Provincial (Nova Scotia) Status Report

on

Northern White Cedar
Thuja occidentalis

prepared for

Nova Scotia Department of Natural Resources

by

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EXECUTIVE SUMMARY

Species information

Cedars are evergreen trees belonging to the Cypress Family (Cupressaceae). They are generally 10-20 m tall with flattened branchlets which form horizontal sprays. The leaves are scale-like and very small (1-2 mm) occurring as alternating pairs in four rows. The light reddish-brown bark occurs as narrow, vertically peeling, shreddy strips. The trees are monoecious with inconspicuous male and female flowers occurring in small aments on separate twigs or branchlets. The erect, ovoid cones are woody and about 1 cm long. The wood has a characteristic odor and the light brown heartwood is resistant to decay.

Distribution

Globally, cedar extends from southeastern Manitoba east to Nova Scotia and southwards in the United States as far as the Great Lakes Region and the states of New England. South of the main range there are isolated, scattered stands along the Appalachians as far as Tennessee and North Carolina. In Nova Scotia, cedar is currently known from five western Counties. These include Yarmouth, Digby, Annapolis, Kings and Cumberland. Cedar has been documented in the past from an additional five counties i.e., Shelburne, Hants, Halifax, Pictou and Antigonish. There are no current confirmed records from these additional counties.

Habitat

In Nova Scotia cedar occurs in swamps, lakeside forests, forests (woodland), old pastures and forested brook- and stream-sides. Soil drainage and pH play an important role in the occurrence and performance of this species over its range.

Biology

The flowering period for cedar is early through to late May. The cones mature in one season with fruiting taking place from early August to February. Most seeds however are dispersed by November. Seeds are wind-disseminated and usually travel less than 60 m. Seed production can occur on plants as young as 6 years with optimal productions occurring at 75 years. Seeds show only slight dormancy and have a high drought-related mortality rate. Cedar grows more slowly than associated trees but live longer reaching ages of 400+ years. Vegetative reproduction by layering is common on organic soil sites such as swamps. Cedar can be propagated vegetatively by cuttings and this is a commonly used technique in the horticulture industry. Deer and rabbit browsing can cause significant damage to cedar stands. Cedar is resistant to disease and insect damage.

Population sizes and trends

Cedar is reported from thirty-two sites in five counties in Nova Scotia, two of which are believed to have originated from planted stock. Due to their small and localized nature, it is likely that more populations will be discovered in the future. In terms of mature individuals known populations vary in size from 0 to 1000+. An estimate of total number of mature individuals is 12,000. Historically, cedar has been reported from an additional five counties. No confirmed records exist for these counties today. Logging and clearing for agriculture has undoubtedly reduced the size of some populations and eliminated others throughout its range in Nova Scotia.

Limiting factors and threats

Clearcutting as well as selective cutting have reduced population sizes in a number of cases and may have eliminated some populations. Highway construction has occurred through three populations. Field observations suggest that regeneration levels are low in many populations. This may be due to browsing by deer and snowshoe hare as well as to a tendency for this plant to exhibit high drought-related seedling mortality rates. An unsuitable soil pH may limit the occurrence of this species in Nova Scotia.

Special significance of the species

Thuja occidentalis is an important Mi'kmaq ceremonial plant. Due to its light weight and resistance to decay, cedar is a popular wood in home construction and wood product industries. It has a variety of medicinal uses and is a component in cleansers, insecticides, liniment, etc. Cedar is widely utilized in ornamental silviculture. It is an important browse food for several species of wildlife and seeds are eaten by a number of bird species. Cedar also provides important winter shelter to deer populations in parts of its range.

Existing protection

Thuja occidentalis is designated as a Red Species in Nova Scotia which acknowledges it's rarity but does not give it protection under provincial legislation. Only one population occurs within a protected area (Amherst Point Migratory Bird Sanctuary).

