# A Review of Non-Native Plants in the Valdez Creek Mining District, Alaska, and Invasive Plant Management Guidance

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Cover photo: Common dandelion (*Taraxacum officinale*) growing on disturbed gravel roadside above Valdez Creek.

## Acknowledgements

The Bureau of Land Management, Anchorage Field Office funded this project. In particular, Laurie Thorpe (BLM) was instrumental in mobilizing this effort and conducted an earlier reconnaissance visit of the mining area. Thanks to Matt Carlson, Timm Nawrocki (Alaska Natural Heritage Program, UAA), and Charlotte Crowder (Chicago Botanic Gardens, Bureau of Land Management) for participating in field data collection. Matt Carlson also offered comments and edits to previous drafts of this report.

## Introduction

The establishment, growth, and persistence of non-native[1] plant species pose a serious threat to native ecosystems. Even though not all non-native species cause significant economic or ecological harm, a small portion of these plants may be invasive[2] and may significantly alter community composition, successional pathways, nutrient cycling, hydrology, and fire regimes, and can also reduce or eliminate threatened and endangered native species populations (U.S. Congress 1993, Busch 1995, Myers 1997, Brooks 1999, Stein et al. 2000, Ehrenfeld 2011).

While invasive plants constitute a major problem in the lower 48 states (Randall 1996), Alaska has remained much less affected. However, in recent decades there has been a marked acceleration in the rate of introduction of non-native plants to the state, probably driven by increases in population, commerce, development, gardening, and outdoor recreation activities (Carlson and Shephard 2007). Invasive species have become costly in Alaska, with an annual average of $5.8 million spent between 2007 and 2011 (Schwörer et al. 2012).

The susceptibility of native plant communities to invasion is largely a function of the degree of natural or anthropogenic disturbance (Hobbs and Huenneke 1992). In Alaska, non-native plant occurrence is most strongly correlated with high-use and highly disturbed areas such as urban centers and transportation routes (Carlson et al. 2014). Their abundance declines rapidly off of trail and road corridors (Bella 2011). Invasive plants establish in these types of areas because there are more opportunities for introduction, less competition from native plants, and plenty of disturbed substrates on which invasive plants (hereafter also referred to as weeds) thrive. For these same reasons, mining sites and mine access roads are also likely to harbor non-native plants. In some cases invasive weeds have been documented moving off the human footprint into natural ecosystems (Carlson and Shephard 2007).

In addition to direct anthropogenic factors, climate change may also affect non-native plant establishment (Carlson et al. 2014). At higher latitudes climate change is more pronounced (Holland and Bitz 2003), which may lead to a higher rate of non-native species establishment and accelerated population growth in the future. Non-native species are often more adaptable and better competitors relative to native species (Prentis et al. 2008), and they are therefore likely to have an advantage with changing weather, temperature, and disturbance patterns. Native species have slower migration rates (Malcolm et al. 2002, van Grunsven et al. 2007) and are likely to lag behind invasive species in their response to environmental changes.

[1] Non-native plants are those whose presence in a given area is due to the accidental or intentional introduction by humans.

[2] Invasive plants are non-native plants that produce viable offspring in large numbers and have the potential to establish and spread in natural areas (AKEPIC 2005).

In Alaska's interior boreal forests – as delineated by Nowacki et al. (2003; Figure 1) – 169 non-native plant species were present as of 2013. Valdez Creek Mining District is situated within this region, albeit near treeline. Many native species of the interior boreal ecoregion are stress tolerant, including bryophytes, lichens, and ericoid shrubs; however, many of these species have a difficult time reestablishing once they are removed (Grime 1979, Haeussler et al. 2002). If native species are eliminated from an area (e.g. by fire, clear cut logging, roads, resource extraction, pipelines) habitats are opened up for more opportunistic species. Consequently, as the frequency and scale of these types of disturbances increase, so does the chance that invasive species will be introduced and successfully establish (Byers 2002). Some specific examples of the deleterious effects non-native plants have on interior boreal ecosystems are included in Appendix I.

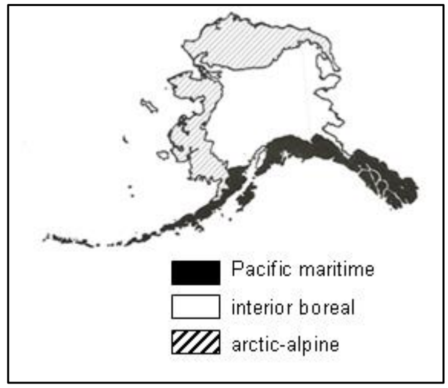


Figure 1. Basic ecoregions of Alaska. From Nowacki et al. 2003.

Mines in remote locations are of particular concern because they provide opportunities for weeds to spread from urban centers to more remote areas and to develop large population sizes that facilitate establishment in adjacent natural ecosystems. Additionally, mines inherently have a high rate of substrate disturbance, further aiding non-native plants in establishing self-perpetuating populations.

# Background information and objectives

## Description of the Mining District

Valdez Creek Mining District is located in central Alaska. Valdez Creek flows west out of the Clearwater Mountains of the south flank of the Alaska Range for fifteen miles before emptying into the Susitna River. The region is approximately 100 miles east of Mount McKinley, 50 miles east of the Alaska Railroad, and 60 miles west of the Richardson Highway (Figure 2). Valdez Creek and mining district is accessed from the Denali Highway and the access road is located near milepost 81. Most of the mining district is above treeline (> 3000 ft) with the exception of a small section near the confluence of Valdez Creek and the Susitna River (Tuck 1938, Dessauer and Harvey 1980, King 2003).

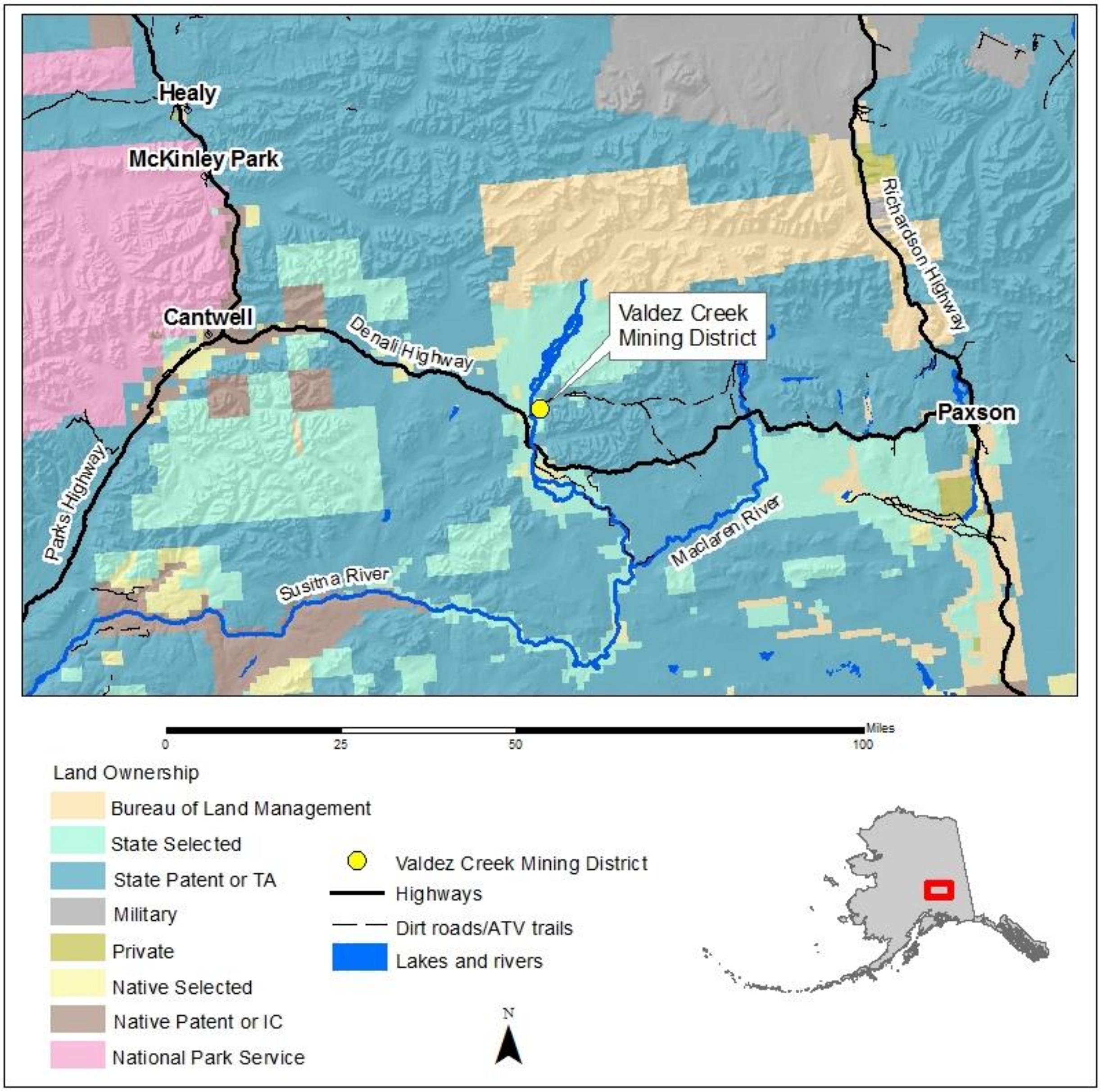


**Figure 2. Location of Valdez Creek Mining District within central Alaska.**

The Valdez Creek region is largely composed of long, broad slopes, surrounded by higher peaks, with open expanses of dwarf shrubs, including willow, Labrador tea, dwarf birch, and bryophytes (Tuck 1938, Walton and McCaffrey 1984, King 2003). The most commonly noted dominant vegetation observed on the 2014 survey includes trees and shrubs of *Salix* spp. (willows), *Picea glauca* (white spruce), *Alnus viridis* (alder), and *Betula glandulosa* (resin birch). Common forbs and grasses include *Chamerion angustifolium* (tall fireweed), *Chamerion latifolium* (dwarf fireweed), *Festuca rubra* (red fescue), and *Agrostis scabra* (rough bentgrass). For a complete list of documented species, see Appendix II.

Gold mining first began in the Valdez Creek region in 1903. Over the years mining sites and techniques have varied, and claim ownership and operation has changed hands numerous times. Placer gold mining, hydraulic mining, and open pit mines have all been employed in the attempt to extract gold from creeks and ever-deeper veins underground. In addition to Valdez Creek, other creeks in the area have been prospected and mined, including Surprise, Eldorado, White, Timberline, and Fourth of July creeks, as well as Lucky Gulch (see Figure 3). More recently, mining activities were carried out by the Denali Mining Company from 1979-1983. In 1984 mining was taken over by Valdez Creek Joint Venture with plans to enlarge the spoil storage area, create new settling ponds, and build a new public access road. In the late 1980s the Cambior Mining Company of Canada took over and created a large open pit mine to 300 feet below surface. This stage of the mine closed in the mid-1990s and has since been reclaimed. Cambior Lake, A 0.7 mile long lake toward the upper end of Valdez Creek, was established during reclamation efforts. Revegetation of the reclamation appears to have inadvertently introduced non-native plants (Tuck 1936, Walton and McCaffrey 1984).

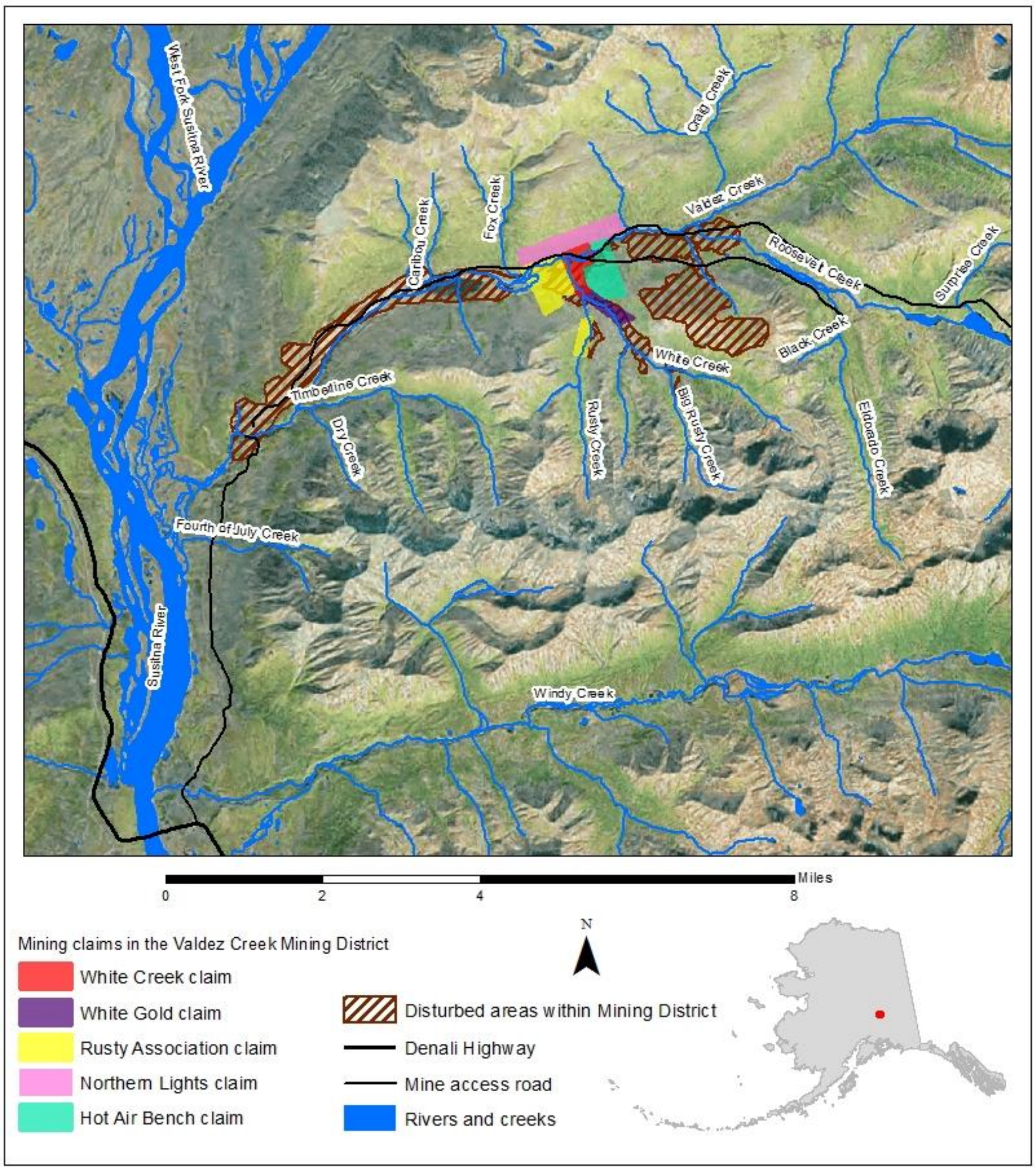


Figure 3. Streams and mining claims at the Valdez Creek Mining District.

