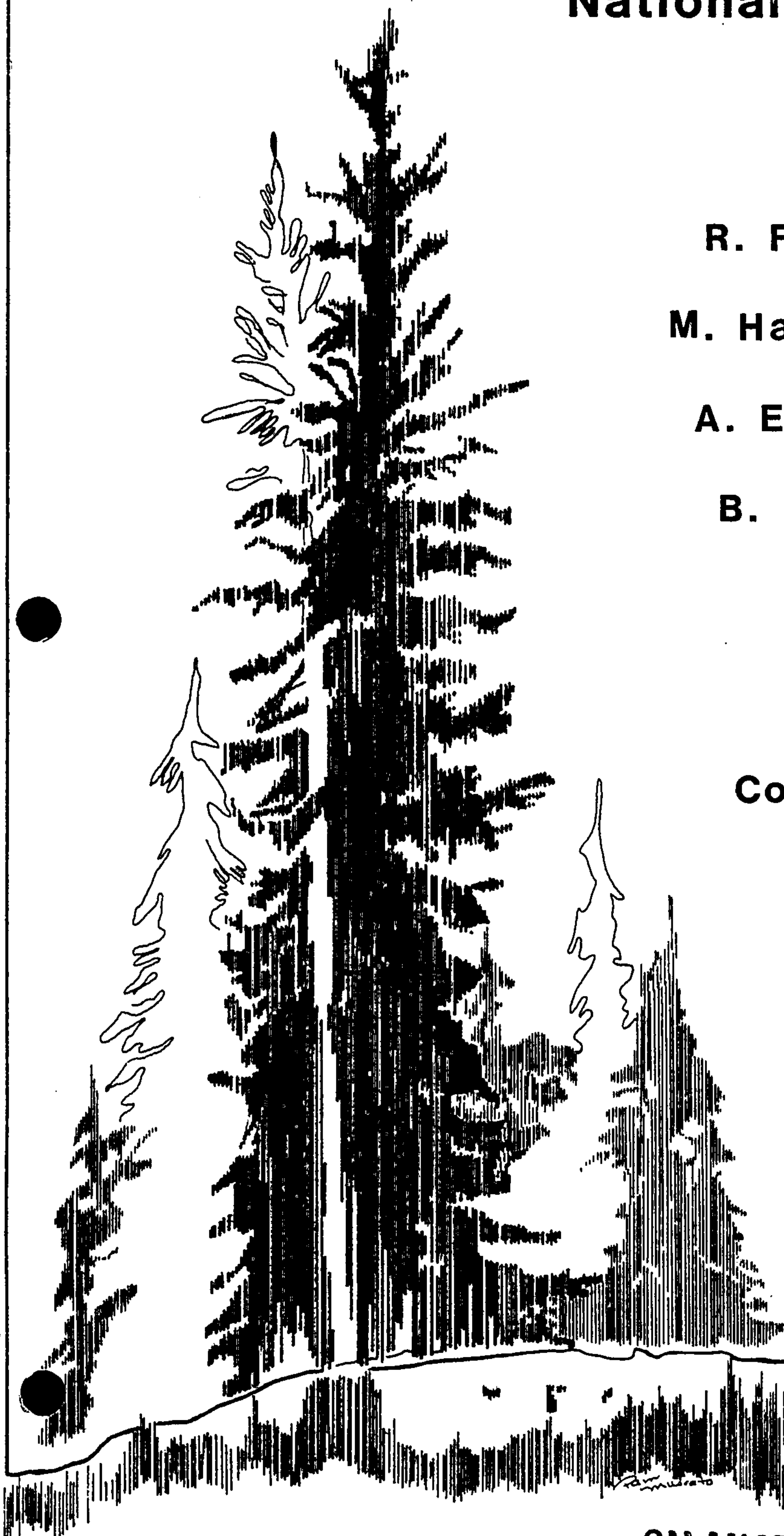
HIRSCHMAN

D-51

Revegetation With Native Plant Species on the John Day Fossil Beds National Monument



R. F. Miller

M. Haferkamp

A. Evenden

B. Youtie

NATIONAL PARK SERVICE

Cooperative Park Studies Unit

College of Forestry

Oregon State University

Corvallis, Oregon 97331

CPSU/OSU 84-8

REVEGETATION WITH NATIVE PLANT SPECIES ON THE JOHN DAY FOSSIL BEDS NATIONAL MONUMENT

R. F. Miller
M. Haferkamp
A. Evenden
B. Youtie

Dept. of Rangeland Resources

Final Report
Contract CX-9000-0-E020

National Park Service
Cooperative Park Studies Unit
College of Forestry
Oregon State University
Corvallis, Oregon 97331

Table of Contents

Introduction - 1

Evaluation of Establishing Bluebunch Wheatgrass - - - - - - - - - - - 1

Seed Crops - 1
Broadcasting 1980- 4
Broadcasting 1982- 6
Tublings - 7
Seedling Establishment - 9

<u>Astragalus</u> spp.- -13

Germination- -13
Insect Predation (See Appendix)

Conclusion and Recommendations -17

Future Outlook -19

Appendix -20

INTRODUCTION

The intent of this study was to evaluate the feasibility of re-establishing pristine plant communities on deteriorated portions of the John Day Fossil Beds National Monument. This report includes data collected from spring 1979 through spring 1983. Discussions on seed availability on the Fossil Beds, germination and seedling establishment are included. Sites studied are classified as Artemisia tridentata/ Poa sandbergii communities. These communities, which are probably an Artemisia tridentata/Agropyron spicatum habitat type, are the most common on the lower elevation slopes on the Monument. Plant species intensively studied were Agropyron spicatum, Stipa thurberiana, Astragalus purshii and A. filipes. The results and discussion section will be followed by a conclusion and recommendation section. This will include suggestions on what direction the revegetation program in the Park Service should take.

EVALUATION OF ESTABLISHING BLUEBUNCH WHEATGRASS

Seed Crops

The primary objective of this portion of the study was to evaluate the feasibility of collecting and using seeds grown on the John Day Fossil Beds. The two criteria measured were seed availability and viability. The success of collecting high quality seed for planting is dependent on the source, which may greatly vary from year to year, and timing of collection. Seeds collected too early typically are low in viability, and vigor for establishment low. Maximum yields of viable seeds are obtained with collections made when the majority of the seed crop is mature.

Methods

The variability of seed crop production and seed viability for Agropyron spicatum was evaluated in 1979, 1980, 1981 and 1982. Germination of Stipa thurberiana seed was measured in 1979. Seed development was monitored on a weekly basis to determine when seeds became mature. When seeds became hard they were hand stripped from plants on three locations on the Fossil Beds (Foree, Sheeprock and Picture Gorge). The number of spiklets per culm were measured on 25 plants on each site. Seeds were tested for germination in each of the four years at the Oregon State University seed laboratory. Five lots of 100 seeds were imbibed in controlled environments for 14 days under day/night - alternating temperatures of 25°C/15°C. One hundred bluebunch wheatgrass seeds were weighed on a Mettlar Balance each year to relate the amount Pure Live Seed to weight.

