CAMPBELL TRACT WEED INVENTORY
- INVASIVE NON-NATIVE PLANT SURVEY -
2006

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Abstract

Campbell Tract was surveyed by the Alaska Natural Heritage Program for the presence of invasive, non-native vascular plants from July to September 2006. The project was comprised of two phases. The first phase was an inventory of high use areas and potential "source" locations of non-native plants. These locations were roads, trails, parking lots, areas adjacent to buildings, the heliport, and the airstrip. The second phase inventoried less human disturbed habitats, along creeks and in forested areas, to better understand the extent of problematic infestations. Additionally we investigated the behavior of those invasive species relative to habitat. We surveyed all the major trails, roads, and developed areas; this was a total of approximately 175 acres. Additionally, we surveyed Campbell Creek and Little Campbell Creek and established nine monitoring plots on Campbell Tract. We collected data on non-native plant cover relative to associated vegetation type, substrate composition, and disturbance type for the monitoring plots. A total of 136 infestations were recorded in the surveys, with 20 Alaska BLM listed invasive plants. An additional 11 non-native plant species were observed. Weed infestations occupied an estimated 165 acres of Campbell Tract. The most commonly encountered invasive plants were white clover (*Trifolium repens*), alsike clover (*Trifolium hybridum*), narrow leaf hawksbeard (*Crepis tectorum*), white sweetclover (*Melilotus alba*), and timothy (*Phleum pratense*). These species were present on most roadsides, the airstrip, and most trails, and in a few cases had established in woodland habitats. Large and nearly continuous populations are present for these species except white sweetclover and timothy, which are composed of numerous, yet small and controllable, infestations. A few small infestations of more problematic invasive species were also located. Orange hawkweed (*Hieracium aurantiacum*), butter and eggs (*Linaria vulgaris*), brittlestem hempnettle (*Galeopsis tetrahit*), and oxeye daisy (*Leucanthemum vulgare*) are highly invasive species that were found in largely undisturbed woodlands. Two individuals of European bird cherry (*Prunus padus*) were found along Campbell Creek. Areas of greatest concern, based on the threat of invasive plants moving into natural habitats, are the temporary materials source, the meadow adjacent to the airstrip parking lot, a number of isolated invasive plant populations in the forests, and the airstrip margins. We outline areas for initial weed control and suggest future research efforts.

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Introduction

The Alaska Natural Heritage Program (AKNHP) conducted an invasive plant survey of the Campbell Tract, a 760 acre site in south-central Alaska managed by the Anchorage Field Office of the Bureau of Land Management, Department of the Interior. Campbell Tract is used by many for recreation, education, and research purposes. In order to ensure good stewardship and maintain the natural ecology, species diversity, and ecosystem functioning of the area the BLM is stepping up efforts to reduce negative impacts of non-native vascular plants. The first step in stemming invasive plant infestations is early detection and rapid response. To meet these goals, the AKNHP entered into an agreement with BLM to survey the Tract for invasive plants, recording their locations and recommending areas for control. This survey is the first step in a multi-year strategy to scientifically document, monitor, and control noxious and invasive plants on the BLM Campbell Tract. The baseline information on location and extent of infestations will be used in the development of a weed management plan for Campbell Tract.

Background

Campbell Tract is located within the area of highest human concentration in Alaska and yet maintains a largely intact natural ecology. For example, brown and black bears are frequently observed despite the large number of recreational users and the extensive urbanization on three of the Tract's sides. The area is showing signs of alteration in its plant communities through establishment and spread of non-native vascular plants. Alaskan habitats are certainly not immune to invasion by non-native plants and land managers across the state are beginning to increase their attention to this problem that has plagued the Lower 48 states. It is unclear what the future of the non-native species will be in Campbell Tract and what their cumulative impacts on natural resources will be. Therefore, avoiding additional establishment and spread of these plants is a primary goal.

Figure 1. Location of Campbell Tract, represented by the white polygon in the Anchorage Bowl.

The vegetation of Campbell Tract is a typical mix of boreal forest types of south-central Alaska. Birch-white spruce forests are found throughout much of the area, black spruce forests dominate the poorly drained sites; alder, willow, and cottonwood mixed forests or shrublands are found in natural or anthropogenically disturbed sites. Landscaping with primarily native species is occurring at the Science Center. Roadsides and the airstrip margin appear to have been seeded (intentionally or not) with mixes of non-native clover and grasses for stabilization and erosion control.

Two primary roads and two building complexes are present and approximately 12 miles of trail are found on the Tract. All of the road margins, parking lots, and most of the trails are overlain with imported fill material or asphalt. A 5,000 ft airstrip and heliports are present in the central part of the Tract.

Objectives

The main objectives of this inventory were to:

a) identify and record the location and extent of non-native plant species in developed areas (potential "source" or "high use" locations)
b) in a second phase of the project, identify and record the location and extent of non-native plant species in more wild ("lower risk") areas on Campbell Tract
c) in both phases, we use the data collected to prioritize infestation areas for weed management and eradication

The AKNHP agreed to complete the initial analysis of the data collected, and to produce maps and lists in which sites sampled are ranked according to their need for control treatments.

Voucher specimens for the BLM were to be prepared, as well as brief descriptions of the botanical characteristics of all surveyed areas.

The first phase was initially slated to be funded in 2005, but scheduling required both the first and second phase to be conducted in 2006. The objectives and methodologies of Phase I and Phase II were discussed and approved by Luise Woelflein of the BLM.

Methods

Phase I

Baseline inventories in Phase I were conducted on foot by one to two Alaska Natural Heritage Program (AKNHP) botanists from 26 July to 10 September 2006. We recorded the location, spatial extent, associated habitat, control measures taken, aggressiveness, and phenology of high priority weed species. High priority weed species were initially identified in the scope of work and later modified to those outlined in the BLM BAER-funded survey work of interior Alaska (Table 1). These species are those with AKNHP May 2006 invasiveness scores greater than 50 (scale 0-100, from least to most invasive). Additionally, species that are new to the region and not ranked, and those appearing problematic (despite the invasiveness score) are considered "invasive weeds". Plants with extremely wide distributions and broad abundances (e.g., common dandelion *Taraxacum officinale* ssp. *officinale*) and scores greater than 50 were rejected as "invasive weeds" for full data collection since tracking and control of these species requires far more resources than are available. However, we did collect data on common chickweed (*Stellaria media*) since populations were small, widely scattered, and could easily be controlled. This list also contains some species that are not well adapted to the boreal forests of south-central Alaska, but that were included in the event they were seen.

Priority weeds of the same species located within 50 m of one another are defined as an "infestation" by the BLM. The minimum area of an infestation is 0.1 acre and may be composed of a single individual or many thousands. For each infestation, we recorded the estimated number of stems and percent foliar cover. Quite often infestations of different species overlapped. In general, the location information of each infestation is near the center of the plant patch. Location data were collected with Garmin 76 GPS units as vector digital data in Geographic AK NAD83.

Data on the surrounding habitat were collected using AKEPIC vegetation codes (see http://akweeds.uaa.alaska.edu/pdfs/akepic_manual_05_final.pdf). Any ground or vegetation disturbance was noted and the age of disturbance was estimated. AKEPIC protocols were also used to estimate the area surveyed for each infestation. A general description of all non-native species was made in a few areas of high priority for weed control.

Infestations that appeared threatening and difficult to identify (e.g., cryptic grasses such as timothy and meadow foxtail) were flagged with yellow flagging and marked with the USDA species code. Infestations that were too extensive (e.g., clovers) or that were readily identifiable without flagging (e.g., white sweetclover) were not flagged.

When only a few isolated priority weeds were located the surveyors often removed the plants manually, bagging those species that were in late flower or fruit to avoid seed dispersal. Control activities were recorded in the BLM and AKEPIC databases. Voucher specimens were made of priority species, labeled and mounted on herbarium paper.

Phase II

The surveys in Phase II expanded the earlier work into the riparian corridors of Campbell Creek and Little Campbell Creek and into the forests. One invasive species (*Prunus padus*) is known to be expanding up Chester Creek and potentially Campbell Creek. We therefore inventoried the two creeks on the Tract for *Prunus padus* and all other priority species, recording all the site and population information required in Phase I.

Table 1. List of Alaska BLM priority non-native plants.

Plant species	Invasiveness Score (22 May 2006)
Centaurea biebersteinii DC	88
Polygonum cuspidatum Sieb. & Zucc.	87
Euphorbia esula L.	84
Lythrum salicaria L. & *L. virgatum* L.	84
Phalaris arundinacea L.	83
Impatiens glandulifera Royle	82
Hieracium aurantiacum L. and *H. caespitos*	81
Melilotus alba Medikus	80
**Nymphaea odorata* ssp. *odorata* Ait.	79
Bromus tectorum L.	78
**Rubus discolor*	77
Cirsium arvense (L.) Scop.	76
Vicia cracca L.	75
Caragana arborescens Lam.	75
Lepidium latifolium	72
Prunus padus L.	72
**Alliaria petiolata* (Bieb.) Cavara & Grande	70
**Cytisus scoparius* (L.) Link	69
Lonicera tatarica L.	67
Melilotus officinalis (L.) Lam	65
Campanula rapunculoides L.	64
Medicago sativa ssp. falcata (L.) Arcang.	64
Sonchus arvensis ssp. *uliginosus* (Bieb.) M	64
Linaria vulgaris Miller	63
**Senecio jacobaea* L.	63
Bromus inermis ssp. *inermis* Leyss.	62
Leucanthemum vulgare Lam.	61
Carduus nutans, C. acanthoides, C. pycno	61
Cirsium vulgare (Savi) Ten.	61
Hordeum murinum ssp. leporinum	60
Trifolium repens L.	59
Medicago sativa ssp. *sativa* L.	59
Elymus repens (L.) Gould	59
Convolvulus arvensis L.	58
Tanacetum vulgare L.	57
Trifolium hybridum L.	57
Gypsophila paniculata	57
Phleum pratense L.	56
Linaria dalmatica L.	55
**Ranunculus repens L. and R. acris*	54
Verbascum thapsus	53
Sorbus aucuparia L.	53
Trifolium pratense L.	53
**Zostera japonica Aschers. & Graebn.*	53
**Hypericum perforatum*	52
Vicia villosa Roth	52
Crepis tectorum L.	52
Rumex acetosella L.	51
Digitalis purpurea L.	51
Fallopia convolvulus	51
Tragopogon dubius L.	51
Hieracium umbellatum L.	51
Dactylis glomerata L.	50
Non-native species not ranked and new to the region	
Non-native species appearing threatening (regardless of invasiveness score)	
Plant species rejected from consideration due to abundance and broad distribution	
Hordeum jubatum L.	63
†*Stellaria media* (L.) Vill.	57
Taraxacum officinale G.H. Weber ex Wigge	56
Poa pratensis ssp. *pratensis* L., *P. pratens*	52

Additionally, we erected nine transects beginning at a known infestation of a priority weed species into adjacent, less developed areas. The transects ranged from 10 m to 30 m in length depending on the extent of the infestation, with the transect continuing for at least 4 m beyond the last invasive plant individual encountered. Within each transect a series of 0.1 x 1 m temporary subplots spaced 1 m apart were sampled (Fig. 2A). The spatial distribution of these transects across Campbell Tract is shown in Fig. 2B. GPS points were taken at the origin and end points, which we marked using permanent markers and were put in place at the origin and end points and marked with nearby flagging tape for areas not subject to extensive human use. Reference photos were taken to assist with any potential future sampling efforts by the BLM. Data collected within each 0.1 x 1 m plot included the following: percent cover of the weed species and native species, percent canopy cover, vegetation type (e.g., open white spruce forest), disturbance type (i.e., imported fill, brush cutting/mowing, trampling, stream erosion, or none), description of substrate-type (i.e., relative proportion of organic to mineral soil), and previous control action.

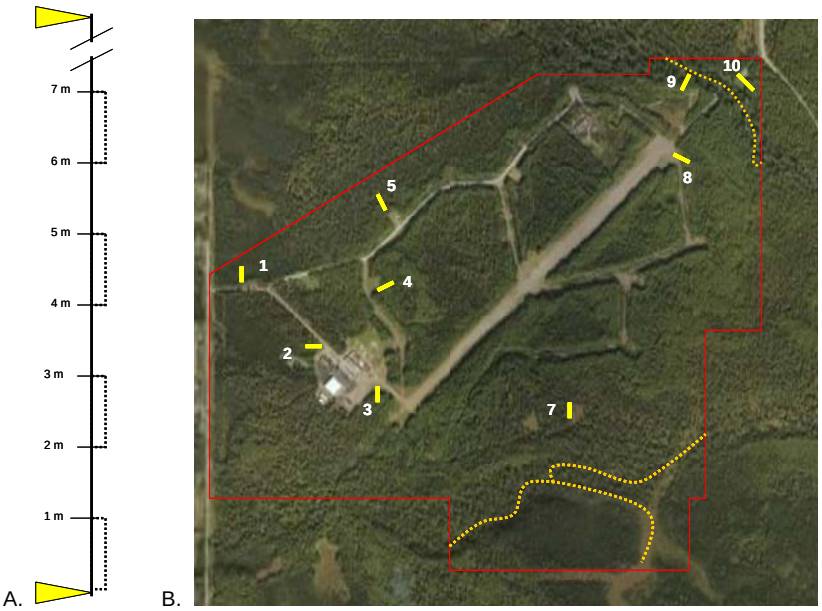


Figure 2. A) Transect and subplot (dotted rectangles) representation, and B) locations of nine weed transects in Campbell Tract, shown as numbered yellow lines. Transect #6 from the study plan was omitted. The dotted lines represent the riparian areas surveyed.

This strategy allows us to detect the extent of weed establishment outside of trails, roads, and parking lots, as well as to gain an understanding of how weed invasions are influenced by substrate type, habitat, and distance from disturbance. Furthermore, the permanently marked transects can be revisited in future years to determine changes in the abundance of species.

The transects were located at:

1. Smoke Jumper Trailhead - *Galeopsis tetrahit* plants were observed growing in undisturbed forests adjacent to the parking lot. Origin: 61.15863ºN, -149.8013ºW; Endpoint: 61.15881ºN, -149.80141ºW.

2. BLM headquarters parking lot - *Linaria vulgaris*, *Trifolium repens*, and *T. hybridum* were recorded to be expanding into relatively undisturbed forests. Origin: 61.1567ºN, -149.79591ºW; Endpoint: 61.15646ºN, -149.79663ºW.

3. BLM headquarters parking lot/corner between parking lot and Coyote Trail/ by sign Stop No Entry Active Runway - *Melilotus alba*, *Vicia cracca*, *Trifolium hybridum* and *Phleum pratense*. Origin: 61.15511ºN, -149.79205ºW; Endpoint: 61.15491, -149.79208 ºW.

4. 8-Mile Loop/ heavily wooded portion of trail - *Trifolium repens* forms a large population and appears to be extending off the trail in a heavily wooded portion of the latter. Origin: 61.15781ºN, -149.79099ºW; Endpoint: 61.15787ºN, -149.79094ºW.

5. Road to Campbell Creek Science Center, gravel-fill material site - *Linaria vulgaris* and a number of other less invasive non-native species were observed at this site. Origin: 61.16099ºN, -149.79045ºW; Endpoint: 61.16114ºN, -149.79024ºW.

6. *PROPOSED TRANSECT WAS NOT CONSTRUCTED* – 8-Mile Loop - *Hieracium aurantiacum* was observed along a heavily wooded section; however, this population was controlled in late July, and reading a transect was not advised by the BLM.

7. Viewpoint Trail, at the tower and big green shed – multiple species are present at the tower and threaten the integrity of the adjacent forest. Origin: 61.15377ºN, -149.78072ºW; Endpoint: 61.15374ºN, -147.7803ºW.

8. Northeast end of airstrip – *Melilotus alba*, *Trifolium repens*, and *Crepis tectorum*. Origin: 61.16339ºN, -149.77066ºW; Endpoint: 61.16334ºN, -149.77016ºW.

9. Campbell Creek, west of sled dog trail bridge – *Stellaria media*. Origin: 61.1657ºN, -149.76979ºW; Endpoint: 61.16587ºN, -149.76971ºW.