## Climate and geology

Plant growth is strongly influenced by abiotic factors, including climate and geology. The nearest weather station is in the town of Cantwell, approximately 58 miles to the west of the Valdez Creek Mining District. The Continental Subarctic Climate of this region is relatively dry, with low humidity and most precipitation falling in the form of snow (Weatherbase 2014). The mean annual temperature in Cantwell is 26.7° F, with cool to warm summers (average July temperature is 55.1° F) and cold and dry winters (average January temperature is 0.8° F). Cantwell receives an average of 17.02 inches of total precipitation, with 130 inches falling as snow. The growing period is similar to other subarctic locations, with a few growing degree days in mid-late May, increasing in June, climaxing in July, and tapering off in August and September (Western Regional Climate Center 2011).

The geology of this part of Alaska is complex, including Precambrian metamorphics and recent alluvial and volcanic deposits. South of the Alaska Range spine and north of Eureka Creek, there are clusters of rich mineral deposit, which include some unusual substrates, such as ultramafics (Bittenbender et al. 2007). These substrates, at least at lower latitudes, can host narrowly endemic vascular plants (Kruckeberg 1987, Kruckeberg 1991). The Wrangellia in this region is composite terrane made up of a complex assembly of accreated material, and includes a mixture of carbonate layers, mafic-ultramafic intrusives, and basalts (Bittenbender et al. 2007). Glaciers largely produced extensive Quarternary deposits, and also shaped valleys and mountains about 150,000 ybp, at maximum glaciation (Carlson 2007; see Manley and Kaufman 2002). Metamorphosed sedimentary rocks lie beneath the Valdez Creek Mining District; these are composed primarily of greenstone, tuff, schist, slate, and argillite, with small intrusions of quartz diorite and diorite. All the valleys in the district have glacial and stream deposits of boulders, gravel, sand, and clay (Tuck 1938).

## Previous non-native plant studies in the area

In 2013 Laurie Thorpe of the BLM Anchorage Field Office visited Valdez Creek Mining District for basic non-native plant reconnaissance. *Taraxacum officinale* (dandelion), *Trifolium hybridum* (alsike clover), *Crepis tectorum* (narrowleaf hawksbeard), and *Vicia cracca* (bird vetch) were noted. During our 2014 surveys we revisited some of these sites, and confirmed these species, with the exception of *Vicia cracca*, which was likely eradicated in 2013 when pulled upon initial observation. In addition to surveying roadsides and other disturbed areas, at the BLM's request, we also surveyed downstream of waterways that were crossed by the mine access road. This was to determine whether weed propagules were being washed off vehicles and deposited downstream. Happily, we found no evidence of this, as weeds were not found spreading outside of disturbed sites.

Non-native plant species have been observed on nearby BLM lands, as noted in previous studies conducted by AKNHP for the BLM. In particular, a 2006 survey of Tangle Lakes (Carlson 2007) found *Rumex acetosella* (sheep sorrel) in a remote part of the district, at what appeared to be a hunting camp. This species is found in disturbed mineral soils, is widespread throughout Alaska, and is known to invade remote sites. It has an Invasiveness Rank[3] of 51, but this is largely due to a lack of documentation of its effects on ecosystems; this non-native has traits of difficult to control, weedy species.

A 2008-2009 survey of the Delta and Gulkana River corridors describes additional infestations on relatively remote BLM lands in interior Alaska (Cortés-Burns et al. 2010). Out of the 22 non-native species recorded, most are common in disturbed sites throughout Alaska and are of low Invasiveness Rank. Only two are highly ranked: *Melilotus alba* and *Bromus inermis* ssp. *inermis*. Findings from this study suggest that human activities are the primary vector for invasive propagules, and more specifically, that actions causing recurrent exposure of mineral soils encourages the establishment of non-native species. Moreover, evidence suggests that unvegetated areas – that instead had a groundcover of gravel, sand, or mud – were most frequently infested with weeds. One hundred percent of sites with gravel fill importation hosted non-native species. Where trampling was the primary cause of soil disturbance, 82% of sites supported weeds.

Similar findings have been previously documented. For example, invasive plant surveys on the Iditarod National Historic Trail (Flagstad and Cortés-Burns 2010) noted that infestations along the trail are most strongly correlated with exposed mineral soil, rather than with other disturbance such as sled dog bedding straw and cabins. Non-native plant surveys in National Wildlife Refuges throughout Alaska following wildfires showed that infestations were most correlated with areas where mineral soil had been exposed (Cortés-Burns and Carlson 2006a, b).

Several other vegetation studies have recorded non-native species along the Denali Highway, which is used to access the Valdez Creek mining area. These records have been submitted to the Alaska Exotic Plants Information Clearinghouse (AKEPIC), a database and mapping application administered by AKNHP that provides geospatial information for non-native plant species in Alaska and the Yukon Territory (available at http://aknhp.uaa.alaska.edu/botany/akepic). According to AKEPIC (as of 2014) The following taxa – and their associated Invasiveness Ranks – in decreasing order of frequency, are: *Poa annua* (annual bluegrass, 46), *Plantago major* (common plantain, 44), *Hordeum jubatum* (foxtail barley, 63), *Taraxacum officinale* (common dandelion, 58), *Matricaria discoidea* (pineappleweed, 32), *Polygonum aviculare* (prostrate knotweed, 45), *Stellaria media* (common chickweed, 42), *Bromus inermis* ssp. *inermis* (smooth brome, 62), *Phleum pratense* (timothy, 54), and *Trifolium repens* (white clover, 59).

## History of mine site revegetation

As an integral part of mine site restoration, revegetation has taken place in the Valdez Creek Mining District in the past. Specifically, we were able to obtain a record of the 1996 reseeding of slopes surrounding Cambior Lake. Alaska Garden & Pet Supply Inc. (Alaska Mill & Feed Company) supplied

[3] Invasiveness Rank is calculated based on a species' ecological impacts, biological attributes, distribution, and response to control measures. The ranks are scaled from 0 to 100, with 0 representing a plant that poses no threat to natural ecosystems and 100 representing a species that poses a major threat to natural ecosystems (see Carlson et al. 2008 for more information).

special seed mixes to the Canadian mining company Cambior Inc. in June and September of 1996. The first seed mix consisted of 20% Manchar brome, 28.3% Arctared fescue, 23.4% Boreal Red fescue and 28.3% alsike clover. The second consisted of 28.3% alsike clover, 28.3% Arctared fescue, 23.4% Boreal Red fescue, 10% Manchar brome and 10% Carleton brome (Mackin 1996).

Manchar brome is a cultivar of smooth brome (Invasiveness Rank 62) that is native to Europe and Asia and was released for commercial use in 1943. In the U.S., it was developed by the Pullman Plant Materials Center, in cooperation with USDA-SCS, Washington State University Agricultural Experiment Station, and Idaho Agricultural Experiment Station. However, the Pullman Plant Materials Center stopped producing seeds after an environmental evaluation in 2002 determined that this grass was invasive in certain habitats. This grass is able to outcompete native vegetation due to a number of characteristics. It is a deep-rooted, cold-tolerant, long-lived perennial that establishes easily and begins growing early in the spring. Its rhizomes are strong and difficult to eliminate, and it creates dense, coarse sod. In addition to spreading by rhizome, it also spreads by seed and produces on average 349 pounds of seed per acre. Manchar brome has excellent seedling vigor and is quick to recover after cutting or grazing. Moreover, it tolerates a wide range of pH and soil types and is resistant to salinity, drought, and flooding. This grass is ideally suited to be grown in combination with legumes, as it requires a lot of nitrogen, and maintains a good balance with clover or alfalfa. Its recommended use is for hay production, pastures, and grazing/forage for wildlife and livestock. Manchar brome may not be as aggressive as other brome varieties, and has been suggested for use in conservation, particularly for erosion control. However, the aforementioned traits make it highly competitive with native plants and it is generally not recommended for restoration (Granite Seed Company [undated], Preferred Seed 2009, Western Wonder 2015).

No information is available on Carleton brome.

Red fescue is native to Alaska, but the plants seeded in the Valdez Creek Mining District are two cultivars derived from native populations. Arctared fescue was developed from a plant collection near Palmer, Alaska, by the University of Alaska Agricultural Experiment Station and Agricultural Research Service and was released in 1965. Seeds are currently maintained and produced by the Alaska Plant Materials Center (Hodgson et al. 1978, Wright 2005, Hunt and Wright 2007). Boreal red fescue was developed by the Canada Department of Agriculture Research Station, Beaverlodge, Alberta, in 1966, and is still maintained there (USDA 1994). Over 200 varieties of red fescue have been cultivated, some specifically designed for conservation and restoration (St. John et al. 2012). Red fescues are used in phytoremediation of contaminated soils after mining activities, as they can accumulate zinc, manganese, lead, and copper (Wong et al. 1994, Padmavathiamma and Li 2009). This grass is also used as a soil stabilizer (St. John et al. 2012). Arctared fescue is used at mine sites throughout Alaska, and is also used on right-of-ways, lawns, and golf courses (Hunt and Wright 2007). Boreal red fescue is similar to Arctared and is sometimes substituted for it, as it is less expensive (Wright 2005). However, Boreal red fescue is intended for use in pastures and lawns (USDA 1994). Arctared fescue is highly aggressive and sod-forming. This makes it effective at stabilizing soil, but a detriment to native plant growth and species diversity. In particular, Arctared fescue inhibits the growth of shrubs, including native willow and alder (Wright 2005, Wright and Czapla 2011).

Alsike clover is known to be invasive in Alaska, with an Invasiveness Rank of 57. It is native to Europe, western Asia and northern Africa (Hultén 1968). It was cultivated in Sweden as early as 1750 and derives its name from the Alsike parish of Sweden. It was introduced to North America around 1834. This biennial to short-lived perennial legume fixes atmospheric nitrogen in the soil, which supports the growth of smooth brome cultivars it was coplanted with. Alsike clover blooms continuously and produces white to pink flowers along the entire length of its stem. As a result, it produces many seeds throughout the growing season. The seeds remain viable for over three years, and the plants easily regrow after cutting. In addition to spreading by seed, alsike clover spreads by creeping tillers, with long, slender, prostrate stems. It also has deep, branching roots which reach into subsoil and can grow new plants from broken off segments. Alsike clover does well in low-lying, moist areas, in acidic and organic soils, and also tolerates a higher alkalinity than other clovers. It is winter hardy and easily tolerates cold, frost heaving, and waterlogged soils and can survive inundation from spring flooding for up to six weeks. These characteristics make alsike clover well suited for hay production, as a cover crop, and as forage for wildlife and livestock. These characteristics also allow this clover to form dominant stands and delay and the establishment of native plant species. Although alsike clover has been used in the past for erosion control and to revegetate roadsides and other disturbed areas, its traits make it ill-suited for these applications (Kubanis 1982, Smoliak et al. 1990, AKNHP 2011).

## Present study

The Bureau of Land Management Anchorage Field Office (BLM-AFO) administers the Valdez Creek Mine region and has requested a non-native plant inventory and management guidelines for the site. In support of these objectives, the BLM-AFO entered into an agreement with the Alaska Natural Heritage Program, University of Alaska Anchorage, to conduct a non-native plant inventory of disturbed sites throughout Valdez Creek Mine District and to establish best management practices to address existing weed populations, potential future infestations, and to limit new introductions and spread.

This report describes findings from the 2014 Valdez Creek Mining District non-native plant study, outlines best management practices (BMPs) and early detection rapid response (EDRR) measures, prioritizes sites for monitoring and control, and explains control methods to manage and limit future unwanted introductions.

# 2014 Non-native plant surveys

## Methods

On July 28-30, 2014, AKNHP conducted an invasive plant survey at the Valdez Creek Mining District, targeting roadsides and mining areas, and travelling by four-wheeler and on foot. Starting at the junction of the Denali Highway and the mine access road, we stopped along the mine access road at half mile intervals, at which point we parked the four-wheelers and surveyed by foot areas 0.5-1 acre in size.