Results

Rate and timing of seed development varied by 2 weeks in the 1979, 1980, and 1981 growing seasons for bluebunch wheatgrass (Table 1). Timing of seed development also varied with plant species. In 1979, A. spicatum seed ripened by late July and seed of Poa sandbergii and Bromus tectorum ripened 9 and 4 weeks earlier, respectively (Figure 1).

Table 1. Dates when the majority of the bluebunch wheatgrass seed crop reached maturity and dehisced in 1979, 1980 and 1981

Year	Mature	Dehisced
1979	June 26	July 14
1980	July 12	July 25
1981	July 4	July 20

Significantly (P>.05) more spiklets were produced per culm in 1980 than in 1979 (Appendix 1). Spiklet production was, however, similar in 1979, 1981 and 1982. Neither number of culms per plant nor number of seeds per spiklet varied significantly the 4 years period. In 1979, 34% of the florets collected produced filled seed. In 1980, 37% were filled, 43% in 1981 and 41% in 1982.

Percent germination was highest in 1980 and lowest in 1979 (Table 2), however, the poorest germination of 86% would be considered good from a native harvest.

Table 2. Percent germination of bluebunch wheatgrass seed

	% Germination			
	Year			
Lot # (100 seeds)	1979	1980	1981	1982
1	83	97	93	90
2	87	96	92	77
3	90	92	94	86
4	77	98	91	91
5	92	93	93	92

Seed weights are reported in Table 3. Approximately 8 kg of seed should be planted per hectare or 200 PLS/m^2 if a seed drill is used. If seed is broadcast, 2.5 times this rate should be used which equals approximately 5,000,000 seed.

Table 3. Average seed weight of bluebunch wheatgrass

Year	Number of seed/kg
1979	253,000
1980	297,000
1981	251,000
1982	303,000

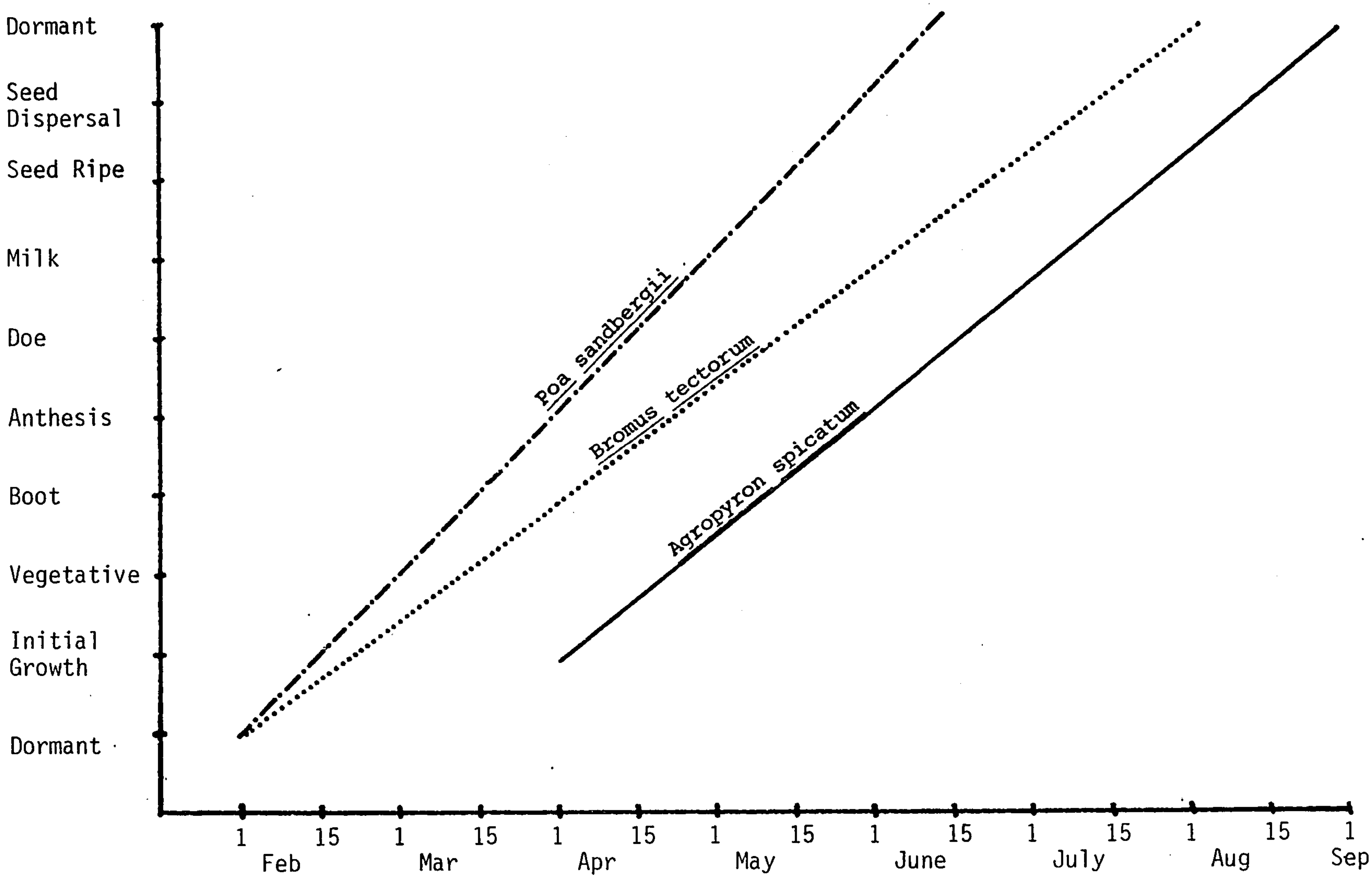


Figure 1. Phenological development of three perennial grasses in 1979.

Conclusion

Based on the above data, it is feasible for the Park Service to harvest bluebunch wheatgrass in the vicinity of the Fossil Beds for planting. Bluebunch wheatgrass seed was available in all 4 years ranging in viability from 86 to 95%. Remanent populations of bluebunch wheatgrass in Picture Gorge and Foree areas should provide good seed. These areas should be examined for maturity by mid-June and visited at 5 to 7 day intervals thereafter. Seed should be hard when mature. Spiklets can be stripped quickly from the culms and stored in paper sacks in a cool dry environment.

Due to labor required for harvesting seed and the release of Secar bluebunch wheatgrass by the Soil Conservation Service, harvesting seed at or near the Fossil Beds for revegetation should only be done on a limited scale if local seed is desired. Secar bluebunch wheatgrass would be well adapted on the Monument.

Thurber needlegrass was also tested for germination in 1979, however, only 1% of the needlegrass germinated without artificial scarification. Seed coat characteristics of this species would make it more difficult to successfully establish by seeding.

