Revegetation with Adapted Grasses in Competition with Dalmatian Toadflax and St. Johnswort[1]

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Over two million acres of once valuable grazing lands of the West have been invaded by common St. Johnswort *(Hypericum perforatum* L.), also known as Klamath weed and goatweed (Harris, 1951). The Ponderosa pine-bluebunch wheatgrass *(Pinus ponderosa-Agropyron spicatum)* association (Daubenmire, 1952) of Spokane County, Washington, is an area of heavy St. Johnswort infestation. As a means of controlling this serious pest, St. Johnswort beetles *(Chrysolina gemellata* and *C. hyperici)* were introduced into the Spokane area about 1950. It now appears that the beetles will be an effective means of control in the area under discussion.

Conflicting reports on competitive ability of the plant have been presented. Sampson and Parker (1930) reported that St. Johnswort successfully competed with all types of herbaceous vegetation, including sod-forming grasses. On the other hand, Jenkins and Jackman (1938) have stated the plant will not thrive or spread in good stands of grass. Robbins, Crafts and Raynor (1952) have concluded that St. Johnswort is almost exclusively a grassland weed, occuring on pastures, meadows and ranges, and that the densest and most extensive infestation on western ranges occurs on slightly acid soil in regions having an annual average rainfall of 25 or more inches. They have further stated that the weed is readily controlled by cultivation, and that vigorous perennial grass should be planted to prevent reinvasion by St. Johnswort. Harris (1951) Hafenrichter *et el.* (1949 remained viable for at least 10 years, and that the seedling was intolerant of shade.

Huffaker and Kennett (1959) summarizing a 10-year study of St. Johnswort and Chrysolina beetles in California, noted that the weed is now less than one per cent of its former occurrence. There was also a marked increase in perennial grasses and winter annuals, and no noxious weeds have entered to any great extent land vacated by St. Johnswort.

A reduction in the stand of St. Johnswort produces a vacuum within the vegetation complex which will be soon occupied by other plants. Unless these plants are of positive economic value, little good will accrue from control of the St. Johnswort. Dalmatian toadflax *(Linaria dalmatica* Mill.), an aggressive and prolific weed, is becoming well established on disturbed sites in local areas formerly occupied by St. Johnswort.

Known methods of chemical control of St. Johnswort are too expensive for large infestations, but may be economical for small patches and scattered plants. Beetles may not get to all small areas of infestation, or build up a large enough population for immediate control or eradication. Chemical treatment may well be the answer on such areas. Wolfe (undated) recommended an application of 6 pounds of Borascu per square rod, or 8 to 10 pounds on light, rocky soil, applied in the fall in eastern Washington and in the winter or early spring in western Washington. An application of 1½ to 2 lb/A of 2,4-D in at least 20 gallons of water with an emulsifier, applied when the plant is 6 to 8 inches tall has also been recommended for St. Johnswort control (Wolfe, undated).

Little work has been done and little is known concerning either the ecology or control of dalmatian toadflax. Lange and Wolfe (1954) reported some success in control of dalmatian toadflax by using 2 to 3 pounds of chlorate-borate mixture per 100 square feet, applied from August though November. Alex[2] has stated that the plant was a prolific seed producer and also produced vigorous underground roots when mature. No satisfactory method of control is known for dalmatian toadflax.

Gates and Harris (1959) and Hafenrichter *et. al.* (1949 reported work which indicated that many forage grasses were adapted to the area if competing vegetation was eliminated.

An understanding of some of the ecological relations between St. Johnswort, dalmatian toadflax, and adapted forage grasses would be of considerable value in a program of revegetation in the area. Data reported in this study are the result of trial plots established in 1957 to study these relations.

Methods and Materials

The trials were set up so that all species of grass would be seeded with and without competition of seeded dalmatian

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[2] *Alex, Jack F. 1959.* Unpublished *Ph.D. Thesis, Washington State* University.

