

# **Nova Scotia Provincial Status Report**

on

## **Rockrose (Canada Frostweed)**

*(Helianthemum canadense (L.) Michx.)*

prepared for

**Nova Scotia Species at Risk Working Group**

by

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## EXECUTIVE SUMMARY

### Species information

Rockrose is a perennial herb with few to many, ascending to erect stems usually less than .5 m tall. Stems are essentially unbranched at start of flowering period, later becoming much branched. Most parts of the plant are (false) stellate-pubescent. The simple, alternate, short-petiolate leaves are generally narrowly elliptic in shape. Plants produce two types of flowers: showy, yellow chasmogamous (open-pollinated) flowers and small, non-showy, cleistogamous (closed, self-fertilizing) flowers. The former are produced first in the growing season at the top of the main stems, the latter are produced later on branches and branchlets. Both flower types produce capsules which bear small numbers of papillose seeds.

### Distribution

In Nova Scotia, populations are concentrated within the three closely associated communities of Kingston, Greenwood and Green Acres, Kings County (in the Annapolis Valley) with but a single known population occurring outside of this area in Greenfield, Queens County. There is a historic record for Five Island Lake, Halifax County.

Within Canada, populations also occur in southern Quebec and in southern Ontario.

Globally, Rockrose is restricted to eastern North America.

### Habitat

In Nova Scotia, Rockrose is most often associated with the dry, sandy, *Corema* barrens (heathland) of the Annapolis Valley. Within this sand barren ecosystem, it is usually found in areas where there is limited competition from woody species. It can tolerate light shade but is otherwise shade intolerant. In Queens County, a small population occurs in small openings in pine woodland.

### Biology

Rockrose is an herbaceous perennial with a dual reproductive system. Chasmogamous (open-pollinated) flowers (in Nova Scotia) are produced from late June/early July to early August while cleistogamous (self-pollinated, closed flowers) flowers are produced from August to October. Both bees and bumblebees have been observed pollinating the showy, large, yellow chasmogamous flowers. Capsules of both chasmogamous and cleistogamous mature in 3-4 weeks. Seeds lack a specialized dispersal mechanism falling close to the parent plant. Seeds developing from chasmogamous flowers germinate readily whereas seeds from cleistogamous flowers

germinate poorly and may remain dormant in the seed bank until exposed to fire. Rockrose is drought tolerant, shade intolerant and fire/disturbance dependent.

### **Population sizes and trends**

Currently, there are seven known populations in Nova Scotia with an estimated total count of 5000-5500 mature individuals. Many populations are small and localized and may not be self-sustaining. Rockrose in one area of Kings County (Green Acres) has been observed to decline significantly over the last 30-40 years. Because of habitat loss over the last 50-100 years through agriculture, fire suppression, housing developments, etc., it is assumed that the overall trend for Rockrose populations is one of decline as well.

### **Limiting factors and threats**

Rockrose habitat in the Annapolis Valley has declined significantly within the last 50 - 100 years due to wild fire suppression, steadily increasing agriculture in the area, housing and commercial developments and the establishment of at least one aggressive invasive tree species i.e., Scots Pine (*Pinus sylvestris*). The extirpation of caribou in Nova Scotia has also been cited as having a negative impact on Rockrose populations. Browsing by caribou is thought to have been part of the natural disturbance regime which kept Rockrose habitats open by preventing the establishment of woody species.

### **Special significance of the species**

*Helianthemum canadense* is used medicinally as an astringent and tonic. Historically, it has been used to treat scrofula, diarrhea, dysentery and syphilis.

Many members of the Rockrose family are used in the horticulture industry.

### **Existing protection**

There is no current legal protection for *Helianthemum canadense* in Nova Scotia. Within the province, it is listed provincially as a Red species (i.e., a species known to be or thought to be at risk). Under the general status of species in Canada website, it is listed nationally as 3 (sensitive) and provincially as 2 (may be at risk). The largest known populations occurring in Nova Scotia are found at CFB Greenwood. The Base Environment Officer is aware of the presence of this species and has indicated a strong interest in protecting these populations.

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## SPECIES INFORMATION

### Name and classification

Scientific name:	<i>Helianthemum canadense</i> (L.) Michx.
Common names:	Rockrose, Canada Frostweed, Long-branch Frostweed, Longbranch Frostweed, Hélianthème du Canada, Frostweed, Frostwort, Frostplant, Sunrose
Synonyms:	<i>Lechea major</i> L., <i>Cistus canadensis</i> L., <i>Heteromeris canadensis</i> (L.) Spach, <i>Crocantemum canadense</i> (L.) Britt.; <i>Helianthemum canadense</i> var. <i>sabulonum</i> Fern.
Family:	Cistaceae
Order:	Violales
Class:	Dicotyledoneae

### Morphological description

Detailed technical descriptions are found in Gleason & Cronquist (1990), Fernald (1950) and Daoud & Wilbur (1965).

Rockrose is a perennial herb (Figures 1 & 2) ranging in height from (6)15 to 45(65) cm. Plants have few to many, ascending to erect stellate\*-pubescent stems. Stems are essentially unbranched at start of flowering, later becoming much-branched. The short-petiolate, alternate, simple leaves are elliptic-oblong to narrowly elliptic in shape and 18-30 mm long by 5-8 mm wide. The shiny upper leaf surface is thinly (sparsely) stellate-pubescent intermixed with simple, pilose hairs. The lower leaf surface is densely stellate-tomentose.

*Helianthemum canadense* produces two types of flowers, chasmogamous (open-pollinated flowers) and cleistogamous (small, self-fertilizing flowers that never open). The two types of flowers mature at different times in the growing season and occupy different positions on the plant. The chasmogamous flowers are yellow, short-lived, many-stamened and showy with five petals 8-15 mm long. The cleistogamous flowers are small, lack petals and have few stamens. The former number 1-2(5) per stem and appear first in the growing season (at the top of the primary stem). These are followed later in the season by the cleistogamous flowers which are relatively numerous and occur on the later developing branches and branchlets. The fruit of the chasmogamous flowers ranges from 6-7 mm and bears 30-45 seeds whereas the fruit of the cleistogamous flowers are 2-3 mm and have fewer seeds (5-10).

Canada Frostweed is similar to three other eastern North American species of *Helianthemum*: *H. dumosum*, *H. bicknellii* and *H. propinquum*. Of these three species, Rockrose is considered most closely related to *H. dumosum* (Daoud & Wilbur, 1965).



Figure 1. *Helianthemum canadense* showing chasmogamous flowers (and fruit) and cleistogamous flowers (Britton and Brown, 1913).



Figure 2. *Helianthemum canadense* with chasmogamous flowers; June 26<sup>th</sup>, 2005, Kingston, Kings County, Nova Scotia.

*H. canadense* and *H. dumosum* differ from *H. bicknellii* and *H. propinquum* in number of chasmogamous flowers, position of chasmogamous flowers relative to lateral branches, types of pubescence present on upper leaf surface, size of cleistogamous capsule, numbers of seeds and seed surface characteristics.

*H. canadense* and *H. dumosum* differ from each other by the former having a stem at maturity with strongly ascending braches and branchlets and the latter having a mature stem with widely spreading branches and branchlets.

The common name “frostweed” originates from the plants odd characteristic of exuding ice crystals (from sap) in the shape of ribbons from the base of the stem in late fall ([http://en.wikipedia.org/wiki/Frost\\_flowers](http://en.wikipedia.org/wiki/Frost_flowers)).

\*Although described as “stellate” in much of the literature, in actuality, the hairs are made up of several unicellular hairs clustered in tufts (see Zomlefer, 1994). It is these particular hairs which give the plants a grey or silvery appearance (Zomlefer, 1994).

