University of Alberta

Prairie Plant Species At Risk In Southern Alberta:
Identification Of Critical Habitat At The Microsite Level
For *Halimolobos Virgata* (Nutt.) O.E. Schulz
And
Determination Of Set Back Distance Between Pipeline Disturbance
And *Halimolobos Virgata* And *Cryptantha Minima* Rydb.

by

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ABSTRACT

Little is known about the effect disturbances such as pipelines can have on prairie plant species at risk and their critical habitat in Alberta. *Halimolobos virgata* appears to be a ruderal, disturbance evolved species that occupies a unique rim niche. This habitat around the rim of depressional areas is slightly compacted with high bare ground, low litter, lower surrounding vegetation height and slightly different soil chemical properties compared to random, typical prairie environments. A pipeline changes the environment up to 25 m from the pipeline right of way edge with increases in soil compaction, bare ground and non native plant species richness and decreases in litter cover. This distance is recommended as a set back for *Cryptantha minima*. *Halimolobos virgata* can recolonize a pipeline right of way under certain pipeline construction conditions, thus a set back distance is not required provided construction is under these specified conditions.

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A DESERT TRAGEDY

By Eugene E. White

Once, in the heat of a desert sun,
I searched about one day
For a peaceful place with a bit of shade,
Just to while the time away.
But shade ain't easy to find right off
Out on the desert floor;
Though, finally, I did -- I found a spot
Just like I was lookin' for.
It was beneath a rocky overhang
Where a lonely willow grew,
Whose shade I shared with clumps of grass...
And with a daisy, too.
It was quiet there and the air was still
And my thoughts ranged far and wide;
There with my head propped up a bit
And the daisy at my side.
With eyes half closed I was nearly asleep
When a voice began to call;
The faintest voice I have ever heard,
If there'd been one at all.
Yes! There it was! I heard it again,
For now I was awake;
A voice that sounded to my ear
As though its heart would break.
And somehow, I knew; the daisy, of course,
And whispering even now.
It was her tearful voice I heard
Just inches from my brow.
Well, needless to say, I was caught off guard
And just a bit in shock,
For, after all, I never knew
A flower could even talk.
Still, through the tears, I heard her explain
How she was so alone,
And the delicate beauty that was hers to share
Was soon to go unknown.
Except for you, the flower said,
I've simply gone to waste,
And that's just not the kind of thing
A flower wants to face.
Her voice soon grew too faint to hear;
Her time, I knew, had come;
And by the dawn there'd be nothing more
Than the sand and desert sun.
Yet to this day I still recall
With the greatest heartfelt sigh,
The day I met and lost a friend,
And heard a daisy cry.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I. ANTHROPOGENIC DISTURBANCES AND PLANT SPECIES AT RISK

1. BACKGROUND

1.1 Native Grassland Pressures

After cradling human needs for centuries, indigenous temperate grasslands are now considered the most altered terrestrial ecosystem on the planet and the most endangered ecosystem on most continents (International Union for Conservation of Nature 2011, Henwood 2010). The Canadian prairie is one of the most intensively developed landscapes in the world (Alberta Environmental Protection 1997, Coupland 1973), with losses through cultivation, roads, urbanization and other anthropogenic disturbances estimated at 70% (Alberta Environmental Protection 1997, Weins 1996, Samson and Knopf 1994, Diamond 1993, Coupland 1973). Remaining native grassland is approximately 43% in Alberta and less than 20% in Saskatchewan and Manitoba (Nernberg and Ingstrup 2005, Alberta Environmental Protection 1997) (Figures 1-1, 1-2).

In spite of this loss, less than 1.5% of temperate grasslands in the Northern Great Plains are managed for biodiversity conservation (Forrest et al. 2004). Most function as rangelands, providing energy, forage, consumable products for all life forms, site stability, capture and beneficial release of water, nutrient cycling and maintenance of plant species diversity (Adams et al. 2005). These functions, combined with structure, contribute to the ecological integrity of the landscape.

Pressures contributing to loss of the remaining native prairie include agriculture and cultivation, urban expansion, petroleum and natural gas development and transportation and access development (Diamond 1993, Trottier 1992). While a major contributing factor to reduction of native grasslands has been conversion to cultivated land, linear development has further fragmented the few remaining tracts. Oil and gas exploration, pipelines, utility corridors, roads and highways all pass across natural grasslands (Bailey et al. 2010). The Grassland Natural Region in Alberta contains over 75,000 well sites, 45,000 km of access roads and 3,000 km of pipelines (Sinton and Pitchford 2002). Habitat fragmentation is recognized as a serious threat to biological diversity and a problem of global proportion (Alberta Environmental Protection 1997, Wickett et al. 1992, Wilcox and Murphy 1985). Anthropogenic disturbances can change ecosystem structure, function and composition beyond the range of natural variability which can result in enrichment or destruction of a species or habitat.

