INVASIVE PLANT MANAGEMENT PLAN

FOR

ANTELOPE CREEK HABITAT DEVELOPMENT AREA

2014-2024

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1. INTRODUCTION

The Antelope Creek Habitat Development Area (ACHDA) was purchased from a private rancher in 1986. Since that time, the property has been managed by the Antelope Creek Management Committee and a ranch manager(s). ACHDA is comprised of the following general cover types: natural grassland (1800 ha), tame pasture (94 ha), flood irrigated hayland (37 ha), pivot irrigated hayland (33 ha), riparian areas and water (386 ha) and other (10 ha). Several wetlands were created in the 1970s to enhance waterfowl production on the property. ACHDA supports a number of resource uses including:

- The provision of grazing opportunities for local livestock producers,
- Oil and gas extraction which began in the 1940s,
- Irrigated hay and pastureland, and
- Recreational uses such as hunting.

The conservation targets of the ACHDA include:

- Natural grassland plant community types of the dry mixedgrass prairie (emphasis on maintaining grasslands in high range health),
- Biodiversity of the dry mixedgrass prairie (emphasis on diversity of wildlife).

Disturbance is extensive on ACHDA. Various types of disturbance include:

- Cultivation
    - Tame grasses on flood irrigation
    - Tame grasses on pivot irrigation
    - Crested wheatgrass pastureland
- Water developments
    - Irrigation canals
    - Water diversion canals
    - Dams and impoundments used to create wetlands
    - Dugouts to provide water sources for livestock
- Petroleum development
    - Wellsites, risers, batteries, control shacks
    - Pipelines
    - Access roads
- Utility lines
    - Electrical transmission lines
- Residential and ranch development
    - House, yard, corrals and outbuildings
    - Shelterbelts
    - Fencelines

The mission of ACHDA is to use the ranch as a demonstrative and educational tool to show land users and resource managers how to manage and integrate agricultural, recreational and industrial use of the prairie landscape to optimize the societal benefits derived from

this landscape while maintaining its health and the integrity of its ecosystems (Antelope Creek Management Committee 2008). The goals that guide management and use of the property include:

1. Maximize the transfer of information from ACHDA to ranchers, other resource users and developers of the mixed grass prairie.
2. Ensure that the ranch is ecologically sustainable.
3. Minimize the impacts of individual activities and integrate these activities to minimize the accumulated impact and footprint.
4. Facilitate the use of the ranch for research.
5. Manage ranch governance, staffing and finances to perpetuate the ACHDA as an effective, efficient and economically self-sustaining entity.

1.1 Invasive Plant Management

Each goal in the Antelope Creek Ranch Strategic Plan has several objectives (Antelope Creek Management Committee 2008). Objective #2 under Goal #2 states that one of the strategies for that goal is to *identify and correct existing ecological problems on the Ranch. The percentage of disturbed land will be decreased. Invasive species will be controlled.*

The implementation strategy for this objective includes:

1. Develop a baseline inventory of current disturbance and invasive species.
2. New disturbances will be accompanied by reclamation/restoration at a rate of three units (kms or acres) of reclamation: 1 unit of new disturbance.
3. Develop and implement a Reclamation Plan which will address invasive species and man-caused disturbances.
4. Monitor success and modify as appropriate.
5. Cooperate with local communities and authorities.
6. Work with oil and gas companies and other ranch users to ensure that they understand this objective and do their part.

The Invasive Plant Management Plan for ACHDA addresses sub-objectives #1, 4, 5 and 6. The goals of the invasive plant species strategy for ACHDA are geared towards maximum effectiveness of implementation and include:

1. Prevention of invasion of new species into ACHDA,
2. Early detection of new invasions, especially in high risk areas,
3. Rapid response to invasions of high priority species,
4. Containment, control and eventual eradication of high priority species, and
5. Collaboration with county, industry, livestock patrons and other stakeholders with the ability to influence invasive plant management on ACHDA.

2. INVENTORY OF INVASIVE PLANT SPECIES

An inventory of non-native invasive plant species was compiled for ACHDA. Different species received different levels of inventory. Designated noxious weeds and non-native species that pose a threat to the conservation targets on ACHDA received the highest level of inventory. Several partial inventories have been conducted on ACHDA in the past decade. The field surveys conducted in 2013 were designed to complement existing data with the goal of compiling a more complete inventory.

The 2013 surveys focused on high risk areas (i.e., potential pathways of invasion) primarily including roads, permanent vehicle trails, pipelines, utility rights-of-way, petroleum installations, parking areas, streams, irrigation canals, tame forage and adjacent lands (i.e., the ranch perimeter). In addition we surveyed the perimeter of wetlands.

Occupancy survey methodology was used in which precise occurrence and area of occupancy information was gathered using density estimates, patch sizes and GPSed points and/or polygons. Points were used for infestations less than $5m^2$ and polygons for any larger infestations. Polygons smaller than about one acre in size are designated as points on the maps included in this report, but are polygons in the GIS database. 100m was the minimum distance required between plants to separate infestations for mapping.

Detailed surveys and mapping were conducted for Canada thistle, hoary cress, downy brome, bull thistle and common tansy. Each of these species wase mapped by infestation and the following measurements were recorded:

- presence of non-native plant species,
- location of non-native plant sites (general description and UTM by GPS unit),
- size of infestation (GPS perimeter if larger than ~ 5 m^2),
- percent cover, and density/distribution of each non-native species (using AB range health protocols),
- density of seedheads (estimate number of seedheads per square meter),
- developmental stage of the non-native species (rosette, bolt, prebud, bud, early bloom, full bloom, fall regrowth),
- vegetation community,
- potential for spread (none, limited, selected edges, vigorous),
- if the site is being actively managed, then record the date and type of treatment,
- site characteristics: distance to and description of nearest water, slope and aspect, and
- disturbance factor (roadside, trail, cultivated field, pipeline, utility line, energy installation etc.)

A photo point was also established at each infestation to aid in future monitoring and gauging success in controlling an infestation.

Crested wheatgrass was mapped, however descriptive measurements were not taken for a variety of reasons. Previous mapping of crested wheatgrass was undertaken on various parts of the property in 2007 and 2008. The 2007 and 2008 surveys are integrated into the overall ACHDA crested wheatgrass map provided in the invasive species management plan. The 2013 survey only verified and supplemented the presence of crested wheatgrass spatially as measurements were not taken on the previous surveys. Crested wheatgrass is a continuous extensive occurrence on ACHDA which makes polygons very large. This results in making it difficult to distinguish between source and satellite populations, and making cover and density measurements widely variable within a polygon.

Some species were extensive, but naturalized on the property. They were listed as invasives present but were neither surveyed nor mapped. These species include Kentucky bluegrass, dandelion and western goat's-beard.

Some species are biennial or annual invasives whose extent and location will vary from year to year. They were listed as invasive species but neither surveyed nor mapped. These species include the yellow and white sweet clover, flixweed and annual sow thistle.

Other invasive species had limited extent and were associated only with disturbed areas. These are primarily tame forages including smooth bromegrass, alfalfa and Russian wild rye, but also included foxtail barley, a native invasive plant.

All GPS measurements and mapped polygons were transferred into a GIS database. The 2007 and 2008 inventory information was transferred into the GIS database and cleaned. The three years of inventory data was merged to create the maps and area data used in this report. The spatial database containing this information is provided as a deliverable supporting this management plan.

3. RISK ASSESSMENT

3.1. Introduction to Invasive Species Risk Assessments

An Invasive Species Risk Assessment is a method that attempts to mathematically model the risk to human and ecological values from non-native invasive species. Species ranking models meet the need to find the correct mix between pure mathematical modeling which is extremely expensive and very precise, but not necessarily accurate, and anecdotal risk assessment which is inexpensive, but not very precise and usually only accurate in the case of common species.

Risk assessments using species ranking models provide a method to document and standardize the prioritization process and help focus limited resources on priority species, high risk pathways and susceptible habitats. Scoring of species is based on scientifically valid information such as peer-reviewed research and technical transfer information.

3.2. Species Listing Process

The first step in the development of the Risk Assessment was to create a list of invasive non-native plant species that are currently found on and near ACHDA, and which are a potential threat to the ecological integrity of the conservation targets. An inventory of invasive plants was completed during the summer of 2013. This information was combined with previous survey information for select species.

In order to establish which species are not currently on the ranch but are a potential threat, the weed information from Newell County which is available by township was used. The portion of the county west of the City of Brooks was used as the region from which species are most likely to invade. In addition, one of the Newell County Weed Inspectors (Matt Matoba) provided input on which species were the greatest threats and where the closest source populations of the species were in relation to ACHDA.

3.3. ACHDA Ranking System

A comprehensive category and criteria list was compiled from developed criteria used in existing ranking systems for invasive plants in the Canadian prairie. The Ranch Managers chose categories and criteria and an importance rating (from 1 to 4) for each criteria, resulting in a two part ranking system including a species evaluation ranking and a population evaluation ranking using criteria and scoring specific to ACHDA.

Sub-criteria were then developed for each criterion. Each criterion is eligible for a score of 1 to 4 with 1 representing the least importance or impact and 4 representing the highest importance, impact or most difficult or urgent management requirements. A score of 0 is

available when there is a neutral impact or no impact as a result of the criterion. A default score of 2 is used if information is lacking with which to score a criterion.

The delineation between ranks was calculated in the following manner. If a species scored the equivalent of all 1s or 2s, it ranked low; if it scored the equivalent of between all 2s and all 3s, it ranked moderate; if it scored the equivalent of up to halfway between all 3s and all 4s, it ranked high; and if it scored the equivalent of more than halfway between all 3s and all 4s, it ranked extreme. A final list of the ranks for the invasive species established on ACHDA and established in the region but not yet on ACHDA can be found in Table 1.

One of the goals of the Risk Assessment was to differentiate the priority species already established on ACHDA from priority species not yet established. Therefore, the ranking was designed in two stages. The first part of the ranking system is a species ranking. Each species is ranked using the species ranking system which uses biological traits of the species, ecosystem impact, economic and social impact and noxious status as criteria. These criteria are the same for a species established and a species not yet established.

The second part of the Risk Assessment is population based and differs depending on the location and expansion stage of the species in the region. The criteria used in the second part of the ranking system include trend, vulnerability and rareness of communities invaded, constraints to treatment, potential to be spread by human activity, probability of eradication, containment or control, need for cooperative management and impact on aesthetic values. This population assessment is specific to ACHDA and the region. Input was obtained from the Ranch Managers in completing the population assessments. The risk assessment model and evaluation ranking for each invasive plant species is contained in an Excel spreadsheet (Michalsky and Mackenzie 2013) which is a companion document to this Invasive Plant Management Plan.

Table 1. Prioritized List of Invasive Plant Species

Invasive Plant Species		**Rank (Overall)**	**Rank (ACHDA)**
Common Name[1]	**Scientific Name**		
Crested Wheatgrass	*Agropyron cristatum*	**M**	**H**
Hoary Cress	*Lepidium draba*	**M**	**M**
Canada Thistle	*Cirsium arvense*	**M**	**H**
Downy Brome	*Euphorbia esula*	**M**	**M**
Bull Thistle	*Cirsium vulgare*	**L**	**L**
Smooth Brome	*Bromus inermis*	**M**	**M**

[1] Black: present on ACHDA
Red: Found within approximately 5 km of ACHDA
Blue: Found within Newell County west of Range 14

Kentucky Bluegrass	*Poa pratensis*	**M**	**H**
Dandelion	*Taraxacum officinale*	**M**	**M**
Common Tansy	*Tanacetum vulgare*	**M**	**L**
Yellow Sweetclover	*Melilotus officinalis*	**M**	**M**
White Sweetclover	*Melilotus albus*	**M**	**M**
Flixweed	*Sisymbrium sophia*	**L**	**L**
Sow Thistle	*Sonchus oleraceus*	**L**	**L**
Russian Wild Rye	*Elymus junceus*	**L**	**L**
Western Goat's-Beard	*Tragopogon dubius*	**L**	**L**
Alfalfa	*Medicago sativa*	**L**	**L**
Foxtail Barley	*Hordeum jubatum*	**M**	**M**
Field Pennycress / Stinkweed	*Thlaspi arvense*	**L**	**L**
Kochia	*Kochia scoparia*	**L**	**L**
Diffuse Knapweed	*Centaurea diffusa*	**M**	**M**
Spotted Knapweed	*Centaurea stoebe*	**H**	**M**
Yellow Toadflax	*Linaria vulgaris*	**M**	**M**
Scentless Chamomile	*Tripleurospermum inodorum*	**M**	**M**
Blue Mustard	*Chorispora tenella*	**M**	**L**
Russian Knapweed	*Rhaponticum repens*	**M**	**M**
Leafy Spurge	*Euphorbia esula*	**H**	**M**
Dalmatian toadflax	*Linaria dalmatica*	**M**	**L**
Common Burdock	*Arctium minus*	**M**	**L**
Baby's Breath	*Gypsophila paniculata*	**M**	**L**
Purple Loosestrife	*Lythrium salicaria*	**M**	**M**
White Cockle	*Silene latifolia*	**L**	**L**
Blueweed	*Echium vulgare*	**L**	**L**
Storksbill	*Erodium cicutarium*	**L**	**L**
Tall Buttercup	*Ranunculus acris*	**M**	**L**
Bladder Campion	*Silene cucubalus*	**L**	**L**
Cow Cockle	*Saponaria vaccaria*	**L**	**L**
Black Henbane	*Hyoscyamus niger*	**L**	**L**
Field Bindweed	*Convolvulus arvensis*	**L**	**L**
Common Mullein	*Verbascum Thapsus*	**L**	**L**
Oxeye Daisy	*Leucanthemum vulgare*	**L**	**L**
Nodding Thistle	*Carduus nutans*	**M**	**L**

The rankings assigned to species by the Risk Assessment represent the relative risk to ecological, economic and social values associated with ACHDA. The species rankings are used to focus activities to the highest need and to prioritize limited resources to have the greatest effect. For example, knowing which species exist in the surrounding region and knowing where and how they might enter the property facilitates early detection, which is

the most cost effective form of invasive species management. Likewise, knowing which species that already exist on ACHDA have the greatest potential impact on the values of the property facilitates focusing limited resources on control measures that reduce the impact or threat of impact from the highest risk species. Overall, the Risk Assessment allows monitoring, vigilance and resources to be applied where they will be most effective and efficient.

4. PATHWAYS OF INVASION

Pathways of invasion or dispersal pathways are defined as the combination of processes and opportunities resulting in the movement of propagules from one area to another, including aspects of the vectors involved, features of the original and recipient environments, and the nature and timing of what exactly is moved (Wilson *et al* 2009).

Numerous pathways of invasion exist on ACHDA that facilitate the expansion of existing infestations on the property as well as the spread onto the property of species that occur in the vicinity but which have not yet established on ACHDA.

Potential pathways of invasion of new invasive plant species into ACHDA are listed below in order of descending risk:

1. Maintenance of developed roadways and trails including mowing, grading and plowing and the transport of gravel, sand or fill. Species that may use this pathway include scentless chamomile, blue mustard, Russian knapweed, leafy spurge or bladder campion.
2. Maintenance of oil and gas facilities (i.e., wellsites, pipelines and associated facilities) and maintenance of canals. Species that may use this pathway include scentless chamomile, blue mustard and bladder campion.
3. Irrigation canals and other watercourses where water enters the property. Species that may use this pathway include diffuse knapweed, yellow toadflax, scentless chamomile, leafy spurge, purple loosestrife, tall buttercup, field bindweed and nodding thistle.
4. Traffic on roadways, trails and oil and gas facilities. Species that may use this pathway include diffuse knapweed, spotted knapweed, Russian knapweed, scentless chamomile, dalmation toadflax, and cow cockle.
5. Seed sources for revegetation programs. Species that may use this pathway include downy brome, bull thistle, Kentucky bluegrass, foxtail barley, scentless chamomile, blue mustard, Russian knapweed, white cockle, field bindweed and oxeye daisy.
6. Livestock and wildlife. Species that may use this pathway include yellow toadflax, dalmation toadflax, leafy spurge, common burdock, purple loosestrife, white cockle, blueweed, stork's bill, tall buttercup and field bindweed.
7. Transboundary spread from adjacent lands. Species that may use this pathway include smooth brome and baby's breath.
8. Import of forage for livestock. Species that may use this pathway include crested wheatgrass, hoary cress, Canada thistle, bull thistle, smooth brome, Kentucky bluegrass, yellow and white sweetclover, Russian wild rye, alfalfa, foxtail barley, spotted knapweed, scentless chamomile, Russian knapweed, baby's breath and oxeye daisy.
9. Firefighting equipment. Species that may use this pathway include downy brome, baby's breath, yellow and white sweetclover and leafy spurge.

Pathways of invasion for the spread of invasive plant infestations already existing on ACHDA are listed below in order of descending risk:

1. Maintenance of oil and gas facilities (i.e., wellsites, pipelines and associated facilities). Species using this pathway include crested wheatgrass and downy brome.
2. Maintenance of developed roadways and trails including mowing, grading and plowing. Species using this pathway include crested wheatgrass, hoary cress, downy brome, and alfalfa.
3. Traffic on roadways, trails and oil and gas facilities. Species using this pathway include crested wheatgrass, Canada thistle, downy brome, bull thistle, smooth brome, and flixweed.
4. Movement of water down canals and streams. Species using this pathway include Hoary cress, Canada thistle, downy brome, dandelion, common tansy, yellow and white sweetclover, flixweed, sowthistle, foxtail barley, stinkweed and kochia.
5. Maintenance of canals. Species using this pathway include Canada thistle, hoary cress and foxtail barley.
6. Livestock and wildlife. Species using this pathway include crested wheatgrass, Canada thistle, downy brome, bull thistle, smooth brome, Kentucky bluegrass, flixweed, sowthistle, goatsbeard, alfalfa and stinkweed.

Figure 1 highlights the features of ACHDA that contribute to pathways of invasion.

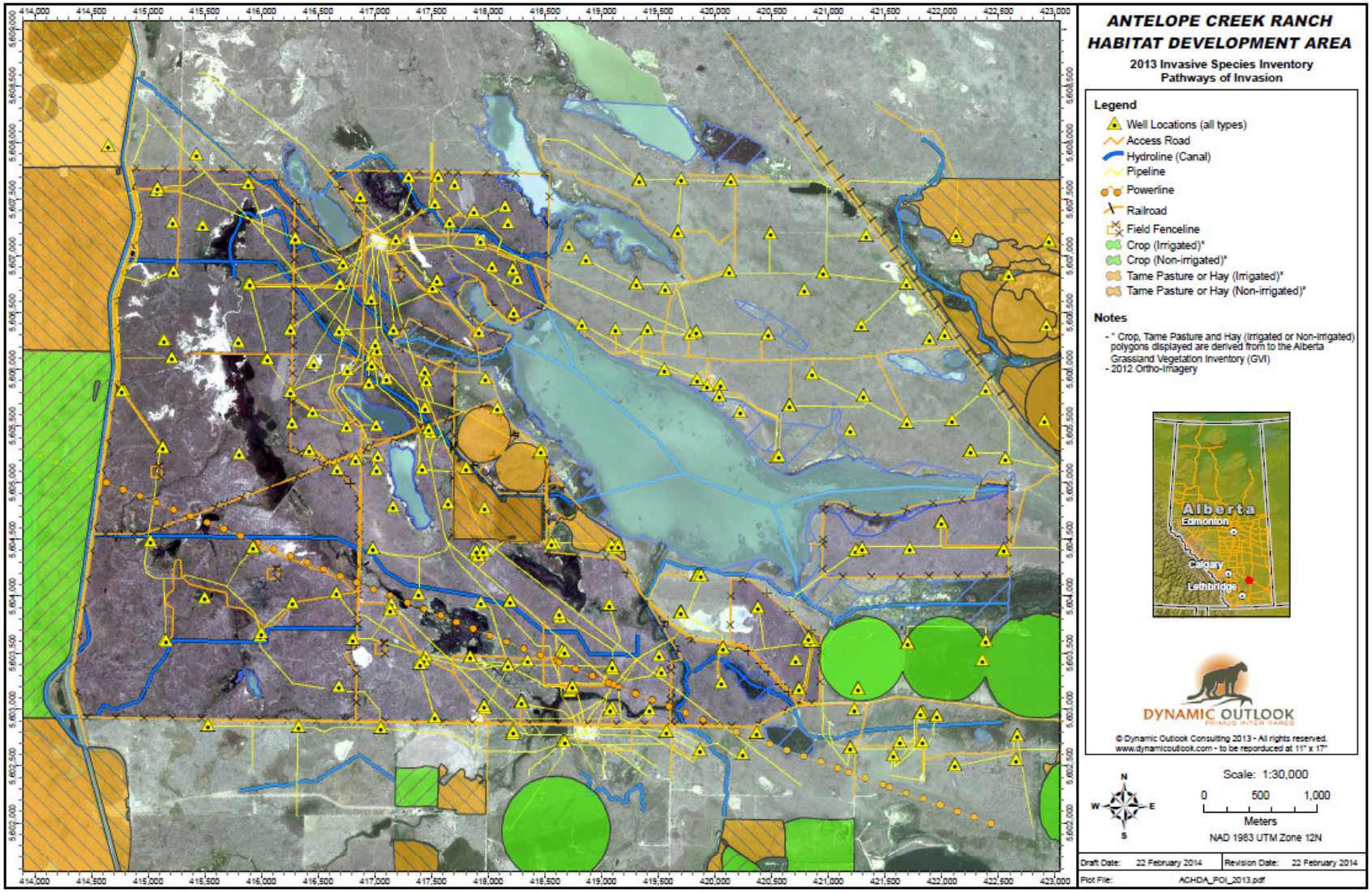


Figure 1. Pathways of Invasion on ACHDA.

