# Tansy Ragwort Control Program
# Cedar River Municipal Watershed
# 1999 – 2017


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# Introduction

The Cedar River Municipal Watershed (CRMW) is managed under the 50-year Cedar River Watershed Habitat Conservation Plan (CRW-HCP) (City of Seattle 2000). "The overall goal of the HCP is to implement conservation strategies designed to protect and restore habitats of all species of concern that may be affected by the facilities and operations of the City of Seattle on the Cedar River, while allowing the City to continue to provide high quality drinking water and reasonably priced electricity to the region." (CRW-HCP: 2.4-43). The CRW-HCP mandates restoration of natural processes and functions, with a goal of fostering natural biological diversity. According to the United States Fish and Wildlife Service, non-native species threaten as many as two thirds of all threatened or endangered species in the United States, and are second only to habitat destruction as the largest threat to biodiversity. Consequently, controlling or eliminating non-native invasive species is critical to achieving the goals of the HCP.

The City of Seattle has had a policy since 1989 to not apply herbicides in the CRMW, limiting options for control of tansy ragwort to manual pulling. Watershed natural resources staff initiated the first surveys of tansy ragwort (*Senecio jacobaea)* in 1999, along with very limited control efforts. Survey and control efforts were minimal during 2000 and 2001 due to limited staff availability. Survey efforts were increased in 2002 to cover additional road systems not covered in 1999, and most plants encountered were pulled. Starting in 2003, most drivable roads were surveyed at least every other year, with sections of road where any tansy ragwort had been found within the past five years surveyed and controlled annually. Since that time all bolting plants encountered were documented and pulled.

**Legal Designation**

Tansy ragwort was first reported in British Columbia in 1913. It appeared in Portland, Oregon, in 1922 and spread into Washington shortly thereafter. The Washington State Noxious Weed Control Board has designated tansy ragwort a Class B weed, meaning that it is established in some regions of Washington, but is of limited distribution or not present in other regions of the state. Because of differences in distribution, treatment of Class B weeds varies between regions of the state. In regions where a Class B weed is unrecorded or of limited distribution, prevention of seed production is required by state law. In regions where a Class B species is already abundant or widespread, control is a local (county) option. Tansy ragwort is also listed on the Washington noxious weed seed and plant quarantine list, meaning it is prohibited to transport, buy, sell, or distribute within Washington State.

Tansy ragwort is prevalent in portions of King County (heaviest infestations are in areas surrounding Auburn, Enumclaw, Maple Valley, and Covington), so legally mandated control is a county option. The King County Noxious Weed Control Board has designated tansy ragwort as a Class B Weed within all of King County, legally requiring control and containment by all property owners. This mean property owners must not let any plants on their property reproduce or disperse.

**Life History**

Tansy ragwort is a biennial or short-lived perennial in the daisy family, Asteraceae. It typically grows in full sun to partial shade on disturbed sites such as roadsides, gravel bars, meadows, and in recently cleared areas. The seeds normally germinate in fall or early winter and produce a rosette of deeply lobed leaves up to nine inches long during the first year. Flower stalks develop the second year, growing from one to six feet tall, with many flowering branches near the top. Numerous bright yellow daisy-like flowers containing 10-15 ray petals with golden or light brown centers are clustered at the top of each branch (Figure 1). Flowers begin to appear in lower elevations in the CRMW in late June and some plants have been found flowering as late as December during years with a warm autumn.

**Figure 1**. Flowering tansy ragwort infestation on a gravel bar along the Cedar River (left) and several tansy ragwort rosettes growing in a ditch along a heavily traveled road (right)

Plants in the CRMW usually form seeds from mid-August through October and a large plant can produce as many as 150,000 seeds in one year (King County 2002). Seeds are very small and tipped with hair-like plumes, an adaptation for long-distance dispersal by wind. They are also easily dispersed by animals, in hay, and on equipment or vehicles. Most seeds are naturally dispersed less than ten feet from the parent plant, however. One study in Oregon found that 89% of all tansy ragwort seeds dispersed less than five meters from the parent plant (McEvoy and Cox 1987). Seeds can remain viable in the soil for more than15 years.

Tansy ragwort can create large infestations in areas lacking other vegetation, and ground disturbance often causes dormant seeds to germinate (McEvoy and Rudd 1993). Unvegetated and disturbed roadsides are an ideal location for initiation of a tansy ragwort infestation and are the most common location for the species in the CRMW. All portions of tansy ragwort plants are poisonous and contain pyrrolizidine alkaloids that can cause liver damage to grazing ungulates and other herbivores, including insects.

**Similar Species**

Tansy ragwort can be confused with other commonly seen plants in the Pacific Northwest, including common tansy (*Tanacetum vulgare*), common groundsel (*Senecio vulgaris*), and common St. John's wort (*Hypericum perforatum*) (Figure 2). Common tansy grows to the same height as tansy ragwort, but the flowers lack ray petals and the leaves are more dissected and feathery. It is also poisonous, but because the taste is bitter, herbivores rarely eat the plant. Common groundsel is an annual growing to a height of 4 to 18 inches. The leaves are lobed like tansy ragwort, but are generally smaller and the flowers lack ray petals. Common groundsel is less toxic than tansy ragwort.  Common St. John's wort has similar flowers to tansy ragwort, but they have fewer petals and the leaves are small and rounded.