10. Campbell Airstrip entrance to the Tract hosts an abundance of invasive non-native plants (*Elymus repens*, *Leucanthemum vulgare*, *Phleum pratense*, *Trifolium repens*, *Melilotus alba*, etc.). It is unknown if these species are moving into less disturbed portions of the Tract. Origin: 61.16557ºN, -149.76587ºW; Endpoint: 61.16542ºN, -149.76541ºW.

Results and Discussion

Phase I

The AKNHP surveyed 27 miles of the major roadways and trails and areas of high human use, for an approximate total of 175 acres. Infestations were widespread along heavily used trails, roadsides, buildings, and the airstrip. Most of the surveyed area had at least one species of invasive plant present. Some of the trails without fill importation had low levels of all non-native plants. These were Moose Meadow, 8, 12, 16-mile Loops, Moose Track, and Woodard Trails.

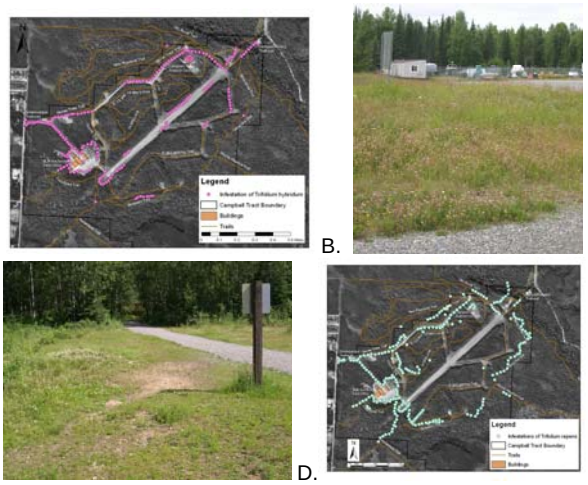


Figure 3. A.) Infestations of *Trifolium hybridum*, and B.) infestation of primarily *Trifolium hybridum* and *Crepis tectorum* at the BLM Regional Headquarters equipment lot. C.) *Trifolium repens* along the Old Rondy Trail, and D.) infestations of *Trifolium repens*.

<u>Noteworthy Invasive Species</u>

A total of 20 BLM-invasive plants were observed (see the Appendix for maps of their locations). The most common species were white clover (*Trifolium repens*), alsike clover (*Trifolium hybridum*), narrow leaf hawksbeard

(*Crepis tectorum*), white sweetclover (*Melilotus alba*), and timothy (*Phleum pratense*). The clovers were ubiquitous along roadsides and the airstrip (Fig. 3, and see Appendix I for larger-scale maps) and were most likely seeded for erosion control during construction and maintenance activities. White clover was often found along trails and in deep woodlands; these infestations should be prioritized above the roadside populations. Elimination of the clovers will require considerable time and expense. If these species are removed from roadsides, suitable native species for erosion control will need to be established.

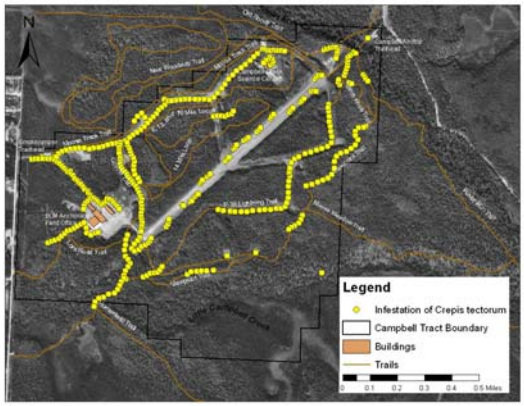


Figure 4. Infestations of *Crepis tectorum* (yellow dots).

Narrow leaf hawksbeard (Fig. 4) is very widespread on gravel substrates and trail edges throughout the Tract; however, individuals are generally widely dispersed and control may not be difficult. Additionally, this species is an annual with short-lived seeds, so that the investment in control may be minimal.

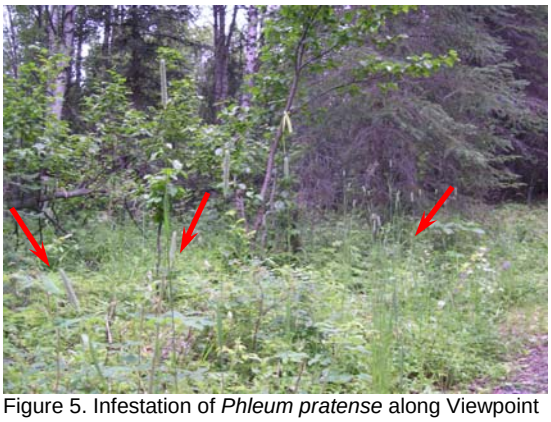


Figure 5. Infestation of *Phleum pratense* along Viewpoint Trail.

Timothy was observed more often than expected on the Tract and it was often found on humic substrates along less used trails in closed forests (Fig. 5). Most of the infestations were composed of only a few isolated clumps and control of this grass should not be particularly difficult. It appears that this species may be spreading due to horses, since it was often observed growing out of old horse scat and most prevalent along trails with greatest use by horses.

White sweetclover is composed of small and relatively controllable infestations, despite being widely dispersed throughout the Tract (Fig. 6). Control of this species should occur soon before a large seed bank and a more continuous suite of populations are formed. White sweetclover is a biennial to short-lived perennial that produces copious quantities of very long-lived seeds (with longevity of over 80 years, J. Conn pers. comm.). White sweetclover is generally associated with open gravel and imported fill substrates. Isolated individuals are often found along trails in closed-mixed forests. These individuals were flowering and setting seed, so presumably shaded environments do not limit sweetclover growth. It is critical to eliminate sweetclover in all habitats to preclude this species from moving into more natural portions of Campbell Tract.


Figure 6. Isolated Infestation of *Melilotus alba* along CoyoteTrail.

A few small infestations were located of more problematic invasive species. Orange hawkweed (*Hieracium aurantiacum*), butter and eggs (*Linaria vulgaris*), oxeye daisy (*Leucanthemum vulgare*) and brittlestem hempnettle (*Galeopsis tetrahit*) are highly invasive species that were found in largely undisturbed woodlands (Fig. 7). Orange hawkweed was observed in three locations on the Tract. One flowering individual was observed in a natural woodland margin at the Abbott Loop entrance. This plant was destroyed. Two

infestations were observed along the 8, 12, 16 Mile Loop Trails, and were composed of between 10 and 50 flowering stems. These plants were growing in the middle of lower-use woodland trails and rhizomes were extending out into the undisturbed humic-shrub-forb boreal habitat. These populations were marked and the BLM was immediately notified and manually eliminated these two populations.

Butter and eggs was found in five locations widely scattered in Campbell Tract. One moderate sized population (ca. 100 stems) was observed at the materials source near Moose Track Trail, a few individuals were observed near the northeast end of the airstrip, and hundreds of individuals were observed along the Coyote Trail near the airstrip where garden throw-outs and grass cuttings had accumulated (Fig. 7C). This population appears to be poised to move into the adjacent less disturbed habitats. Last, we observed a large population of butter and eggs near the Regional Office Parking lot that were moving from the ditch and road edge into the shrub-forb and woodland habitats.

A.  B.  C. 

Figure 7. A.) Infestations of *Hieracium aurantiacum*, B.) *Linaria vulgaris*, and C.) *Galeopsis tetrahit* in Campbell Tract forests and forest edges.

Brittle stem hempnettle, which is often a seed contaminant in soil, is becoming more commonly encountered in Alaska. Two small infestations were recorded, one infestation of a few individuals was from the new landscaping at the Science Center and the other was in an undisturbed, closed white spruce-birch forest 10 m from the Smoke Jumper's Parking Lot (Fig. 7B). Finding a population in such a dense and natural habitat is unnerving since it indicates that this habitat is not resistant to invasion by hempnettle. This population was marked for control.

A few infestations of the invasive oxeye daisy (*Leucanthemum vulgare*) and quackgrass (*Elymus repens*) were recorded. The infestations tended to be small so that control would be relatively easy.

Bird vetch (*Vicia cracca*) was only observed in two locations in or adjacent to parking lots and at low densities. The BLM pulled numerous infestations prior to the survey. Assuming that a seed bank and underground portions of these plants are still present, more infestations of bird vetch may be present in the area than are apparent from this survey.

We collected data on a number of species that are not common or are previously unknown from Alaska. Most of these were observed at the materials source site. This included cats-ear (*Hypochaeris radicata*), smartweed (*Persicaria lapathifolia* = *Polygonum lapathifolium*), dooryard dock (*Rumex longifolius*), and a new species to Alaska, woodland ragwort (*Senecio sylvaticus*). Additional non-native species observed on Campbell tract include: *Capsella bursa-pastoris*, *Chenopodium album*, *Hordeum jubatum*, *Matricaria discoidea*, *Plantago major*, *Poa annua*, *Poa pratensis* ssp. *irrigata*, *Polygonum aviculare*, *Taraxacum officinale* ssp. *officinale* and *Tripleurospermum perforatum* (= *T. inodoratum*). BLM employees had also collected tumble mustard (*Sisymbrium altissimum*) on the Tract in 2006.

Noteworthy Areas

The density of invasive plants was clearly not randomly distributed in Campbell Tract. Less used trails without imported fill had the lowest number of invasive species; these areas generally had spotty distributions of clover, narrowleaf hawksbeard, and white sweetclover. Parking lot margins had high numbers of invasive species. Smoke Jumper's, Regional Office, Science Center, and Airport parking lots all had very high diversities and densities of invasive species. These lots are the areas with the highest density of human use and the initial area of contact between people and the Tract. The Airport parking lot and the adjacent grass-forb meadow was particularly rich with non-native plants (Fig. 8A).

The roadways and airstrip margins and tower sites tended to have consistent populations of clover, narrowleaf hawksbeard, and more dispersed populations of white sweetclover. These sites have very thick, although not particularly diverse, invasive species communities and will require a greater investment for control.

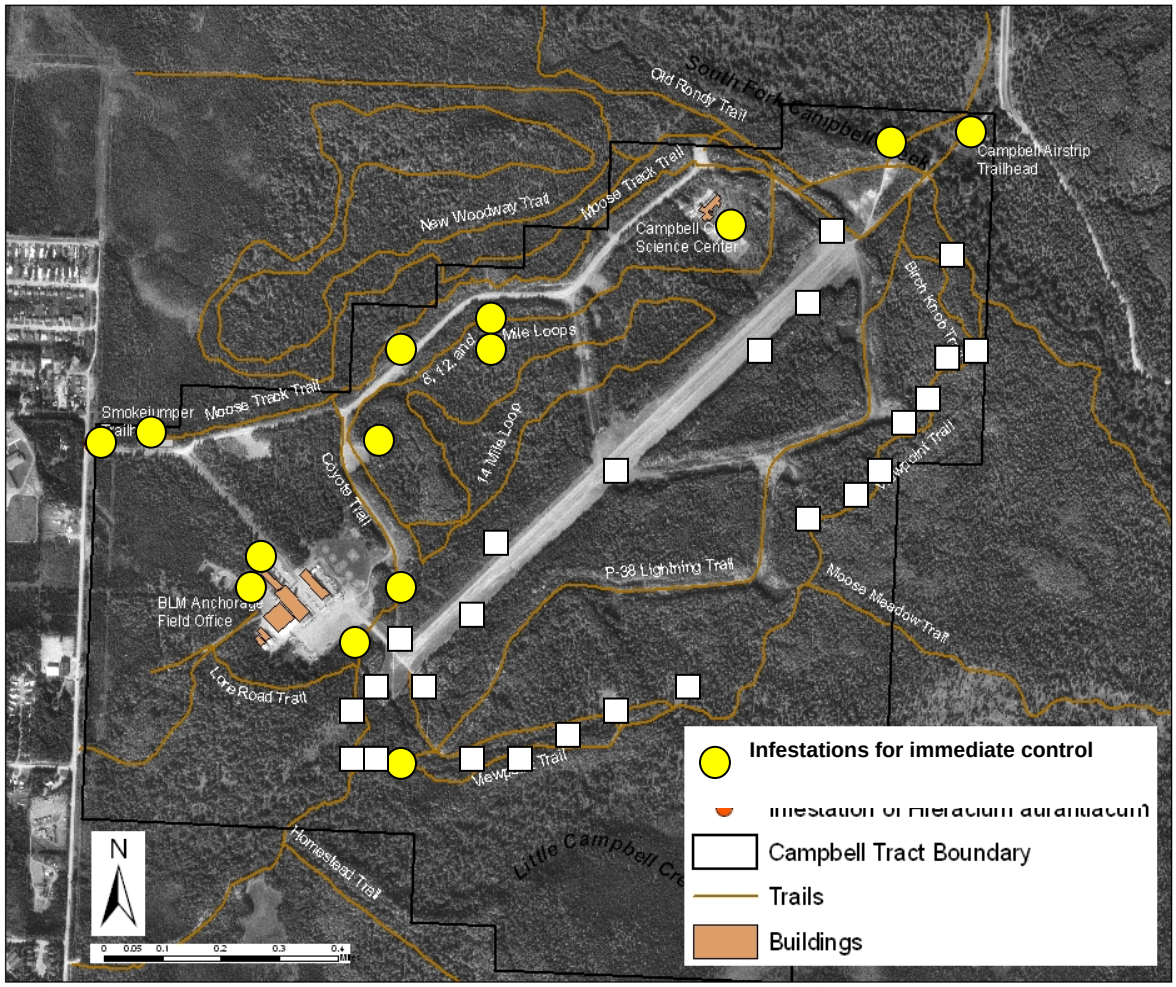
The materials source between the Science Center Road and the Moose Track Trail is the single greatest invasive species threat to the natural integrity of Campbell Tract (Fig. 8B). This area has recycled top soil, as well as gravel, and other materials that appear to be used for trail construction and landscaping. Many invasive species were found growing directly on the soil and gravel, so that moving any of the soil will result in spreading invasive species throughout the Tract. Additionally, a non-native species new to Alaska (*Senecio sylvaticus*) and a number of species rarely encountered were found at this location, suggesting that equipment that is moving the soil or the soil itself is importing unwanted species into Campbell Tract.

Areas suggested for immediate control are shown in Figure 9; see Appendix II for details on their locations.

A.  B. 

Figure 8. A.) Airport parking lot, and B.) Materials source infestation sites.

Figure 9. Areas suggested for immediate control (yellow dots) include all locations of *Hieracium aurantiacum*, *Prunus padus*, *Galeopsis tetrahit*, *Leucanthemum vulgare*, *Linaria vulgaris*, *Vicia cracca*, as well as isolated populations of *Trifolium repens* in forested habitats. Areas of small *Melilotus alba* populations are indicated as white squares and should be a secondary priority. All the known *Hieracium aurantiacum* populations were destroyed in August 2006; however, these sites should be revisited to make sure all individuals have been destroyed.



Phase II

Stream Surveys

Focusing on less used portions of Campbell Tract in Phase II, we found that a serious invader was beginning to establish along Campbell Creek, but that most infestations were restricted to disturbed trail and roadside margins. European bird cherry trees (*Prunus padus*) had established at the margin of the South Fork of Campbell Creek (Fig. 10; 61.16582ºN, 149.76967ºW). Naturalized populations of this species are well established along Campbell and Chester Creeks in the western and highly urbanized portion of the Anchorage Bowl, but it was surprising to find this species this far upstream.

