

**Post application efficiency of the organic herbicides Topgun and Ecoclear, for the control of the weed species Canadian Thistle (*Cirsium canadensis*), Morning Glory (*Convolvulus* spp.) and Horsetail (*Equisetum arvense*)**

**Teale B. Dunsford**

**University of British Columbia**

**BIOL 448**

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**BIOL 448 – DIRECTED STUDIES IN BIOLOGY**

**TEALE B. DURNSFORD**

**July 20, 2012**

**Research Supervisor: DR. SANTOKH SINGH**

Department of Botany Faculty of Science University of British Columbia

## Abstract

Objectives of this study were to examine the long term control of the weedy species Canada Thistle, Morning Glory, and Horsetail with previously applied Topgun and Ecoclear concentrations and combinations. No re-spraying of herbicides occurred. Weeds were counted biweekly to observe changes in plant densities. Results concluded that 100% Topgun was most effective in long term low densities of Thistle and Horsetail. Morning glory data was insignificant to show any difference.

## Introduction

Ever since people started growing specific species of plants for their gain, other plants have gotten in the way, and hence the birth of the weed. Weeds can be any plant that competes with a crop/garden, has little value, or affects the health of livestock and humans (Royer & Dickenson, 2006). Three of Canada's most troublesome weeds include Canada Thistle, Morning Glory, and Horsetail.

Canada Thistle (*Cirsium arvense* L. Scop.) is a weedy species of the plant family Asteraceae. It is a hardy perennial that was introduced from France in the late 1700's. It has prickly stems and leaves, extensively creeping rhizomes, and a purple-pink flower head with disk-florets only (no ray florets). Each female flower head can produce up to 45 seeds, with a total of 40,000 seeds per plant each year. Unfortunately for gardeners and crop growers, seeds can be viable in the soil for up to 21 years. The underground rhizomes are another large problem. A single plant has the ability to produce over 6m of rhizome ever year (Royer & Dickenson, 2006). This weed uses these rhizomes to store food energy, which is especially beneficial throughout the winter months when photosynthesis decreases (Benzil et al., 2008). If left unmanaged in a crop system, Canada Thistle can reduce yield by 100% (Royer & Dickenson, 2006).

Weedy morning glory's (*Convolvulus* spp.) are perennial weeds with twining stems, arrow shaped leaves and white funnel shaped flowers. They reproduce both vegetatively and by seed. Two specific species of concern in Canada are Field Bindweed (*Convolvulus arvensis* L.) and Hedge Bindweed (*Convolvulus sepium* L.). Both species look quite similar, except Field Bindweed has smaller, pinkish white flowers with two small leafy bracts below. Both of these species have an extensive system of creeping rhizomes. Field Bindweed has even been reported to have up to 30m long rhizomes at a depth of 9m. These weeds entangle other plants, as well as compete for light and nutrients (Royer & Dickenson, 2006).

Common Horsetail (*Equisetum arvense* L.) is a perennial weed that is native to North America. They have jointed stems, with leaves in whorls of 8 to 12. They reproduce vegetatively via rhizomes, but unlike the other two weeds, Horsetails do not reproduce by seeds but by spores. They can produce millions of spores at a time but these spores are only viable for about 48 hours. What are of greater concern however, are their rhizomes. Their rhizomes can grow up to 100m long, which are dark brown/black and feel like felt. Horsetails are also very toxic, especially to horses. This toxic effect is due to a substance within the weeds tissue that destroys vitamin B (Royer & Dickenson, 2006).

In North America alone, it is estimated that 27\$ billion a year is spent on trying to manage weeds (White & Landis, 2007). One method of control is the use of herbicides, which are the most widely used method in the world today, with 67% of crop farmers using them (Koroluk et al., 1995). This is due to their low cost, ability to reduce labour and ability to increase crop yields. Herbicides vary immensely in their mode of action, their selectivity, their movement, their toxicity, their environmental factors, etc (Li, 2010). With today's ever increasing concern over hazardous herbicide use, searching for an organic, decomposable

herbicide that is still effective is essential. Two organic herbicides that can be used to combat the three mentioned weedy species are Topgun and Ecoclear.

Topgun is a non-selective, contact type herbicide that contains Pelargonic acid and Capric acid. It has a low toxicity, with an LD50 > 5000 mg/kg (Topgun MSDS). Capric acid is a 10-carbon fatty acid (Lederer, 2004) and Pelargonic acid is a 9-carbon fatty acid.

Pelargonic acid can be used as a herbicide for annual and perennial weeds, as well as for thinning blossoms in apple and pear crops. It can be found within many different types of plants naturally, and is even an FDA approved food substance (U.S. Protection Agency, 2011).