5. SPECIFIC CONTROL PLANS FOR PRIORITY INVASIVE SPECIES

An important component of an Invasive Species Management Plan is the specific plans for managing existing invasive species for the plan area (ACHDA). Attainable goals with practical, measurable objectives for each species are key to success. Many control options are available for different species. Scientists, municipalities, and on-the-ground managers have all moved towards the approach called Integrated Pest Management (IPM). IPM combines the right combination of control approaches based on the species characteristics, and specific site characteristics such as associated vegetation, soil, moisture regime, age of infestation, and size and density of the infestation. Available time and financial resources can be allocated to IPM activities detailed to be most useful on ACHDA in an appropriate time period and in the most practical way.

Recommended management actions were determined based on the information presented in the Risk Assessment. Control options were discussed with the Ranch Managers and recommendations made with consideration for the skills, schedules and preferences of the Ranch Managers and the tools they currently have available to help manage invasive plant species.

5.1 Common name: Hoary Cress (Whitetop)
Scientific name: *Lepidium (Cardaria) draba*

A. PRIORITY **Moderate**

B. DESCRIPTION

Hoary cress is a highly competitive perennial. It develops an extensive rhizomatous root system that allows the plant to persist in adverse conditions and spread its patch-size outwards. A hoary cress plant produces 1200-4800 seeds per year with viability extremely low by year three. Hoary cress spread to North America and throughout North America mainly through contaminated forage seed. Hoary cress can invade rangelands, roadsides, irrigated hayfields, riparian areas and wetland areas.

C. CURRENT DISTRIBUTION ON THE SITE

A total of 62 mapped infestations of hoary cress currently cover approximately 5 ha (12 acres) of ACHDA (Figure 2). Infestations range in size from $1m^2$ to 14,000 m^2. Aerial cover of hoary cress ranged from less than 1% to 40% within an infestation, and distribution ranged from 2 (a few sporadically occurring individuals) to 11 (continuous occurrence of plants with a few gaps). Plants were in early to full bloom when surveyed in 2013 and the number of seedheads/m^2 ranged from approximately 5 to 200. The potential for spread was vigorous for most infestations, but a few infestations were limited to select edges.

Hoary cress was found in a variety of plant communities. Infestations are primarily found in disturbed areas associated with tame grassland and weed cover including Kentucky

bluegrass, smooth bromegrass, crested wheatgrass, slender wheatgrass, Russian wild rye, foxtail barley and sow thistle. It was found to a limited extent in invaded natural grasslands including Kentucky bluegrass – western wheatgrass, western wheatgrass – Canada thistle/ dandelion, and slender wheatgrass – green needle grass. Three infestations were found in undisturbed, uninvaded saline grasslands including Sandberg's bluegrass dominated grassland and western wheatgrass – foxtail barley.

The common disturbance factors associated with hoary cress include borrow sites associated with created wetlands, dams, dugouts, canals, roads, pivot irrigation and oil and gas facilities such as wellsites, pipelines, risers and compressors. Less common disturbance factors include building sites and yards, fences, lakeshores, shelterbelts and ground squirrel burrows.

The historic spread of hoary cress on the site has likely been slow. Many of the infestations associated with natural and created waterbodies, roads, and pivot irrigation probably established soon after the disturbance and may have been on site for more than 30 years.

D. DAMAGE & THREATS

Hoary cress can form dense stands and out-compete native vegetation. It is largely avoided by livestock and wildlife and therefore reduces the overall productivity of the ACHDA. It spreads relatively slow once established and therefore represents a low threat to the property unless management changes. For example, if hay were produced from the pivot irrigation and transported to sites within or off the property without hoary cress infestations, the risk of invasion on those sites due to contaminated feed would be high.

Additionally, hoary cress spreads well in water and given the number of canals and creeks flowing through ACHDA, the potential to infest adjacent and downstream lands is very high.

E. GOALS

Available management strategies and technologies for hoary cress combined with species attributes, and characteristics of the region make control of this species possible, but eradication or prevention unlikely.

The goal for hoary cress on ACHDA is to eradicate existing infestations of hoary cress on access roads and oil and gas facilities and to prevent hoary cress from setting seed on irrigated lands, close to waterbodies, and along canals with the hope that the number of plants will decrease over time.

The goal of preventing and rapidly responding to any new hoary cress infestations is a high priority.

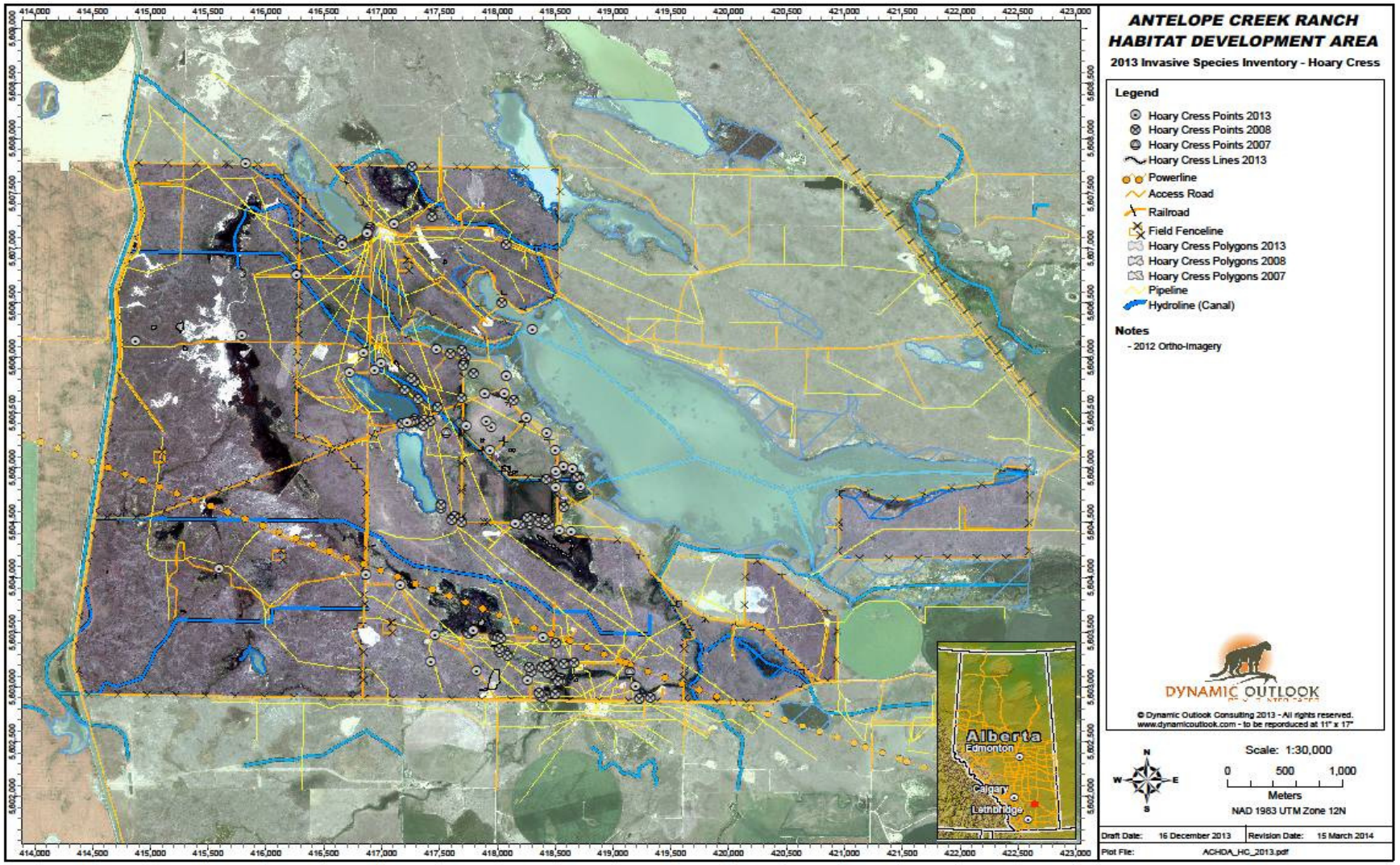


Figure 2. Hoary Cress Infestations on ACHDA

F. OBJECTIVES

Objective 1: Reduce the number of single populations of hoary cress on accessible, non-water areas by 50% in 5 years.

Objective 2: In hoary cress populations close to water prevent seed set on 70% of infestations within 5 years. Within 7 years prevent seed set on 90% of infestations.

Objective 3: Prevent 95% of new infestations documented from establishing.

G. MANAGEMENT OPTIONS

Many different management options can be used in an integrated control plan. There are a number of management options available when dealing with hoary cress.

1) **No Treatment**- Historically, hoary cress has been increasing very slowly on the ACHDA. However, the species characteristics and the continued industry and irrigation activities on the ranch and in the local area warrant increased attention to the species as it is a moderate risk.

2) **Prescribed Grazing**- A hoary cress (and Canada thistle) grazing prescription was designed by Kathy Voth in 2013 for the ACHDA. Livestock can be trained to eat hoary cress to prevent seedset. However, in other grazing studies, although hoary cress was found to be grazable, plants contain glucosinolates (sulphur toxin) which can be mildly toxic to cattle (McInnis et al. 1993). Livestock should not be used to graze invasive plants during seedset due to the chance of the livestock spreading viable seeds in their manure. Using livestock for grazing invasive plants (as an integrated control measure) can be feasible when livestock are already used on an operation, time is available to train livestock to select invasive plants and the size and density of infestations make the other control methods less feasible (such as a high number of infestations or wide extent of polygons).

3) **Spot Burning**- The extensive rhizomatous root system of the perennial hoary cress does not lend itself to control by fire. Burning can be used to kill or wilt top-growth. New growth will begin again from the crown. In field trials Rosenfels and Headley (1944) used a commercial, coil-type burner at intervals of 2, 3, 4, and 8 weeks on hoary cress. Hoary cress plants were eradicated in about 2.5 seasons at every interval except 8 weeks. They conclude that under the conditions of these tests, searing can be regarded as an acceptable substitute for hoeing, but not as a method giving quick results (Rosenfels and Headley 1944). Spot burning could be integrated in areas where herbicides are unable to be used to reduce flowering and seed set (canals, waterbodies) or used to promote vegetative growth for better herbicide uptake. A torch or coil burner and staff time would be the expenses associated with this practice.

4) **Mowing**- The extensive rhizomatous root system of the perennial hoary cress does not lend itself to control by mowing alone. Mowing can effectively decrease rhizomatous

root vigor after multiple growing seasons with repeated frequent mowing (Sheley and Stivers 2014). Care needs to be taken to not decrease the ability of the accompanying forage species to compete with the hoary cress. Mowing can be used to prevent seed set. Mowing can also be used in conjunction with herbicides to increase control by keeping the plant in the vegetative stage and encouraging translocation of herbicides down into the root system. Mowing is not restricted in or near waterways or waterbodies.

5) **Hand-pulling**- Hoary cress' rhizomatous roots do not allow the plant to be hand-pulled as a one-time control operation. The plants will re-sprout from the underground roots. Single new infestations that have yet to establish can be controlled by repeated hand-pulling of new shoots. The practice of hand-pulling repeated every few weeks as a plant re-sprouts over a number of years (1.5 -2 yrs) may be used in sensitive areas. Hand-pulling will keep hoary cress in the vegetative state (Kadrmas and Johnson 2002).

6) **Herbicide Applications**- Herbicides are an effective means of controlling hoary cress. When infestation patch sizes are small and infestation numbers are relatively low herbicides provide the advantage of a rapid control before populations may explode. Selective herbicides are best applied in the vegetative stage prior to flowering, at flowering and with some control up to seed set (Kadrmas and Johnson 2002). If fall re-growth occurs, herbicides can be effective prior to the killing frost. Herbicides on small infestations (< 1 acre) can be applied with a backpack sprayer (costing approximately $200), or quad sprayer with wand or boomless nozzle (costing approximately $400). Mowing to produce new vegetative parts prior to a herbicide application has proven effective in other jurisdictions (Sheley and Stivers 2014). Refer yearly to the current Alberta or Saskatchewan Crop Protection Book for updates to application buffer restrictions and the opportunity to apply new herbicides. The restriction on distance-to-water-of-spraying varies from product to product with spot applications.

   The non-selective herbicide glyphosate is effective on hoary cress, but can kill the good competing vegetation if sprayed generally. Glyphosate is good to use on non-crop areas or along trails if no vegetation is present. A weed- wiper or weed-wick can be used to brush a non-selective herbicide onto the hoary cress, sparing the shorter non-target vegetation. The challenge with this method is to have hoary cress taller than the good competing vegetation.

   Although there are no herbicides registered specifically for use in Range and Pasture on hoary cress in Alberta or Saskatchewan, there are some crop herbicides that are referred to in the Saskatchewan Crop Protection Guide, 2014.

Hoary Cress- Saskatchewan Crop Protection Guide 2014- *excerpt*

Amitrol 240 - For non-selective patch treatment in pastures and non-crop land, apply 8.9 to 13.8 L/acre.
Glyphosate - As a spot treatment in labelled crops, apply 2.83 to 4.86 L/acre (360 g/L formulations or equivalent of other formulations) in 10 to 30 gallons/acre (45 to 135 L/acre) water when most plants have reached the early bud stage. Do not disturb treated plants for at least 10 days following treatment.
Escort (Metsulfuron Methyl) Off-label Pasture and Rangeland use– up to 12 g per acre (+ appropriate surfactant)
** NOTE - Since applications to forage grasses have been registered under the User Requested Minor Use program, the manufacturer assumes no responsibility for herbicide performance. Application to forage grasses is at the risk of the user. Hoary cress at the 2-4 leaf stage is best.*

The following chart includes herbicide recommendations (based on Canadian and US studies) from the publication *Hoary Cress Management: Montana/ New Mexico (Duncan and Renz 2006).*

Herbicide	Active Ingredient	Rate of Herbicide (amount/acre)	Timing of Application	Comments
Many products	2,4-D ester or amine	Depends on formulation (1 to 2 lb a.i.	Bolting to bud	• No soil residual to control seedlings • Control minor after bud growth stage. • Apply annually for at least 2 years to reduce density. • Selective, will not harm grass
Plateau + MSO	Imazapic	8 to 12 fl oz (0.124 to 0.188 lb a.e.) + MSO 1 qt/ac	Full bloom or fall to rosettes	• Residual activity • Before using note crop restrictions • May cause injury to some grasses at the 12 oz rate
Many products	Glyphosate	Depends on formulation (2 to 3 lbs a.e.)	Bolt growth stage	• Non-selective, can damage most plants
Cimarron + NIS	Metsulfuron	0.75 to 1 oz (0.45 to 0.6 oz a.i.) + NIS 0.25% V/V	Pre-bloom to bloom; or fall	• Residual herbicide • Selective, will not harm many grasses
Telar + NIS	Chlorsulfuron	1 to 1.5 oz (0.75 to 1.12 oz a.i.) + NIS 0.25% V/V	Pre-bloom to bloom; or fall	• Residual herbicide • Selective, will not harm many grasses
Raptor + MSO + Nitrogen	Imazamox	6 fl oz (0.047 lb a.e.) + MSO 1 qt/ac	Rosettes – spring or fall in crops (alfalfa)	• Residual herbicide • Registered for use in alfalfa • Suppression only
Pursuit + MSO + Nitrogen	Imazethapyr	6.0 fl oz (0.095 lb a.e.) + MSO 1 qt/ac	Rosettes – spring or fall in crops (alfalfa)	• Residual herbicide • Registered for use in alfalfa • Suppression only

7**) Prevention Strategies**- Preventing the establishment of hoary cress is the best means of control and most cost effective overall on the ACHDA.

a. Hay and Seed Purchases- Hoary cress is often found in hay fields (baled forage) or in forage seed. Purchase certified weed free hay or begin producing the ranches own hay that can be guaranteed weed free. Feed hay only on cultivated fields or tame monocultures that are visited often in the summer (to scout for invasive species). Forage seed used in irrigated hayfields, on Canals, or on Rights of Way can contain hoary cress seeds. Analyzing the forage seed certificate(s) prior to approving or purchasing a seed mix is an important preventative measure. The revegetation of trail edges is critical to maintain a competitive ground cover (use species such as western wheatgrass or northern wheatgrass).

b. Industry/ Energy Sector- Fostering the ACHDA's relationship with the Industry companies and personnel that work on and around the ranch can prove rewarding (cooperative weed management). The goal with the building of the relationship should be to increase their overall awareness and cooperation for control which can serve as a model and demonstration for others. Work to time mowing operations on all trails and lease sites prior to hoary cress seeds becoming viable.

c. Irrigation Sector - High risk arises from the potential for infestations starting on irrigated lands or in irrigation canals. In Montana, hoary cress is a major weed of irrigation as it spreads through the system and takes hold on irrigated land. Screening irrigation water prior to applying to the field or filling wetlands will decrease the risk of invasion from hoary cress, among other weeds (Duncan and Renz 2006). For fellow irrigators and the Irrigation District, the first line of defense against new hoary cress invasions is to increase the overall awareness of the species in the area along with efforts to actively control the species.

H. ACTIONS PLANNED

Begin treatment in 2014 summer on working from the perimeter of infestations and along the perimeter of fields inwards and in locations of ACHDA where little infestations exist. Utilize the hoary cress 2013 map and upload infestation GPS points to allow for documentation of treatments or changes in infestations.

The relatively infrequent number and low density of infestations of hoary cress on ACHDA does not warrant trained cattle grazing as the primary means of control of this species. There are infestations throughout the ranch, which would not allow cattle grazing to get to all of the infestations prior to seed set yearly. Grazing hoary cress is not a disadvantage, but it should not be relied on as the primary means to meet the management goals.

As with any invasive species application timing is an important component of integrated management. Hoary cress begins flowering early in the year, then produces seeds within a few weeks to a month. Document the approximate time of flowering from 2014 through 2016 for reference in the future year's control plans.

1) **Control activities on new infestations**- Begin hand pulling or herbicide applications immediately. If hand-pulling, repeat every 2-4 weeks whenever new growth is initiated. If applying herbicide by backpack sprayer, quad sprayer or weed wiper/wick select an appropriate herbicide from the list in Section G (above). Target applications to take place just prior to or just at flowering. GPS any new infestations. Continue control activities in the following year(s) until no plants are present. Continue to check the locations that were infested in the next 2-3 growing seasons to ensure no new hoary cress germinates.

2) **Control activities on well established spotty infestations (upland)**- In Native Field 4, Native Field 1 and at the north end of Native Field 2 (near dam) very few infestations exist. Begin control activities on these well established spotty infestations within the next two growing seasons (2014/15). Use a selective or non-selective herbicide of the ACHDA choice (selected from Section G) depending on other weeds being controlled and what is most comfortable and convenience for the operator/applicator. Respond rapidly to these infestations with appropriate herbicide applications prior to seed set, post mowing or in the fall if regrowth occurs. Monitor herbicide effectiveness in the late fall and in the following three (3) springs. Treat any remaining plants accordingly with follow up herbicide applications.

   As the well established spotty infestations are brought under control, begin adding other infestations into the treatment regime. Once again, select infestations closest to the perimeter of a field. Over time, control will be moving towards the interior of the field from all sides.

3) **Control activities on riparian infestations-** Riparian hoary cress infestations pose a significant challenge to control due to the wet soil conditions or chance of standing water, and the short and spread-out hoary cress. Begin control activities in 2015 on riparian infestations. In areas where herbicides cannot be used (water is present, collateral damage on associated vegetation would be too high) hoary cress should be hand pulled, burned or mowed. Mow every 2-4 weeks beginning in May through September (or when growth ceases). If dry conditions exist, observe plants- time between mowing may be lengthened. However, mowing still should occur and the goal is to not only 1) prevent seed set, but 2) decrease vigour of rhizomatous roots. If no growth exists, hold off mowing and continue observing the infestation.

   Begin implementing a glyphosate herbicide regime of spot spraying with a back pack sprayer or weed wiping on any plants that are accessible. Glyphosate application rates (for sprayer) are listed in Section G. Continue to repeat throughout the growing season

on individual plants as they become evident. Aim to apply glyphosate to as little associated vegetation as possible to decrease injury to the non-target plants.

4) **Implement prevention strategies-** Begin implementing the preventative strategies discussed in Section G to slow the establishment on new hoary cress infestations on the ACHDA. Initiate work with the energy sector by 2016. Set out a plan (plan authored by 2016) to screen irrigation water entering the irrigated lands and filled wetlands (the plan then may take a few years to implement).

