MONTANA STATE UNIVERSITY

Chemical control of clubmoss (Selaginella densa Rydb.)
by Don Wilms Stroud

A thesis submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE IN Range Management
Montana State University
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Abstract:
Selective chemical control of Selaginella densa Rydb. was investigated at three locations involving 15 trials representing spring, summer and fall treatments from "1964 through 1968. Treatments were evaluated for percent clubmoss control, vegetational change, and production of herbage.

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Atrazine and monuron killed existing fringed sagewort plants and prevented refinfestation for one or more growing seasons.

The addition of 50 lbs/A of nitrogen to atrazine and monuron treatments significantly increased the production of herbage over herbicidal treatments alone.

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of

MASTER OF SCIENCE

IN

Range Management

Approved:

Head, Major Department

Chairman, Examining Committee

Graduate Dean

MONTANA STATE UNIVERSITY
Bozeman, Montana

December, 1970

ACKNOWLEDGEMENT

The author would like to express his sincere appreciation to Laurence O. Baker for his valuable advice, constructive criticism and encouragement throughout the course of this investigation.

Appreciation is also expressed to Dr. Erwin Smith for his advice and assistance in processing the data at the Montana State University Computer Center, and to Dr. G. F. Payne and Dr. Don E. Ryerson for their assistance throughout the course of the study.

Special thanks is extended to the Bureau of Land Management who supplied the grant under which this project was carried out.

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ABSTRACT

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INTRODUCTION

Selaginella densa Rydb., commonly called dense clubmoss (hereafter referred to as clubmoss) is a spore producing, mat-forming plant common to extensive areas of the Northern Great Plains and foothill-mountain regions bordering the plains.

Clubmoss is found on native rangeland throughout the State of Montana, except at extremely high elevations and some sedimentary plains areas in the southeastern part of Montana. Clubmoss is most abundant on plains and foothill ranges east of the Continental Divide and north of the Missouri River. Apparently clubmoss prefers well developed soils of medium texture and nearly neutral reaction on level to moderately sloping topography (Payne et al., 1967).

Substantial acreages of land administrated by the Bureau of Land Management in northern Montana are infested with clubmoss. To aid in future management of clubmoss infested range the Bureau entered into a research contract with the Montana Agricultural Experiment Station in 1963 to study clubmoss.

Mechanical methods of clubmoss control were investigated by the Animal & Range Sciences Department and reported by Dolan (1966) and Ryerson et al. (1969). Soil-water relationships were studied by Houlton at the North Montana Branch Station and reported by Ryerson et al. (1969).

Chemical methods of clubmoss control were studied by the Plant and Soil Science Department. Preliminary results were reported by Wagner (1966). This thesis represents a continuation of the work he initiated and summarizes results of all selective chemical control work on club-moss.

REVIEW OF LITERATURE

Dolan (1966) and Wagner (1966) extensively reviewed the literature available on clubmoss. Their reviews covered taxonomy, reproduction, growth, cytology and factors affecting distribution and control of clubmoss. No additional literature was available since completion of their reviews except for that originating in Montana.

Although low in stature clubmoss was found to be an important component of the vegetation present because of its high degree of ground cover (over 90 percent basal cover in some heavy infestations) (Ryerson et al., 1969). Clubmoss was found throughout Montana except at extremely high elevations and some sedimentary plains areas (Payne et al., 1967).

On clubmoss infested range Houlton seldom found available moisture below 18 inches at the beginning of the growing season. Reserve moisture rapidly depleted as the growing season progressed. He attributed these losses to suspected high evapotranspirational rates of clubmoss. He found that evapotranspiration losses continued to occur in the late summer whenever light rains fell, even though grasses were in a summer dormant condition (Ryerson et al., 1969).

Yearly herbage production from pitting and scalping at the North Montana Branch Station (Havre) consistently exceeded check yields. Scalping-with-seeding outyielded pitting at the Nyquist allotment near Glasgow and in some tests at Havre (Ryerson et al., 1969).

Wagner (1966) in reporting 1964 results of herbicides applications made in the field during the spring of 1964 found that clubmoss was controlled by several chemical treatments. Herbage yields increased following certain treatments (AMS, atrazine) but were reduced by monuron and paraquat[1/]. Bromacil treatments destroyed all vegetation present.