Emphasis was placed on road margins and roadside ditches; where non-native taxa were present, we surveyed farther off the sides of the road to determine if weeds were moving into less disturbed habitats. In the active mining region we surveyed around the main camp areas and along roadsides we could safely access without getting in the way of mine activities. We traveled the south branch of the mining road, in the White Creek drainage, and continued down the trail until we reached a turn-around with retired mining equipment and other refuse, which appeared to be the southeastern extent of anthropogenic ground disturbance. We followed the road another three quarters of a mile beyond this point (to site 35), by foot, and did a complete inventory of existing vegetation. Additionally, we surveyed along Valdez Creek downstream of where it is crossed by the mine road, to determine if weed propagules were being washed off vehicles and deposited downstream, but we found no evidence of this. Survey sites are illustrated in Figure 4.

For a complete description of non-native taxa found at each survey site, see Appendix III.

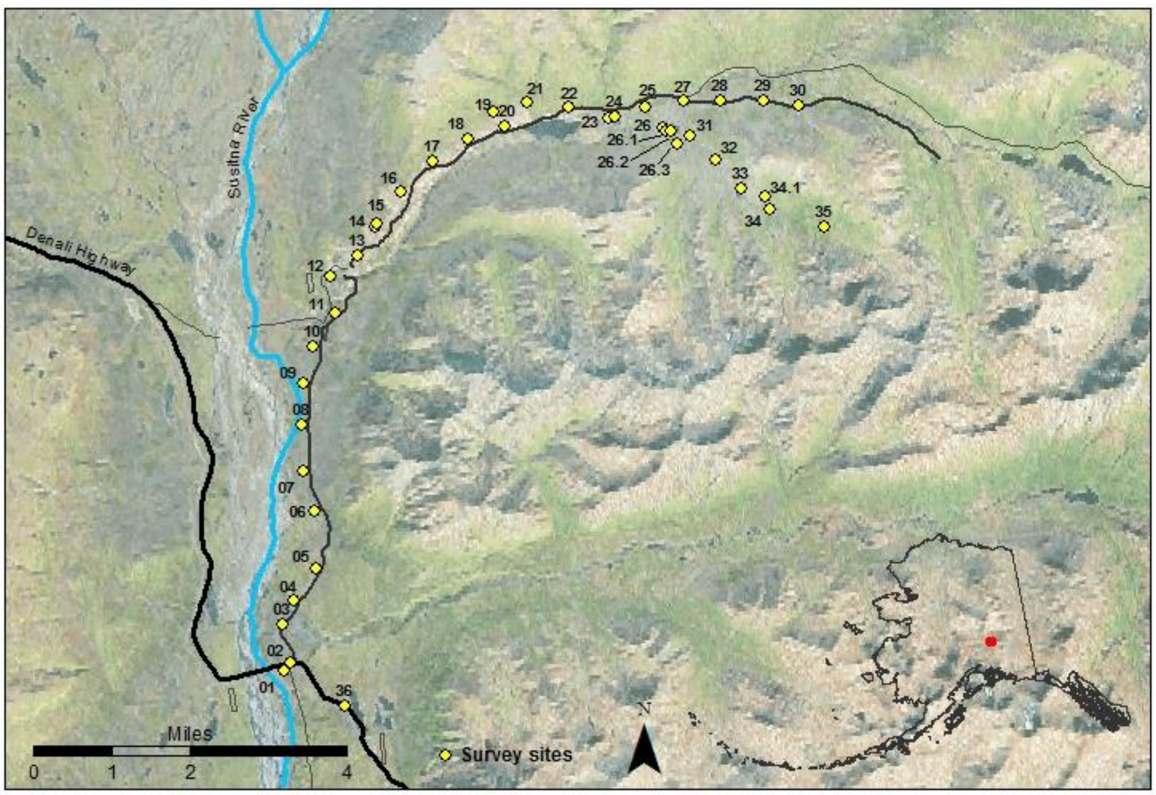


Figure 4. Locations of sites surveyed for non-native plants at the Valdez Creek Mine, Alaska.

## Results

We recorded sixteen non-native plant species in the Valdez Creek Mine District (Table 1), many of which are of low to moderate Invasiveness Rank. Most weeds occurred along the primary access road. Figures 5 and 6 show infestation sizes and species richness of non-natives at survey sites. Out of the 40 sites surveyed, the most frequently occurring non-native species is *Taraxacum officinale* (common dandelion), found at 22 sites (26.5% frequency), followed distantly by *Trifolium hybridum* (alsike clover) found at 11 sites (13.3% frequency), *Bromus inermis* ssp. *inermis* (smooth brome) found at 10 sites (12% frequency), and *Crepis tectorum* (narrowleaf hawksbeard) found at 9 sites (10.8% frequency). Aside from these taxa, other non-native species were found at five sites or fewer, representing 6% frequency or less. For a more detailed breakdown of species and percent covers, see Appendix IV.

Table 1. Overview of all non-native plants found.

| **Scientific name** | **Common name** | **Invasiveness Rank*** |
|---|---|---|
| *Alopecurus geniculatus* | water foxtail | 49 |
| *Bromus inermis* ssp. *inermis* | smooth brome | 62 |
| *Chenopodium album* var. *album* | lambsquarters | 37 |
| *Crepis tectorum* | narrowleaf hawksbeard | 56 |
| *Hordeum jubatum*[†] | foxtail barley | 63 |
| *Lepidium densiflorum* | common pepperweed | 25 |
| *Matricaria discoidea* | pineappleweed | 32 |
| *Phleum pratense* | timothy | 54 |
| *Plantago major* | common plantain | 44 |
| *Poa annua* | annual bluegrass | 46 |
| *Poa pratensis* ssp. *irrigata / pratensis* | spreading/Kentucky bluegrass | 52 |
| *Polygonum aviculare* | prostrate knotweed | 45 |
| *Silene latifolia* | bladder campion | 42 |
| *Taraxacum officinale* | common dandelion | 58 |
| *Trifolium hybridum* | alsike clover | 57 |
| *Trifolium pratense* | red clover | 53 |

*Invasiveness Rank is calculated based on a species' ecological impacts, biological attributes, distribution, and response to control measures. The ranks are scaled from 0 to 100, with 0 representing a plant that poses no threat to natural ecosystems and 100 representing a species that poses a major threat to natural ecosystems (see Carlson et al. 2008 for more information).

[†] *Hordeum jubatum* appears to be native to the eastern and central interior of Alaska, but has expanded its range dramatically in the last few decades and can cause health concerns for dogs and wildlife.

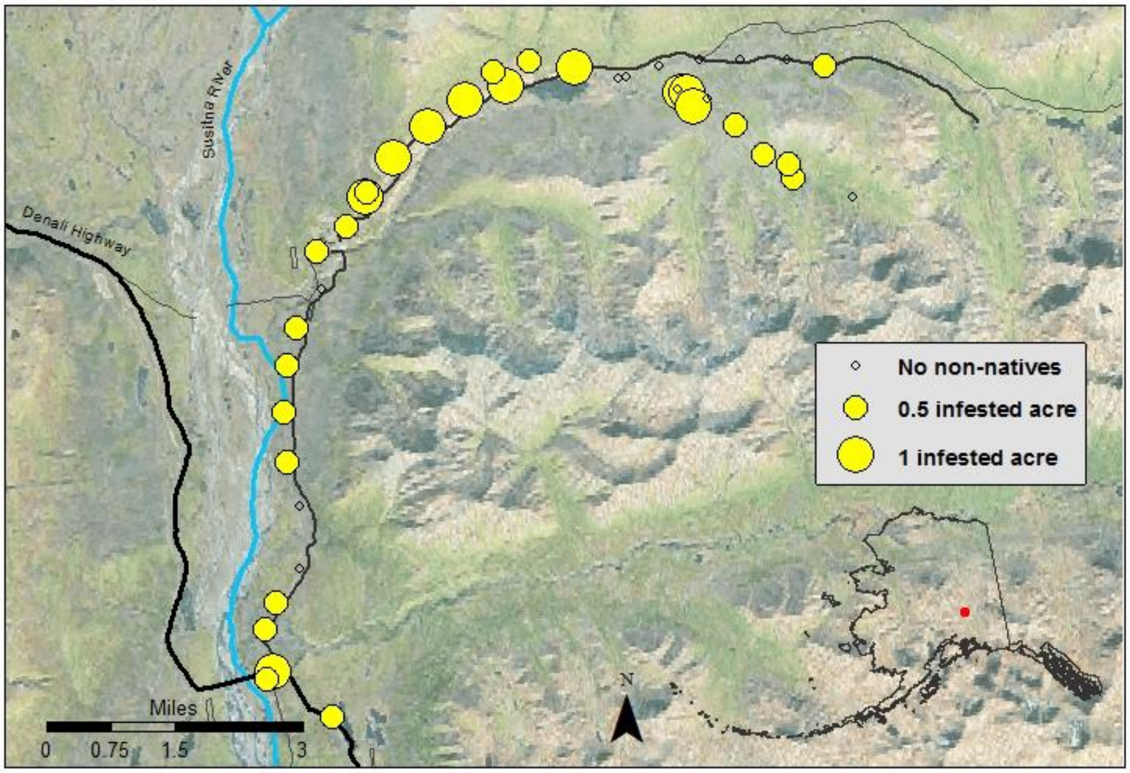

Figure 5. Presence and absence of non-native taxa throughout the Valdez Creek Mine area. Roads are shown in black and ATV trails are shown as fine dark lines.

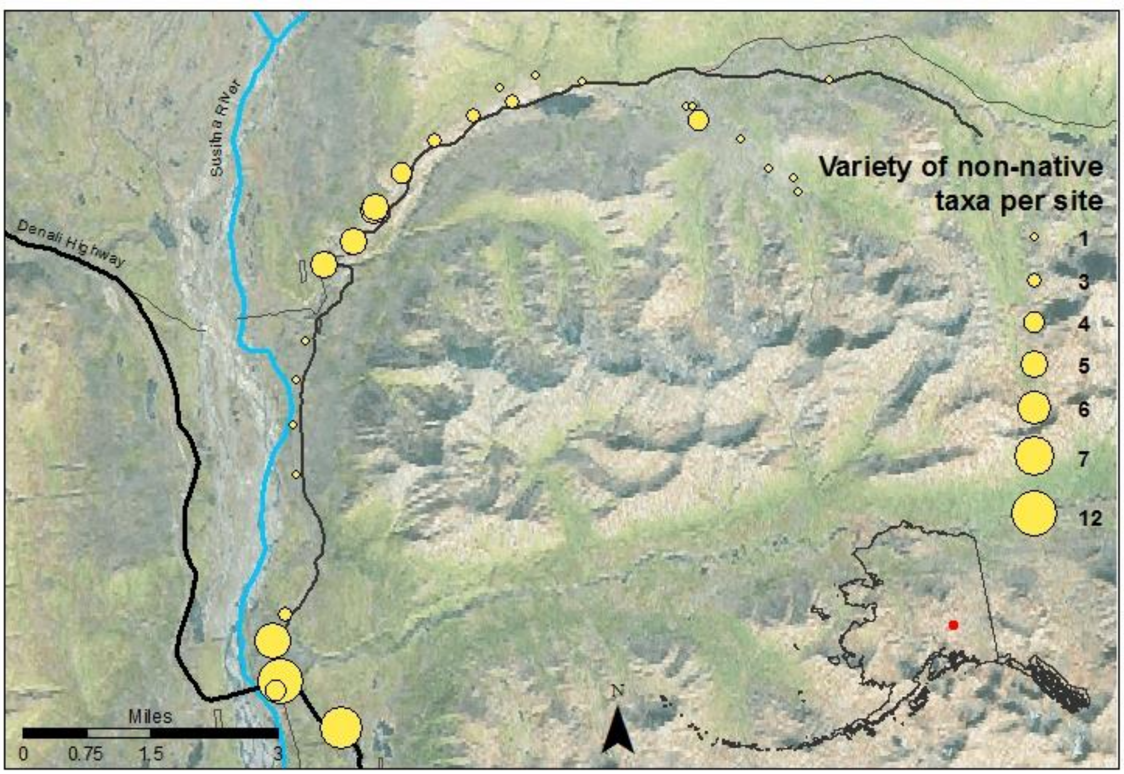


Figure 6. Number of species of non-native plants found at each survey site throughout the Valdez Creek Mine area. Roads are shown in black and ATV trails are shown as fine dark lines.

At each survey site an estimate of infested acres was made, and total infested acres followed the same pattern as the frequency of occurrence. *Taraxacum officinale* was most prevalent, with an estimated total of fifteen infested acres, followed by: *Trifolium hybridum*, 8.5 acres; *Bromus inermis* ssp. *inermis*, 8 acres; and *Crepis tectorum*, 6.5 acres; other individual species total three acres or less. However, when total percent covered is examined rather than infestation size, *Trifolium hybridum* is in greatest abundance (19% cover) as it has formed more dense, monotypic stands than the other weeds. Percent cover of *Crepis tectorum* was 8%, *Taraxacum officinale* was 6%, and *Bromus inermis* ssp. *inermis* was 5%. All other non-natives have a total cover of 1% or less.

In summary, just four taxa make up 62% of the invasive species occurrence at Valdez Creek Mine, 63% of the infested acreage, and 97% of invasive plant coverage. The other twelve taxa are relatively sparse. The areas most heavily infested are at the junction of the mine access road and the Denali Highway, and along the middle reach of the access road, where *Bromus inermis* ssp. *inermis* and *Trifolium hybridum* were nearly continuous along the roadside. Figures 7-10 show the distribution of these top four most prevalent weeds.