I. RESOURCE NEEDS

Activity	**Timeline**	**Person hours required (estimate)**	**Equipment or supplies required/ cost**
New infestations of hoary cress *(control)*	June 2014-2017	Yearly **6 hours**	- quad sprayer (one time purchase @ $400) -water tank (on hand) - Herbicide (estimate $50 max yearly) - GPS (one time purchase @ $1500)
Hoary cress infestations herbicide applications – *well established on upland sites. Begin working in Native Field 4, Native Field 1 and at the north end of Native Field 2 (near dam)*	Initiate by June 2015 (continue through 2024)	Yearly **8 hours**	- quad sprayer (one time purchase @ $400) -water tank (on hand) - Herbicide (estimate $50 max yearly) - GPS (one time purchase @ $1500)
Riparian infestation control measures - *glyphosate app* - *hand pulling/ mowing*	2015	Yearly **8 hours glyphosate** Yearly **8 hours mowing or hand pulling**	- quad sprayer (one time purchase @ $400) - wick applicator (one time purchase @ $400) - mower (on hand)
Hoary cress infestation prevention. *Energy sector communication- trail*	Year-round 2016-2024	Yearly **10 hours**	

maintenance and mowing(protocol), seed & hay purchases			
Breaking irrigated fields due to hoary cress infestations	Potential future activity		Dependant on breaking and rental arrangements made

5.2 Common name: Downy Brome
Scientific name: Bromus tectorum

A. PRIORITY: Moderate

B. DESCRIPTION

Downy brome is an annual grass with mass seed production and the ability to grow in thick, dense stands. Downy brome can grow and produce seed from a height of mere millimeters to 6 inches and under limited growing conditions. Downy brome most easily inhabits areas of disturbed ground, where competition from perennial grass species is weak, or when there is bare ground between plants.

C. CURRENT DISTRIBUTION ON THE SITE

There are six (6) downy brome infestations on the ACHDA (Figure 3). An additional site was located in 2008 (Figure 3) that was not observed in 2013. These infestations range in size from 2 m^2 to 10 m^2. These are relatively small infestations. Aerial cover of downy brome ranged from 5% to 40% within an infestation, and distribution ranged from 4 (a single patch plus a few sporadically occurring plants) to 11 (continuous occurrence of plants with a few gaps). Plants were in full bloom, but green in June and had set seed when surveyed in July, 2013. The number of seedheads/m^2 ranged from approximately 40 to 200. The potential for spread was vigorous on two sites, and limited to select edges on the other three sites Downy brome was found in association with disturbed vegetation communities in all cases. Communities were dominated by Kentucky bluegrass, crested wheatgrass and Russian wild rye. The common disturbance factors include roads, wellsites and batteries. The largest infestation had been handpicked in 2009, however seed continues to germinate. The other sites were mowed annually, but in most cases mowing occurred after seed set and had no control effect on downy brome. In fact, mowing after seed set has the potential to spread downy brome to other locations. The site in Cassils Field which was discovered in 2008 (Figure 3) was handpicked just as it was beginning to set seed. That site is monitored annually for germination, but no plants have been noted since 2009.

The risk assessment for downy brome highlighted a concern for the potential spread onto the ranch from an extensive population in relatively close proximity. In addition, a Newell County Weed Inspector (M. Matoba pers com) indicated that some of the sources of gravel used on county roads in the vicinity of the ranch had downy brome infestations associated with the gravel pits. The presence of downy brome on ACHDA is likely relatively recent and mainly associated with vehicles and aggregate or fill being brought onto the property during the development of oil and gas facilities and associated infrastructure.

D. DAMAGE & THREATS

Downy brome poses a very really threat to ACHDA and the surrounding area because of the damages it may cause. 1) Downy brome plants mature early in the growing season and then are not palatable to livestock after that. This results in damage to habitat by increasing populations and a decrease in 'production' in the infested area. 2) Large

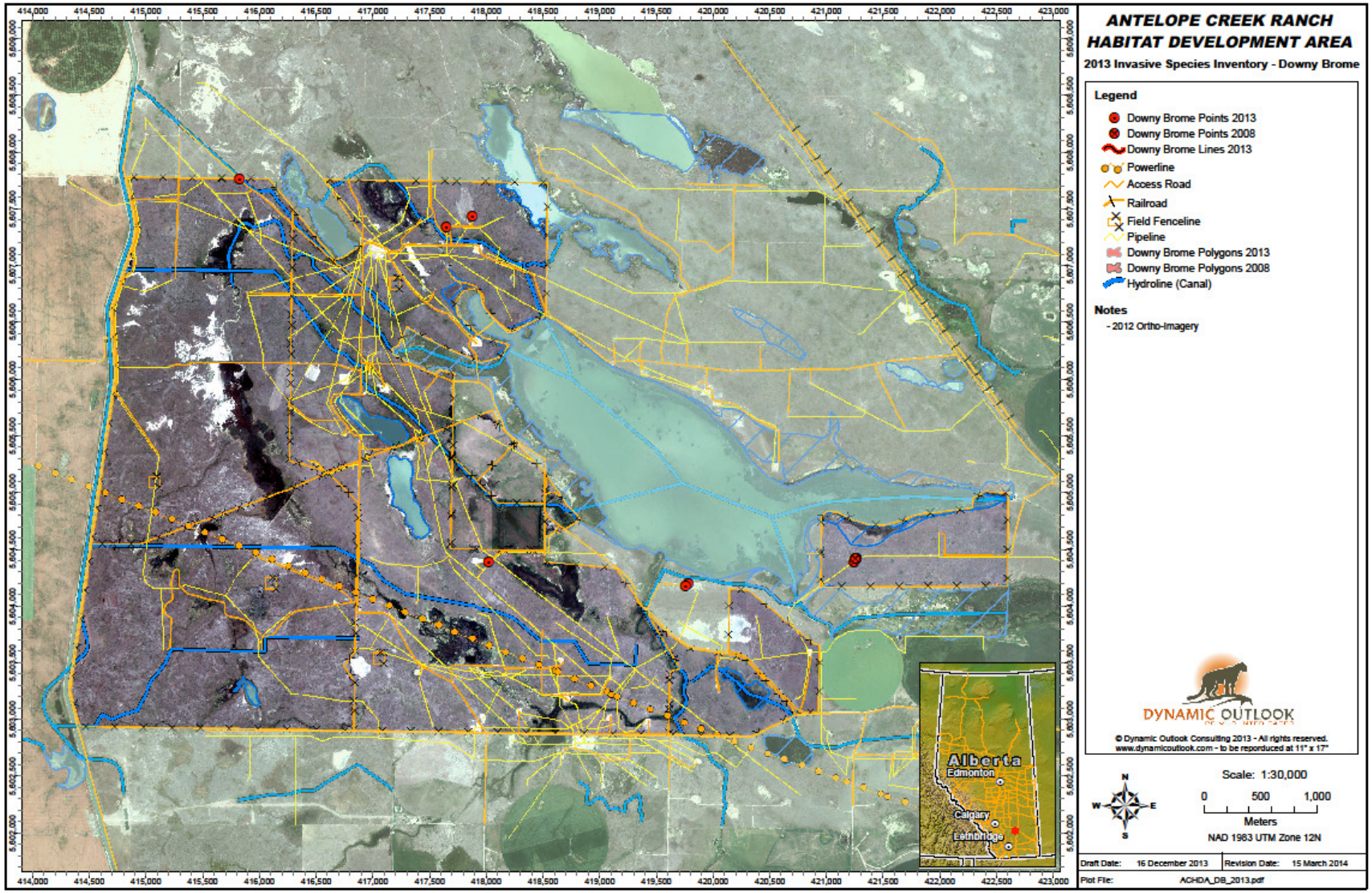


Figure 3. Downy Brome Infestations on ACHDA

infestations of dried downy brome are at a high risk of wildfire as they become dead and dry early in the growing season. Fire is a constant threat on the prairie, but is elevated in areas infested with downy brome.

E. GOALS

The goal for downy brome is twofold; 1) is to eliminate current infestations to stop further spread into native habitats as large patches become forever persistent once established, and 2) prevent further establishment of downy brome patches on the ACHDA through working with industry active on ACHDA (a major vector of spread).

F. OBJECTIVES

Objective 1: Eliminate the current downy brome patches found on the ACHDA within 6 years.

Objective 2: Prevent further patch establishment of downy brome (through prevention, early detection and rapid response). Record the number of infestations where establishment was prevented.

G. MANAGEMENT OPTIONS

Viable control options include:

1) **Revegetate disturbed areas promptly**- Downy brome is an opportunistic invader in areas where vegetation is not vigorous, soil is disturbed, or where vegetation is sparse. Revegetate disturbed areas promptly. By reducing bare ground and increasing competition from desired perennial forage species in areas where downy brome is invading, has previously invaded, or is susceptible to invade, integrated downy brome control can be achieved (Alberta Fish and Game Association's Operation Grassland Community 2014; Fowers 2011). Downy brome has been proven to be choked out of healthy alfalfa stands and kept out of native prairie with dense vegetation and adequate carryover.

   Any sized area is a candidate for revegetation. These may include small areas such as around watering locations or large areas such as along the expanse of a trail or pipeline. Revegetation should occur early in the spring with proper seeding rates of certified weed free forage seed and using clean equipment. Weed control prior to planting (such as glyphosate) will assist in a successful establishment.

2) **Mowing**- Mowing can be a moderately effective means of controlling downy brome seedset if properly timed. Alberta Agriculture (2007) recommends that mowing can be used at the bloom stage for control, but short plants can often be missed with the mower. This allows them to still produce seed. Others note (USDA 2014) that timing of mowing can be tricky because plants that are cut too soon before seed set can generate new culms and produce seeds at the cut height (a shorter plant). Plants that are cut after seed ripening will still leave viable seeds in the cut material. The plant height,

vigour and stage of growth (uniform in the stand or not) will all contribute to the effectiveness of mowing. A combination of mowing and herbicide applications is commonly used where large infestations persist. If mowing is to occur, ensure timing is appropriate and equipment is cleaned after the infestation has been mowed prior to moving to a new job or area free of downy brome (This includes general RoW mowing.)

3) **Spot Burning**- Spot burning small downy brome infestations has proven effective for various individuals with confined infestations. Live downy brome plants are susceptible to heat kill, as with a hand torch or tiger torch, though they are difficult to burn when green (USDA 2014). If burned during a crucial time during seed ripening, fire can greatly reduce the density of the succeeding cheatgrass (downy brome) stand (USDA 2014; Whisenant and Uresk 1990). Alberta Agriculture (2007) recommends burning up to and at the milky seed stage when the risk of wildlife remains low. Repeated spot burning to eliminate the entire stand of downy brome can be successful. The seed bank must be drained to get effective control. Further integrated controls such as reseeding bare ground are beneficial to stop future infestations (DiTomaso et al. 2006).

4) **Hand Pulling**- Downy brome plants have short, shallow fiberous root systems which allow the plants to be pulled from most soils relatively easy. Hand pulling is an effective means of removing downy brome plants if done prior to seed set. At seed set, seeds knocked from the plants will be viable to produce new plants the following year(s). Established downy brome infestations tend to be thick with plants at various growth stages which can make hand pulling of moderately larger infestations extremely difficult and time consuming. Hand pulled plants must be bagged and disposed of properly (e.g. rot the bag contents and then burn). Hand pulling of downy brome must be carried out in successive years to deplete the seed bank as new plants germinate. Seeds generally remain viable for 2-3 years.

5) **Tillage**- Cultivation of downy brome can be used to control an infestation when no established beneficial perennial species are found to be present. This may be the case in such circumstances as infestations in a cropland situation or on a bare ground area (e.g. a newly constructed well site). Repeated cultivation to a depth of 4-6 inches will bury the downy brome seeds deterring plant establishment at germination (Montana State University 2012). The first cultivation most likely will act to stimulate downy brome germination. Chemical control and reseeding competitive perennials are most often used as integrated methods with tillage.

6) **Herbicides**- There are various herbicides that can contribute to the control of downy brome depending on the infestation location (habitat), the competing vegetation, and the time of application.

   Non-selective herbicides such as **glyphosate** can be used successfully very early in the growing season on disturbed areas. Many publications noted the successful spot application of glyphosate when perennial grasses are still dormant and the downy

brome has initiated growth (Hirsch et al. 2012). However, this is risky with the potential for high collateral damage if perennial plants have initiated growth. If growing conditions permit germination of new downy brome seedlings in the fall, a fall application of herbicides may also be effective (Alberta Agriculture 2007).

Although there are no herbicides registered specifically for use in range and pasture on downy brome in Alberta or Saskatchewan, there are various crop herbicides that are commonly used and referred to in different government and scientific publications (see following excerpt from the Saskatchewan Crop Protection Guide, 2014). Timing herbicides prior to flowering and seed development will provide the highest rate of control. A quad sprayer or backpack sprayer may be used on small infestations. Chemical application must be repeated for years to come (3+ years) until the entire seed bank has been depleted. Continued monitoring of the site should catch any new plants that emerge after the chemical control period (Morris et al. 2009).

Downy Brome & Japanese Brome- Saskatchewan Crop Protection Guide 2014- *excerpt*

Adrenalin, Altitude FX /FX2 - Apply at label rates to suppress Japanese brome to the 4 leaf stage in CLEARFIELD wheat.
Glyphosate - Prior to crop emergence, apply 0.51 to 0.77 L/ acre (360 g/L formulations or equivalent of other formulations) in 5 to 10 gallons/acre (23 to 45 L/acre) water before
downy brome is 6 inches (15 cm) in height.
Glyphosate /dicamba - Prior to crop emergence, apply 1.0 L/acre in 5 to 10 gallons/acre (23 to 45 L/acre) water between emergence and heading of downy brome.
Odyssey DLX - control spring seedlings of Japanese brome in registered crops.
PrePass - Apply in spring or fall, prior to seeding cereal crops or in fallow at registered rates to control downy brome up to the 4 leaf stage.
Simplicity - Suppression of downy brome and control of Japanese brome up to the 6 leaf stage when applied at 0.2 L per acre in the fall in winter wheat. Apply in spring at 0.2 L
per acre to control Japanese brome up to the 6 leaf stage in winter or spring wheat (including durum).
Solo - Apply at label rates to suppress Japanese brome to the 4 leaf stage in registered crops.
Tandem - Applied at the maximum labelled rate in spring wheat (including durum) will control Japanese brome up to the 6 leaf stage.
Trifluralin - Apply at recommended rates for weed control in broadleaf crops prior to emergence.
Velocity m3/All-in-One - Apply at registered rates in registered crops to suppress Japanese brome.
Viper - In field peas, at registered rates to suppress Japanese brome.

Sencor (Metribuzin)- This is registered for use in winter wheat. It needs to be applied when downy brome is quite small. In this case the fall is the best time for application. An advantage of using this herbicide is that some tame forage grasses have varying degrees of tolerance to Sencor. The tolerance of native grasses to Sencor is unknown. It's usually applied at 300g/acre. (Alberta Agriculture, 2007)

7) **Growth Inhibitor Herbicide Application** (aminopyralid/ Milestone)- New research on Japanese brome and downy brome control out of the Fort Keogh Livestock and Range Research Laboratory in Miles City, MT has shown that growth inhibitor herbicides designed for use on broadleaf plants interfered with reproductive processes of these invasive grasses (Rinella et al. 2010a, 2010b). The researchers (Rinella *et al* 2013) found "*In a greenhouse, picloram was not effective against downy brome (which showed effective in greenhouse and field on Japanese brome) while aminopyralid (Milestone) greatly reduced downy brome seed production. Downy brome seed production was reduced approximately 90% when applied at the heading stage and approximately 98% when applied at three earlier growth stages. This encouraging result should promote field studies designed to more fully evaluate the potential for using aminopyralid to control downy brome.*" The seed bank must be drained to obtain effective control.

8) **Grazing**- In the western United States (California, Nebraska, Wyoming, and southern Montana) grazing the extensive 'cheatgrass' rangeland infestations early in the growing season has allowed the invasive to be used as a forage prior to it becoming un-palatable. In these situations the rangeland is primarily composed of downy brome. When downy brome is lush and green early in the growing season and into the boot stage it is highly nutritious. The effectiveness of grazing can be limited by the height of the downy brome plant in different growing conditions. Fortunately, no such extensive infestations of downy brome are found on the ACHDA which warrant this means of control.

9) **Prevention Strategies**- Preventing the establishment of downy brome is the best means of control. As an annual grass, downy brome characteristically invades habitat areas dominated by perennial grass. Control activities are limited because of the potential for collateral damage to the perennial grass. Prevention strategies include:

a. Maintain average to above average *litter cover* in areas susceptible to downy brome invasion including areas adjacent to existing infestations. Shading and a lack of bare ground decreases the chance of downy brome infesting the area.

b. The *timing of trail maintenance and mowing* should be such as to not mow downy brome plants past the soft dough stage. Viable seeds may be possible at this time, thus spreading infestations. If mowing after seeds may be viable, infestations are to be marked out and cut around. (Flag any infestations on the ranch at the start and end of the infestation and request Operators not mow through your flags.)

c. While preventing the spread of downy brome across the ACHDA from existing infestations is very important, *preventing the importation of new infestations* is even more critical. Only clean equipment is to enter onto the ACHDA. When a clean

equipment protocol is established and implemented (including for irrigation, oil & gas industry and County), both awareness and accountability will prove extremely important.

d. Downy brome can be found in *hay or greenfeed fields (baled forage) or in forage seed*. Purchase certified weed free hay or begin producing one's own hay that can be guaranteed weed free. Feed hay only on cultivated fields, or tame monocultures that are visited often in the summer (to scout for invasive species). Forage seed used in irrigated hayfields, on canals, or on Rights of Way can contain downy brome seed. Analyzing a forage seed certificate prior to approving or purchasing a seed mix is an important preventative measure. Beware that some labs may list 'bromus spp.' on the seed certificate but not stipulate if it is downy brome or meadow bromeGrass. Analyze all seed mixes in detail (including irrigation, oil & gas industry, County, and ranch seeding). The revegetation of trail edges is critical to maintain a competitive overall ground cover (western or northern wheatgrass may prove successful).

H. ACTIONS PLANNED

There are six (6) downy brome infestations currently found on the ACHDA. These infestations range in size from 10 m^2 to 20 m^2. These are relatively small infestations.

1) **Control on small infestations with hand pulling, spot burning, or glyphosate.** Hand pull infestations or spot burn infestations with the tiger torch/ hand torch. Time these activities to occur before downy brome reaches the soft dough stage (viable seeds). Continue the timed removal of downy brome for 3-4 consecutive years. At that time, viable seed reserves should be depleted and new seedlings should no longer be germinating/visible.

   If any of the six current infestations are established on areas where there is no other vegetation, the option of using glyphosate EARLY in the year may be used instead of hand pulling or spot burning. Continue applications for 2-3 years until viable seed reserves have been depleted.

2) **Revegetate disturbed areas.** Once infestations are decreased (at 3-4 years or sooner if using non-herbicide methods), follow with revegetation. Newly disturbed areas or areas with older disturbances must also fall into a planned schedule of revegetation activities. Many different methods of seeding are possible. Ensure early seeding with good seed to soil contact through drilling in or broadcasting and harrowing. Ensure seed is free of invasive species, and has high germination and vigour. Native seedling plugs of rhizomatous grasses may be beneficial to plant in the area to quickly establish competitive species. Create a revegetation schedule for the disturbed areas on the ACHDA. Engage Industry in the schedule/plan.

3) **Apply new research technology.** Stay abreast of any new downy brome growth inhibitor herbicide research out of Fort Keogh Livestock and Range Research Laboratory. Share the potential for demonstrating this up-and-coming technology with current and prospective research and demonstration scientists/ professionals. This may prove to be a good demonstration on the ACHDA or with a partner offsite. The suppression of downy brome with Milestone (can be used for Canada thistle control) may allow for a prolonged period without seeds or flowers which may result in a larger window where hand pulling is effective. Any native perennial grasses mixed in the downy brome infestation will indeed live through a Milestone application.

4) **Prevent new downy brome infestations.** Follow the downy brome prevention protocol set out in the possible management activities section. These preventative actions are key to stopping downy brome on the primary pathways of invasion. In addition to these actions develop an official mowing protocol (with downy brome and other invasive species considered in it) and shared with the land users.

I. RESOURCE NEEDS

Activity	**Timeline**	**Person hours required (estimate)**	**Equipment or supplies required/ cost**
Option 1: Small downy brome infestations hand pulling *(6 infestations from 10-20m^2)*	May - June 2014-2017	Yearly 6 hours per infestation. Monitor while implementing control. **(36 hours)**	-large indestructible heavy plastic bags ($100) - GPS (one time purchase @ $1500)
Option 2: Small downy brome infestations spot burning *(6 infestations from 10-20 m^2)*	June yearly 2014- 2017	1 hour per infestation (each infestation visited twice). Monitor while implementing control. **(6 hours)**	Hand or tiger torch ($100) - Propane ($20) - GPS (one time purchase @ $1500)
Option 3: Small downy brome infestations glyphosate applied *(6 infestations from 10-20 m^2)* *** non-vegetated sites*	May 2014-2017	Yearly 2 hours per infestation (includes mixing and travel time). Monitor while implementing control. **(12 hours)**	- quad sprayer (one time purchase @ $400) -water tank (on hand) - Glyphosate herbicide (2 L/ year = 8 L @ $8/L per year= $64) - GPS (one time purchase @ $1500)
a) Set up a revegetation schedule for disturbed areas.	2014	**16 hours**	Based on the plan set out this budget will be formed (based on acres

b) Revegetate disturbed areas. (*By 2017/18 reveg areas previously infested with downy brome)*	As planned, beginning in 2015-2024.	Dependant on the revegetation schedule.	vegetated per year). Costs to include: seed, seeding labour, seeder, harrows, and additional site prep such as pre-seed burn-off.
Downy brome infestation prevention. *trail maintenance and mowing(protocol), seed & hay purchases, litter cover*	Year-round 2014-2024	Yearly **20 hours**	- flags for mowing markers ($80)

5.3 ***Common name*****: Canada Thistle**
Scientific name: Cirsium arvense

A. PRIORITY **High**

B. DESCRIPTION

Canada thistle is a short lived perennial with extensive rhizomes. Plants will be either male or female (as a result small patches could contain just one sex). When conditions are cool or moist there is a general increase in populations. Plants will either bolt in June and set seed thereafter or remain in a rosette or bud stage into the fall. The plant's fall nutrient reserves and the ability of the root system to overwinter are strong determinants of the plant's survivability. Canada thistle is a weed of all habitats.