A.  B. 

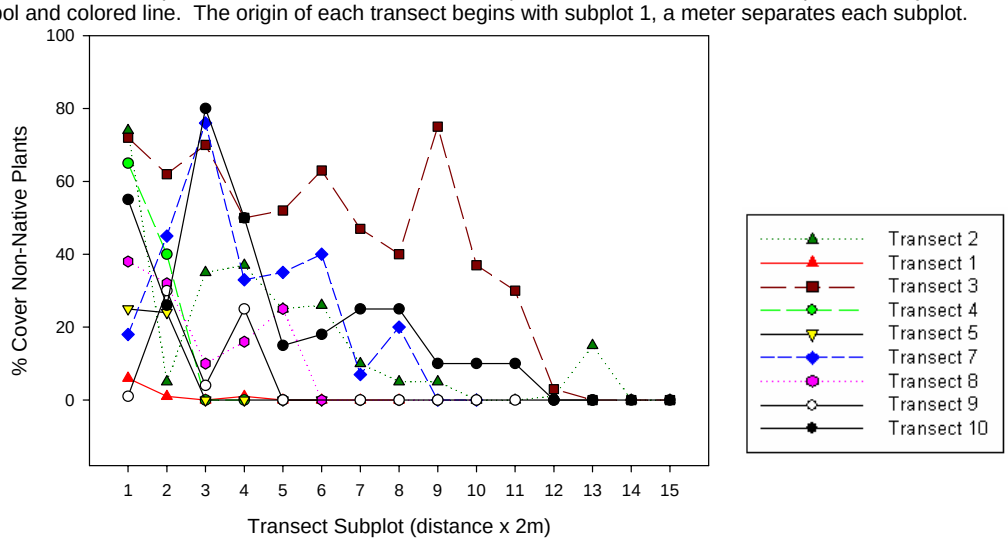
Figure 10. A.) *Prunus padus* plant and B.) associated habitat adjacent to Campbell Creek; the arrow shows the location of the plant.

Outside of the European bird cherry, only a few isolated infestations of marginally problematic species were found, which included timothy and narrowleaf hawksbeard. Most of the riparian areas are primarily free of non-natives, but less invasive and more widespread species such as common dandelion (*Taraxacum officinale* ssp. *officinale*) and prostrate knotweed (*Polygonum aviculare*) were also observed in one location along the South Fork of Campbell Creek.

Transects

The cover of non-native plants declines from the center of the infestation towards undisturbed habitats as expected, but in some cases detectible amounts of non-native species extend beyond 20 m from the center of the infestation (Fig. 11). Non-native plants extended at least four meters from the origin for all nine transects, and four of the nine transects had non-native plants throughout the first 12 meters. With all transects taken together, increases and decreases in non-native plant cover are variable within the first six meters, with some plots having low non-native cover at the origin and rising sharply the following few meters, while others begin with high percent cover and decline rapidly. The overall pattern of decline in non-native cover from the infestation center indicates that the weedy species fade in dominance rather than having a patchy distribution. This pattern suggests either the suitability of habitat for non-natives decreases gradually or that the non-natives are in the process of colonizing new areas. Repeated sampling of transects is necessary to separate these possibilities.

Figure 11. Percent non-native plant cover for nine transects in Campbell Tract. Each transect is represented by a different symbol and colored line. The origin of each transect begins with subplot 1, a meter separates each subplot.



The transect at the back of the BLM Regional parking lot (Transect 3) had high non-native cover throughout the majority of its length. This site is a broad highly disturbed clearing that appears to have been seeded with clovers a number of years ago. *Galeopsis tetrahit* was observed in the forest adjacent to the Smoke Jumper Trailhead, but when the transect (Transect 1) was erected and read those plant appeared to have been removed.

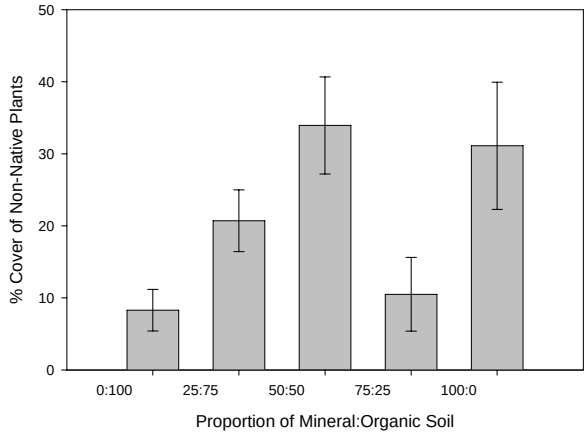


Figure 12. Mean percent cover (and standard error) of non-native plants relative to the approximate proportion of organic to mineral soil.

The type of substrate was not particularly important in explaining non-native plant cover, but mineral and mixed mineral-organic soils tended to have a greater cover of non-natives than did pure organic soils (Fig. 12).

The associated vegetation type was strongly related to non-native cover. Open herbaceous vegetation had higher non-native plant cover than mixed shrub-herbaceous and forest classifications, and mixed shrub-herbaceous was significantly higher in cover than forest classifications (Fig. 13.; $p < 0.001$, $df = 95$, one-way ANOVA). It is important to note that non-native species can be present in forested habitats.

Disturbance type was also very important in predicting non-native cover. Ground disturbance had significantly higher non-native cover than brush cutting/mowing, trampling, and stream eroded disturbances (Fig. 14; $p < 0.001$, $df = 95$, one-way ANOVA). No non-native plants were observed in subplots without disturbance and none were observed in subplots with natural stream erosion. All the subplots in forested habitats with non-native species had some anthropogenic disturbance (brush cutting or trampling).

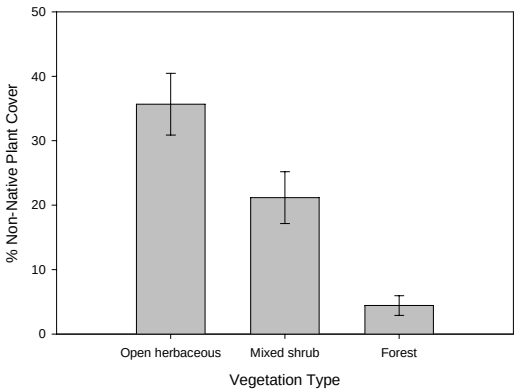


Figure 13. Mean percent cover (and standard error) of non-native plants relative to the surrounding vegetation type.

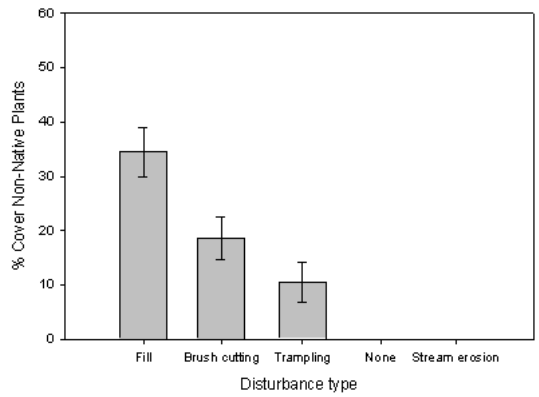


Figure 14. Mean percent cover (and standard error) of non-native plants relative to disturbance type.

Conclusion and Recommendations

The Bureau of Land Management's Campbell Tract in the Anchorage Bowl shows a mixed picture of a few invasive plants entrenched in high-use areas and a few species established in small populations in more remote sections of the Tract. Roadsides, parking lots, high-use trails, and the fill-source lot have a high density and diversity of invasive plants. The clover species (*Trifolium hybridum* and *T. repens*) have the highest percent cover across the Tract, probably due to their use in roadside and airstrip stabilization (or as a contaminant in revegetation seed mixes), but have since spread into trails and forest margins. Controlling outlying populations in forests is recommended prior to well-established roadside populations. Narrowleaf hawksbeard is extremely widespread, but at low population densities (and as an annual); control of this species should not require high levels of resources. White sweetclover is currently widely dispersed, but at relatively low population densities so that control of this species should be a high priority before populations become continuous. Observations along the Dalton and Elliot Highways over two years suggest that, if left unmanaged, small and scattered infestations of white sweetclover quickly become large and continuous (S. Seefeldt, unpublished data).

The invasive species with few populations (quack grass, oxeye daisy, brittlestem hempnettle, orange hawkweed, and European bird cherry) should be targeted for eradication. The three orange hawkweed and a single European bird cherry infestations were eliminated, but should be monitored in the future to remove any plants that were missed.

Reducing future importation of non-native species will be a significant challenge for the BLM. One of the first tasks is to identify the sources and their relative contributions to new infestations. It is unknown how many infestations are due to plant dispersal from within the Tract, relative to propagules arriving from outside the Tract. Additionally identifying the most problematic vectors is necessary. Vehicles and hikers likely carry many weed seeds, but earthmoving equipment is a particular concern. Additionally, it would be useful to gain a better understanding of how many weed seeds are arriving in Campbell Tract due to horses and to dog teams (straw and hay used for dog kennel insulation has recently been shown to have millions of weed seed per bail; J. Conn unpublished data). Last, we have observed robins (*Turdus migratorius*) and rusty blackbirds (*Euphagus carolinus*) feeding on European bird cherry fruits in western Anchorage and these birds may be responsible for the dispersal of seeds along the upper riparian areas of Campbell Tract. It is unclear how many bird cherry fruits are being dispersed by these species and what their temporal and spatial movements are. Knowing these patterns may improve the efficiency of survey efforts to identify early infestations.

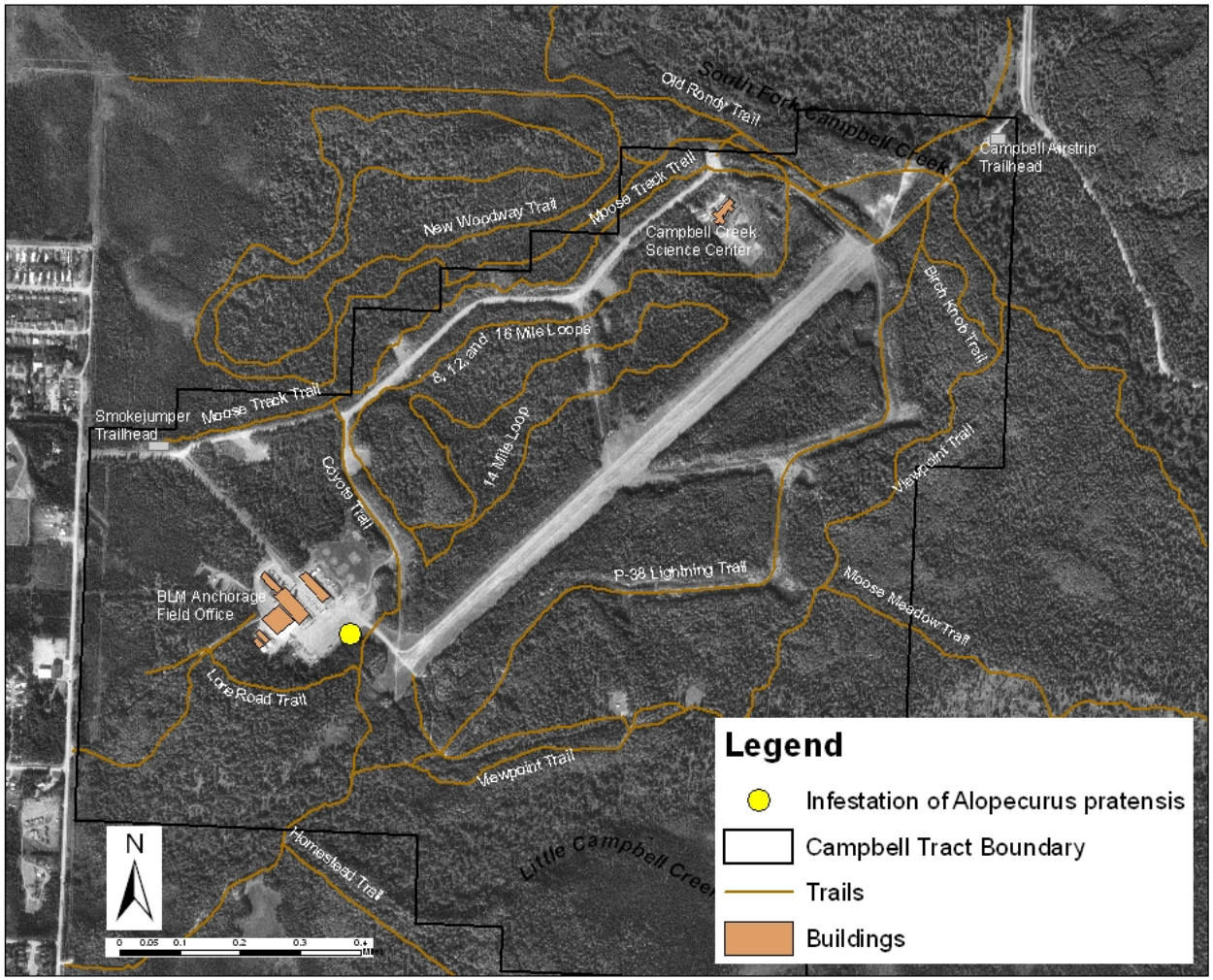
Additional surveys for European bird cherry are recommended in late October or early May, since the bird cherry leafs-out prior to alder and most other species and maintains its leaves for longer in the fall.

A major task will be to clean the fill materials site and equipment of all non-native propagules. The movement of soil from this location to other portions of Campbell Tract likely represents the single greatest contribution to new infestations. Cleaning the soil and fill may be achieved with steam sterilization or preemergence herbicides.

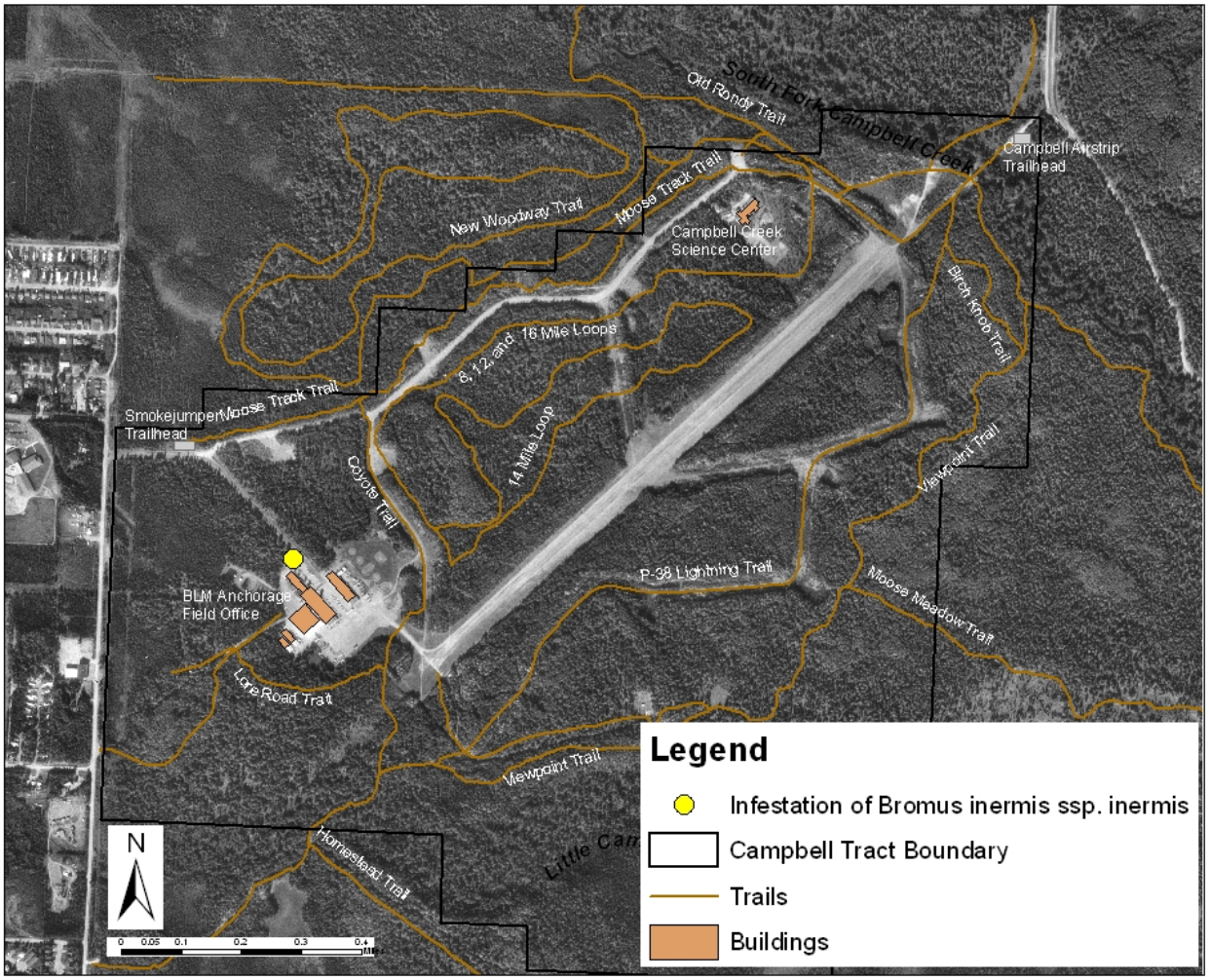
Acknowledgements

Luise Woelflien and Jeanne Standley of the BLM offered extensive direction, encouragement, and help in the project. Michelle Sturdy ably assisted in erecting and reading the transects.

