ALTERNATIVE CONTROL OF TANSY RAGWORT

ON THE SKAGIT TRANSMISSION RIGHT-OF-WAY

THIRD ANNUAL PROGRESS REPORT

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SUMMARY

This report describes the third year of a multi-year study to control tansy ragwort (*Senecio jacobaea*) on a transmission right-of-way near Darrington, Snohomish County. Seattle City Light authorized the study in 1986 to compare the feasibility of biological control with traditional methods of ragwort control (hand weeding and herbicide).

Two insect species that feed on ragwort, the cinnabar moth (*Tyria jacobaeae*) and ragwort flea beetle (*Longitarsus jacobaeae*), have been released in the study area. Insect populations are being monitored along with ragwort densities in each of three experimental treatment types. Depending on the success of biological control, the City may reduce the use of herbicide for controlling tansy ragwort on the right-of-way.

Currently, the distribution of tansy ragwort in the study area appears to be determined largely by the presence of surface water, with minor effects due to manual and herbicide control. Although cinnabar moth and flea beetle populations are successfully established in the area, their numbers are still too small to reduce the ragwort population. The seedhead fly, another biological control agent, has colonized the area through natural dispersal.

There is indirect evidence that Beverly Creek and other local water sources may be contributing to the spread of ragwort by washing seeds downstream. Flea beetles may also be dispersed downstream by high water. To enhance the long-term effectiveness of biological control, insect introductions should be considered in other problem areas where they are not already established.

INTRODUCTION

Tansy ragwort (*Senecio jacobaea*) is a biennial or short-lived perennial member of the daisy family *(Compositae)*, introduced to North America from Europe (Figure 1). It is considered a major noxious weed in Oregon and Washington, causing economic losses by poisoning cattle, horses, and goats (Bedell et al. 1981; Macdonald 1983) and by displacing desirable forage (McEvoy 1985). Land owners in the State of Washington are required under RCW 17.10 to control and prevent the spread of ragwort and other noxious weeds to adjacent agricultural lands.

For several years Seattle City Light has been using the herbicide Banvel, combined with hand weeding near streams, to suppress tansy ragwort on a transmission right-of-way near Darrington, Snohomish County. In 1986, the City authorized a study of the feasibility of biological control of ragwort on the right-of-way. The purpose of the study is to establish populations of two insect species, the cinnabar moth (*Tyria jacobaeae*) and ragwort flea beetle (*Longitarsus jacobaeae*), and to test their effectiveness, against herbicide and hand weeding, in keeping ragwort at low densities. Ultimately, the City would like to eliminate the use of herbicide for tansy ragwort control on the right-of-way.

Successful biological control of ragwort may take several years, depending on how quickly the insect populations establish themselves. The City views this as a multi-year project, and has renewed the study annually since 1986. Results of the first two years of study and a literature review on the biology and control of tansy ragwort were reported previously (Parametrix 1987, 1988). This report describes the results of the third year's study.

STUDY AREA

The tansy ragwort study area is located north of Darrington near the Snohomish-Skagit County line (Figure 2). The site is part of a 300-foot-wide transmission right-of-way used to convey power from the Skagit Hydroelectric Project to Seattle.

Vegetation on the right-of-way consists of early successional forest communities (shrubs, grasses, and forbs) interspersed with pasture. The terrain on the study area is relatively flat, and is bisected by Beverly Creek, an intermittent stream that joins the Sauk River. The creek flows intermittently from November through March, and has flooded during three of the past four winters.

Ragwort density is highest near the creek in the northeast part of the study area. Before the study, cattle from adjacent farmlands had access to the study area through coniferous forest bordering the right-of-way. To prevent the interference of cattle with this study, their use of the area has been eliminated.