Ecoclear is a non-selective, contact type herbicide (Ivany, 2010) that contains acetic acid, citric acid, and small amounts of 1,2,4- Trimethylbenzene and solvent naphtha. Both acids have a low toxicity, with an LD50 (oral, rat) > 3000 mg/kg. They are also over 90% degraded in the soil within 48 hours of application by microorganisms. The other two ingredients, which are not very toxic (LD50 (rat) = 5,000 & 84000, respectively), are degraded within a week (Ecoclear MSDS).

The objectives of this study were to examine the ability of various concentrations and combinations of Topgun and Ecoclear in long term control of the weedy species Canada Thistle, Morning Glory, and Horsetail without reapplication of the herbicide.

**Materials and Methods**

There are a total of 5 plots on the UBC campus. Each plot is then subdivided into various treatment sections. Since this is a long-term herbicide effect observation, no respraying of herbicides occurred. Instead, weeds were just counted biweekly and photographs were taken. If any weeds appeared to be brown and not showing any green regrowth, they were considered dead and not counted. Any weeds that started to grow along the outside perimeters of the plots were pulled out, to ensure there were no boarder effects. Heavy-duty gloves and a camera were taken along with every counting. Plot details include:

**Site 1: Canadian Thistle, foliar applied herbicides**

Located on University Boulevard and West Mall in a rose flowerbed. Plot was divided into 18 sections, which consisted of Topgun treatments (100%, 50%, 25%, 10%), Ecoclear (100%, 50%, 25%, 10%), Mixture (100%, 50%, 40%, 30%, 25%, 20%, 15%, 10%), and two controls (Figure 1).

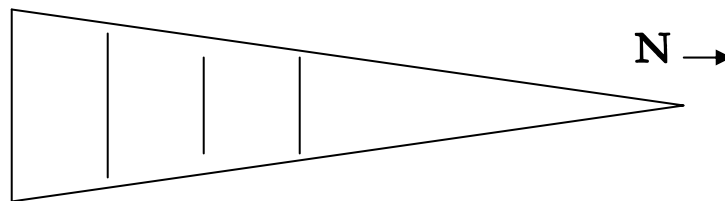
Control 1											
Control 2											
M40											
	T50	E10	M50	M100	T50	M10	T25	T10	E50	T100	M25
	E25	E100	M15	M20	M30						



**Figure 1:** Site 1 plot details. Topgun treatments are labeled T(%treatment), Ecoclear treatments are labeled E(%treatment) and Mixture treatments are labeled M(%treatment).

**Site 2: Canadian Thistle, basal applied herbicides**

Located on Sustainability Road. Plot was divided into 4 sections, which consisted of a 50% Mixture treatment, 50% Topgun treatment, 50% Ecoclear treatment, and a control (Figure 2).



**Figure 2:** Site 2 plot details. From left to right, treatments were control, 50% Mixture, 50% Ecoclear, and 50% Topgun.

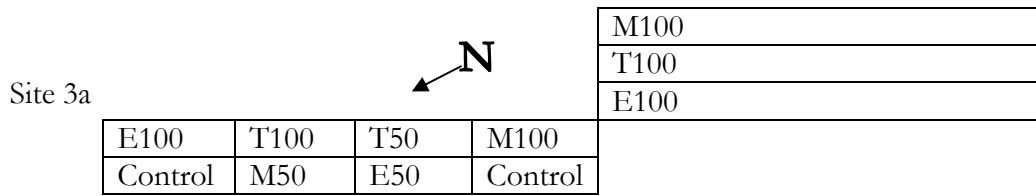
**Site 3a: Canadian Thistle, soil injected herbicides**

**Site 3b: Canadian Thistle, basal applied herbicides**

Located behind the southwest corner of the McMillian Building. Site 3a was divided into 8 sections, consisting of 100% & 50% each of Topgun, Ecoclear and the mixture, as well as two controls. Site 3b was divided into 3 sections, 100% each of Ecoclear, Topgun and the mixture (Figure 3).

Site 3b



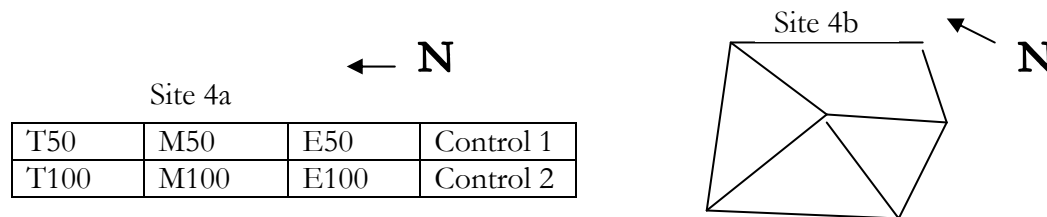


**Figure 3:** Site 3a and 3b plot details. Topgun treatments are labeled T(%treatment), Ecoclear treatments are labeled E(%treatment) and Mixture treatments are labeled M(%treatment).