**Figure 2.** Common tansy with feathery leaves and lacking ray petals (upper left), common groundsel with similar leaves but lacking ray petals (right) and common St John's wort with fewer petals and small rounded leaves (lower left)

**Biological Control**

Classical biological control involves the introduction and management of selected natural enemies of a non-native invasive plant.  Because non-native species are free from the natural enemies found in their homelands, they have a competitive advantage over native plants and can become invasive.  Biological control reunites the invasive plant with its natural enemies, usually some type of insect.

The practice of biocontrol is regulated and guided by federal and state laws, an International Code of Best Practices, and specific protocols that are designed to ensure the safety and effectiveness of biocontrol programs.  Organisms selected for biocontrol are imported into the United States only after rigorous testing for host-specificity to ensure that the potential biocontrol agent attacks only the target invasive plant, will be limited in the host range, and will not threaten any endangered, native, or crop plants.

Federal and state governments provide rigid guidelines for testing, importation, and quarantine of biocontrol agents, and extensive biological data are required by state and federal agencies before agents can be released from quarantine. Foreign exploration, quarantine, rearing, and host specificity testing all follow a specific set of guidelines and protocols established and monitored by the Technical Advisory Group (TAG) on the Introduction of Biological Control Agents of Weeds of the USDA Animal and Plant Health Inspection Service (APHIS). TAG members review petitions for candidate biocontrol agents and provide information and advice to researchers and those in APHIS responsible for issuing permits for importation, testing, and field release of biocontrol agents. The entire process, from initial identification of an agent to final release in the United States, takes many years, often more than a decade.

Three insects have been approved for biological control of tansy ragwort. The cinnabar moth (*Tyria jacobaeae*), a red and black moth, can be seen on plants during May and June. Eggs are deposited and hatch in 1-3 weeks. The caterpillars are easily recognized by their black and orangish bands (Figure 3). They pupate in the soil and emerge the following spring as adult moths. The cinnabar moth can help reduce tansy ragwort growth in heavily infested areas. However, one study found that while the cinnabar moth reduced the fecundity of tansy ragwort, it did not cause reductions in the biomass or cover of the plant (McEvoy and Rudd 1993).

**Figure 3**. Cinnabar moth, caterpillars (left) and adult (right)

A second insect, the ragwort seed fly (*Botanophila seneciella*), emerges in June when tansy ragwort plants are beginning to develop flowers. The larvae feed on the developing seeds for several months and can eat up to 95 percent of the seeds. The presence of the ragwort seed fly can be recognized by a frothy substance on the top of the floret. When present in combination with other biocontrol agents, it can help reduce tansy ragwort fecundity, but as with the cinnabar moth, likely not biomass or cover of the plant.

The third insect, the tansy ragwort flea beetle (*Longitarsus jacobaeae*), is the most effective biocontrol for tansy ragwort in the Pacific Northwest (Figure 4). It was first released in the United States in 1969, and there are many documented successes of the flea beetles virtually eliminating large tansy ragwort patches (Jennifer Andreas, pers. comm.). The tansy flea beetle lays eggs in the fall on rosettes or in the nearby soil. When the larvae hatch, they burrow into the tansy ragwort roots and feed on them. Adults emerge in the spring and feed on tansy ragwort leaves before entering a resting phase during the summer. High numbers of tansy flea beetles can reduce local tansy ragwort populations significantly. The activity of the ragwort flea beetle complements the damage done by the cinnabar moth to tansy ragwort plants (Burrill et al. 1984). McEvoy and Rudd (1993) found that the flea beetle reduced tansy ragwort survival and had a measurable impact regulating abundance. Reductions of up to 90% in tansy ragwort populations are not uncommon once the tansy ragwort flea beetle population becomes established.

**Figure 4.** Tansy flea beetle

## Objectives

The tansy ragwort control program objectives are to:

- Comply with the legal mandate to control and contain tansy ragwort on lands owned by the City of Seattle in the CRMW.
- Track long-term trends in the distribution and density of tansy ragwort in the CRMW.
- Identify potential factors affecting the distribution and density of tansy ragwort in the CRMW.
- Conduct an experimental biocontrol program on appropriate sites.
- Evaluate the effectiveness of the tansy ragwort control program in the CRMW.

- Make recommendations to guide future management efforts to control tansy ragwort in the CRMW.

## Methods

Surveys along drivable roads are conducted by zeroing the vehicle odometer at a known road junction and driving slowly until a tansy ragwort plant is detected, often by the flowering head, although experienced surveyors can easily find bolting plants before any flowers are present. The surveyor records the number of bolting tansy ragwort plants successfully pulled (i.e., the entire root is extracted), along with the vehicle mileage (to the tenth of a mile) and direction from the known starting point, whether the plant was within a right-of-way, and any appropriate notes (see example of datasheet in Appendix I). In some cases, decommissioned roads or roads that are not currently drivable are walked, with distances from known starting points estimated.