C. CURRENT DISTRIBUTION ON THE SITE

A total of 55 mapped infestations of Canada thistle currently cover approximately 343 ha (848 acres) of ACHDA (Figure 4). Infestations range in size from $1m^2$ to 201 ha. Aerial cover of Canada thistle ranged from less than 1% to 50% within an infestation, and distribution ranged from 2 (a few sporadically occurring individuals) to 10 (continuous uniform occurrences of well spaced plants). Plants were in early to full bloom when surveyed in 2013 and the number of seedheads/m^2 ranged from approximately 5 to 100. The potential for spread was vigorous for most infestations, but a few infestations were limited to select edges.

Canada thistle was found in a variety of plant communities. Infestations are primarily found in disturbed areas associated with tame grassland and weed cover dominated by Kentucky bluegrass, smooth bromegrass, crested wheatgrass, Russian wild rye, foxtail barley and sow thistle. It was found to a limited extent in invaded natural grasslands including most commonly Kentucky bluegrass – western wheatgrass, Kentucky bluegrass – green needlegrass, western wheatgrass – Kentucky bluegrass, and speargrass – Kentucky bluegrass. Several infestations were found in undisturbed grasslands including western wheatgrass – speargrass, Blue grama – speargrass and pure western wheatgrass grasslands. Canada thistle infestations on ACHDA are highly correlated with subirrigated polygons as identified by the Grasslands Vegetation Inventory.

The common disturbance factors associated with Canada thistle include borrow sites associated with created wetlands, dams, dugouts, canals, roads, pivot irrigation and oil and gas facilities such as wellsites, pipelines, risers and compressors. Less common disturbance factors include building sites and yards, telephone pole piles and badger burrows. However, undisturbed areas were also invaded by Canada thistle including streambanks, wetland edges, lakeshores and grasslands.

The historic spread of Canada thistle on the site has likely been slow. Many of the infestations associated with natural and created waterbodies, roads and pivot irrigation probably established soon after the disturbance and may have been on site for more than

30 years. In addition, Canada thistle infestations fluctuate in size substantially from year to year depending on moisture and temperature conditions.

D. DAMAGE & THREATS

Canada thistle has the ability to invade a number of habitats present on the ACHDA. The native prairie vegetation is of high value and with numerous Canada thistle populations present on the ranch (source of seeds), the native prairie is at risk of invasion. Disturbance that exposes bare soil is required for new infestations to establish. However, disturbance can be as small as a ground squirrel burrow. Seed longevity of Canada thistle can be as long as 20 years and the presence of seed is extensive on ACHDA. Therefore, disturbances are easily and quickly colonized by Canada thistle. The ability of Canada thistle to spread vegetatively through an extensive root system means that once established by seed it has the capability to spread into undisturbed areas. The canal systems connecting the irrigated land and constructed wetlands are an area where infestations currently exist and can easily spread. Water movement is impacted and the receiving waterbodies or their riparian areas are at risk of invasion.

E. GOALS

The long term goal for Canada thistle on the ACHDA is to reduce the number and densities of infestations that currently exist as a means to limit the spread into the high-value native prairie and riparian habitats on the ranch.

F. OBJECTIVES

Objective 1. Reduce the total number of isolated Canada thistle patches by 70% within 5 years.

Objective 2. Reduce the ability of Canada thistle infestations to set seed by initiating control measures on infestations with seed head density greater than 71/m^2 .

Objective 3. Deplete the nutrient reserves in the root systems of large extensive patches over the duration of this management plan. The result will be a less vigourous plant susceptible to plant death in the case of a hard winter or dry spring.

G. MANAGEMENT OPTIONS

Viable control options include:

1) **Prescribed Grazing**- A Canada thistle (and hoary cress) grazing prescription was designed by Kathy Voth in 2013 for the ACHDA. Livestock can be trained to eat Canada thistle to prevent seedset, keep the plants in the vegetative stage, and reduce the plants vigour (above and below ground). Livestock should not be used to graze invasive plants during seedset due to the chance of the livestock spreading viable seeds in their manure to other un-infested areas. Using livestock for grazing invasive plants (as an integrated control measure) can be feasible when livestock are already used on an

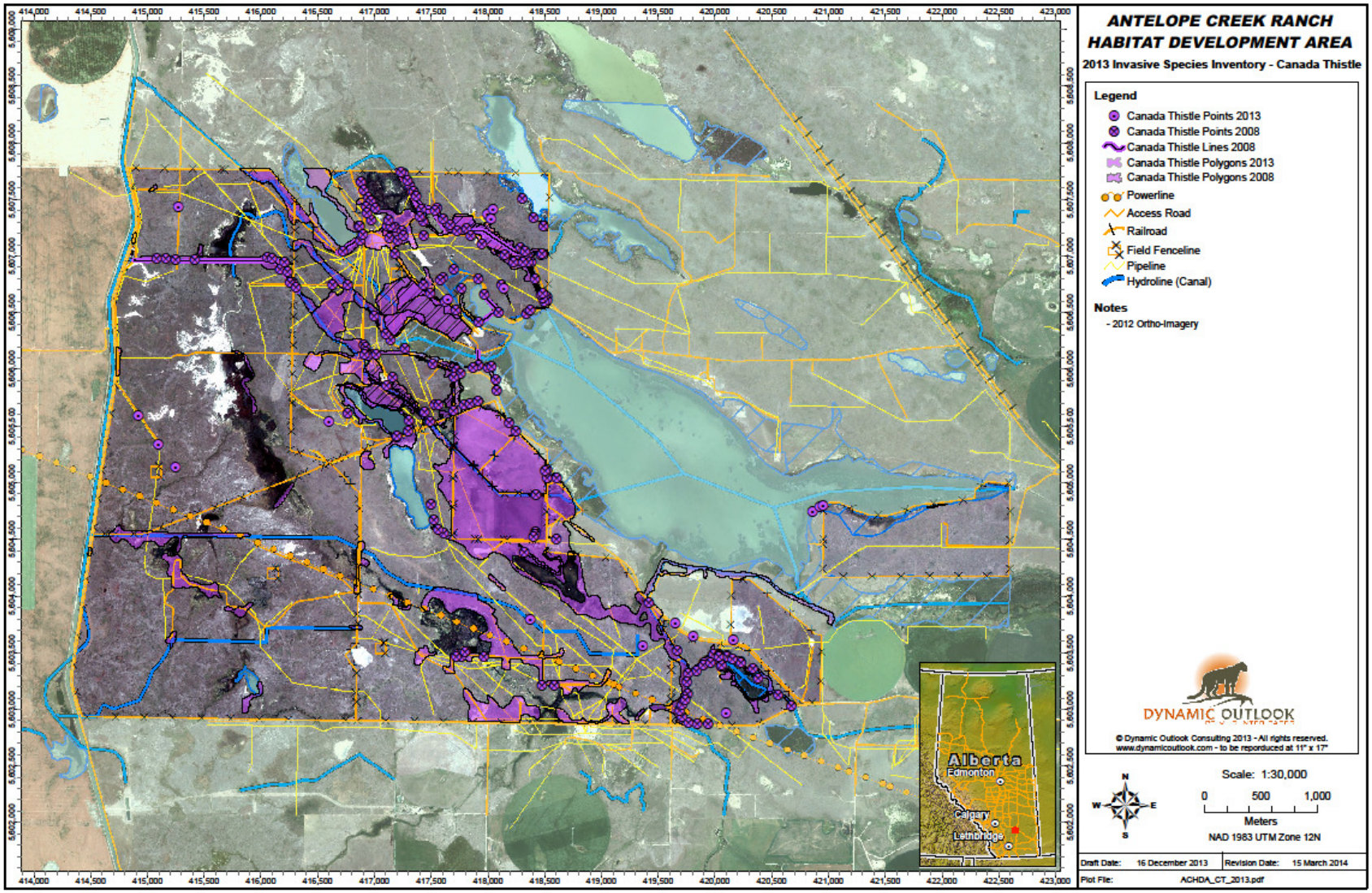


Figure 4. Canada Thistle Infestations on ACHDA

operation, time is available to train livestock to select invasive plants and the size and density of infestations make the other control methods less feasible (high number of infestations or wide extent of polygons).

Recent Canada thistle grazing research (De Bruijn & Bork 2006) has demonstrated that High-intensity-low-frequency (HILF) grazing (herbage grazed to an approximate height of 2-cm, with a 8–9 week rest period between the two annual grazing periods) almost eliminated Canada thistle stems (remaining were vegetative). A Season-long grazing system maintained or increased the infestation, and a Short-duration (SD) grazing (herbage grazed to an approximate height of 15-cm in 2–3 days, with a 4–6 week rest period between grazing periods) decreased Canada thistle but by less than HILF grazing.

1) **Mowing**- Mowing reduces Canada thistles seed set and can cause it to stay vegetative. Mow in late June when root energy reserves are at the lowest for greatest impact on Canada thistle above and below ground growth. Repeat when new aboveground growth establishes. Published research suggests that mowing over a span of 3-4 years can keep it from expanding or possibly reduce Canada thistle up to 80-100 % (Jacobs *et al* 2006). Mowing to make Canada thistle stay vegetative will allow for greater fall herbicide uptake. Mowing can be cost effective in slowing spread in situations with a high number of infestations, a wide extent of polygons, or where herbicides are not practical.

2) **Herbicide Applications** (spray and wiping)- Herbicide is an effective means of control for Canada thistle. Studies consistently find that a reduction in Canada thistle results in a detectable yield improvement (Grekul and Bork 2004). The ideal time to implement a herbicide control is early in the growing season when the Canada thistle is in the rosette/ bud stage (June), or in the fall on plants in the rosette stage (either plants that initiated growth in the summer or plants that were grazed or mowed during shoot elongation which kept them in the rosette). A wide range of herbicides that translocate herbicide into the root system are effective (Almquist and Lym 2010). Contact herbicides are effective at controlling top growth and can weaken and kill roots under the right conditions. Glyphosate is highly effective on Canada thistle and can be sprayed or wiped on plants, however it is a broad spectrum herbicide (kill all vegetation it contacts) (Grekul *et al* 2005). Picloram and clopyralid, then dicamba tend to be more effective than 2,4-D and MCPA. The herbicide used should be selected based on the application means chosen and the comfort level of the person applying the herbicide in consultation with an Agrologist well versed in herbicide selection.

   The necessity for control of Canada thistle needs to be balanced with (or outweigh) the possibility of non-target species damage (Grekul and Bork 2004; Bork *et al* 2007). Weed wiping Canada thistle which is taller than the non-target species will reduce collateral damage as would the use of a back-pack sprayer for smaller infestations (Grekul *et al* 2005). Spraying is time effective and coverage is steadier.

3) **Spot Burning**- Late spring spot burning may be effective in removing above ground biomass of Canada thistle. However, the consistent indication from the USDA Fire Effects Database research suggests that Canada thistle is more likely to survive and flourish post fire than be impacted in such a way to positively contribute to control measures.

4) Spread Prevention Strategies

a. Carefully purchase hay and seed. Canada thistle can be found in hay fields (baled forage). Purchase certified weed free hay or begin producing own hay that can be guaranteed weed free. Feed hay only on cultivated fields, tame monocultures that are frequented often in the summer or are already infested with Canada thistle (to scout for invasive species).
b. Increase the vegetation's competitiveness. Vegetation that has the ability to compete with Canada thistle can help contain an infestation or patch or stop one from forming (Grekul and Bork 2007). Examine vegetation along constructed wetland canals. Consider re-vegetation of canals without a good cover of native vegetation 1) on canals not yet infested with Canada thistle, and 2) on canals where Canada thistle has been controlled.
c. Increase the existing plants' competitive ability in areas prone to infestations. Depending on the vegetation this could include fertilization, a varied grazing regime, management changes or burning.

5) **Tillage & Herbicide**- On the flood and pivot irrigated land (tame forage) the area could be temporarily converted to cropland under which the extensive Canada thistle infestation could be brought under control with tillage and herbicide applications combined with the seeding of annual crops. Cropping would need to take place for a number of years (3-4 most likely) before the land would be clear of Canada thistle and reseeded to perennial forages.

6) **Biological Control**- Biological control agents are most often insect, fungal or bacterial pests that prey on the above or below ground plant growth. Canada thistle has many different biological agents that cause harm to the plant. There are a small number that cause a significant enough amount of damage to the Canada thistle plants to be considered control means. *Hadroplontus (Ceutorhynchus) litura* is a stem-boring weevil- noted in MT and BC in Canada thistle; *Rhinocyllus conicus* is a seed-head weevil. It however, has the ability to also feed on native thistles which may limit its justified use on ACHDA. Various research has shown the seed head weevil can reduce thistle populations by 90-95 percent in eight to ten years (Jacobs *et al* 2006). Biological control agents are advantageous when limited financial resources are available as a minimal amount of staff time is needed to distribute and monitor the biological control agent.

7) **Increase Forage Competitiveness**- Forage competitiveness can be increased through fertilization, grazing for more competitive adjacent plants, and seeding bare areas. De

Bruijn *et al* (2010) found in their Alberta studies that when adjacent non-Canada thistle plants were vigorous and competitive it slowed the Canada thistle invasion. Deferred grazing and high-intensity-low-frequency grazing were most effective. Fertilization has proven beneficial for the grass species in different experiments but not-significantly effective in others. A review of current management activities on irrigated acres to increase forage competitiveness against Canada thistle may slow infestations.

H. ACTIONS PLANNED

Appendix 1 contains a series of maps showing relative cover, seedhead density and plant distribution for the point and polygon infestations surveyed in 2013. This analysis was used to determine priority actions for Canada thistle control in consultation with the Ranch Managers.

1) **Carry out rapid response in fields with small infestations.** Spot or quad spray the points and polygons with the highest seedhead density (71 – 100 seedheads/m^2). These include 07-50, 07-56, 07-12 and 07-46 (polygon 46(10)). In addition spot spray the small point infestations on the west side of the property where native grassland is dominant, disturbance from development is lowest and Canada thistle infestations are least common. These include points 07-19, 07-20, 07-39. In addition, there is an opportunity to spray site 07-21 (polygon 21(14)) once the willows have been removed. The goal is to eradicate these infestations which are small and have the greatest capacity to provide sources of seed for new infestations.

   Carry out herbicide treatments at bolting or mow/weed whip once at bolting/early flower and then spray regrowth of rosettes in the fall. When bolting occurs is dependent on the year and moisture conditions but generally falls in mid-June. The lowest water levels in the wetland and canals on ACHDA occurs between late June and mid July before wetlands are filled with diverted irrigation water. Fall spraying may afford natural water drawdown around very small wetlands (non-filled) or canals which would allow for non-residual herbicide applications in those locations at this time. Herbicide application can be carried out with a backpack sprayer, quad sprayer or weed wiper/wick. The ACHDA Management Team should select a herbicide in consultation with their local Agrologist from the following list (discussed in section G): glyphosate, picloram (or picloram/2,4-D), clopyralid, or dicamba/2,4-D.

   Points should be monitored for resprouting each spring for several years and sprayed again. Polygons should be monitored for seedhead production annually and retreated when seedhead production becomes greater than 20 seedheads/m^2.

2) **Graze to prevent seedset and reduce vigour.** Test the effectiveness of a grazing treatment by electric fencing site 07-23 (polygon 23(9)). This site exhibits high percent cover and high distribution and has a water source for cattle. The next priority for treatment with cattle grazing would be site 07-44 (polygon 44(11)). This site exhibits high distribution and moderately high seedhead density. A third option for cattle

grazing treatment would be site 07-3 (polygon 3(11)). This site exhibits high distribution and moderately high seedhead density. However, it lacks a water source for cattle.

Apply the basic invasive species grazing and training principles supplied by Kathy Voth to the training of some livestock to eat Canada thistle. Corral training (or a very small pasture) a smaller group of cattle may be more easily accomplished than training in a large pasture. This could be accomplished early in the growing season to accommodate the manager's other duties. Once a core group of cows is trained in 2014, re-training will not be required, as long as the core group of cattle remain together for the purpose of grazing Canada thistle.

Keep in mind that on areas with plants that were grazed, the Canada thistle can be more susceptible to herbicide control later in the same year.

3) **Utilize biological control agents**. Work with provincial weed specialists and county weed personnel to locate biological control agents (stem and seed-head weevils) to introduce to infestations along areas where herbicide treatment cannot be carried out without collateral damage. Sites with the highest seedhead densities would be the most appropriate locations. These would include 07-07 (polygon 7(2)), 07-03 (polygon 3(11)), 07-02 (polygon 2(11)), 07-36 (polygon 36(17)), and 07-44 (polygon 44(11)). Monitor biological control agents and move them around to other infestations over the next 10 years when appropriate.

4) **Limit spread.** Do not allow infestations to spread out further upstream or downstream on canals. Using the current GPS coordinates of the ends of infestation, return to those locations yearly. Each year, ensure no Canada thistle plants have spread beyond the 'end' GPS points. If plants are detected respond with chemical control. Spot application with a backpack sprayer or hand wand on a quad sprayer is recommended.

   Channel clearing provides an opportunity to limit spread and reduce infestations of Canada thistle along canals. Weed wipe Canada thistle infestations right after channel clearing is conducted.

   One of Canada thistle's main ways of spreading onto the ACHDA is through seed and hay. The actual ranch, the oil & gas industry and the irrigation sectors must only bring weed-free seed and hay onto the ACHDA.

5) **Infestation management on irrigated land.** The ACHDA Canada thistle map shows the most extensive infestation to be located on the irrigated lands. While grazing may prove effective on the pivot and flood irrigated land to reduce Canada thistle seedset and plant densities, it could possibly prove ineffective in controlling the infestation to an acceptable level. Evaluate the population once the grazing regime has been implemented for 2-3 years. If the population continues to grow and spread outwards (in canals, trails, wetlands) action must be take (timeline 2017). Tillage and chemical

application on the irrigated lands for 3-4 years with the eventual return to a competitive forage stand will overall be the most effective means of bringing the main Canada thistle infestation under control.

I. RESOURCE NEEDS

Activity	**Timeline**	**Person hours required (estimate)**	**Equipment or supplies required/ cost**
Small Canada thistle infestations herbicide app & monitoring. *Infestations 07-50, 07-56, 07-12 and 07-46 (polygon 46(10)), 07-19, 07-20, 07-39, 07-21 (polygon 21(14)). Add new infestations as these are deemed controlled.*	Mid to late June 2014-2020	Yearly **12 hours**	-quad sprayer (one time purchase @ $400) -water tank (on hand) - herbicide (e.g picloram 1.8 L/acre yearly @ $80/acre x 5 acres) or 1.4-2 L/acre Glyphosate 500 gae/L) - GPS (one time purchase @ $1500)
Canada thistle Biological control agent collection, monitoring and management. *Native Field 2 & high seed density infestations 07-07 (polygon 7(2)), 07-03 (polygon 3(11)), 07-02 (polygon 2(11)), 07-36 (polygon 36(17)), and 07-44 (polygon 44(11)).*	June yearly 2014- 2024	County staff or Agency Partners (collect, GPS, monitor) **8 hours** yearly	
Electric fencing Canada thistle infestations *Sites 07-23 (polygon 23(9)), 07-44 (polygon 44(11)), 07-3 (polygon 3(11))* & re-tooling/removing fence	April 2014	One time- **16 hours** staff time	-electric fence supplies $600.00
Train cattle to eat Canada thistle -Move cattle and	Training early June 2014 Use same group of livestock	Training 7 days @ 3 hours per day = **21 hours**	-novel training supplies (molasses, grain, etc) $300.00

manage for Canada thistle defoliation S*ites 07-23 (polygon 23(9)), 07-44 (polygon 44(11)), 07-3 (polygon 3(11))*	summer 2014-2017 (or beyond)	Moving livestock-normal routine work.	
Limit spread on canal/ canal infestations (monitoring, spot spraying)	June yearly 2014-2024	Yearly **8 hours**	-quad sprayer (one time purchase @ $400) -water tank (on hand) - herbicide for 1 acre (for example: 1.4-2 L/acre Glyphosate 500 gae/L) - GPS (one time purchase @ $1500)
Breaking irrigated fields due to extensive Canada thistle infestations	Potential future activity		Dependant on breaking and rental arrangements made

5.4 *Common name*: Crested Wheatgrass
Scientific name: Agropyron cristatum

A. PRIORITY: High

B. DESCRIPTION
Crested wheatgrass (*Agropyron cristatum*) is a seeded agronomic grass species which has the ability to maintain itself within a stand for 50+ years through mature plants and new seedling recruitment. Grazed, seeded stands will deplete production over time. Although a prolific seed producer (1000 + seeds/ m2), the majority of seeds do not remain viable for more than a year (only a very small % up to 5 yrs). Populations establish and spread through seed spread. Crested wheatgrass produces early spring growth, often becoming the first green plant in the spring.