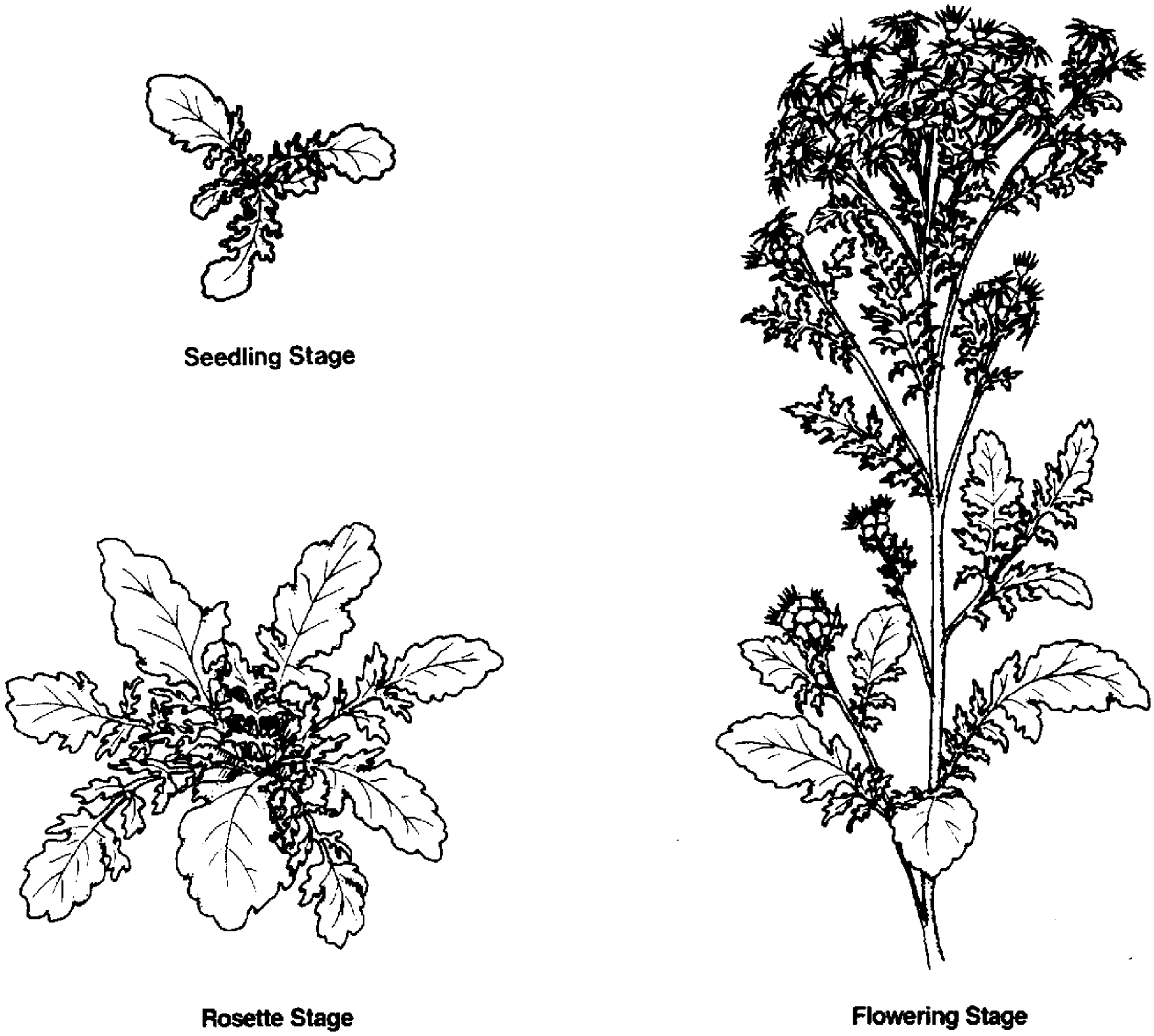


Figure 1.
The three life stages of tansy ragwort.

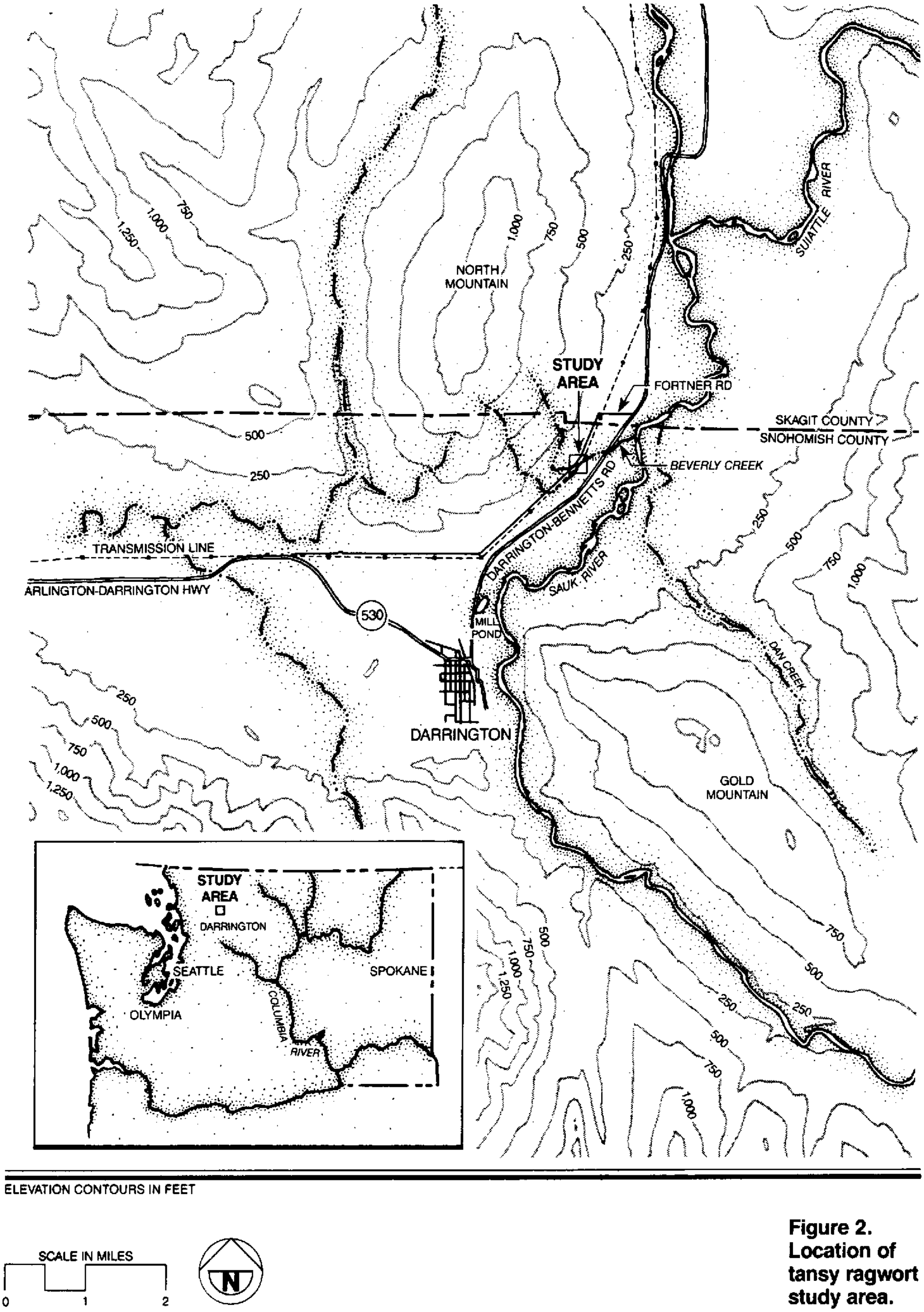


Figure 2. Location of tansy ragwort study area.

METHODS

This study is designed to evaluate the feasibility of biological control of tansy ragwort. Control is being evaluated in terms of its success in reducing the ragwort population and the dollar costs associated with its removal. Three experimental treatments–insects, hand weeding, and herbicide–are being compared on a 7.5-acre section of the right-of-way (Figure 3). The study design was influenced by the following factors:

- The need to establish insects in the area of highest ragwort density.
- A City of Seattle ban on herbicide use within 50 ft of the streambed.
- The need for easy interpretation by right-of-way maintenance crews responsible for manual and herbicide treatments.
- A requirement of the Snohomish County Weed Control Board that some form of treatment be administered to tansy ragwort on all parts of the study area.

As a result of these constraints, the study lacks several key elements of experimental protocol, including replication of experimental units, random assignment of treatments, and use of untreated controls (McEvoy 1988 personal communication). Despite these limitations, we expect to obtain useful information on the establishment of insect populations and their effectiveness in controlling tansy ragwort.