Active gravel pits are checked and controlled multiple times per year. In addition, tansy ragwort is controlled wherever it is found during unrelated surveys in wetlands, meadows, along streams and rivers, and other off-road habitats. All surveys conducted by experienced biologists are comprehensive, meaning that legally required or ecologically damaging invasive species either known to be present in the CRMW or with the potential to be present are documented wherever found and controlled as appropriate. This is part of the Early Detection/Rapid Response protocol described in the Invasive Species Strategic Management Plan, found online at: http://www.seattle.gov/util/EnvironmentConservation/OurWatersheds/Habitat_Conservation_Plan/ManagingtheWatershed/ProtectWatershedHabitats/ProtectionEfforts/index.htm#invasiveSpecies.

From 1999 to 2003 the entire tansy ragwort plant was left to desiccate on the roadbed after it was pulled. Early in the 2003 season, staff observed that these pulled plants were producing apparently viable seeds which were being spread by vehicular traffic. Consequently, since then we have cut off and bagged all flowers and disposed of them in the garbage. We usually leave the stalks and roots near the roadbed to desiccate on site, although we may dispose of entire small plants in the garbage.

In 2003, surveyors began recording the presence of cinnabar moths and caterpillars on plants. In cases where the caterpillars were especially abundant, the flowers were removed but the remainder of the plant was left in situ for the insects to consume. Staff found, however, that plants defoliated by the caterpillars subsequently flowered again in late September once the caterpillars began pupating. Consequently, starting in 2004 all bolting and flowering plants, even those with abundant caterpillars, were pulled and caterpillar data were no longer recorded.

Plants in the rosette stage are occasionally pulled, but these data are recorded separately from the bolting plants, to ensure data consistency. We found that pulling rosettes often results in the root breaking off. The plants rapidly regrow from root fragments, so in recent years only the occasional rosette in very soft soil is pulled. Roots of bolting plants are much easier to completely extract.

Because plants grow at variable rates throughout the growing season, in order to ensure we control all plants, we need to survey and control along roads with high rates of infestation a minimum of three times per year. Some heavily infested roads are controlled much more often. Logistically we can only survey roads with isolated plants once per year. As such, we try to time those surveys such that most plants at that elevation will be in full flower, but not yet seeding, to try and capture most growth stages. Often plants are pulled incidental to other work, so we always carry datasheets with us, to ensure that all pulled plants are documented.

Each year all raw data are entered into spreadsheets and then summarized by individual road and road system. The location data are entered into ArcGIS and displayed on maps to analyze tansy ragwort distribution, abundance, and response to control efforts over time. Plant density is grouped into four categories (1-9, 10-49, 50-99, and >100 plants) and mapped by 500 foot intervals along all roads surveyed using color codes. This method allows us to simultaneously illustrate both density and distribution.

## Results

**Distribution and Status 1999 – 2001**

The first surveys to assess the distribution and abundance of tansy ragwort in the CRMW were undertaken in 1999, from late July to early October. Portions of most road systems were driven, with a total of 208 miles surveyed. A total of about 3,900 plants were estimated to be present in the entire CRMW, but individual plants were not counted and only a limited number of plants were pulled.

The distribution of the plants in 1999 was concentrated in the lower watershed along the major travel corridors (the 9, 10, and 50 Roads), and along the western and southern boundaries (Appendix II). Primary distribution in the upper watershed was limited to the section of the 100 Road system west of the Masonry Pool, portions of the 100 Road near Chester Morse Lake, and the 121 Road. The remaining distribution consisted of isolated locations with low densities (less than 9 plants per 500 feet) in all other road systems surveyed, except the 150 and 500 Road systems, where no plants were detected.

Very limited surveys were conducted in 2000, when only 64 miles were surveyed and 3,118 plants were individually counted and pulled. Virtually no survey or control work was conducted in 2001 (only 230 plants pulled). Consequently, information on the distribution and status of tansy ragwort during 2000 and 2001 is not available.

**Distribution 2002 - Present**

Comprehensive survey and control of tansy ragwort in the CRMW began in 2002. Miles of road surveyed during 2002 was comparable to that of 1999, with approximately 180 miles of road surveyed. Surveys were conducted from early August to mid-October, analogous to the timing of the 1999 surveys. After 2002, survey and control work was timed more closely with the growing season, generally mid-June through October. The most comprehensive road surveys were conducted in 2003, when over 460 miles of road were surveyed. Since that time, an average of 336 miles were surveyed annually (Figure 5). We generally try to conduct more extensive surveys every two to three years, to ensure that we are capturing all isolated tansy ragwort clusters. All roads where we have found any tansy ragwort within the past five years are surveyed annually.