1.2 Species Losses

Anthropogenic activities have had an unprecedented effect on the natural world, causing extinction rates to rise by three to four orders of magnitude (Venter et al. 2006, May and Tregonning 1998, Pimm et al. 1995). Of the threats to species at risk in Canada, habitat loss is most prevalent, affecting 84% of species, followed by over exploitation (32%), native species interactions (31%), natural causes (27%), pollution (26%) and introduced species (22%) (Venter et al. 2006). More than one threat can affect a species at a given time complicating recovery efforts.

Transformation of landscapes is considered a major driver behind species loss (Lingborg and Eriksson 2004). In the North American Great Plains, 464 species of concern (half plants) have been identified and of those 70.5% are endemic or nearly endemic to the region (Alberta Environmental Protection 1997, Ostlie et al. 1996). Existence of those 464 species therefore depends on their survival in the Great Plains (Alberta Environmental Protection 1997). Threatened or endangered species within the Great Plains are often associated with special landscape features such as wetlands, rivers and sand hills (Sieg et al. 1999).

In Canada, there are 602 species in various species at risk categories as defined by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2010a) (Tables 1-1, 1-2). As of October 2010, 13 wildlife species have become extinct (COSEWIC 2010a) (Table 1-3). Of the 324 rare vascular plant species, approximately 25% are prairie species (Alberta Environmental Protection 1997, Bradley and Wallis 1996, Argus and Pryer 1990, Packer and Bradley 1984).

1.3 Plant Species at Risk

According to Schedule 1 of the Species at Risk Act, eight vascular plant species are at risk in Alberta (excluding species of special concern) (Government of

Canada 2011). They are *Halimolobos virgata* (Nutt.) O.E. Schulz (slender mouse ear cress), *Yucca glauca* Nutt. (soapweed), *Cryptantha minima* Rydb. (tiny cryptanthe), *Iris missouriensis* Nutt. (western blue flag), *Tripterocalyx micranthus* (Torr.) Hook. (small flowered sand verbena), *Tradescantia occidentalis* (Britt.) Smyth (western spiderwort), *Isoetes bolanderi* Engelm. (Bolander's quillwort) and *Chenopodium subglabrum* (S. Wats.) A. Nels. (smooth goosefoot). All except *Isoetes bolanderi* and *Iris missouriensis* occur in the Dry Mixedgrass Subregion (Alberta Environmental Protection 1997).

The Canadian Species at Risk Act (SARA) protects individual species and their critical habitat. An individual is defined as a wildlife species, living or dead, at any stage of development and includes larvae, embryos, eggs, sperm, seeds, pollen, spores and asexual propagules (Canada Department of Justice 2002). Critical habitat is necessary for survival or recovery of a listed species and is identified in its recovery strategy or action plan. Destruction of critical habitat is any alteration that adversely modifies biological, chemical or physical features (topography, geology, soil, air, vegetation, hydrology, microclimate) to the extent that critical habitat no longer exists or cannot be used, preventing or reducing its capacity to contribute to survival or recovery (Environment Canada 2009). Destruction of critical habitat occurs if part of it is temporarily or permanently degraded, and can not serve its function needed by specific species (Government of Canada 2010).

Conservation data centers use the same criteria to determine rarity, so status can be assessed at subnational, national and global levels (Kershaw et al. 2001). The Nature Conservancy Element Ranks system uses a number or letter preceded by G for global, N for national and S for subnational (provincial or state) rank. When information on genetics and propagule dispersal is lacking, element occurrences or subpopulations are defined as separate populations when they are at least 1 km apart and intervening habitat is unsuitable, and at least 3 km apart when intervening habitat is suitable (Alberta Sustainable Resource Development and Alberta Conservation Association 2009, NatureServe 2004). In instances with limited information on critical habitat requirements, professional judgement may be used with the best available knowledge at the time.