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SPECIES INFORMATION

Name and classification

Scientific name
Thuja occidentalis L.
Common names
American arborvitae (English)
Arborvitae (English)
Atlantic red cedar (English)
Balai (French)
Canada cèdre (French)
Cèdre (French)
Cèdre blanc (French)
Cèdre-thuya occidental (French)
Eastern American arborvitae (English)
Eastern arborvitae (English)
Eastern thuja (English)
Eastern white cedar (English)
Gasgosi (Mi'kmaq)
Giizhik (Anishinaabe)
Gijikandug (Ojibway)
Kakskus (Maliseet)
Northern arborvitae (English)
Northern white cedar (English)
Oosootah (Onondaga)
Swamp cedar (English)
Thuier cèdre (French)
White cedar (English)
Family
Cuppressaceae (cypress family)

Although several forms and one variety have been described (*Thuja occidentalis* L., f. *gaspensis* Vict. & Rousseau, *T. occidentalis* L, f. *prostràta* Vict. & Rousseau and *T. occidentalis* L., var. *douglasii* Rehder), no subspecific taxa are currently recognized (Chambers, 1993; NatureServe, 2005; ITIS, 2005) .

Morphological description

Cedar trees are evergreen with angled, buttressed, often branched trunks. They are 10-20 m tall with conical crowns (often stunted in harsh environments). The branchlets form flattened, leaf-covered, horizontal sprays (Fig. 1). The yellowish-green, scale like leaves are very small – 1-2 mm and occur as alternating pairs in four rows - side pair keeled, flat pair with gland-dot). The bark is thin; light red-brown with narrow shreddy long strips peeling vertically. The trees are monoecious with flowers that are inconspicuous, non-showy and

usually borne in small cones or aments on separate twigs or branchlets. The male flowers are yellowish, female flowers pinkish. Cones woody, erect, ovoid or egg-shaped and about 1 cm long. The cone scales number 4- 6 pairs, are rounded or sometimes minutely spine tipped. The upper and lower scales are sterile; the fertile scales bear 2 or 3 laterally winged seeds. Wood is light, soft, has a characteristic odor. The heartwood is light brown and resistant to decay whereas the sapwood is nearly white and less resistant.

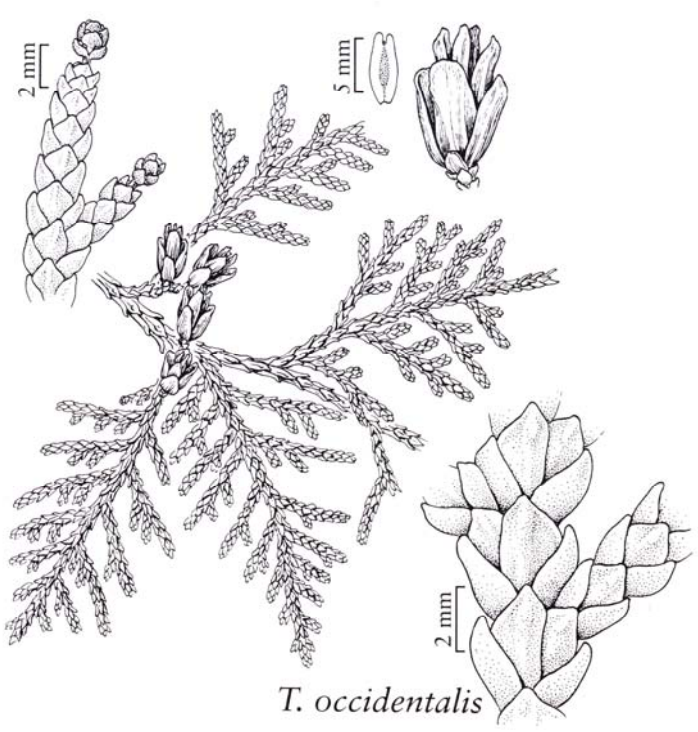

Figure 1. *Thuja occidentalis* with pollen cones, seed, seed cones and branchlets (with permission of the Flora of North America Association; Flora of North America, Vol.2)

It is not apt to be confused with any other native tree species in Nova Scotia.

Similar appearing evergreen trees occurring outside of Nova Scotia but within the North American range of cedar are Atlantic White Cedar (*Chamaecyparis thyoides*) and Eastern Red Cedar (*Juniperus virginiana*). The seed cones of Eastern Red Cedar are berrylike and remain closed (they are woody and open to release seeds in *Thuja occidentalis*). The branchlets of Atlantic White Cedar are terete instead of flattened and the cones are globose instead of ovoid as in *Thuja occidentalis*.

More detailed descriptions may be found in Flora of North America (Chambers, 1993), Manual of Vascular Plants of Northeastern United States and Adjacent Canada (Gleason and Cronquist, 1991), etc.

No hybrids have been reported, natural or artificial (Johnston, 1990).

Genetic description

Thuja occidentalis has a chromosome number of 2n = 22 (Chambers, 1993).