Broadcasting

The success of broadcasting seed was evaluated for a 1980 and 1982 planting. Both studies will be discussed separately

Methods:1980

In early December 1980, the 1980 collection and Secar bluebunch wheatgrass seed were broadcast on three study sites west of the highway at the Cant Ranch Headquarters. Seeds of each source were planted in six separate 2X10 m plots at each site. Prior to planting three of the six plots for each seed source were cultivated in December to decrease competition from annuals which germinate in the fall. Seeds were broadcast by hand at a rate of 20 to 25 PLS per square foot.

Plant germination and survival were monitored every 4 weeks from March 1981 through July 1982. Seedling density was subsampled in in 10 randomly placed permanently marked 1 m plots in each 2X10 m plot. The 1 m^2 plots proved too large for the high seeding densities in 1981. Therefore, six 10 cm^2 microplots were established on alternating sides of a north-south center line in the 1 m^2 plots. Density and cover of bluebunch wheatgrass were taken every 4 weeks within the same 10 cm^2 microplots. In 1982 plants were counted in the 1 m^2 plots due to a significant decrease in density, and cover was not measured. Tests of significance were made using the student t-test for two sample means of cultivated and control at the 95% confidence level.

Results

Data for 1981 are a measure of germination and survival through the first growing season. As moisture became limited in July, seedlings entered a dormant stage.

Cultivation significiantly increased percent cover and density of bluebunch wheatgrass (Table 4 and 5). Although exclosures were in similar habitat types, bluebunch seedlings competed with different species in each exclosure. Exclosure 1 also had, less rocky soils. Differences in density between John Day and Secar were not compared due to a higher seeding rate on the John Day plots.

Table 4. Percent ground cover of John Day and Secar bluebunch wheatgrass on noncultivated and cultivated broadcast plots (6/24/81)[1]. Percent ground cover was significantly greater in the cultivated plots within the two wheatgrass sources

	% Cover			
	John Day		Secar	
	Cultivated	Noncultivated	Cultivated	Noncultivated
Exclosure 1	9.47	4.91	4.16	1.73
Exclosure 2	3.62	0.40	2.17	0.18
Exclosure 3	2.83	0	3.27	0
Average	1.46	0.57	1.4	0.6

1 Percent cover between John Day and Secar was not compared due to a higher seeding rate on the John Day plots.

Table 5. Density of John Day and Secar bluebunch wheatgrass on cultivated and noncultivated broadcast plots in 1981 and 1982[1]. Density was significantly greater in the cultivated plots within the two wheatgrass sources

	# Plants/m^2							
	John Day				Secar			
	Cultivated		Noncultivated		Cultivated		Noncultivated	
	1981	1982	1981	1982	1981	1982	1981	1982
Exclosure 1	236	9.6	201	1.4	153	7.9	44	0.7
Exclosure 2	88	1.4	20	0	51	0.3	3	0
Exclosure 3	35	0.8	11	0	48	1.0	4	0
Average	120	3.9	77	0.5	84	3.1	17	0.2

1 Density between John Day and Secar was not compared due to a higher seeding rate on the John Day plots.

Conclusion

Broadcasting seed produced marginal results. Successful stands were established on tilled plots in exclosure 1, the most productive of the three sites. On tilled plots competition from annuals quickly re-established in the first growing season. Both John Day and Secar bluebunch plants were small, producing few seedheads following the second year of growth.

Methods:1982

In 1981 five exclosures 20X16 m were constructed on the lower rocky slopes east of the John Day River. During the fall of 1982 established plants were sprayed with Roundup (1 kg/ha). Plant species present on the site were Wyoming and basin big sagebrush, snake weed (*Xanthocephalon sarothrae*), cheatgrass, Sandberg's bluegrass and a few bluebunch wheatgrass plants.

Secar seed was planted in early winter 1982. Treatments were arranged in a randomized complete block design with replicates. Treatments were an unplanted control, broadcast coated seed (CelPril coating), broadcast uncoated seed with and without straw mulch. Mulch was chopped straw applied at kg/ha. Seeding rate was 545 PLS/m^2, 2.5 times the recommended rate if seed were drilled.

In the early summer of 1983, seedling numbers were counted in ten 30X60 cm plots placed along the center of each 2X10 plot. Seedling density between treatments were compared with analysis of variance and significant differences were separated with Tukey's test at $P<0.05$.

Results

Broadcasting seed and covering with mulch was the only successful treatment. In the first year 91 seedlings/m had established as compared to near zero in the other treatments (Table 6). If a portion of these seedlings survive through the summer drought and winter there are potentially enough seedlings to make this seeding a success.

Table 6. Secar seedling densities in four broadcast treatments

# Plants/m^2			
Control	Seed coated	No mulch	Mulch
0[a1]	1.1[a]	3.3[a]	91[b]

[1] Data followed by a different letter are significantly different at the .05 level.

Conclusions

Although the mulch broadcast treatment looks encouraging, these plots need to be measured again in 1984 to determine the success.

Tublings

Methods

Bluebunch wheatgrass seed collected on the monument in the summer of 1979 and Secar were planted in tube paks at Oregon State University greenhouses in February 1980. When seedlings were 8 months old they were taken to the Monument and placed outside to harden off. In mid-October John Day and Secar bluebunch wheatgrass plugs (seedlings) were planted in 2X10 m plots, at each of three sites. Plugs were planted in 10X20 cm holes formed by an auger mounted on a chain saw motor. Twenty plugs were planted in each plot. Six plots in each exclosure were planted with John Day plugs and six with Secar plugs. Three plots of both bluebunch wheatgrass sources were cultivated to reduce competition.

Percent cover of plugs and other vegetation was estimated using a 30 cm circular plot centered around each plug. Measurements were taken July 6, 1981. Plug survival and number of reproductive culms per seedings were measured in July of 1981, 1982 and 1983 by counting individual seedlings and their culms.

To evaluate the possibility of growing the tube pak seedlings under outside conditions at the Monument, seed was planted in April of 1981. Seedlings were watered frequently throughout the spring and summer months.

Tests of significance were performed using either the student t-test or analysis of variance at the 95% confidence level.

Results

The 9-month old bluebunch wheatgrass seedlings had well developed root systems when planted at the Monument. It was observed, however, that Secar bluebunch wheatgrass seedings had a greater root biomass than John Day seedlings. Seedling survival in 1981 was significantly greater in Secar control plots, however, no significant difference between sources was observed on cultivated plots (Table 7). In 1982 and 1983 seedling survival was significantly greater the Secar than John Day in both cultivated and control plots.

Table 7. Percent survival of John Day and Secar plugs on cultivated and noncultivated plots

	John Day		Secar	
Date	Cultivated	Noncultivated	Cultivated	Noncultivated
	%			
July 9, 1981	69a[1]	51a	80b	70b
July 13, 1982	28a	23a	67b	68b
July 7, 1983	14a	14a	62b	56b

[1] Percent survival within years followed by a similar letter were not significantly different at the P>.05.