### **Genetic description**

Yorke (2007) used randomly selected individuals from populations in Nova Scotia, Maine, New Hampshire and Quebec to study genetic diversity and structure within and among *Helianthemum canadense* populations occurring at the northern limits of the geographical range of this species.

Amplified fragment length polymorphisms (AFLPs) were used as a basis for generating genetic diversity data. Data were analyzed with Analysis of Molecular Variance (AMOVA) and Principal Coordinates Analysis (PCoA). Neighbour-joining trees were also generated to illustrate relationships among individuals and populations.

Results of this study which are pertinent to conservation planning for Nova Scotia populations of *Helianthemum canadense* are listed below:

1. The results of this study indicate that Nova Scotia populations are genetically unique from the nearest neighbouring populations both in Canada and the United States.
2. Quebec populations were found to be more divergent from Nova Scotia populations than New England populations. This indicates that New England is a probable source for Nova Scotia populations. Results also indicate that the Quebec populations also originated from the New England area. It is suggested that the regional populations within Canada were probably never connected.
3. Genetic variability within Nova Scotia and Quebec populations was significantly lower than variability within New England populations. It was hypothesized that New England populations may exhibit higher variability because they are more continuously distributed thereby increasing potential for gene flow among populations.



4. Within Nova Scotia, Kings County populations were found to be significantly genetically distinct from Queens County populations suggesting either genetic drift due to prolonged isolation or that the populations may have had separate post-glacial origins.

5. Kings County populations i.e., CFB Greenwood (Greenwood), west Kingston (Kingston) and east Kingston (Green Acres), exhibited little genetic divergence overall suggesting the occurrence of gene flow among these local populations or recent fragmentation. This study also suggests that because Kings County populations do not appear significantly distinct from each other and these sites could possibly represent a single population.

## DISTRIBUTION

### Global range

Globally, *Helianthemum canadense* is restricted to eastern North America where it extends from Nova Scotia, Quebec and Ontario in the north southwards to Georgia and Tennessee and westwards to Iowa, Missouri and Wisconsin.

In the United States, it is considered to be presumed extirpated in Tennessee, imperiled or critically imperiled in Georgia, Kentucky, Ohio, Vermont and West Virginia and vulnerable in North Carolina (Natureserve, 2007) (Table 2).

### Canadian range

In Canada, Rockrose has been documented from three provinces, Ontario, Quebec and Nova Scotia.

Rockrose is an uncommon and local species in southern Ontario occurring in dry, open or partially open sites often on sandy soil (Oldham, 2005). It occurs in the Carolinian Zone, in the St. Lawrence River Valley in the Thousand Islands area, near Sault Ste. Marie and in the Upper Ottawa near Petawawa and Calumet Island.

Due to declining populations, the Ontario Natural Heritage Information Centre has recently changed the provincial rank of Rockrose from S4 (apparently secure) to S3 (vulnerable) (Oldham, 2005).

In Quebec, *Helianthemum canadense* is limited to the Outaouais region in the southwestern part of the province. Here, it occurs in *Pinus banksiana* forest. Rockrose is considered critically imperiled in Quebec (Natureserve, 2007).

Nova Scotia (Figure 3)

Rockrose is listed as critically imperiled in Nova Scotia by Natureserve (2007) and as a species which may be at risk by the General Status of Species in Canada website (<http://www.wildspecies.ca/wildspecies2005/>). Provincially, Rockrose is listed as a RED species i.e., a species that is known to be at risk (<http://www.gov.ns.ca/natr/wiildlife/genstatus/ranks.asp>).

In Nova Scotia Rockrose is almost entirely confined to one small section of the sand plains of the Annapolis Valley - in open Corema barrens in the vicinity of the closely associated communities of Kingston, Green Acres and Greenwood (Figure 4). There is but a single known population outside of the Annapolis Valley (Figure 5). Although first reported in 1942 from the border of dry, mixed woods in Greenfield, Queens County by Weatherby (1942), Rockrose had not been reported from this location since that time. Field work conducted in the Greenfield area by R.E. Newell and A. Yorke in 2006 located one very small population on the west side of Greenfield in openings in pine woodland. There is one historic record from a dry clearing at Five Island Lake, Halifax County. Several specimens were collected by A.E. Roland & W.G. Dore in 1945 from here and deposited at ACAD, NSPM and DAO. Efforts in 2006 to relocate this population or others in the general area were unsuccessful.

The extent of occurrence of *Helianthemum canadense* in Nova Scotia is estimated to be between 15 and 20 km<sup>2</sup>. This excludes the geographic area between the Kings County populations and the Queens County population as this area is made up of habitat considered unsuitable for Rockrose (Yorke, 2007). The area of occupancy is estimated to be < .05 sq.m.

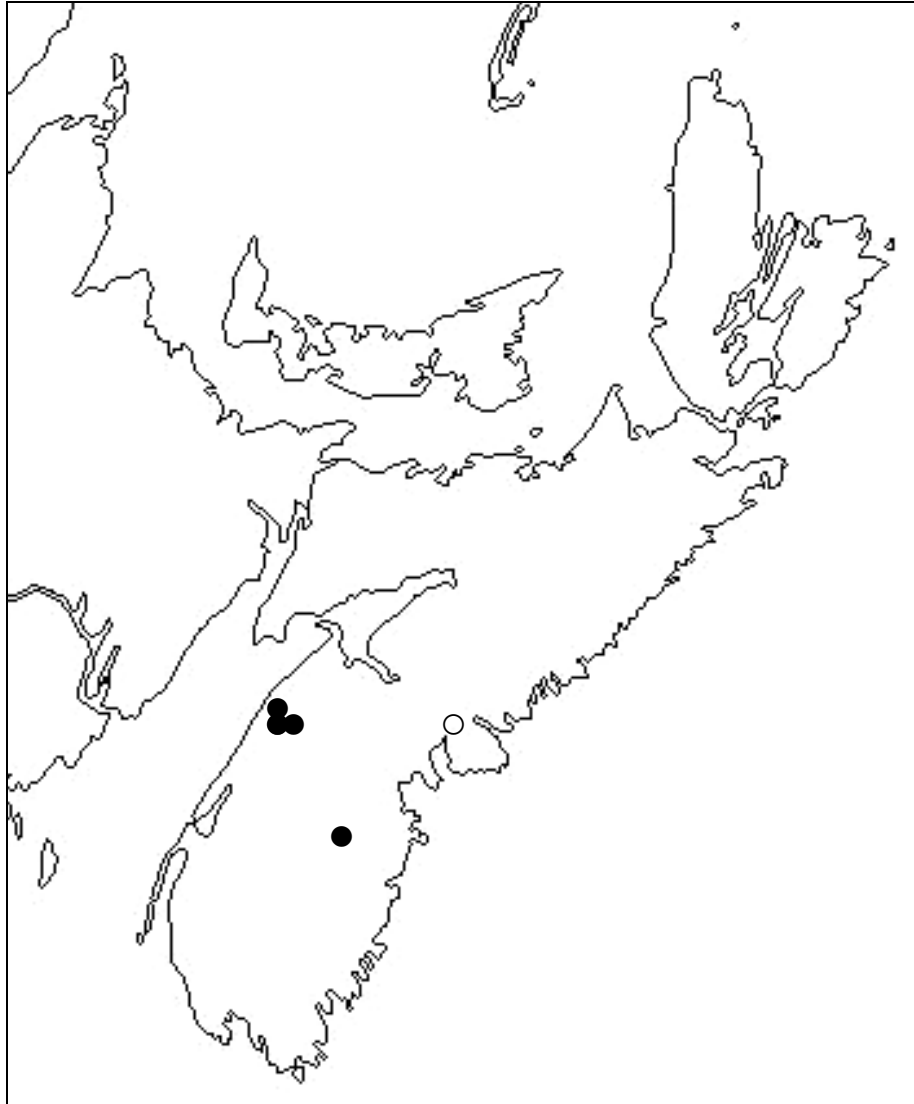


Figure 3. Distribution of Rockrose in Nova Scotia. See Figures 4 and 5 for more detailed occurrence information within the two documented sites within the province; ● = recently confirmed sites; ○ = historic sites.