**Site 4a: Canadian Thistle, foliar applied herbicides**

**Site 4b: Canadian Thistle and Morning Glory foliar applied herbicides**

Located under the glass walkway that connects the Institute for Computing, Information, and Cognitive Systems/Computer Science Building and the Macleod Building. Site 4a was divided into 8 sections, consisting of 100% & 50% each of Topgun, Ecoclear and the mixture, as well as two controls. Site 4b was divided into 4 sections, 50% each of Ecoclear, Topgun and the mixture, as well as a control (Figure 4).



**Figure 4:** Site 4a and 4b plot details. Topgun treatments are labeled T(%treatment), Ecoclear treatments are labeled E(%treatment), Mixture treatments are labeled M(%treatment). For site 4b, treatments (starting from top, going clockwise) are 50% Ecoclear, 50% Mixture, 50% Topgun, and the control.

**Site 5: Horsetail, foliar applied herbicides**

Located on the south side of the Irving K. Barber Learning Center. Site 5 was divided into 9 sections, consisting of mixture treatments (100%, 50%, 40%, 30%), Topgun treatments (100%, 50%, 25%), a 50% Ecoclear treatment, and one control (Figure 5).

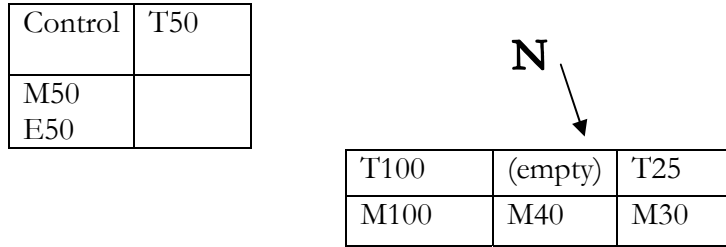
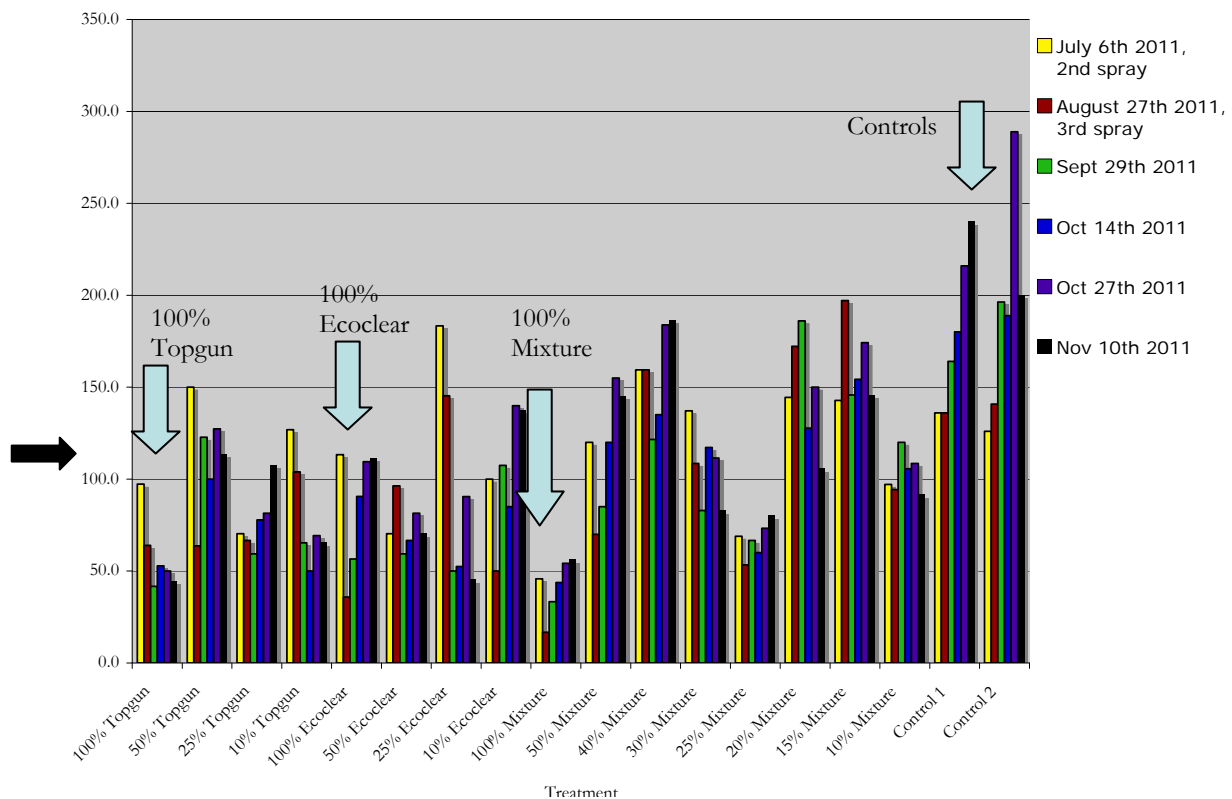