Conservation of rare plant populations is important to biodiversity (Bevill and Louda 1999). Biodiversity can be on various levels including ecological, species and/or genetic. On an ecological level, no species lives in isolation. There are many complex interrelationships, some might be known while others may be poorly understood. On a species level, rare species are often an indicator of ecosystem health or may one day contribute to pharmaceuticals (which may be increasingly important as the global human population grows). On a genetic level, many rare species are edge of range and genetically may be a bit different (Goff 1982) and more adaptable to changing environments (which will be critical with global warming). Small, remnant populations may retain a larger than expected heterozygosity and adaptability (Lesica and Allendorf 1992). So whether ones' value system is ecological, economical or ethical, rare plant species are important. Threats to conservation of rare plants include direct mortality and fragmentation and/or destruction of critical habitat from land use. Maintaining native plant diversity, detecting exotic species and monitoring rare species are thus important in prairie conservation (Stohlgren et al. 1998).

1.3.1 *Cryptantha minima* Rydb.

Cryptantha minima Rydb. is native to North America (Environment Canada 2006). COSEWIC designated it endangered in 1998 and confirmed that status in 2000. Alberta Conservation Information Management System (ACIMS) (formerly ANHIC) and the province of Saskatchewan rank it critically imperilled (S1) (Saskatchewan Government 2011, Kemper 2009, Environment Canada 2006). Nationally *Cryptantha minima* is ranked extremely rare with five or fewer occurrences or few remaining individuals (N1) (Environment Canada 2006, Vujnovic and Gould 2002). In the United States, it is ranked vulnerable (S3) in Wyoming and apparently secure (S4) in South Dakota. Remaining states have not ranked it or are reviewing its status (NatureServe 2010a, Environment Canada 2006). Globally, it is ranked demonstratively secure (G5).

Cryptantha minima is found in Alberta and Saskatchewan in Canada (Figure 1-3), and in Colorado, Kansas, Montana, Nebraska, New Mexico, Oklahoma, Wyoming, Texas and South Dakota in the United States (NatureServe 2010a, Environment Canada 2006). There are 28 known populations in Alberta and four in Saskatchewan. Most occur along the South Saskatchewan River near the Alberta-Saskatchewan border. It has also been found near the lower Bow and upper Oldman rivers in Alberta and the Red Deer River in Saskatchewan.

Cryptantha minima is a small, bristly looking annual in the *Boraginaceae* family, commonly called small cryptanthe and cat's eye (Environment Canada 2006, Moss 1994). It has minuscule tube shaped flowers with white petals and yellow centers, along the top side of the branches. At the base of each flower is a small leaf or bract. Flowers are up to 2 mm across and 3 mm long. Green sepals with whitish midribs surround flower petals forming a calyx. Stems are branched near the base and grow 10 to 20 cm tall. Leaves are spatula shaped, up to 6 cm long, 0.5 cm wide at the base and generally get smaller as they proceed up the stem.

Cryptantha minima flowers late May to early July (Environment Canada 2006, Alberta Sustainable Resource Development 2004, Kershaw et al. 2001, Smith 1997). Most of its life cycle is as dormant seed. How long seeds remain viable or what proportion of seeds produced reside in the seed bank are unknown. Continued existence of populations is reliant on the seed bank, as annuals often depend on seed longevity to buffer environmental unpredictability. Seed dispersal is passive with seeds falling close to parent plants or carried on animal fur via calyx bristles. Most seeds move a few meters, beyond 100 m is rare (Environment Canada 2006, Cain et al. 2000, Primack and Miao 1992, Harper 1977). Annual plant number varies depending on amount and time of rainfall, past seed production and germination conditions.

Wei et al. (2009) suggested *Cryptantha minima* is regulated by a unique temperature requirement. They found seeds had base temperatures of -3.9 ^{o}C for germination with highest germination near freezing. Germination was sensitive to water potential below 20% at -0.5 MPa. Small seeds had higher germination than large seeds at the same temperature and water potential suggesting greater dormancy. Large seeds initiated germination at lower temperatures across water potentials, a possible advantage under cooler snow melt conditions (Wei et al. 2009, Vaughton and Ramsey 1998). Smaller seeds likely take advantage of prolonged rainfall during cool weather over late spring and throughout summer. These regeneration strategies may complement each other in maintaining long term site persistence despite annual plant density fluctuations.