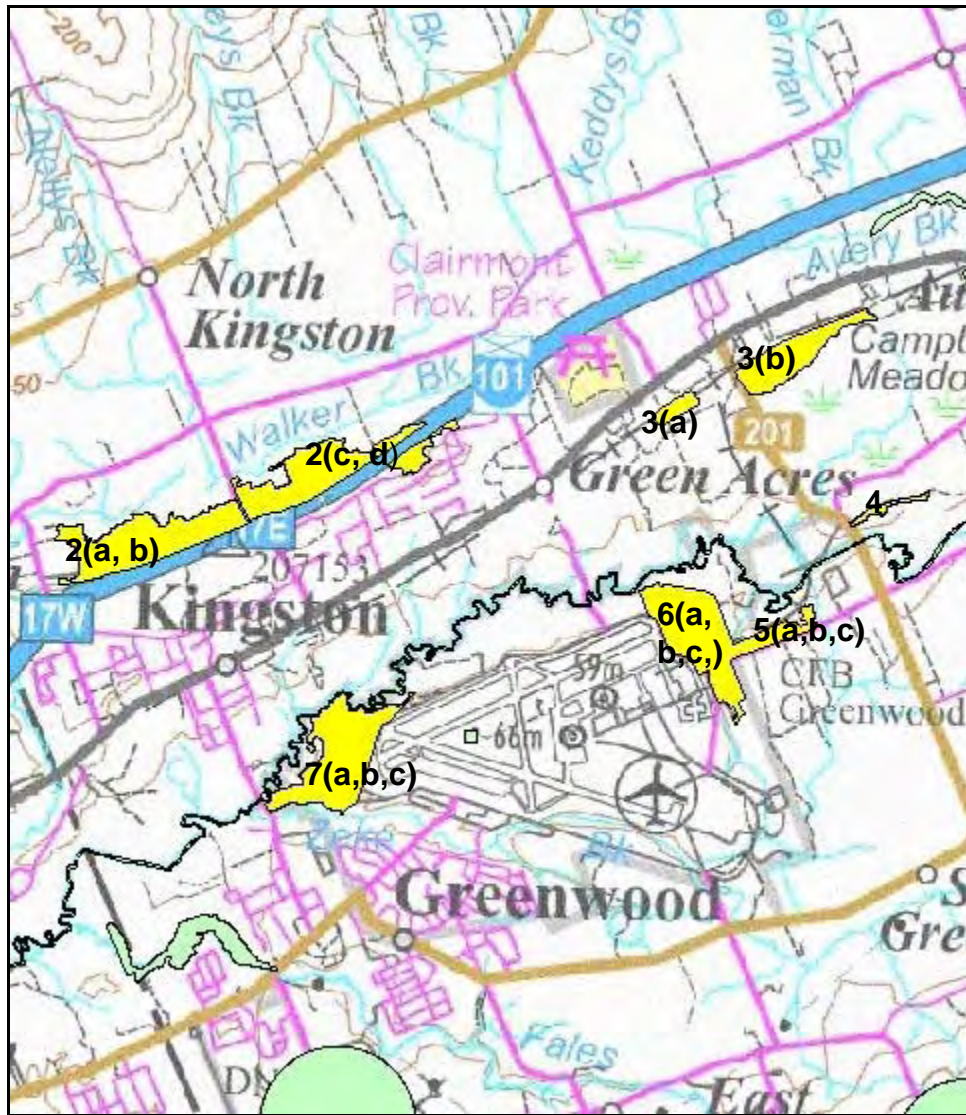


Figure 4. Map showing general areas of occurrences of Rockrose populations in Kings County, Nova Scotia (map provided by Department of Natural Resources).

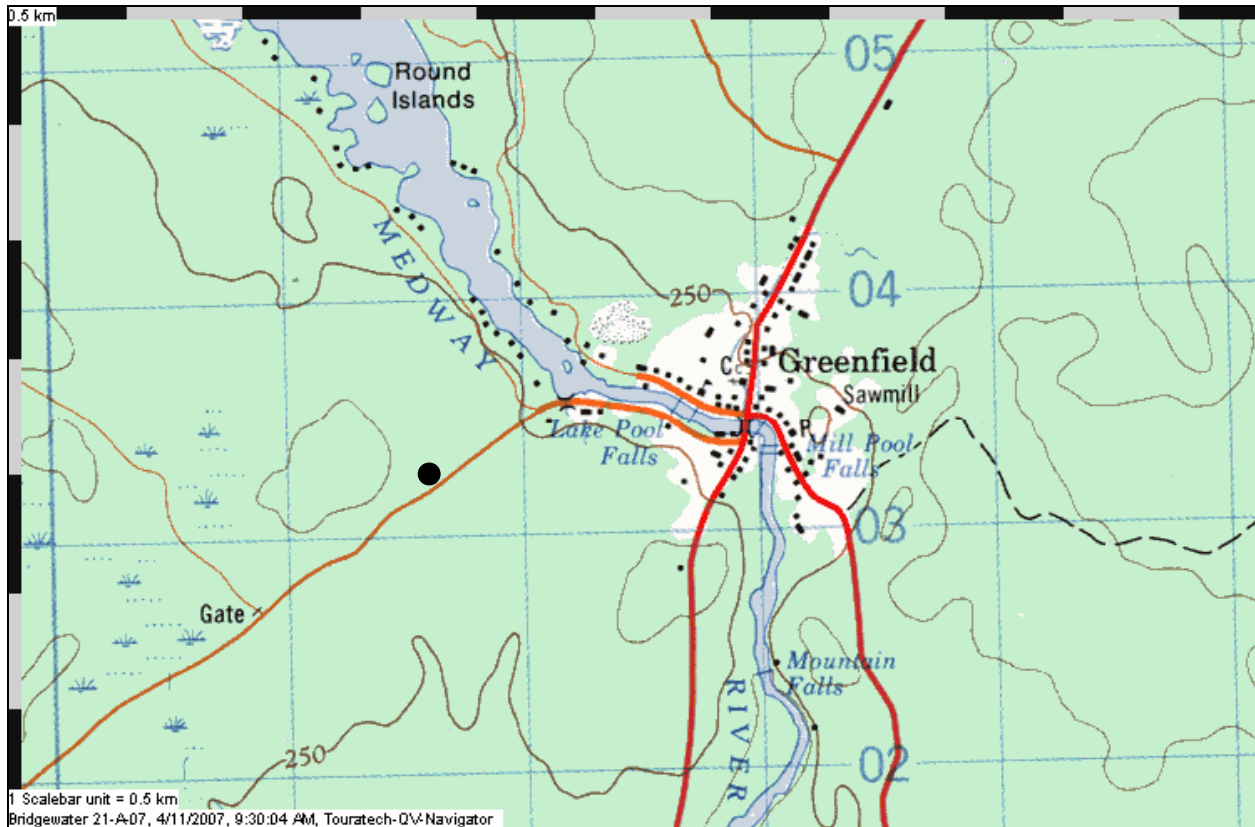


Figure 5. Location of single known occurrence of Rockrose in the Greenfield area of Queens County.

## HABITAT

### Habitat requirements

In Nova Scotia, Rockrose occurs on sand in dry, open or lightly shaded habitat where there is minimal competition from woody species. In the Annapolis Valley, it is generally found in open, *Corema*-dominated sand barren habitat (also referred to as *Corema* heathland by Catling & Carbyn, 2005) in the vicinity of the three closely associated communities of Green Acres, Kingston and Greenwood. It is occasionally also found here in lightly shaded areas under Trembling Aspen (*Populus tremuloides*). *Corema* or Broom Crowberry (*Corema conradii*) is a low-growing evergreen shrub which is very characteristic of sand barren habitat often being the dominant plant over large areas.