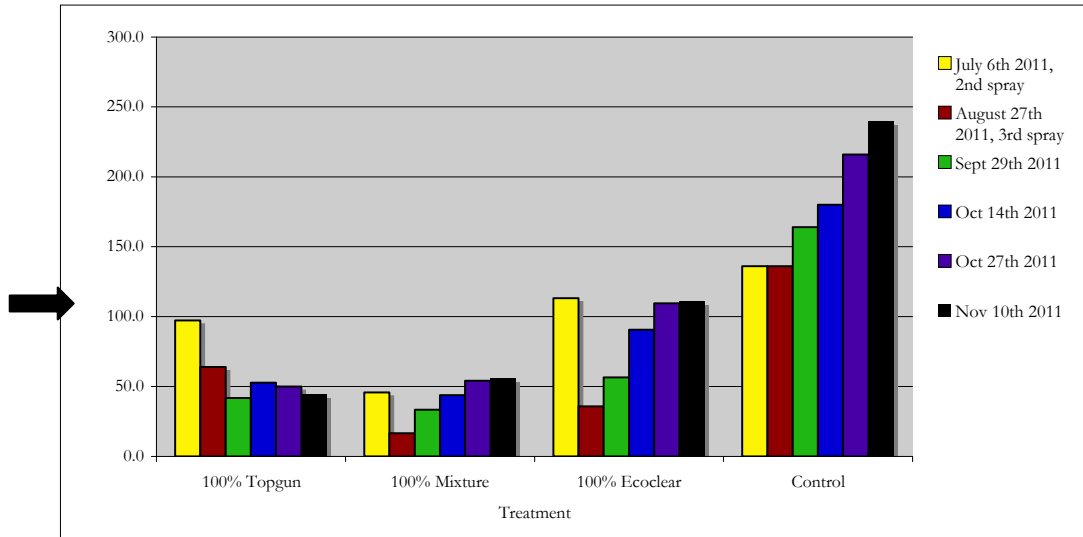
Figure 5: Topgun treatments are labeled T(%treatment), Ecoclear treatments are labeled E(%treatment), Mixture treatments are labeled M(%treatment).

## Results

In site 1 (Fig. 6a), thistle numbers showed the greatest changes with the highest concentration treatments, i.e. 100% Topgun, 100% Ecoclear, and 100% Mixture treatments. Looking at these three treatments, and a control for comparison, thistle numbers right after application of the herbicide showed the greatest decrease with the 100% Mixture treatment (yellow and red bars, figure 6b). For long-term management, without reapplication of the herbicide, notice the decreasing trend with the 100% Topgun treatment (warm coloured bars, figure 6b). These indicate that there is a decreasing amount of thistle numbers even after a long period of time without reapplication. This is contrasting the other two treatments and the control in which thistle numbers start to increase once the treatments have ceased.

