Final Report

Project Title: **Assessing the effect of the scale of soil disturbance on the colonization potential of yellow toadflax (Linaria vulgaris) and native vegetation.**
P. I.(s): **Erik Lehnhoff and Dr. Lisa Rew**
Funding: ($5,000, 1 yr.) (awarded 2005)
Budget Detail: M258-05-W0094 (4W0415 LRES)

Proposal:

Abstract:

Yellow toadflax (*Linaria vulgaris)* has invaded a wide range of habitats in the Hebgan Lake area, but demographic studies in a couple of the environments have indicated that not all the populations are invasive. Our previous work has shown that soil disturbance (representative of burrowing animals) adjacent to established yellow toadflax patches leads to patch expansion by vegetative growth. To our surprise, seed production has been highly variable but generally low during the study period. Therefore we designed two experiments to test the hypotheses that yellow toadflax seedling establishment and survival would (1) increase with increasing area of soil disturbance, (2) increase with greater seed density and (3) that yellow toadflax colonization success would vary with site, being more successful in sites with less available water and nutrients and lower native plant dominance. The two experiments described herein were conducted by Erik Lehnhoff (Ph.D. student). In the first experiment soil disturbance areas ranged in size from 10 cm^2 to 10,000 cm^2 at four different sites of varying soil water and nutrient levels; these sites were sown with the same density of yellow toadflax seed. In the second experiment disturbance area was held constant and seed pressure varied (10 to 1000 seeds m^2). Yellow toadflax seedling emergence and survival, and re-colonization by native species was recorded during the 2005 season. Unfortunately only a small number of yellow toadflax seedlings had emerged by the end of the season. Therefore, the experiments were replanted in fall 2005 at one site and will be assessed during the 2006 season; results for these experiments will be forthcoming.

Problem Description:

Yellow toadflax has invaded a wide range of habitats in the Hebgan Lake area, but demographic studies in three of the environments have indicated that not all populations are invasive. In fact our study of 6 populations has observed significant variation in the dynamics of the populations

across environments and over years. Vegetative reproduction has played a major role in these studies, but we also need to understand the role of seeds as potential sources for new colonization. We therefore want to evaluate the role of disturbance area and seed density i.e. propagule pressure, on the establishment of new populations.

Results:

Experimental Design:

Disturbances of four different sizes (100 cm^2, 1,000 cm^2, 4,000 cm^2 and 10,000 cm^2) were created in the first experiment by removing existing vegetation and homogenizing soil to a depth of 7 cm. Seeds were then planted in the disturbed areas at a rate of 1,000 seeds per m^2 (i.e., 10, 100, 400, and 1,000 yellow toadflax seeds for the different disturbance sizes, respectively). Each disturbed area was paired with a non-disturbed area of equal size that was seeded in the same manner. This set of plots was replicated three times at each of four sites (Meadow, Clearcut, Wildfire and Riparian).

In the second experiment, five disturbances of 1,000 cm^2 were created and seeded at the rate of 50, 100, 250, 500 and 1,000 yellow toadflax seeds per m^2 (i.e., each 1,000 cm^2 disturbed area was planted with 5, 10, 25, 50 or 100 seeds). Each disturbed area was paired with an undisturbed area and seeded in the same manner. This experiment was replicated four times at each of the four sites.

In October 2005, a new experiment was initiated at the Meadow site. As described above, four different sizes (100 cm^2, 1,000 cm^2, 4,000 cm^2 and 10,000 cm^2) of disturbances were created. These disturbances were replicated three times and paired with one set of plots that were undisturbed. For this planting, a density of 10,000 seeds per m^2 was chosen (i.e., 100, 1,000, 4,000 and 10,000 seeds for the respective plot sizes).

As in the original experiment, varying yellow toadflax seed density plots were all 1,000 cm^2 in size, but for this experiment, we used a seed densities of 500, 1,000, 5,000, 10,000 and 20,000 seeds per m^2 (i.e., each 1,000 cm^2 disturbed area was planted with 50, 100, 500, 1,000 or 2,000 seeds). These plots were replicated three times with one set of undisturbed plots also seeded.

Data:

Both original experiments were initiated in May 2005. Plots were checked weekly for seedling emergence throughout May and June and periodically thereafter. No emergence was noted in any of the plots on any site in May, June or July. The first emergence was noted in August. At the Wildfire site, seedlings were only present in one of the 10,000 cm^2 plots (6 plants). At the Riparian site, seedlings were only found in one 4,000 cm^2 plot (7 plants) and one 10,000 cm^2 plot (4 plants). At the Meadow site, seedling production was much higher, but still only a fraction (~39%) of the total plots had seedlings. For the varying size plots, 1-1,000 cm^2, 3-4,000 cm^2 and 3-10,000 cm^2 plots had seedlings. For the varying seed density plots, seedlings were identified in 2 plots seeded with 10 seeds (3 plants), 1 plot with 25 seeds (2 plants), 3 plots with 50 seeds (8 plants) and 4 plots with 100 seeds (12 plants). All plots that had yellow toadflax seedlings were disturbed plots. No seedling emergence occurred in the adjacent undisturbed ones.