RAGWORT POPULATION ESTIMATES

Tansy ragwort densities were sampled on June 6, 1989 using a stratified random design as in past years (Parametrix 1987). Plants were classified as seedlings (<7.5-cm diameter), rosettes (>7.5-cm diameter), and flowering plants (McEvoy 1985) (see Figure 1). Each treatment area was staked in a rectangular grid pattern, with individual grid cells measuring 30 by 30 ft (Figure 3). Ragwort plants were randomly sampled within grid cells using a 1/4-m^2 quadrat. There were 51-68 samples per treatment.

We analyzed our data for statistical differences in ragwort densities. We compared mean seedling and rosette densities among treatment areas using the Kruskall-Wallis test. This nonparametric test is designed for data, such as ours, which are not normally distributed.

Flowering ragwort plants were counted on June 29, 1989. Counts were necessary because densities of flowering plants were generally too low to estimate reliably by sampling. Counts of individual plants were transformed to numbers of stems based on the ratio of stems to plants observed in a subsample. Ragwort population data were gathered before the City applied manual and herbicide treatments.

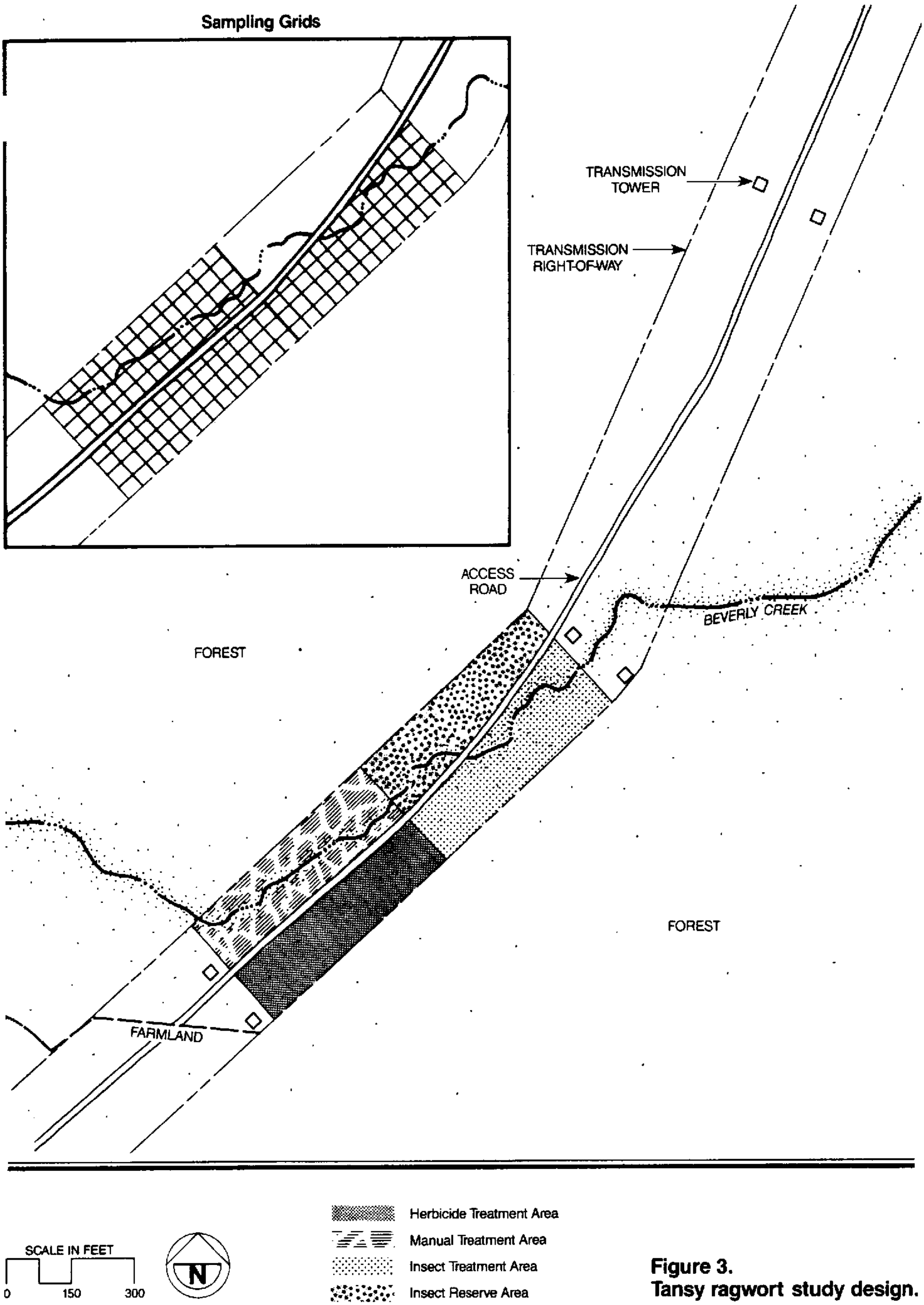


Figure 3.
Tansy ragwort study design.

We attempted to monitor the survival of individual ragwort plants and sources of mortality by marking 100 rosettes distributed throughout the study area. Unfortunately most of our markers disappeared or disintegrated as a result of snowpack, plant growth, and weathering. We will repeat our efforts in 1990 using marker flags attached to wire posts.

RAGWORT DISTRIBUTION

A supplemental task during the 1989 field season was to assess the potential spread of ragwort downstream from the study area. On July 26, we conducted a foot survey along Beverly Creek to document the occurrence of ragwort between the study area and the Sauk River. We also completed a float survey of the Sauk River between Darrington and the Suiattle River (approximately 8.2 river miles) to compare the incidence of ragwort upstream and downstream of the confluence with Beverly Creek. The creek enters a side channel of the Sauk River near the midpoint of the float, 4.3 miles above the Suiattle (see Figure 2).

In addition to documenting the distribution of plants, we looked for evidence of seeds being carried in Beverly Creek during early winter flood conditions. On December 5, after a weekend of heavy rain, we took water samples from the creek to assess the abundance of ragwort seed entering and leaving the study area. Using a bucket and fine-mesh wire screens (1.2- and 0.85-mm in series) we filtered a total of 150 gallons of water from three sample stations along the creek. One station was at the downstream end of the study area; one was at the upstream end, and the third was within a flooded stand of ragwort in the middle portion of the study area. Creek flows entering and leaving the study area were estimated by measuring stream cross sections and visually estimating current velocities.