Mean number of reproductive culms per seedling was one or less for both John Day and Secar on cultivated and control plots during the 2 years after planting (Table 8). The third year after planting, number of reproductive culms increased for both species in both treatments. An analysis of variance was not run on reproductive culm numbers due to a high number of plants having zero.

Table 8. Number of reproductive culms per John Day and Secar plugs on cultivated and control plots

	John Day		Secar	
Date	Cultivated	Control	Cultivated	Control
July 9, 1981	0.5	0.1	0.7	0.5
July 13, 1982	0.1	0.1	1.0	0.8
July 7, 1983	5.0	1.2	3.3	4.5

Secar seedlings appeared larger and more vigorous than John Day seedlings (Table 9). On both control and cultivated plots Secar plants covered significantly more ground ($P<.05$).

Table 9. Percent ground cover of John Day and Secar plugs on control and cultivated plots (July 6, 1981)

	Percent Ground Cover			
	John Day		Secar	
Exclosure	Cultivated	Control	Cultivated	Control
1	8.2	7.5	12.4	11.2
2	7.8	8.6	11.6	12.8
3	10.8	7.0	12.8	10.7
Average	8.9	7.7	12.3	11.6

Seedlings grown outside at the Monument in April developed well and were of sufficient size for planting by October. Greenhouses would not be necessary for starting bluebunch wheatgrass seedlings to revegetate the Monument.

Data indicate Secar bluebunch wheatgrass is better adapted than John Day bluebunch wheatgrass for establishing with tube paks. Secar developed a more vigorous root system which enabled it to establish better than John Day. Removing competition is not necessary for the establishment of Secar plugs.

Conclusions

Secar bluebunch wheatgrass is well adapted for establishment at the John Day Fossil Beds National Monument. The Soil Conservation Service released Secar as a commercial variety of bluebunch wheatgrass 6 months after this study was initiated and Secar seed is now available commercially. Unless local seed is desired, it will be more efficient to purchase Secar rather than to hand collect seed from the Monument.

Secar seedlings grown in tube paks were highly successful. Although labor intensive, this is an effective way of re-establishing bluebunch wheatgrass in areas that have high visitor visibility. On a large scale it may be too costly depending on the availability of labor. Use of volunteers or youth and school groups could reduce labor costs.

Seedling Establishment

An understanding of the relationship of seed germination and seedling development to a range of environmental conditions can be useful for planning successful seedings. This is especially true in areas such as the Monument where steep rocky terrain and harsh environmental conditions often limit seedling establishment. The steep rocky terrain will require broadcasting to distribute seed. The disadvantage of broadcasting is seed lying on the soil surface is more exposed to environmental extremes than seed which is covered.

The objectives of this study were:

1. Evaluate the response of Secar and John Day bluebunch wheatgrass seed germination to a range of temperature and moisture conditions.

2. Evaluate the influence of different soil moisture regimes on early seedling development of Secar and John Day of bluebunch wheatgrass.

3. Evaluate the response of Secar bluebunch wheatgrass to spring growing conditions on the Monument.

Three studies were developed in attempt to evaluate these objectives. Each study is briefly reported in the following abstracts. A detailed account of these studies is reported in the enclosed thesis. The results will be discussed in the conclusion and recommendation section of this report.

INFLUENCE OF TEMPERATURE AND MOISTURE STRESS ON GERMINATION OF TWO SOURCES OF BLUEBUNCH WHEATGRASS (AGROPYRON SPICATUM)

ABSTRACT

Germination response to a range of moisture stress and temperature conditions during a 30-day period was observed in two sources of bluebunch wheatgrass. Seeds collected near John Day, Oregon and Secar, a newly released cultivar, were evaluated. Seeds were incubated in the dark at constant temperatures of 10, 20 and 30°C, and water potentials from 0 to -2.2 megapascals (MPa) simulated with polyethylene glycol 6000. Seeds of both sources germinated over the widest range of water potentials at 20°C. In all temperature regimes, rate of germination and total percent germination declined as moisture stress increased. Germination rate and total percent germination of John Day and Secar were similar at moderate temperatures (10 and 20°C) and low levels of moisture stress. However, as moisture stress increased at these temperatures Secar germinated faster and with larger amounts of total percent germination than John Day. In the high temperature regime, 30°C, John Day consistently germinated faster and with a greater amount of total percent germination than Secar. Since Secar is able to germinate well under high levels of moisture stress at moderate temperatures, it may show promise as a useful cultivar for reseeding deteriorated bluebunch wheatgass communities.

EARLY SEEDING DEVELOPMENT OF TWO SOURCES OF BLUEBUNCH WHEATGRASS (AGROPYRON SPICATUM) GROWN IN SIX SOIL MOISTURE REGIMES

ABSTRACT

Research was conducted to evaluate the effects of six soil moisture regimes on early seedling development in two sources of bluebunch wheatgrass (*Agropyron spicatum*). Seeds collected near John Day, Oregon and Secar, a newly released cultivar were planted and grown for 6 weeks in the greenhouse in moisture regimes representing patterns of soil wetting and drying. John Day seedlings emerged faster than Secar seedlings and due to an increased opportunity for growth, John Day seedlings developed the largest leaf areas and root systems. With adequate moisture conditions in all regimes at the onset of the study seedlings of both sourcs developed good seminal root systems. As soil moisture decreased, however, the rate of seedling growth for both sources was suppressed. When seedlings were in the three-leaf stage and exposed to surface soil moisture greater than field capacity (-.033 MPa) adventitious roots were initiated. Secar seedlings developed adventitious roots sooner than John Day seedlings and at 36 days after planting these seedlings had produced significantly more and longer adventitious roots than John Day seedlings. Subsurface soil moisture above field capacity provided a favorable environment for rapid extension of adventitious roots once initiation had occurred.

EARLY SEEDLING DEVELOPMENT OF SECAR BLUEBUNCH WHEATGRASS UNDER SPRING GROWING CONDITIONS IN EASTERN OREGON

ABSTRACT

The purpose of this study was to relate the development of Secar bluebunch wheatgrass (*Agropyron spicatum*) seedlings to soil moisture and air temperature under spring growing conditions on a site in eastern Oregon. Soil moisture was adequate for 80% of total emergence to occur by 22 days after planting. Following emergence, limited rainfall and rising air temperatures resulted in dry conditions which suppressed seedling growth. Most seedlings did not develop three leaves until the tenth week after planting when rainfall increased soil moisture to field capacity (-.033 MPa). This moisture also stimulated initiation of adventitious roots. However, at the end of the 10 week study, adventitious root system length averaged only 5.6 cm, and at this depth these roots would be very susceptible to drying conditions.

ASTRAGALUS SPP.

Both *Astragalus purshii* and *A. filipes* are important forbs on the John Day Fossil Beds National Monument. Those species are abundant in the little disturbed plant communities on the higher slopes of the Monument. The following data were collected to evaluate the seed availability and seed germination, to assist in determining the feasibility of re-establishing these two *Astragalus* species.