There is evidence to suggest that although cedar shows little morphological variation throughout its range, significant genetic variation exists. Ecotypic variation within the species has been documented on several occasions (USDA NRCS, 2005; Musselman et al., 1975).

Johnston (1990) suggests that the existence of more than 120 ornamental cultivars of cedar reflects significant genetic variation in natural populations.

Deer and hare have been shown to exhibit preference between cedar grown on different sites and genetic links for this preference have been demonstrated in Douglas-fir (*Pseudotsuga menziesii* var. *glauca*) (Miller, 1990).

A genetic study conducted by Lamy, *et al.* (1999) on white cedar in the province of Quebec, found low estimates of outcrossing for relatively pure stands of cedar that established on elevated mesic sites following clearcutting. Early 20th century forest harvesting at these sites was followed by cattle-grazing. These conditions favored the establishment of pure, dense stands of *Thuja*. The low amount of outcrossing for these stands suggest that white cedar embryos originating from inbreeding have relatively higher rates of survival when compared with other conifer species. A similar finding was made in Ontario for mixed white cedar populations by Perry and Knowles (1990) i.e., high levels of self-fertilization. These two studies suggest that in contrast to the majority of other conifers, this species may be less affected by inbreeding depression at the seed stage.

DISTRIBUTION

Global range

Cedar is native to North America. Its global range encompasses an area that stretches from southeastern Manitoba east to Nova Scotia, and south of its Canadian range to the states of New England and the Great Lakes region. South of the main range, it occurs in scattered stands and follows along the Appalachians into North Carolina and Tennessee where it is generally rare or extirpated.

Distribution maps illustrating the global range of cedar are readily available in various publications including Farrar (1995), Johnston (1990), Chambers (1993), etc.

Canadian range

Within Canada, cedar occurs from western Nova Scotia and western Prince Edward Island westward throughout New Brunswick, and southern Quebec to the south end of James Bay (including Anticosti Island). Its range continues across southern and central Ontario to the south end of Lake Winnipeg in Manitoba. Isolated patches occur near the north ends of Lake Winnipeg and Lake Winnipegosis.

In terms of forest regions, cedar is found throughout the Great Lakes-St. Lawrence Forest Region, most of the Acadian Forest Region and in the central and eastern parts of the Boreal Forest Region as far north as James Bay (Hosie, 1990).