Cryptantha minima usually occurs within a few km of river systems (Environment Canada 2006, Alberta Sustainable Resource Development 2004). Macro habitat is sandy, level to rolling uplands, sand dunes near valley breaks, valley slopes up to 50% and level or gently sloping terraces in valley bottoms, particularly meander lobes. Microhabitat is xeric to subxeric on < 20 degree slopes of south to east aspects. It occurs with low litter and > 10% bare soil. Associated plant communities are dominated by *Stipa comata* Trin. & Rupr. (needle and thread grass) and *Bouteloua gracilis* (Willd. ex Kunth) Lag. ex Griffiths (blue grama grass). Associated species are *Opuntia polyacantha* Haw (prickly pear cactus), *Plantago patagonica* Jacq. (pursh's plantain), *Chenopodium pratericola* Rydb. (goosefoot), *Artemisia frigida* Willd. (pasture sage), *Carex filifolia* Nutt. (thread leaved sedge), *Carex stenophylla* Wahlenb. (low sedge), *Lepidium densiflorum* Schrad. (pepper grass), *Oryzopsis hymenoides* Roemer & J.A. Schultes (indian rice grass), *Poa juncifolia* Scribn. (alkali blue grass) and two non natives, *Salsola kali* L. (russian thistle) and *Lappula squarrosa* (Retz.) Dumort. (blue bur).

Cryptantha minima appears to require periodic disturbance (Environment Canada 2006). Its habitats are characterized by occasional natural disturbance including deposition from water (terraces in meander lobes), wind (sandy, upland plains, dunes), gravity (valley and upland slopes) and animals that create bare soil patches. Repeated intense disturbances such as active sand bars, cultivation and actively eroding slopes and cut banks do not appear to support it (Environment Canada 2006, Alberta Sustainable Resource Development 2004).

Cryptantha minima is threatened primarily by habitat alteration including land use such as cultivation and urban development, grazing reduction or loss, fire control, invasive vegetation encroachment, oil and gas activities, sand and gravel removal and military activities (Environment Canada 2006). Habitat destruction occurs with soil compression, covering, inversion, excavation or extraction (pipeline construction); hydrologic regime alteration (berms, roads), fertilizer or pesticide application (affecting competition interactions and/or pollinators), spreading liquid wastes (manure, septic tank fluids, drilling mud) and deliberate introduction or promotion of non native species (driving vehicles, spreading bales contaminated with seeds and/or propagules) (Government of Canada 2010).

1.3.2 *Halimolobos virgata* (Nutt.) O.E. Schulz

Halimolobos virgata (Nutt.) O.E. Schulz is native to North America (Environment Canada 2010a). Originally named *Sisymbrium virgatum* (Nutt. Ex. Torrey & A.

Gray) in 1838, *Halimolobos virgata* was renamed *Halimolobos virgata* (Nutt.) O.E. Schulz in 1924 (Alberta Sustainable Resource Development and Alberta Conservation Association 2009). Most recently, with DNA sequencing, it has been classified by some taxonomists as *Transberingia virgata* (Nutt.) N.H. Holmgren and by others as *Transberingia bursifolia* subsp. *virgata* (Nutt.). In this study, it will be referred to as *Halimolobos virgata* (Nutt.) O.E. Schulz. according to the most recent recovery strategy (Environment Canada 2010a).

COSEWIC designated *Halimolobos virgata* endangered in 1992 and threatened in 2000 (COSEWIC 2010b, Alberta Sustainable Resource Development and Alberta Conservation Association 2009). Reassessment was due to new information on locations (Environment Canada 2010a, COSEWIC 2000, Smith 1992). In 2005, the Alberta Endangered Species Conservation Committee recommended its status be data deficient. ACIMS ranks *Halimolobos virgata* as critically imperilled to imperilled (S1S2) (Environment Canada 2010a, Kemper 2009). In Saskatchewan, *Halimolobos virgata* is listed as critically imperilled (S1) and threatened under the Saskatchewan Wildlife Act (Saskatchewan Government 2011, Environment Canada 2010a). Nationally, it is listed as imperilled (N2) and globally as apparently secure (G4) (Environment Canada 2010a, NatureServe 2010b). In the United States, it has a national status of vulnerable (N3) (Environment Canada 2010a) (Table 1-4).

Halimolobos virgata is found in mixedgrass prairie in southeastern Alberta and southwestern Saskatchewan (Figure 1-4) and in the Sweetgrass Hills of Montana (Alberta Sustainable Resource Development and Alberta Conservation Association 2009). It is distributed across semiarid mountain ranges and basins of seven states from eastern California and central Colorado to southwest Montana and northwest Wyoming. It is the only species of the genus *Halimolobos* in Alberta (Alberta Sustainable Resource Development 2005). The only other subspecies of *Transberingia* in Canada occurs north of the Arctic Circle. In Alberta, there are 14 populations believed to be extant (still in existence) (Environment Canada 2010a). Two of these have insufficient information to relocate; three are more than 25 years old and not recently relocated. In Saskatchewan there are 17 populations believed to be extant. Two do not have enough information to be relocated and five are historic. Most of the known locations for *Halimolobos virgata* occur on gently rolling prairies with some in valleys of the South Saskatchewan and Red Deer Rivers (Alberta Sustainable Resource Development 2005). Plants typically grow along low depressions or at the base of slopes and low sand dune edges (Environment Canada 2010a).