Reduction of live and dead clubmoss ground cover 30 years after mechanical treatments was observed by Dolan (1966).

Three annual applications of 100 pounds of nitrogen per acre significantly reduced dormant clubmoss ground cover but did not affect live clubmoss. Water, however, increased both live and dormant clubmoss ground cover (Klages and Ryerson, 1965).

Herbage yield increases with applications of 40-320 lbs/A of nitrogen plus monuron at 1 lb/A were greater than with nitrogen alone (Choriki et al., 1969).

A standardized system of reporting herbicide characteristics was developed by the Weed Society of America (1967). Information regarding physiological and biochemical behavior, behavior in or on soils, toxicological properties, physical properties and use were some of the items requested for each herbicide from the manufacturer. Information regarding three of the chemicals tested is summarized in Table 1.

AMS is rapidly absorbed by foliage, is highly soluble and is subject to leaching in the soil. However, AMS is also rapidly decomposed by microbial action in the soil.

Atrazine and monuron are less subject to leaching, being more readily adsorbed by clay particles and organic matter. They are also

1/ Full chemical names are given in Appendix Table 2.

Table 1. Physical and chemical characteristics of AMS, atrazine and monuron[1].

Physiological and Biochemical Behavior	AMS	Atrazine	Monuron
Solubility in water at 25° C	68.4 ppmw	70 ppmw	230 ppmw
Absorption	Rapidly absorbed through foliage and stems.	Through both roots and foliage, Foliage absorption often small.	Readily absorbed through root system, less so in foliage and stems.
Translocation	Translocation does occur.	Translocated acro-petally in the xylem and accummulates in the apical meristems.	Primarily upward in the xylem.
Mechanism of action		A photosynthetic inhibitor.	Strong inhibitor of the Hill reaction.
Behavior in or on soils			
Adsorption and leaching	Not retained in soils, moves like chlorate.	More readily adsorbed on muck or clay soils than on soils of low clay and organic mat-ter. Not normally found below upper foot of soil.	Increases as clay and/or organic matter increases, leaching not important.
Microbial breakdown	Species of fungi and bacteria converted sulfamate to sulfate in approx. equimolar proportions to amount of N assimilated.	Probably accounts for major breakdown in the soil. Micro-organisms can utilize it as a source of energy and N.	Primary factor in dis-appearance from soils. Some organisms can use monuron as sole source of carbon.

1/ Information obtained from the Herbicide Handbook 1967.

Table 1 (continued).

Behavior in or on Soils	AMS	Atrazine	Monuron
Loss from photo-decomposition and/or volitalization.		Both occur to some extent. More subject to UV and volatility.	Probably are insignificant except when exposed on soil surface for extended length of time.
Average persistance at recommended rate	6-8 weeks at 3 lbs. per 1000 sq. ft. under humid eastern conditions.	Most rotational crops can be planted 1 year after application, except under arid or semi-arid climate.	At lower selective rates phytotoxic concentrations disappear within one season. Higher rates may require more than one season. Accumulation from annual application is not a problem.

Toxicological properties

General toxicity to wildlife.	Deer fed AMS treated foliage suffered no ill effects.	Investigations conducted on 2 species of birds and 3 species of fish, showed a very low toxicity.	
Information provided by	E.I.DuPont deNemours and Company.	Geigy Agricultural Chemicals.	E.I. DuPont deNemours and Company

subject to microbial breakdown, but at a slower rate than AMS. Neither would be expected to appear in ground water. Movement in surface water would be dependent on movement of soil particles to which the chemical was adsorbed (WSA 1967).

MATERIALS AND METHODS

STUDY AREAS.-

Herbicides which appeared to control clubmoss in initial greenhouse experiments by Wagner (1966) were further evaluated in field trials. These trials were conducted at the North Montana Branch Station near Havre (Havre site), the Buggy Creek State Grazing District (Fabian Nyquist allotment) near Glasgow (Glasgow site) and the Red Bluff Research Ranch near Norris (Norris site).