Rockrose was recently relocated in Greenfield, Queens County, Nova Scotia by the author and A. Yorke in several small clearings in pine woods (July 4, 2006). The only other know record for this area dates back to 1941 when a large colony was observed on the border of dry, mixed woods in association with *Symphotrichum*

*undulatum (Aster undulatus)* (Weatherby, 1942).

Rockrose is shade intolerant and a poor competitor. It is therefore highly dependent on disturbances which create open, sparsely vegetated areas. Historically, these disturbances would have included wild fires and browsing, trampling etc. by caribou (Catling *et al.*, 2004). Today, all-terrain-vehicles create limited suitable disturbance in open sand barrens (edges of ATV trails). As well, activities associated with runway development and maintenance at the Canadian Forces Air Base in Greenwood, and the maintenance of railroad and highway corridors have also provided habitat where Rockrose populations continue to exist.

It has recently been estimated that a significant proportion (>97%) of the original sand barren habitat occurring in the Annapolis Valley of Nova Scotia has been lost as a result of fire suppression, farming, subdivision and highway development and invasion by non-indigenous species (Catling, *et al.*, 2004).

Elsewhere in North America, Rockrose occurs in dry, sandy, or rocky, open woods and woodland openings, dunes, railroad embankments and sandy riverbanks.

### **Habitat trends**

It is estimated that less than 3% of the original heathland (open sand barren) habitat of the Annapolis Valley remains (Catling *et al.*, 2004). Reasons for this dramatic decline include 1) suppression of natural fires which maintained an open landscape, 2) extirpation of caribou from southern Nova Scotia in the early 1900's – browsing and the establishment of regular paths by the caribou provided natural disturbance, 3) the establishment of invasive plant species which are displacing native barren species, and 4) road, residential, commercial and agricultural development which is rapidly eliminating natural areas (Catling *et al.*, 2004).

### **Habitat protection/ownership**

The only *Helianthemum* habitat that currently has some degree of protection is that which occurs at 14 Wing Greenwood (CFB Greenwood). Environment personnel on the Base have indicated a willingness to protect, monitor and manage populations of rare species and therefore their habitats.

## **BIOLOGY**

### **Life cycle and reproduction**

Rockrose is a subcaespitose, herbaceous perennial with a duo reproduction system.

It produces both chasmogamous (open-pollinated flowers) and cleistogamous (self-pollinated flowers).

Chasmogamous flowers (Figures 1 & 2) are showy, yellow, many-stamened and short-lived. They open only in full sunlight. They number 1-2 per stem and develop first in the growing season (at the top of the primary stem). These flowers are homogamous to slightly protogynous (Zomlefer, 1994). The fruit (capsules) ranges from 6-7 mm and bear 30-45 seeds.

Cleistogamous flowers are small, lack petals and have few stamens. They develop later in the growing season than the chasmogamous flowers, and are produced on the branches and branchlets. The flowers remain closed. The capsules are 2-3 mm long and bear 5-10 seeds.

The number of cleistogamous flowers produced by individuals in other members of the Cistaceae has been shown to increase due to stressors such as low light, frost or drought and self pollination is considered to be a back up mechanism in conditions unfavourable for pollination (Herrera, 1992).

Any given mature plant does not necessarily produce chasmogamous flowers during a growing season. A stem does not however, have to produce chasmogamous flowers in order to produce cleistogamous flowers. Therefore, plants that do not produce the large showy yellow flowers early in the season still are capable of producing the late summer self-fertilizing flowers (pers. comm., S. P. vander Kloet, 2007).

Generation time i.e., average age of parents of the current cohort is unknown. Plants grown from seeds in the greenhouse remained as small rosettes until their second year at which point they produced a stem (pers. comm., vander Kloet, 2007). It is possible that at this time the plants become reproductive.

The following phenological observations were made by Dr. S.P. vander Kloet of Acadia University at one of the populations of Rockrose occurring at CFB Greenwood, Kings County, Nova Scotia in 2004:

- 1) First aerial shoots emerged from the sandy soil in mid-May and reached maximum height in about three weeks
- 2) The first chasmogamous flowers opened in late June to early July
- 3) Chasmogamous flowers had their highest frequency in late July when ca. 100 flowers were at full anthesis
- 4) Petals of chasmogamous flowers unfurl at about 8 AM and began to drop at 11 AM
- 5) Few pollinators (only five were caught) visited these chasmogamous flowers on July 21<sup>st</sup> from 9 AM until 11 AM: *Bombus vagans*, *B. rufocinctus*, *Agapostemon virescens*, *Andrena thaspii* and *Lasioglossum pilosum* – all species of bees/bumblebees

- 6) Three weeks subsequent to flowering, a three- to five-valved capsule was produced which broke open thereby initiating seed dispersal (seed dispersal is passive)
- 7) Seed capsules from chasmogamous flowers initially contained about  $11 \pm 15$  seeds ( $n=9$ ) but seed capsules collected in late July had very few seeds:  $1 \pm 1$  ( $n=11$ )
- 8) Half of the capsules collected from chasmogamous flowers contained no seeds at all - just frass or the occasional maggot
- 9) Seeds from the capsules germinate readily (58% success:  $n=85$ ) when placed on wet filter paper in Petri dishes on the greenhouse bench
- 10) The first radicles appear in about seven days and the first true leaves in about 12 days
- 11) After August 8<sup>th</sup>, no chasmogamous flowers were observed, rather, all new flower buds were cleistogamous
- 12) By early September, these cleistogamous flowers had produced small, 3-valved capsules which were ready to disperse their seeds
- 13) Fruiting capsules from these cleistogamous flowers produced  $16 \pm 4$  seeds in early September,  $19 \pm 6$  seeds in late September,  $11 \pm 6$  in early October and  $7 \pm 3$  in late October
- 14) Seeds from cleistogamous flowers germinated rather poorly: seed lots from September had ca. 1% germination ( $n=95$ ;  $n=111$ ) and none germinated from the October harvest ( $n=114$ ;  $n=40$ )

“All these observations indicate that *Helianthemum canadense* has a well developed bet-hedging recruitment strategy. Open-pollinated flowers produce seed that will germinate directly allowing seedlings to become established during the summer provided the soil is wet and the weather warm. Cleistogamous flowers however produce seeds that are largely dormant and thus provide the plant with a mechanism to disperse in time. Seeds from selfing allow a lineage to persist in a favourable micro-habitat whilst seeds from open-pollinated flowers maintain genetic diversity in this disjunct population” (pers. comm., S.P. vander Kloet, 2007).

### Seeds and Seed Banks

An experiment conducted by Dr. S. P. vander Kloet of Acadia University initially appears to indicate that this species does not maintain a seed bank and that its seeds require light for germination (pers. comm., 2007). On the 20<sup>th</sup> of April, 2004, soil samples were taken in the field and subsequently sown on the 22<sup>nd</sup> of April 2004. No *Helianthemum* seedlings emerged from any of the cores. 142 seedlings belonging to 19 taxa emerged from these soil samples, the most abundant being *Juncus bufonius*. In short, soil cores from these heathlands contained ca. 3215 ready to germinate seeds per m<sup>2</sup> which is quite typical of heathlands (vander Kloet & Hill, 1994). The absence of *Helianthemum* or *Hudsonia* from the seed bank was not considered surprising. Troumbis & Trabaud (1986) reported that *Cistus* spp. (a genus to which *Helianthemum* once belonged) produce up to 20,000 seeds per plant per year but form no seed banks (Parker & Kelly, 1989). This was thought to suggest that *Helianthemum* seeds may have



a testa that rots quickly as the radicle emerges from a fresh seed, given moist conditions in as little as four days. These results lead to the conclusion that this species cannot reproduce in time only in space.