FIGURE 1. Typical ponderosa pine-bluebunch wheatgrass site where experimental plots were established. Photo 10/57.

toadflax, in cultivated and uncultivated plots and with and without competition of St. Johnswort. The experimental area was located approximately 25 miles north of Spokane, Washington, in the ponderosa pine-bluebunch wheatgrass association. The soil was a gravelly till with a pH of approximately 6.0. Chemical analysis indicated that the soil was very low in phosphorous, medium in potassium and low in both calcium and magnesium. Average annual precipitation of the area is approximately 20 inches.

Two sites in close proximity and of similar soil and topography in a ponderosa pine-bluebunch wheatgrass association, were selected for the study. One site was heavily infested with St. Johnswort with an understory consisting primarily of annual lotus (*Lotus americanus* (Nutt.) Bisch.) and cheatgrass (*Bromus tectorum* L.) (Figure 1). Beetles were working actively on the St. Johnswort. The other site appeared to be similar in all respects except that it contained no St. Johnswort.

In September 1957, one-half of each of the two experimental sites was thoroughly disked. Plots were seeded in November in a split plot design with three replications on each of the cultivated and non-cultivated areas of each site. Each replication consisted of eight drilled grass plots (whole plots). The eight grasses seeded were: (1) Canada bluegrass (P410) (*Poa compressa* L.), (2) hard fescue (*Festuca ovina* L. var. *duriuscula* (L.) Koch), (3) orchardgrass (*Dactylis glomerata* L.), (4) tall wheatgrass (*Agropyron elongatum* (Host) Beauv.), (5) Primar slender wheatgrass (*Agropyron trachycaulum* (Link) Malk), (6) intermediate wheatgrass (*Agropyron intermedium* (Host) Beauv.), (7) Nordan crested wheatgrass (*Agropyron desortorum* (Fisch.) Schult.), and (8) Whitmar beardless wheatgrass (*Agropyron inerme* (Scribn. & Smith) Rydb.). Each whole plot consisted of four rows of grass 18 inches apart and 20 feet long. The plots were seeded at approximately 25 live, pure seeds per foot of row.

Dalmatian toadflax seed was collected in the fall of 1957 from

Table 1. Average stand counts per 6 feet of row of several grasses seeded in the fall of 1957[1]

	St. Johnswort site						Non-St. Johnswort site					
	Cultivated			Non-Cultivated			Cultivated			Non-Cultivated		
	Sdlgs[2]	Estab[3]		Sdlgs	Estab		Sdlgs	Estab		Sdlgs	Estab	
Grass	1958	1959	1960	1958	1959	1960	1958	1959	1960	1958	1959	1960
Canada bluegrass	36	6	2	24	0	0	174	12	7	30	0	0
Hard fescue	30	6	3	30	0	0	42	6	4	18	0	0
Orchardgrass	132	12	2	168	0	0	156	6	2	126	0	0
Tall wheatgrass	24	0	2	18	0	0	24	6	2	12	0	0
Slender wheatgrass	54	12	4	36	0	0	60	12	2	24	0	0
Intermediate wheatgrass	42	12	6	18	0	0	36	12	8	30	0	0
Crested wheatgrass	72	12	6	6	0	0	76	12	4	12	0	0
Beardless wheatgrass	24	6	2	12	0	0	12	0	2	6	0	0
Average	52	8	3	39	0	0	72	8	4	32	0	0

[1] Average of 4 readings in each of 3 replications.
[2] Seedling grass.
[3] Established grass plants.

plants growing on a site similar to that of the study. Following the grass drilling operation, the dalmatian toadflax was broadcast by hand over one-half of each drilled grass plot at the rate of 2 lb/A.

Following the seeding operation, a set of gypsum soil-moisture blocks was installed in each of the cultivated and non-cultivated parts of each site at 6, 12, and 18-inch depths.

In April of 1958, a rain gauge and a two-pen recording thermograph were installed in the experimental area. The thermograph recorded air temperature at a height of 12 inches and soil temperature at a depth of 1 inch. Readings of the rain gauge, soil moisture blocks and thermograph were made throughout the 1958 and 1959 growing seasons.