Screened creek samples were analyzed in the laboratory. Seeds were counted and identified with reference to known seeds of tansy ragwort and Canada thistle (the other common *Compositae* onsite). Ragwort seeds were removed from seedheads collected during the creek sampling for an ongoing study to determine the effect of soaking on seed germination.

INSECT RELEASES AND POPULATION ASSESSMENTS

Annual insect releases were made in 1986-88, and averaged 4,500 cinnabar moth larvae and 4,500 adult flea beetles (Table 1). Further releases were not made in 1989 because there was good evidence that the insect populations had established themselves. Methods and timing of insect collection and release were described in *Alternative Control of Tansy Ragwort on a Transmission Right-of-Way* (Parametrix 1988).

Table 1. Insect releases on tansy ragwort study area, July 1986-October 1988.

	Date	Number	Origin
Cinnabar Moth (larvae)			
	7/10/86	2,500	Thurston County, Washington
	7/15/86	1,500	"
	7/01/87	4,500	"
	7/21/88	5,000	"
Ragwort Flea Beetle (adults)			
	10/09/86	5,000	Tillamook County, Oregon
	10/14/87	5,000	"
	10/13/88	3,500	"

We evaluated cinnabar moth establishment and damage on July 19, 1989. Sampling was conducted by estimating the number of larvae and level of defoliation in a sample of three plants in each cell of the ragwort sampling grid (see Figure 3). We also recorded the level of damage to flower heads caused by seedhead flies, which colonized the study area through natural dispersal (Parametrix 1987). Sampling was confined to the insect treatment area due to the scarcity of cinnabar larvae in the rest of the study area.

We conducted our annual flea beetle survey on October 19, 1989. Population trends were estimated by counting the number of adult beetles collected in timed vacuum net (D-Vac) samples. Sampling was conducted in stands of ragwort within the insect treatment and manual treatment areas. We developed indexes to quantify insect abundance and damage levels.

ALTERNATIVE TREATMENTS

Alternative treatments (manual pulling and herbicide application) were administered by right-of-way maintenance crews on July 5, 1989. Banvel herbicide (diluted 1:100 with water) was applied with a backpack sprayer to flowering plants in the herbicide treatment area. Flower heads were clipped and bagged to reduce the spread of seeds. In the manual treatment area, flowering plants were pulled and bagged. All plant residues were buried offsite in a landfill. To compare the costs of treatments, labor and travel time were recorded and multiplied by the hourly rate.

In response to concerns raised by the Skagit County Noxious Weed Control Board, the City also agreed to a limited control program for tansy ragwort within the insect treatment area. Beginning in mid-July, flower heads of plants growing within the flood zone of Beverly Creek were clipped and bagged. This procedure was repeated in late August to remove late-blooming and resprouting plants. Approximately one-third of the flowering plants within the treatment area were clipped.

RESULTS

RAGWORT POPULATION AND DISTRIBUTION

Since the study began in 1986, ragwort population densities have generally been much higher within the insect treatment area than in other parts of the study area (Tables 2 and 3, Figure 4). Densities have been intermediate within the manually treated area and lowest in the herbicide treatment area. Differences are statistically significant for vegetative plants (seedlings and rosettes) in all years ($H > X^2_{.001[2]}$).

Ragwort densities within the insect treatment area have exhibited a cyclic pattern of increase and decrease, with annual fluctuations in numbers of vegetative plants followed one year later by those of flowering plants. Ragwort densities in the other treatment areas have been relatively stable or declining (see Figure 4).

Due to heavy forest cover and lack of light, very little ragwort was present along most of Beverly Creek between the right-of-way and the confluence with the Sauk River. However, near the confluence where the canopy opens up, there were approximately 25 flowering plants on either side of the creek. Another 12 plants were growing just downstream from the confluence. A local resident near the creek reported seeing tansy ragwort on their property for the first time about four years ago.

The float survey of the Sauk River indicated that tansy ragwort was more common along the 4 miles of river below Beverly Creek than in the 4 miles above it. Of 12 groups of plants observed, 9 were downstream of Beverly Creek and 3 were upstream.

Creek samples collected in early December from the upper and lower ends of the study area did not contain any ragwort seeds. Only two seeds were collected from a flooded stand of ragwort in the middle of the study area. Creek flows during sampling were approximately 25 cfs at the upstream end of the study area, and 100 cfs at the downstream end.

INSECT POPULATIONS

Evidence of continued population growth made releases of cinnabar moth larvae and ragwort flea beetles unnecessary in 1989. Cinnabar larvae were still concentrated within the insect treatment area, although small numbers of caterpillars were found as far as

Table 2. Tansy ragwort seedling and rosette sampling densities in the study area, 1986-89.

Year	Treatment	Sample Size	Size Class	Density (/m^2)
1986	Insect	69	Seedling	0.346
			Rosette	0.200
	Manual	68	Combined[1]	0.152
	Herbicide	51	Combined[1]	0.016
1987	Insect	68	Seedling	44.000
			Rosette	0.882
	Manual	68	Seedling	2.000
			Rosette	0.765
	Herbicide	51	Seedling	1.020
			Rosette	0.471
1988	Insect	68	Seedling	2.824
			Rosette	1.235
	Manual	68	Seedling	0.353
			Rosette	0.529
	Herbicide	51	Seedling	0.157
			Rosette	0.000
1989	Insect	68	Seedling	145.471
			Rosette	2.706
	Manual	68	Seedling	0.000
			Rosette	0.000
	Herbicide	51	Seedling	0.000
			Rosette	0.000

[1]Seedlings and rosettes not differentiated.

750 ft in either direction along the right-of-way corridor. Larval densities increased substantially, from an estimated 2-5% of plants infested in 1988 to 50% in 1989. Ragwort defoliation levels were generally light, with concentrated damage in a few locations (Figure 5).

Seedhead fly damage continued to be evident throughout the study area in 1989. Seventy-two percent of the flowering plants had damaged seedheads, although most of the damage was relatively light (Figure 6).

Table 3. Tansy ragwort flowering plant densities in the study area, 1986-89.