There may however, be another explanation for the absence of *Helianthemum* and *Hudsonia* seedlings arising from soil cores in this study. A study of 42 Old World Species and one New World species of the Rockrose Family (Cistaceae) found that hardseededness is a prominent characteristic of the entire family (Thanos *et al.*, 1992). Promotion of seed germination in the laboratory was obtained by mechanical scarification and thermal pretreatment. In nature, heat generated from fires is considered probably the major trigger factor for seed germination. Observations by S.P. vander Kloet (see above) on *Helianthemum canadense* seeds, suggest that seeds produced by chasmogamous flowers germinate readily on moistened filter paper following maturation of capsules whereas seeds from cleistogamous flowers germinated poorly. It may be that the cleistogamous seeds remain in the seed bank intact until stimulated by heat from a wild fire before they germinate.

Reestablishment of *Helianthemum canadense* within several months after plowing in a field in the New Jersey pine barrens (McCormick & Buell, 1957) may be an indication that Rockrose seeds were present in the seed bank.

Rockrose was one of a number of herbaceous sand barren species which re-established in a sand barren (Badger Barren) located in northwestern Ohio. This area was farmed intensively from ~1840 to 1951 at which point it was allowed to revert to natural vegetation. Today, Rockrose occurs here at densities considered typical for this particular geographic region. This barren is almost completely surrounded by second-growth forest which may have limited re-colonization in some cases to those species which maintain a seed bank (Neher *et al.*, 2003).

Experimental prescribed burning in coastal heathlands in Massachusetts resulted in an increase in seedling establishment for the rare rockrose *Helianthemum dumosum* (Dunwiddie, 1990). In this case, it was concluded that both heavy lichen cover and dense litter cover inhibit seedling establishment. Occasional burning is thought to lower levels of both thereby encouraging the establishment of *H. dumosum* seedlings.

### Reproductive Capacity

Some initial observations on reproductive capacity of *Helianthemum* at CFB Greenwood were made by Dr. S.P. vander Kloet in 2004. Ten square meter quadrats were laid out at random on 23 April 2004 along three 50-m transects, each in a distinctive habitat where at least one *Helianthemum* was observed during the preliminary survey in the autumn of 2003. The number of plants observed in each quadrat varied markedly (range 0 to 33) with a mean of  $5 \pm 7$  for mature plants and  $2 \pm 4$  for seedlings per m<sup>2</sup>. Seed production for this sample population was calculated at 20,578 seeds or  $2058 \pm 3327$  per m<sup>2</sup>. Out of this number of seeds, 19% will germinate directly with a net result of 20 seedlings observed in these quadrats, i.e., 2% of these

seeds were successful in becoming established in 2004.

Vegetative reproduction has not been reported for *Helianthemum canadense*.

### Pollination

Brief observations on pollinators by S.P. vander Kloet (pers. comm., 2007) revealed the following pollinators visiting chasmogamous flowers of Rockrose plants on July 21, 2004 between 9 AM and 11 AM: *Bombus vagans*, *B. rufocinctus*, *Agapostemon virescens*, *Andrena thaspiae* and *Lasioglossum pilosum* – all species of bees/bumblebees.

Steve Javorek, entomologist with Agriculture and Agri-food Canada, Kentville, NS, found that all pollinators of Rockrose were generalists with a functional foraging radius of 400m (pers. comm., 2005).

### Herbivory/predation

No reports on herbivory or predation were found in the literature.

### Physiology

*Helianthemum canadense* is shade intolerant although populations can exist in light shade. Plants are drought tolerant and disturbance dependant. Rockrose grows in acid, neutral and alkaline soils (Plants for a Future, 2006).

Experimental prescribed burning of coastal heathlands in Massachusetts resulted in an increase in both numbers of plants and numbers of flowers produced for the endemic species *Helianthemum dumosum* (Bushy Rockrose) (Dunwiddie, 1990).

### Dispersal/migration

Observations at CFB Greenwood suggest seed dispersal is passive (pers. comm., S.P. vander Kloet, 2007) and therefore generally takes place close to the parent plant. Short-distance seed dispersal is considered characteristic of the Rockrose family as a whole as there is no specialized mode of dispersal found within the family (Thanos, et al., 1992).

There is very limited potential for rescue from populations outside of Nova Scotia. The closest out of province population of *Helianthemum canadense* is in southern Maine, a distance of approximately 450 km.

Kings County populations of Rockrose appear effectively isolated from Queen County populations by absence of suitable habitat between the two regions (Yorke, 2007). Populations from these two regions also display genetic distinctness suggesting prolonged isolation (Yorke, 2007). Research by Yorke (2007) show that populations within Kings County are similar genetically and therefore either undergo gene exchange

or were recently fragmented.

### **Interspecific interactions**

Three species of *Helianthemum*, *H. canadense*, *H. bicknellii* and *H. scoparium*, from North America, were shown by Malloch & Thorn (1985) to have ectomycorrhizae, i.e., mycorrhizal infections.

### **Adaptability**

Seeds from chasmogamous flowers germinate readily on moist filter paper in Petri plates whereas seeds of cleistogamous flowers remain dormant for an unknown period of time (S.P. vander Kloet, pers. comm., 2007)

Rockrose is described by Bailey (1949) as the hardiest of the genus in cultivation.

Members of the genus are reported to grow well in gardens as long as plants are grown in well-drained, poor soil in full sun (WSU Whatcom County Extension, <http://whatcom.wsu.edu/ag/homehort/plant/sunrose.htm>).

Propagation Guideline (from Plants for a Future, <http://www.pfaf.org>)

Seed – sow in spring in a greenhouse. When they are large enough to handle, pick the seedlings out into individual pots and grow them on in the greenhouse for at least their first winter. Plant them out into their permanent positions in late spring or early summer, after the last expected frosts. Cuttings of half-ripe wood, 6 - 8cm with a heel, late summer in a sandy soil in a frame.

## **POPULATION SIZES AND TRENDS**

### **Search effort**

Fieldwork was conducted in 2006 by R.E. Newell and A. Yorke in an effort to relocate two historic populations of Rockrose: (1) Weatherby (1942) discovered Rockrose in Greenfield, Queens County in 1941; several collections were made of Rockrose at Five Island Lake, Halifax County in 1945 by W.G. Dore & A.E. Roland (E.C. Smith Digital Herbarium, <http://herbarium.acadiou.ca/>).

Two small patches (with a total of 55 plants) occurring in close proximity to each other were located in the Greenfield area (Table 1) on July 4, 2006. Although many areas were surveyed in and about Greenfield at this time, no other populations were found. It is believed however, that there remains a good possibility that more populations will be located in the Greenfield area with more field effort.

A survey conducted on July 26, 2006 was not successful in relocating Rockrose in

the Five Island Lake area of Halifax County. Any potentially suitable open habitat occurring in this area was generally dominated by Knapweed (*Centaurea nigra*). A broader-based survey may yet reveal populations of Rockrose in this area.

In addition, two days (x three people) during 2006 were spent revisiting previously documented sites in the Greenwood, Green Acres and Kingston areas of Kings County in order to check current status of various populations and to search for new sites.

As part of a separate study taking place in 2006, previously undocumented populations of Rockrose were discovered at CFB Greenwood by the author on June 28<sup>th</sup> and 29<sup>th</sup> (Newell, 2007).

## **Abundance**

An estimate of the total number of individuals of all ages in Nova Scotia based on recent observations is 5000 to 5500 (Table 1). Only a small number of seedlings were observed during fieldwork conducted in 2006 by the author. Plants become capable of reproduction in their second or third year when stems are produced from basal rosettes (pers. comm., vander Kloet, 2007). Plants observed and counted within populations were those with stem development. It is therefore considered reasonable to apply the same estimate given above for total number of individuals in Nova Scotia to the total number of mature individuals.