C. CURRENT DISTRIBUTION ON THE SITE
Crested wheatgrass currently covers approximately 244 Ha (602 Ac) of ACHDA (Figure 5). Of this total area, 54 Ha (133 Ac) are seeded crested wheatgrass fields. Infestations not including seeded fields range in size from a single plant to 9 Ha (133 Ac). Aerial cover of crested wheatgrass ranged from 1% to 75% within an infestation. The potential for spread was vigorous for outlier infestations, but established seeded fields appear to be limited to select edges.

Crested wheatgrass is a unique species to design a management plan for as there are seeded, intentional populations at specific locations on the ranch that will be maintained, but also the need to control and limit the spread of other populations.

D. DAMAGE & THREATS
Crested wheatgrass has the ability to invade into healthy native range sites or range in excellent condition. Crested wheatgrass may alter the structure of the plant stand, compete with rare species and out-compete native species. The best season of grazing use of crested wheatgrass does not fall in line with the time when most conservative grass managers try to graze the majority of native plant species. Therefore, seedset occurs and crested wheatgrass can proliferate and spread outward from the initial population.

E. GOALS
The long term goal for crested wheatgrass on the ACHDA is to prevent further spread into the high value native prairie habitat (new seedlings) and to remove and revegetate localized populations on oil & gas pipelines found running through the high value native prairie habitat (established plants & seedlings).

F. OBJECTIVES
Objective 1. Reduce the crested wheat grass seed set on pipeline and wellsite populations by 20% in 5 year rotation.

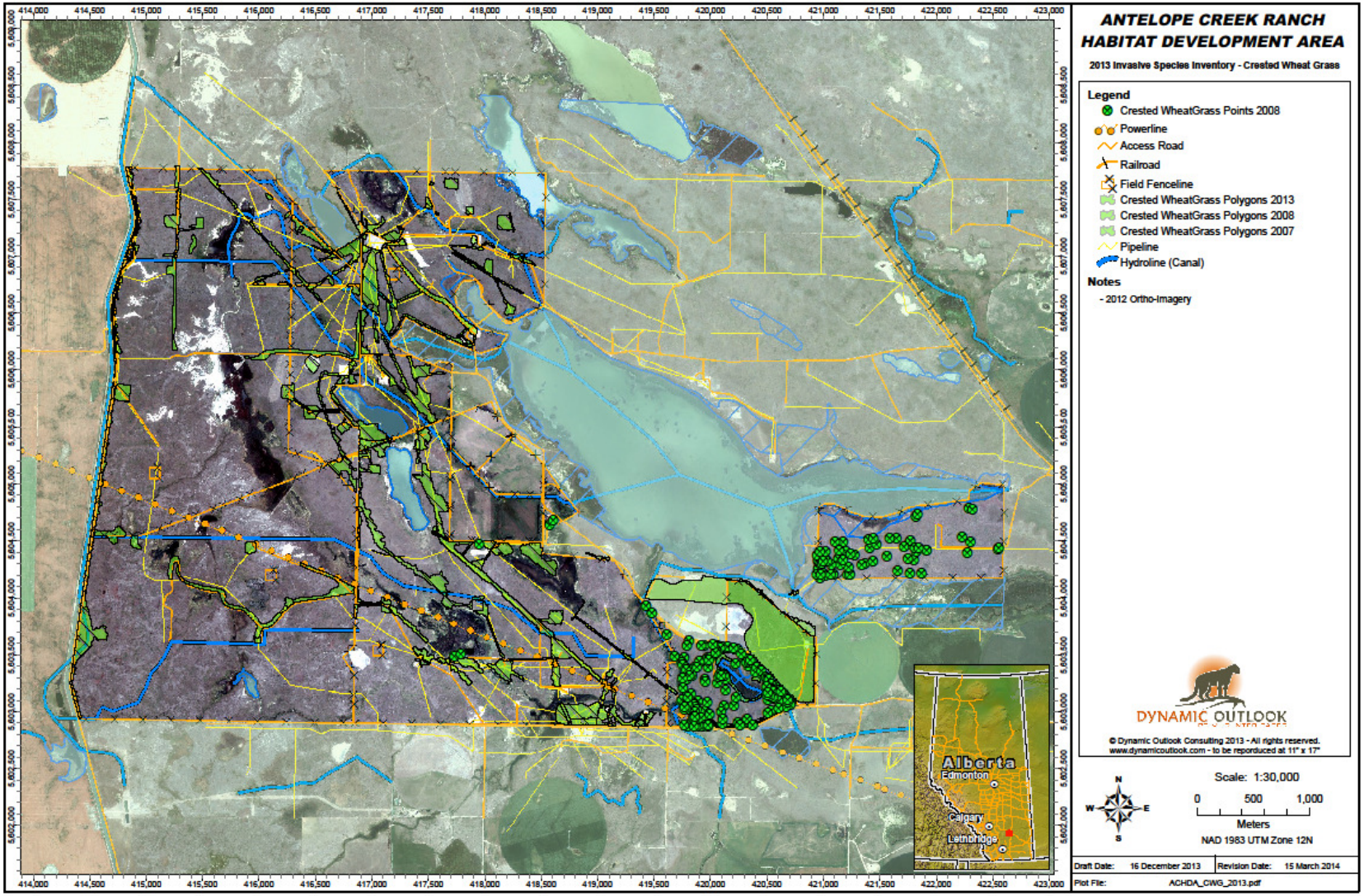


Figure 5. Crested Wheatgrass Infestations on ACHDA

Objective 2. Within 5 years begin revegetation with native species on at least 5 acres of pipeline areas.

Objective 3. Prevent seeded crested wheatgrass fields used for grazing from setting seed from summer 2014 onwards.

G. MANAGEMENT OPTIONS

Viable control options include:

1) **No Treatment-** Leaving crested wheatgrass to slowly invade certain locations close to source populations will most likely see a relatively small to moderate rate of spread outwards. A Grasslands National Park decision support tool (Frid 2006) determined for input of resources, time and results that new infestations (early detection and rapid response) should be the focus. Older established infestations were most unlikely to be eliminated without a great deal of work.

2) **Grazing-** As an agronomic species, crested wheatgrass is selected for its grazability and nutritional qualities. Grazing crested wheatgrass can be used as a tool to reduce/limit seed set and plant vigour and increase individual plant mortality. Grazing has been found to be the most effective means of depleting the overall crested wheatgrass seed bank. Romo & Harrison (1999) confirmed that grazing between the last week of May and the second week of June (in Saskatchewan), when the plants were in the boot stage to very early flowering, tiller growth was halted for the rest of the growing season and biomass was reduced. A uniform, intense grazing event must occur across all of the crested wheatgrass plants. Defoliation should be timed so that plants are just entering their flowering stage as they are defoliated. Seedlings have a difficult time withstanding heavy grazing pressure.

   There are challenges using grazing to control crested wheatgrass on locations such as the long skinny infestations along pipelines in areas with other palatable native grasses. These challenges include: keeping livestock focused on grazing the crested wheatgrass, obtaining a high grazing impact, and ensuring all crested wheatgrass is grazed so plants cannot go to seed. When small infestations are found within a larger, healthy native plant community (grazed mid to late growing season) livestock do not actively select and graze the crested wheatgrass plants. The result is seed dispersal from crested wheatgrass plants.

3) **Mowing-** Mowing can be used as a tool on crested wheatgrass infestations. Mowing can stop plants from setting seed if mowed at the boot/elongation stage (to early flowering stage). However, mowing does not have the same ability as grazing to stop new seedlings from establishing. Mowing low to the ground (within 5 cm) can be used as a

tool to remove plant growth when livestock are not easily used (such as in smaller patched or on long narrow infestations) (Pellant and Lysne 2005).

4) **Burning-** Burning alone will not cause a decrease in crested wheatgrass infestations. However, burning can be used in select situations to aid in further control measures on crested wheatgrass. Burning can remove old 'wolfy' crested wheatgrass growth (Romo *et al* 1997). Burning will act to stimulate tillering. When new crested wheatgrass tillers are taller than other species in the plant community contact with herbicides is feasible. Caution is necessary when burning to ensure fires remain under control. Burning during the summer growing season will not only impact crested wheatgrass, but injure the native species within the plant community. To remove wolfy growth spring burns while native species remain dormant will be best for the native species.

5) **Cultivation-** Cultivation will kill crested wheatgrass plants if the roots are turned over and exposed. Before using cultivation as a control means many factors should be considered. In established stands with large seedbanks cultivation will bury seeds and promote new seedling growth, resulting in a thicker stand (Pellant and Lysne 2005). However, on the flip side, good chemical control may be achieved at this point. If native vegetation is found in the plant community with the crested wheatgrass cultivation will also kill the good native vegetation. In light soils, the risk of soil erosion post cultivation may be too high to implement cultivation. However, in other situations with heavier soils cultivation may prepare a suitable seedbed for revegetation. The machinery costs associated with cultivation or breaking are much higher than chemical control. Small or long and narrow invasions with little native vegetation may benefit from an integrated control program which includes some cultivation.

6) **Herbicides-** The non-selective herbicide glyphosate is the only herbicide that is well researched for use on crested wheatgrass in grasslands. The use of a wick herbicide applicator allows for the operator to apply glyphosate to the crested wheatgrass plants by directly wiping herbicide onto the taller crested wheatgrass plants and leaving the shorted or dormant plants untouched by the herbicide wick. Apply the concentrated glyphosate by wick onto crested wheatgrass when the plants are actively growing prior to seedset (Lym and Kirby 1991). Spraying glyphosate distributes the herbicide evenly over the entire area. Any plants that are growing/ not dormant will be impacted by the glyphosate.

   A Canadian study (Bakker et al. 1997) confirmed that a spring application of glyphosphate reduced the crested wheatgrass stand by 50 percent. The researchers found that the level of reduction provided adequate enough control to establish a native warm season grass (such as blue grama) seeded at a high rate on the site. Further herbicide applications can then be used in the spring when the crested wheatgrass is actively growing and the warm season grass is still dormant. The crested wheatgrass invasion will be further reduced over time with herbicide applications and a

competitive seeded grass which reduces the ability of crested wheatgrass seedlings to establish on the site.

Kerb is a herbicide that prairie producers will often use for the control of foxtail barley in legumes and grass. Kerb cannot be used on crested wheatgrass because it kills/ caused severe injury to it. The Kerb label states (DowAgro Sciences 2010): *Caution- Do not use on pastures that contain high proportions of timothy, crested wheat grass or meadow fescue, as severe stand reduction will occur. Some of the less tolerant pasture grass species, (e.g. tall fescue, creeping red fescue) may experience a 10-15% reduction as a result of the treatment.* Although unproven as a means of control (off label), exploring the option of researching Kerb use on crested wheatgrass could prove successful as an integrated tool.

7) **Revegetation**- Integrated control involves many different practices. Revegetating disturbed areas and areas where other crested wheatgrass control measures have been implemented has been well researched in Canada and the United States. In Grasslands National Park blue grama (warm season species) is used as the primary species in revegetating areas invaded with crested wheatgrass. In any revegetation situation, ensuring seed to soil contact is very important. Seed to soil contact can be achieved through loosening the soil (harrowing or cultivating), broadcasting seed, then harrowing and packing to further firm the soil. Alternatively, seed to soil contact can be achieved through seeding with a sod seeder or discer (situation dependant). Good quality seed produces competitive seedlings and healthy plants. Grazing must be managed once the planted seedlings establish so that they can be healthy and compete with the remaining crested wheatgrass (Fansler and Mangold 2010).

8) **Integrated Plan-** Utilizing a number of different control practices in combination to control crested wheatgrass in grasslands is most commonly used and demonstrates the most positive results. Henderson (2005) proposed a template for recovery from *A. cristatum* dominance. The author proposed initial treatment with 2-3 years of properly timed grazing to reduce seed production and reduce the density of the seedbank. After grazing, the site should be treated with glyphosate to reduce the density of adult plants and allow native forb species to emerge from the seedbank. Once the site is dominated by native forbs, succession should occur, but may need to be assisted by addition of native grass seed. Addition of native seed will be particularly necessary when attempting to restore large areas whose interior regions will be isolated from stands of native species. Continued grazing and herbicide treatment may be required to suppress *A. cristatum* reemergence while native species are becoming established, however, they must be used carefully to prevent harm to desirable native species (Vaness and Wilson 2007).

H. ACTIONS PLANNED

1) **New infestation detection and control.** Early detection and control of any new infestations is the most important action. Spot spray or wick glyphosate on new infestations (including individual plants) after they have been mapped using a GPS.

2) **Reduce outlier plants and expanding edges.** The potential spread of crested wheatgrass from older revegetated pipelines is significant. Implement a pipeline mowing regime in which pipelines that have been seeded to crested wheatgrass are mowed in rotation every three years. This practice has proven to significantly decrease wolfy plants (increase grazing) and decrease seed production which overall reduces the chance of outlier plants and expanding edges. The same treatment could be applied to well access roads and wellsites to reduce spread.

3) **Integrated control on small, isolated infestations.** In Field 1 and Field 4 relatively small, isolated crested wheatgrass infestations are present. The greatest impact of control could be achieved on these outlier plants and expanding edges. Evaluate the infestations within these two fields. Determine if wolfy vegetation is present in the infestations. If so, mow or burn the infestations to reduce the wolfy plants (with old growth removed only new growth will be receiving the herbicide). Implement glyphosate control within these two fields using a wick applicator. Ensure fenceline infestations are attended to. Pay particular attention to the west fenceline along the canal and pipeline infestations that go underneath the east fenceline. Continue herbicide applications for the next 2-3 years until both seedlings and mature plants are reduced within the infested area.

   Prior to considering revegetation determine the density of native grasses and forbs that are found in the area invaded with crested wheatgrass. Weigh the potential for native plants to contribute positively to the area with the need for the area to be cultivated prior to seeding. Cultivate for 1-2 years if chosen as the way to prepare the seed bed. Spring seed a mix heavy with warm season species in crested wheatgrass infestations where little native vegetation is present. Utilize equipment available at the time (custom seeded, partnership with oilfield company, University revegetation equipment, etc.). Post seeding, continue to wick glyphosate onto crested wheatgrass plants that remain until little or no plants are present. Continue to monitor revegetated areas yearly. Follow-up crested wheatgrass control may be needed on an on-going basis into the future.

4) **Control in fields with extensive infestations.** Once integrated control has been successfully initiated on Fields 1 and 4, control practices on the ACHDA crested wheatgrass infestations elsewhere should begin (approximately 5 years from plan date). Initiate control on outer infestations in Field 2 and Field 3. Implement control practices used in Fields 1 and 4, ensuring to modify control practices based on lessons learned on Fields 1 and 4. Fencing livestock into large crested wheatgrass infestations (such as found along the southern edge of Field 3) may be feasible if providing water and

carrying out additional fencing is practical. Grazing should occur at the boot stage prior to flowering. Over time, begin work on the inner infestations once a control schedule on outer infestations has been well established.

5) **Trained cattle grazing**. In Field 2 and Field 3 livestock will be trained to defoliate Canada thistle as per the Canada thistle control plan. Mature CWG will not have the high protein so livestock most likely will not select it but will instead have to be fenced on and forced or may need a supplement added (lick tub) because it will be somewhat like winter grazing. A reduction in mature, wolfy plants will result in livestock more readily selecting the crested wheatgrass the following year.

6) **Initiate control demonstration projects.** The ACHDA is an area that fosters research. Currently, a small field scale conversion of crested wheatgrass to native species in the Dry Mixed natural region of Alberta with ARD has been initiated involving mowing, herbicide application and reseeding (Neal Wilson pers. comm.). ACHDA should initiate additional control demonstration project for crested wheatgrass as opportunities arise. As such, implementing novel techniques will add to the further knowledge on how crested wheatgrass will specifically respond on the ranch. Include the application of Kerb (4 L/ha rate) as one of these demonstration sites. Include repeated glyphosate applications followed by revegetating. Work with leaders in the field to determine other novel techniques to include.

7) **Prevent seed set on agronomic fields**. The crested wheatgrass fields on the southeast side of the ACHDA provide valuable forage at this time. Crested wheatgrass seed set must be prevented within the field to stop the spread of seeds to elsewhere on the property. Grazing just prior to the boot stage through the booth stage will prevent seed formation. Graze with a livestock density that results in all plants being defoliated 1) prior to the crested wheatgrass setting seed (10 days post flowering) and 2) prior to their movement to a different field.

I. RESOURCE NEEDS

Activity	**Timeline**	**Person hours required (estimate)**	**Equipment or supplies required/ cost**
Detection and control *New infestations*	Summer long yearly 2014-2017	**8 hours** plus general observations while doing other ranch work.	- quad sprayer (one time purchase @ $400) or quad weed wicker@ $400) -water tank (on hand) - Glyphosate herbicide as needed - GPS (one time purchase)

Mowing to reduce outlier plants & expanding edges	Yearly 2014-2020 with infestations set on a rotation to be mowed every 3 years	**8 hours**	- mower & tractor (on-hand)
Integrated control on small, isolated infestations - mowing or burning if needed, glyphosate application, revegetation. *Field 1 and Field 4*	Yearly 2015- 2020	Glyphosate application **8 hours for 3 years** (repeat on diff. infestations) Revegetation once per infestation 8 hrs	- quad sprayer (one time purchase @ $400) or quad weed wicker@ $400) -water tank (on hand) - Glyphosate herbicide as needed - GPS (one time purchase) Based on the revegetation plan set out this budget will be formed (based on acres vegetated per year). Costs to include: seed, seeding labour, seeder, harrows, and additional site prep such as pre-seed burn-off.
Control in fields with extensive infestations Initiate control on outer infestations in Field 2 and Field 3.	May 2020-2024 (or earlier if time and resources allow)	Roll time and resource budget from smaller isolated infestation work once completed.	
Train cattle to eat crested wheatgrass with the Canada thistle-move cattle and manage for Canada thistle defoliation but piggy-back crested wheatgrass *Crested Wheatgrass Field (south west area), Native Field 3,*	Training early June 2014 Use same group of livestock summer 2014-2017 (or beyond) *As per Canada thistle plan*	Training 7 days @ 3 hours per day = 21 hours Moving livestock-normal routine work. ***As per Canada thistle plan***	- novel training supplies (molasses, grain, etc) $300.00 - electric fence supplies $600.00 *As per Canada thistle plan*

Irrigation Lands and Native Field 2			
Initiate control demonstration projects.	2015- 2020	**16 hours yearly**. (Initially locate funding & demonstration partners; additional hours from partners)	Costs to be covered by funding or partners
Prevent seed set on agronomic fields (straight crested wheatgrass grazing fields)	2014- 2024	No additional time resources beyond regular ranch management hrs	

5.5 *Common name*: Kentucky bluegrass
Scientific name: Poa pratense

A. PRIORITY: High

B. DESCRIPTION
Kentucky bluegrass is a tame naturalized grass species prevalent across Alberta. It capitalizes in areas with moderate to high moisture. Although Kentucky bluegrass was not scouted and mapped in 2013, it is considered an invasive species on the ACHDA.

Kentucky bluegrass requires high fertility and high moisture to proliferate. Heavy litter facilitates a moist cool growing environment. However, at the same time, Kentucky bluegrass can withstand overgrazing with growing points at ground level.

C. CURRENT DISTRIBUTION ON THE SITE
Kentucky bluegrass is common in most native prairie pastures on ACHDA. It has invaded communities where litter levels are associated moisture levels are high. It is less common on low productivity, saline soils where litter levels tend to be lower. Kentucky bluegrass is also common in riparian areas and in forested communities on the property.

Kentucky bluegrass control options within the diverse native prairie fields dominated by grasses on the ACHDA are limited. Decreasing the chance of spread outwards from current locations can work through numerous cultural control practices paired with natural climatic cycles.

D. DAMAGE & THREATS
Kentucky bluegrass is known to compete with native species, reducing overall diversity and altering species composition. It is less nutritious and has a shorter growing period than native grasses and therefore it can negatively impact grazing species unless grazed during the period of peak nutrition.

E. GOALS
The long term goal for Kentucky bluegrass is to reduce the prevalence in native plant communities.

F. OBJECTIVES
Objective 1. Reduce the amount of litter in highly invaded native grassland communities to 60% or less of expected levels (Adams *et al* 2009) in 3 years.

G. MANAGEMENT OPTIONS
Due to the nature of the Kentucky bluegrass invasions on ACHDA, management options will be suggested, but reaching the objective for Kentucky bluegrass (how it will be achieved) is left up to the Ranch Managers.

1) **Grazing Rotation-** Altering a grazing rotation for earlier spring grazing can be used to keep Kentucky bluegrass from setting seed. Grazing to reduce litter and carryover in areas with Kentucky bluegrass will also slow the plant's spread, particularly in drier years. However, still allow for maintaining a healthy plant community resilient to future invasions. Livestock can be encouraged to graze in and around lower depression areas to reduce the litter during their planned rotation (encourage with salt, mineral, grain feeding). Litter removal, not bare soil is the goal. Work with the landscape to keep other palatable grass species in the niche area with the Kentucky bluegrass.

2) **Integrated Alternatives-** Generally, burning followed by the herbicide imazapic (a herbicide not registered for use in Canada) reduced Kentucky bluegrass in the species composition in North Dakota (Hendrickson and Lund, 2010). Burning, where appropriate, may be used to limit Kentucky bluegrass current growth and future spread.