		Number			Density (/m^2)	
Year	Treatment	Stems	Plants	Ratio	Stems	Plants
1986	Insect	NA[1]	767	NA	NA	0.094
	Manual	NA	89[2]	NA	NA	0.012[2]
	Herbicide	NA	84	NA	NA	0.013[2]
1987	Insect	465	294	1.58	0.057	0.036
	Manual	889	366	2.43	0.122	0.050
	Herbicide	NA	88	NA	NA	0.013
1988	Insect	6,760	4,507	1.50	0.830	0.553
	Manual	696[3]	286	2.43[3]	0.096[3]	0.039
	Herbicide	10	5	2.00	0.001	0.001
1989	Insect	2,239	1,419	1.58	0.275	0.174
	Manual	710	293	2.42	0.098	0.040
	Herbicide	10	8	1.25	0.001	0.001

[1]No data collected.
[2]Count and density underestimated (field data collected after treatment).
[3]No data collected; estimate based on average stem/plant ratio in 1987 and 1989.

Significant growth was also evident in the local flea beetle population (Figure 7). Adult beetles were visible on ragwort plants from late September through early December, and the overall capture rate increased from 12.2 per minute in 1988 to 62.4 per minute in 1989. (The initial capture rate in 1987, one year after the first release, was only one beetle per minute). A small number of flea beetles were also observed on the right-of-way near Fortner Road, about 0.6 miles north of the study area. This group may have been established from earlier releases at that location.

The observation of many adult flea beetles onsite during a flood in early December suggested the possibility that flea beetles, like seeds, might be washed downstream by high water. We tested the immersion tolerance of flea beetles by placing an adult beetle in a jar of water, shaking it up, and then setting the jar aside at room temperature for 24 hours. The following day the flea beetle was still floating, and to our surprise, hopped away when we tried to examine it! This feat of endurance was all the more amazing because the beetle had been captive for two weeks before our experiment.

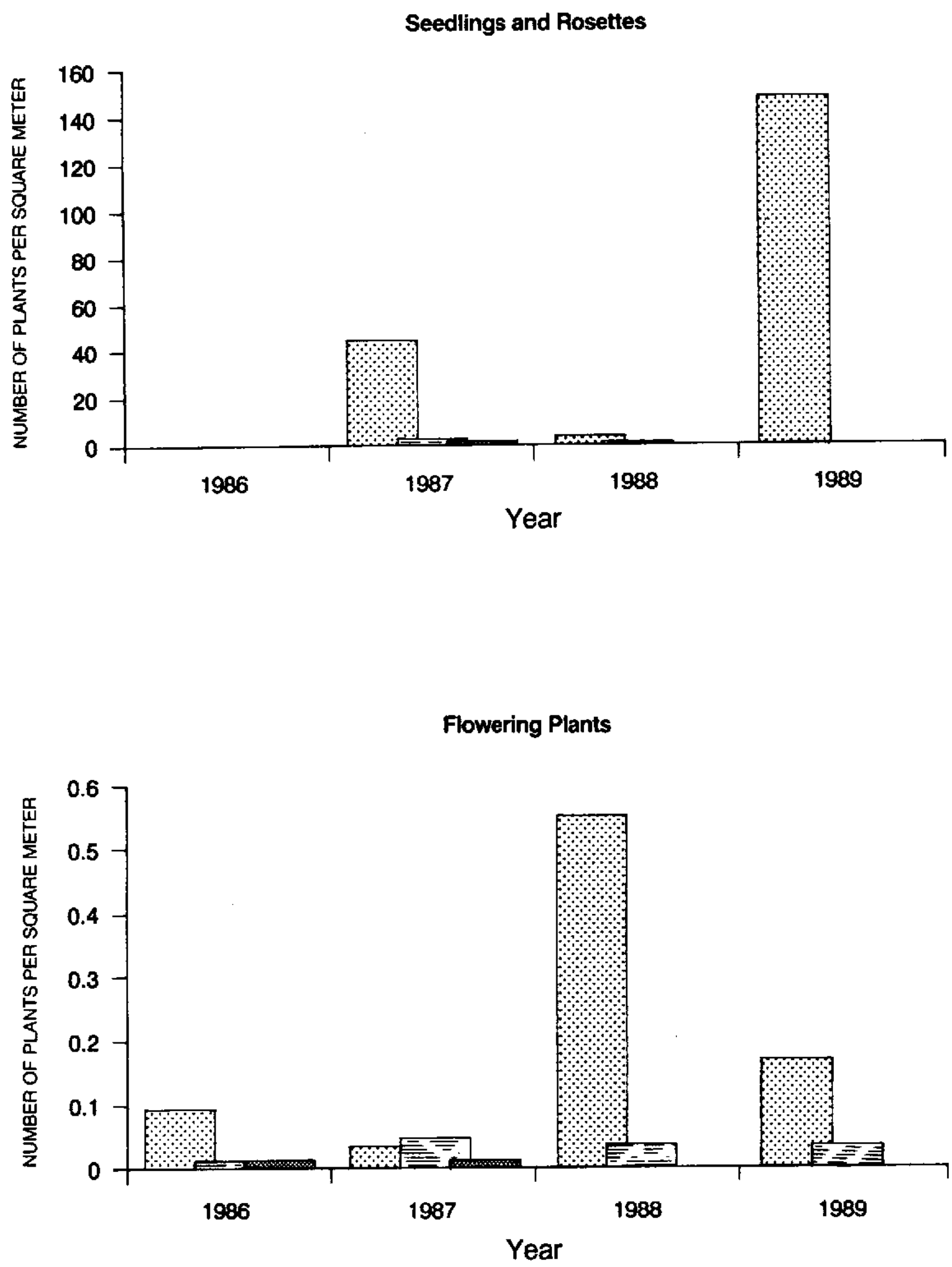


Figure 4.
Density of tansy ragwort in study area, 1986-1989.