Because all of the Rockrose sites within Kings County are relatively close to each other, it is difficult to know where to draw borders between populations. For the purposes of this document, the Kings County plants were somewhat arbitrarily divided into 6 populations (Table 1). The Kingston population (population 2) has four sub-populations, all within sight of Hwy 101 with the exception of the Marshall Road sub-population which is approximately 250 m north of the highway. The Green Acres population (population 3) is considered to be made up of two sub-populations one of these with a population count of 1. Greenwood (east of Hwy 201) (population 4) is a very small population which was not visited in 2006 by the author due to the presence of no-trespassing signs. Greenwood (near a back entrance to CFB Greenwood) (population 5) has 3 sub-populations. CFB Greenwood – east side of base within the restricted access area (population 6) has 3 sub-populations and CFB Greenwood – west side of base – west and north of airfield (immediately outside of the restricted access area) (population 7) has 3 sub-populations.

It is interesting to note that genetic work conducted by Yorke (2007) indicated that there is little genetic diversity between the Kings County populations suggesting that they in actuality may represent one population.

It is likely that there are some undocumented populations of Rockrose in Nova Scotia both in the general vicinity of the Greenwood, Kingston and Green Acres triangle and in the Greenfield area of Queens County. If so, these are expected to be small and localized populations.

Table 1. Summary of Rockrose population data for Nova Scotia. Total population estimate for Nova Scotia: 5000-5500 individuals.

Populations (and sub-populations)	Habitat	Population Size	Area of Population	Ownership	Recent Observer(s) & Date	Comments
1 Five Island Lake (Queens County) (historic)	in dry clearing	unknown	unknown	unknown	W.G. Dore and A.E. Roland (Sept. 14, 1945)	this area was unsuccessfully searched in 2006 in an attempt to relocate <i>Helianthemum canadense</i>
2(a) Kingston - Marshall Road	in <i>Corema</i> barren along edge of well-used ATV trail	<b>~5-10 plants</b>	~20 sq. m	private	R.E. Newell (June 17, 2006)	some plants were destroyed in 2005 when they were run over by ATV's
2(b) Kingston - along Hwy 101 (approximately .4 km west of Exit 17E - north side of highway)	approximately 5 m N of gravel shoulder of Hwy 101 in open disturbed barren	<b>~10-20 plants</b>	~15 to 20 sq. m	Crown	R.E. Newell (June 17, 2006)	this site is mowed periodically by the Dept. of Highways – this is likely beneficial to the Rockrose plants by preventing the establishment of woody species
2(c) Kingston - along Hwy 101 (east of Exit 17E - north side of highway)	population extends in narrow band along the top of a high sand bank paralleling highway for distance of ~.3 km	<b>~150 plants</b>	300 sq. m	private?	R.E. Newell, P. Mills, L. Benjamin (Aug. 1, 2006)	previously documented here by Gini Proulx (20± plants, June 1, 1999), and S. Carbyn & P. Catling (120 plants, July 11, 2003)
2(d) Kingston - along Hwy 101 (east of Exit 17E - south side of highway)	three scattered patches of plants along edge of ATV trail	1) 7 plants 2) 21 plants 3) 5 plants <b>TOTAL= 33 plants</b>	3 sq. m	private	R.E. Newell, P. Mills, L. Benjamin (Aug. 1, 2006)	
3(a) Green Acres - along abandoned railroad (west of Hwy 201)	on north and south sides of abandoned railroad; in open barren between <i>Corema</i> mats (north side of railroad) and in light shade under <i>Populus tremuloides</i>	North side of tracks: ~32 plants; south side of tracks: ~350 plants; <b>TOTAL= ~380 plants</b>	~900 sq. m	Crown	R.E. Newell, P. Mills, L. Benjamin (August 1, 2006); R.E. Newell, Celia Symons, Alicia Pray-Leslie (August 16, 2006)	in close association with the abandoned railroad (this area was documented by Carbyn & Catling in 2003 with a population count of ~150 plants)

Populations (and sub-populations)	Habitat	Population Size	Area of Population	Ownership	Recent Observer(s) & Date	Comments
	(south side of railroad)					
3(b). Green Acres - vicinity of abandoned railroad (east of Hwy 201)	open, recently disturbed sandy ground	<b>1 plant</b>	< 1 sq. m	private	P. Catling et al. (July 11, 2003)	Rockrose in this area has declined over the last 40 years possibly due to over collecting and establishment of woody species
4 Greenwood - east side of Hwy 201	Unknown	<b>2 plants</b>	unknown	private	S. Carbyn, S. vander Kloet (July 11, 2003)	not re-surveyed in 2006 due to presence of no-trespassing signs
5 (a) Greenwood - near back entrance (east gate) to CFB Greenwood (Greenwood Square Road)	field with <i>Hieracium pilosella</i> , thin <i>Arctostaphylos</i> , <i>Deschampsia flexuosa</i> , <i>Danthonia spicata</i> , etc.	north side of road: 25 plants, south side of road: 14 plants; <b>TOTAL= 39 plants</b>	< 10 sq. m	private	R.E. Newell, P.Mills, L. Benjamin (Aug. 1, 2006)	low numbers of plant on both sides of road at west end of road (close to Base Gate)
5(b) Greenwood - near back entrance (east gate) to CFB Greenwood (Greenwood Square Road)	disturbed open ground with <i>Festuca</i> , <i>Hudsonia</i> and <i>Carex umbellata</i> beside road near house	<b>227 plants</b>	unknown	private	P. Catling (July 11, 2003)	same site as 5(a)?
5(c) Greenwood - near back entrance (east gate) to CFB Greenwood (Greenwood Square Road)	unknown	<b>2 plants</b>	unknown	private	S. Carbyn, S. vander Kloet (July 11, 2003)	
6(a) CFB Greenwood - east side of Base - restricted access area (MAD SHACK)	mostly disturbed sand barren between MAD SHACK and POL	1) 20-30 plants; 2) 200-500 plants; 3) ~100 plants; 4) ~50 plants;	1) 160 sq. m.; 2) 600 sq. m; 3) 72 sq. m; 4) ~100 sq. m	Federal	R.E. Newell (June 28 & 29, 2005)	

Populations (and sub-populations)	Habitat	Population Size	Area of Population	Ownership	Recent Observer(s) & Date	Comments
	Compound	<b>TOTAL= 400-700 plants</b>				
6(b) CFB Greenwood - east side of Base - restricted access area (ARMAMENT DISPOSAL AREA)	1) in disturbed sand barren 2) edge of <i>Populus tremuloides</i> woodland	1) ~35 plants; 2) 25-30; <b>TOTAL= ~60-65 plants</b>	1) 6 sq. m; 2) 30 sq. m.	Federal	R.E. Newell (June 28 & 29, 2006)	
6(c) CFB Greenwood - east side of Base - restricted access area (off of button of Runway 26)	sub-population sparsely distributed over large area of disturbed sand barren	<b>~500 plants?</b>	3-4 ha	Federal	R.E. Newell (June 28 & 29, 2006)	
7(a) CFB Greenwood - west of airfield (outside of restricted access area)	sand barren with areas of open sand and scattered patches of vegetation	<b>33 plants</b>	1350 sq. m	federal government?	R.E. Newell, C. Symons, A. Pray-Celeste (August 16, 2006)	this sub-population is currently fenced
7(b) CFB Greenwood - west of airfield (outside of restricted access area)	nearly continuous herbaceous vegetation cover; common plants include: <i>Arctostaphylos uva-ursi</i> , <i>Festuca filiformis</i> , <i>Danthonia spicata</i>	<b>~1900 plants</b>	3510 sq. m	Federal	R.E. Newell, C. Symons, A. Pray-Celeste (Aug. 16, 2006)	this sub-population is currently fenced; many plants are short and single-stemmed
7(c) CFB Greenwood - north of airfield (outside of restricted access area)	open barren with <i>Comptonia peregrina</i> , <i>Arctostaphylos</i> , <i>Festuca filiformis</i> , <i>Hudsonia ericoides</i> , <i>Corema conradii</i> , etc.	<b>~1400 plants</b>	2700 sq. m	Federal	R.E. Newell, C. Symons, A. Pray-Celeste (Aug. 16, 2006)	this sub-population is currently fenced; Rockrose growing in <i>Corema</i> mats and amongst <i>Comptonia peregrina</i>
8 Greenfield (Chapel Hill Drive - unpaved road between Pleasantfield and Greenfield) (Queens County)	1) in middle of turnoff ("driveway") to abandoned homestead in pine woods; very close to road 2) small opening in pine woods - former	1) ~30 plants; 2) 22 plants <b>TOTAL= 55 plants</b>	1) 6 sq. m; 2) 1.25 sq. m	private	R.E. Newell & A. Yorke (July 4, 2006)	2 small sub-populations (patches)