5.6 ***Common name*: Foxtail Barley**
Scientific name: Hordeum jubatum

A. PRIORITY: Moderate

B. DESCRIPTION
Foxtail barley is a first successional species in wet, saline areas. Although 'native', this species has become widespread invasive in many habitats where it is not naturally part of the native vegetation composition. Foxtail barley has a high seed production, but short duration of seed viability. It has the ability to germinate in the fall and over winter as a seedling, or germinate in the spring. Although a perennial, foxtail barley has shallow fiberous roots.

C. CURRENT DISTRIBUTION ON THE SITE
Foxtail barley is associated with most wellsites on ACHDA that are not minimum disturbance wells, roads and trails where bare ground occurs or gravel has been added, and other areas where continual disturbance maintains bare ground.

This species was not mapped due to its status as a native plant. It occurs in many areas on ACHDA as a native plant in ecosites where it is not considered an invader.

D. DAMAGE & THREATS
Ecologically, in highly disturbed areas such as non-reclaimed wellsites, batteries, trails, and high disturbance wellsites, foxtail barley can invade and proliferate into other adjacent areas. With an ever- increasing seed production foxtail barley can quickly colonize an area and a more suitable perennial species not establish. Therefore, the greatest threat in these situations is that reclamation efforts will be impeded.

Another significant threat associated with foxtail barley on an operation running livestock is the health risk of the sharp awns from the seed heads piercing the animal's mouth and lodging in the flesh causing an abscess.

While foxtail barley is not currently listed as a noxious weed in Alberta, it has been listed in the past and is currently considered a noxious weed in Saskatchewan. Therefore, foxtail barley will be treated as a weed species on ACHDA in locations where it is invasive.

E. GOALS
The long term goal for foxtail barley on the ACHDA is to reduce the occurrences of populations and number of individual plants of foxtail barley in the highly disturbed areas (foxtail barley's non-natural habitats). This will reduce the risk of transport to other areas and eliminate the health risks for livestock.

F. OBJECTIVES

Objective 1. Reduce the density of foxtail barley from current levels on highly disturbed sites (non-reclaimed well sites, batteries, trails, and high disturbance well sites) by 50% in 7 years.

G. MANAGEMENT OPTIONS

Viable control options include:

1) **No Treatment**- Foxtail barley is a first successional species of wet and/or saline areas. Over time, a natural plant population shift can result in less foxtail barley on a site and other long lived, well rooted perennial species becoming established. The conditions which are best for this 'non-treatment' are in wet saline areas where foxtail barley may be contained.

2) **Facilitate a Shift in Conditions**- Various conditions favour the establishment of foxtail barley. Foxtail barley cannot compete with a competitive crop or well established healthy plants. Examining what conditions are causing the other associated vegetation to not compete with the foxtail barley and then modifying management (if possible) to shift conditions against foxtail barley.

3) **Grazing**- Foxtail barley is a nutritional plant that has a period of palatability early in the growing season prior to the boot stage (similar growth curve to crested wheatgrass). Foxtail barley begins to flower mid-June through early July. Grazing will limit the seed production of foxtail barley. Graze foxtail barley hard/heavy and early in the year to prevent heading. A second period of grazing in the same year may be needed to prevent plants from trying to initiate seed head production (boot & flowering) a second time.

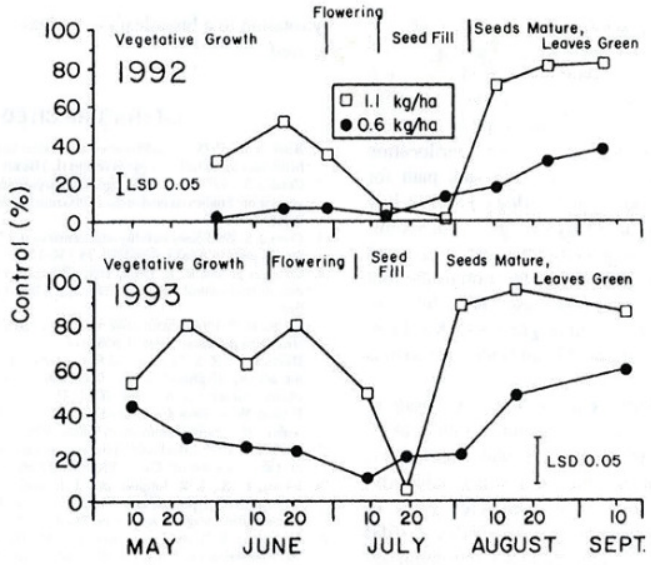
4) **Mowing**- Mowing can be used on foxtail barley in a similar manner as grazing to limit the seed production of the foxtail barley early in the growing season prior to the boot stage. Mowing must be done low to the ground to cut as much foxtail barley vegetation as possible. Repeat mowing as the foxtail barley population grows taller and gets close to the boot stage again. Continue mowing foxtail barley to prevent flowering and seed set (seeds become viable about 10 days after flowering). Limiting seed production through mowing can allow for other perennial species to establish in the area. As a shallow rooted, relatively short lived perennial, foxtail barley becomes less vigourous or dies allowing the favoured species to then become more established.

5) **Revegetation**- Competition from other plants can result in a decrease of foxtail barley. Bare or disturbed soil is a point of infestation for foxtail barley. 2006-2012 research (Wall and Steppuhn 2013) in Oyen and Warner, Alberta investigated the use of different tame and native grasses to compete with established foxtail barley. On saline sites the saline tolerant tame grasses tested outcompeted and choked out the foxtail barley (green wheatgrass showed best results). Northern and western wheatgrass (native

cultivars) along with a mix that included slender wheatgrass were also used and demonstrated their ability to outcompete foxtail barley on less saline sites. Reseeding disturbed soil immediately following the disturbance can negatively impact a foxtail barley infestation.

Revegetation requires a means to distribute the seed (spreader, disc drill seeder, valmar/rotary harrow) and a way to ensure seed-to-soil contact such as by harrow, rotary harrow, or roller. Seedling establishment is most successful with an early spring seeding or after a late fall planting where germination only occurs the following spring. As demonstrated in the 2006-2012 study, over time, as the seeded species establish, foxtail barley is choked out (results were proven over a period of six growing seasons).

6) **Herbicides**- Herbicides are a means to remove mature and seedling foxtail barley plants from a specific area. The non-selective herbicide glyphosate is most commonly used on disturbed sites and in dormant perennial grassed areas. As seen below, glyphosate control is most effective after seed fill when the foxtail barley plants are sinking nutrients into root reserves, followed by the active spring growing period.



Conn J.S. and R.E. Deck. 1995. Optimal Glyphosate Application Timing for Foxtail Barley Control. Weed Technology 9: 267-269.

In Blackshaw *et al*'s (2000) Alberta study fall glyphosate application is most effective with an October post harvest (6 wks post harvest) application (800 g / ha) had 60-70'% mature plant control, 100% seedling plant control. A risk with fall glyphosate application is that a killing frost could interfere with the planned herbicide application if the frost occurred early. The early spring application at 400 or 800 g per ha killed seedlings, but the mature plants were not that easy to kill. Time spring application when the new leaves are through the litter. A paired fall and then spring glyphosate application would be best/ most effective for the greatest cumulative control results

(applied at 1-2 L/ acre). Glyphosate can be used in areas where perennial grasses are present when grasses are dormant with little collateral damage.

Kerb is the only other herbicide registered for control of foxtail barley in perennial grasslands. Kerb SC Herbicide is a selective herbicide used to control quackgrass, certain other perennial grasses such as orchardgrass and timothy, and most annual grasses, including wild oats and volunteer wheat. Kerb SC Herbicide also controls chickweed. Dandelion, thistles and other members of the Compositae family are not controlled by Kerb SC Herbicide (DowAgro Sciences 2010). Foxtail barley control has varied results using Kerb. Apply Kerb in October below +12 and above freezing, with sufficient soil moisture present. The MSDS sheet cautions use on pastures with crested wheatgrass as damage to that species will occur.

Herbicide application requires appropriate application equipment such as a quad sprayer, truck sprayer or tractor pulled sprayer. Post application, establishment of competitive vegetation to reduce seedling establishment is important. If establishment is not possible, a continued herbicide application plan is needed to control seedlings until the seedbank is depleted or vegetation can establish.

7) Cultivation- The proliferation of foxtail barley in habitat types other than wet-saline lowlands has occurred because of the shift in agricultural production away from tillage practices to zero-till (Mori, 2014 pers comm.). Foxtail barley capitalizes on shallow soil moisture with its shallow fiberous roots. Foxtail barley is easily controlled through tillage- up to 100% control of established plants (Mori, 2014 pers comm.). Tillage with a cultivator, disc, disker, or plow may be implemented on disturbed sites. A follow up of reseeding is critical thereafter to lessen new seedling establishment.

H. ACTIONS PLANNED

1) **Allow natural succession where appropriate**. Allow foxtail barley to be part of the successional process on wet- saline low areas or appropriate complexes on the ACHDA. During yearly invasive species monitoring make note of any new infestations slightly out of the expected habitat. Observe to ensure the plant population evolves into another long-lived perennial species.

2) **Coordinate partnerships with Industry**. The invasions of concern are those associated with highly disturbed areas. The management of these invasions will need to be negotiated between the ACHDA and the Industry companies responsible for the highly disturbed site. A cooperative arrangement must be developed for success. Meet with and build a relationship with the occupying companies. Set out a joint plan. Appropriate, timely management of foxtail barley must be coordinated.

3) **Properly time current mowing activities**. Mowing is currently a maintenance operation carried out on the larger wellsites, trails, and batteries. Mowing must be timed to 1) prevent the seed head from emerging from the boot and 2) prevent the spread mature

seed heads. Work with all who are mowing to use the practice of mowing advantageously.

4) **Begin integrated control on existing infestations**. Apply a paired spring-fall glyphosate application to foxtail barley infestations. Carry out applications for multiple years until density is significantly reduced and seed set has been prevented for multiple years.

   Revegetating highly disturbed sites is critical for the overall control of foxtail barley on the ACHDA. Revegetate areas where bare soil is not required for industry safety. Revegetate with a mix of competitive native species. Seed early in the spring using equipment that ensures good seed to soil contact. Any straw matting used to stabilize the soil must be weed free, and locally sourced. Organic straw is not recommended because of the high weed density anticipated.

   Areas that must stay as bare-ground for industry safety will have continued glyphosate control applied on a yearly or twice-a-year schedule.

I. HOW ACTIONS WILL BE EVALUATED

Evaluate foxtail barley control methods during the yearly monitoring periods and just prior to control means being implemented. This timing of monitoring will allow for observations on the success of the previous control activities. Encourage Industry partners to monitor foxtail barley spread on wellsites and trails they maintain.

J. RESOURCE NEEDS

Activity	**Timeline**	**Person hours required (estimate)**	**Equipment or supplies required/ cost**
Coordinate partnerships with industry	On-going 2014-2024	Yearly **16 hours** (may require more hours in first years of developing partnerships and relationships)	
Properly time current mowing activities	On-going (June yearly) 2014- 2024	**8 hours** over the year (time with County & Industry)	
Integrated foxtail barley control. *Paired spring and fall glyphosate applications*	Late April & late September 2015-2024	Yearly **16 hours** (Industry partners may be able to provide this time)	-quad sprayer (one time purchase @ $400) -water tank (on hand) - Glyphosate herbicide (1.5-2 L/acre) - GPS (one time purchase @ $1500)
Integrated foxtail	May 2019- 2024	Yearly **8 hours**	Based on available

barley control. *Revegetation once foxtail barley population reduced*			budget areas to be revegetated will be determined. Costs to include: seed, seeding labour, seeder, harrows, and additional site prep such as pre-seed burn-off.

5.7 **Common name: Common Tansy**
Scientific name: Tanacetum vulgare

A. PRIORITY: Low

B. DESCRIPTION
Common tansy is an invader of disturbed sites and is commonly found on roadsides, fence rows, pastures, stream banks and waste areas. Reproduction is by expansion of short rhizomes and seeds that are spread by wind and water. It produces numerous tufted seedheads. It grows in sandy and loamy soils.

C. CURRENT DISTRIBUTION ON THE SITE
One small, but dense infestation of common tansy occurs on ACHDA (Figure 6). It was likely seeded into a flower garden as the infestation is adjacent to an old building site. Percent cover of the infestation is 70%. Distribution is 8 and the average number of seedheads/m^2 is 40. The size of the infestation is 72 m^2.

D. DAMAGE & THREATS
Common tansy is ranked as a low threat to ACHDA because it is contained in one infestation and has been present on the site for decades. At the same time, it presents a substantial seed source that may be spread throughout the ranch and to neighboring properties. Transport is a relatively high risk because the infestation is located in the ranch yardsite where livestock and vehicles may readily come in contact with seed.

Common tansy can invade pastures by forming very dense patches that crowd out native plants. It can also clog drainage ditches restricting the flow of water.

E. GOALS
The long term goal for common tansy on ACHDA is to eradicate the population. This will eliminate the risk of transport to other areas of the ranch.

F. OBJECTIVES
Objective 1. Eradicate the common tansy infestation adjacent to the old building site within 5 years.

G. MANAGEMENT OPTIONS
Viable control options are:

1) **Hand Pulling, Cultivation, or Rototilling**- Frequent and repeated handpulling, cultivation, or rototilling common tansy. Removing the rhizomes over time is key for the successful eradication of the patch (Missoula County Weed District, 2013). For small patches, pulling or tilling can be practical.
2) **Chemical Control-** Herbicides are an effective means of control for common tansy. Glyphosate can be used in areas where other vegetation is not present (such as along old building or in old flowerbeds). The Saskatchewan Crop Protection Guide

(2014) recommends a high rate of glyphosate (1.9-2.8 L/acre in 10 gallons of water/acre) applied to short, non-flowering plants for the best control. Restore and Escort can be used in grassland areas for suppression at low application rates and control at higher rates. See updated Crop Protection Guide recommendations for appropriate application rates.

A herbicide application should be followed up with monitoring and further herbicide applications the following year(s) to eliminate any seedlings or regrowth from rhizomes.

H. ACTIONS PLANNED

Due to the nature of the common tansy population (small, adjacent to old building in a yardsite, in a non-crop area) the most appropriate action is to eradicate the plants through a glyphosate application followed up with future applications as needed until the plants have all been removed and no additional seedlings are sprouting. Application will likely be most appropriate in early June (vegetative stage pre-flowering).

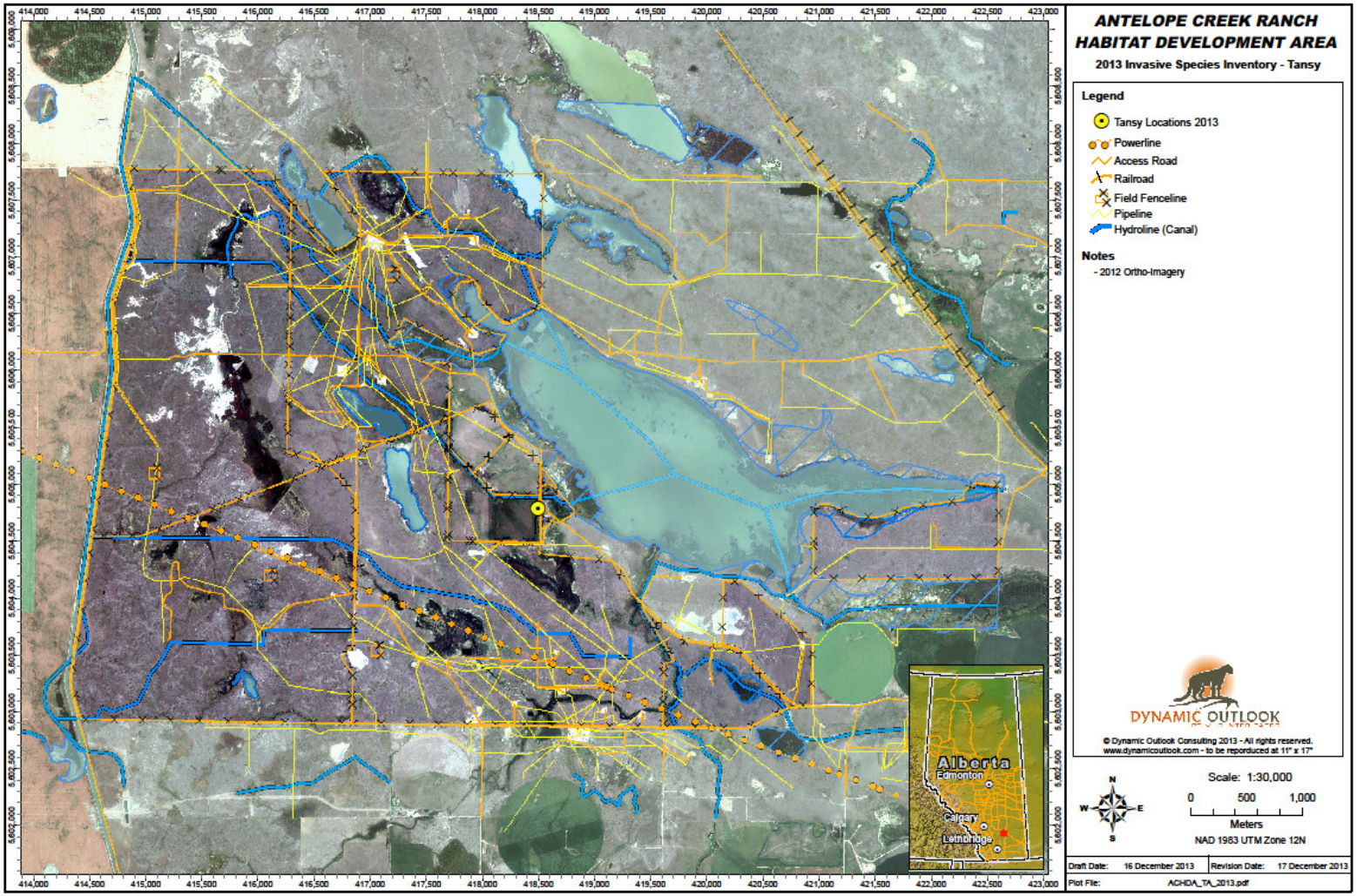


Figure 6. Common Tansy Infestations on ACHDA

5.8 Common name: Bull Thistle
Scientific name: Cirsium vulgare

A. PRIORITY: Low

B. DESCRIPTION
Bull thistle is a biennial, and sometimes annual or monocarpic perennial, forb. In the juvenile phase, individual bull thistle plants form a single rosette with a taproot up to 28 inches (70 cm) long. Rosettes may develop up to 3.3 feet (1 m) in diameter. The taproot does not spread, but develops several smaller lateral roots. Stems have spiny wings and grow 1 to 6.6 feet (0.3 to 2 m) tall, with many spreading branches, and sometimes a single stem .

Populations of bull thistle tend to be short lived, establishing after disturbance, dominating for a few years, and then declining as other vegetation recovers. Bull thistle seedling establishment is favoured by soil disturbance and seedling growth is favoured by vegetation disturbance. Bull thistle can grow in a wide range of environments but is most troublesome in recently or repeatedly disturbed areas such as pastures, overgrazed rangelands, and along roads, ditches, and fences. Even small-scale disturbances such as gopher mounds promote bull thistle establishment and survival, and density tends to increase as grazing intensity increases.

Individual plants can produce a great abundance of seed (100 - 300 seeds per flowerhead), which have a high germination and survival rate. Thus, this plant can be quite aggressive. Because the seeds remain viable for only 1-2 years, one control strategy consists of destroying individual plants before they reach the flowering stage. It is possible for a plant to reestablish itself if a portion of the taproot remains in the ground.

C. CURRENT DISTRIBUTION ON THE SITE
Three infestations of bull thistle occur on ACHDA (Figure 7). These infestations total 1987 m^2 in area. Aerial cover of bull thistle ranged from less than 1% to 30% within an infestation, and distribution ranged from 2 (a few sporadically occurring individuals) to 5 (several sporadically occurring plants). Plants were in early bloom when surveyed in 2013 and the number of seedheads/m^2 ranged from approximately 30 to 40.

D. DAMAGE & THREATS
Bull thistle is ranked as a low threat to ACHDA because it is not considered a noxious weed species in the municipality and because of its biennial nature it competes with perennial vegetation for only a short period. However, two of the infestations on ACHDA occur in native prairie and the third is expanding from a disturbed area into native prairie.

The litter of Cirsium species may inhibit the growth of other plants. In bull thistle, this is probably a result of the immobilization of nutrients during the process of litter breakdown.

Bull thistle is usually avoided by grazing animals because of its spines, and thus its proliferation is encouraged by heavy gazing on rangeland and in pastures. Mammalian herbivores don't eat the Bull Thistle because it is heavily armed with spines. Even in overgrazed pastures where cattle and sheep have little to eat, the Bull Thistle is one of the few plants that is left alone.

E. GOALS

The long term goal for bull thistle on ACHDA is to eradicate the present populations and prevent new populations from establishing on freshly disturbed soil.

F. OBJECTIVES

Objective 1. Eradicate the three (3) bull thistle infestation found on ACHDA within 5 years.

Objective 2. When conducting yearly surveying, monitor for additional bull thistle plants on disturbed ground.

G. MANAGEMENT OPTIONS

Viable control options include:

1) **Hand Pulling and Digging**- The biennial nature of bull thistle and tap root growth allow for effective hand pulling and digging of plants. Remove plants prior to or just at flowering. Seed set, even in pulled plants, will be prevented. Dig down into the tap root and remove as much root as possible. Plant death will result (Lincoln County Weed Control Board 2014).