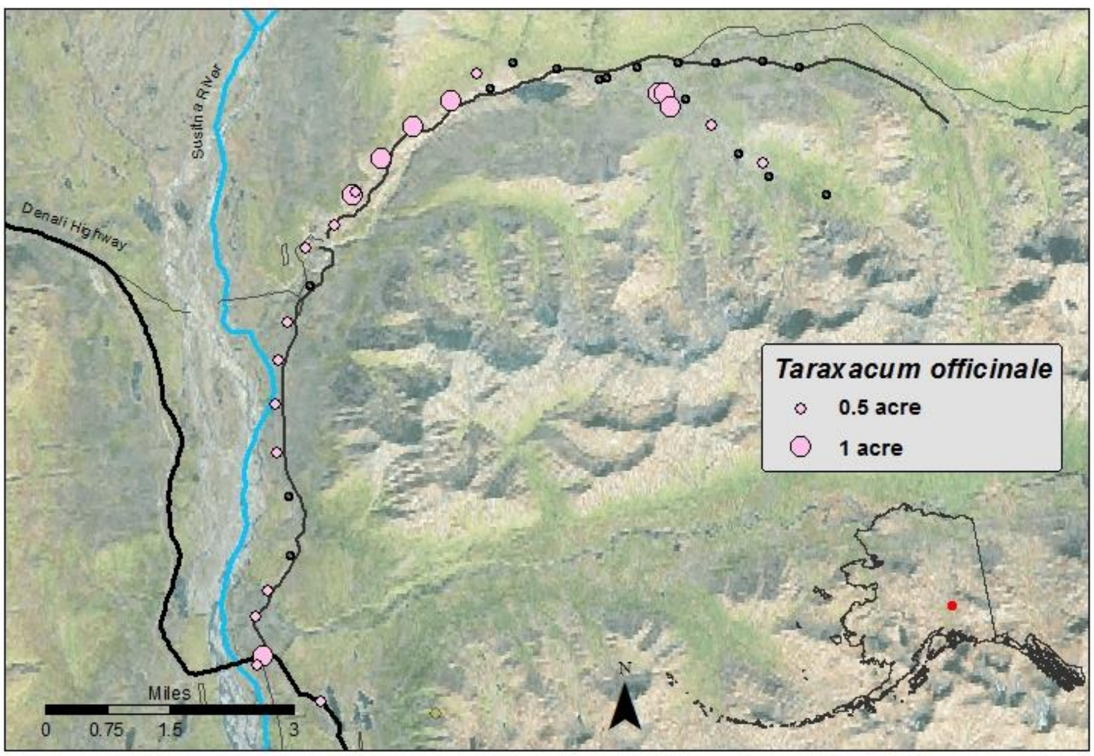


Figure 7. Occurrence of *Taraxacum officinale* (common dandelion) throughout the Valdez Creek Mine area. Sites surveyed without *T. officinale* are shown as block dots.

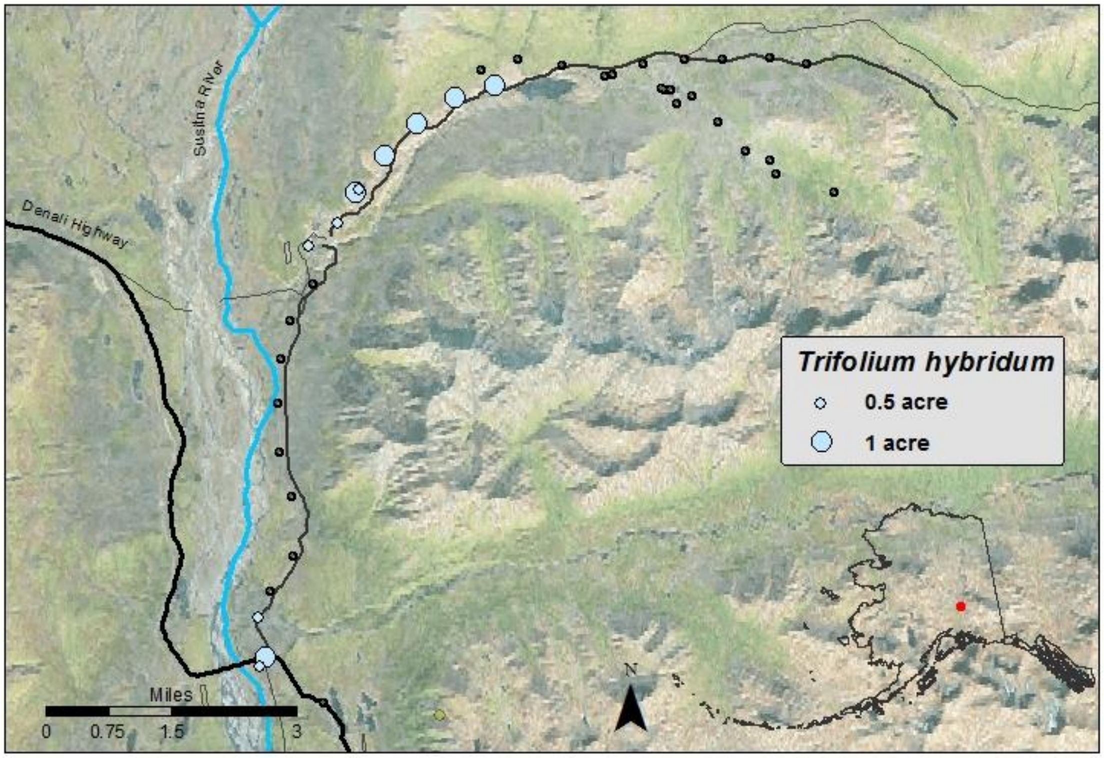


Figure 8. Occurrence of *Trifolium hybridum* (alsike clover) throughout the Valdez Creek Mine area. Sites surveyed without *T. hybridum* are shown as block dots.

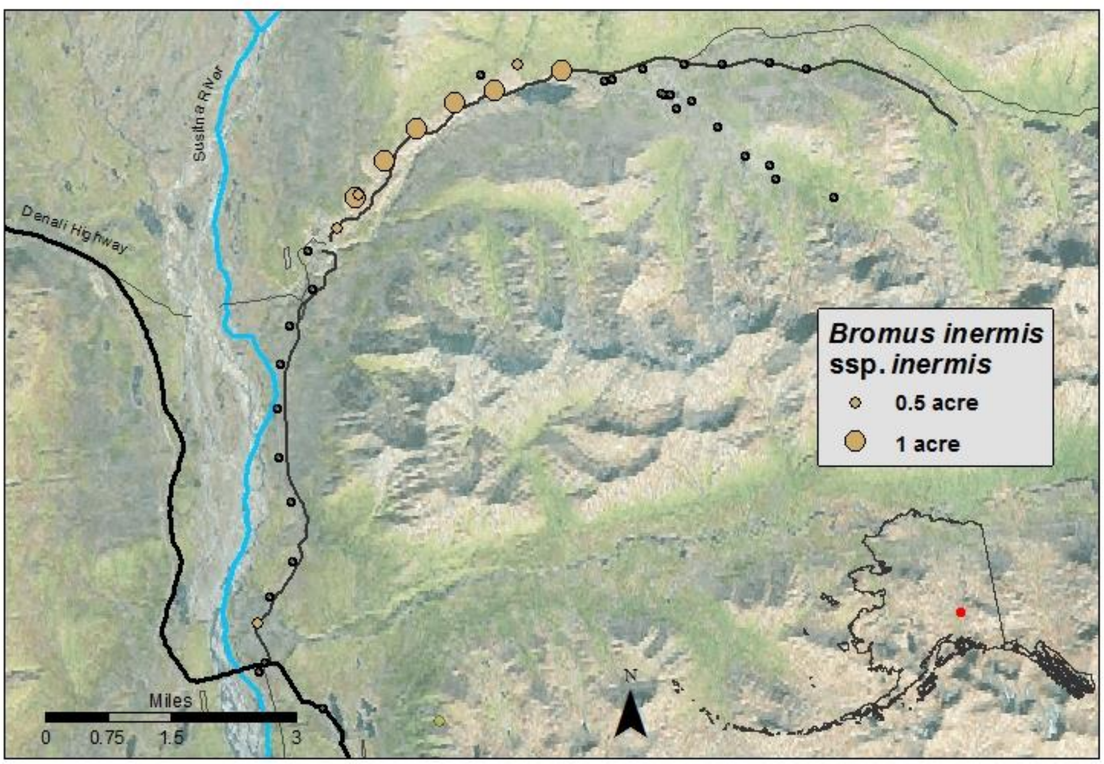


Figure 9. Occurrence of *Bromus inermis* ssp. *inermis* (smooth brome) throughout the Valdez Creek Mine area. Sites surveyed without *B. inermis* ssp. *inermis* are shown as block dots.

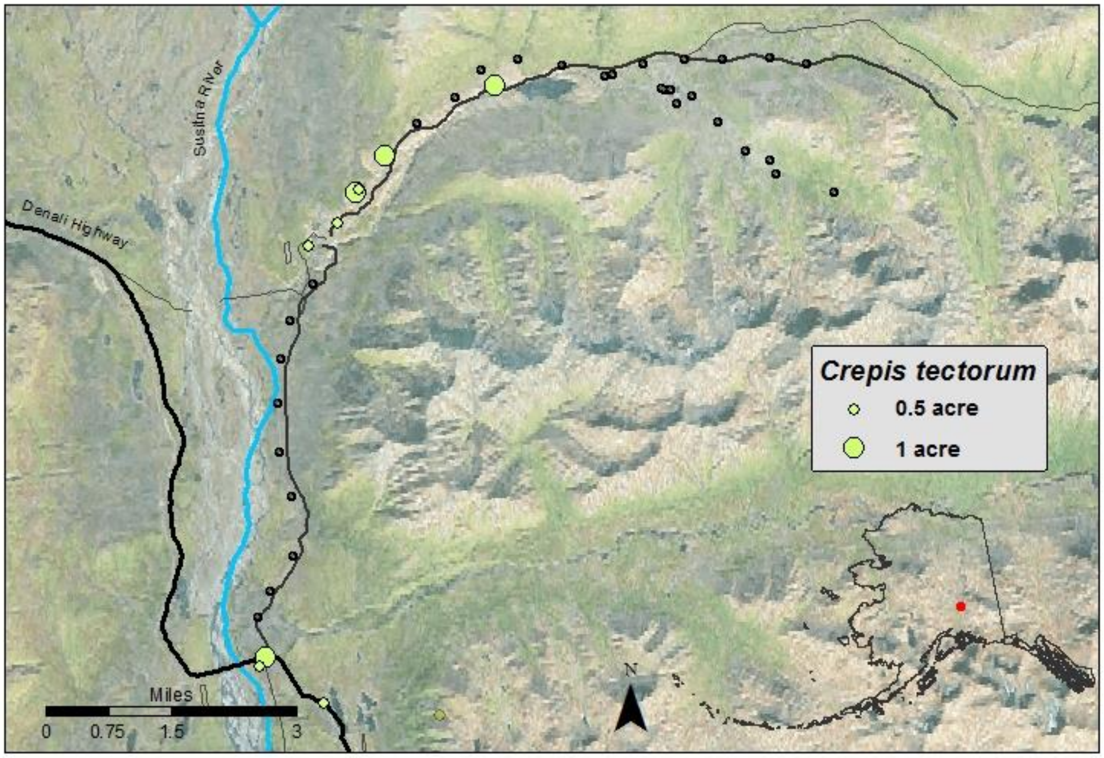


Figure 10. Occurrence of *Crepis tectorum* (narrowleaf hawksbeard) throughout the Valdez Creek Mine area. Sites surveyed without *C. tectorum* are shown as block dots.

## Weed management recommendations at Valdez Creek Mining District

For the most part, the present weed populations are found along roads and at disturbed sites, growing among native ruderal species, such as fireweed, and do not yet appear to be moving into undisturbed, natural areas. However, it is worth noting that invasive plants often have a lag time between their establishment and spread, so these incipient populations may exhibit more aggressive behavior in the future.

A large number of non-native species currently inhabiting interior boreal ecosystems were intentionally introduced in conjunction with revegetation aimed at preventing erosion, stabilizing soil after disturbance, and reseeding roadsides. Such is the case with a few infestations in the Valdez Creek Mining District, where *Bromus inermis* ssp. *inermis* (smooth brome) and *Trifolium hybridum* (alsike clover) were used for reclamation and soil stabilization. This highlights the importance of prioritizing prevention, risk assessment, and proper restoration approaches in areas undergoing development.

Many of the less-invasive species (such as *Plantago major*) found at the mine are widespread throughout Alaska and are strongly associated with roadside habitats; they are often introduced to sites through contaminated heavy equipment and/or imported fill. These small populations pose little threat to ecosystem structure and function and the likelihood of reintroduction from people, vehicles, and equipment is high. For these reasons, we recommend that efforts be placed first on preventing the introduction of new, more aggressive species to the site and second on controlling the ruderal non-native species currently present.

Minimizing the introduction and spread of non-native species and populations can be accomplished by following best management practices (BMPs) and early detection and rapid response (EDRR) measures, and by monitoring known and susceptible areas of infestation, as well as involving mine staff in weed management.

## Best management practices (BMPs)

In order to minimize impacts to natural resources, it is helpful if construction, maintenance, or mineral extraction projects assess risks associated with weeds in the planning stage, including the likelihood of spread into the project area and potential effects of weed establishment in the area. Similarly, maintenance operations can also evaluate the potential impact of weeds. If a risk or threat is identified in the planning stages, weed prevention practices can be developed. Not all weed management actions are appropriate for all sites; management plans are most useful when they are site-specific. It can be helpful to evaluate prevention practices to ensure they meet project-specific goals and stipulations, can be feasibly implemented, and are cost-effective. The latter goal can compare the costs associated with implementing a project, versus the cost associated with doing nothing and dealing with the consequent ecological damage (USFS 2001).