Havre Site.- This heavily infested clubmoss site is located on a gently undulating glacial till plain dissected by moderately deep coulees. The approximate elevation is 2,800 feet. Average annual precipitation is 11.25 inches measured at Fort Assinniboine five miles north of the site.

The dominant soils are Telstad loams with other unidentified soils occurring locally in small vegetated micropits. Telstad soils are classified in the fine-loamy, mixed family of Aridic Argiborols. Similarity with the Scobey classification is noted. Typically Telstad soils have grayish brown loam surface, brown prismatic clay loam B2, ca, and C horizons. The thickness of solum over the calcareous ca horizons ranges from 10 to 15 inches. Compared with Scobey there is less clay throughout the profile. Both soils are well drained and moderately permeable[1/].

1/ Classification of soils at all study sites have been made by Soil Conservation Service Soil Scientists Fred A. Boettcher, R. L. Moshier, R. E. Richardson and J. L. Parker. Information much the same as reported by Ryerson et al., 1969.

Native vegetation other than clubmoss is dominated by needleandthread and blue grama. Associated grasses and grass-like plants include Sandberg bluegrass, prairie junegrass, plains reedgrass, western wheatgrass, green needlegrass, six-weeks fescue and needleleaf sedge[1].

Important forbs are scarlet globemallow, Hoods phlox, American vetch, hairy goldenaster, penstemon, pussytoes, milkvetches, cudweed sagewort and green sagewort. Half-shrubs include fringed sagewort and broom snakeweed.

Glasgow Site.- This area is located approximately 3 miles north and one and one-half miles west of the Glasgow Air Force Base.

Soils of the Glasgow study area were formed on a gently rolling till plain at an elevation of 2,300 feet. Average annual precipitation is 12.27 inches measured at Glasgow airport 25 miles south of site. On the more level slopes and in the swales and drainage areas, the soils are Thoeny loams classified in the fine montmorillonitic family of Borollic Natragids. Typically they have grayish brown loam A2, columnar clay B2t, clay loam B3ca, Cca and C horizons. The platy structured A2 extends to a depth of about 10 inches. The structural columns of the B2t are graycapped, hard when dry, and exhibit few roots or pores in the dense interior. Gypsum crystals are found in the C horizon about 2 feet below the soil surface. Thoeny loams are well drained with medium to slow infiltration and runoff. Permeability is very slow.

1/ See Appendix Table 1 for complete list of common and latin names.

Scobey loams occur on areas with 4 to 8 percent slopes. These soils are classified in the fine, montmorillonitic family of Aridic Argiborolls.

Typically they have brown clay loam A, blocky light clay B2t, B3ca and C horizons. There are many roots in the B2t which begins at a depth of about 4 inches. Depth to the prominant ca horizon is commonly 14 to 16 inches. Scobey soils are well drained. Runoff and permeability are moderate.

The vegetation is very similar to that at Havre with the addition of thickspike wheatgrass and Montana wheatgrass. The lowland sites support colonies of porcupine grass.

Norris Site.- The experimental site is located approximately one-half mile west of the Red Bluff Research Ranch headquarters and approximately one mile east of Norris, Montana. Annual precipitation averages 15.05 inches measured at ranch headquarters.

The dominant soil on the study site is tentatively identified as Sappington loam. This site is situated on a southeast-facing four percent slope of an upland fan at an elevation of 4,700 feet. Like the Telstad, the Sappington is classified in the fine-loamy, mixed family of Aridic Argiborolls. Although the sequence of horizons are very thin at this site, sandy loam, sandy clay loam, clay loam and loamy sand occurs below 40 inches. A typifying profile has 2 inches of grayish brown loam A1, underlain by 3 inches of clay loam B2t, 3 inches of light clay loam

B3ca, 12 inches of silt loam C1ca and 20 inches of sandy loam C2. Run-off is slow to medium. Permeability is moderate.

The principal grass and grass-like species present on this foothill grassland range are needleandthread, blue grama, needleleaf sedge and western wheatgrass. A few remnants of bluebunch wheatgrass can be found. Forbs, including clubmoss are Hoods phlox, hairy goldenaster, biscuit-root, American vetch, pussytoes, woolly Indianwheat, with tansy mustard present on disturbed areas. Among the shrubs, fringed sagewort is common with an occasional plant of rubber rabbitbrush.