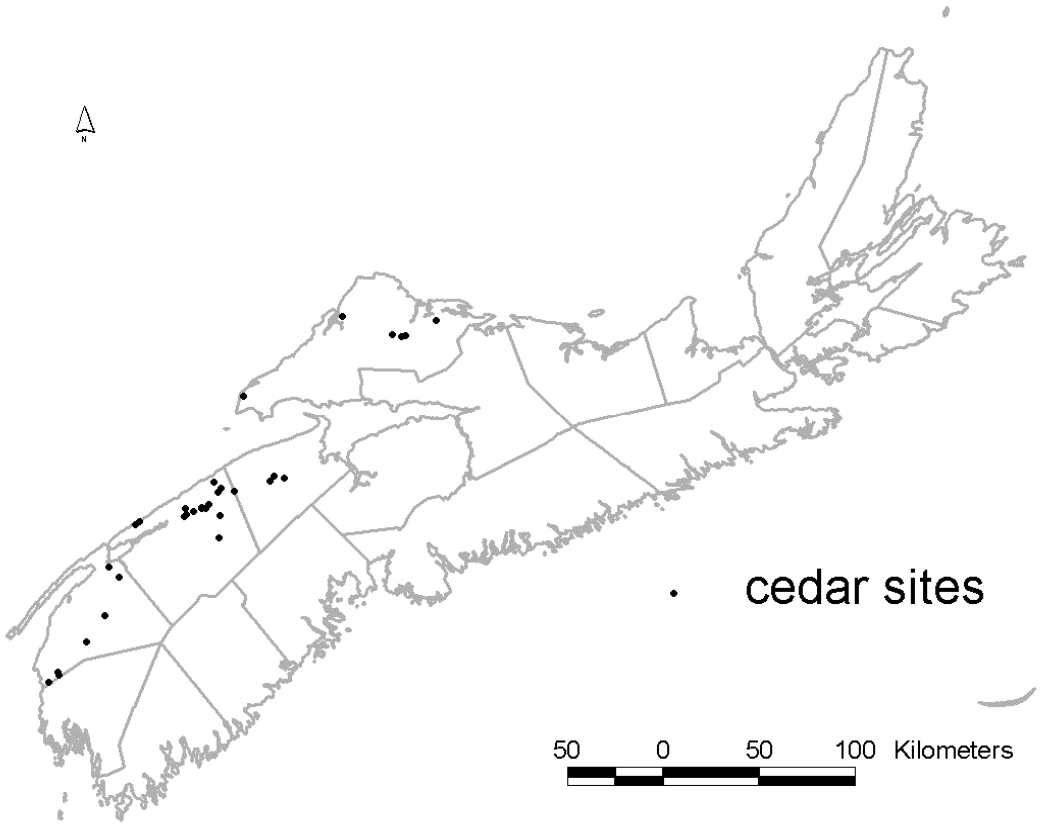

Figure 2. Distribution of *Thuja occidentalis* in Nova Scotia.

Nova Scotia range

In Nova Scotia, native cedar stands are currently known from five western counties (Fig. 2). These include: Yarmouth, Digby, Annapolis, Kings and Cumberland. The two confirmed records for Yarmouth County represent Cedar Lake and Norwood Clearwater Lake populations both of which straddle the Digby/Yarmouth County Line.

The extent of occurrence (EO) is estimated at 2804 km^2. The area of occurrence (AO) is estimated at 7.63 km^2. These figures may change if more populations are confirmed in the future.

There is one site currently represented by a herbarium specimen at the E.C. Smith Herbarium (ACAD) that should be investigated. This is a Shelburne County location (north of Lake John Road; C. Dolliver, 1994) that may represent an existing native population.

Johnson (1986) notes from writings by Nicholas Denys in the mid-1600's, that cedar was once more common in Nova Scotia than it is today. Denys, who traveled extensively throughout coastal Nova Scotia, mentions observing cedar at Havre Boucher (northern tip of Antigonish County) and at Pictou, Pictou County. These two areas are not known to have cedar today. Johnson goes on to say that a forestry survey conducted in the early 1800's by Titus Smith Jr. did not record cedar indicating that although common in the 1600's, by 1801, it was rare. He postulates that cedar may have been diminished because of insects or disease. This is a questionable conclusion as cedar is known to be resistant to both insects and disease (Johnston, 1990). Johnson also states that with the large export of ship knees in the 1840's and the 1850's, cedar and larch became scarce in the province.

The forest inventory document of 1958 (Hawboldt and Bulmer, 1958) gives gross volumes (total volume of all trees, 4 inches dbh. and larger, from the ground level to their tips expressed in cubic feet) for cedar from seven counties. These are Annapolis, Kings, Hants, Halifax, Shelburne, Digby and Yarmouth Counties. This represents three more counties than we know it from today. The inventory was conducted from 1953-57. Either there has been a decrease in the range of cedar since the 1950's or we have lost knowledge of the existence of cedar in these three counties (i.e., Hants, Halifax and Shelburne).

There undoubtedly has been a historic decrease in the range of cedar within the province due to settlement. The Annapolis Valley has a long history of intensive farming and settlement. Today cedar is known from both the north and south sides of the valley as well as from the valley floor. It seems highly probable that there were more populations in the past that were eliminated through land clearing for farms, towns, etc.

There have been several cedar plantings in the province in the last 45 years. In 1959, 2700 cedar were planted along with some red pine in a plantation located at Carleton, Yarmouth County (E. Quigley, pers. comm. 2005). 10,000 cedar seedlings were grown at the Tree Breeding Centre in Debert in the late 1990's from native seed sources. Half of these were planted in Lawrencetown, Annapolis County on municipal land south of the community swimming pool and the other half were given to the Irving Company (H. Frame, pers. comm. 2005). These latter seedlings were planted near Ramsey Lake on the top of the North Mountain in Annapolis County (L. Benjamin, pers. comm. 2005).

HABITAT

Habitat requirements

General

Cedar requires cool, moist, nutrient-rich sites on calcareous or neutral soils (soil pH commonly ranges from 5.5 to 7.2). It is most often found on one of two broad habitat types (1) upland sites over mineral soil (e.g., pastures, limestone cliffs) and (2) lowland sites on well decomposed organic soil with actively moving soil water (swamps, lake-sides, stream banks). It seems to grow best, i.e., display faster growth, on moist but well-drained, calcareous mineral soil of upland sites. It will however, do relatively well in swamps with a strong flow of moderately mineral-rich soil water or on organic soils near streams or other drainage-ways. It does not do well on extremely wet or extremely dry sites. Cedar occurs on a wide variety of organic and mineral soils (Johnston, 1990).