For example, Kim et al. (2006) found that the most economically efficient strategy to manage invasives is to invest the most resources on exclusion (e.g. importation restrictions, equipment inspections) before non-native plants are discovered, up to a threshold point. Once non-native plants are discovered, exclusionary practices and control methods (e.g. mechanical, chemical) are financially competitive. However, the value of exclusionary strategies declines as the size of an infestation increases.

Numerous authorities agree that early detection and exclusion are the best financial investments. These can be viewed as the offensive approach to weed management, employing EDRR and aiming for eradication. Alternatively, the defensive approach is used where EDRR was not employed, or is not successful, and requires an infinite financial commitment to keep populations in check (Rejmanek and Pitcairn 2002).

Early detection and rapid response can be difficult, given that non-native plants often have a lag phase between introduction and establishment. That is, they may be introduced to an area but not increase their range or numbers for up to 100 years. A taxa can maintain a small population for years, as genotypes develop that are more well-suited to rapid spread in their new environment. An episodic event could occur, such as a flood or windstorm, which promotes expansion of the non-native species. In some cases, population growth is continuous, but goes unnoticed by land managers or scientists until it is widespread (Hobbs and Humphries 1995). This problem is illustrated in Figure 11 as early detection and small infestation size correlate with proactive, cost-effective management. Late detection and large infestations correlate with reactive management and larger, long-term financial commitments.

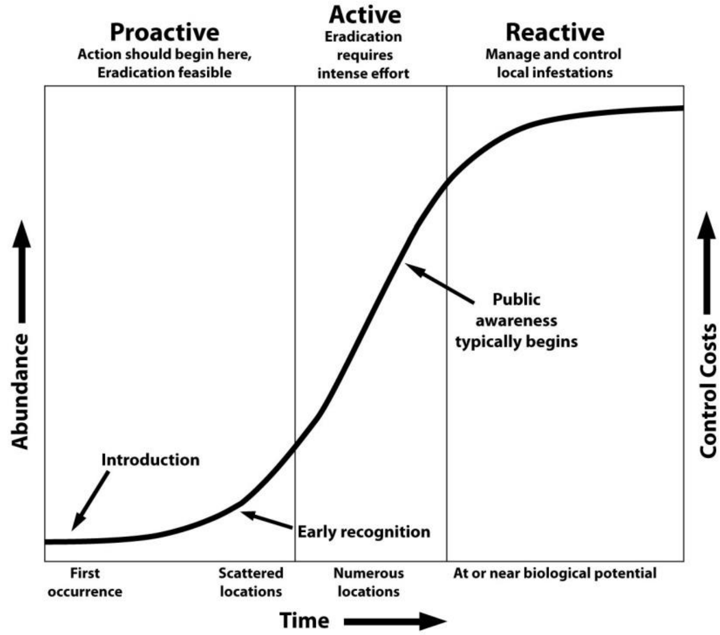


Figure 11. Invasion curve. Concept originally from Chippendale (1991). Image from newaygo-edrr.blogspot.com

The most effective, economical, and ecologically sound approach to managing invasive plants is to prevent their introduction. There are a number of BMPs available to help mine operators, recreational users, and land managers actively prevent the introduction of weeds into Valdez Creek Mining District, which are provided below (modified from USFS 2001).

### *Action items for mine operators*

- Incorporate weed prevention and management into project planning, design, implementation, and monitoring.
    - Assess the risks of possible introduction and spread, analyze treatment options for high-risk sites, and identify prevention practices.
    - Determine necessary actions to control weeds at the start of project planning (e.g. thoroughly washing heavy equipment and tools prior to transportation and use; determine how to obtain herbicide permits, if needed).
    - Manage sources of weed propagules and seeds to prevent and limit their spread.
- Prior to ground-disturbing actions, inventory weed populations at the project site and along access routes, and prioritize populations for control. Take control actions where necessary.
    - Start projects in areas not infested, or minimally infested with weeds, then move into weed-infested areas later.
    - Use staging areas that are weed-free. Restrict or minimize travel through weed-infested areas, or move through these areas only when propagules and seeds are not likely to spread (i.e. before plants begin to flower and produce seed).
    - Identify sites for equipment cleaning. It is preferable that plant parts, mud, and dirt be removed from equipment at point of origin before moving into the project area, when exiting the project area if the site has weeds, or traveling to weed-free sites. Where practical, seeds and plant parts can be incinerated.
    - Consider closing off access to sensitive areas to allow native vegetation to reestablish.

- Clean equipment and gear
    - Workers are encouraged to inspect their clothing, boots, tool bags, and other gear. These should be free of plant parts, seeds, and mud; debris can be removed and double bagged for later incineration.
    - Inspect and clean equipment, vehicles, machinery, and other gear. When cleaning equipment, areas to target include the insides of bumpers, wheel wells, undercarriages, belly plates, excavating blades, buckets, tracks, rollers, drills, shovels, and any digging tools. High pressure washing is recommended to clean heavy equipment and vehicles.
    - Cleaning gear is particularly important when moving from a site infested with non-native plants to a weed-free site. It is recommended that attention be paid when vehicles and gear are moved from outside regions that have high non-native plant densities and diversity (e.g. Anchorage, Fairbanks, Mat-Su, and Kenai). Heavy equipment, pallets, and other materials can be inspected and cleaned prior to transport to the mine to prevent new introductions.
    - If equipment cannot be cleaned prior to transport, consider cleaning equipment at the start of the mine access road, by the Denali Highway.
- Prevent weed introduction and dispersal via gravel, sand, or other fill materials.
    - Maintain stores of materials in weed-free condition. Regularly inspect material source areas for weeds. If weeds are found, treat these sites and strip off contaminated material before use of pit material. Do not use any materials contaminated with weeds.
    - During construction activities, do not dump invasive plant-contaminated waste on established, desired vegetation; instead, dispose of waste and invasive plant contaminated soil at a designated disposal site.
    - Where soil has been disturbed and/or where weed treatment takes place, continue monitoring and control actions for at least five years after project completion.
- Minimize sources of non-native plant seed along roadsides to limit transportation to other areas.
    - Avoid reseeding roadsides with non-native seeds or seed mixes of unknown composition.
    - Roads and right-of-ways can be inspected periodically for weeds. Inventory, document, and schedule treatment for infestations.
    - Ensure proper equipment cleaning.
    - If acquiring water for dust abatement during road construction projects requires travel through weed-infested areas, it is recommended that alternative sources be used.
    - When decommissioning a road, treat weeds on the road before they become impassible. Monitor and carry out follow-up treatments.
    - Consult a professional before pulling or cutting weeds to ensure effective methods are used. Schedule treatment for when propagules and seeds are least viable and likely to be spread. Work from areas with fewer weeds to areas more densely infested. Minimize soil disturbance. Properly dispose of weed waste or keep it contained on-site.
- Maintain intact ecosystems as much as possible.
    - In areas with a naturally dense canopy cover, maintain this cover as much as possible to inhibit the establishment of weeds. Keep as much native vegetation as possible in and around the project area.

    - Minimize soil disturbance as much as possible to avoid causing conditions in which weeds thrive.
- Use appropriate revegetation methods. Revegetation can include planting, seeding, mulching, fertilizing, liming, and topsoil replacement.
    - Restore disturbed sites in a timely manner if weed populations are present or nearby. Site reclamation is most effective when it takes place shortly after a soil-disturbing project is completed.
    - Revegetate sites in a site-specific manner. That is, match the appropriate species and seed mix density for the habitat.
    - Where practical, set aside sod and/or topsoil before projects commence on weed-free sites, and use the sod or topsoil to restore disturbed ground.
    - Where sod and/or topsoil are not set aside for site restoration, reseed with weed-free perennial grasses and forbs that are quick to establish; this encourages the growth of native species and provides competition for non-natives.
    - All revegetation projects should use certified weed-free products. Weed-free, locally sourced material is recommended. Use of locally-produced certified weed-free straw and plant materials will decrease the potential for seed contaminants. More information about sources of these materials and planting guidelines can be found at the Alaska Plant Materials Center website (see Appendix V).

***Action items for recreational users and visitors***

- Equestrian use:
    - Horses appear to be commonly used in this region (Clearwater Control Use Area – non-motorized hunting area; see ADF&G 2014). Equestrian staging areas and trails are at high risk for weed introductions because hay often contains weed seeds that remain viable after digestion and can be spread by horses into remote areas.
    - Feed horses certified weed-free feed while on Mining District or other public lands, and for one day prior.
    - If weed-free feed is not used, clean up animal waste and/or use a manure catcher.
- Other recreational use:
    - Inspect and clean vehicles, trailers, and ATVs prior to use in the area.
    - Inspect and clean personal and camp gear prior to use in the area, including clothing and boots. These should be free of plant parts, seeds, and mud.

***Action items for land managers***

- Emphasize education. Raise awareness among staff and visitors regarding non-native plants. A particular emphasis can be placed on measures to prevent introduction from off-site sources.
    - Provide training and educational materials regarding plant identification, impacts, and preventative actions to mine staff and the general public.
    - Designate at least one weed management expert on the mine staff.
    - Create incentives for workers to look out for new weeds.
    - Post educational displays, including prevention practices. A display board would be

particularly helpful at the start of the mine access road, near the Denali Highway.
    - Education is very important for seasonal mine staff that come from out of state, who could potentially introduced propagules of taxa not yet known to occur in Alaska.
- Recommend that all permitted activities require Best Management Practices in authorizations.
- Work cooperatively across agencies to take a landscape-based approach to weed management.
- Lead by example. Prevent and treat weeds around administrative sites.
- Treat recreational use staging areas with Early Detection Rapid Response methods, and consider the use of herbicides.

## Early detection and rapid response (EDRR)

Early detection and rapid response (EDRR) is the process of locating, assessing, and eliminating invasive species populations before they have a chance to spread to unmanageable levels. Invasive plant populations often exhibit a lag time before they begin to spread. EDRR enables land managers to find incipient populations of invasive plants and eradicate or contain them during this lag period, consequently reducing environmental and economic impacts.

This strategy includes monitoring, assessment, and control of new and emerging non-native species. Early detection of new infestations requires vigilance and regular monitoring of the managed area and surrounding ecosystem. At Valdez Creek Mine EDRR efforts would be most effective if they focus on areas of high traffic and disturbance (e.g. mining sites, roads, and trails), and are surveyed yearly, preferably in July when most plants have flowered but not yet set seed; unfamiliar species should be identified. In particular, the mine access road could be surveyed annually by truck or ATV; one person can drive slowly (ca. 5 mph), while another person watches the roadside for any plant that stands out from the common vegetation. In addition, the gravel pit at the start of the mine road could be used as a wash station for equipment entering the mining district. As weeds washed off gear begin to grow, they could be treated with herbicide, thus reducing or eliminating the need for herbicide throughout the rest of the site.

We request that populations identified through EDRR be submitted to the Alaska Exotic Plants Information Clearinghouse database at the Alaska Natural Heritage Program to augment the knowledge base of new infestations and movements of known populations within Alaska. A comprehensive picture of the distribution of non-native species and infestations throughout the larger region is important for the development and adaptation of effective management strategies.

The species listed in Table 2 are recommended for EDRR based on their likelihood to become established if introduced to the mine and on their potential to alter the structure and function of ecosystems. The species listed on the EDRR watch list are included for a variety of reasons. *Phalaris arundinacea* and *Lythrum salicaria* pose threats to riparian and wetland areas and can have significant negative impacts. *Melilotus* spp. and *Vicia cracca* thrive in interior Alaska and are difficult to remove once established. *Hieracium aurantiacum* is also extremely difficult to eradicate, requiring the use of herbicides; this species does well in organic soil and does not require human disturbance to establish. *Elodea* sp. grows in slow-moving freshwater and can clog up waterways, destroying fish habitat and limiting recreational use of rivers and wetlands. For more details about species' impacts visit the Alaska Natural Heritage Program's website, listed in Appendix V.

Table 2. EDRR watch list

| Scientific name | Common name | Invasiveness Rank |
|---|---|---|
| *Elodea* sp.* | waterweed | 79 |
| *Hieracium aurantiacum* | orange hawkweed | 79 |
| *Lythrum salicaria* | purple loosestrife | 84 |
| *Melilotus albus* | white sweetclover | 81 |
| *Melilotus officinalis* | yellow sweetclover | 69 |
| *Phalaris arundinacea* | reed canarygrass | 83 |
| *Vicia cracca* | bird vetch | 73 |

*Both *Elodea nuttallii* and *E. canadensis* have been known to form fertile hybrids, which exhibit morphologically intermediate vegetative characteristics and are only distinguishable by their floral structures, which are rarely found. In the absence of floral structures, genetic techniques are necessary to determine taxonomic identity. Both species share geographic ranges. To date, a determination of the species found in Alaska has not been made.

### *Prioritizing infestations for control work*

Prioritization for control of infestations is most effective when based on weed distributions and abundance, known or perceived risk to natural ecosystems, and government mandates for control (e.g. presence on the State of Alaska Noxious Weed List, which can be found in Appendix VI). General tools for prioritizing populations for control can be found in AKEPIC (2005) and in Cortés-Burns and Flagstad (2013).