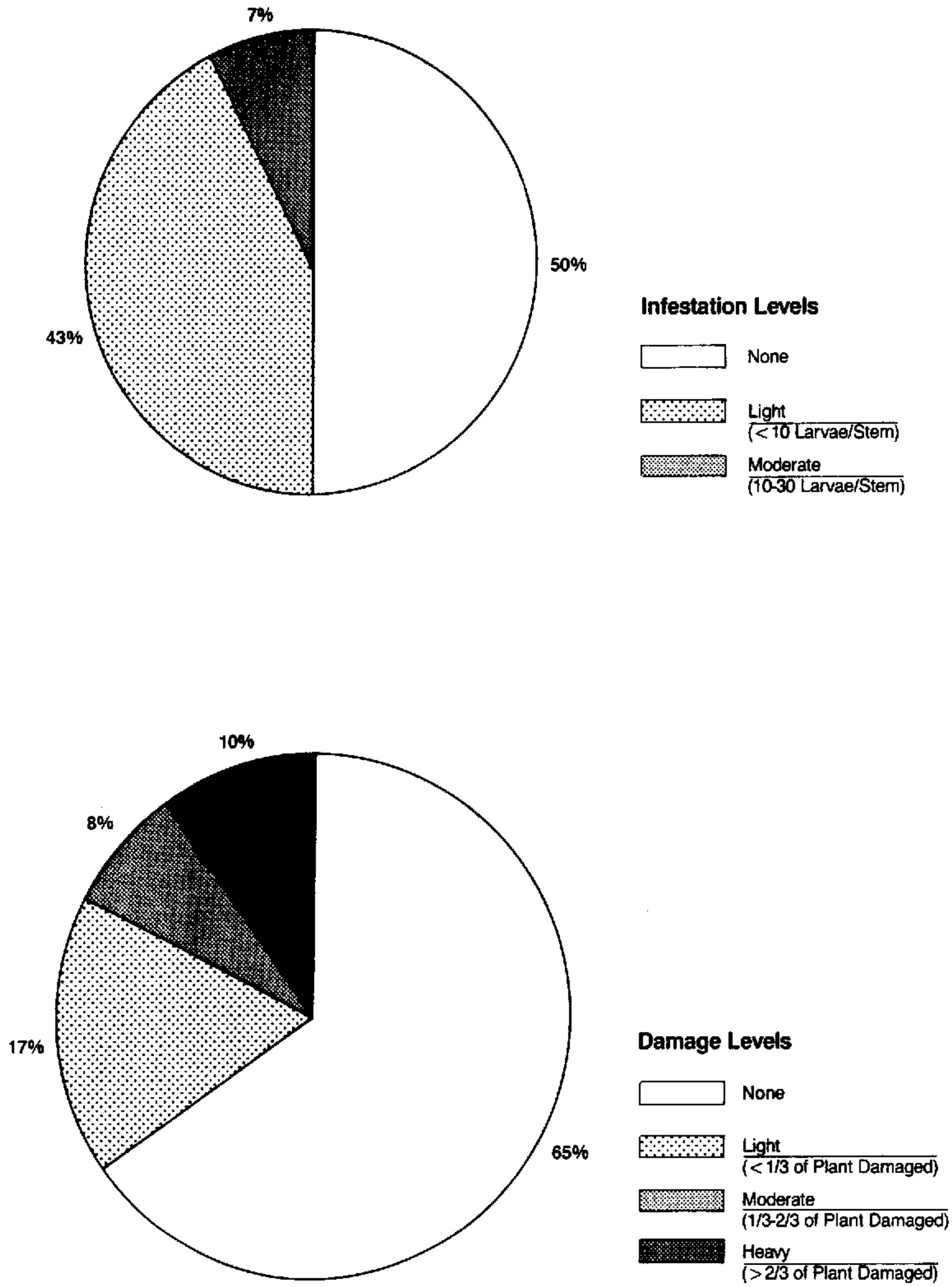
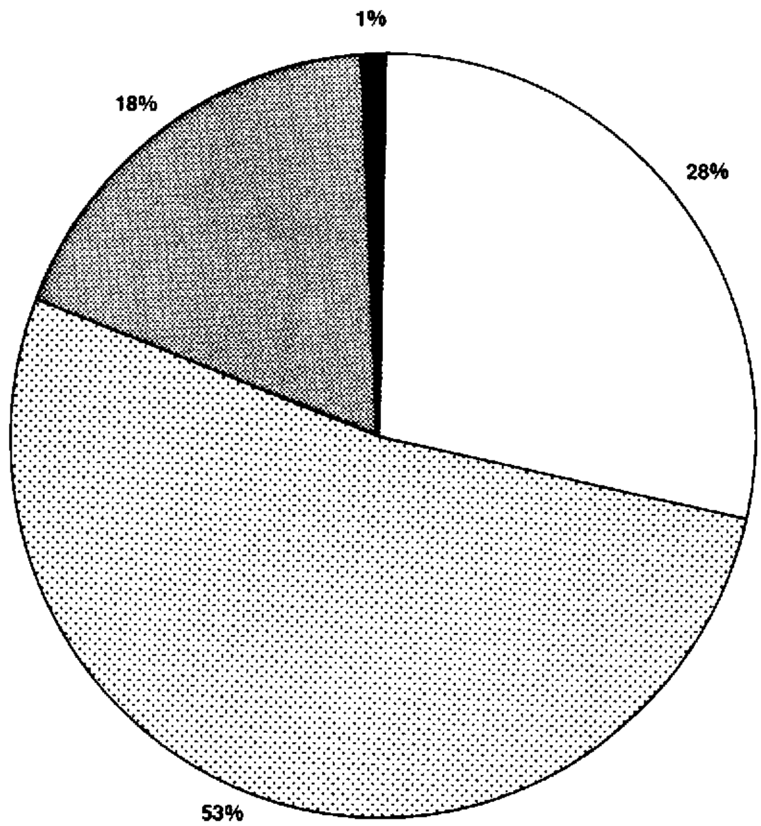


Figure 5.
Cinnabar moth infestation and damage levels — insect treatment area, 1989.



Damage Levels

None

Light
(< 1/3 of Seedheads Damaged)

Moderate
(1/3-2/3 of Seedheads Damaged)

Heavy
(> 2/3 of Seedheads Damaged)

Figure 6.
Seedhead fly damage levels – insect treatment area, 1989.