On April 30, 1958, counts were made on all plots to determine grass seedling emergence. At the same time, both perennial and annual forbs and the stands of seedling grasses on each plot were rated. Ratings ranged from 1 to 5, with 1 the lowest and 5 the highest degree of infestation. A sample consisted of the vegetation within a 6 x 36-inch frame placed on each of the two center rows of each subplot. Forage grass seedlings were counted and ground cover of other vegetation estimated. Thus, estimates of seeded grass stands were based on six linear feet of row and other vegetation on three square feet for each subplot.

Following the first growing season, ratings were made in the fall of 1958 on the survival of seeded species. This rating was based on two independent estimates over the three replications on the cultivated and non-cultivated parts of each site. The ratings were 1, 2, 3 and 4 for failure, fair, good and excellent survival.

In the spring of 1959 and 1960, grass stand counts and ratings of cover were again made by the same technique as in 1958. In addition, specific counts were made for St. Johnswort and dalmatian toadflax on each subplot where applicable.

Results and Discussion

Stand counts made in the spring of 1958 indicated that all grass species had germinated and emerged satisfactorily on both the cultivated and non-cultivated portions of both the St. Johnswort and non-St. Johnswort sites. (Table 1). Average number of seedlings varied from a high of 144 per 6 feet of row for orchardgrass on the cultivated areas to a low of 9 per 6 feet of row for beardless wheatgrass and crested wheatgrass on the non-cultivated areas. On the St. Johnswort site, the average number of all grass seedlings was slightly higher for the cultivated than the non-cultivated area (Table 1). On the non-St. Johnswort site, there were over twice as many seedlings on the cultivated as on the non-cultivated area. A rating of weedy species on the basis of 1 to 5 indicated that the cultivated areas were only slightly less weedy than the non-cultivated. Mosses, however, which were not included in the rating system, entirely covered the soil surface of non-cultivated areas. Seedlings of dalmatian

FIGURE 2. Plot on the cultivated, non-St. Johnswort site showing stand of slender wheatgrass interspersed with plants of dalmatian toadflax. Photo 10/59.

toadflax emerged for a considerable period and a scattered stand was noted on cultivated areas at the time of rating.

Visual ratings made in October 1958 indicated that all seedings on the non-cultivated sites were considered failures. All seedings on the cultivated sites, however, were considered successful. At this time, close observations were also made in an attempt to ascertain the presence or absence of dalmatian toadflax seedlings on the portion of each plot where it had been seeded. While no ratings were made, it was concluded that dalmatian toadflax seedlings were abundant in all plots in the cultivated sites where it had been seeded. In no case was a dalmatian toadflax seedling observed in the non-cultivated areas, where seed had been broadcast.

Data obtained from weather instruments and soil moisture blocks indicated that moisture conditions were generally favorable to the 18-inch depth, air temperature was not excessive, nor did soil temperature appear critical through the month of June. Beginning the first part of July, however, and continuing throughout the remainder of the growing season, precipitation practically ceased, soil moisture in the surface 6 inches was depleted, air temperature increased, and soil temperatures at the 1-inch level frequently exceeded 120° F. A combination of temperature and moisture stresses, intensified by competition of other vegetation, resulted in high seedling mortality, especially on the non-cultivated plots.

Grass stand counts made in the springs of 1959 and 1960 verified observations made the fall of 1958 (Table 1). No seeded grass plants were found on any non-cultivated plot. When comparing seedlings in 1958 with established plants in 1959 (Table 1), it will be noted that grass stands on all cultivated plots had been considerably reduced. Numbers of established plants varied from a high of 12 per 6 feet of row for slender, intermediate and crested wheatgrass to a low of 3 per 6 feet of row for beardless and tall wheatgrass. Whether this reduction in stand was due entirely to conditions of the experimental area is open to question. Many mature grasses in a species adaptation nursery adjacent to the experimental area were severely injured or killed by the especially cold, open winter of 1958-59.