Astragalus Germination

Methods

Astragalus purshii seed was hand collected during the summers of 1979 and 1980 and *Astragalus filipes* seed in 1980 only, from sites on the Monument. Pods of both *Astragalus* species were crushed by hand and seeds separated by hand screening. It was necessary to manually remove seed from many of the firm *A. purshii* pods. Seed was stored in bags at room temperature until germination tests were initiated.

Seeds were imbibed in covered petri dishes containing squares of kimpak germination pads moistened with distilled water. Dishes of 25 seeds each were prepared for *A. purshii* and 10 seeds each for *A. filipes*.

Seeds were incubated for 30 days in the dark at constant temperatures of 5, 10 and 20°C, and alternating 15/25°C. Alternating temperatures were for 16 hour and 8 hour periods, with colder temperatures occurring during the longer period. Two treatments (scarified and non-scarified) were investigated at a constant 20°C with photo periods of 16 hours dark and 8 hours light. Each of the three seedlots were scarified by rubbing the seed between two sheets of medium grit sandpaper (Ziembiewicz and Cronin, 1981). Germination dishes were arranged in a completely random design with four replications. Seed of both *A. purshii* collections and *A. filipes* were germinated in March 1981. In March 1982 germination trials were conducted on the 1980 *A. purshii* and *A. filipes* collections. Germination counts were made four or more times weekly and germination was defined as extension of the radicle 5 mm.

Cummulative mean daily percent germination was plotted for all treatments and both trials. Analysis of variance was used to detect significance in germination response between years and scarified vs. non-scarified seed treatments.

Results

Astragalus filipes

Optimum germination occurred at 20°C in scarified seed treatments (Table 10), both rate of germination and total percent germination were greater than at other temperatures. Rate of germination and total germination were greatly reduced at 5°C. At 10°C rate of germination was slow, however, total percent germination at 30 days was high.

Table 10. Percent germination for Astragalus filipes

	1981	1982
5°C	31.5	8.8*
10°C	97.5	37.5*
20°C nonscarified	10.5	6.3
20°C dark	94.8	57.8*
20°C light/dark	95.0	69.3*
15/25°C	89.8	21.3*

* = significant at .05 level.

Nonscarified seed germinated poorly; total germination was 11 and 6%, respectively, for 1981 and 1982 trials (Figure 2). Total percent germination of nonscarified seed was significantly lower than scarified seed at 20°C for both years. Most nonscarified seed were unable to imbibe water.

Seed viability was lower the second year of germination trials as evidenced by lower total percent germination in all treatments in 1982. Total percent germination in 1981 was significnatly higher than in 1982 for all treatments.

Germination percentages in the light/dark and dark treatments at 20°C were similar each year. Rate of germination, however, was slightly faster in the light treatment.

Astragalus purshii

Optimum germination for both the 1979 and 1980 collections was at 20°C, with total percent germination and rate of germination being greatest (Table 11, Figure 3). For the 1980 collection germinated in 1981, the 10°C incubation temperature yielded the highest levels of germination. However, the growth chambers set for 10°C were off for 15 hours on day 20, causing temperatures to temporarily rise to 20°C. Both rate of germination and total percent germination were lowest at 5°C

At 20°C, nonscarified seed germinated significantly poorer than scarified seed. By the end of the 30-day period most nonscarified seed had not imbibed water. A yellow leachate was observed surrounding seed that imbibed water. The composition and possible inhibitory effects of this substance were not determined.

In the 1981 germination trial, seed collected and stored for 22 months germinated poorer than seed harvested in 1980. Seed viability also declined in the second year for seed collected in 1980.

No significant differences in total percent germination were observed between the light/dark and dark treatments at 20°C, however, rate of germination was slightly faster in the light treatment.

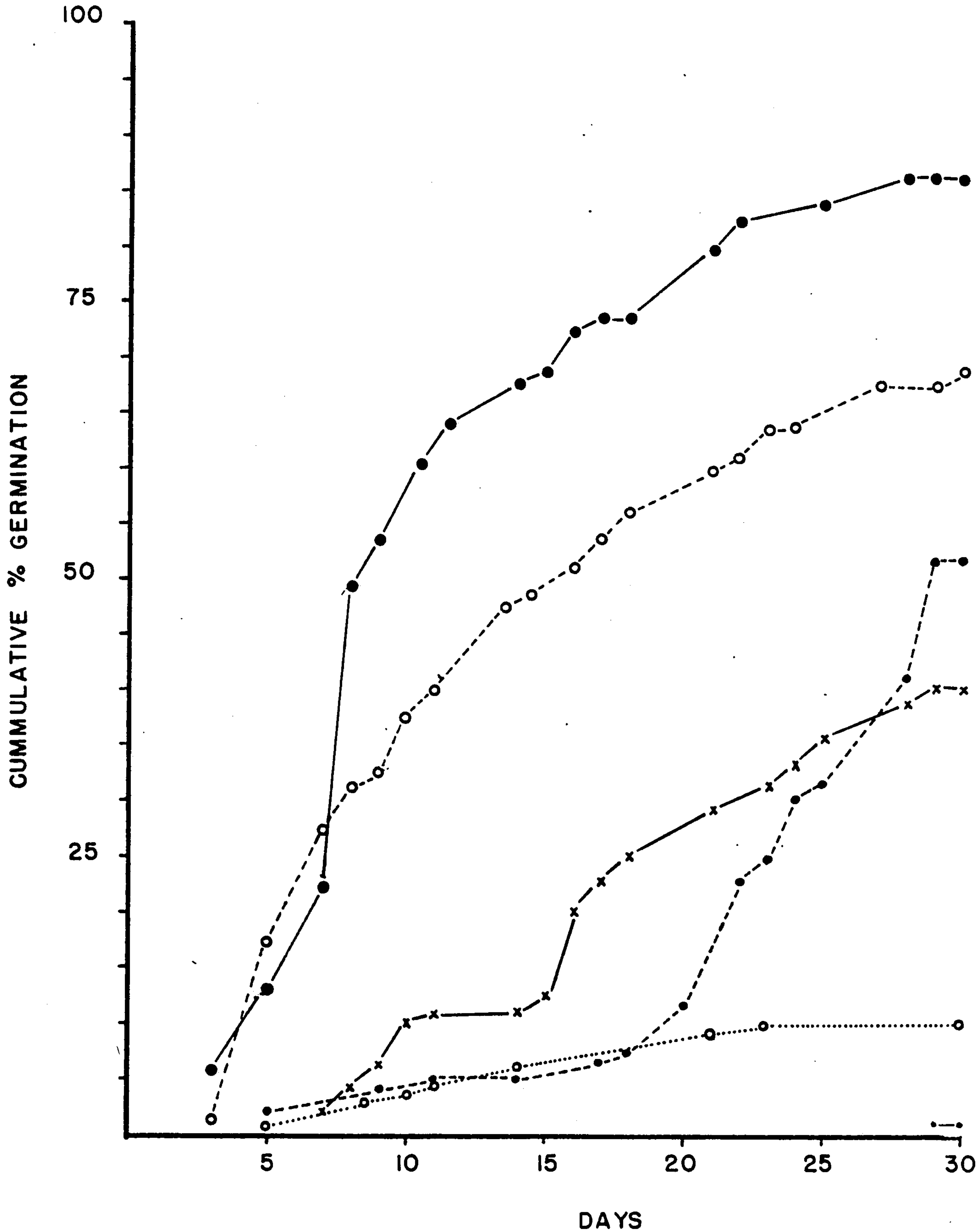


Figure 3. Cummulative % germination of Astragalus purshii in 1982 over a 30-day period for six treatments. Treatments are 5°C (•----•), 10°C (•----•), 15/25°C (x——x), 20°C nonscarified (o···o), 20°C 8 hrs light - 16 hrs dark (●···●) and 20°C (o···o). All treatments scarified and exposed to dark conditions unless otherwise specified.