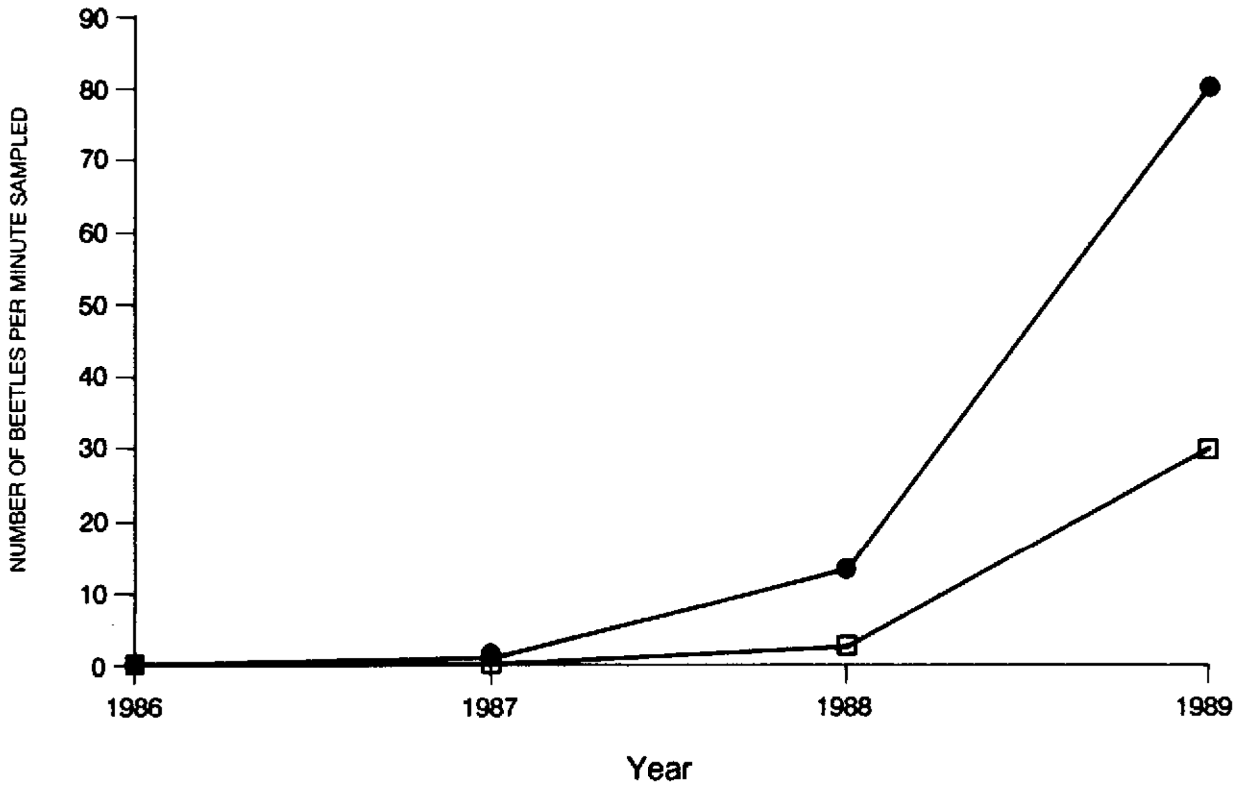


Figure 7.
Flea beetle population trend in study area, 1986-1989.

ALTERNATIVE TREATMENTS

Cost comparisons for 1986-88 suggested that insect application and hand pulling were more expensive than herbicide use (Table 4). The higher initial cost of biological control reflects the expense of establishing insect populations, a cost that will decline markedly if control is effective. Hidden costs for herbicide use are difficult to quantify, but include employee training and potential liability to the City. Monitoring costs, though not included in the estimates, are expected to be about the same for all of the treatments.

Table 4. Preliminary cost comparisons of treatments on tansy ragwort study area during 1986-88.[1]

	Hours	Rate[2]	Cost
MANUAL			
Labor	17.0	$28.00[2]	$476.00
Travel	8.5	28.00	238.00
TOTAL			**$714.00**
HERBICIDE			
Labor[3]	2.0	$28.00	$56.00
Travel	5.5	28.00	154.00
Chemical			2.00
TOTAL			**$212.00**
INSECTS			
Cinnabar Moth (larvae)			$0.00
Labor	6.0	$28.00	168.00
Travel	6.0	28.00	168.00
Subtotal			$336.00
Flea Beetle (adults)			$275.00
Labor	3.0	$28.00	84.00
Travel	3.0	28.00	84.00
Subtotal			$443.00
TOTAL			**$779.00**

[1] Higher set-up costs for biological control reflect the experimental nature of the project and the initial expense of establishing insect populations. Long-term maintenance costs of biological control are expected to be lower.
[2] Hourly rates used to estimate treatment costs were those of City right-of-way maintenance crews.
[3] Does not include cost of annual employee training.

A study of mechanical alternatives for controlling tansy ragwort (Parametrix 1988) concluded that manual removal can be effective on small, scattered populations. Larger infestations of ragwort require an integrated approach, such as a combination of biological and manual control. All methods require yearly monitoring for plant outbreaks, due to the resilient nature of ragwort and the longevity of its seeds. A new type of tool that could be effective for manual removal of ragwort is the weed wrench (Appendix A).

DISCUSSION

Results of the three years of study are still preliminary, given that insect populations are just now becoming established. In a survey of 42 sites in western Oregon, McEvoy (1988 personal communication) found that it took six years after beetle release for ragwort populations to decline to very low levels. A valid comparison of treatments can therefore only be made over the long term.

Current patterns of ragwort abundance within the study area appear to be determined largely by the presence of surface water, with minor effects due to manual and herbicide control. Ragwort is noticeably associated with Beverly Creek and its tributary channels, and is most abundant within the insect treatment area where winter flows are the highest. It is considerably less dense within the manual treatment area, where creek flows are lower and flowering plants have been pulled annually. Very little ragwort is present within the herbicide treatment area which lacks any direct influence from the creek. We suspect that Beverly Creek functions as a dispersal corridor for tansy ragwort, and provides a good medium for establishment of the plants, through seasonal watering and soil disturbance.

The occurrence of tansy ragwort at the mouth of Beverly Creek, and its distribution along the Sauk River suggest that wintertime flows may be dispersing seed downstream from the study area. Since there are at least 10 tributaries entering the surveyed reach of the Sauk River, it is quite likely that other local sources are also contributing to the spread of ragwort. The lack of ragwort seeds found in Beverly Creek during December may reflect the rapid removal of any ungerminated seeds from the soil surface during the first fall freshet.

Cinnabar moth and flea beetle populations in the study area have grown substantially in the last two years. Flea beetles hold the greater promise for biological control because they are hardier and more capable of suppressing ragwort on their own (Brown 1989 personal communication). The mild fall weather in 1989 allowed the beetles to breed well into December, raising the possibility that they produced a large brood of young. This phenomenon coincides with a proliferation of ragwort seedlings in the insect treatment area that may yield a bumper crop of flowering plants in 1990. We will be watching for a change in the expected pattern of ragwort abundance that could indicate that biological control is beginning to exert itself. We do not know what, if any, additional effect will result from the required clipping of seedheads within the insect treatment area.