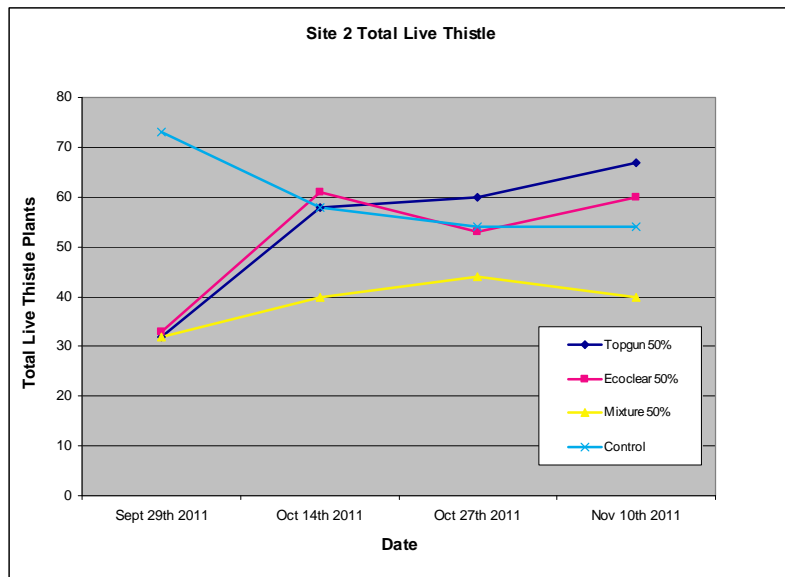


**Figure 6a:** Site 1 – Change in thistle numbers (% on Y-axis) as compared to pre-application numbers. Bars above black arrow indicate an increase in thistle numbers, whereas bars below indicate a decrease. Light blue arrows show the three highest concentration applications as well as the controls.



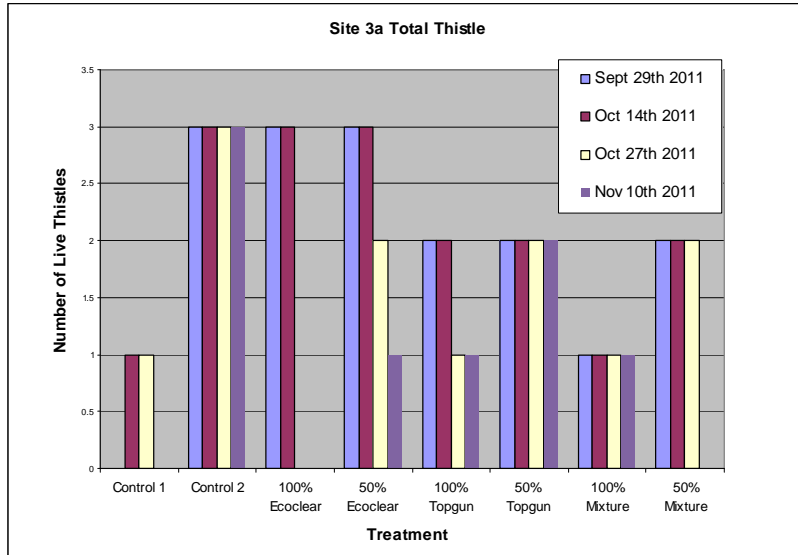
**Figure 6b:** Site 1 – Three highest treatment concentrations (100% Topgun, 100% Ecoclear, 100% Mixture) and one control. Yellow and red bars are during application times. Green, blue, purple and black bars are post-application. Bars above black arrow indicate an increase in thistle numbers, whereas bars below indicate a decrease.

In site 2, the 50% mixture plot maintained thistle numbers around 40 individuals. 50% Topgun and 50% Ecoclear had a general increase in number to 67 and 60, respectively. The control had a decrease in numbers from 73 initially to 54 (Figure 7).

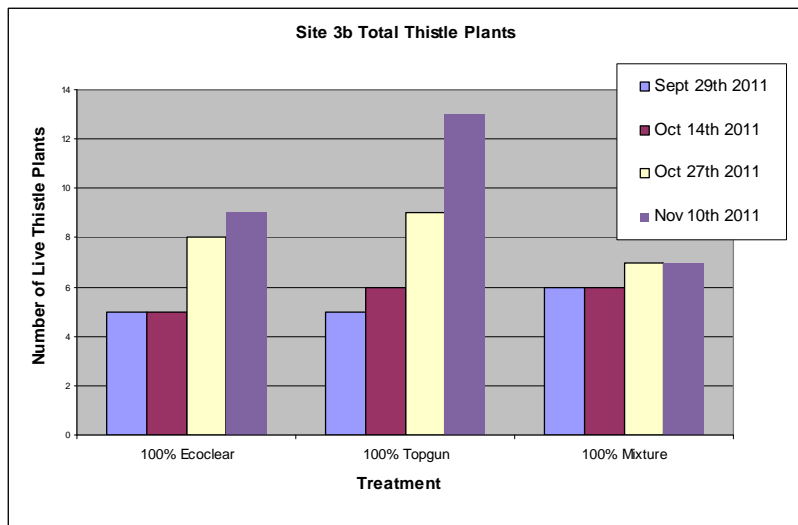


**Figure 7:** Total live thistle in site 2 in autumn months with varying basal applied herbicide treatments

In site 3, no treatment had much of a change in numbers throughout the fall. Ecoclear and Topgun at 100% only increased from 5 to 9 and 5 to 13, respectively. That is only a change in 4 and 8 plants (Figure 8&9).