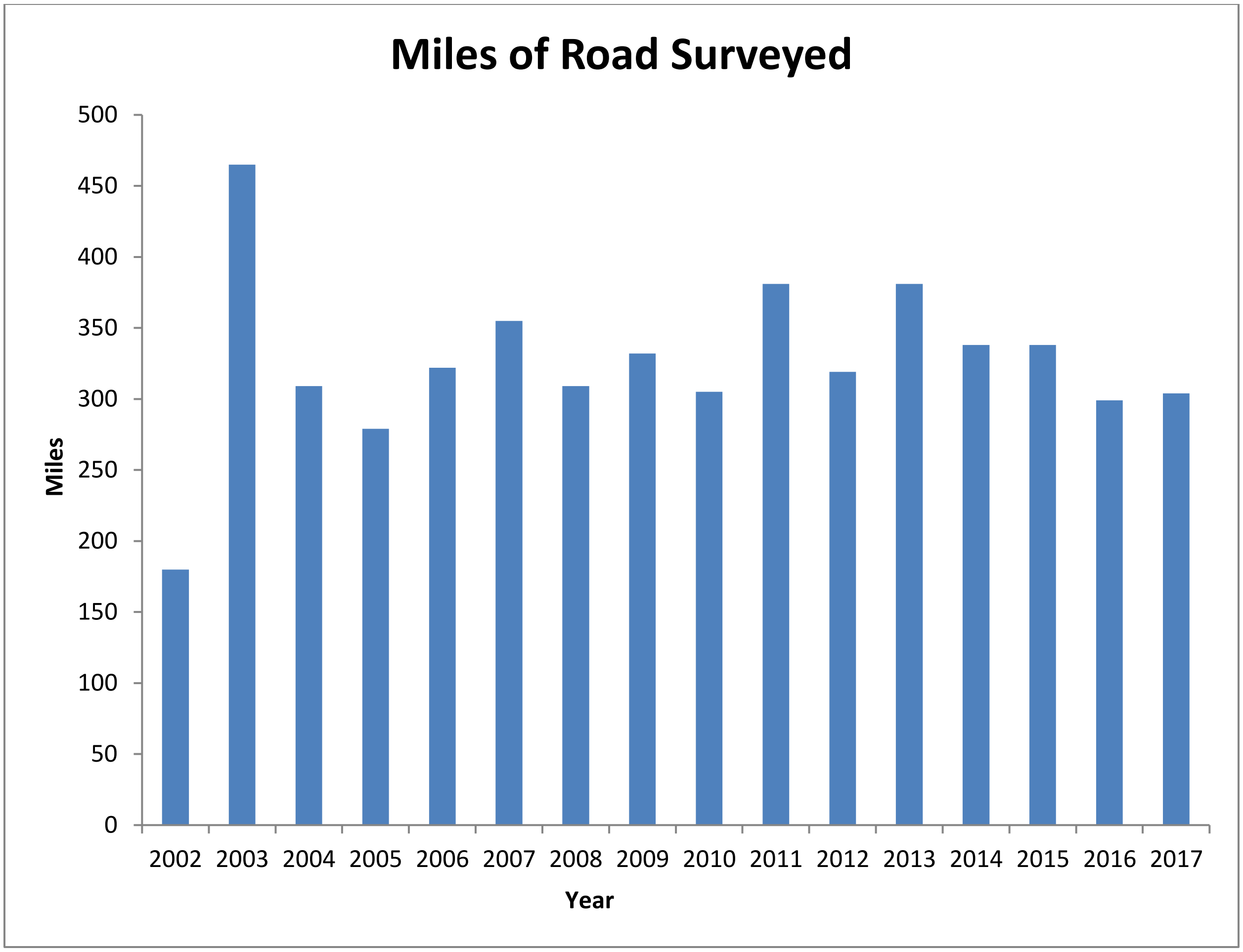

**Figure 5**. Annual miles of road surveyed for tansy ragwort in the CRMW

Distribution has remained generally consistent throughout the years, with the majority of plants concentrated in the lower CRMW along the major travel corridors and the southern and western borders (see Appendix II for distribution and density maps by year). Many roads in the 30, 40, and 50 road systems, as well as the 9 road, have had plants found along virtually all 500-foot segments of drivable roads in most of the years. Many of these roads are heavily traveled and frequently disturbed for maintenance and repair, which provide conditions favorable for tansy ragwort persistence. Many of these areas also had high initial tansy ragwort densities, and so a large seed bank which can remain viable for more than 15 years. Decommissioned roads in the lower watershed that had moderate numbers of plants before the decommissioning (e.g., the 57 road decommissioned in 2011 and the 58.2 road decommissioned in 2010) continued to have persistent patches for several years, although numbers are also decreasing over time.

Most plants in the upper watershed are found along the 100 and 120 roads, and in the 800 and Little Mountain systems. Small clusters or individual plants are generally scattered in low densities throughout the rest of the upper watershed. Location of persistent patches in the upper watershed has generally been on south facing slopes where snowpack melts quickly in the spring (e.g. 120 and Little Mountain Road systems). The longer growing season, drier conditions, and greater sun exposure found in these road systems may provide better conditions for tansy ragwort. Some of these road systems have also been the focus of road decommissioning work, and the initial disturbance may have played a role in the successful colonization and reproduction in these areas. However, the lack of on-going disturbance and the eventual regrowth of shrub and tree layers on the decommissioned roadbed should suppress the tansy over the long term. Decommissioned roads in the upper watershed that have been undisturbed for several years, had low initial numbers of tansy, and that now have good competing native vegetation, currently have few to no tansy ragwort plants present (e.g., the 390 system decommissioned in 2001 and the 812 road decommissioned in 2011).