The observed activity of flea beetles during fall flooding and their tolerance to immersion raises the possibility that flea beetles, like seeds, may be dispersed downstream by high water. This passive dispersal is most likely when flooding precedes freezing weather because flea beetles generally stop breeding and die with the first hard frost. Eggs and larvae of flea beetles are located well down in the plant material and resist the effects of flooding (Brown 1989 personal communication).

Preliminary cost comparisons among treatment types reflect the higher initial expense of establishing insect populations, and the relative scarcity of ragwort in the herbicide treatment area. Assuming that biological control proves feasible, the only expected long-term cost would result from monitoring, and, if necessary, periodic reintroductions of insects if their populations decline to very low levels. In contrast, manual and chemical control methods require continued, annual maintenance costs. All control methods will require yearly monitoring of ragwort populations.

CONCLUSIONS AND RECOMMENDATIONS

Results of the study to date show that the cinnabar moth and ragwort flea beetle are establishing populations from releases made on the right-of-way, and that the seedhead fly is already established from natural dispersal. Although insect populations are beginning to cause localized damage, they are still too small to suppress the tansy ragwort population. We expect this situation to change within the next 1-2 years. The spread of insects along the right-of-way may eventually reduce or eliminate the need for other methods of ragwort control.

Continued monitoring of insect, manual, and herbicide treatments is needed to compare the effectiveness of these control methods. Insect populations will continue to expand throughout the study area, so the study will measure the influence of biological control, with and without the other treatments. As long as these interactions are acknowledged, valid comparisons among treatments can still be made. To enhance the long-term survival of the insects, introductions should be considered in other problem areas where they are not already established.

Recommended additions to next year's study are to survey the headwaters of Beverly Creek for tansy ragwort, and to sample downstream sites near the mouth of the creek for flea beetles. These surveys will indicate whether there is any ragwort upstream of the study area that could affect the City's control efforts, and whether passive dispersal of flea beetles could make downstream introductions unnecessary. We also recommend that cost comparisons among control methods be discontinued. Three years of data are adequate to make a valid comparison, and further changes are unlikely to be significant. Other studies should be continued as in 1989.

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APPENDIX A

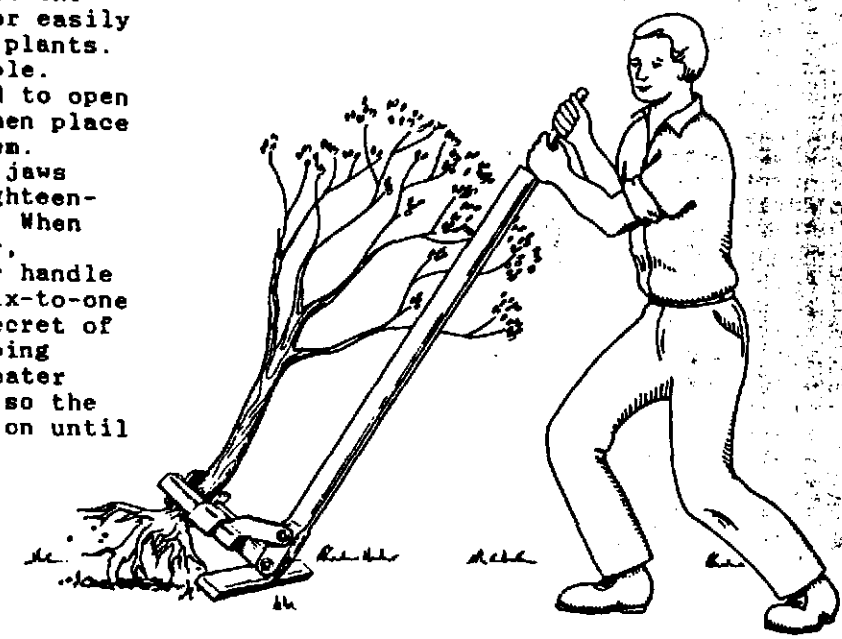
WEED WRENCH

A POSSIBLE TOOL FOR MANUAL CONTROL OF TANSY RAGWORT

WEED WRENCH got its start in June of 1988 in a volunteer effort for the National Park Service. We needed to come up with some way to control ever-expanding broom thickets in Golden Gate National Recreation Area, without resorting to herbicides or bulldozers. Our new "broom puller" was an instant success, and quickly turned out to have broader applications. The more people we talked to about restoration ecology, the more we heard about other exotic plant invaders threatening native plant communities. Agriculturists and landscapers also welcomed news of this device that could help them remove woody plants and small trees. Some people asked if our "broom puller" could pull stakes; used properly, we now know that it can.

If you have much weeding to do, you're well aware of the limits of what you can pull by hand. By the time a woody plant gets very large, a spinal disc is as likely to let go as the plant's root system. What's needed is a device with the right mechanical advantages in the right places to turn a difficult or even impossible task into a satisfying success.

HOW IT WORKS: Weed Wrench is the only weeding tool designed for easily grasping and uprooting <u>woody</u> plants. The concept behind it is simple. Rock the lever handle forward to open the jaws at ground level. Then place the jaws around the plant stem. Rock the handle back and the jaws close on the stem with an eighteen-to-one mechanical advantage. When the jaws can close no further, continue to pull on the lever handle to uproot the plant with a six-to-one mechanical advantage. The secret of Weed Wrench is that the grasping force increases at a much greater rate than the lifting force, so the jaws lock on and stay locked on until the plant has been defeated.



WEED WRENCH

COMES IN THREE SIZES: The most common objection to Weed Wrench is the weight. The HEAVY DUTY model is 25.5 pounds. That's about the same as a three-gallon herbicide sprayer, and you don't have to walk back to refill a Weed Wrench. Most users find the weight a small price to pay for the effectiveness, and once you arrive at the job site the weight rests on the ground most of the time, anyway. At any rate, the caloric expenditure carrying and operating a Weed Wrench is far less than any other human-powered removal method yet devised. Since not all jobs require such a big tool, we also offer MEDIUM DUTY (17.25 lbs.) and LIGHT DUTY (11.75 lbs.) models. There is no lower limit to the size of plant any Weed Wrench can pull, as long as the plant has a woody stem to grip. Of course all three models have their respective upper limits (see stem sizes specified on our order sheet).

NEW TRIBE

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