CHEMICAL CONTROL.-

Initial herbicide screenings for clubmoss control were carried out in the greenhouse on cores of clubmoss sod (Wagner, 1966). Herbicides showing clubmoss control were further trested in the field at the Havre and Norris sites in the spring of 1964. Trials were conducted using plots 8¼ X 16½ feet with treatments applied in triplicate using a randomized block design. The third site (Glasgow) was added in the fall of 1964 using plots 8¼ X 33 feet (Wagner, 1966).

Following observations of the 1964 treatments seven chemicals were selected for further trials in the spring of 1965 at all three locations. AMS, monuron, atrazine and picloram were applied at Norris on April 22, at Havre on May 21 and at Glasgow on May 22. Paraquat, diquat and endothall were applied at Norris on June 18, at Glasgow on June 22 and Havre on June 23, 1965. Surfactant Ortho X-77 was added to paraquat spray solution. Additional applications of AMS, atrazine, monuron and paraquat were made at all three locations in the fall of 1965 to plots 8¼ X 33 feet in size following the same procedures. Treatments were applied at Norris November 11, Havre October 30 and Glasgow October 31, 1965. Nitrogen fertilizer was included as an additional variable applied to one-half (8¼ X 16 feet) of each plot at a rate of 50 pounds N per acre in the form of granular ammonium nitrate.

After evaluation of all 1964 and 1965 treatments, plots 40 X 60 feet were treated in the spring of 1966 with what was thought to be optimum rates of AMS, atrazine, monuron and paraquat. Applications were made at two locations - Havre March 24 and Norris March 28. Nitrogen at 50 lbs. N per acre was applied to half (20 X 60 feet) of each plot.

On June 15, 1966 at Norris an additional test was established on plots 8¼ X 16½ feet to evaluate spray surfactants. Spray surfactants are designed to increase the wetting, spreading and sticking of pesticide sprays on plant surfaces and thus enhance herbicidal activity. (Jensen, 1964). Two surfactants were used - Ortho X-77 and DuPont Spreader Sticker. In this test X-77 at .5 percent by volume was combined with paraquat. DuPont Spreader Sticker at .5 percent was combined with lower rates of AMS and monuron treatments.

In May, 1968 further trials were established at Norris on rod square plots to evaluate effectiveness of spray adjuvants with lower rates of AMS, atrazine and monuron. DuPont Spreader Sticker was combined with AMS at the rate of .126 percent by volume. DuPont T-MULZ AOZ emulsifier formulated by Thompson Hayward Chemical Company especially for use with atrazine was used at 1 percent by volume with atrazine. DuPont surfactant W-K was combined with monuron at the rate of .5 percent by volume.

All spray applications were made with a compressed air sprayer using 40 gallons of water per acre as the carrier. Applications to small plots (less than 40 X 60 feet) were made putting water and chemical for one plot into a sprayer equipped with a single teejet nozzle. The entire plot was sprayed twice, first in one direction then in the other. Large plots (40 X 60 feet) were treated with a hand carried 8 foot boom equipped with nine teejet nozzles and constant air pressure. Application rate on the large plots was controlled by length of spraying time.

Plots were visually evaluated at least twice during each growing season to determine the response of clubmoss to the herbicidal treatments. All evaluations were made by the same person and were generally made following a rain when clubmoss was in a period of active growth. Comparisons were made between the amount of green clubmoss present on the untreated check plots and the chemically treated plots. Results were tabulated for each plot based on 0 for no control to 100 for complete clubmoss control.

Most, but not all, treatments were evaluated (for effects on vegetational production) by hand clipping, usually in early August. Yield samples included all vegetation except clubmoss. The vegetation was clipped at ground level from a 2 square foot circular plot and separated by species groups to sample herbicidal affect on herbage yield. The 8¼ X 16½ feet plots were sampled at two locations and the 8¼ X 33 feet plots at Glasgow were sampled at three locations. When nitrogen was applied to half of the 8¼ X 33 feet plots the plots were sampled at four locations. Ten locations were sampled on the 40 X 60 feet plots. Where nitrogen was applied half of the samples were from the nitrogen treated portion of the plot. Sampling locations within plots were changed each growing season.

