research Council 1976) were met by all species on tree-harvested sites and by squirreltail,

Table 3.—Concentrations of percentage nitrogen and percentage phosphorus in grass species on tree-harvested and nonharvested south, west, and north aspects

	Nitrogen		Phosophorus	
Grass	Nonharvest	Harvest	Nonharvest	Harvest
	----------------------------Percent----------------------------			
	South			
Sandberg bluegrass	1.04	2.25 +[1]	0.12	0.16 +
	West			
Sandberg bluegrass	.85	1.57*	.09	.15*
Squirreltail	1.50	1.94 +	.22	.22
Junegrass	1.47	1.64	.24	.31*
Idaho fescue	1.11	1.43*	.19	.21
	North			
Sandberg bluegrass	1.18	1.95*	.17	.22 +
Idaho fescue	1.54	1.64	.20	.21

[1]Significant (*, +, p = 0.05, p = 0.1) differences between nonharvested and harvested plots.

junegrass, and Idaho fescue (north aspect) on non-harvested sites. But nitrogen levels of all species remained below recommended levels for the nutritional needs of deer (16 percent protein $\cong$ 2.56 percent N: Halls 1970; Verme and Ullrey 1972).

Percentage phosphorus (P) was numerically greater on tree-harvested plots for all species (except squirreltail) and significantly so (p = 0.1) for Sandberg bluegrass and junegrass. Minimum phosphorus requirement for lactating cows of 1,100 lb (500 kg) is 0.28 percent P (National Research Council 1976). This value would be marginally adequate for deer nutritional needs as well (Verme and Ullrey 1972).

Soil Microsite Impact on Species

We were unable to determine differences (p = 0.1) in percentage nitrogen or percentage phosphorus of grass species growing on different microsites in tree-harvested or nonharvested plots. Our results are at variance with other reports of increased percentage nitrogen levels in grasses under semiarid shrubs (Rickard and others 1973) or mesic tree cover (Holecheck and others 1981). We speculate that on our tree- harvested plots, the increased grass yields (table 1) of the tree-associated microsites diluted nutrient concentrations. On our nonharvested plots, uniform moisture stress (Everett and Sharrow, unpublished) may have limited nutrient uptake and plant growth equally among microsites.

Composite Forage Response by Soil Microsite

We found no yield differences among soil microsites on any of the nonharvested plots, and grass yield was not different (p = 0.1) for individual microsites among aspects. Tree dominance was sufficiently intense to mask inherent microsite differences that emerged following tree removal.

Grass yield was greater on tree-associated microsites (duff and transition) than in interspace on west and north tree-harvested plots. Grass yield was not different among microsites on the south aspect (table 4). Yields of interspace microsites on tree-harvested plots were consistently similar to interspace yields on nonharvested plots.

Composite Forage Response by Aspect and Harvest Treatment

We caution that because aspect plots were not replicated, statistical results apply only to these specific plots. These plots are, however, characteristic of the population of pinyon-juniper communities from which they were drawn.

Grass cover increased for 2 years (1979 and 1980) following tree harvest on north and west aspects, but the rate of increase declined the next 2 years (fig. 1). Cover on nonharvested plots increased to a lesser extent from 1979 to 1983 and may reflect the effect of livestock exclusion on the site. The large peak in cover on the west aspect in 1981 reflects the rapid dominance and decline of squirreltail following tree harvest.

Table 4.—Total grass yield (lb/acre) by soil microsite on tree–harvested and nonharvested plots on south, west, and north aspects

	Nonharvest			Harvest		
Aspect	D[1]	T	I	D	T	I
	---Lb/acre---					
South	41.1[a2]	41.1[a]	31.2[a]	26.1[a]	39.3[a]	41.9[a]
West	31.2[bc]	41.1[bc]	14.3[bc]	574.7[a]	334.6[a]	97.3[b]
North	31.2[c]	43.7[bc]	33.9[c]	205.2[ab]	223.1[ab]	169.5[abc]