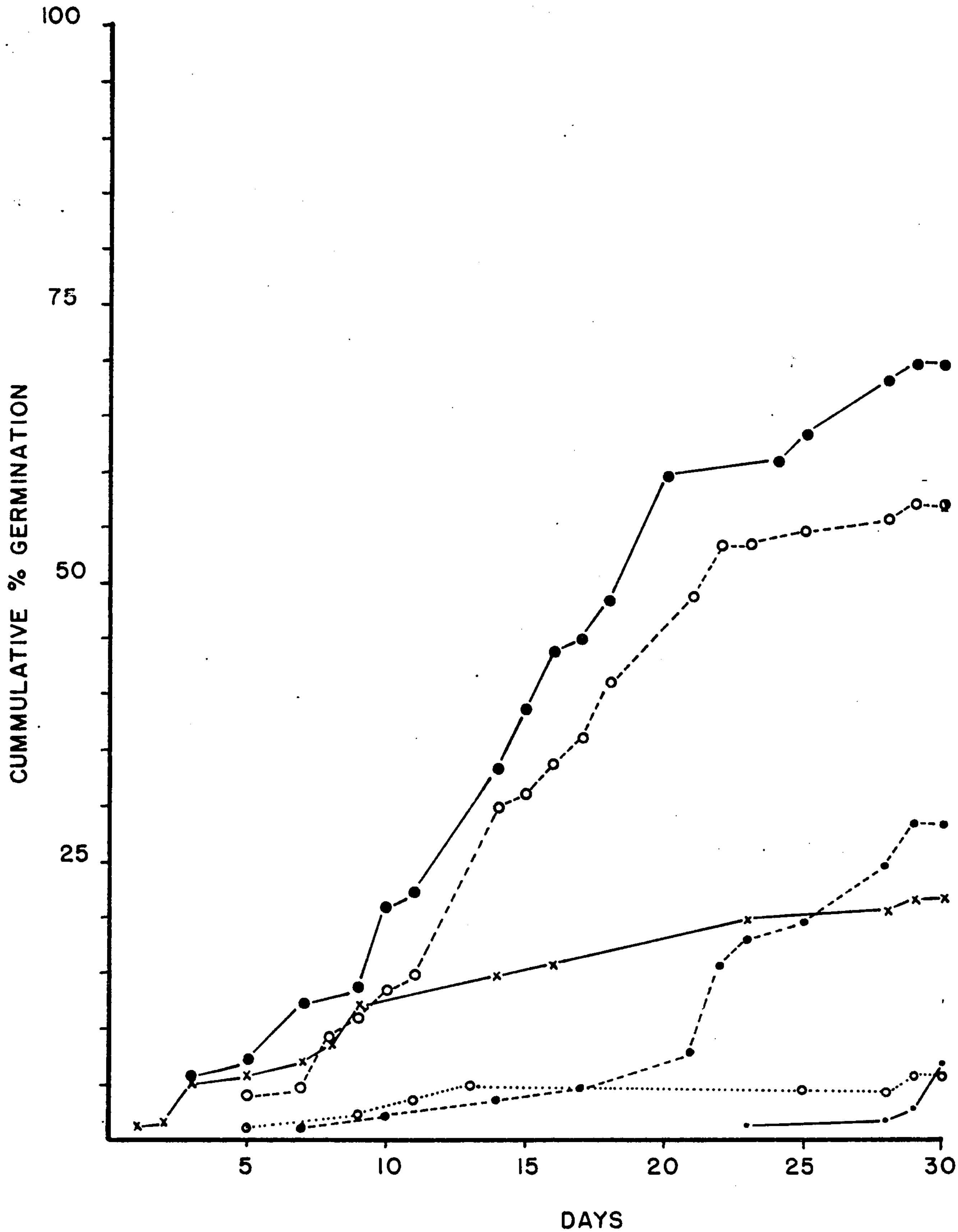


Figure 2. Cummulative % germination of Astragalus filipes in 1982 over a 30-day period for six treatments. Treatments are 5°C (•——•), 10°C (•----•), 15/25°C (x——x), 20°C nonscarified (o···o), 20°C 8 hrs light - 16 hrs dark (●···●) and 20°C (o---o). All treatments scarified and exposed to dark conditions unless otherwise specified.

Table 11. Percent germination for Astragalus purshii

	1981	1982
Aspu 1979 collection		
5°C	15.0	not available
10°C	52.3	
15/25°C	62.25	
20°C nonscarified	10.8	
20°C light/dark	65.0	
20°	57.8	
Aspu 1980 collection		
5°C	36.0	1.3*
10°C	93.5	54.0*
15/25°C	83.3	48.5*
20°C nonscarified	19.3	12.0
20°C light/dark	83.3	88.0
20°	86.3	75.5

* = significant at .05 level.

In the later part of the incubation period most of the dishes contained rather extensive fungal growth. No fungicide was used in these trials. It is possible that these organisms inhibited germination.

Conclusions

Astragalus filipes and A. purshii both exhibited seed dormancy caused by impermeable seed coats, and most seeds were unable to imbibe water unless scarified. Therefore, at least a portion of the seed should be scarified by some means prior to planting to encourage higher germination levels. Unscarified seed would provide a reservoir of seed that may germinate at a later date.

Storing seed for approximately 2 years reduced germination more than storage for 1 year. These results indicate the relatively new seed should be used, or seeding rates increased. Seed coats should be scarified to enhance germination.

CONCLUSIONS AND RECOMMENDATIONS

Over the past several years there has been no evidence to show natural establishment of climax species is occurring on the lower slopes of the Fossil Beds. This is primarily based on the lack of young plants on these sites and data in Table 8. Factors probably limiting the establishment of native perennials are lack of seed source on the lower slopes, the presence of competitive species already established in the stand and harsh environmental conditions on the soil surface. If pristine plant communities are to be re-established on the Monument (in a period of less than 100 years) artificial seeding must be used.