Control of invasive species that are locally uncommon is more likely to be successful than control of invasive species that are widespread on regional and local scales. Control of such incipient populations, regardless of perceived invasiveness, is recommended. Similarly, we recommend prioritizing populations that are small and disjunct, or that are actively invading – or capable of invading – undisturbed native vegetation. Populations that are continuous and large, or that tend to remain restricted to anthropogenically disturbed habitats, are of lower priority.

When prioritizing species with similar distributions and abundances, initially target those species present on the State of Alaska Noxious Weed List, with higher Invasiveness Ranks, or demonstrated aggressiveness. In general, species with Invasiveness Ranks greater than 50 represent species considered modestly to extremely invasive (Carlson et al. 2008) and are reasonable targets for control in areas with low levels of infestation and non-native plant diversity, such as the Valdez Creek Mining District.

We recommend the top priority at the Valdez Creek Mining District be preventing the introduction of new, more aggressive species. A second priority of controlling the small populations around the mining camp (Site 26 and subsites 26.1-26.3) is recommended, as there is presumably high traffic between this site, other parts of the mining area, and potentially less disturbed areas. It is preferred that the camp not be a nexus for weeds to expand their range or move off the human footprint. The few stems of *Taraxacum officinale, Hordeum jubatum, Poa annua,* and *Poa pratensis* found at the camp could be easily removed by hand.

As a third priority, we recommend controlling the large infestations of *Trifolium hybridum* and *Bromus inermis* ssp. *inermis* along the road and on slopes surrounding Cambior Lake. The spatial extent of these infestations will likely necessitate the use of herbicides, and could be followed up with reseeding of native ruderal grasses and forbs that are quick to establish after disturbance (e.g. *Calamagrostis canadensis, Chamerion* spp.). Density of native and non-native plants was very low on the reclaimed substrates despite nearly 20 years following reseeding. This is likely due to the invasive characteristics of the plants used for reseeding in the 1990s, including: early growth in the spring; spreading by rhizomes/tillers and through high seed production; deep roots; quick recovery after grazing; tolerance to a wide range of soil types, moisture, and salinity; and forming sod, which allows them to inhibit the growth of native plants. Additionally, soils were largely inorganic and of large particle size, and soil properties (water holding capacity, potential toxicity) could also hinder the establishment of native vegetation.

Both *Trifolium* spp. and *Bromus inermis* ssp. *inermis* were documented growing off the road system in the Valdez Creek area. Because these infestations are closely linked to the larger Susitna River watershed (just ca. 5 miles from the Susitna River proper along Valdez Creek), these infestations pose a threat to early successional habitats at a broader scale in the region.

Of equal importance is removing populations of *Crepis tectorum,* particularly around the culverts at the lower Valdez Creek road crossing (Site 12). Currently infestations of this species are not extensive, but if it is not controlled early, this species is likely to spread quickly into sites dominated with mineral substrates. *Crepis tectorum* can be easily removed by hand pulling, as it has shallow roots, although larger infestations may be more easily controlled with herbicide. Similarly, it is recommended that weeds growing at sites where the road crosses a waterway be controlled, to prevent the spread of non-native seeds downstream and into natural habitats.

Given its abundance, widespread distribution, and high migration potential, control of *Taraxacum officinale* is not perceived to be of high priority. However, as time and funding allow, it is recommended that all infestations of non-native plants be treated. For more details about species' growth habits and treatment options visit the Alaska Natural Heritage Program's website listed in Appendix V.

## Inventory and monitoring

Monitoring involves periodic surveys and documentation for adaptive management planning and implementation. It is an ongoing and dynamic process and is an integral part of a successful weed control program. Monitoring includes gathering information to gauge the effectiveness of management actions in meeting predetermined objectives. A monitoring program can elucidate objectives that are not being met, actions that could be modified, and actions that are not working and could be stopped. It is useful to evaluate an inventory and monitoring plan annually if possible, or at least every three years, so that its efficacy can be assessed and modifications can be implemented where appropriate to increase the plan's success.

We recommend that non-native plant surveys at the Valdez Creek Mining District are conducted once a year, in July when most species are easily identifiable but have not yet produced seed. Identifying and prioritizing infestations before seed set decreases the risk of inadvertently spreading plants. Ideally, some member(s) of mine staff could be continuously on the lookout for new or unfamiliar plants.

### *Sources and dispersal vectors to prioritize for monitoring*

Areas that are recommended as a top priority for monitoring include potential points of introduction, dispersal corridors, material source areas, material storage sites, and other high-use or high-disturbance locations. Specific sites for survey work include:

- The mine access road
- Gravel quarries
- Snow and soil storage sites
- Spoil piles
- Main camp
- Trail heads and informal camp sites, particularly where horses are commonly kept
- Natural aquatic habitats and riparian corridors; these are often more susceptible to invasive plant introductions and spread

## Control methods

Effective control relies on a number of factors. For one, it is essential to clearly establish treatment goals (e.g. eradication, containment). It is also necessary to understand the biology of the target species (e.g. whether it reproduces vegetatively or sexually or by both plant propagules and seed). It is important to recognize the pathways associated with a species' introduction and to understand the ecosystem that has been invaded. It is also critical to know which control methods are effective for which species, as there is no single panacea for treating all infestations and the most effective control often combines manual, mechanical, and chemical techniques over several years. To learn more about the control methods discussed below, see additional resources in Appendix V.

### *Integrated weed management*

A single technique is rarely adequate for successful control of multiple species or infestations; under an integrated approach, all control methods are considered and often applied in combination. Specific treatment prescriptions are determined by the biology of the particular plant species, site characteristics, management objectives, and resources available. Management techniques fall into three categories:

- **Manual/Mechanical:** Hand pulling, mowing, tilling, and burning are commonly used to physically destroy weeds or interfere with their reproduction and can be used on small infestations of annual or biennial species. The most effective treatments are those that take place before seed production. It is recommended that plants that have flowered be removed from the site and destroyed. Plants can be double bagged and transported to a designated disposal site; if possible, they can be incinerated. Repeated mowing or tilling during the growing season can effectively control or contain many weed species. Generally, manual/mechanical methods are not recommended as the sole approach for control of species that spread vegetatively.

- **Chemical:** Herbicides are likely to be the best option for larger infestations and for perennial species that do not respond well to manual and mechanical methods. The particular herbicide used and its rate of application depend on specific site characteristics, target plants, non-target vegetation, and land use. Herbicides are a particularly important method of treatment when complete eradication of a population is the management objective. Treatment at the earliest stage of invasion will greatly minimize the need for future herbicide applications. Herbicides often provide the only effective and feasible control of rhizomatous species and species for which hand pulling or cutting is not effective. If applied in a specific manner and according to the label, herbicides can be extremely efficient in selectively removing weeds that are mixed in with native vegetation.

- **Biological:** This method involves the use of herbivores and pathogens that are known to attack or eat the non-native species of interest in its native range. Introduced biological control species often have few natural enemies and consequently have the potential to become invasive themselves and attack non-target species. Permitting release of biological control agents requires many years of host specificity testing and evaluation by the U.S. Department of Agriculture's Animal and Plant Health Inspection Service. This type of control is only used on very large infestations (big enough to support the insect or pathogen population) and, to date, has not been implemented in Alaska.

## Education and outreach

Developing active awareness regarding threats posed by invasive species through educational programs and outreach activities helps promote effective weed management. We recommend that at least one environmental compliance official attend a non-native plant identification workshop. These are often jointly hosted by the BLM and AKNHP in Anchorage, Glennallen and other locations. To raise awareness among mine staff and other users of the area, educational materials covering topics such as threats posed by, and diagnostic characteristics of, EDRR species could be shared with the staff and posted in common areas. Incentives could be offered, for example, providing a reward for being the first to spot a new plant invader on the premises, in order to encourage involvement and foster stewardship of the natural resources in the region. Additionally, posting an interpretive sign outlining the threats of weed invasion and what steps users can take to limit the risk of invasion at the Denali Highway-Valdez Creek access road junction would help raise awareness for all visitors.

## Conclusion

Although there has been large scale disturbance in the Valdez Creek Mining District in the last 112 years, there is limited sign of invasive species outside of areas disturbed in the last fifteen to twenty years. It is likely that non-native species have been introduced in former decades, but seed sources for weeds were smaller in the past. Additionally, the area is remote and surrounded by intact native vegetation, and the region has a short and cool growing season. For these reasons it is likely that past weed populations were ephemeral. It is worth noting that the variety and abundance of non-native species in Alaska has increased dramatically in the past couple decades, and that the climate is warming, and the movement of goods, people, and vehicles are increasing in the state. These factors suggest that it is prudent to take weed control action now and in the future.

Moving off the human footprint (i.e. site 35), we found a largely intact weed-free ecosystem. Optimistically, we could infer that the alpine tundra habitats surrounding the mining district are inhospitable to invasive species. It is likely difficult for most non-native species in the state to establish off the human footprint around Valdez Creek, given the surrounding habitats.

The attempted revegetation of Cambior Lake may illustrate this point. The lakeside slopes show poor colonization by willows and other native shrubs and substantial development of a cryptobiotic crust. The lack of overall plant growth, while in part a result of highly aggressive and tenacious introduced species, could also be attributed to high substrate toxicities, poor soil nutrients and water-holding capacity, low native seed densities, or other complicating factors. To date, roughly eighteen years after reseeding, the area is still scarcely vegetated. There is a very low cover of plants overall and a high proportion of non-native species, as the area was seeded with non-native *Trifolium hybridum* (alsike clover) and *Bromus inermis* ssp. *inermis* (smooth brome) cultivars. The current sparse vegetation reflects low survival rates of both native and introduced plants. It is not clear to us what the vegetation patterns and degree of erosion would have been like had either only native seed been used or the site was left for colonization by adjacent native vegetation. However, the extensive *Trifolium hybridum* and *Bromus inermis* ssp. *inermis* infestations would certainly not be present. The current infestations on reclaimed lands in the region highlight the importance of continued monitoring and management of reclaimed areas and the avoidance of unvetted seed mixes.

Most non-native species found at the Valdez Creek Mining District are of low to moderate invasiveness. *Hordeum jubatum* (foxtail barley) is ranked the highest, but its nativity is disputed and it is abundant throughout the state, including on the Denali Highway. Moreover, this species is not as widespread as the more abundant but slightly lower ranked species *Taraxacum officinale*, *Trifolium hybridum, Bromus inermis* ssp. *inermis,* and *Crepis tectorum.* However, other less abundant taxa may appear more aggressive in the future, or other highly ranked species on the EDRR Watch List could be introduced. For these reasons, monitoring and prevention are top priority.

Although the non-native species present are not very aggressive, it is recommended that an effort be made to control and eliminate populations to the extent practicable. Areas with much human traffic and soil disturbance are at high risk for the establishment of more aggressive and potentially damaging invasive species that have not yet been documented in the area. Increasing education and outreach among mine staff and environmental compliance officers can help avoid more serious invasive species problems down the road. Enacting comprehensive weed monitoring and management measures is the best way to avoid future financial expenditures and to defend against long-term degradation of native plant communities.

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## Appendix I – Examples of non-native plant effects on boreal forests

| Species | Invasiveness Rank | Effect on boreal forests |
|---|---|---|
| *Caragana arborescens*<br>Siberian peashrub | 74 | Fixes nitrogen, forms dense stands, is highly competitive, shades and smothers native plants (Cortés-Burns et al. 2007, Carlson et al. 2008) |
| *Centaurea stoebe*<br>spotted knapweed | 86 | Allelopathic; interferes with native plant germination and growth (Bais et al. 2003) |
| *Cirsium arvense*<br>Canada thistle | 76 | May be allelopathic; reduces seedling emergence and performance of fir trees (*Abies* spp.; Humber and Hermanutz 2011) |
| *Cirsium vulgare*<br>bull thistle | 61 | Can out-compete conifer seedlings in clear-cuts (Randall and Rejmanek 1993) |
| *Crepis tectorum*<br>narrowleaf hawksbeard | 56 | Inhibits native species reestablishment after fire (Villano 2008) |
| *Lonicera tatarica*<br>Tatarian honeysuckle | 66 | Interferes with forest succession and limits tree regeneration (Batcher and Stiles 2000) |
| *Senecio jacobaea*<br>tansy ragwort | 63 | Invades clearcuts but does not extend into undisturbed forests (Carlson et al. 2008) |
| *Trifolium pratense*<br>red clover | 53 | Invades clearcuts but does not extend into undisturbed forests (Carlson et al. 2008) |
| *Vicia cracca*<br>bird vetch | 73 | Can smother young conifers, causing branch dieback and inhibiting regeneration (Buchholdt et al. 2010) |