[1]D = duff, T = transition, I = interspace microsites.
[2]Superscripts (a,b,c) denote significant (p = 0.05) differences between microsites on the same aspect for harvested and nonharvested plots.
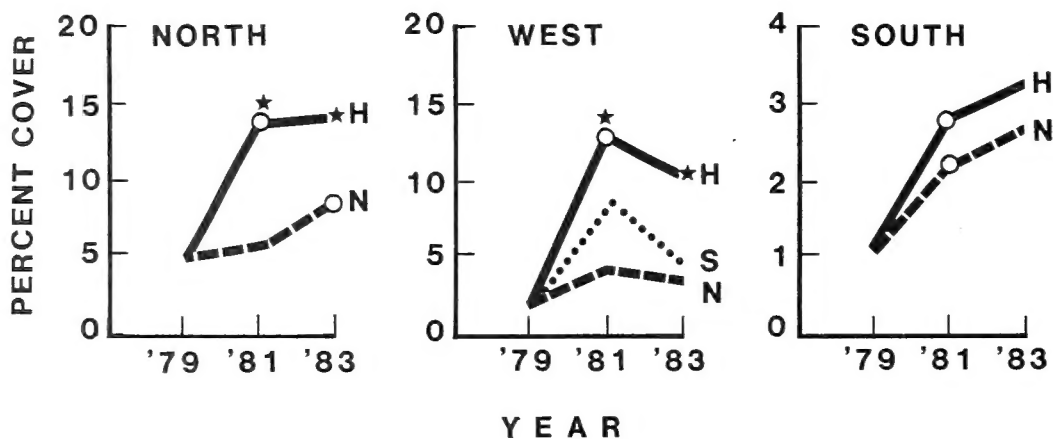
Figure 1.—Percentage grass cover on tree-harvested (H) and nonharvested (N) plots on north, west, and south aspects over time. (*) denotes significant (p = 0.05) differences between harvested and nonharvested plots in the same year. (O) denotes significant differences in cover from the preceding year on the same plot. (S) refers to cover of squirreltail (Sitanion hystrix).

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Yield of dry matter, digestible dry matter, digestible energy, protein, and phosphorus was greater on tree-harvested than on nonharvested plots on north and west aspects (table 5). Yield was similar on tree-harvested and nonharvested plots of the south aspect. O'Rourke and Ogden's (1969) suggestion that high tree cover is an indication of potentially high understory production did not hold in this instance (tree cover 28 percent north vs 54 percent south). Tree cover had not yet stabilized on the north aspect (Meeuwig and Cooper 1981). The reported loss in production of cool season grasses following tree harvest in Arizona (Clary and Morrison 1973) did not occur here. Basic climatic differences exist between the two woodland systems.

The "minimal area" required to provide the daily digestible energy requirement for a 1,100-lb (500-kg) lactating cow (24.41 M cal DE: National Research Council 1976) utilizing 50 percent of the grass yield varied from 1.43 acres (0.58 ha) on nonharvested plots to 0.15 acre (0.06 ha) on tree-harvested plots (T-5). A clearcut area of 4.5 to 7.4 acres (1.8 to 3 ha) would furnish 1 animal unit month (AUM) of forage on the west and north aspects. Nonharvested woodlands and the harvested south aspect would require 26.7 to 43.0 acres (10.8 to 17.4 ha)/AUM. Nonharvested singleleaf pinyon-Utah juniper woodlands provide much less forage than nonharvested alligator juniper woodlands—5.4 acres (2.2 ha)/AUM (Clary 1974)—but harvested plot forage production is comparable at 3.7 acres (1.5 ha)/AUM (Clary 1974) vs 4.5 acres (1.8 ha)/AUM on our sites.

Protein increased significantly following tree harvest on west and north aspects but not on the south aspect. If animals grazed until they met their maintenance energy requirements, protein uptake would be adequate, 2.0 lb (0.91 kg)/day (National Research Council 1976), on north and west tree-harvested plots and the nonharvested plot on the north aspect. South (0.1 lb [0.05 kg] N) and west (1.3 lb [0.60 kg] N) nonharvested plots and the south tree-harvested plot do not provide adequate protein levels. Minimum phosphorus intake of 0.6 oz (17 g)/day (National Research Council 1976) would not be met grazing either nonharvested (0.4 to 0.7 oz [13 to 20 g]/day) or tree-harvested (0.5 to 0.9 oz [15 to 25 g]/day) plots.

CONCLUSIONS

Grass cover, yield, and nutrient content increased substantially following tree harvest on north and west aspects, but there was minimal response on the south aspect. These results require verification on other sites. South aspects should not be tree-harvested for increased forage for livestock. But increased forage quality following tree removal may provide improved deer habitat.