Halimolobos virgata is an annual or biennial of the Family *Brassicaceae* (Environment Canada 2010a, Alberta Sustainable Resource Development and Alberta Conservation Association 2009, Alberta Sustainable Resource Development 2005, Moss 1994, Smith 1992, Looman and Best 1979, Harper 1977). Plants are tap rooted and vary from tall, multi branched robust plants to thin, single stems. Stems are 15 to 40 cm tall, simple or branched and pubescent with a mix of long, straight, simple or forked hairs and short, branched hairs. Basal rosette leaves are toothed with stalks (petioles); leaves are clasping with ear like lobes at the base. The leaves get smaller towards the top of the plant. Flowers have four whitish petals, 4 to 8 mm across. Fruit pods (siliques) grow up to 4 cm long and 1 mm wide, enclosing 16 to 26 seeds. Pods are circular, slightly compressed, generally hairless and erect and stalks usually form a 45 degree angle with the stem. When pods ripen, they turn reddish brown. Seeds are held to the dry silique by a thin stalk and readily pull away from the septum.

Flowering occurs late May to early June; fruit pods form in June to July and split open before mid July (Environment Canada 2010a, Alberta Sustainable Resource Development and Alberta Conservation Association 2009, Alberta Sustainable Resource Development 2005, Moss 1994, Smith 1992, Looman and Best 1979, Harper 1977). Although wind shakes the stalks to release seeds, seeds are wingless, limiting dispersal distance. Like most biennial and annual species, it may not disperse to new sites quickly but seeds can remain viable for years until conditions become suitable for germination. Biennials of this nature often produce large numbers of seeds after a local disturbance or unusual climate event. There is no information on seed germination or seedling survival.

Halimolobos virgata macrohabitat includes lightly disturbed mixed grass prairie, mixed grasslands on sand plains and open sage thickets of river slopes and basins (Environment Canada 2010a, Alberta Sustainable Resource Development 2005). Soils are usually sand to sandy loam textured. Habitats include subxeric (moderately dry) to occasionally xeric (very dry) flat to very gently undulating sand plains, dry to vernally moist (in spring) low depressions with level to >5% slopes or submesic (moderately moist) 3 to 8% north facing slopes. Associated species are *Koeleria macranthra* (Ledeb.) J.A. Schultes f. (june grass), *Stipa comata* Trin. & Rupr (needle and thread grass), *Stipa curtiseta* Hitchc. (western porcupine grass), *Agropyron trachycaulum* (Link) Gould ex Shinners (slender wheat grass), *Agropyron smithii* (Rydb.) A. Löve (western wheat grass), *Carex stenophylla*, *Chenopodium pratericola* Rydb. (desert goosefoot) *Arabis holboellii* var. *retrofacta* Hornem. (reflexed rock cress) and *Draba reptans* (Lam.) Fernald (whitlow grass). *Halimolobos virgata* also occurs in low, shrubby prairie thickets of *Artemisia cana* Pursh. (silver sage bush) and *Opuntia polyacantha*.

Halimolobos virgata appears to withstand or require disturbance. Most known locations in Alberta have had light grazing (Environment Canada 2010a, Alberta Sustainable Resource Development 2005). In Wyoming it is classed as an increaser, prospering under grazing. Disturbance that exposes sand and creates depressions may facilitate seedling establishment. Plants are often in close proximity to *Artemisia cana* or stout succulents such as *Opuntia polyacantha* (Alberta Sustainable Resource Development and Alberta Conservation Association 2009, Alberta Sustainable Resource Development 2005, Smith 1992). This may provide protective cover and snow deposits in the lee of mounds that provide soil water early in the growing season and late autumn. Number of plants fluctuate substantially from year to year and may be linked to weather conditions that affect seed germination and production and plant growth.