Nova Scotia

In Nova Scotia, cedar occurs in swamps, lakeside forests, forests (woodland), old pastures and forested brook- and stream-sides.

Bentley & Smith (1957-58) found that drainage rather than pH or calcium content of the soils may be the limiting factor in determining the distribution of cedar within the province of Nova Scotia. They reported that in Nova Scotia, cedar exists as a post climax community about lake shores, and rarely as a pioneer forest stage in succession on old pastures. Cedar in lake-side habitats tended to be of mixed age, occurred in mixed stands and did not form the dominant species. In old-pastures, cedar tended to occur in nearly pure, even-aged stands and formed the dominant species. The pH of soils in cedar stands in Nova Scotia as measured by Bentley & Smith averaged 5.0 for the A soil layer and 5.1 for the B layer. They also found that in general, the pH of the old-pasture sites was slightly higher than that of the lake-side sites. Old-pasture sites also generally had better drained soils than lake-side sites.

Bentley and Smith point out the discrepancy between Fernald's (1919) statement that *Thuja occidentalis* is confined chiefly to basic soils and reaches its maximum development in all its outlying stations only in particularly calcareous areas, and the relatively high soil acidity that they recorded for cedar stands in Nova Scotia.

There is the possibility that Nova Scotia's cedar may tolerate slightly more acidic soils than cedar elsewhere over its range. Peripheral populations of a species are often genetically distinct from central populations. This is of potential significance with respect to the long-term survival of the species as a whole (Lesica and Allendorf, 1995)

Today cedar is known from 24 more sites than were known when Bentley and Smith did their study. However, no further detailed studies have been done relating to cedar habitat in Nova Scotia.

Habitat trends

Undoubtedly, cedar habitat has been lost in Nova Scotia due to agricultural and forestry practices over the past 200-300 years. At the same time, cedar appears to have taken advantage of the creation of pastureland – a habitat where it enjoys less competition and a release from shade suppression.

Because cedar populations are generally small and localized in Nova Scotia, the probability of more stands being discovered in the future remains high. It follows therefore that additional habitat will also be found. New populations have been documented in Cumberland and Digby Counties as well as in the Annapolis Valley in the recent past.

Habitat protection/ownership

All known cedar populations in Nova Scotia are on private land with the exception of Cedar Lake//Nictaux South (Crown), Dockertys Brook (part Crown, part privately-owned), Hectanooga (mostly privately-owned, small part Crown), Cedar Lake (mostly privately-owned, small part Crown) and Amherst Point Migratory Bird Sanctuary (part Federal and part privately-owned). There is no legal protection afforded cedar habitat in Nova Scotia with the exception of the population in the Amherst Point MBS. This sanctuary is located within the Chignecto National Wildlife Area. Under the Canada Wildlife Act – Wildlife Area Regulations, persons are prohibited from damaging vegetation and therefore habitat within NWA boundaries.

BIOLOGY

All of the information presented in this section unless otherwise noted, was obtained from *Silvics of North America* (Johnston, 1990). This document summarizes a great deal of the pre-1990 literature pertaining to cedar.

Life cycle and reproduction

Cedar is monoecious. The flowers are non-showy and inconspicuous. They are borne in small cones or aments on the ends of separate twigs or branchlets on the same tree (Fig. 1). The male flowers are yellowish, the female flowers pinkish.

Flowering takes place early through late May. The cones mature in one season but remain attached until the next spring. Fruiting takes place from early August through February although most seeds have been dispersed by November. The interval between cone ripening and cone opening is short, varying from 7 to 10 days

Seeds are wind-disseminated and generally travel less than 60 m. Squirrels inadvertently disperse seeds when they clip small branches bearing cones. Seeds do not remain viable in the forest floor for more than 1 year.

Cedar produce good seed crops every 2-5 years with light to medium crops in the intervening years. Good cedar seed crops can often be predicted by similar-sized crops in

Red Maple the preceding spring. Seed production has been observed in nature, on plants as young as 6 years with abundant crops occurring at 30 years and best productions occurring after 75 years. There are some indications that white-cedar trees on upland sites produce more cones per tree, more seed per cone and a higher percentage of full seeds than those on wet sites.