2) **Chemical Control-** Herbicides are an effective means of control for bull thistle. Herbicides can be used in the spring/ early summer rosette stage or the later fall rosette stage. The hairy nature of bull thistle may lead applicators to include a surfactant in a herbicide mix to increase the plant's uptake of the chemical in large populations (Moechnig *et al* 2011).

   Glyphosate can be used in areas where other vegetation is not present (such as in disturbed areas) or when it can be spot applied to individual plants. A high rate of glyphosate (1.9-2.8 L/acre in 10 gallons of water/acre) should be used. Restore (aminopyralid/ 2,4-D), Milestone (aminopyralid), Curtail (clopyralid), Tordon (picloram) or dicamba (various) can also be used to control easily control bull thistle (Moechnig *et al* 2011) . See updated Crop Protection Guide recommendations for appropriate application rates.

   A herbicide application should be followed up with monitoring and further herbicide applications the following year(s) to eliminate any seedlings.

H. ACTIONS PLANNED

Due to the nature of the bull thistle infestations (small number of small sized infestations) the most appropriate action is to eradicate the plants through a herbicide followed up with future applications as needed until the plants have all been removed and no additional seedlings are sprouting. Application will likely be most appropriate in early June (vegetative stage pre-flowering) or later fall. Applications can coincide with spot spraying for Canada thistle. The herbicide used can be chosen by the ranch manager to fit with other chemical control means being implemented at the same time to achieve time and budget efficiencies.

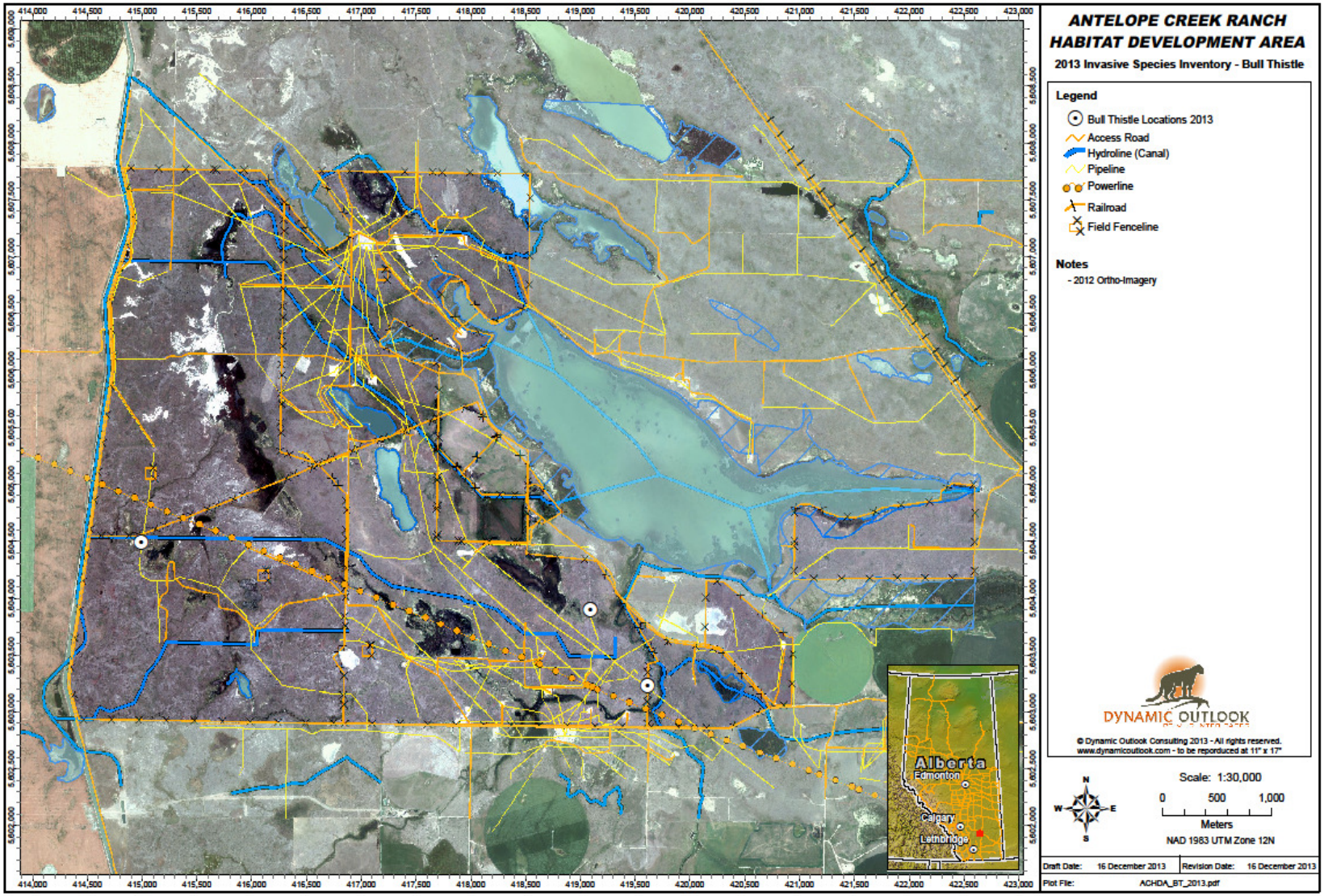


Figure 7. Bull Thistle Infestations on ACHDA

6.0 MONITORING RECOMMENDATIONS

Monitoring is necessary in natural area management because invasive plants interfere directly with the overall management goal of maintaining ecological integrity of conservation targets. Monitoring helps keep track of problematic species. Monitoring facilitates the prevention and early detection of new invasions, tracks populations over time and tracks treatment efforts and successes.

The goal of the monitoring program for ACHDA is to focus limited resources in control of invasive plant invasions. Objectives that meet this goal include:

1. Detect new invasions of non-native plants so they can be eradicated before developing into a population,
2. Locate established and establishing populations of invasive plant species, targeting limited control resources toward highest priority species,
3. Monitor the spread of existing infestations of priority established species, and
4. Monitor results of management and control activities on established populations of invasive non-native plant species.

On a relatively smaller landbase, such as ACHDA, the steps and components of an invasive plant monitoring program include first inventorying and mapping the distribution of invasive plant species, prioritizing among species and sites, and then designing a monitoring program for each of those priorities. Thomas *et al* (2002) outline those steps shown in Figure 8.

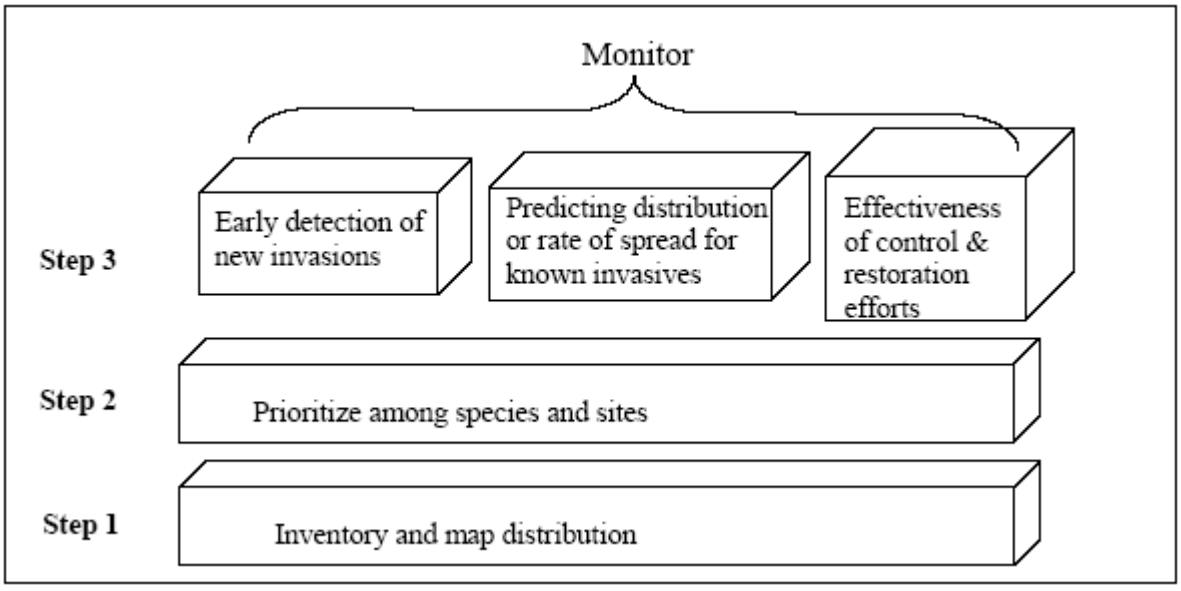


Figure 8. Schematic diagram of the potential steps and components of a non-native plant monitoring program (adapted from Thomas *et al* 2002).

ACHDA has an inventory of invasive plant species designated as noxious weeds in Alberta as well as crested wheatgrass and bull thistle found on the ranch. Other species are primarily restricted to highly disturbed sites roadsides (smooth bromegrass and flixweed) or are naturalized on the property (e.g., Kentucky bluegrass and dandelion) and have not been mapped. Inventorying and mapping of invasive plant species is an ongoing process, guided by the risk assessment.

The most effective and efficient invasive plant management is prevention of invasion. If invasions can be prevented, non-native plants are prevented from becoming problematic in a natural area. Surveying for new invasions annually or even several times a year can detect new problems which can be responded to rapidly, treated and eradicated. Questions that help design this portion of a monitoring program include:

- Which non-native invasive species are likely to threaten ACHDA in the near future?
- Where are the likely pathways of invasion both within and adjacent to ACHDA?
- Which areas within ACHDA are most likely to be threatened by invasive plants?

Some non-native plant species are already well established in ACHDA. These invasions need to be tracked over time, including the rate of growth of the invasion as well as the impact of the invasion on ecological integrity, so that species and infestations can be prioritized for management activities. Questions that help design this portion of a monitoring program include:

- Where within ACHDA do invasive plants currently threaten conservation targets such as native plant communities, revegetation sites or rare species?
- Where and how quickly are invasions impacting conservation targets?
- Where should control efforts be concentrated to prevent further invasion or reduce rate of spread?

The Invasive Plant Management Plan for ACHDA is designed not only to increase the amount of management activity targeting invasive plants, but to track treatment activities and monitor the impact of those efforts on the target invasive species. Monitoring management activities helps evaluate the cost effectiveness of control activities and the effectiveness of those activities in meeting management goals. Questions that help design this portion of a monitoring program include:

- Are native species resprouting and setting seed following management activities?
- Are target invasive species declining in density and is seed production prevented or limited?
- Are control activities resulting in negative, unintended consequences for native plant or wildlife species?
- Is the treated or restored area approaching the desired plant community composition?
- Is the treated or restored area resistant to subsequent non-native plant invasion?

These approaches and considerations have been used in developing the following monitoring protocols for ACHDA. The ACHDA monitoring program combines high priority species

monitoring with site-based monitoring to provide the most critical information that will result in the most effective management program in a cost-effective manner. The monitoring program is intended to be a long–term program. It should extend for a minimum of ten years and should be considered an ongoing process. An effective invasive plant species management program is dependent on constant vigilance.

6.1 Early Detection of New Invasions

Early detection of new invasions is the highest priority monitoring activity for ACHDA. As such, many of the monitoring protocols recommended in this plan are measures to prevent invasion. Monitoring efforts to detect invasions of new species will be focused primarily on high priority species identified in the Risk Assessment. Table 2 presents a watch list for personnel to use in monitoring. Although downy brome infestations already exist in ACHDA, downy brome is on the watch list, because it should be possible to eradicate existing infestations on the ranch in a short period of time. Therefore, new infestations would come from outside the property.

Table 2. Watch list of non-native species.

Common Name	**Scientific Name**
Diffuse Knapweed	*Centaurea diffusa*
Spotted Knapweed	*Centaurea stoebe*
Yellow Toadflax	*Linaria vulgaris*
Scentless Chamomile	*Tripleurospermum inodorum*
Russian Knapweed	*Rhaponticum repens*
Leafy Spurge	*Euphorbia esula*
Purple Loosestrife	*Lythrium salicaria*
Downy Brome or Japanese Brome	*Bromus tectorum; B. japonicus*

6.1.1 Monitoring Protocols

Monitoring begins with a keen awareness of what is around you every day and the subtle changes that occur. Many of the components of the monitoring protocol are done daily throughout the growing season, while others are set tasks at a specific time of year.

-**Surveillance.** Watch road ditches leading up to the ranch and adjacent to the ranch, oil and gas facilities including pipelines, and canals when driving, quading or horse-back riding. These routes are primary pathway of invasion especially for invasive plants such as scentless chamomile, downy brome, field bindweed, leafy spurge and the knapweeds that are yet to come to the ranch. They can be spread through hay, soil, gravel, fill, catching a ride on a vehicle or spread through maintenance equipment. Revegetation sites are also a potential source of new invasions and should be checked periodically. Leafy spurge provides a good example. Leafy spurge moves quickly along watercourses

and establishes well in riparian areas especially on coarse soils. The nearest known infestation of leafy spurge is along the main irrigation canal upstream of ACHDA. However, leafy spurge is capable of invading any habitat on the property. Some species that are expected to initially invade disturbed areas, including leafy spurge, spotted and diffuse knapweed, and downy brome, are capable of invading native grassland vegetation types if they are able to establish a point source population on the disturbed site.

-**Outside Input.** Become friendly with the local weed personnel and County Grader Operators. These individuals can let the Ranch Managers know of any new infestations that are getting close to ACHDA.

-**Education & Awareness.** Provide an Invasive ID Field Guide to anyone doing work on the ranch. Include a sticker on the back of the ID guide that says why preventing and detecting invasive species is important on the ACHDA and provides the Ranch Managers' contact information. These guides should be given to: Lease Site Operators, Mower Operators, Researchers, Naturalists, Hunters, Patrons, Grader Operators, and Irrigation District Personnel.

-**Monitoring of Revegetation Seed Sources.** Work with Industry and Reclamation personnel to ensure invasive plant free seed sources are used. Obtain certificates whenever possible.

- Monitoring of Feedstuffs. While only a small quantity of feedstuff is brought onto the ACHDA, there is a possibility of bringing new invasive species onto the ranch in hay or green-feed. Prior to purchasing feedstuffs, ensure they are weed-free (no propagating weed parts within them) by: 1) purchasing the hay prior to it being baled and observing the field for invasive species, 2) inquiring with the producer of the feed about the invasive sspecies within the harvested field, or 3) purchasing one random bale from the producer and rolling it out at the producer's farm to see what is contained in a bale. If feed with questionable content is brought onto the ranch feed in a contained location where control of any new invasive species would be manageable.

- Systematic Invasive Plant Rides- A (one) invasive plant ride will be used in the second week of July yearly. At this time, most plants should be easily identifiable as they will be mature and flowering or setting seed (Figure 9). This monitoring will be done with GPS, pocket sized ID guide and notebook in hand. Make note of any new infestations found (of invasive plants that are new to the ranch or a new infestation of an existing invasive plant). Note the extent of the infestation and the location. Checking the main pathways of invasion on the ranch during the annual invasive plant ride is the most important thing to do. These main pathways of invasion are: Roads and trails, Oil & Gas Sites (including pipelines), livestock watering sites, and canals entering onto the property (particularly the main canal along the west boundary of the ranch). If the remaining canals and riparian areas are not casually frequented over the summer these

should be added as a secondary priority in the invasive plant ride. Prior to conducting an invasive plant ride, flip through an identification guide to become re-familiarized with the high risk species not yet on the ranch.

If an invasive species is found on the invasive plant ride, begin implementing rapid response measures to bring the infestation under control. These measures may include hand pulling or spraying, depending on the species and habitat characteristics. If an invasive species that is not currently on the ranch is found (a species without a species management plan), work with the County Weed Personnel and an experienced local Agrologist to respond rapidly and appropriately to the infestation.

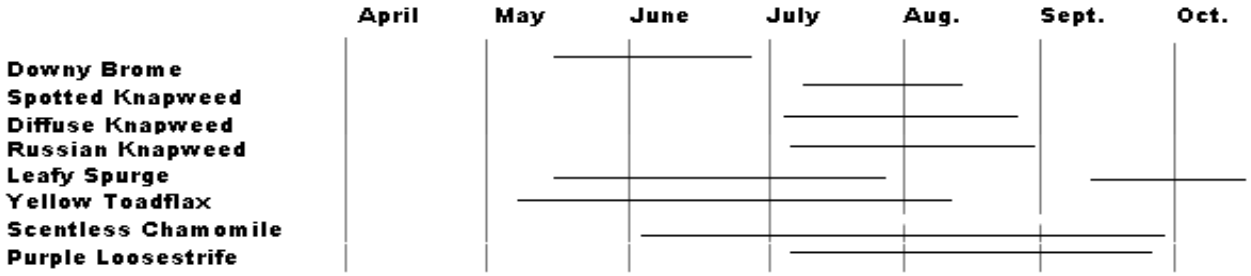


Figure 9. Local flowering periods of watch list plant species.

6.2 Tracking Distribution or Rate of Spread of Invasive Plant Species with Existing Source Populations

Predicting distribution or rate of spread on known invasives is the lowest monitoring priority for ACHDA. However, there are three well established species for which monitoring rate of spread should be considered.

Crested wheatgrass is widespread on ACHDA and is the most rapidly expanding invasive plant on the property. The rate of spread from point source populations without control efforts is expected to average about 1 m annually, but may extend up to 3m annually downwind from source populations (Henderson 2005). Natural communities are now at the greatest risk from this species. Natural grassland communities on ACHDA are primarily in high range health (Carlson and Kupsch 2008) and are therefore highly susceptible to rapid invasion by crested wheatgrass (Henderson 2005).

Kentucky bluegrass is extensively established in all native grassland community types except saline communities. Again, because these communities are primarily in high range health they are susceptible to rapid invasion by Kentucky bluegrass. However, Kentucky bluegrass has less impact on conservation targets than crested wheatgrass and is not a noxious weed.

Canada thistle is also widespread on ACHDA, but may be past the expansion stage of invasion. Canada thistle has extensive root systems and in years where climatic conditions are favorable

for growth, the above ground extent of an infestation will expand. 2013 was considered to have favorable conditions for Canada thistle (Neal Wilson, pers comm.) and therefore, expansion beyond the infestations mapped in 2013 may be limited.

Hoary cress infestations are well established on ACHDA, but most are likely decades old. They appear to be slowly expanding from source populations into adjacent habitat (Neal Wilson, pers comm.). Riparian areas and moist grasslands are at risk.

Monitoring rate of spread can be time consuming and may take resources away from other more vital components of the Invasive Plant Management Strategy. Therefore, it is recommended that monitoring be done for crested wheatgrass, and if time and resources allow, for Canada thistle and Hoary Cress.

A minimum of two sampling locations where Crested wheatgrass is invading from a source population into native grassland should be chosen. The following sampling methodology is adapted from Michalsky and Sissons (2006). The invasion of crested wheatgrass from source locations into vulnerable natural communities is complex. Two types of spread must be monitored: 1) the spread of crested wheatgrass source locations through wind and runoff disseminated seed which is limited to a few meters of the invasion front, and 2) satellite plants which are primarily a result of seed disseminated great distances by animals and have the potential to source new invasive populations. A series of three transects will be established at a permanently marked central point located inside the invasion front (Figure 10). The direction of the transects will be selected randomly between 0 and 190 degrees based on the prevailing wind direction (west). Transects will be permanent allowing surveyors to measure the advance of the source populations as well as tracking the number and growth of satellite populations.

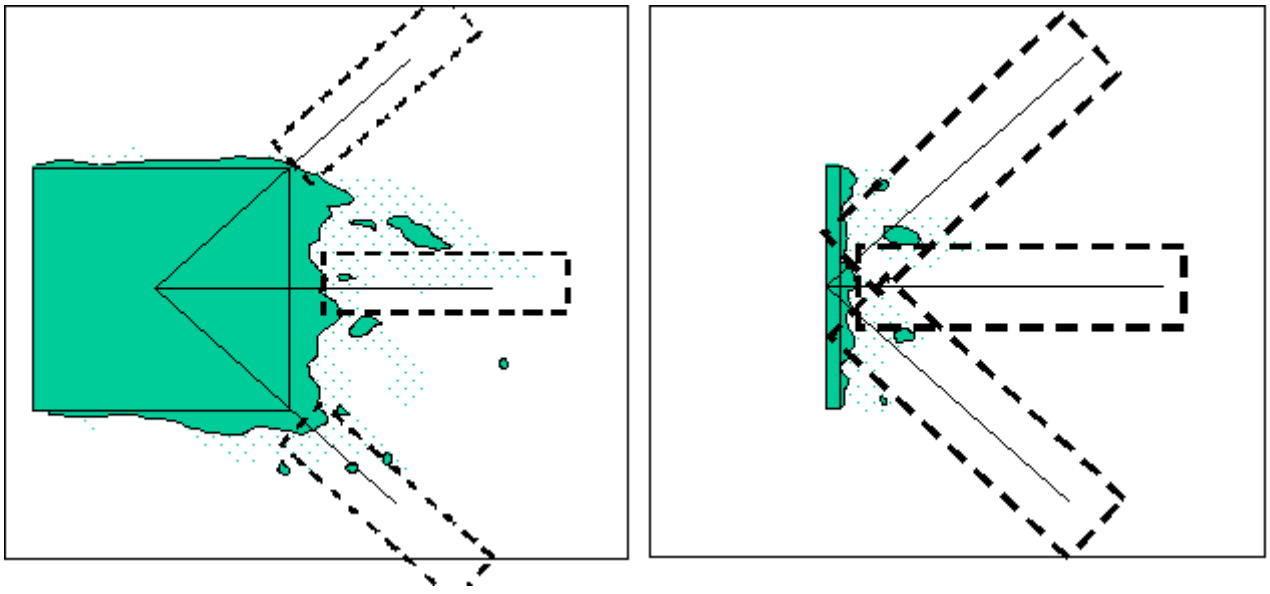


Figure 10. Example layout of crested wheatgrass monitoring transects adjacent to field or roadside (Adapted from Michalsky and Sissons 2006).