The above data show a general trend of yellow toadflax establishing better in larger disturbed areas or in the plots of equal size planted with a greater number of seed. However, recruitment was extremely low in plots at all sites. The Meadow site was the only one with any appreciable establishment, and even this was quite low. Based on this data, we decided to repeat the experiment, in the Meadow site only, with a much higher seeding rate in the fall of 2005.

An additional part of the original study was to collect soil samples from the four different sites and assess differences in soil pH and nutrient availability. Soil samples were collected in May of 2005 and analyzed by the Montana State University Soil Testing Laboratory. The following table presents the results of soil sample analysis.

Sample ID	K mg/kg	EC 1:2 mmhos/cm	Initial NH4-N mg/kg	Post-Incubation NH4-N mg/l	NO3-N mg/kg	O.M. mg/kg	Olsen Phos mg/kg	pH 1:2	Calculated PMN (mg/kg)
MW1	462	0.05	10.48	9.74	2.01	5.54	5.95	6.1	63.31
MW2	488	0.06	6.71	9.65	1.13	6.26	4.09	6.1	66.40
MW3	466	0.07	12.61	13.37	0.77	7.06	4.98	6.0	88.68
MW4	488	0.07	12.36	11.63	3.47	7.12	5.62	5.9	75.75
MW5	508	0.06	23.32	11.16	3.64	7.40	7.39	5.8	61.23
CC1	166	0.04	7.58	5.32	2.50	5.48	15.98	5.5	26.52

CC2	156	0.05	5.20	5.41	0.96	5.44	10.26	5.6	29.48
CC3	120	0.04	3.25	3.27	2.13	6.70	24.87	5.2	17.71
CC4	124	0.03	2.28	2.34	0.73	9.53	18.74	5.2	12.72
CC5	138	0.04	2.78	2.41	2.27	11.50	21.98	4.5	12.67
RP1	336	0.05	8.65	8.32	1.53	4.85	9.36	6.0	42.97
RP2	282	0.05	2.56	7.70	1.11	5.30	10.26	5.9	45.21
RP3	222	0.04	5.76	6.01	0.80	4.99	8.20	5.9	31.53
RP4	222	0.04	2.17	3.48	0.69	4.46	11.82	5.8	19.42
RP5	166	0.03	2.62	3.84	1.18	3.94	13.12	5.6	21.21
WF1	164	0.02	2.15	1.54	0.77	2.02	13.12	6.3	6.75
WF2	142	0.02	3.52	2.02	0.69	2.55	11.17	6.2	8.15
WF3	114	0.02	1.78	0.75	0.56	1.74	13.20	6.3	2.55
WF4	122	0.02	1.50	0.99	1.30	2.09	6.21	6.3	4.22
WF5	192	0.03	1.51	1.54	0.85	2.49	18.50	6.3	7.39

Analysis of the data indicates that there were significant differences in several of the categories across sites. For example, the samples from the Meadow site had significantly more potentially minerizable nitrogen (PMN) and potassium (K) than the other sites, but significantly less phosphorus (P). Due to the lack of seedling emergence we perform any statistical comparisons between seedling establishment and soil characteristics.

Conclusions:

The study has been continued beyond the length of the grant, because of the potentially abnormally dry conditions in 2005 that may have altered our results. We hesitate to conclude that yellow toadflax populations have an extremely low probability of establishment even following disturbance (i.e. ideal conditions). Clearly, there are enough areas invaded in the Hebgan Lake region to believe that colonization must readily occur under some set of conditions. With the increased seed numbers, and the optimal planting time (seeds were planted at the time when yellow toadflax was naturally dehiscing) used in 2005, we hope to get better seedling recruitment in spring and summer 2006. The experimental plots will be monitored regularly after snowmelt in the spring of 2006 to determine emergence. Afterwards, plots will be monitored periodically to document establishment and survival.

Products: There are no products from this project currently.

Long-term goal and continued progress of research: This seed grant project covered the 2005 field season, and we are now collecting data in 2006, we hope the results from this season are more conclusive.

Benefits of seed money: We have received seed grant money to initiate this project, and with results from this summer we hope to use the data in a competitive grant to the National Research Council.

Further assistance in advancing this research: Understanding the role of disturbance and propagule pressure is vital to understanding invasion biology and will help develop more effective management approaches for yellow toadflax. However, depending on the results of this season we may need to collect data on another species before we have sufficient preliminary data to apply for competitive grants in the future.

Website: Not available