Germination normally begins in May or June of the year following seed dissemination. Most seeds show only slight internal dormancy with occasional lots showing significantly more. Best root and shoot development occur in full light, but drought-caused mortality of cedar seedlings may be extremely high under any light condition.

Germination and early growth are best on moist seed beds such as rotten wood (i.e., decaying logs and stumps), compacted moss and burned soils. Slash and thick moss layers tend to retard germination. The main requirements for early development seem to be a constant moisture supply and warm temperatures. After the first few years, ample light is necessary for continued seedling development. Mortality of seedlings is very high with the most important cause being drought. Other causes include smothering by sphagnum moss or logging slash, cutting or girdling by small rodents, and deer browsing. Germination is epigeal with the cotyledons rising above the ground. Seeds seem to geminate best at high temperatures such as 29˚C.

Although cedar trees generally grow best on neutral or slightly alkaline soil, seedlings appear to do best on neutral or slightly acid soil. Seedlings are resistant to damping-off fungi. The initial taproot system is eventually replaced by a fibrous root system.

White cedar generally grows more slowly than associated trees but lives longer, reaching ages of 400 or more years on organic soil sites. Small stunted trees over 700 years old occur on limestone cliffs of the Niagara Escarpment in southern Ontario (Farrar, 1995). One individual from Ontario has been dated at 1650+ years (USDA, NRCS, 2005).

Vegetative Reproduction
Cedar can send out roots from any part of a branch or stem if moisture conditions are favorable. Vegetative reproduction by layering i.e., development of roots on a stem while the stem is still attached to the parent plant, is common on organic soil sites (swamps). Many more stems probably originate vegetatively than from seed in most swamps because vegetative reproduction is more tolerant of shade and is never without an adequate root system. Seedlings have the ability to layer at 5 years. Layering is most common in younger stands and in areas where windthrown trees are prevalent. Cedar rarely sprouts from roots or stumps.

Cedar can be propagated vegetatively by cuttings with a high degree of success and is a commonly used technique in the horticulture industry.

Herbivory/predation

Deer and rabbit browsing cause significant damage to cedar seedlings and saplings

(Johnston, 1990; Rooney, 2002; Miller, 1990). Porcupines have been found to frequently injure trees by partially to completely girdling the stem and branches; red-backed voles make small cuttings of terminal twigs and laterals of smaller seedlings; prairie meadow mice sometime partially girdle the stem near the ground line although they are believed to not especially prefer the species; red squirrels are reported to clip cone-bearing branches and also to frequently eat the flower buds.

Cedar is reported to be avoided by grazing cattle (Lamy *et al.* 1999).

Physiology

Cedar is shade tolerant but vegetative reproduction is considered more tolerant than seedlings. Cedar is less tolerant than balsam fir but slightly more tolerant than black spruce.

Seedlings, saplings, and overstory trees can survive prolonged periods of suppression and grow rapidly when released by a disturbance. Cedar seedlings and saplings therefore have a competitive advantage over new germinants. “Advance regeneration is an important reproduction mechanism in many deciduous and coniferous forest types” (Heitzman *et al*., 1997).

Thinning response by cedar depends on site quality, residual stand density, and stand age.

White Cedar is generally resistant to disease. Occasionally seedlings are attacked by juniper blight (*Phomopsis juniperoora*) and by cedar leaf blight (*Keithia thujina*) but the damage is rarely serious. Farrar (1995) states that although the dry wood is resistant to decay, the living trees are subject to heart-rot, hence, many trees have hollow trunks.

The trees are generally insect tolerant unless they are growing on poor sites where they may be more susceptible to an insect infestation such as arborvitae leafminer (*Argyresthia thuiella*).

Dispersal/migration

Seeds are wind-disseminated and generally travel less than 60 m. Red squirrels inadvertently disperse seeds by clipping and transporting branchlets bearing cones. Seeds do not remain viable in the forest floor for more than one year.

The cones mature in one season but remain attached until the next spring. Fruiting, i.e., seed dispersal, takes place from early August through February.

It is likely that cedar from New Brunswick would be adapted to survive in Nova Scotia but the Chignecto Isthmus may hinder propagule migration as most of the isthmus is open marshland and appears to be unsuitable habitat for cedar establishment. The possibility exists for accidental dispersal via waterfowl or mammals.