Transects will begin at the permanently marked point and run for up to 2 km in the randomly chosen direction (Figure 10). A common method to survey for satellite populations is to determine the distance between the most distant satellite and the main infestation and then search twice that distance from the main infestation (Tim Prather, pers. comm.). Two km is roughly twice the maximum dispersal distance measured by Darcy Henderson (pers. comm.) on native rangelands in southern Alberta. However, it is recognized that pastures on ACHDA may not be large enough to accommodate a 2 km transect.

Using a GPS, the monitoring technician moves along the transect recording patches of crested wheatgrass that are visible within a certain distance from the transect. The perpendicular distance from the transect will need to be determined during the initial transect layout and satellite crested wheatgrass plants should be readily visible from the transect. A maximum distance would be approximately 20 m on each side of the transect. The surveyor identifies only satellite populations outside the invasion front of the source population. The centre point of each patch is located using the GPS, size estimated or measured using the GPS if greater than 1 square meter, density estimated and the perpendicular distance from the transect recorded.

Transects should be remeasured every three to five years in June or early July and rate of spread calculated.

This methodology can be applied to Canada thistle and hoary cress. Transect length would be much shorter (i.e., 300-500 m) than crested wheatgrass transects. Kentucky bluegrass invasion can be monitored in association with the four range exclosures on ACHDA. Existing sampling protocols for measuring species composition can be used and transects should be measured both inside and outside exclosures. Historic data from exclosures can give an estimate of the rate of spread of Kentucky bluegrass in the absence of grazing.

6.3 Assessing Effectiveness of Control or Restoration Efforts

New Invasions: If new invasions are detected and controlled through hand pulling or herbicide application, the location should be recorded using a GPS. The location should be checked the following year in June or early July to assess whether the species is resprouting or germinating. Continue removal of any new plants. Locations should be checked annually for 5 years to ensure no new plants have sprouted. Depending on the species attributes (e.g., seed viability, ability to resprout from rhizomes etc.) or the number of sequential years that new seedlings are detected a longer period of monitoring may be necessary.

Established Invasions: Once infestations are selected for control activities, at least two monitoring points should be chosen and permanently marked. One point should be placed well within the source population and the other on an expanding edge. At each point, record the following measurements:

- Stage of growth

- Percent cover
- Density of stems/m^2
- # of seeheads/m^2
- Percent bare ground
- Percent cover by species of re-establishing native plants

A photo should be taken at each point. Record the direction of the photo and include a landmark such as a fence post or tree as well as something marking the monitoring point for vertical scale. The monitoring point should be established and measurements taken prior to treatment and again following treatment on an annual basis. After treatment monitoring should be done at the same stage of growth every year.

This methodology can be applied to all species treated with herbicides, mechanical control or hand pulling. It can also be applied to grazing treatments in most situations. However, in the case of grazing treatments for crested wheatgrass, it is recommended that a set of transects as described in section 4.2 also be established and measured at the same frequency as transects measuring rates of invasion on uncontrolled crested wheatgrass infestations.

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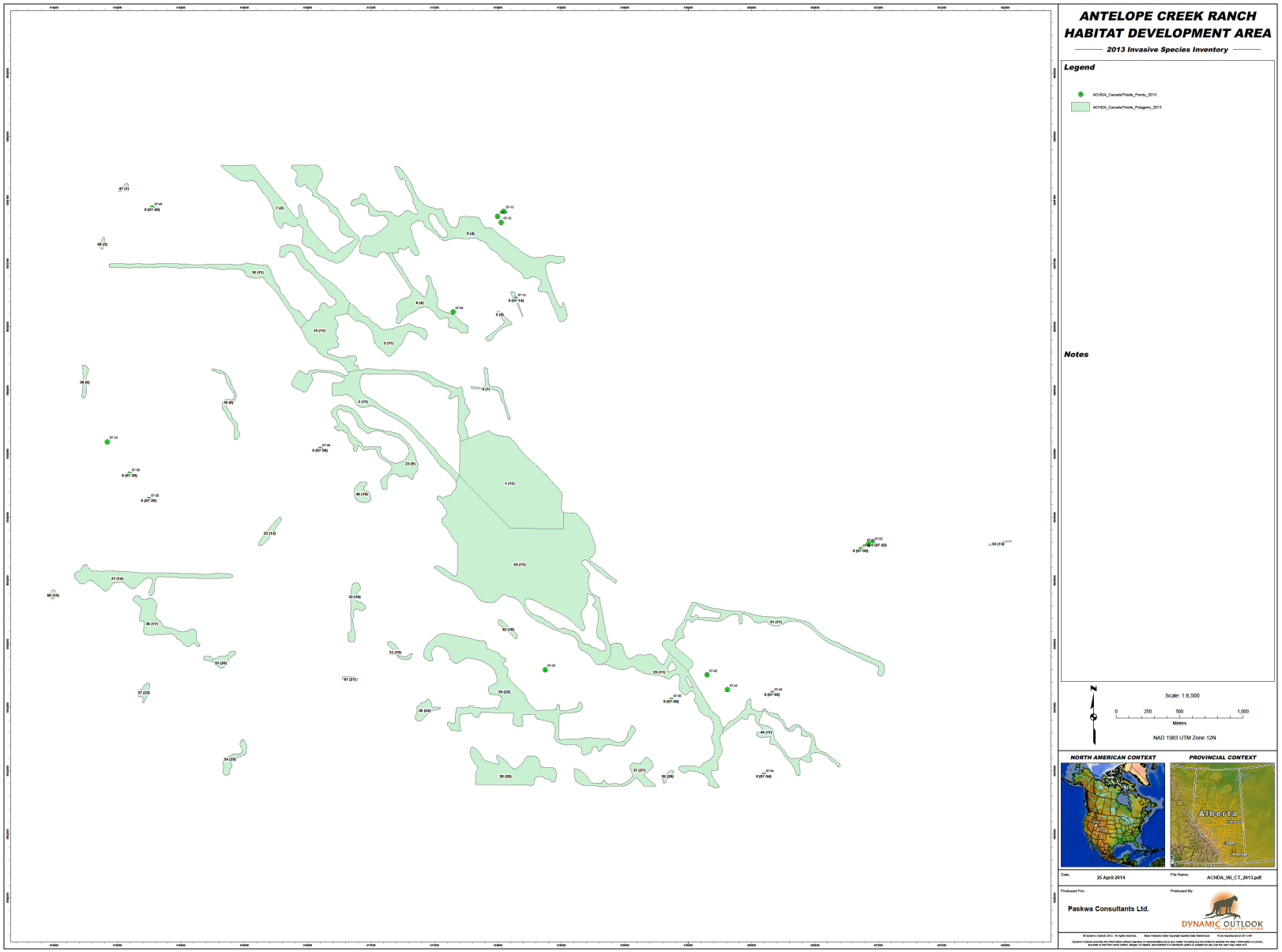
Appendix 1. Canada Thistle Analysis Maps


ANTELOPE CREEK RANCH
HABITAT DEVELOPMENT AREA
2013 Invasive Species Inventory
Legend
ACHDA_CanadaThistle_Points_2013
ACHDA_CanadaThistle_Polygons_2013
Notes
Scale: 1:8,500
0
250
500
1,000
Meters
NAD 1983 UTM Zone 12N
NORTH AMERICAN CONTEXT
PROVINCIAL CONTEXT
Alberta
Date:
25 April 2014
File Name:
ACHDA_ISI_CT_2013.pdf
Produced For:
Paskwa Consultants Ltd.
Produced By:
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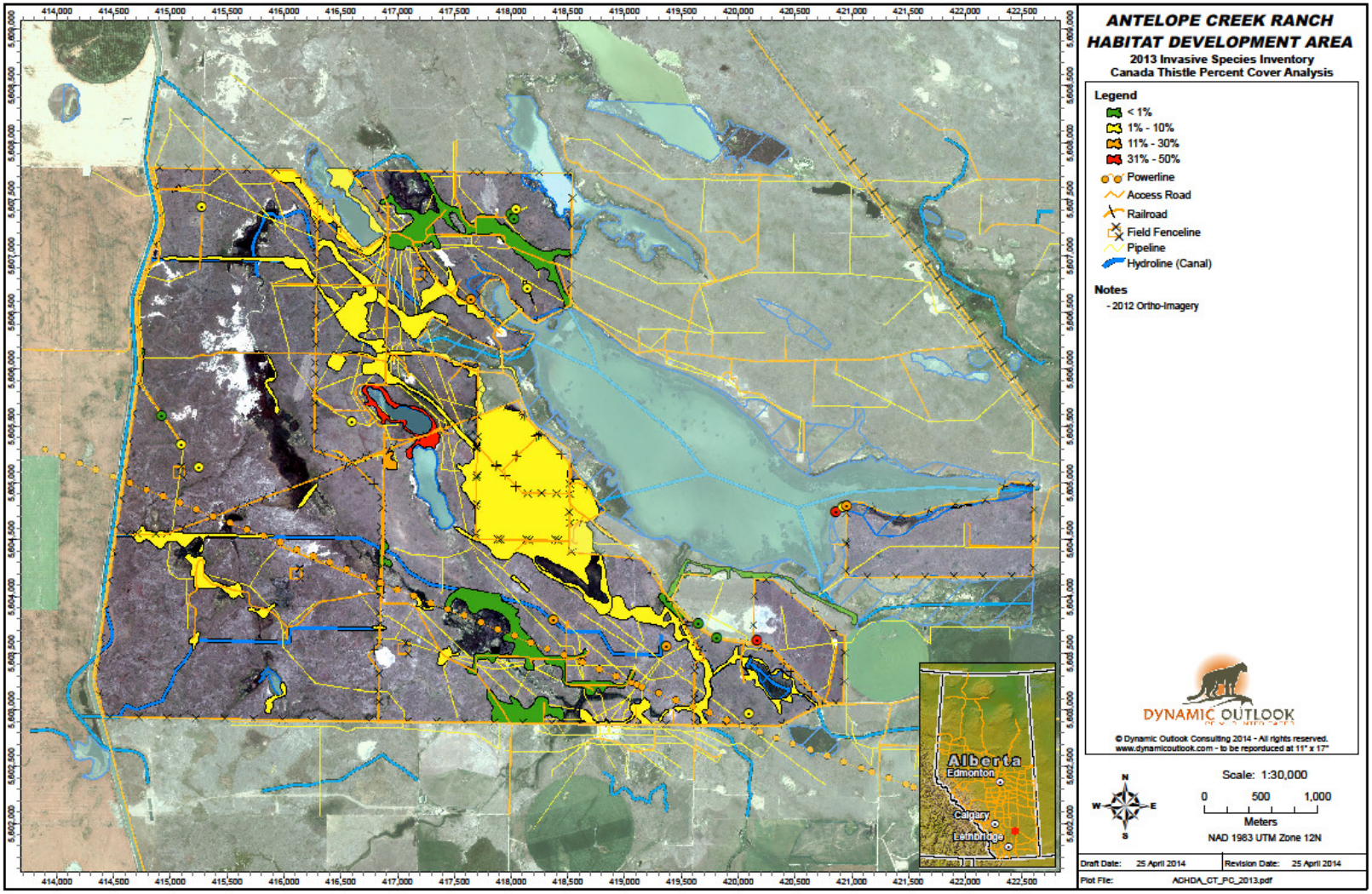
ANTELOPE CREEK RANCH
HABITAT DEVELOPMENT AREA
2013 Invasive Species Inventory
Canada Thistle Percent Cover Analysis
Legend
< 1%
1% - 10%
11% - 30%
31% - 50%
Powerline
Access Road
Railroad
Field Fenceline
Pipeline
Hydroline (Canal)
Notes
- 2012 Ortho-Imagery
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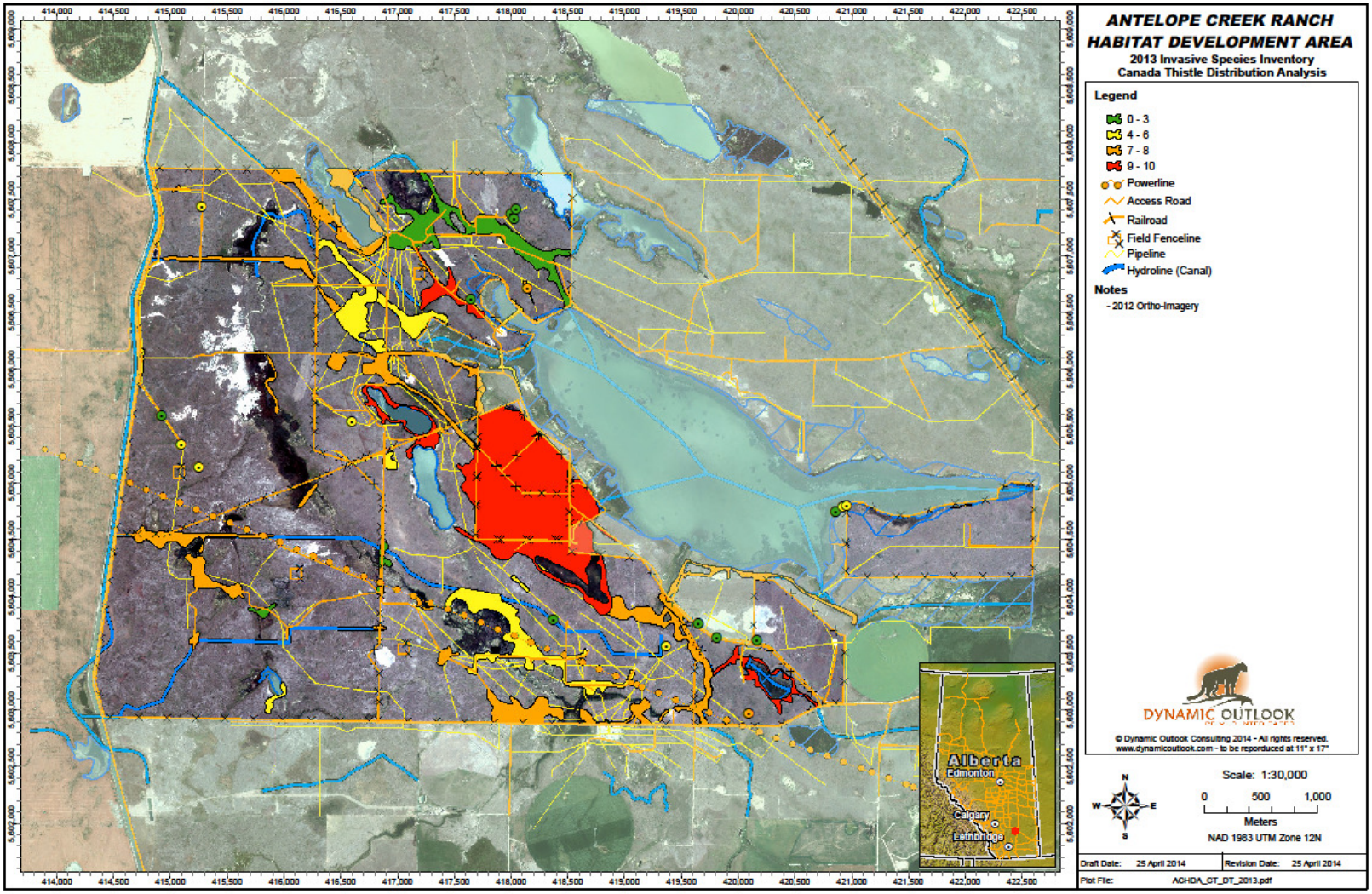
Alberta
Edmonton
Calgary
Lethbridge
N
W
E
S
Scale: 1:30,000
0
500
1,000
Meters
NAD 1983 UTM Zone 12N
Draft Date: 25 April 2014
Revision Date: 25 April 2014
Plot File: ACHDA_CT_PC_2013.pdf


ANTELOPE CREEK RANCH
HABITAT DEVELOPMENT AREA
2013 Invasive Species Inventory
Canada Thistle Distribution Analysis
Legend
0 - 3
4 - 6
7 - 8
9 - 10
Powerline
Access Road
Railroad
Field Fenceline
Pipeline
Hydroline (Canal)
Notes
- 2012 Ortho-Imagery
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Alberta
Edmonton
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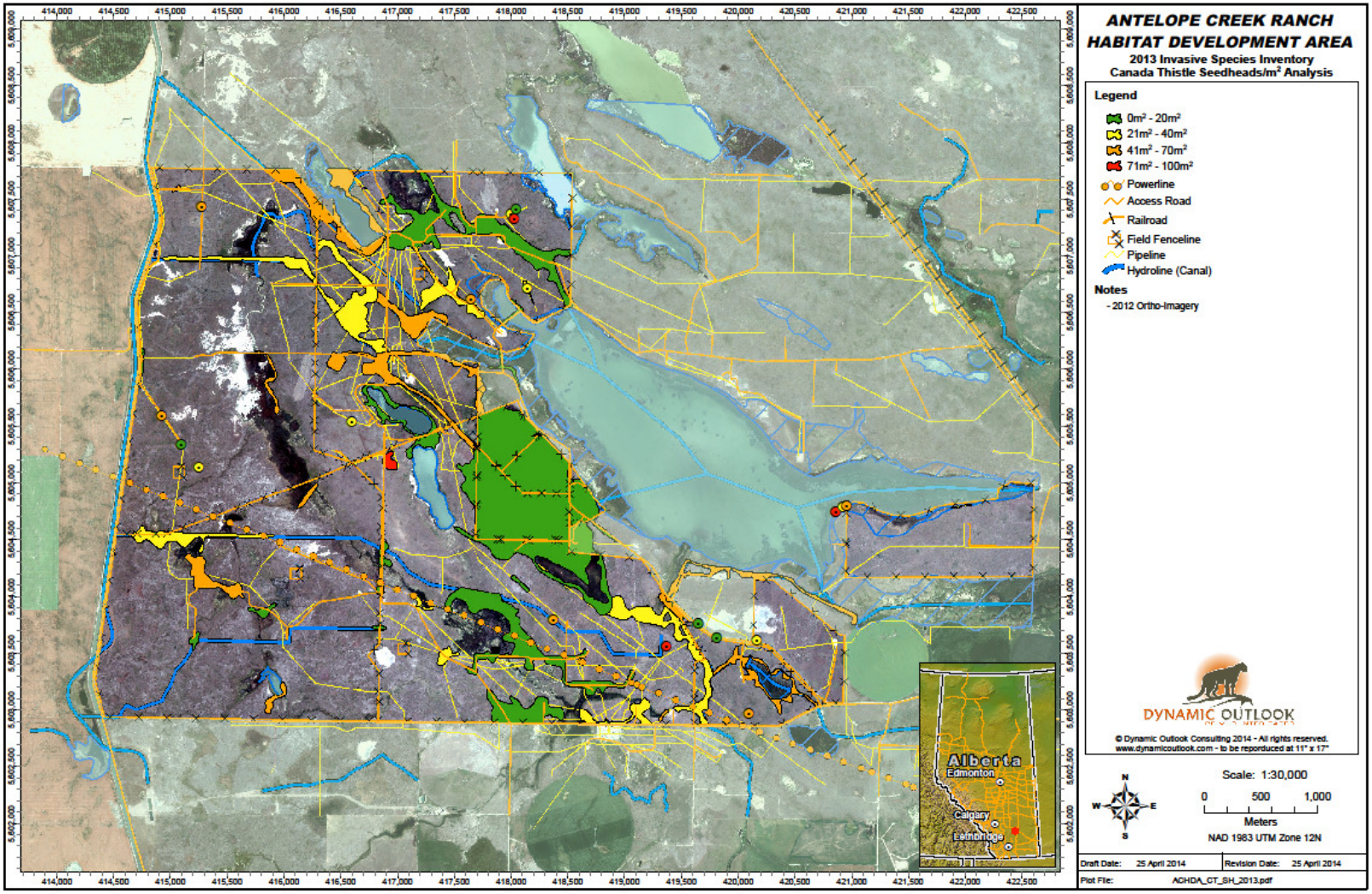
Scale: 1:30,000
0
500
1,000
Meters
NAD 1983 UTM Zone 12N
Draft Date: 25 April 2014
Revision Date: 25 April 2014
Plot File: ACHDA_CT_DT_2013.pdf


ANTELOPE CREEK RANCH
HABITAT DEVELOPMENT AREA
2013 Invasive Species Inventory
Canada Thistle Seedheads/m² Analysis
Legend
0m² - 20m²
21m² - 40m²
41m² - 70m²
71m² - 100m²
Powerline
Access Road
Railroad
Field Fenceline
Pipeline
Hydroline (Canal)
Notes
- 2012 Ortho-Imagery
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Meters
NAD 1983 UTM Zone 12N
Draft Date: 25 April 2014
Revision Date: 25 April 2014
Plot File: ACHDA_CT_SH_2013.pdf