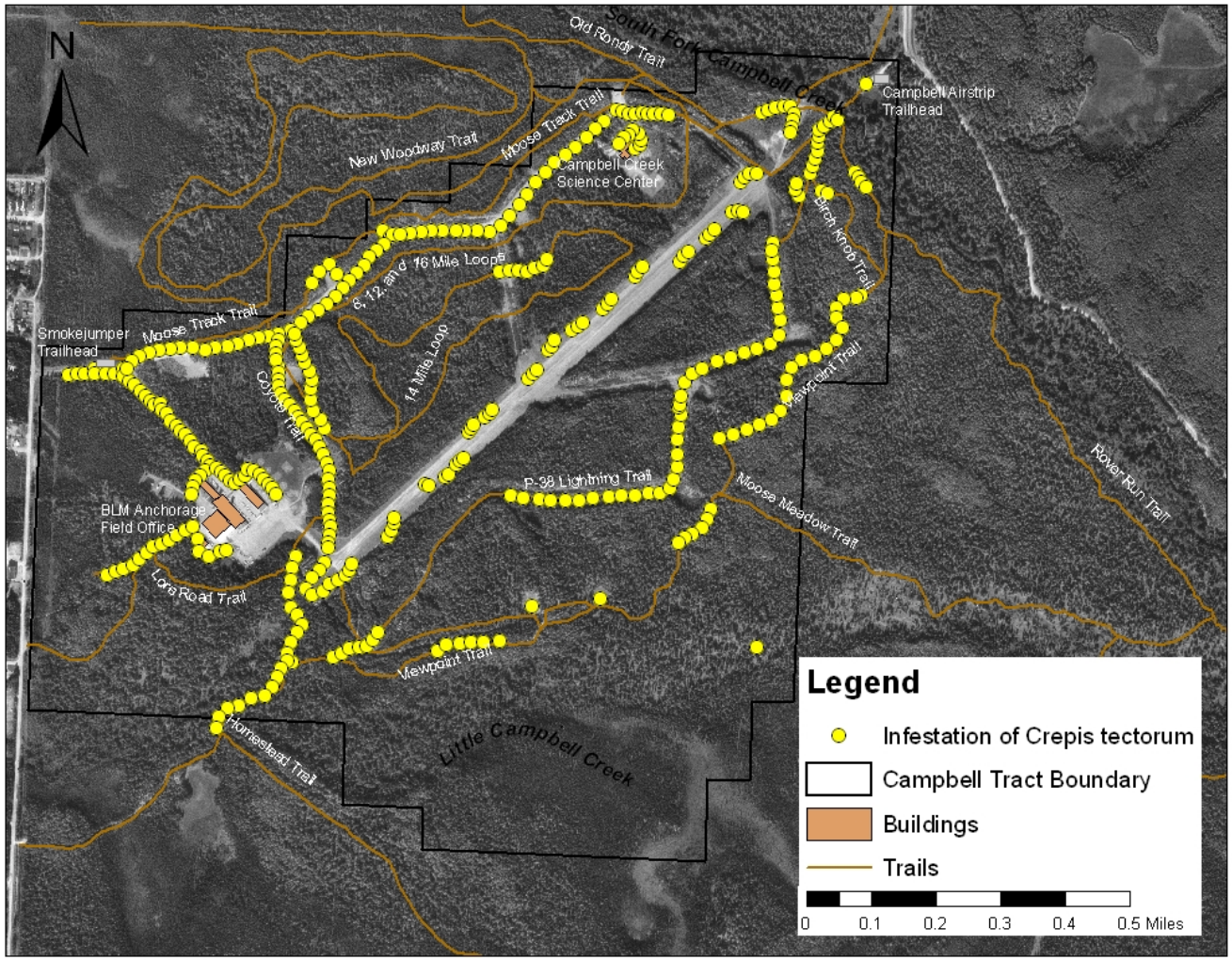
Appendix I – Maps of Infestations
Alopecurus pratensis