Developed from Sanderson et al. 2012

# Appendix II – Native plant species list found in Valdez Creek Mining District

| | |
|---|---|
| **Trees** | |
| *Alnus viridis* ssp. *fruticosa* | Siberian alder |
| *Alnus viridis* ssp. *sinuata* | Sitka alder |
| *Picea glauca* | white spruce |
| *Picea mariana* | black spruce |
| *Populus balsamifera* | balsam poplar |
| *Salix alaxensis* | feltleaf willow |
| *Salix glauca* | grayleaf willow |
| *Salix pulchra* | tealeaf willow |
| **Shrubs** | |
| *Betula glandulosa* | resin birch |
| *Dasiphora fruticosa* | shrubby cinquefoil |
| *Empetrum nigrum* | black crowberry |
| *Rhododendron tomentosum* ssp. *decumbens* | Labrador tea |
| *Rubus arcticus* | arctic raspberry |
| *Salix arctica* | arctic willow |
| *Salix reticulata* | netleaf willow |
| *Salix rotundifolia* | least willow |
| *Vaccinium uliginosum* | bog blueberry |
| *Vaccinium vitis-idaea* | lingonberry |
| **Forbs** | |
| *Achillea millefolium* | common yarrow |
| *Aconitum delphiniifolium* | larkspurleaf monkshood |
| *Anemone parviflora* | smallflowered anemone |
| *Anemone richardsonii* | yellow thimbleweed |
| *Antennaria monocephala* | pygmy pussytoes |
| *Antennaria* sp. | pussytoes |
| *Artemisia arctica* | boreal sagebrush |
| *Artemisia tilesii* | Tilesius' wormwood |
| *Astragalus alpinus* | alpine milkvetch |
| *Bistorta plumosa* | meadow bistort |
| *Bistorta vivipara* | alpine bistort |
| *Boykinia richardsonii* | Richardson's brookfoam |
| *Campanula lasiocarpa* | mountain harebell |
| *Cassiope tetragona* | white arctic mountain heather |
| *Chamerion angustifolium* | fireweed |
| *Chamerion latifolium* | dwarf fireweed |
| *Claytonia sarmentosa* | Alaska springbeauty |
| *Dodecatheon frigidum* | western arctic shootingstar |
| *Dryas alaskensis* | Alaska mountain-avens |

| | |
|---|---|
| *Dryas octopetala* | eightpetal mountain-avens |
| *Equisetum arvense* | field horsetail |
| *Equisetum scirpoides* | dwarf scouringrush |
| *Erigeron acris* | bitter fleabane |
| *Eurybia sibirica* | arctic aster |
| *Fragaria virginiana* | strawberry |
| *Gentianella propinqua* | fourpart dwarf gentian |
| *Hedysarum boreale* | sweetvetch |
| *Huperzia arctica* | fir clubmoss |
| *Mertensia paniculata* | tall bluebells |
| *Oxyria digyna* | alpine mountainsorrel |
| *Oxytropis borealis* | boreal locoweed |
| *Oxytropis campestris* | field locoweed |
| *Parnassia palustris* | marsh grass of Parnassus |
| *Pedicularis* sp. | lousewort |
| *Petasites frigidus* | arctic sweet coltsfoot |
| *Polemonium caeruleum* | charity |
| *Ranunculus nivalis* | snow buttercup |
| *Rhodiola integrifolia* | ledge stonecrop |
| *Rumex arcticus* | arctic dock |
| *Sanguisorba canadensis* | Canada burnet |
| *Sanguisorba officinalis* | great burnet |
| *Saxifraga hieracifolia* | stiffstem saxifrage |
| *Senecio lugens* | small blacktip ragwort |
| *Solidago multiradiata* | Rocky Mountain goldenrod |
| *Spiranthes romanzoffia* | hooded lady's tresses |
| *Stellaria longipes* | longstalk starwort |
| *Taraxacum alaskanum* | northern dandelion |
| *Tephroseris frigida* | arctic groundsel |
| *Thalictrum alpinum* | alpine meadow-rue |
| *Tofieldia coccinea* | northern asphodel |
| *Valeriana capitata* | captiate valerian |
| **Graminoids** | |
| *Agrostis scabra* | rough bentgrass |
| *Anthoxanthum monticola* | alpine sweetgrass |
| *Arctagrostis latifolia* | wideleaf polargrass |
| *Calamagrostis canadensis* | bluejoint |
| *Carex aquatilis* | water sedge |
| *Carex nesophila* | Bering Sea sedge |
| *Carex podocarpa* | shortstalk sedge |
| *Carex* spp. | sedge |
| *Eleocharis palustris* | common spikerush |

| | |
|---|---|
| *Eriophorum chamissonis* | Chamisso's cottongrass |
| *Festuca altaica* | Altai fescue |
| *Festuca rubra* | red fescue |
| *Juncus arcticus* | arctic rush |
| *Juncus castaneus* | chestnut rush |
| *Luzula arcuata* | curved woodrush |
| *Luzula parviflora* | smallflowered woodrush |
| *Poa alpina* | alpine bluegrass |
| *Poa arctica* | arctic bluegrass |
| *Trisetum spicatum* | spike trisetum |

# Appendix III – Site descriptions

Site: 01
Acres surveyed: 0.5
Coordinates: 63.10578, -147.50726
Elevation (ft): 2470
Site description: Denali Highway at the Valdez Creek Mine access road; just east of where the highway crosses the Susitna River and adjacent white spruce forest and willow shrubland.
Non-native taxa:

| Scientific name | Infested acres | Percent cover |
|---|---|---|
| *Taraxacum officinale* | 0.5 | 0.001 |
| *Trifolium hybridum* | 0.5 | 0.001 |
| *Plantago major* | 0.5 | 0.001 |
| *Crepis tectorum* | 0.5 | 0.001 |

Site: 02
Acres surveyed: 1
Coordinates: 63.10714, -147.50467
Elevation (ft): 2469
Site description: Gravel pit just north of the Denali Highway on the mine access road, commonly used as a campsite. Weeds such as *Phleum pratense* appeared to be associated with hay bale remnants and an area where horses were kept.
Non-native taxa:

| Scientific name | Infested acres | Percent cover |
|---|---|---|
| *Crepis tectorum* | 1 | 1 |
| *Trifolium hybridum* | 1 | 0.001 |
| *Plantago major* | 1 | 0.001 |
| *Taraxacum officinale* | 1 | 0.001 |
| *Matricaria discoidea* | 1 | 0.001 |
| *Poa pratensis* ssp. *irrigata / pratensis* | 1 | 0.001 |
| *Hordeum jubatum* | 1 | 0.001 |
| *Polygonum aviculare* | 1 | 0.001 |
| *Chenopodium album* var. *album* | 1 | 0.001 |
| *Phleum pratense* | 1 | 0.001 |
| *Lepidium densiflorum* | 1 | 0.001 |
| *Poa annua* | 1 | 0.001 |

Site: 03
Acres surveyed: 0.5
Coordinates: 63.11424, -147.5061
Elevation (ft): 2479
Site description: Gravel road at Windy Creek crossing in white spruce forest and tall willow floodplain; lush forb-graminoid open areas adjacent to campsites on both sides of the road. Evidence of past use by horses.
Non-native taxa:

| Scientific name | Infested acres | Percent cover |
| --- | --- | --- |
| *Taraxacum officinale* | 0.5 | 0.001 |
| *Bromus inermis* ssp. *inermis* | 0.5 | 0.001 |
| *Matricaria discoidea* | 0.5 | 0.001 |
| *Plantago major* | 0.5 | 0.001 |
| *Trifolium hybridum* | 0.5 | 0.001 |
| *Phleum pratense* | 0.5 | 0.001 |

Site: 04
Acres surveyed: 0.5
Coordinates: 63.12399, -147.4906
Elevation (ft): 2632
Site description: Gravel roadside and adjacent open white spruce woodland-willow shrublands.
Non-native taxa:

| Scientific name | Infested acres | Percent cover |
| --- | --- | --- |
| None | 0 | 0 |

Site: 05
Acres surveyed: 0.5
Coordinates: 63.11858, -147.50075
Elevation (ft): 2523
Site description: Gravel roadside and adjacent open white spruce woodland-willow shrublands.
Non-native taxa:

| Scientific name | Infested acres | Percent cover |
| --- | --- | --- |
| *Taraxacum officinale* | 0.5 | 1 |
| *Matricaria discoidea* | 0.5 | 0.001 |
| *Plantago major* | 0.5 | 0.001 |

Site: 06
Acres surveyed: 0.5
Coordinates: 63.1344, -147.48882
Elevation (ft): 2562
Site description: Gravel roadside and adjacent white spruce woodland-mixed shrublands.
Non-native taxa:

| Scientific name | Infested acres | Percent cover |
| --- | --- | --- |
| None | 0 | 0 |

Site: 07
Acres surveyed: 0.5
Coordinates: 63.14214, -147.49153
Elevation (ft): 2532
Site description: Pullout on west side of the road overlooking the Susitna River and adjacent mixed shrublands.
Non-native taxa:

| Scientific name | Infested acres | Percent cover |
| --- | --- | --- |
| *Taraxacum officinale* | 0.5 | 0.001 |

Site: 08
Acres surveyed: 0.5
Coordinates: 63.15057, -147.49069
Elevation (ft): 2524
Site description: Gravel roadside in white spruce woodland and willow-alder shrubland.
Non-native taxa:

| Scientific name | Infested acres | Percent cover |
| --- | --- | --- |
| *Taraxacum officinale* | 0.5 | 0.001 |

Site: 09
Acres surveyed: 0.5
Coordinates: 63.15821, -147.48793
Elevation (ft): 2531
Site description: Gravel roadside in white spruce woodland with sparsely vegetated margins.
Non-native taxa:

| Scientific name | Infested acres | Percent cover |
|---|---|---|
| *Taraxacum officinale* | 0.5 | 0.001 |

Site: 10
Acres surveyed: 0.5
Coordinates: 63.16461, -147.48293
Elevation (ft): 2593
Site description: Gravel roadside in white spruce woodland.
Non-native taxa:

| Scientific name | Infested acres | Percent cover |
|---|---|---|
| *Taraxacum officinale* | 0.5 | 0.001 |

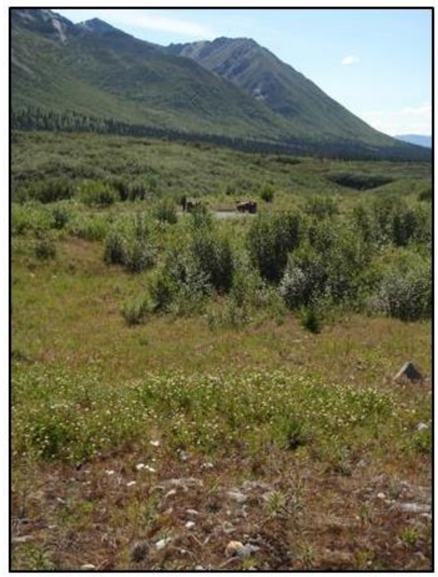
Site: 11
Acres surveyed: 0.5
Coordinates: 63.17055, -147.47261
Elevation (ft): 2698
Site description: Gravel road in white spruce woodland.
Non-native taxa:

| Scientific name | Infested acres | Percent cover |
|---|---|---|
| None | 0 | 0 |

Site: 12
Acres surveyed: 0.5
Coordinates: 63.17717, -147.47289
Elevation (ft): 2621
Site description: Gravel roadside, mining camp, bridge and lower Valdez Creek crossing; all sparsely vegetated. A large population of *Crepis tectorum* was present.
Non-native taxa:

| Scientific name | Infested acres | Percent cover |
|---|---|---|
| *Crepis tectorum* | 0.5 | 5 |
| *Matricaria discoidea* | 0.5 | 0.001 |
| *Polygonum aviculare* | 0.5 | 0.001 |
| *Taraxacum officinale* | 0.5 | 0.001 |
| *Trifolium hybridum* | 0.5 | 1 |

Site: 13
Acres surveyed: 0.5
Coordinates: 63.18066, -147.46098
Elevation (ft): 2817
Site description: Gravel roadside and sparsely vegetated mixed shrublands. Population of *Trifolium hybridum* extends far back from the road in sparsely vegetated gravel substrate.
Non-native taxa:



| Scientific name | Infested acres | Percent cover |
|---|---|---|
| *Trifolium hybridum* | 0.5 | 10 |
| *Taraxacum officinale* | 0.5 | 0.001 |
| *Bromus inermis* ssp. *inermis* | 0.5 | 1 |
| *Crepis tectorum* | 0.5 | 1 |
| *Trifolium pratense* | 0.5 | 0.001 |

Site: 14
Acres surveyed: 1
Coordinates: 63.18554, -147.45256
Elevation (ft): 2923
Site description: Sparsely vegetated gravel pullout and roadside along rocky tall willow shrubland.
Non-native taxa:

| Scientific name | Infested acres | Percent cover |
|---|---|---|
| *Taraxacum officinale* | 1 | 2 |
| *Crepis tectorum* | 1 | 1 |
| *Bromus inermis* ssp. *inermis* | 1 | 0.001 |
| *Trifolium hybridum* | 1 | 0.001 |
| *Trifolium pratense* | 1 | 0.001 |

Site: 15
Acres surveyed: 0.5
Coordinates: 63.18612, -147.45161
Elevation (ft): 2934
Site description: Sparsely vegetated gravel roadside and mixed willow shrublands.
Non-native taxa:

| **Scientific name** | **Infested acres** | **Percent cover** |
|---|---|---|
| *Taraxacum officinale* | 0.5 | 2 |
| *Crepis tectorum* | 0.5 | 0.001 |
| *Bromus inermis* ssp. *inermis* | 0.5 | 1 |
| *Trifolium hybridum* | 0.5 | 1 |
| *Trifolium pratense* | 0.5 | 0.001 |

Site: 16
Acres surveyed: 1
Coordinates: 63.19147, -147.44058
Elevation (ft): 3117
Site description:  Sparsely vegetated gravel parking area and roadside.
Non-native taxa:

| **Scientific name** | **Infested acres** | **Percent cover** |
|---|---|---|
| *Taraxacum officinale* | 1 | 1 |
| *Bromus inermis* ssp. *inermis* | 1 | 0.001 |
| *Crepis tectorum* | 1 | 0.001 |
| *Trifolium hybridum* | 1 | 4 |