During 2003-2005, staff installed 148 permanent vegetation plots within upland and riparian forests throughout the CRMW. Eighty-seven of the upland forest plots were resampled from 2011 to 2014. No tansy ragwort plants were found in any of these plots during any of the sample periods, likely because of the general lack of disturbance and seed source within the forest. In areas of natural disturbance in upland forest areas (e.g., landslides, wind-throw) no tansy ragwort plants have been found, likely because of no pre-existing seed bank and lack of a nearby seed source.

Climate change is predicted to result in warmer temperatures and less snowpack in the winter, with potentially larger or more frequent storms and flood events. Drought stress could increase the chance of insect or disease outbreaks, and the risk of large wildfire could also rise. Increased ground disturbance would increase the risk of invasion by tansy ragwort. However, if monitoring and control is continued annually, thereby minimizing the seed source, this should help ameliorate the risk.

**Control 2003 - Present**

The relatively small number of tansy ragwort plants (3,900) estimated to be present in the CRMW in 1999 had increased significantly by 2003 to over 19,000 plants. The 1999 estimate was undoubtedly low, but tansy ragwort populations can increase exponentially under appropriate conditions, and this may have played a factor as well.

Number of bolting plants pulled peaked in 2005 at more than 23,000 plants (Table 1). The annual total number of plants pulled had no consistent pattern from 2002 through 2009, ranging from around 8,000 to over 23,000. This is likely due to varying levels of annual ground disturbance along roads, usually from road maintenance and upgrade projects. Because of the longevity of the seeds, this disturbance continued to stimulate the existing seed bank. With consistent prevention of seeding over many years, the seed bank should eventually be depleted, and ground disturbance should no longer trigger growth from pre-existing seeds, although it will provide good substrate for any new seeds that are transported to the area.

Since 2009 there has been a downward trend of pulled plants, which likely represents a decreasing tansy ragwort population in the CRMW, along with a decreasing seed bank of viable seeds. From 2008 to the present, the lower watershed has contained >80% of all tansy ragwort plants, which correlates with the distribution data. The 9, 10, and 50 road systems, the most heavily traveled roads in the lower watershed, have consistently had the highest numbers of plants throughout all the years.