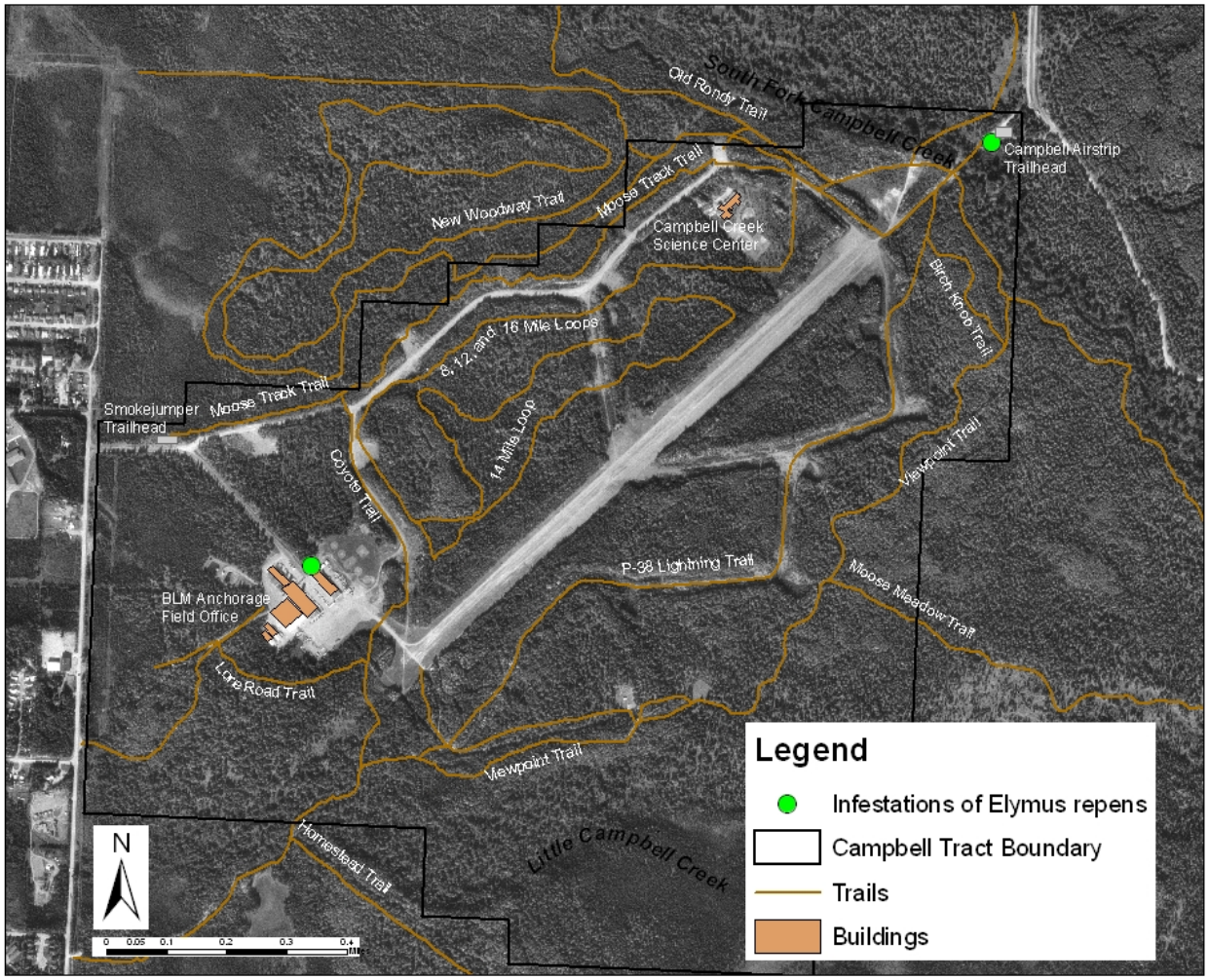
Bromus inermis ssp. *inermis*



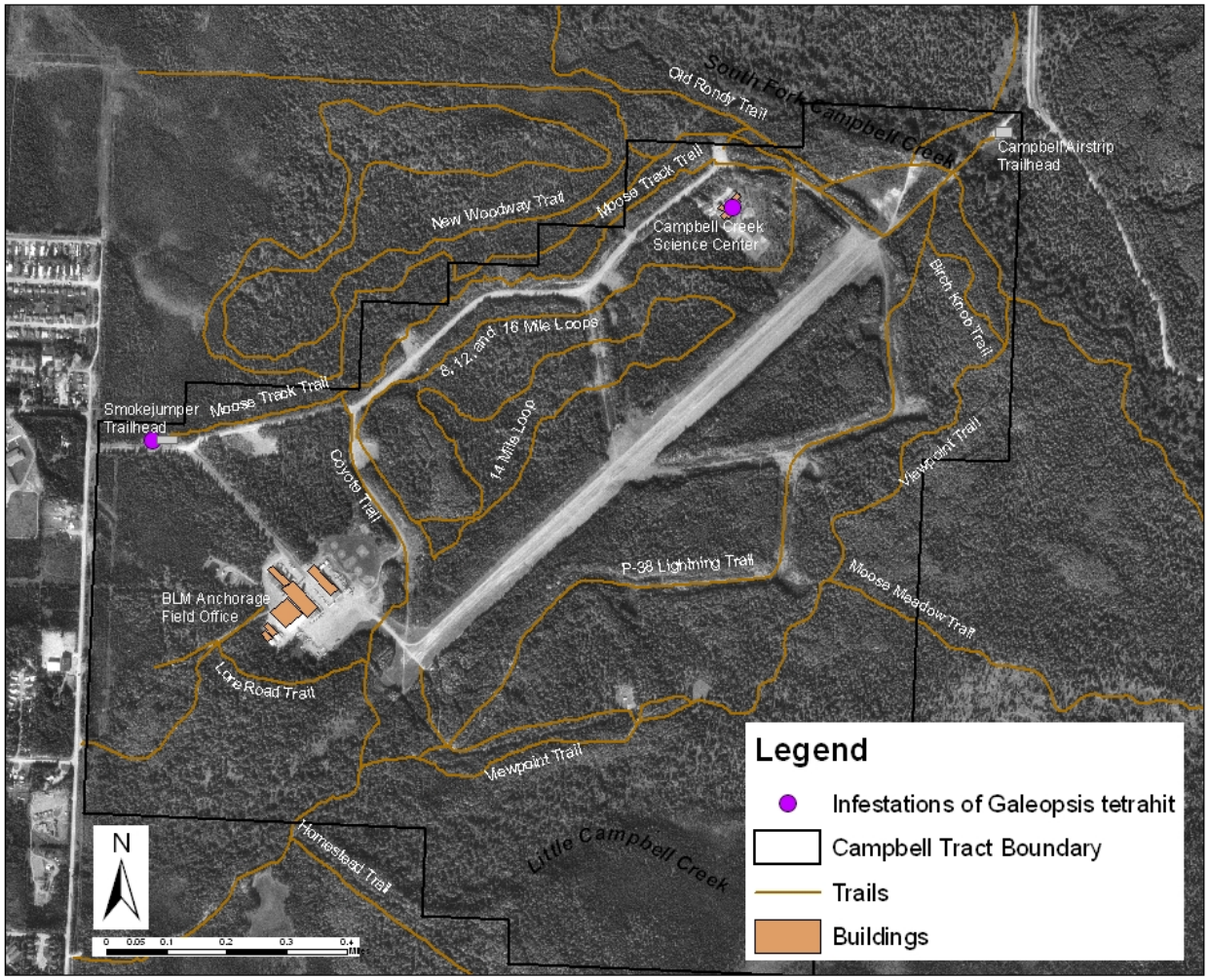
Crepis tectorum



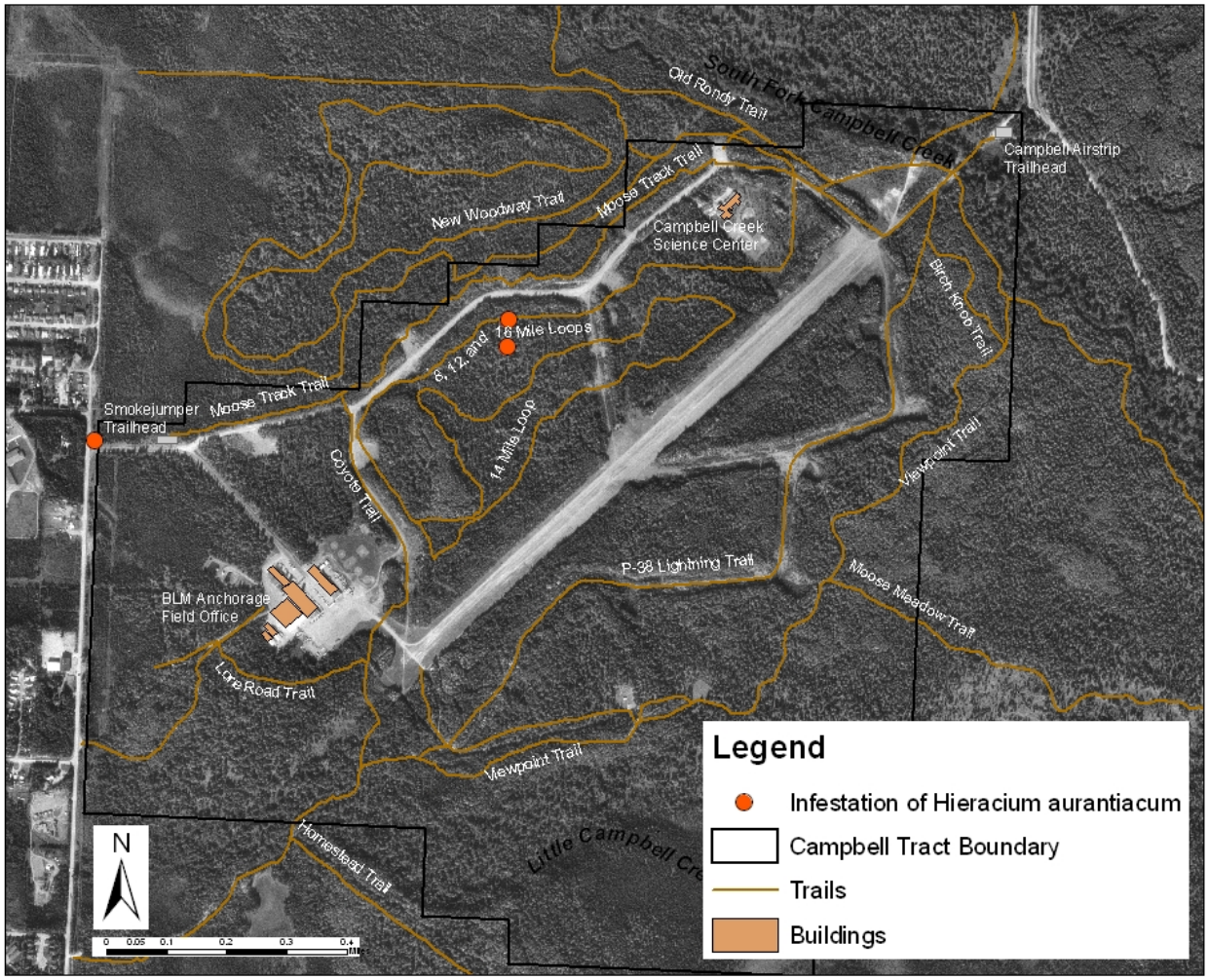
Elymus repens



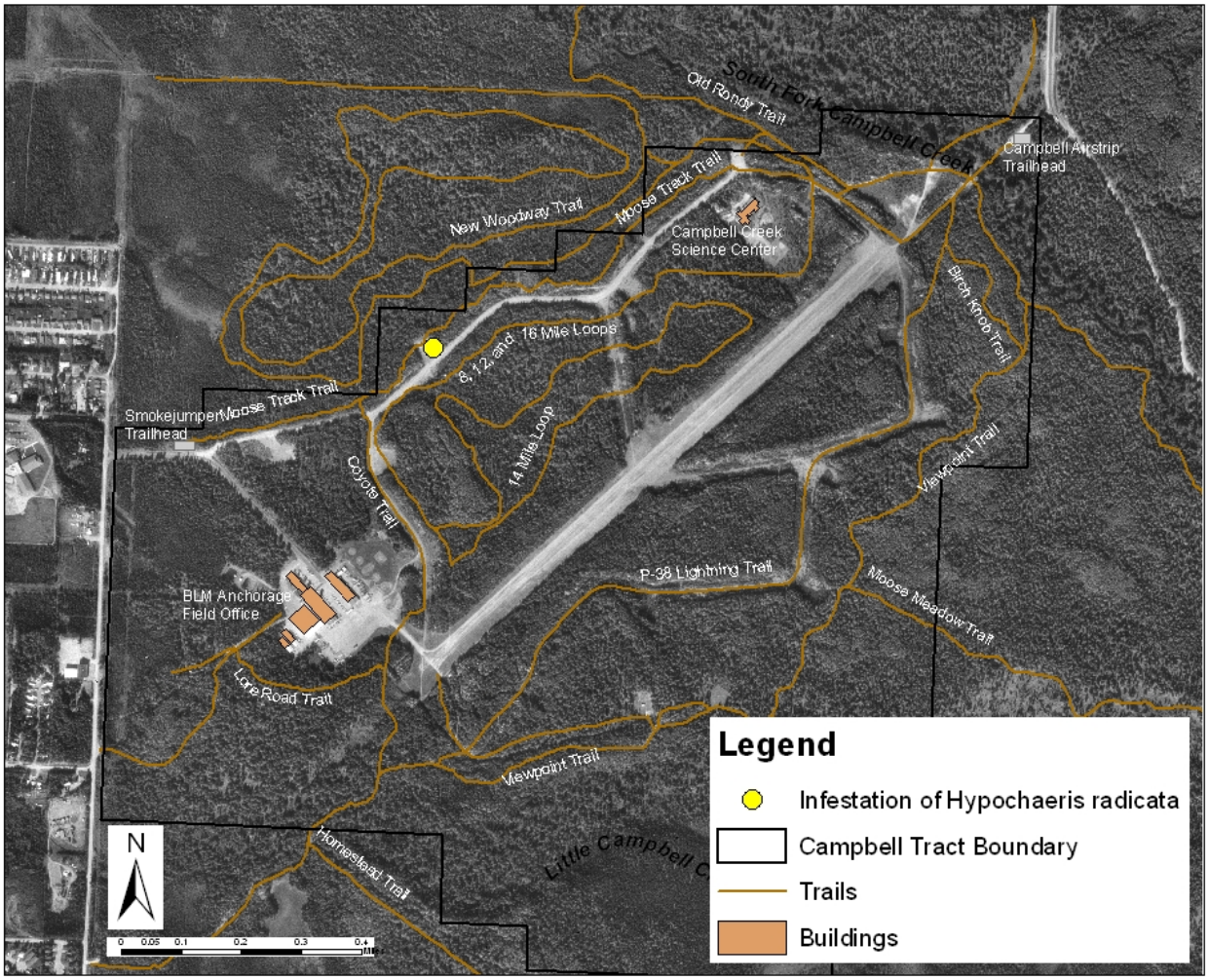
Galeopsis tetrahit



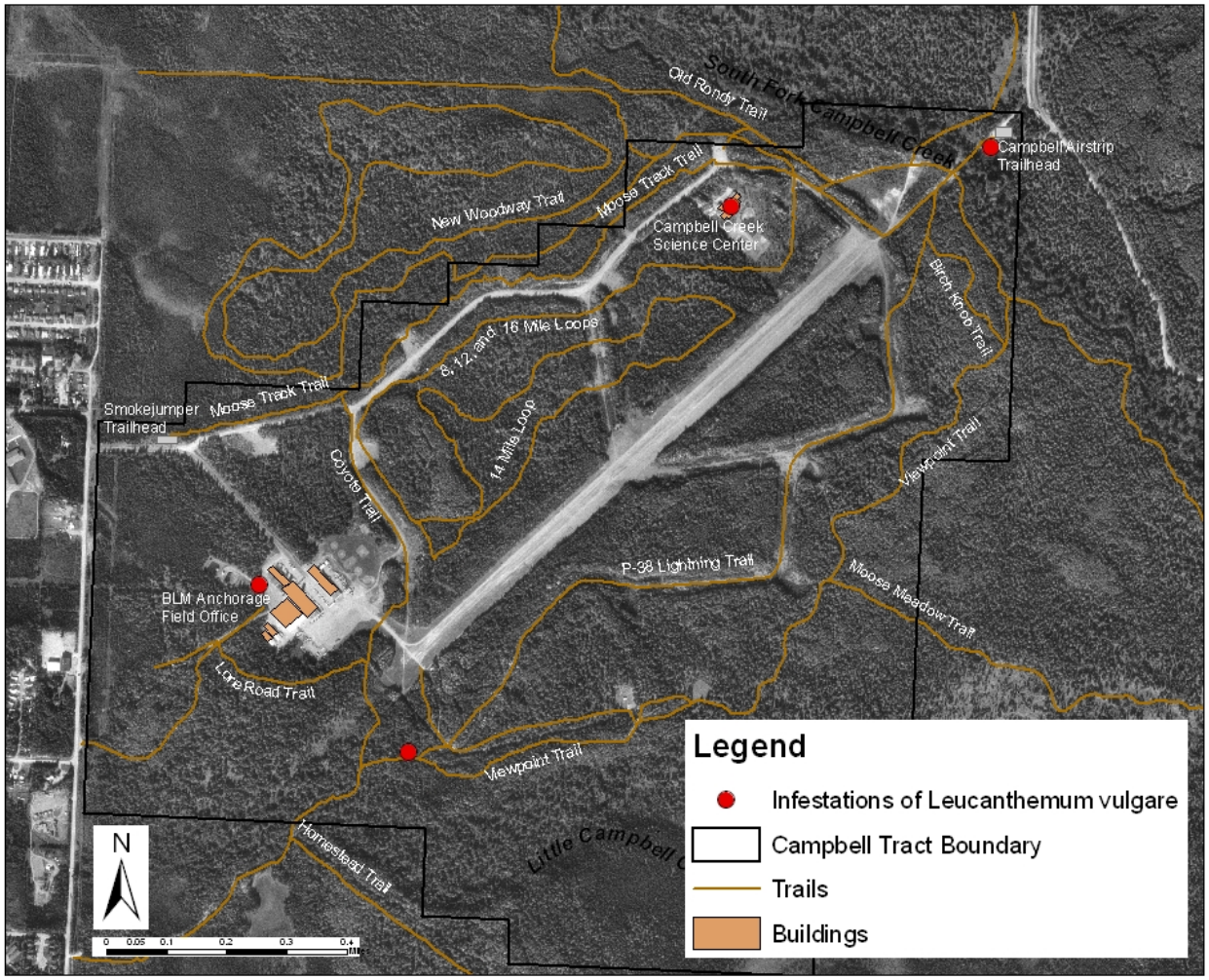
Hieracium aurantiacum



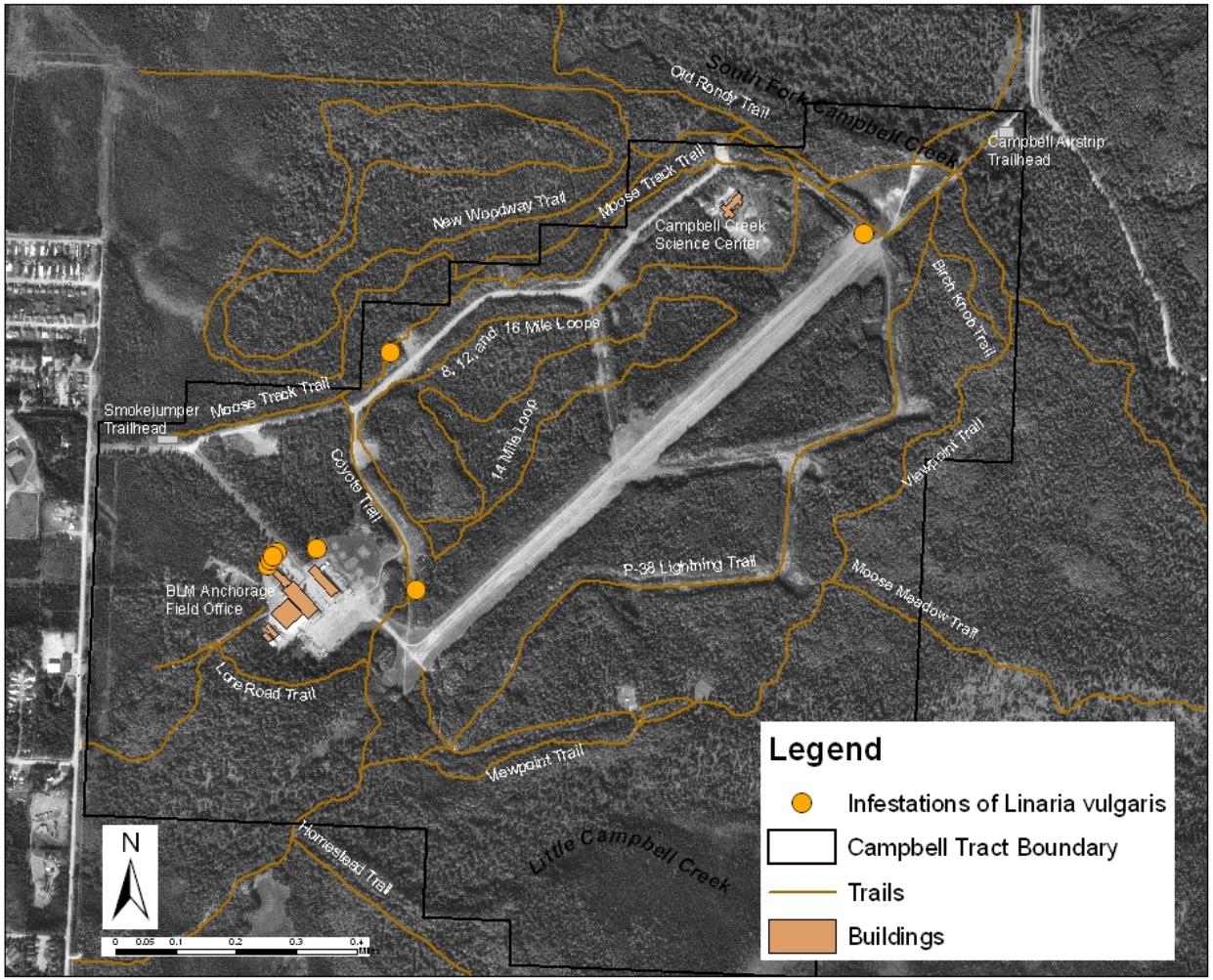
Hypochaeris radicata



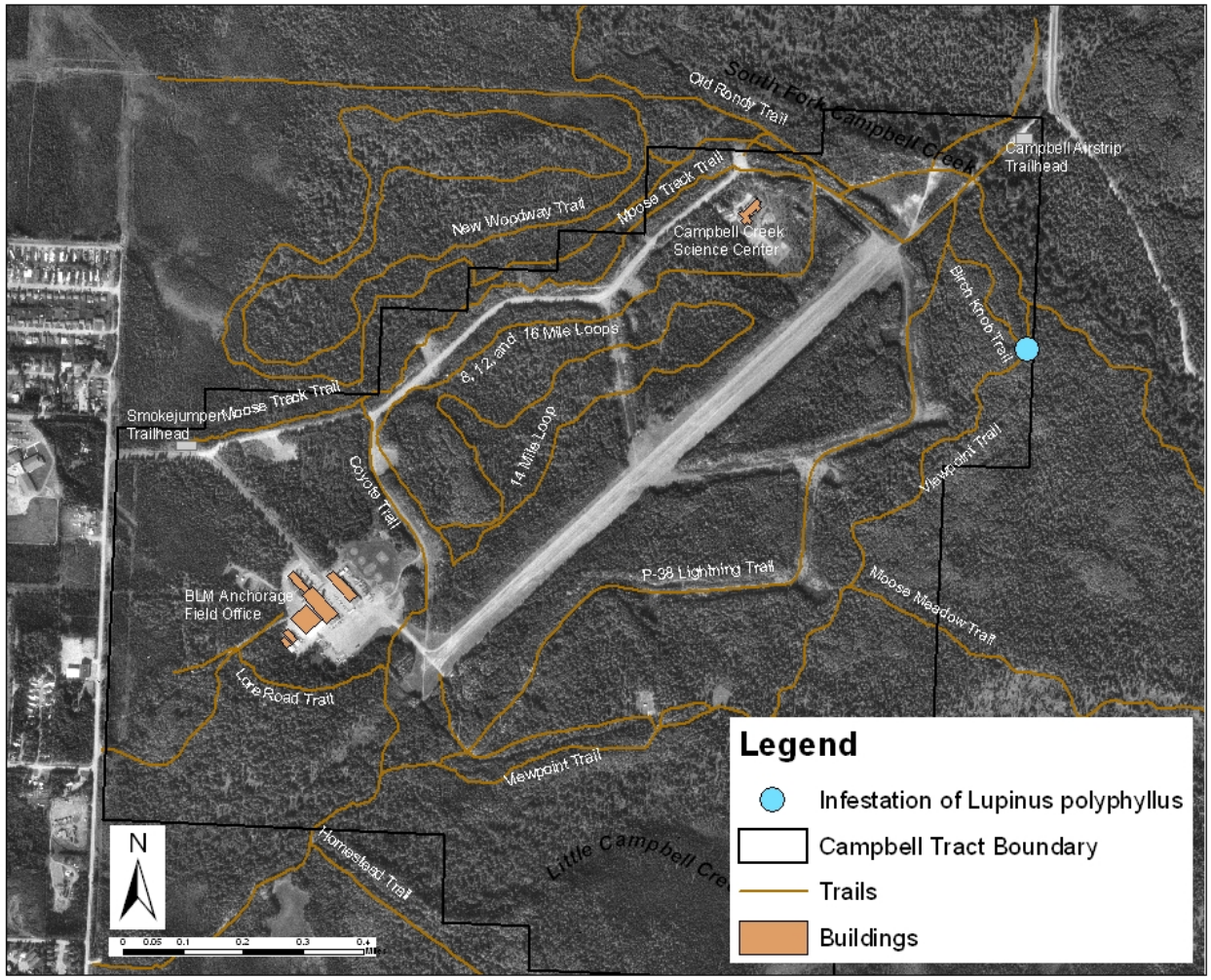
Leucanthemum vulgare



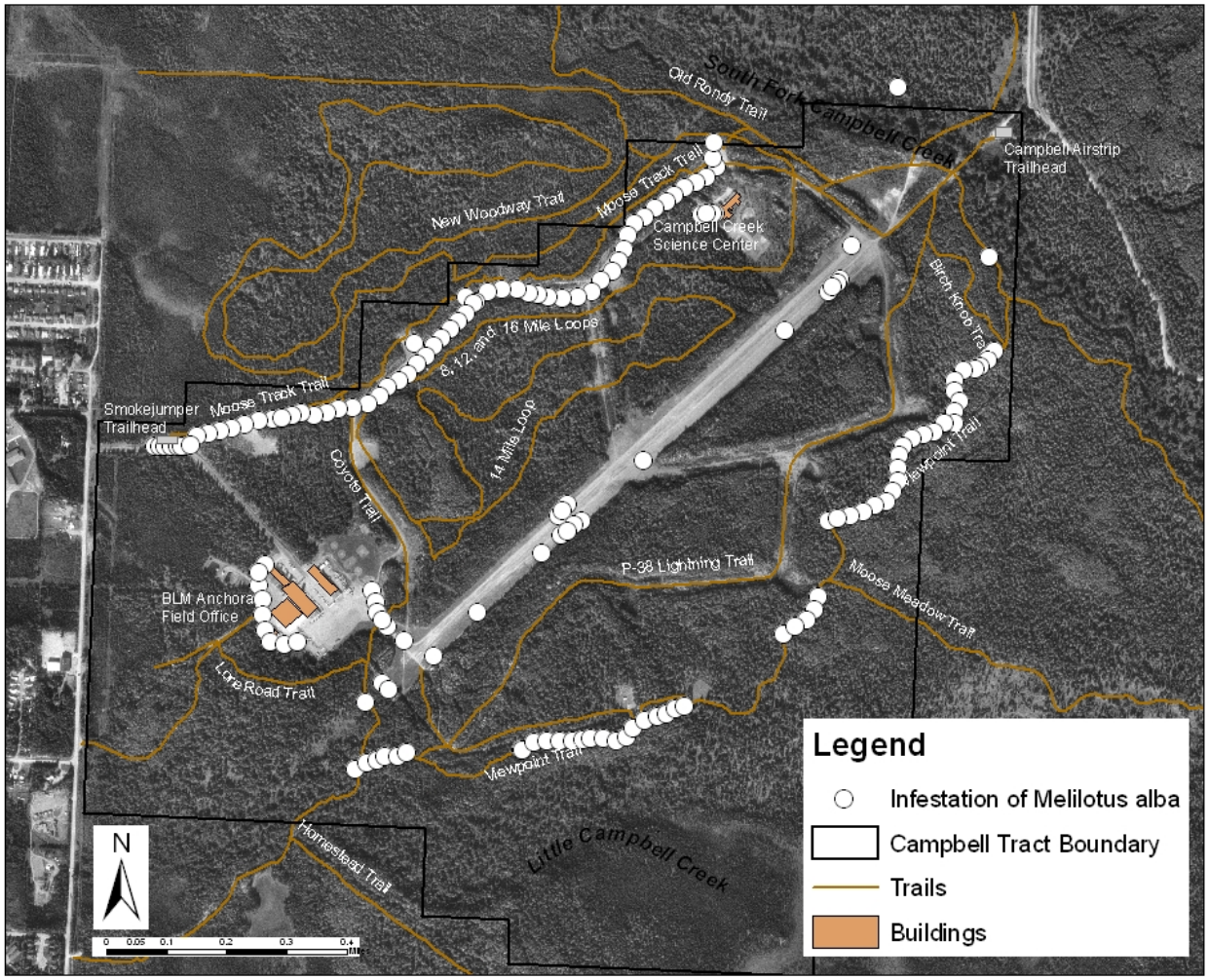
Linaria vulgaris



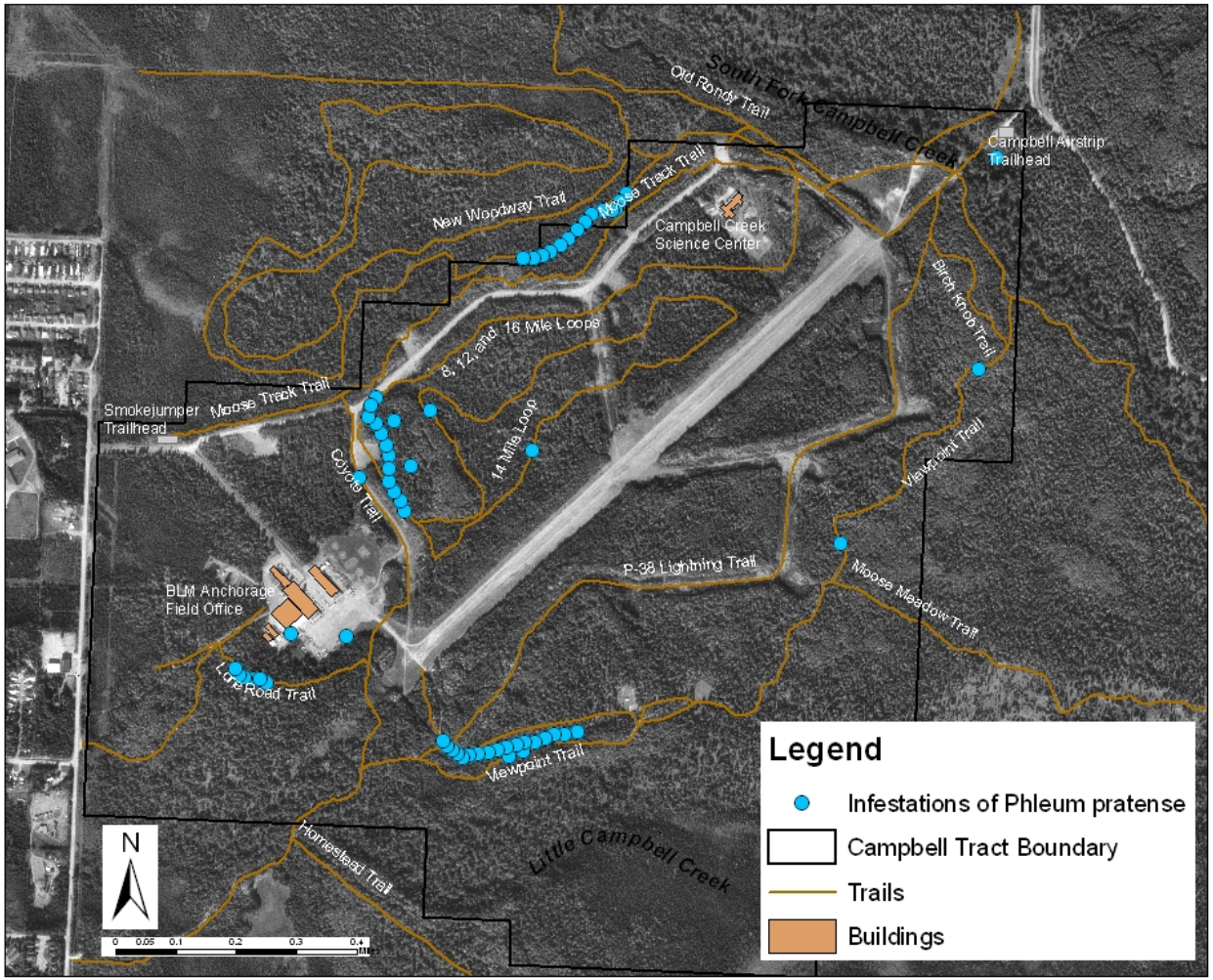
Lupinus polyphyllus



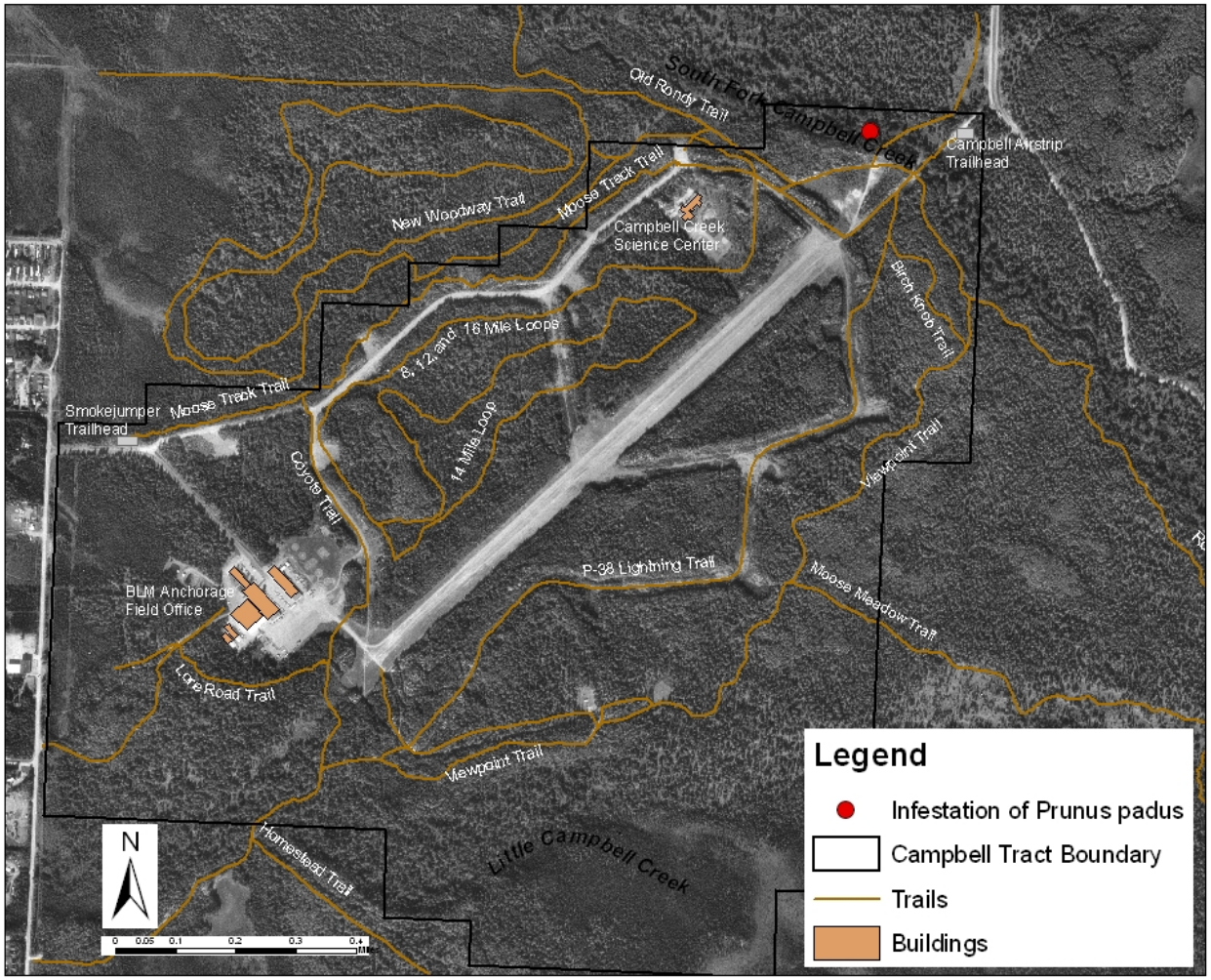
Melilotus alba



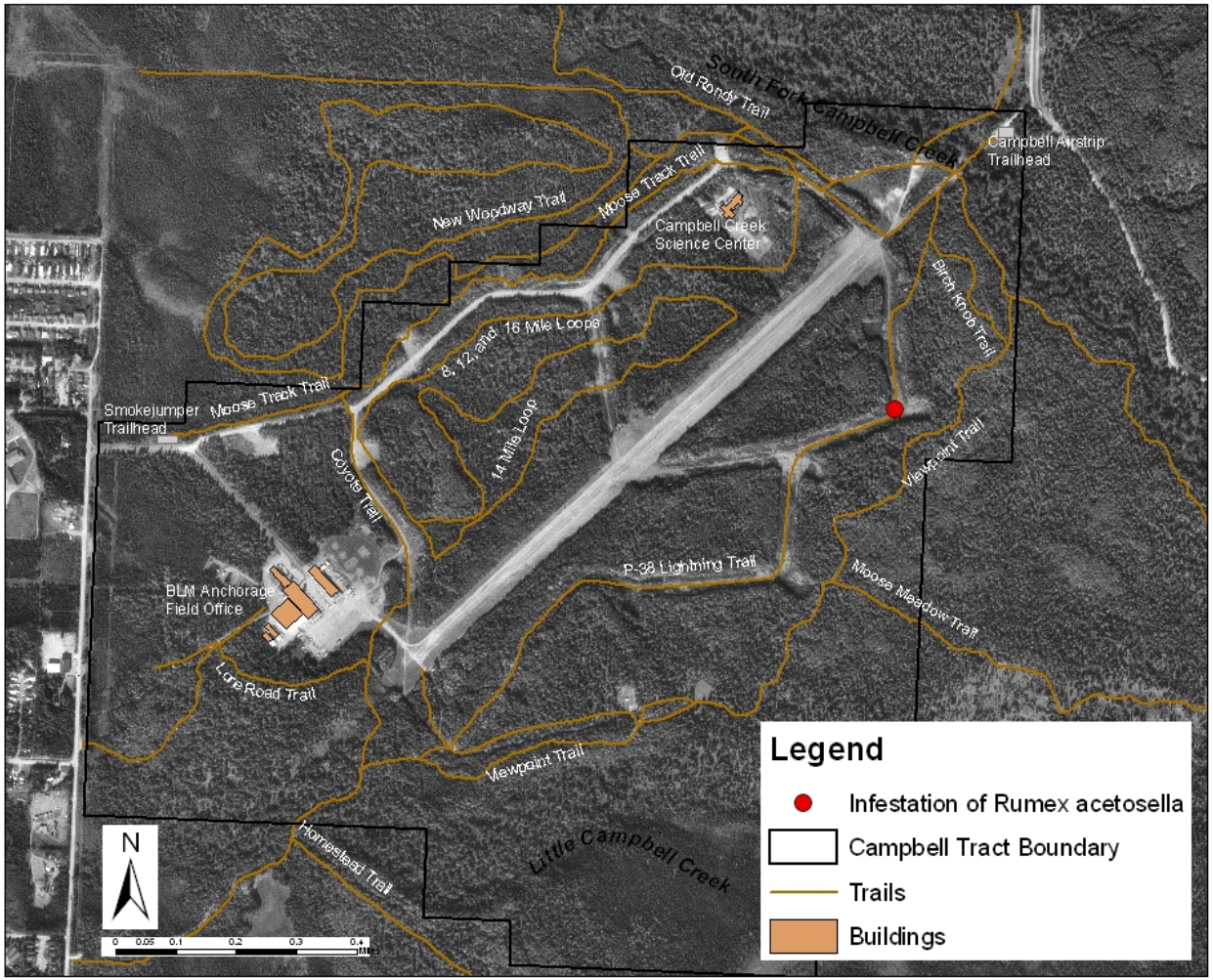
Phleum pratense



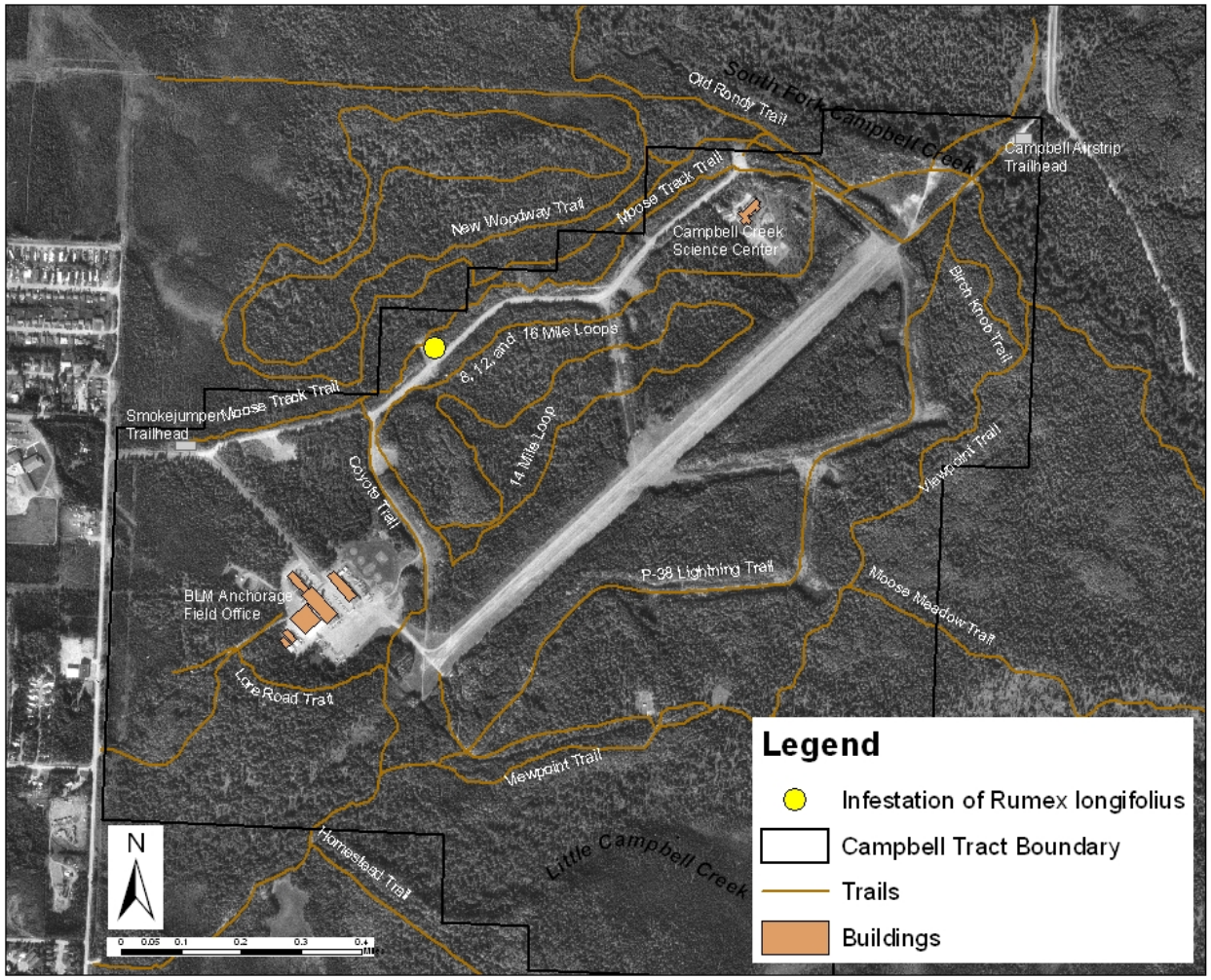
Prunus padus



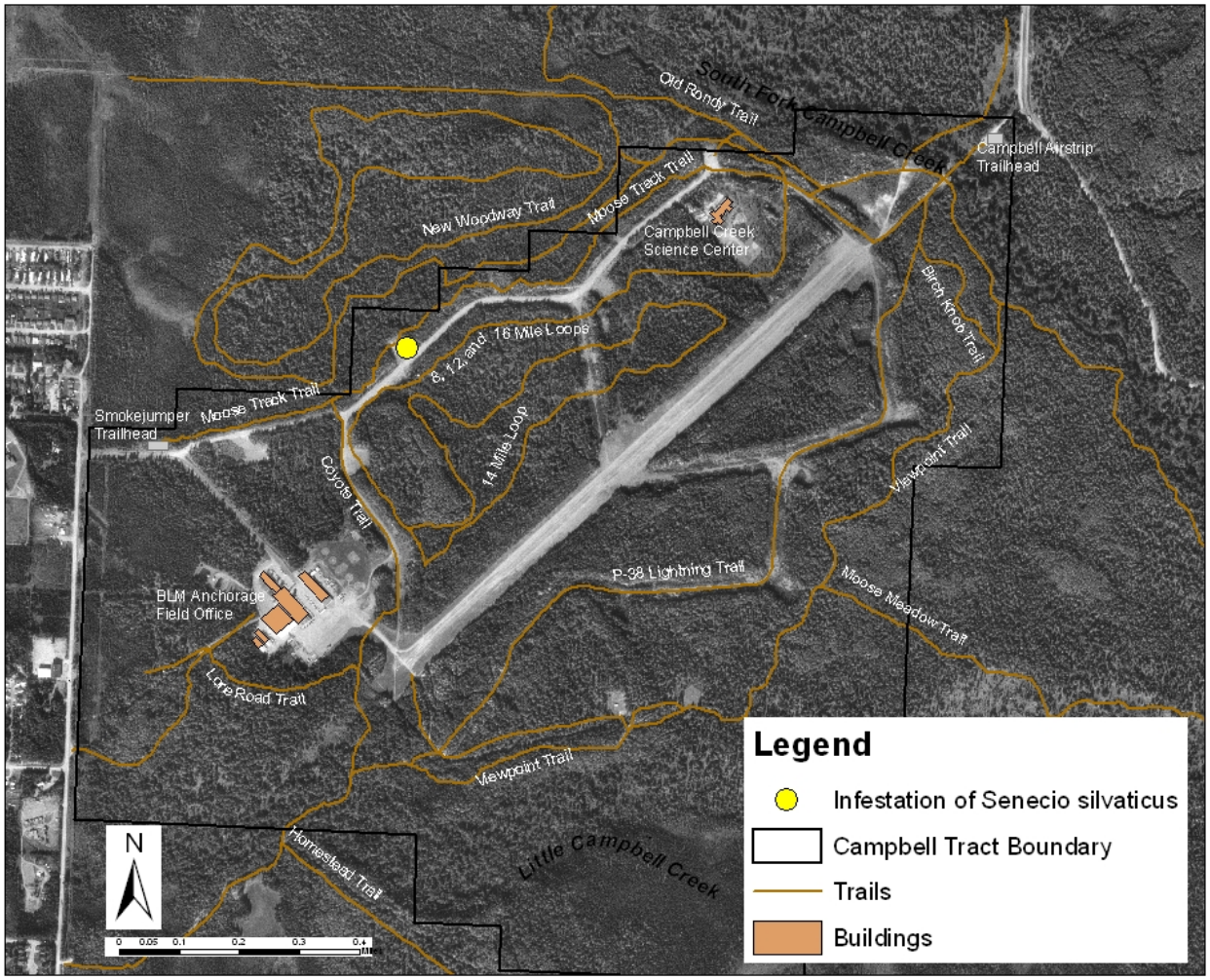
Rumex acetosella



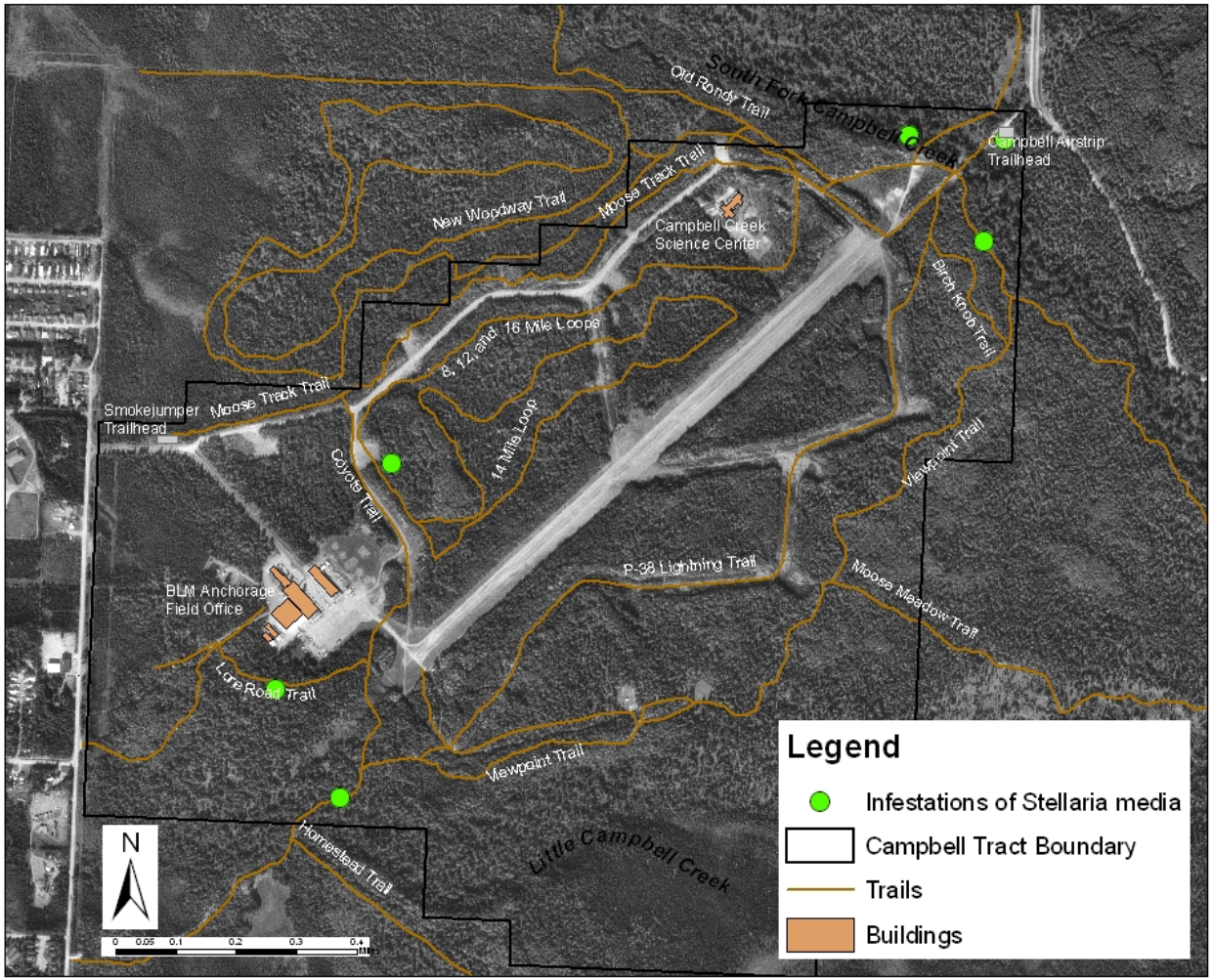
Rumex longifolius



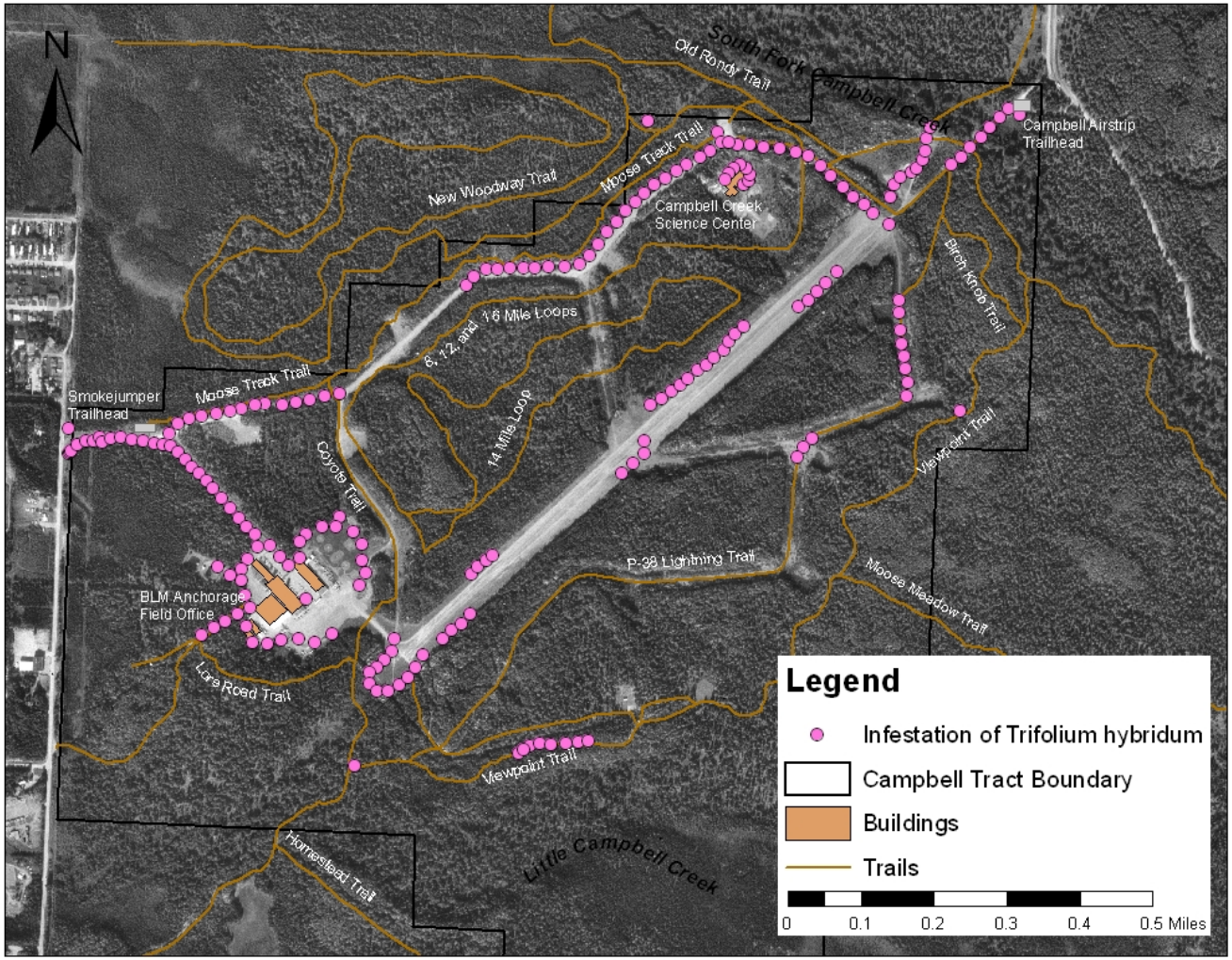
Senecio sylvaticus



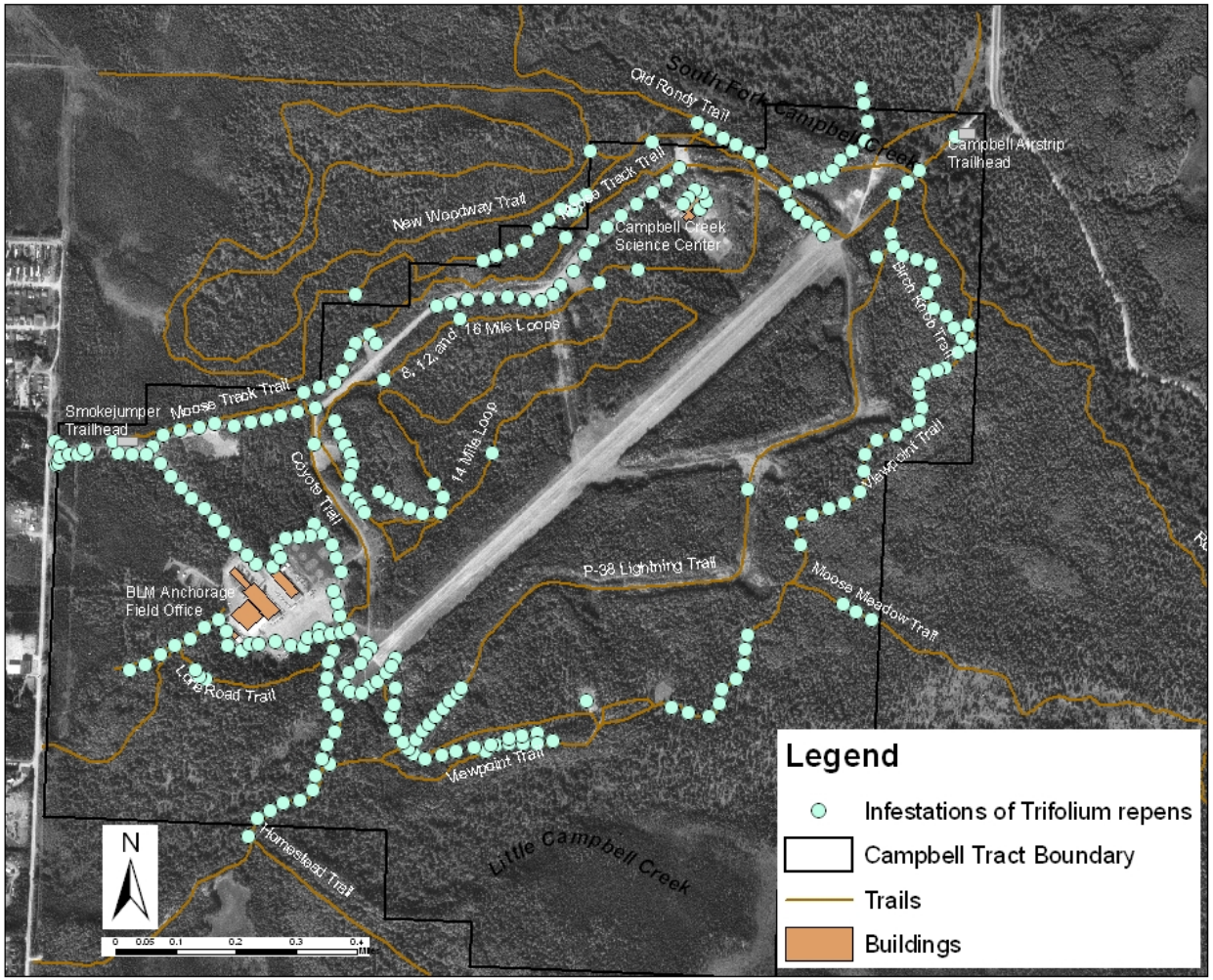
Stellaria media



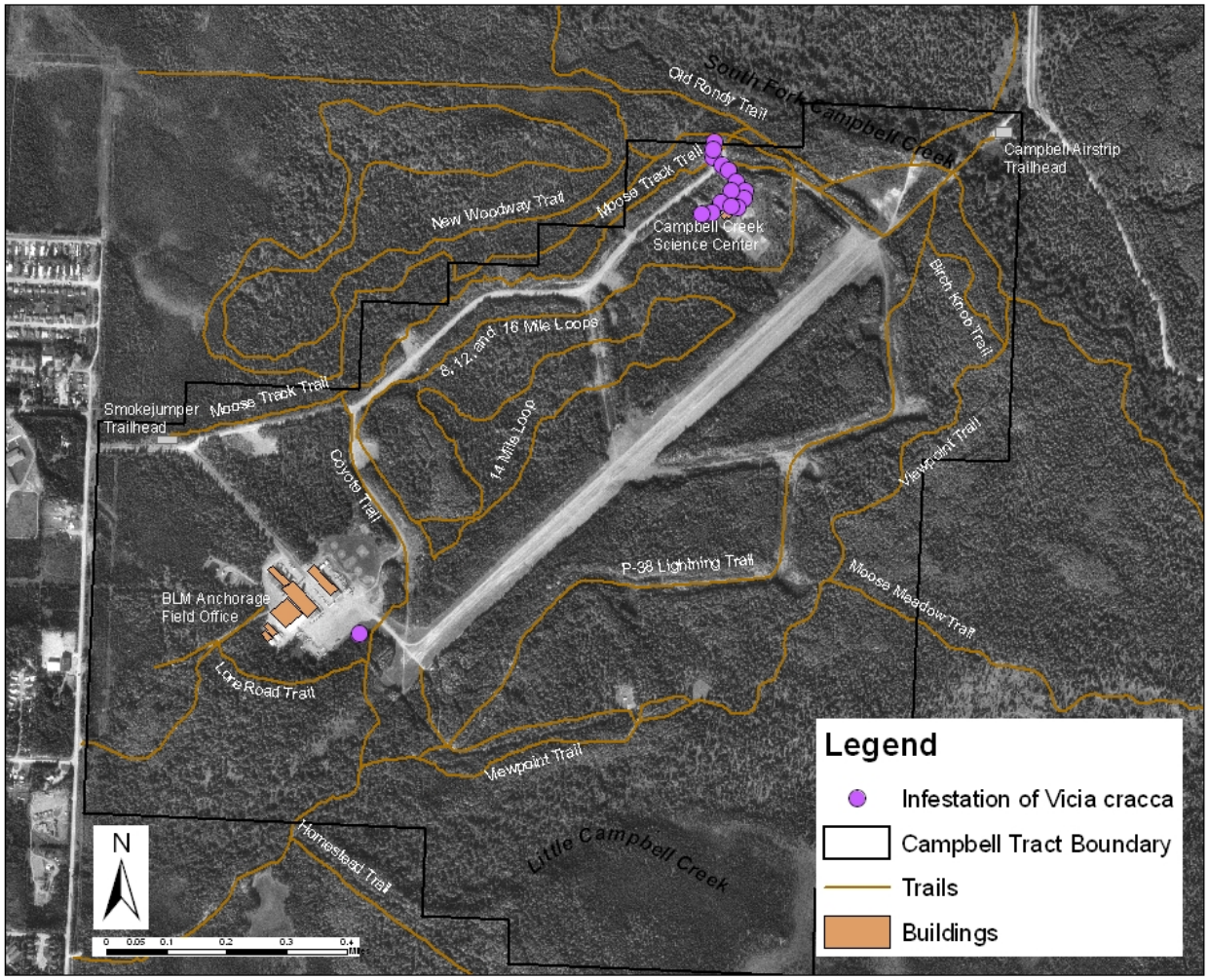
Trifolium hybridum



Trifolium repens



Vicia cracca



Appendix II – List Of Priority Infestations For Control

PRIORITY	SITE_CODE	WAYPOINT	LATITUDE_D	LONGITUDE_	LOCATION_II	PRIMARY_PLANT	EST_AC	EST_CVR_CL	EST_STEM_C	AGGRESS	OTHER_SPP	NOTES
HIGH	MLC066	WP077	61.160760	-149.791550	GRAVEL-FILL MATERIAL SITE, MOOSE CR	ERUCASTRUM GALLICUM	0.10	LOW(1-5%)	6-25	LOW	MANY OTHER NO	MLC 066 & IV443 ARE DIFFERENT PORTIONS OF THE SAME SUITE
HIGH	MLC046	WP057	61.165530	-149.766100	AIRSTRIP PARKING LOT	LEUCANTHEMUM VULGARE	0.50	MED (6-25%)1000-	500-1000	HIGH		MOVING INTO ALNUS, HERACLEUM, CALAMAGROSTIS MEADOW
TREATED - HIGH MONI	IVL443		61.1609900	-149.7904500	GRAVEL-FILL MATERIAL SITE, Road to Car	SENECIO SYLVATICUS	0.10	LOW(1-5%)	1-5	None	MANY OTHER NO	MLC 066 & IV443 ARE DIFFERENT PORTIONS OF THE SAME SUITE
TREATED - HIGH MONI	MLC114	WP138	61.161550	-149.786470	8, 12, 16 MILE LOOPS	HIERACIUM AURANTIACUM	0.10	LOW(1-5%)	26-50	HIGH		FOUND IN THE MIDDLE OF THE TRAIL AND EDGE OF WEAKLY TRA