Populations (and sub-populations)	Habitat	Population Size	Area of Population	Ownership	Recent Observer(s) & Date	Comments
	homestead site					

### Fluctuations and trends

There is no indication that populations of *Helianthemum canadense* fluctuate dramatically from year to year.

One of the Green Acres sub-populations (east of Hwy 201) occurring in the vicinity of the railroad has slowly declined over the past 30-40 years. Although there are no numbers to indicate the original size of this population, plants were once common enough to be readily found and collected by university students on regular yearly botanical field trips up until about twenty years ago. A recent survey by Catling et al. (2003) was only able to locate 1 plant in this area. This unfortunate decline may be due to over-collecting or collecting may have hastened a decline that was already in progress. There has been much in growth of woody species in this area over the last 30-40 years which would also lead to population declines.

The general trend for the Annapolis Valley i.e., the Kingston, Green Acres and Greenwood area would be one of steady and continuing decline over the last century due to steady loss of suitable habitat through agriculture, highway and housing construction and suppression of natural disturbances such as wild fires.

Wild fire suppression may also have contributed to population declines in both the Greenfield area of Queens County and the Five Island Lake area of Halifax County by allowing the establishment of woodlands where once there were open barrens. The Five Island Lake area seems poised to undergo a major population expansion. A major subdivision expansion was observed during field work conducted here in 2006.

There undoubtedly was some loss of Rockrose populations at CFB Greenwood during past Base-associated runway, hangar and housing development. Populations currently occurring on the Base (at least in association with the runways) are now documented and according to the current Chief Environment Officer (Geoff Mercer), will be protected.

### Rescue effect



The closest out of province population of Rockrose to Nova Scotia populations occurs in southwestern Maine. A distance of approximately 450 km separates Nova Scotia populations from those in Maine. The likelihood of propagule migration between these locations would appear to be slim although survival if such an occurrence did occur may be possible.

## LIMITING FACTORS AND THREATS

### ***Nova Scotia***

#### Kings County

The original extent of the Annapolis Valley sand barren ecosystem was believed to be approximately 200 km<sup>2</sup>. Today it is estimated that less than 3 % remains (Catling et al., 2004).

#### **Habitat Destruction**

Extensive farming, commercial and housing developments, road construction and sand extraction are ongoing and imminent threats to Rockrose populations and habitat in the Annapolis Valley. From 1991-2001, Greenwood had the highest per cent population increase (48.6%) of all growth centers in Kings County. Kingston was the third highest with a population increase of 31.2% (<http://www.county.kings.ns.ca/comdev/demo/population.htm>).

Not all forms of agriculture may present an absolute threat to Rockrose. A study of the natural revegetation of a recently plowed field in the New Jersey pine barrens (McCormick & Buell, 1957), revealed an abundance of herbaceous perennials within a few months after plowing including *Helianthemum canadense*. This may indicate that many of these herbaceous perennials were relics from the old orchard present on the site prior to plowing.

In another situation, Rockrose was one of a number of herbaceous sand barren species which re-established in a sand barren (Badger Barren) located in northwestern Ohio. This area was farmed intensively from ~1840 to 1951 at which point it was allowed to revert to natural vegetation. Today, Rockrose occurs here at densities considered typical for this particular geographic region. This barren is almost completely surrounded by second-growth forest which may have limited revegetation to those species which maintain a seed bank (Neher et al., 2003).

#### **Invasive species**

Scots Pine (*Pinus sylvestris*) has been shown to be an aggressive invader of the

Corema dominated sand plains of the Annapolis Valley (Catling & Carbyn, 2005). Dense stands of Scots Pine are shown to reduce native cover to 12%, vascular plant biodiversity to less than 42% and the cover of the heathland dominant, *Corema conradii*, from 100% to less than 2%. Rockrose is shade intolerant and would not be able to survive in dense stands of Scots Pine.

There are a number of non-native herbaceous species that quickly become dominant in sand barren habitat following a disturbance. These include Mouse-eared Hawkweed (*Hieracium pilosella*), Sheep Sorrel (*Rumex acetosella*), Canada Bluegrass (*Poa compressa*) and Sheep Fescue (*Festuca filiformis*) (Catling et al., 2004) (Newell, 2007). Open habitats in the Five Island Lake area of Halifax County were noted by the author (pers. obs., 2006) to have abundant Knapweed (*Centaurea nigra*). It is not known if these aggressive alien species negatively impact *Helianthemum canadense*.

### **Suppression of Natural Disturbances**

Wild fire suppression has had a significant impact on the quality of the sand barren ecosystem in the Annapolis Valley. Fires have served through time to maintain a variety of successional stages, thereby maximizing biodiversity. The persistence of an open landscape by eliminating or keeping at bay woody species is particularly critical for the continuing existence of *Helianthemum canadense*. Succession to woodland is currently steadily replacing open barren especially on more mesic sites (Catling et al. 2004). Drier barrens are less susceptible to the establishment of native woody species however, the invasive woody species, *Pinus sylvestris* is able to quickly establish in these areas (Catling & Carbyn, 2005).

In a study (Beck & Vogl, 1972) on the effects of spring burning on rodent populations in a brush prairie savanna in Wisconsin, the burning treatment which involved the highest number of burns over a period of 15 years had the greatest impact on the occurrence of Rockrose. Eleven burns (as compared to 2 and 4 burns) led to a 25% or greater frequency in the occurrence of *Helianthemum canadense* between unburned and burned portions of the study areas.

Jack Pine barrens in northern lower Michigan have been mostly converted to managed Jack Pine plantations. In order to manage for both production of Jack Pine and preservation of natural barrens flora (includes *Helianthemum canadense*), it was recommended (Houseman & Anderson, 2002) that plantation management strategies simulate natural processes including prescribed burning.

The extirpation of Woodland Caribou in southern Nova Scotia in the early 1900's is also thought to represent a significant loss of natural disturbance to the sand barren habitat in the Annapolis Valley (Catling et al., 2004). Browsing by herds of caribou as well as the regular usage of trails through the barrens would have contributed to the maintenance of a variety of disturbance regimes.

All-terrain-vehicle activity is very high in remaining pockets of open Corema barren

in the Annapolis Valley. One small population of *Helianthemum canadense* was observed by the author along the edge of one of these in the Kingston area. Although ATV 's do provide a level of disturbance which may fill some of the void left by suppression of natural fires, it is a precarious existence for any Rockrose plant that establishes along the edge of an ATV trail.