Data concerning the stands of dalmatian toadflax and St. Johnswort under the various treatments are presented in Table 2. These data indicate that in the spring of 1959, cultivation had reduced the St. Johnswort stand from an average of 32 to 11 plants per 10 square feet. In addition, it appeared that dalmatian toadflax had become firmly established on all cultivated plots. There was an average of over four times as many dalmatian toadflax plants, however, on the non-St. Johnswort as on the St. Johnswort sites. These data suggest that the prior presence of St. Johnswort plants on the cultivated area may have had a restrictive effect on the establishment of dalmatian toadflax seedlings. Since, in no case, were dalmatian toadflax seedlings found on the non-cultivated areas, this plant may be unable to become established in heavy stands of competing vegetation. Disturbance of established vegetation in a local area, in a region of summer drought, to remove or markedly restrict growth of competing vegetation may be necessary to allow establishment of dalmatian toadflax. Additional studies will be necessary to clarify these implications.

Data obtained in the spring of 1960 indicate a further change in composition of the vegetation (Table 1). While there had been only minor changes in composition of the seeded grass plots (Table 1), and the amount of dalmatian toadflax, definite changes were evident in the amount of St. Johnswort on the experimental site. Beetles were active on St. Johnswort in the 1959 season. Close examination of St. Johnswort crowns on May 12, 1960, indicated that beetles had been actively working prior to that date and had completely stripped live plants of new foliage. Whether these plants will survive or succumb to the beetle damage is uncertain.

Table 2. Dalmatian toadflax and St. Johnswort plants (Spring of 1959) per 10 square feet on cultivated and non-cultivated plots drilled to 8 grasses and overseeded with 2 pounds of dalmatian toadflax per acre[1]

	St. Johnswort site				Non-St. Johnswort site	
	Cultivated		Non-Cultivated		Cultivated	Non-Cultivated
	St. J.[2]	T.F.[3]	St. J.	T.F.	T.F.	T.F.
Canada bluegrass	13	2	23	0	22	0
Hard fescue	13	3	36	0	12	0
Orchardgrass	10	3	28	0	6	0
Tall wheatgrass	18	1	32	0	14	0
Slender wheatgrass	5	3	30	0	15	0
Intermediate wheatgrass	7	3	51	0	13	0
Crested wheatgrass	12	3	25	0	12	0
Beardless wheatgrass	7	3	30	0	19	0
Average	11	3	32	0	14	0

[1]Figures are an average of readings made on 2 subplots for each of the 3 replications.
[2]St. Johnswort
[3]Dalmatian toadflax

Considerable variation in the amount of St. Johnswort in an area can be expected due to the cyclic nature of beetle populations alone. Continued observations over a period of years will give information as to whether dalmatian toadflax will become established in an area during the time when the St. Johnswort population is low. Continued observations will also give indications as to the effectiveness of the seeded grasses in preventing invasion by dalmatian toadflax and re-invasion by St. Johnswort.

When comparing numbers of grass seedlings and established plants (Table 1) with numbers of dalmatian toadflax and St. Johnswort seedlings (Table 2), it is evident that the seeded grasses have had little or no adverse effects on the weedy species. Whether the reverse is true or not is open to conjecture. It would appear that neither of these weedy species materially affected grass seedling establishment (Figure 2). The survival potential of the seeded grasses, dalmatian toadflax and St. Johnswort should become manifest as each species exerts its full competitive effect on associated species. Observations will be continued for several years to determine these ecological relationships.

CONCLUSIONS

Under the conditions of this study, all grasses seeded in the fall of 1957 gave satisfactory initial seedling stands, but none survived on non-cultivated sites. On cultivated sites, seedling mortality was high during the cold, open winter of 1958-59, and continued into the spring of 1960, leaving rather thin, though still more or less acceptable, stands of grass.

Dalmatian toadflax became established where seeded on cultivated sites, but not on non-cultivated sites where seedlings were in competition with cheatgrass and annual *Lotus*. Disturbance of the soil, or elimination of competing vegetation, or both, may be necessary to establish dalmatian toadflax from seed.

Fewer plants of dalmatian toadflax were established from seed on cultivated sites formerly occupied by St. Johnswort, suggesting a possible residual inhibitory effect of the latter.

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