The lack of seed production on the lower slopes is due to the absence of mature desirable species. Bluebunch wheatgrass where present on the Monument produced good crops of viable seed 4 years in a row, and seed viability ranged from 86 to 95%. This would provide a local source of seed to use in revegetation programs. Remanent populations of bluebunch wheatgrass in Picture Gorge and Foree should provide good sources of seed. Seed should be mature (hard) when collected. This could occur as early as mid-June. Stands should be visited every 5 to 7 days after mid-June to check on maturity.

Due to the intensive labor required for harvesting seed and the release of a new variety of bluebunch wheatgrass (Secar) by the Soil Conservation Service, buying commercially available seed would be more practical. Secar bluebunch wheatgass appears to be well adapted to environmental conditions on the Monument. It has proven to be equal or better than bluebunch wheatgrass seed collected on the Monument. It is more vigorous in producing adventitious roots than the local variety which is crucial in seedling establishment.

Available forb seed on the Monument will be more limited. Insects damaged 96 and 71% of the Astragalus filipes seed crop in 1980 and 1981, respectively. Damage to A. purshii seed was 45 and 19% in 1980 and 1981, respectively. Plummer et al. (1968) found seed production of many forbs was greatly reduced due to insect damage. Also any Astragalus seed collected must be scarified to insure germination in the first year following planting.

Caution must be used when purchasing commercially available forb seed. Although some native species may be available, the ecotype may not be adapted to the site. Also little is known about germination requirements of forb seed.

Broadcast

Broadcasting seed has been primarily used on areas where terrain limits the use of more conventional methods. A large portion of the disturbed communities on the John Day Fossil Beds National Monument are situated on steep rocky terrain.

Broadcast treatments were applied in the early winter of 1981 and 1982 on four locations on the Monument. Growing conditions throughout this period were average to above average. Results in 1981 of broadcasting seed on two of the three sites were poor. However, exclosure 1, which had the highest site potential, may have adequate survival to express the bluebunch wheatgrass plants over time. The results of these seedings showed the importance for removal of competition and the potential for a high level of seeding mortality during the second growing season. The mortality was primarily due to dessication of exposed roots of seeds germinating on the soil surface. Seedlings must develop adventitious roots to survive. Bluebunch wheatgrass seedlings were in the three leaf stage before they produced adventitious roots. Soil moisture must be near field capacity in the zone of development for adventitious roots to grow. Surface layers of soils generally do not stay at field capacity for very long periods of time. This is why broadcast seedings often fail.

In 1982 coated seed and mulching uncoated seed were evaluated along with broadcasting uncoated seed with no mulching. Seed coating has been shown to be effective in wetter environments but had not been evaluated in areas of less than 30 cm of precipitation. Coated seed did not enhance seed establishment on the Fossil Beds. These results were comparable to similar experiments in Ritzville, Washington. Survival of uncoated seed without mulching in the first growing season was marginal. Seeding success will depend on the mortality in the summer and winter seedling. Uncoated seed covered with straw mulch gave excellent results in the first year. Mulch increases the duration of favorable surface soil moisture which should enhance adventitious root development.

Broadcasting of seed without mulching on the Monument will be a marginal practice at best. Seedlings are slow to develop and are quickly overwhelmed by weedy annuals. This concurs with Hull and Klomp (1967) who reported that stands developing from broadcast seed became productive slower than when seeds were drilled. The slower rate of establishment from broadcast seed often allows nondesirable species to take foothold. Presently, broadcasting along with mulching appears to potentially to be a method that will provide satisfactory results. Control of competitive species is essential for success.

Tubepaks

Secar bluebunch wheatgrass proved to be better adapted to planting in tubepaks than John Day bluebunch wheatgrass. This may have been due to the more rapid development of adventitious roots in Secar. Survival of tublings planted directly into a stand of low seral stage plants was very good. Development of tublings over a 3 year period was slow, but plant basal areas and heights did increase over time. Tublings should be planted at a minimum density of 1 per m^2. However, due to high levels of competition, establishment of new bluebunch seedlings may take many years. For rapid establishment of a stand, tublings should be planted 0.3 m apart. At this density tublings would suppress annual plant competition in the interspaces.

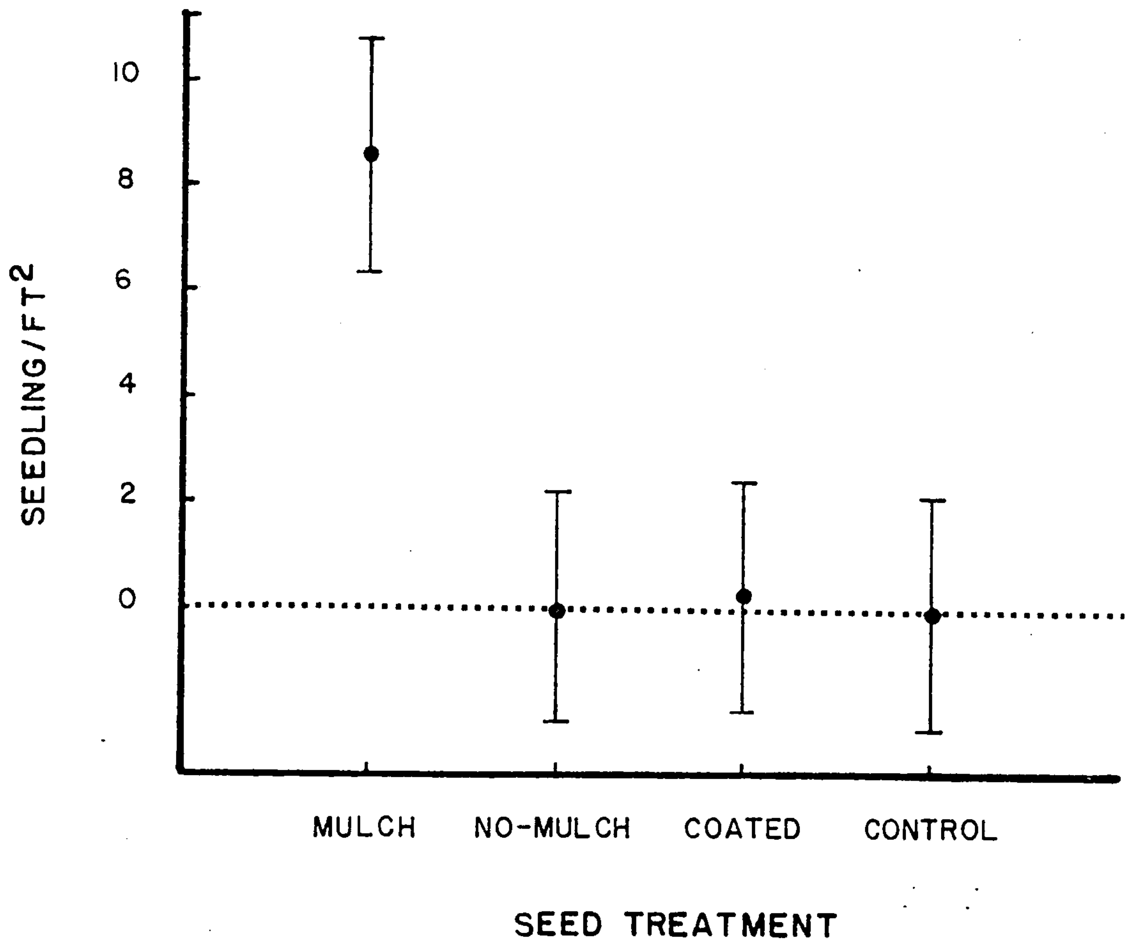
This method is highly labor intensive and should be limited to areas where rapid establshment is the primary objective and the terrain is not suited for heavy equipment. It also enables the establishment of a mixed stand of grasses, forbs and shrubs.