NITROGEN-WATER.-

Treatments consisting of four levels of nitrogen and four levels of water were made in a split plot randomized block design. Rates of 0, 50, 100 and 150 pounds of nitrogen per acre were applied to square rod plots in triplicate May 27, 1965.

Sub-plots consisting of four levels of water were obtained by using metal strips 6 inches wide and formed into rings 2 feet in diameter which were driven 2 inches into the ground. Two rings were used for each water level on each nitrogen plot. Water was added weekly from June 11, 1965 to September 9, 1965 and May 1, 1966 to August 1, 1966 to supplement natural precipitation with enough water to reach one-half, 1 and 2 inches per week.

Yield response was sampled by removing the metal strips and clipping at ground level all vegetation except clubmoss. Harvests were made in August of 1965 and 1966.

RESULTS AND DISCUSSION

Preliminary chemical screening trials were conducted on clubmoss sod in the greenhouse. Results of these trials are reported in detail by Wagner (1966).

In the spring of 1964 those herbicides showing activity in the greenhouse were submitted to field trials for further evaluation on plots established at Norris and Havre. Several chemical treatments including AMS, atrazine and monuron killed all clubmoss at both locations. Significant yield increases were reported for some of these treatments at Norris in 1964 (Wagner, 1966).

CLUBMOSS CONTROL.-

No herbicide has been registered by the USDA for selective control of clubmoss. At the time of this writing a petition requesting approval of atrazine for this purpose has been submitted to the USDA. It is hoped that like action can be taken with AMS and monuron in the near future.

Response of clubmoss to treatments applied in the spring of 1964 varied from 0 to 100 percent control. Based on evaluations made during the summer of 1964 some chemicals were eliminated (Appendix Table 3). Eight chemicals were selected for further testing (Table 2). They all proved to be effective under certain circumstances; however, due to the inconsistant results obtained or to cost relationships, dicamba, diquat, endothall and picloram were dropped from further testing in the fall of 1965.

Table 2. Percent clubmoss control in June, 1967 from herbicidal applications at Glasgow, Havre and Norris for treatments made during 1964, 1965 and the spring of 1966[1].

		Time of Application													
		Spring 1964		Fall 1964			Spring 1965			Fall 1965			Spring 1966		
Chemical	Rate	H[2]	N	G	H	N	G	H	N	G	H	N	H	N	Ave.
	lb/A	%	%	%	%	%	%	%	%	%	%	%	%	%	%
AMS	5.0			23	3	3	70	37	13						25
	7.5									85	70	70			75
	10.0			45	15	13	87	72	97	93	74	97	100	38	66
	20.0	98	90	78	78	50	100	89	98						85
Atrazine	1.0	28	88	38	10	70	58	37	93	53	20	83			53
	1.5									60	25	98			61
	2.0	50	100	93	62	100	97	100	100	93	65	100	97	100	89
Dicamba	1.5			10	3	3									5
	3.0	78	18	10	4	0									22
Diquat	.5					42	16	28	0						22
	1.0	20	38				53	80	37						46
Endothall	3.0	3	40				18	8	7						15
Monuron	1.0	85	95	48	48	95	80	90	90	73	46	92			77
	1.5									90	80	100			90
	2.0	100	100	93	88	100	100	100	100	100	100	100	100	100	99
	4.0	100	100												100
Paraquat[3]	.5						70	70	48	18	12	15	35	25	37
	1.0	48	100				85	68	100	55	13	35			63
Picloram	.5	88	30	27	53	10									42
	1.0	100	83	67	93	50	63	33	40						66
	2.0	100	100												100

1/ Average of three replications from observations in June, 1967.
2/ G - Glasgow, H - Havre, N - Norris
3/ Surfactant Ortho X-77, 1 percent by volume.

A 10 lb/A rate of AMS averaged 66 percent clubmoss control in the 11 trials in which it was included (Table 2). It is not known why poor results were obtained in approximately 25 percent of the trials since they were not necessarily associated with date of application or location of treatment, and since higher percent kill was obtained from several applications at lower rates. AMS in excess of 10 lbs/A produced slightly better clubmoss control, however, such increases were not justified by the increased chemical cost.