**Table 1**. Total number of bolting tansy ragwort plants pulled by road system and year.

| Road System | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 9 | 2,928 | 7,409 | 7033 | 3,793 | 1,496 | 1,069 | 2,377 | 2,383 | 1,543 | 561 | 606 | 876 | 855 | 1,097 | 1,085 | 451 |
| Biocontrol 9 system | | | | 529 | 1,575 | 1,283 | 1,053 | 990 | 735 | 458 | 336 | 518 | ended | | | |
| 10 | 550 | 1,577 | 1542 | 2,781 | 1,037 | 995 | 1,674 | 1,371 | 651 | 949 | 645 | 518 | 495 | 785 | 402 | 471 |
| | | | | | | | | | | | | | | | | |
| Biocontrol 10 system | | | | 441 | 1,085 | 238 | 635 | 412 | 269 | 90 | 40 | 14 | 158 | ended | | |
| 20 | 0 | 194 | 178 | 369 | 219 | 94 | 115 | 351 | 135 | 128 | 168 | 47 | 47 | 48 | 97 | 120 |
| 30 | 367 | 283 | 80 | 406 | 429 | 163 | 235 | 229 | 108 | 250 | 152 | 80 | 122 | 95 | 38 | 161 |
| 40 | 240 | 282 | 238 | 1,666 | 465 | 281 | 833 | 1,126 | 524 | 578 | 405 | 331 | 391 | 477 | 324 | 391 |
| 50 | 2,235 | 5,715 | 1924 | 5,452 | 4,068 | 1,847 | 6,248 | 6,259 | 4,019 | 2,222 | 2,722 | 2,282 | 2,193 | 1,959 | 1,707 | 1,347 |
| 60 | 102 | 106 | 67 | 224 | 323 | 81 | 187 | 379 | 219 | 197 | 105 | 161 | 64 | 123 | 93 | 52 |
| 70 | 329 | 135 | 264 | 422 | 270 | 60 | 277 | 351 | 259 | 302 | 136 | 124 | 57 | 103 | 208 | 118 |
| 80 | 183 | 319 | 381 | 733 | 171 | 152 | 579 | 695 | 558 | 312 | 294 | 294 | 372 | 306 | 391 | 322 |
| 90 | 1 | 29 | 33 | 1 | 0 | 15 | 3 | 8 | 3 | | 5 | | | | | |
| Biocontrol 91 system | | | | | | 300 | 280 | not monitored – no access | | | | | | | | |
| **Total Lower Shed** | **6,935** | **16,049** | **11,740** | **16,817** | **11,138** | ***6,578*** | ***14,496*** | **14,554** | **9,023** | **6,047** | **5,614** | **5,245** | **4,754** | **4,993** | **4,345** | **3,433** |
| | | | | | | | | | | | | | | | | |
| 100-107 | 741 | 1,044 | 422 | 423 | 467 | 413 | 1,221 | 1818 | 1390 | 740 | 492 | 489 | 674 | 277 | 602 | 461 |
| 110 | 1,648 | 17 | 1 | 12 | 11 | 39 | 169 | 70 | 86 | 13 | 19 | 9 | 13 | 4 | 1 | 2 |
| 120 | 1,707 | 2,037 | 2849 | | 50 | 2 | 19 | 37 | 23 | 27 | 16 | | 58 | 76 | 36 | 126 |
| Biocontrol 120 system | | | | 4,256 | 4475 | 806 | 681 | 678 | 322 | 182 | 73 | 12 | ended | | | |
| 150 | 0 | 2 | 0 | 0 | 2 | 3 | 1 | 1 | 0 | 0 | 1 | 3 | 1 | 0 | 0 | 0 |
| Biocontrol Cedar | | | | 1,336 | 548 | 105 | not monitored | | | | | | | | | |
| 200 | 13 | 158 | 25 | 197 | 114 | 114 | 95 | 207 | 122 | 42 | 81 | 24 | 30 | 19 | 15 | 10 |
| 300 | 1 | 2 | 0 | 16 | 4 | 18 | 5 | 24 | 3 | 7 | 2 | 5 | 5 | 3 | 0 | 1 |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Little Mountain | 378 | 5 | 1 | 221 | 163 | 106 | 58 | 143 | 8 | 19 | 33 | 13 | 30 | 15 | na | 27 |
| 400 | n/a | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 500 | 0 | 11 | 1 | 0 | 4 | 11 | 0 | 3 | 0 | 14 | 2 | 7 | 18 | 2 | 3 | 2 |
| 600 | 11 | 9 | 1 | 12 | 0 | 3 | 2 | 1 | 0 | 3 | 1 | 0 | 3 | 0 | 0 | 0 |
| 700 | 96 | 21 | 35 | 68 | 1 | 33 | 36 | 78 | 274 | 139 | 97 | 17 | 19 | 23 | 15 | 19 |
| 800 | 35 | 31 | 4 | 48 | 29 | 41 | 46 | 56 | 19 | 36 | 70 | 19 | 20 | 19 | 27 | 5 |
| **Total Upper Shed** | **4,630** | **3,337** | **3,339** | **6,589** | **5,868** | ***1,694*** | ***2,333*** | **3,116** | **2,247** | **1,222** | **887** | **598** | **871** | **438** | **699** | **653** |
| | | | | | | | | | | | | | | | | |
| Year | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
| **Total entire CRMW** | **11,565** | **19,386** | **15,079** | **23,406** | **17,006** | **8,272** | **16,829** | **17,670** | **11,270** | **7,269** | **6,501** | **5,843** | **5,625** | **5,431** | **5,044** | **4,086** |
| **Miles road surveyed** | 180 | 465 | 309 | 279 | 322 | 355 | 309 | 332 | 305 | 381 | 319 | 381 | 338 | 338 | 299 | 304 |

## Experimental Biocontrol Plots

Seven experimental tansy ragwort flea beetle biocontrol plots were established in 2005. In 2005 and 2006 baseline number of tansy ragwort plants were counted in each plot. In 2007 two biotypes of flea beetles were released at the seven plots (Table 2). An Italian biotype was used at lower elevations and a Swiss biotype at higher elevations. We did a supplemental release of the Swiss biotype on the 120 Road in 2008. The Italian beetle biotype was released in October of 2007, while the Swiss biotype was released in late July in 2007 and early August in 2008.

In plots along major travel corridors (9, 120 roads) flowers were clipped annually to prevent seeding but the plants were allowed to continue to grow to provide substrate for the beetles. On the remaining more isolated plots, plants were allowed to seed, to allow the beetle populations to develop in a more natural way. In 2008 we established an additional plot on the 9 Road (Plot 9AB) where beetle activity was noticed. Evidently the beetles had moved from the two original release locations on the 9 Road.