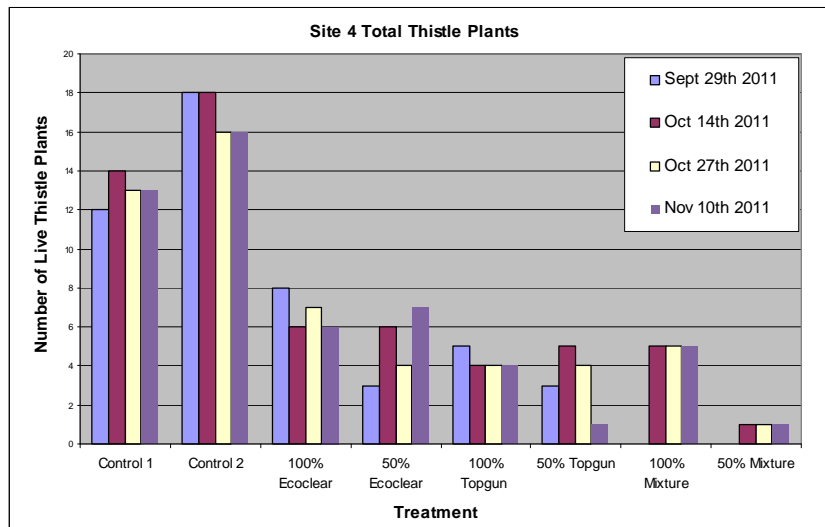


**Figure 8:** Total live thistle in site 3a in autumn months with varying soil injected herbicide treatments

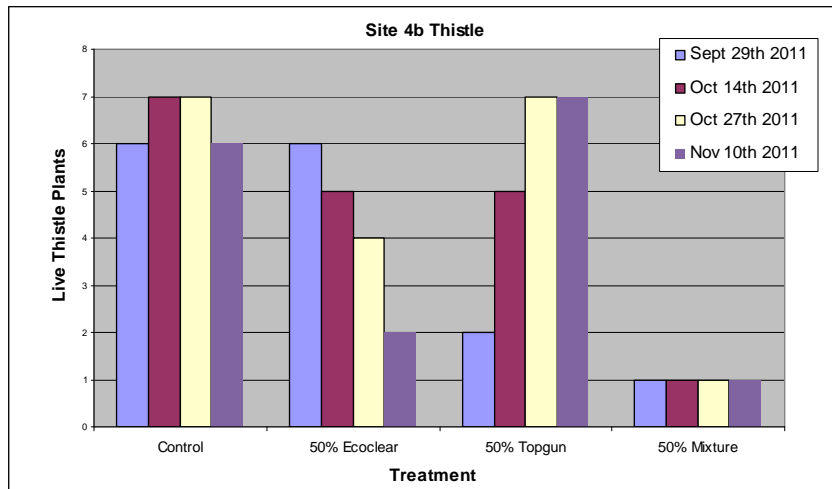


**Figure 9:** Total live thistle in site 3b in Autumn months with varying basal applied herbicide treatments

Site 4 looked at thistle (Fig. 10&11) and morning glory (Table 1). There was no change in morning glory amount in the fall months. Thistle however, had very low numbers in the 50% mixture plot, with only 1 plant. There was no regrowth in this plot as well over the weeks. The control had many plants. There wasn't much change in plant numbers through out the weeks in any of these plots, but the total numbers in the control were much higher than that of the treatments. Ecoclear plots had about half as many plants, the Topgun plots had about a third of the plants, and the mixtures had about one third to one quarter the numbers.