Results from the inclusion of DuPont Chemical Company's Spreader Sticker with AMS at Norris were disappointing (Table 3). Excellent results were obtained from the 1966 treatments; however, there was no apparent advantage obtained from the Spreader Sticker in 1968. Possibly the lack of favorable response to surfactant was due to a reduced rate (from .5 to .126 percent by volume).

Clubmoss control at the 2 lb/A rate of atrazine averaged 89 percent in the 14 trials which it was used (Table 2). At less than 2 lbs/A results were generally not satisfactory. Results from the 1 pound rate varied by location with control highest at Norris and lowest at Havre. Even at the 2 pound rate clubmoss kill was only 63 percent at Havre from the fall applications (1964 and 1965), possibly due to interception of the chemical by the large amounts of vegetative residue on the soil surface.

Table 3. Percent clubmoss control from treatments made at Norris with and without surfactants[1].

Chemical	Rate	Previous Spring Application without surfactant 1964	1965	1966	Ave.	Treatment Date: June, 1966 without Surfactant	June, 1966 with Surfactant[2]	May, 1968 without Surfactant	May, 1968 with Surfactant
	lbs/A	%	%	%	%	%	%	%	%
AMS	5		13		13		88	40	42
	7.5						100		
	10		97	38	68	100	100	82	88
Atrazine	1	88	93		91			43	95
	2	100	100	100	100			100	100
Monuron	1	95	90		93		97	96	100
	2	100	100	100	100	100	100	100	100
Paraquat	.25						12		
	.50						40		
	.75					60	40		

1/ Average of three replications. Observations made in 1967 except in 1969 on May, 1968 treatments.

2/ X-77 .5 percent by volume with paraquat; DuPont Spreader Sticker, .5 percent with AMS and monuron.

3/ AMS - DuPont Spreader Sticker .126 percent by volume.
Atrazine - T-MULZ A02 1 percent by volume.
Monuron - DuPont Surfactant W-K .5 percent by volume.

One percent by volume T-MULZ-A02 emulsifier was used in May, 1968 with atrazine at Norris. It resulted in slight bleaching of the vegetation a few days after treatment. While the 95 percent control resulting from 1 lb/A was more than twice as high as that obtained without surfactants it was not different from the results without surfactant in 1964 and 1965 (Table 3). The 43 percent control without surfactant was the poorest results ever obtained at Norris with any rate of atrazine.

Excellent clubmoss control was obtained with 2 lbs/A of monuron. Fifteen applications, over a four-year period, resulted in an average control of 99 percent (Tables 2 and 3). Twelve applications at the 1 pound rate averaged 78 percent control although three treatments, fall of 1964 at Glasgow and Havre and the fall of 1965 at Havre, gave only about 50 percent control.

The excellent results obtained in June, 1966 and May, 1968 both with and without surfactants at the 1 lb/A level indicated a lower rate of monuron should have been used to determine the effectiveness of surfactants with monuron at Norris (Table 3).

Paraquat supplemented with Ortho X-77 surfactant was generally less effective than AMS, atrazine or monuron although at the 1 lb/A rate paraquat did give complete clubmoss control under certain undefined conditions. A paraquat treatment to be comparable in cost to the 2 pound rates of atrazine or monuron should not exceed .5 pounds per acre. Nine treatments made at this rate averaged only 37 percent clubmoss control (Tables 2 and 3).

Clubmoss control with picloram was generally good with the 1 or 2 lb/A rate. Cost of such treatments precluded further testing of this chemical.

Diquat was generally less effective than paraquat in selectively controlling clubmoss. Dicamba and endothall were eliminated from further tests due to the poor response of clubmoss.

Herbage Yields.-

During the course of these investigations, herbage yields from the untreated check plots varied considerably. Differences between years was at least in part due to amount and distribution of precipitation which was considerably below normal in 1966 and 1967 at Havre, and at Glasgow in 1967. Above normal precipitation was received at Glasgow and Havre in 1965 and at Norris in 1967. Monthly precipitation figures for each year of the study are shown in the Appendix (Table 4) for each location.