Populations of Rockrose in Nova Scotia are generally very small and localized. This increases their vulnerability to extirpation through small scale, stochastic events

#### Queens County

Threats to Rockrose populations in the Greenfield area are similar to those in the Annapolis Valley with some exceptions. Development around Greenfield is basically limited to cottage or resort development on Ponhook Lake. Therefore there is less imminent threat from agriculture, urban sprawl, etc. Fire suppression leading to establishment of woodland has probably been a key factor here as well as in Kings and Halifax Counties. Logging is ongoing in the vicinity of Rockrose in Greenfield. It is not entirely clear whether logging poses a threat to Rockrose. It is considered more than likely to be beneficial to Rockrose populations by opening up habitat. It is unknown if there are any invasive species that might pose a threat in this area.

Threats to Rockrose populations outside of Nova Scotia are similar to those found within Nova Scotia. In Ohio, habitat loss and fire suppression are felt to be the two main causes for the decline of this species (The Green Ribbon Initiative, 2007). Recognized threats in Kentucky include invasion by woody plants (prescribed fire, mowing, hand removal of nearby trees or other means to maintain the open character of the habitat is recommended), soil disturbances such as those caused by ATV's, logging, etc. which may result in increased erosion and weed invasion and exotic plant pests (Kentucky State Nature Preserves Commission, 2007).

One reference to over-harvesting by unrestrained collectors for herbal remedies was noted in the literature (Washington State University Whatcom County Extension, 2006).

### **SPECIAL SIGNIFICANCE OF THE SPECIES**

Rockrose is in use today as an astringent and tonic. Historically used for scrofula (tuberculous swelling of lymph nodes), diarrhea, dysentery and syphilis (Foster & Duke, 1990). Rockrose has also been used in the treatment of cancer.

Isolated and/or disjunct peripheral populations of a species may be genetically distinct from those occurring in the central portion of the species range. It then becomes important to preserve this genetic diversity in terms of the long term survival of a species (Lesica & Allendorf, 1995). Research by Yorke (2007) has shown Nova Scotia

populations of Rockrose to be genetically unique from the next closest out of province populations to the south in Maine.

Many members of the family including *Helianthemum canadense* are valued in the horticulture industry.

### EXISTING PROTECTION OR OTHER STATUS DESIGNATIONS

In Nova Scotia, Rockrose currently has no legal protection. It is a Red-listed species on the Nova Scotia Department of Natural Resources General status Ranks of Wild Species in Nova Scotia website (<http://www.gov.ns.ca/natr/wildlife/genstatus/ranks.asp>) which indicates that it is a species known to be at risk and is therefore a species of high conservation concern.

Populations occurring at CFB Greenwood are known to environment personnel on the Base and verbal reassurance has been given by the Chief Environment Officer (Geoff Mercer) that they will be protected and managed.

The general status of species in Canada website (<http://www.wildspecies.ca/wildspecies2005/>) lists Rockrose as 3 (sensitive) in Ontario and 2 (may be at risk) for Quebec and Nova Scotia. The general status for Canada is listed here as 3 (sensitive).

According to NatureServe (2007), Rockrose has a global status of G5. State and provincial ranks are presented in Table 2.

Table 2. State and Provincial Status of *Helianthemum canadense* (NatureServe , 2007).

S1	S1?	S2	S2S3	S3	S4	S5	SH	SNR	SU
Nova Scotia, Quebec	Georgia, Kentucky	Ohio, West Virginia	Vermont	North Carolina, Ontario*	Iowa	Delaware, New Jersey, New York, Virginia	Tennessee	Connecticut, District of Columbia, Illinois, Indiana, Maine, Maryland, Massachusetts, Michigan, New Hampshire, Pennsylvania, Rhode Island, South Carolina, Wisconsin	Missouri

\*Ontario has recently changed the S-rank of Rockrose from S4 to S3 (Oldham, 2005),

## TECHNICAL SUMMARY

### *Helianthemum canadense* (L.) Michx.

Rockrose, Canada Frostweed

Hélianthème du Canada

Range of Occurrence in Nova Scotia: In the vicinity of the communities of Kingston, Greenwood and Green Acres, Kings County and in Greenfield, Queens County.

<b>Extent and Area Information</b>	
<ul style="list-style-type: none"> <li>• <i>Extent of occurrence (EO)(km<sup>2</sup>)</i> (excludes region between Kings County populations and Queens County populations)</li> </ul>	15-20 km <sup>2</sup>
<ul style="list-style-type: none"> <li>• <i>Specify trend in EO</i></li> </ul>	Declining
<ul style="list-style-type: none"> <li>• <i>Are there extreme fluctuations in EO?</i></li> </ul>	No
<ul style="list-style-type: none"> <li>• <i>Area of occupancy (AO) (km<sup>2</sup>)</i></li> </ul>	< .05 km <sup>2</sup>
<ul style="list-style-type: none"> <li>• <i>Specify trend in AO</i></li> </ul>	Declining
<ul style="list-style-type: none"> <li>• <i>Are there extreme fluctuations in AO?</i></li> </ul>	No
<ul style="list-style-type: none"> <li>• <i>Number of known or inferred current locations</i></li> </ul>	7
<ul style="list-style-type: none"> <li>• <i>Specify trend in #</i></li> </ul>	Declining
<ul style="list-style-type: none"> <li>• <i>Are there extreme fluctuations in number of locations?</i></li> </ul>	No
<ul style="list-style-type: none"> <li>• <i>Specify trend in area, extent or quality of habitat</i></li> </ul>	Declining

<b>Population Information</b>	
<ul style="list-style-type: none"> <li>• <i>Generation time (average age of parents in the population)</i></li> </ul>	Unknown
<ul style="list-style-type: none"> <li>• <i>Number of mature individuals</i></li> </ul>	5000-5500
<ul style="list-style-type: none"> <li>• <i>Total population trend:</i></li> </ul>	Declining
<ul style="list-style-type: none"> <li>• <i>% decline over the last/next 10 years or 3 generations.</i></li> </ul>	
<ul style="list-style-type: none"> <li>• <i>Are there extreme fluctuations in number of mature individuals?</i></li> </ul>	No
<ul style="list-style-type: none"> <li>• <i>Is the total population severely fragmented?</i></li> </ul>	Yes
<ul style="list-style-type: none"> <li>• <i>Specify trend in number of populations</i></li> </ul>	Declining
<ul style="list-style-type: none"> <li>• <i>Are there extreme fluctuations in number of populations?</i></li> </ul>	No
<ul style="list-style-type: none"> <li>• List populations with number of mature individuals in each:</li> <li>• 1 Five Island Lake (Halifax County) (historic)</li> <li>• 2 Kingston : ~200-215</li> <li>• 3 Green Acres: ~380</li> <li>• 4 Greenwood (east of Hwy 201): 2</li> <li>• 5 Greenwood (near back entrance to CFB Greenwood): ~270</li> <li>• 6 CFB Greenwood (within restricted access area): ~960-1265</li> <li>• 7 CFB Greenwood (outside of restricted access area): ~3333</li> <li>• 8 Greenfield, (Queens County): 55</li> </ul>	

<b>Threats (actual or imminent threats to populations or habitats)</b>
<p>Residential, commercial and agricultural developments pose imminent threats to Kings County populations of Rockrose. Wild fire suppression has likely had a significant negative impact on Rockrose populations and habitats in all reported locations (both historic &amp; current) for Rockrose in Nova Scotia.</p>

<b>Rescue Effect (immigration from an outside source)</b>	
<ul style="list-style-type: none"> <li>• <i>Status of outside population(s)?</i> see TABLE 2  <b>USA:</b>  [other jurisdictions or agencies]</li> </ul>	
• <i>Is immigration known or possible?</i>	Unknown
• <i>Would immigrants be adapted to survive in Canada?</i>	Possibly
• <i>Is there sufficient habitat for immigrants in Canada?</i>	Yes
• <b><i>Is rescue from outside populations likely?</i></b>	<b>No</b>
<b>Quantitative Analysis</b>	N/A

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