**Figure 10:** Total live thistle in site 4a in Autumn months with varying foliar applied herbicide treatments

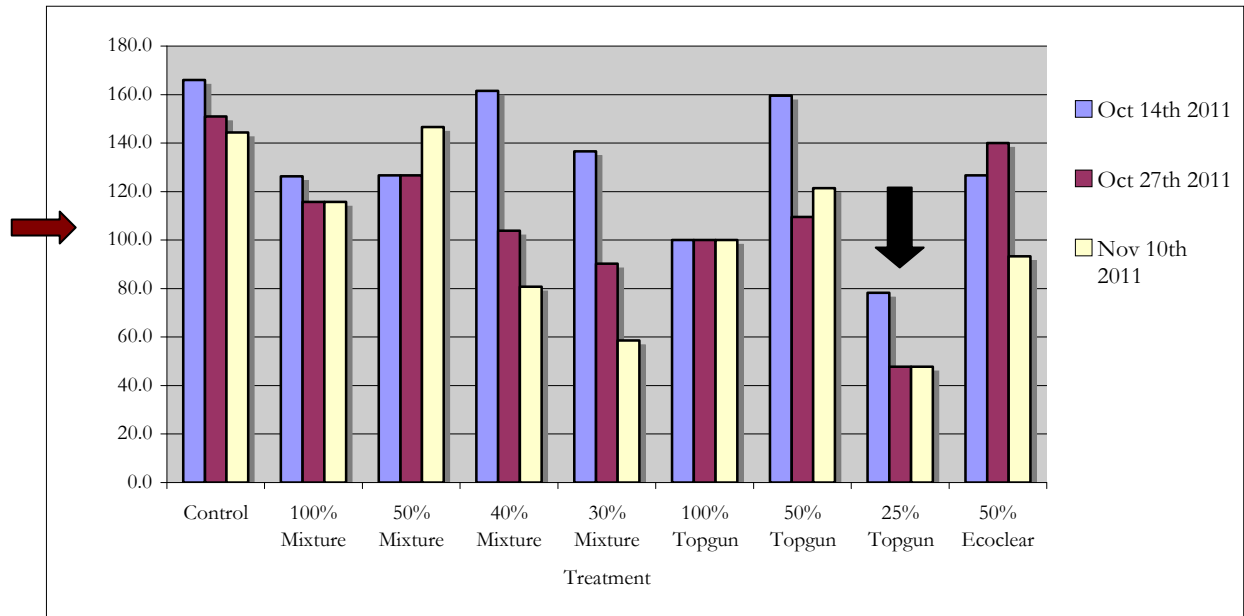


**Figure 11:** Total live thistle in site 4b in autumn months with varying foliar applied herbicide treatments

**Table 1:** Total Morning glory plants in site 4b. Amount of plant material quantified as x = a bit of plant material, xx = moderate plant material, xxx = large amount of plant material.

Site 4b Morning Glory	Control	50% Ecoclear	50% Topgun	50% Mixture
Sept 29th 2011	x	xxx	x	xx
Oct 14th 2011	x	xxx	x	xx
Oct 27th 2011	x	xxx	x	xx
Nov 10th 2011	none	xxx	x	xx

Site 5 looked at horsetails. In the beginning of September, the control plot had just over 100 plants. All other plots started out with between 5 and 60 plants. Date of last herbicide treatment spray was in August. Changes in horsetail numbers are illustrated in figure 12. Regrowth control seems to be best with the 25% Topgun treatment. There were also decreases in weed numbers for the 40% and 30% Mixture treatments.



**Figure 12:** Site 5 change in horsetail numbers relative to the beginning of September. Black arrow indicates the treatment with the greatest change in numbers. Bars above red arrow indicate an increase in horsetail numbers, whereas bars below indicate a decrease.



## Discussion

Control of Canadian thistle is observed mostly in foliar applied application as compared to soil injected and basal application. It was also observed that in foliar applied sites, Topgun was usually the most effective for long term low numbers of individuals. It should also be kept in mind that low growth/death in some plots could have also been due to autumn months be colder, with less sunshine hours per day.

Site 1 contained Canada Thistle that was previously applied with foliar herbicides. This site had up to 2/3<sup>rd</sup> control in plant numbers, as compared to the control (Fig 6a&b). The best treatment was 100% Topgun, with an overall decrease of about 50% even after a period without reapplication. The best mixture treatment was 100%. With this data, as well as previous summer data, it can be noted that mixture treatments are best for killing the weeds, but Topgun is better for limiting long-term regrowth in the fall months. Since both of these herbicides only damage above ground structures, underground rhizomes were not damaged from application. Topgun might have a better ability to slow down regrowth of new shoots, starving the underground rhizomes longer. This may account for rhizome death, and future decrease in weed numbers. For immediate destruction however, the two herbicides together are better at foliar death, as previous studies have seen (Coleman & Penner, 2008 ).

Site 2 had basal application of the herbicides (Fig. 7). Each of the treatment plots actually had an increase in weed numbers, while the control plot numbers decreased. This could have been due to lack of large individuals in the treatment plots from the previous herbicidal application. This allowed for increased space for younger newer shoots to emerge. The control plot had many large thistle plants, which were likely undergoing higher

intraspecific competition with each other for space and nutrients, causing a decrease in their numbers.

Site 3a had soil injected herbicides for the control of thistle. In 6 out of the 8 plots, there was no change in weed numbers (Fig. 8). The only two plots with any change were the 50% Ecoclear and 100% Topgun plots. Numbers only decreased by one plant however. There were not enough total plants in these plots (between 1 and 3 plants) to substantially conclude any difference in results.