TREATED - HIGH MONI	MLC128	WP154	61.160980	-149.786500	8 MI TRAIL	HIERACIUM AURANTIACUM	0.10	LOW(1-5%)	6-25	MED		
TREATED - HIGH MONI	MLC002	WP004	61.158680	-149.804020	ABBOTT LOOP ENTERANCE	HIERACIUM AURANTIACUM	0.10	TRACE (<1%)	1	HIGH		SHOULD LOOK FOR OTHER VEG PLANTS
TREATED - HIGH MONI	IVL454		61.165820	-149.769670	Campbell Creek, west of sled dog trail woo	Prunus padus	0.10	LOW(1-5%)	1-5	MED		
HIGH	MLC015	WP024	61.158730	-149.801530	SMOKEJUMPER PARKING LOT, ABBOTT LO	GALEOPSIS TETRAHIT	0.10	TRACE (<1%)	6-25	HIGH		FLAGGED
HIGH	MLC010	WP019	61.154900	-149.792330	BLM REGIONAL OFFICE LOT EDGE-BACKS	VICIA CRACCA	0.10	TRACE (<1%)	1-5	LOW		FLAGGED
HIGH	MLC081	WP092	61.152500	-149.790010	VIEWPOINT AND P-38	LEUCANTHEMUM VULGARE	0.10	TRACE (<1%)	1-5	HIGH		UNDER ALDER CANOPY
HIGH	MLC072	WP083	61.155880	-149.790040	COYOTE TRAIL NEAR AIRSTRIP	LINARIA VULGARIS	0.10	MED (6-25%)1000-	151-500	LOW		
HIGH	MLC006	WP012-WP0	61.156510	-149.796070	BLM REGIONAL OFFICE LOT EDGE	LINARIA VULGARIS	0.10	LOW(1-5%)	500-1000	HIGH		MOVING INTO UNDISTURBED FOREST
HIGH	MLC013	WP022	61.156640	-149.794340	BLM REGIONAL OFFICE LOT EDGE-AIRSTR	LINARIA VULGARIS	0.10	TRACE (<1%)	26-50	LOW		
HIGH	MLC039	WP048	61.163620	-149.791480	AIRSTRIP (NE END)	LINARIA VULGARIS	0.10	TRACE (<1%)	1-5	LOW		
HIGH	MLC115	WP140-WP1	61.159350	-149.792080	8, 12, 16 MILE LOOPS	TRIFOLIUM REPENS	0.50	MED (6-25%)1000-	500-1000	HIGH		
MED	MLC058	WP070	61.164080	-149.777130	SCIENCE CENTER BACKSIDE	GALEOPSIS TETRAHIT	0.10	LOW(1-5%)	51-150	LOW		
MED	MLC051	WP065 + WP	61.165090	-149.777970	SCIENCE CENTER LOT	VICIA CRACCA	0.10	LOW(1-5%)	26-50	LOW		PLANTS ON GRASSY MOUND
MED	MLC083	WP094-WP0	61.152630	-149.785140	VIEWPOINT	MELILOTUS ALBA	1.00	LOW(1-5%)	26-50	MED		
MED	MLC094	WP109-112-	61.163270	-149.765950	VIEWPOINT TRAIL	MELILOTUS ALBA	0.10	LOW(1-5%)	1-5	MED		
MED	MLC097	WP111-WP1	61.157660	-149.772350	VIEWPOINT TRAIL	MELILOTUS ALBA	0.10	TRACE (<1%)	151-500	MED		
MED	MLC104	WP121-122	61.156070	-149.772640	VIEWPOINT TRAIL	MELILOTUS ALBA	0.10	LOW(1-5%)	151-500	MED		