**Table 2**. Experimental biocontrol plots, CRMW.

| Plot name | Location description | Elevation (ft) | Treatment | Beetle biotype | # beetles released 2007 | # beetles released 2008 |
|---|---|---|---|---|---|---|
| **Lower Watershed** | | | | | | |
| 9 Road, Plot A | 1.0 – 1.7 miles west of 9/54 (active road) | 720 | Count and clip flowers | Italian | 840 | |
| 9 Road, Plot AB | 2.5 - 3.2 miles west of 9/54 (new in 2008) | 640 | Count and clip flowers | | | |
| 9 Road Plot B | 4.1-4.5 miles west of 9/54 (active road) | 600 | Count and clip flowers | Italian | 840 | |
| 10.6 road | Deadend spur off 10 Road | 900 | Count only, leave flowers | Italian | 840 | |
| Cedar Landsburg | Cedar River upstream of Landsburg | 520 | Count only, leave flowers | Italian | 840 | |
| 91 Road | Decommissioned road in Selleck Area. | 1300 | Count only, leave flowers | Italian | 840 | |
| **Upper Watershed** | | | | | | |
| 120 Road | 1.5 miles north of 100/120 for 1.3 miles (active road) | 2700 | Count and clip flowers | Swiss | 150 | 500 |
| Cedar CML | Cedar River upstream of Chester Morse Lake | 1600 | Count only, leave flowers | Swiss | 150 | |

Plots were monitored for beetle activity during the annual counts and flower clipping. Small round holes in the leaves (feeding holes) as well as sightings of adult beetles, indicated establishment of the beetle population. Monitoring was discontinued on two plots in 2009 due to lack of access (91 Road) and a change in river course which flooded the plot site (Cedar River above Chester Morse Lake). The plot along the Cedar River near Landsburg never had any sign that the beetles established. It may have been too wet, as much of the site was periodically flooded. The remaining plots (9A, 9B, 9AB, 10.6, and 120 roads) all had indications that the beetles did establish a population.

The beetles appeared to greatly reduce tansy ragwort plant numbers in the plots where they established (Figure 6). The Swiss strain was particularly effective. Prior to release, over 4,400 plants were counted along the 120 road. By 2013, only 12 plants were present. Similar declines were seen in the lower watershed. In the three plots along the 9 road, there were over 1,200 plants before release, declining to less than 160 in 2014. Finally, along the 10.6 road, there were over 1,000 plants prior to release, declining to only 14 in 2013. By 2014, signs of beetle occupation were declining or absent, likely because there were now too few tansy ragwort plants to support a viable beetle population, and number of plants began to increase. So the experiment was terminated, and all sites reverted to regular control by pulling.