Site: 17
Acres surveyed: 1
Coordinates: 63.19631, -147.4268
Elevation (ft): 3211
Site description: Gravel roadside and shrublands.
Non-native taxa:

| **Scientific name** | **Infested acres** | **Percent cover** |
|---|---|---|
| *Taraxacum officinale* | 1 | 0.001 |
| *Trifolium hybridum* | 1 | 1 |
| *Bromus inermis* ssp. *inermis* | 1 | 1 |

Site: 18
Acres surveyed: 1
Coordinates: 63.20002, -147.4115
Elevation (ft): 3226
Site description: Gravel roadside, patchy shrublands.
Non-native taxa:

| Scientific name | Infested acres | Percent cover |
|---|---|---|
| *Taraxacum officinale* | 1 | 0.001 |
| *Trifolium hybridum* | 1 | 2 |
| *Bromus inermis* ssp. *inermis* | 1 | 1 |

Site: 19
Acres surveyed: 0.5
Coordinates: 63.20429, -147.40002
Elevation (ft): 3371
Site description: Gravel roadside and mixed shrublands.
Non-native taxa:

| Scientific name | Infested acres | Percent cover |
|---|---|---|
| *Taraxacum officinale* | 0.5 | 0.001 |

Site: 20
Acres surveyed: 1
Coordinates: 63.20167, -147.3958
Elevation (ft): 3190
Site description: Side road off mine access road that leads to lake outlet and ridge; sparsely vegetated, 5% south-facing slope.
Non-native taxa:

| Scientific name | Infested acres | Percent cover |
|---|---|---|
| *Crepis tectorum* | 1 | 0.001 |
| *Trifolium hybridum* | 1 | 0.001 |
| *Bromus inermis* ssp. *inermis* | 1 | 0.001 |

Site: 21
Acres surveyed: 0.5
Coordinates: 63.20564, -147.38603
Elevation (ft): 3335
Site description: Roadside above southwest side of lake; 5% southeast-facing slope. *Bromus inermis* ssp. *inermis* mostly continuous along roadside.
Non-native taxa:

| Scientific name | Infested acres | Percent cover |
|---|---|---|
| *Bromus inermis* ssp. *inermis* | 0.5 | 0.001 |

Site: 22
Acres surveyed: 1
Coordinates: 63.20379, -147.36916
Elevation (ft): 3230
Site description: Near top of hill overlooking the pond where a creek runs into it. Miner indicated this area was seeded in 1989. 10% east facing slope. *Bromus inermis* ssp. *inermis* mostly continuous along roadside.
Non-native taxa:

| Scientific name | Infested acres | Percent cover |
|---|---|---|
| *Bromus inermis* ssp. *inermis* | 1 | 1 |

Site: 23
Acres surveyed: 0.5
Coordinates: 63.20123, -147.35344
Elevation (ft): 3179
Site description: Roadside and shrublands just west of Valdez Creek crossing
Non-native taxa:

| Scientific name | Infested acres | Percent cover |
|---|---|---|
| None | 0 | 0 |

Site: 24
Acres surveyed: 1
Coordinates: 63.2013, -147.35033
Elevation (ft): 3179
Site description: Valdez Creek, from crossing of road downstream.
Non-native taxa:

| Scientific name | Infested acres | Percent cover |
|---|---|---|
| None | 0 | 0 |

Site: 25
Acres surveyed: 0.5
Coordinates: 63.20257, -147.33784
Elevation (ft): 3179
Site description: Roadside just west of an intersection; wet ditches and puddles and willow shrublands.
Non-native taxa:

| Scientific name | Infested acres | Percent cover |
|---|---|---|
| None | 0 | 0 |

Site: 26
Acres surveyed: 10
Coordinates: 63.19825, -147.33177
Elevation (ft): 3240
Site description: Mining area; after crossing Valdez Creek, first large turnoff on the right with parked mining equipment. Site 26 represents the overall mining area, while subsites (26.1, 26.2, 26.3) represent where non-native species were found within this highly disturbed region. Mostly exposed mineral soils.
Non-native taxa:

| Scientific name | Infested acres | Percent cover |
|---|---|---|
| None | 0 | 0 |

Site: 26.1
Acres surveyed: 1
Coordinates: 63.19785, -147.33061
Elevation (ft): 3247
Site description: Mining area; after crossing Valdez Creek, first large turnoff on right with parked mining equipment and vicinity.
Non-native taxa:

| Scientific name | Infested acres | Percent cover |
|---|---|---|
| *Taraxacum officinale* | 1 | 0.001 |

Site: 26.2
Acres surveyed: 1
Coordinates: 63.19773, -147.32837
Elevation (ft): 3247
Site description: Mining area; after crossing Valdez Creek, first large turnoff on right with parked mining equipment and vicinity.
Non-native taxa:

| Scientific name | Infested acres | Percent cover |
|---|---|---|
| *Taraxacum officinale* | 1 | 0.001 |

Site: 26.3
Acres surveyed: 1
Coordinates: 63.19521, -147.32655
Elevation (ft): 3311
Site description: Main mining camp.
Non-native taxa:

| Scientific name | Infested acres | Percent cover |
|---|---|---|
| *Hordeum jubatum* | 1 | 0.001 |
| *Poa annua* | 1 | 0.001 |
| *Poa pratensis* ssp. *irrigata / pratensis* | 1 | 0.001 |
| *Taraxacum officinale* | 1 | 0.001 |

Site: 27
Acres surveyed: 0.5
Coordinates: 63.20283, -147.32227
Elevation (ft): 3228
Site description: Gravel roadside at Y-intersection.
Non-native taxa:

| Scientific name | Infested acres | Percent cover |
|---|---|---|
| None | 0 | 0 |

Site: 28
Acres surveyed: 0.5
Coordinates: 63.20213, -147.3073
Elevation (ft): 3371
Site description: Gravel roadside and adjacent shrub-forb vegetation.
Non-native taxa:

| Scientific name | Infested acres | Percent cover |
|---|---|---|
| None | 0 | 0 |

Site: 29
Acres surveyed: 0.5
Coordinates: 63.20158, -147.28949
Elevation (ft): 3470
Site description: Gravel roadside in tall shrub tundra.
Non-native taxa:

| Scientific name | Infested acres | Percent cover |
|---|---|---|
| None | 0 | 0 |

Site: 30
Acres surveyed: 0.5
Coordinates: 63.19986, -147.27568
Elevation (ft): 3559
Site description: Gravel roadside in tall shrub tundra. Small wood shacks on either side of road; one on the north side of road with 40 ft tall pole.
Non-native taxa:

| Scientific name | Infested acres | Percent cover |
|---|---|---|
| *Poa annua* | 0.5 | 0.001 |

Site: 31
Acres surveyed: 0.5
Coordinates: 63.19631, -147.32076
Elevation (ft): 3335
Site description: Active mining site, bare ground, no vegetation.
Non-native taxa:

| Scientific name | Infested acres | Percent cover |
|---|---|---|
| None | 0 | 0 |

(No photos available)

Site: 32
Acres surveyed: 0.5
Coordinates: 63.19142, -147.31142
Elevation (ft): 3413
Site description: North east side of road and channelized creek, south of active mining site and orange building.
Non-native taxa:

| Scientific name | Infested acres | Percent cover |
|---|---|---|
| *Taraxacum officinale* | 0.5 | 0.001 |

Site: 33
Acres surveyed: 1
Coordinates: 63.18591, -147.30209
Elevation (ft): 3532
Site description: Pull off on north side of road and man-made pond. East of cabin with school bus, west of cabin with pink door. Surveyed portion of pond margin; no weeds found along the pond.
Non-native taxa:

| Scientific name | Infested acres | Percent cover |
|---|---|---|
| *Hordeum jubatum* | 0.5 | 0.001 |

Site: 34
Acres surveyed: 0.5
Coordinates: 63.18139, -147.29155
Elevation (ft): 3627
Site description: Past active mine site, across creek, big turn around with retired mining equipment and scrap metal. Merlin nesting site.
Non-native taxa:

| Scientific name | Infested acres | Percent cover |
|---|---|---|
| *Plantago major* | 0.5 | 0.001 |

Site: 34.1
Acres surveyed: 0.5
Coordinates: 63.18381, -147.29305
Elevation (ft): 3678
Site description: Past active mine site, across creek, big turn around with retired mining equipment and scrap metal. Merlin nesting site.
Non-native taxa:

| Scientific name | Infested acres | Percent cover |
|---|---|---|
| *Taraxacum officinale* | 0.5 | 0.001 |

Site: 35
Acres surveyed: 1
Coordinates: 63.17721, -147.27002
Elevation (ft): 3865
Site description: Edge of gravel ATV trail; alpine dwarf shrub-graminoid tundra. Three quarters of a mile east of last non-functional mining camp. A complete list of native vegetation was documented here.
Non-native taxa:

| Scientific name | Infested acres | Percent cover |
| --- | --- | --- |
| None | 0 | 0 |

Site: 36
Acres surveyed: 1
Coordinates: 63.09843, -147.48405
Elevation (ft): 2650
Site description: Not within the mining area, but in a large open gravel pit with fill material off the Denali Highway. Area surrounded by white spruce woodland. Evidence of past horse activity.
Non-native taxa:

| Scientific name | Infested acres | Percent cover |
| --- | --- | --- |
| *Matricaria discoidea* | 0.5 | 0.001 |
| *Taraxacum officinale* | 0.5 | 0.001 |
| *Crepis tectorum* | 0.5 | 0.001 |
| *Silene latifolia* | 0.5 | 0.001 |
| *Hordeum jubatum* | 0.5 | 1 |
| *Phleum pratense* | 0.5 | 0.001 |
| *Alopecurus geniculatus* | 0.5 | 0.001 |

# Appendix IV – Non-native taxa occurrence and total infested area

Table 3. Occurrence, sum of infested acres and percent cover, and percent frequency (calculated as infested acres per taxa divided by total infested acres) for each non-native taxa found at Valdez Creek Mining District.

| Scientific name | Occurrences | Sum of Infested acres | Sum of percent cover | Percent frequency |
|---|---|---|---|---|
| *Alopecurus geniculatus* | 1 | 0.5 | 0.001 | 1.205 |
| *Bromus inermis* ssp. *inermis* | 10 | 8 | 5.005 | 12.048 |
| *Chenopodium album* var. *album* | 1 | 1 | 0.001 | 1.205 |
| *Crepis tectorum* | 9 | 6.5 | 8.005 | 10.843 |
| *Hordeum jubatum* | 4 | 3 | 1.003 | 4.819 |
| *Lepidium densiflorum* | 1 | 1 | 0.001 | 1.205 |
| *Matricaria discoidea* | 5 | 3 | 0.005 | 6.024 |
| *Phleum pratense* | 3 | 2 | 0.003 | 3.614 |
| *Plantago major* | 5 | 3 | 0.005 | 6.024 |
| *Poa annua* | 3 | 2.5 | 0.003 | 3.614 |
| *Poa pratensis* ssp. *irrigata / pratensis* | 2 | 2 | 0.002 | 2.41 |
| *Polygonum aviculare* | 2 | 1.5 | 0.002 | 2.41 |
| *Silene latifolia* | 1 | 0.5 | 0.001 | 1.205 |
| *Taraxacum officinale* | 22 | 15 | 6.018 | 26.506 |
| *Trifolium hybridum* | 11 | 8.5 | 19.005 | 13.253 |
| *Trifolium pratense* | 3 | 2 | 0.003 | 3.614 |
| None | 11 | 0 | 0 | N/A |
| **Total** | 94 | 60 | 39.063 | 100 |

## Appendix V – Additional resources

**University of Alaska Cooperative Extension Service (CES)**
http://www.uaf.edu/ces/

General information and links
http://www.uaf.edu/ces/pests/plants/

Integrated Pest Management (IPM) and reporting portal
http://www.uaf.edu/ces/ipm/

Alaska Invasive Species Working Group (AISWG)
http://www.uaf.edu/ces/pests/aiswg/

Committee for Noxious and Invasive Plants Management (CNIPM)
http://www.uaf.edu/ces/pests/cnipm/
1-877-520-5211

**Alaska Natural Heritage Program (AKNHP)**
Alaska Exotic Plants Information Clearinghouse (AKEPIC), link to submit invasive plant data, and link to AKEPIC data portal
http://aknhp.uaa.alaska.edu/botany/akepic/

Alaska non-native plant species list, ranks, and biographies
http://aknhp.uaa.alaska.edu/botany/akepic/non-native-plant-species-biographies/

**Alaska Department of Fish and Game toll-free hotline for invasive species reporting**
1-877-INVASIV (1-877-468-2748)

## Appendix VI – Prohibited and restricted noxious weeds in Alaska

Provided by the Alaska Department of Natural Resources, Division of Agriculture
Available at http://plants.alaska.gov/invasives/noxious-weeds.php
A new, updated list is in the works; check this website for future revisions.

Table 4. Prohibited noxious weed in the state of Alaska.

| | |
|---|---|
| *Convolvulus arvensis* | field bindweed |
| *Rorippa austriaca* | Austrian fieldcress |
| *Galensoga parviflora* | galensoga |
| *Galeopsis tetrahit* | hempnettle |
| *Solanum carolinense* | horsenettle |
| *Acroptilon repens* | Russian knapweed |
| *Lactuca pulchella* | blue-flowering lettuce |
| *Elymus repens* | quackgrass |
| *Sonchus arvensis* | perennial sowthistle |
| *Euphorbia esula* | leafy spurge |
| *Cirsium arvense* | Canada thistle |
| *Cardaria draba, Cardaria pubescens, Lepidium latifolium* | whitetops and its varieties |
| *Lythrum salicaria* | purple loosestrife |
| *Hieracium aurantiacum* | orange hawkweed |