MED	MLC024	WP032-WP0	61.153900	-149.791240	AIRSTRIP	MELILOTUS ALBA	0.10	LOW(1-5%)	26-50	MED		
MED	MLC028	WP031-LINK	61.154800	-149.790360	AIRSTRIP	MELILOTUS ALBA	1.00	MED (6-25%)	1000-	LOW		
MED	MLC029	WP034	61.154510	-149.789090	AIRSTRIP	MELILOTUS ALBA	1.00	LOW(1-5%)	6-25	LOW		
MED	MLC030	WP035	61.155460	-149.787280	AIRSTRIP	MELILOTUS ALBA	0.10	LOW(1-5%)	26-50	LOW		
MED	MLC031	WP036	61.156730	-149.784590	AIRSTRIP	MELILOTUS ALBA	0.10	TRACE (<1%)	1-5	LOW		
MED	MLC032	WP037-WP0	61.157530	-149.783980	AIRSTRIP	MELILOTUS ALBA	0.10	TRACE (<1%)	26-50	LOW		
MED	MLC033	WP039-WP0	61.157140	-149.783840	AIRSTRIP	MELILOTUS ALBA	0.10	TRACE (<1%)	6-25	LOW		
MED	MLC034	WP041	61.150760	-149.700440	AIRSTRIP	MELILOTUS ALBA	0.10	TRACE (<1%)	1-5	LOW	HORDEUM JUBATUM	
MED	MLC035	WP044	61.161580	-149.774570	AIRSTRIP	MELILOTUS ALBA	0.10	TRACE (<1%)	6-25	LOW		
MED	MLC036	WP045-WP0	61.162420	-149.772780	AIRSTRIP	MELILOTUS ALBA	0.10	TRACE (<1%)	26-50	LOW		
MED	MLC037	WP049	61.163390	-149.771870	AIRSTRIP	MELILOTUS ALBA	0.10	TRACE (<1%)	1-5	LOW		
MED	MLC041	WP052	61.166710	-149.770140	RONDY TRAIL TO AIRSTRIP	MELILOTUS ALBA	0.10	LOW(1-5%)	26-50	LOW		
MED-LOW	MLC047	WP058-WP0	61.165050	-149.767530	BIRCH KNOB-OLD RONDY TRAIL	TRIFOLIUM REPENS	5.00	LOW(1-5%)	1000-	MED		
MED-LOW	MLC103	WP119-120	61.156020	-149.770030	MOOSE MEADOW	TRIFOLIUM REPENS	0.10	LOW(1-5%)	51-150	MED		VERY FEW WEEDS ALONG MOOSE MEADOW - NO FILL!
MED-LOW	MLC113	WP136, WP1	61.162740	-149.779400	8, 12, 16 MILE LOOPS	TRIFOLIUM REPENS	0.10	TRACE (<1%)	6-25	MED		TINY BIT ALONG THE TRAIL
MED-LOW	MLC119	WP143	61.158840	-149.785320	14 MILE LOOP	TRIFOLIUM REPENS	0.10	TRACE (<1%)	6-25	MED		
MED-LOW	MLC122	WP146	61.165410	-149.779020	WOODARD TRAIL	TRIFOLIUM REPENS	0.10	LOW(1-5%)	500-1000	MED		
MED-LOW	MLC123	WP147	61.165170	-149.781660	WOODARD TRAIL	TRIFOLIUM REPENS	0.10	LOW(1-5%)	500-1000	MED		
MED-LOW	MLC124	WP148-WP1	61.164260	-149.781750	WOODARD TRAIL	TRIFOLIUM REPENS	0.10	LOW(1-5%)	500-1000	MED		