Threats to *Halimolobos virgata* include cultivation, oil and gas activities, alteration of grazing and/or fire regime, alteration to the hydrologic regime, invasive alien plant species, sand and gravel extraction, urban development, military activities and drought or other climate change (Environment Canada 2010a). A subpopulation in Alberta was extirpated as a result of municipal development (Alberta Sustainable Resource Development and Alberta Conservation Association 2009). Habitat for eight subpopulations has been altered by oil and gas development including pipelines, although detailed effects have not been documented. As development steadily increases, invasion of suitable habitat by non native species such as *Agropyron cristatum* (L.) Gaertn (crested wheat grass) becomes more likely.

1.4 Plant Species at Risk and Disturbance

Conserving threatened and endangered species requires understanding habitat, environment, demographic and genetic effects on long term species viability (Root 1998). Habitat loss and modification are the main causes of threatened and endangered species (Wu and Smeins 2000, Foin et al. 1998). For rare and declining species, extinction is usually the consequence of local habitat becoming unsuitable through environmental stochastic events or anthropogenic landscape changes (Thomas 1994). These discrete events in time are disturbances which may disrupt ecosystem, community or population structure and change resources, substrate availability or physical environment (Larson 2003).

Disturbance can affect plant community structure and function (Hobbs and Huenneke 1992). Natural disturbances can be a source of mortality and/or a source of establishment for plants (Denslow 1980). In some sand plain forests and shrub lands, disturbances are necessary for creating rare plant habitat. In one study, therophytes (annuals) were the only life form responding positively to soil disturbance although proportions of flat rosettes increased significantly (McIntyre et al. 1995). Rare plants on coastal New England sand plains were restricted to anthropogenically disturbed sites including plowed and mowed fire lines (Clarke and Patterson 2007). In other studies native and rare species richness declined with increasing parent material fertility, water enrichment, livestock grazing and soil disturbance (McIntyre and Lavorel 1994). Rare species richness was lower on low slopes, possibly reflecting a fertility gradient.

Loss of habitats with high conservation value and removal of disturbances necessary for their maintenance are challenges to biodiversity maintenance. Combined with limited information on rare plant biology and ecology, research is essential for their protection (Wu and Smeins 2000, Wiser et al. 1998, Smith et al. 1997). Characterizing biotic interactions and habitat requirements is critical to a species conservation, protection and recovery (Schemske et al. 1994, Brussard 1991, Burgman et al. 1988, Simberloff 1988). Often limited information is available for plant species at risk, including biology, population demographics, reproductive ecology, genetic variability, habitat associations and disturbance effects on populations and identified habitat. This makes balancing protection and conservation of species at risk and industrial development extremely difficult.

1.5 Pipelines

Pipeline disturbances comprise the physical facility through which liquids (crude oil, petroleum products, water) or gases (natural gas, carbon dioxide) are transported including pipes, valves and other equipment attached to the pipe, compressor units, stations (pumping, metering, regulator, delivery), holders and fabricated assemblies (Canadian Energy Pipeline Association 2007). Canada has more than 700,000 km of buried pipelines that transport product from the oil or gas well head to industrial complexes and end use customers (Canadian Standards Association 2004). Types include flow and gathering, feeder and transmission, distribution, product and chemical pipelines. Environmental effects can occur at exploration, construction, operation and decommissioning stages.

Three major types of pipelines are used to transport hydrocarbons depending on product throughput (Canadian Energy Pipeline Association 2007). Approximately 421,300 m^3 (2.65 million barrels) of oil and 484 million m^3 (17.1 billion ft^3) of natural gas flow through Canada’s pipeline network daily. Small pipelines are 5 to 15 cm in diameter and connect well heads to central facilities (batteries). Medium pipelines up to 20 cm in diameter connect groups of batteries with local refineries or larger lines. Large pipelines can be up to 120 cm in diameter and feed provincial, national and international refineries. Degree of disturbance generally increases with pipe diameter due to more complex construction procedures.

1.5.1 Pipeline effects on soils and revegetation

A pipeline right of way (RoW) can be characterized by three general construction related areas: topsoil and subsoil storage area, trench and working (driving) area. The soil storage area is where excavated soil piles are temporarily stored; the trench is the excavation where the pipe is laid down and covered with soil; the work area is the travel lane for pipeline equipment and where sections of pipe are welded together prior to being laid down in the trench. Degree of disturbance depends on site characteristics and construction difficulties. The entire RoW or only the trench may be stripped of topsoil. Construction of a pipeline typically results in an initial disruption of soil properties and flora of an area (Kerr et al. 1993). Many changes caused by this disruption can persist with time (Naeth et al. 1987, Naeth 1985).