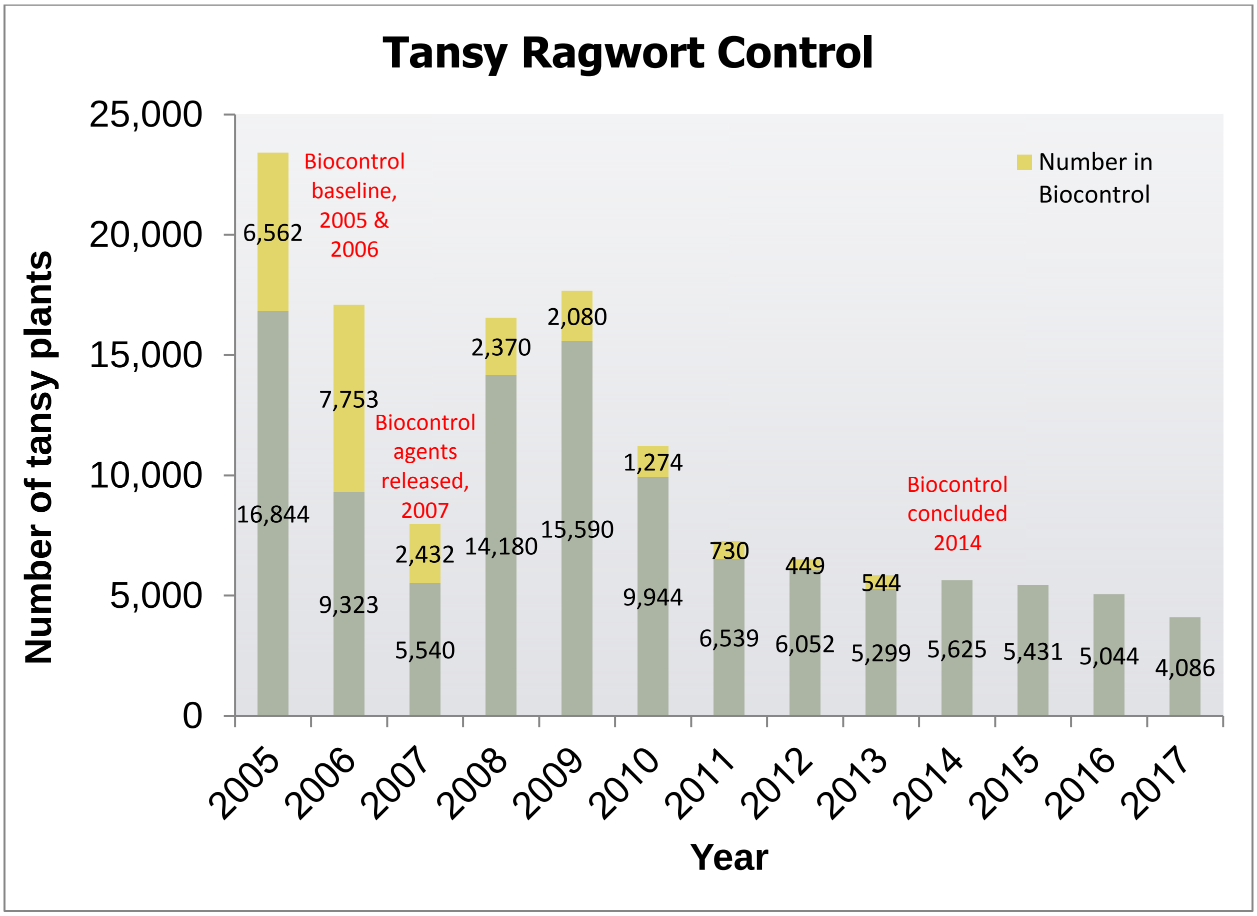


**Figure 6**. Annual number of tansy ragwort pulled or included in biocontrol experiments.

## Effectiveness

Data indicate that manual pulling combined with biocontrol using the tansy ragwort flea beetle is an effective control method in the CRMW. The total number of plants has dropped by almost six-fold, from its high of over 23,000 plants in 2005 to its recent low of approximately 4,000 plants. Additionally, the number of 500-foot road segments containing more than 100 plants has declined from a high of 44 in 2005 to only one road segment containing more than 100 plants in

2017. Total number of road segments containing from 50 to 100 plants has had a similar decline, from 68 in 2005 to one in 2017.

Comprehensive surveys, combined with extensive pulling conducted over many consecutive years, appears to be key to success. Allowing even a few plants to seed refreshes the local seed bank and will significantly increase the length of time that it will take to control or eradicate the patch. If the current level of effort is not continued, the significant gains made could quickly be lost. This is supported by early data from the 9 Road, where a density of 142 plants per mile in 1999 increased to 644 plants per mile in 2003 after four years with no control. Continuing to remove the flowering portion of the plant is also essential to success. Removing and bagging the flowers is not time consuming and is critical to reducing the seed bank of tansy ragwort.

Biocontrol with the tansy ragwort flea beetle was very successful in areas where the beetles established. There are no longer areas with high concentrations of tansy ragwort plants, so this method of control will no longer be viable. Starting in 2014, the entire watershed is controlled using hand pulling.

## Recommendations

The following recommendations have been followed during recent years and have contributed to the success of this program:

### Survey and Control

- Continue to annually survey at a level similar to previous years (i.e., an average of 330 miles of active road per year). At the end of 2017, there are about 365 miles considered either primary or secondary roads that will continue to be regularly driven and frequently maintained. Approximately 225 miles of road have already been decommissioned under the HCP, with an additional 46 miles of road slated for decommissioning 2018-2021. A portion of the decommissioned roads should be surveyed and controlled each year, especially those recently decommissioned roads that had pre-existing tansy ragwort populations.
- Pull tansy ragwort at a level of effort similar to those of previous years. This includes surveying roads with moderate densities a minimum of three times (often many more) throughout the growing season. Roads with high densities should be surveyed every two to three weeks. Pull all bolting plants, making sure to extract all root fragments, and clip the flowering heads off all plants or bag the entire plant. Remove bagged plants from the site in a sealed container, and dispose of them in the garbage.
- Conduct surveys and control efforts prior to planned brushing and ground-disturbing activities (e.g., gravel pit expansion, bridge replacement, road decommissioning, road maintenance, thinning projects) to the greatest extent possible.
- Check active gravel pits for infestations multiple times throughout the growing season.
- Maintain the current level of data collection and analysis so that any unusual trends can be quickly detected and dealt with.

- Ensure field personnel working on and near roads can accurately identify the plant and alert trained staff about the presence of the plant prior to any ground disturbing activity (e.g., gravel pit excavation, road grading).

**Road Maintenance**

- Avoid mowing or regrading roads with high densities of plants during summer until after plant removal during the peak of flowering.
- Frequently clean the equipment used to brush roads to avoid spreading invasive species to other sites.
- Clean culverts prior to transport to field sites if they have been located in an area where weeds have seeded (e.g., the culvert yard).
- Keep brushing heights above 6 inches to maintain existing native shrubs and discourage non-native invasive species from establishing.
- Minimize the brushing schedule on non-essential roads, while ensuring that roads are safe and access is adequate for fire protection purposes.
- Minimize grading, especially on secondary roads.

**Road Decommissioning**

- Ensure hay used for erosion control is certified clean of all weed seeds.
- Clean heavy equipment prior to use, especially if it was stored in an area infested with invasive species.
- Replant areas that had infestations prior to the decommissioning using native shrub and tree species that can provide shade, making the site less favorable for tansy ragwort.

## References


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# APPENDIX I

Example of tansy ragwort data collection sheet.

## *Tansy Ragwort Control -- ONLY RECORD A PLANT IF THE ENTIRE ROOT IS PULLED*

***Date:*** *Observer:* ______________________________

***General Location:***

*Plants in bloom? Yes No Some (circle one)*
*Plants seeding? Yes No Some (circle one)*

| Road Name | ROW? Check if Yes | START Location (Road Junction) | Direction | END Location | Distance (to 0.1 mi) | Count of BOLTING Tansy Ragwort | FROM (GIS) | TO (GIS) | Notes |
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