MED-LOW	MLC126	WP152	61.161990	-149.791440		TRIFOLIUM REPENS	0.10	TRACE (<1%)	51-150	MED	ALSO NATIVE PHLEUM ALPINUM	
MED-LOW	MLC127	WP153	61.161590	-149.786930	8 MI TRAIL	TRIFOLIUM REPENS	0.10	LOW(1-5%)	151-500	MED		
MED-LOW	MLC130	WP156-157	61.158150	-149.787750	8 MI TRAIL	TRIFOLIUM REPENS	0.10	TRACE (<1%)	26-50	MED		
MED-LOW	MLC014	WP023	61.156280	-149.794460	BLM REGIONAL OFFICE LOT EDGE-AIRSTR	ELYMUS REPENS	0.10	TRACE (<1%)	6-25	LOW	LEPIDIUM DENSIFLORUM, HORDEUM JUBATUM	
MED-LOW	MLC009	WP017	61.154850	-149.792890	BLM REGIONAL OFFICE LOT EDGE-BACKS	PHLEUM PRATENSE	0.10	TRACE (<1%)	6-25	LOW		FLAGGED
MED-LOW	MLC044	WP055	61.165330	-149.765950	AIRSTRIP PARKING LOT	PHLEUM PRATENSE	0.10	LOW(1-5%)	26-50	MED		PATCH IN THE MIDDLE OF THE GRASS/CLOVER
MED-LOW	MLC071	WP082	61.158150	-149.792660	COYOTE TRAIL	PHLEUM PRATENSE	0.10	TRACE (<1%)	1-5	LOW		
MED-LOW	MLC082	WP093 + WP	61.152520	-149.785740	VIEWPOINT	PHLEUM PRATENSE	0.10	LOW(1-5%)	26-50	MED		FLAGGED 3 CLUMPS
MED-LOW	MLC087	WP100-WP1	61.153080	-149.782880	MAINTENANCE ROAD FROM TOWERS	PHLEUM PRATENSE	0.10	LOW(1-5%)	1-5	LOW		ORIGINATING FROM HORSES?
MED-LOW	MLC091	WP104-WP1	61.153820	-149.796280		PHLEUM PRATENSE	0.10	TRACE (<1%)	26-50	MED		
MED-LOW	MLC099	WP113	61.160930	-149.766310	VIEWPOINT TRAIL	PHLEUM PRATENSE	0.10	TRACE (<1%)	6-25	MED		PHOTO
MED-LOW	MLC101	WP117	61.157210	-149.771940	VIEWPOINT TRAIL	PHLEUM PRATENSE	0.10	TRACE (<1%)	6-25	MED		PHOTO
MED-LOW	MLC108	WP128	61.154860	-149.795280	P-38 TRAIL	PHLEUM PRATENSE	1.00	TRACE (<1%)	6-25	MED		
MED-LOW	MLC117	WP142 - TO	61.157500	-149.790660	8, 12, 16 MILE LOOPS	PHLEUM PRATENSE	0.10	TRACE (<1%)	1-5	MED	CERASTIUM FONTANUM	
MED-LOW	MLC120	WP143	61.158840	-149.785320	14 MILE LOOP	PHLEUM PRATENSE	0.10	TRACE (<1%)	1-5	MED		
MED-LOW	MLC125	WP148-WP1	61.164260	-149.781750	WOODARD TRAIL ADJACENT TO MOOSE	PHLEUM PRATENSE	0.10	TRACE (<1%)	26-50	MED		
MED-LOW	MLC129	WP155	61.159580	-149.789720	8 MI TRAIL	PHLEUM PRATENSE	0.10	TRACE (<1%)	1-5	MED		
MED-LOW	MLC131	WP158 + WP	61.158420	-149.790440	8 MI TRAIL	PHLEUM PRATENSE	0.10	TRACE (<1%)	1-5	MED		