Differences in yield within years among untreated check plots at each location was at least partially due to differences in distribution patterns of individual species. Because of this variation in check yields, an average check for each year at each location was used to compare most treatments (Table 4). Since there was considerable range in

Table 4. Pounds of dry matter produced by the untreated checks from each test during each year at each location.

Beginning of Test	Glasgow			Havre			Norris			
	1965	1966	1967	1965	1966	1967	1964	1965	1966	1967
	lb/A	lb/A	lb/A	lb/A	lb/A	lb/A	lb/A	lb/A	lb/A	lb/A
Spring, 1964				972[1/]	425	462	320	401	353	477
Fall, 1964	710	605	670	588	391	342		521	392	333
Spring, 1965	437	696	507	657	473	264		617	261	573
Fall, 1965		565	542		554	432			300	421
Spring, 1966					494	303			369	397
Summer, 1966										585
Averages	574	622	573	739	467	361	320	513	358	464

1/ Each yield is an average of three replications.

forage production, all yields are expressed as a percent of average check for each year at each location. (Tables 5, 6, 7, 8 and 9).

Herbage yields from all treatments shown in Tables 5, 6, 7, 8 and 9 were generally more than the average check. Yields of vegetation following treatments with dicamba, diquat, endothall and picloram were not sampled as extensively as AMS, atrazine or monuron treatments due either to poor clubmoss control or higher cost of obtaining similar results.

Individual trials were analyzed for significance using Duncan's Multiple Range Test (1955). Comparisons of yields for 1965, 1966 and 1967 are shown in Tables 10, 11 and 12.

In 1965 significant differences were found in all six trials. Yields significantly higher than untreated check occurred in three trials - AMS 10 pound rate at Glasgow in the spring of 1965, paraquat 2 pound rate in the fall of 1964 at Havre, and atrazine 1 pound rate in the spring of 1965 at Havre. In two trials at Norris yields were significantly lower than the check: Picloram granules at 1 pound rate in the fall of 1964 and in the spring of 1965 by atrazine 1 pound, diquat 1 pound, paraquat 1 pound, and picloram granules at 1 pound.

Yields did not differ significantly in 1966 in any of the trials, however, by the third growing season (1967) after treatment, 18 treatments in five of the trials had significantly higher yields than the

Table 5. Herbage yields in 1964, 1965, 1966 and 1967 as a percent of average check following herbicidal applications in the spring of 1964 at Havre and Norris for selective control of clubmoss.

		Herbage Yield as Percent of Check1/										
		Havre2/			Norris				Average			
Chemical	Rate	1965	1966	1967	1964	1965	1966	1967	1964	1965	1966	1967
	lb/A	%	%	%	%	%	%	%	%	%	%	%
AMS	20	160	84	143	139	144	137	181	139	152	110	162
Atrazine	1	128	85	122	120	97	130	170	120	112	108	146
	2	158	108	163	126	94	163	191	126	126	136	177
	4	143	137	189	62	77	129	184	62	110	133	186
Dicamba	3		104	224			85	119			95	172
Diquat	1	150	110	127		99	110			125	110	127
	2	137	104	140		98	128			118	116	140
	4	192	123	160		104				148	122	160
Endothall	1½	98				89				94		
	3	109				125				117		
Monuron	1	174	158	160	117	118	165	147	117	146	162	154
	4	201	123	198	59	51	116	186	59	126	120	192
	2	182	107	179	87	113	163	165	87	148	135	172
Paraquat3/	1	134	115	149	72	132	144	156	72	133	130	152
Picloram	.5	122	81	160	82	68	94	136	82	95	88	148
	1	151	135	167	76	70	132	141	76	110	134	154
	2	135	108	170	71	60	137	187	71	98	122	178
Nitrogen	50	212	81	137	226	173	154	112	226	192	118	124
Average Check Yields in lb/A		739	467	361	320	513	358	464				

1/ Average of three replications expressed as a percent of the average check for each year at each location.
2/ Not harvested in 1964.
3/ With surfactant X-77, 1 percent by volume.