Fully stocked woodlands provide little forage, approximately 42 acres (11 to 17 ha)/AUM. This can be substantially increased by tree harvesting (4.5 to 7.4 acres [1.8 to 3 ha]/AUM) on more mesic aspects. In early summer, nitrogen levels are generally adequate for livestock on tree-harvested plots but inadequate on nonharvested plots. Grass on nonharvested and tree-harvested plots provides inadequate nitrogen and phosphorus levels for deer.

In undisturbed stands tree competition effectively equalized grass yield among soil microsites and aspects. Grass production and quality increased more on tree-associated microsites (duff and transition) than in the interspace following tree removal. We speculate this was the result of greater soil nutrients under the tree crown and greater preharvest plant density adjacent to the tree crown edge (Everett 1984). Selective feeders, like deer, that maximize nutritional quality would benefit from the more nutritious forage of tree-harvested sites and especially forage on tree-associated microsites.

The lack of greater nitrogen and phosphorus concentrations in grass plants associated with overstory was at variance with previous reports from more arid and mesic plant communities (Duvall 1970; Rickard and others 1973; Holecheck and others 1981). We can only speculate that overstory competitive effects are uniform across our site and prohibit understory from utilizing increased soil nutrients associated with the tree crown.

Table 5.—Yield of dry matter, digestible dry matter, digestible energy, protein, and phosphorus on nonharvested and tree–harvested sites for June 1981 on south, west, and north aspects

Aspect	Nonharvest	Harvest
Dry matter		
Lb/acre		
South	25.3	27.2
West	24.1	345.3[*1]
North	55.9	197.2[+]
Digestible dry matter		
Lb/acre		
South	20.1	20.4
West	18.3	202.9[*]
North	29.8	109.9[+]
Digestible energy		
*kcal/acre * 10³*		
South	36.46	35.89
West	32.09	373.82
North	51.51	188.02
Minimal grazed area²/acres/ animal/day @ 50% utilization		
South	1.28	1.28
West	1.43	.15
North	.89	.25
Protein		
Lb/acre		
South	2.2	3.2
West	2.1	37.6[*]
North	3.0	17.7
Phosphorus		
Lb/acre		
South	0.04	0.05
West	.06	.27[*]
North	.07	.45[*]

[1]Significant (*, +, p = 0.05, p = 0.1) differences between nonharvested and harvested plots.

²Minimal grazed area, that area providing sufficient digestible energy to meet the maintenance requirements for a 1,100–lb (500–kg) lactating cow.

All species (Sandberg bluegrass, squirreltail, Idaho fescue, and junegrass) increased in yield, nitrogen, and phosphorus following tree harvest. Thus, forage quantity and quality are expected to increase following tree harvest regardless of the exact species composition. Differences in digestibility among grass species suggest that grass yield conversion to livestock gains may be overestimated when species with low digestibility predominate.

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Tree harvesting in pinyon-juniper woodlands increases grass yield and quality. Yield per unit area was greater on tree-associated soil microsites than in the interspace between cut stems. All grass species had higher nitrogen and phosphorus levels following tree removal. Tree harvesting reduced the area required per animal unit month from 27 to 7 acres (11 to 3 ha) (north aspect) and 42 to 5 acres (17 to 2 ha) (west aspect), but had no effect on the south aspect (40 acres, or 16 ha). Tree harvesting is a viable method to increase forage production for livestock and wildlife.

The Intermountain Station, headquartered in Ogden, Utah, is one of eight regional experiment stations charged with providing scientific knowledge to help resource managers meet human needs and protect forest and range ecosystems.

The Intermountain Station includes the States of Montana, Idaho, Utah, Nevada, and western Wyoming. About 231 million acres, or 85 percent, of the land area in the Station territory are classified as forest and rangeland. These lands include grasslands, deserts, shrublands, alpine areas, and well-stocked forests. They supply fiber for forest industries; minerals for energy and industrial development; and water for domestic and industrial consumption. They also provide recreation opportunities for millions of visitors each year.

Field programs and research work units of the Station are maintained in:

Boise, Idaho

Bozeman, Montana (in cooperation with Montana State University)

Logan, Utah (in cooperation with Utah State University)

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Provo, Utah (in cooperation with Brigham Young University)

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