FUTURE OUTLOOK

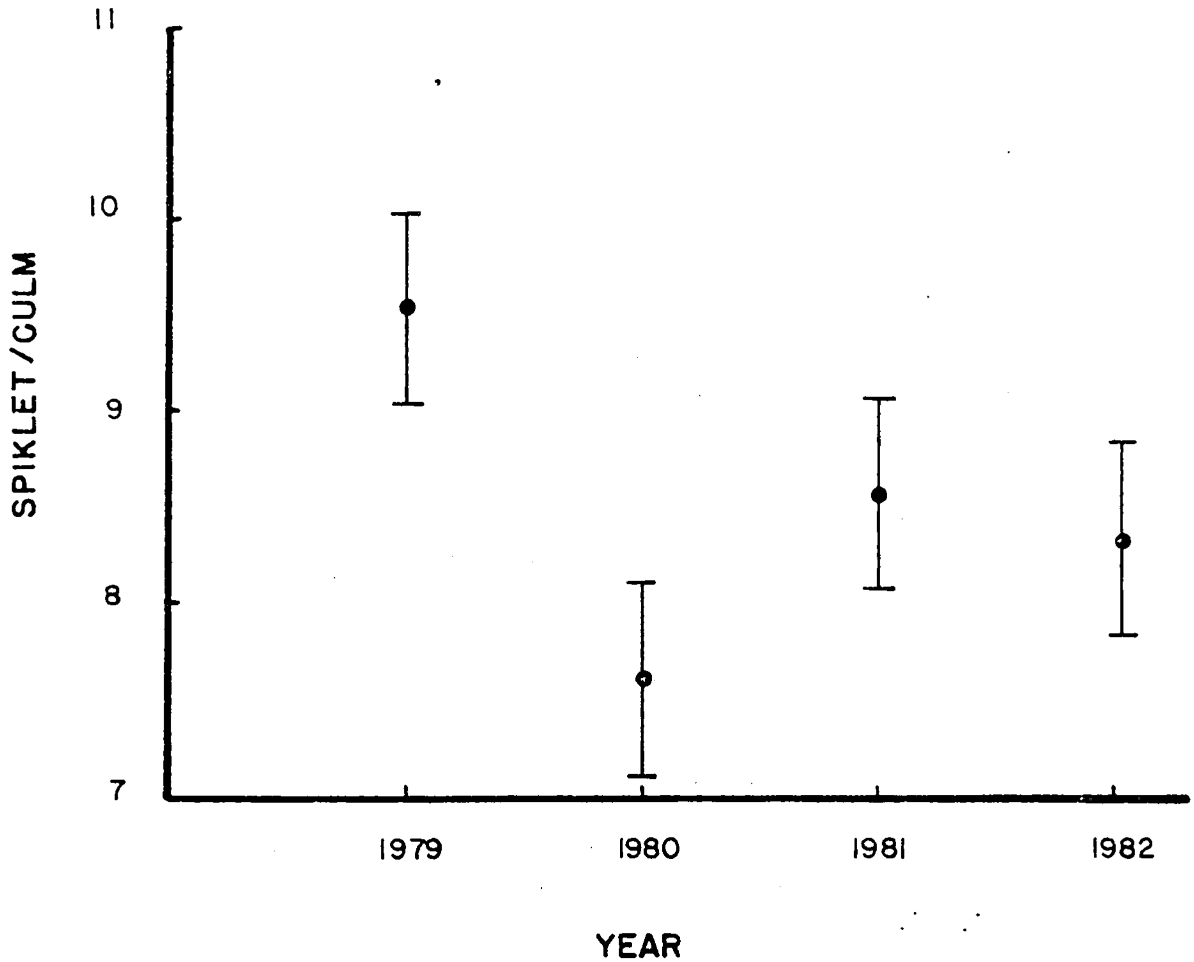
The future potential for reseeding the gentle slopes near the river on the Monument looks good. Recent results from land imprint plots in Ritzville, Washington and Squaw Butte, Oregon have been excellent where ground has been plowed. This would enable seed to be broadcast (not planted in rows) and then imprinted with a land imprinter. The land imprinter appears to cover the seed providing a more desirable environment for adventitious roots.

Little work has been done with Magnar basin wildrye. Several sites on the Monument probably supported basin wildrye in the past. The recent release of Magnar greatly increases the possibility of re-establishing this species on the Monument.

APPENDIX



Seedling/ft^2 for three seeding treatments and control (no seed applied artifically). Bars represent confidence intervals (P>.05) around the means



Number of spiklets/culm occurring on bluebunch wheatgrass. Bars represent confidence intervals (P>.05) around the means.

Astragalus purshii

SEED AGE (Mos)	SCARIFICATION	GERMINATION ENVIRONMENT TEMP (OC)	GERMINATION ENVIRONMENT LIGHT (Hrs)	PERCENT GERMINATION[1]	GERMINATION DAY INITIATED	GERMINATION DAYS TO 50%	FILLED SEED
22	yes	5	0	15	18	30	93
22	yes	10	0	53	4	12	93
22	yes	15/25	0	62	3	6	81
22	yes	20	0	56	3	5	82
22	yes	20	8	50	3	6	71
22	no	20	8	10	3	4	86
10	yes	5	0	36	12	28	97
10	yes	10	0	93	3	12	90
10	yes	15/25	0	83	3	5	83
10	yes	20	0	86	3	6	96
10	yes	20	8	83	3	5	96
10	no	20	8	20	3	5	84

1 Percent germination is based on filled seed only.

Astragalus filipes

SEED AGE (Mos)	SCARIFICATION	GERMINATION ENVIRONMENT TEMP (OC)	GERMINATION ENVIRONMENT LIGHT (Hrs)	PERCENT[1] GERMINATION	GERMINATION DAY INITIATED	GERMINATION DAYS TO 50%	FILLED SEED
10	yes	5	0	32	17	21	92
10	yes	10	0	97	4	11	97
10	yes	15/25	0	90	4	7	97
10	yes	20	0	97	4	11	90
10	yes	20	8	95	3	7	95
10	yes	20	8	11	4	18	93

1 Percent germination is based on filled seed only