Site 3b had basal applied herbicides for the control of thistle. The 100% mixture treatment only had an increase of one plant, from 6 to 7 (Fig. 10). 100% Ecoclear and 100% Topgun were very similar, both starting with 5 plants and ending with 9 and 13, respectively. Since weed numbers in this plot were again very low, a substantial conclusion is hard to make.

Site 4a had foliar applied herbicides for the control of thistle (Fig. 10). The control plots had an average of about 15 plants on the last week. The 50% mixture plot had only one plant through out the weeks with no change but the 100% mixture plot had 5, also with no change. This is a .66 decrease in individuals. The 50% Topgun plot had only one as well, but the 100% plot had 4. Ecoclear wasn't as good as either, with about 6 plants. In general for this site, the mixture and Topgun treatments at 50% and 100% were effective. However, low density of plants does not give a significant result.

Site 4b was 50% foliar application on thistle (Fig 11) and morning glory (Table 1). The thistles were best reduced to one plant in the mixture treatment; however the control only had 6. The Ecoclear plot shows a decrease in numbers from week to week, from 6 to 2 plants. Topgun saw an increase from 2 to 7. Again, low numbers show low significance. Table 1 shows the amount of morning glory in each plot for each week. There was no

change in any plot throughout observations. This was probably due to cold weather and mediocre growing conditions.

Site 5 was the foliar application to control horsetails (Fig. 12). In the control plot, there were greater than 140 plants. The 50% Ecoclear plot had the least number of plants in the last week, with only 14 plants. The change in numbers however, was less than a 15% decrease from initial numbers. The treatment with the greatest decrease was with 25% Topgun, with about a 45% decrease. These numbers however, may be due to cold winter weather limiting growth in all plots. Also notice, from Oct. 14<sup>th</sup> to Oct. 27<sup>th</sup> there was a decrease in most of the plots. Due to site 5 being under deciduous trees, a mulching effect occurred when the trees lost all of their leaves and landed on the horsetails. This caused a decrease in light, and killed off some of the horsetails. It was however, very uniform and didn't alter the differences between treatments.

Since Topgun's main ingredient is pelargonic acid, it acts by rapidly desiccating green plant tissue (Irzyk, 1997). This was seen when the herbicide was first applied. It works by destroying the waxy cuticle that covers the leaf surfaces, disrupting cell membranes, causing the plant to lose excess amount of water, dry out, lose cellular function and die. It also has plant growth regulating effects. Once in the soil however, it does not bind tightly to soil colloids (Thurston County Health Department, 2009) and has a half life of less than a few days. Pelargonic acid is also not a translocated substance (Marin Municipal, 2008). This was evident in the different ways it was applied. With foliar application a larger effect was seen than when it was injected to the soil or basally applied. Topgun was not moved via the shoots to the roots.

Acetic acid herbicides also work by disrupting cellular membranes, causing desiccation and death (Owen, 2002). This too, is best seen in the foliar applied sites.

Previous research by J.A. Ivany has shown that Ecoclear can reduce the weedy species Lamb's Quarters, Corn Spurry, and Wild Radish by greater than 80% in Potato crops with a 20% concentration (Ivany, 2010). In site 1, this is very similar with the 25% Ecoclear treatment. Weed density decreased by about 75% after application, and numbers stayed low as the weeks progressed. At higher concentrations however, weed densities remained similar, with an initial 60% decrease to regrowth right back to before treatment numbers (Fig. 6).

In previous studies by Coleman and Penner, it was shown that the combination of fatty acid herbicides and an organic acid can increase herbicide efficiency by up to 200% (Coleman & Penner, 2008). This was seen after herbicide application with the 100% mixture treatment in plot 1 (Fig. 6). Initial decrease was from 48 to 8 weeds, an 83% decrease. This is compared to the 36% decrease with 100% Topgun and 66% decrease with 100% Ecoclear. For long term control however, 100% Topgun treatments kept the weed numbers down the best, with only 16 plants. It could then be recommended for future applications that the use of a mixture would be best for immediate irradiation and Topgun for long term effects, possibly when reapplication could not be achieved for some time.

Experimental errors include the lack of plant density in many of the plots to make significant conclusions. A large sample number, as in site 1 and site 5, were much better. The mulching effect of fallen leaves in site 5 also altered the data. In the future, raking of leaves away from the plots would counteract this effect. Larger plots would also be advantageous. It would decrease the effects of neighboring plots on each other. For data collection, having more than one surveyor may decrease the effects of human error in counting each of the plots.

Future research could look at how these herbicides suppress growth over an entire year periods without reapplication, and not just autumn months. This could give light as to

the spring time regrowth that occurs with these varying treatments. Observations could also be taken to look at how much rhizome biomass has been destroyed or grown since application.

### **Acknowledgments**

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