Interspecific Interactions

According to an USDA conservation document (USDA, NRCS, 2005) as well as Johnston (1990), cedar stands are stable without major disturbance such as fire, because the trees are long-lived and balsam fir is the only associate sufficiently shade tolerant to offer any competition. In stands that have been disturbed by timber harvesting or severe browsing by white-tailed deer, successional species tend to be balsam fir or swamp hardwoods.

In apparent opposition to the statement in the proceeding paragraph concerning the stability of cedar stands in the absence of major disturbances, Bentley and Smith (1957-58) report cedar to be a poor competitor in Nova Scotia occurring in habitats where there is minimal competition. In addition, L. Benjamin (pers. comm. 2005) has observed that in at least one stand in Nova Scotia, cedar trees have apparently been overtopped and crowded out, i.e., killed by early succession trees such as white birch and white spruce.

Cedar has a natural resistance to most diseases, insect pests and decay.

Cedar in Nova Scotia has been observed to be relatively free of disease and insect damage (L. Benjamin, pers. comm. 2005).

Adaptability

In Wisconsin, seedlings grown from seed collected in upland stands developed deep root systems in well-drained soils and shallow root systems in saturated soils whereas their lowland counterparts showed little plasticity in root development.

Because cedar grows on rocky cliffs throughout its range, the root system is apparently well adapted to secure water and nutrients from cracks in rocks.

A genetic study conducted by Lamy, *et al.* (1999) on white cedar in the province of Quebec, found low estimates of outcrossing for relatively pure stands of cedar that established on elevated mesic sites following clearcutting. Early 20th century forest harvesting at these sites was followed by cattle-grazing. These conditions favored the establishment of pure, dense stands of *Thuja*. The low amount of outcrossing for these stands suggest that white cedar embryos originating from inbreeding have relatively higher rates of survival when compared with other conifer species. A similar finding was made in Ontario for mixed white cedar populations by Perry and Knowles (1990) i.e., high levels of self-fertilization. These two studies suggest that in contrast to the majority of other conifers, this species may be less affected by inbreeding depression at the seed stage.

Cedar seeds remain viable for 5 years or more if stored in sealed containers at 6-8 % moisture content and 0-3˚C.

Seedlings have the ability to layer at 5 years.

Cedar can be propagated vegetatively by cuttings with a high degree of success and is a

commonly used technique in the horticulture industry.

POPULATION SIZES AND TRENDS

Within known cedar populations in Nova Scotia (Table 1), numbers of mature plants range from 0 to 1000+. A rough estimate of total number of cedar within the province (including regeneration) might be in the range of 13,000 -15,000 plants. The population size of the largest known cedar stand in Nova Scotia, i.e., Hectanooga, Digby County, remains to be determined. Many of the smaller populations need to be surveyed to determine number of mature individuals and presence of regeneration. It is assumed that logging and clearing for agriculture has resulted in a decrease in numbers of cedar at some locations. Highway construction has eliminated some cedar in three cases (Table 1). Pasture establishment may have led to some local population expansion particularly in the Annapolis Valley along the north-facing slope of the South Mountain. There is evidence to suggest that the overall range of cedar in Nova Scotia has decreased (Johnson, 1986; Hawboldt and Bulmer, 1958) although it has been very limited for some time.

It has always been accepted that the lake-side and swamp cedar stands in Nova Scotia are native (Bentley and Smith, 1957-58; Ringuis, 1979). The old-pasture stands of the north facing slopes of the Annapolis Valley however were in doubt in terms of their origin (Roland, 1947). Bentley & Smith (1957-58) reported cedar to have seeded into a small area to the east of planted trees about an old homestead at Zwicker Lake, Annapolis County, but otherwise found no other case of a proven planted seed source in the Annapolis Valley. They reported that the seed source for the old-pasture stands in Rockland and Hillsburn were definitely native occurring cedars. Most documented populations in the Annapolis Valley today are considered native with the exception of two (Table 1).

Table 1. Known Nova Scotia cedar populations based on NS Department of Natural Resources Sighab Database (a "?" indicates a lack of data).

Locality	County	Habitat	Regeneration	Population Size (reproducing individuals*)	Ownership	Observer(s)	Date Last observed	Observers Comments
Eel Weir Brook, Lawrencetown	Annapolis	forest (former pasture)	a few seedlings	32	private	L. Benjamin & P. Francis	July 11, 2003	
West Paradise	Annapolis	forest	in places the ground is carpeted with regen < 15 cm tall	300	private	L. Benjamin & P. Francis	July 11, 2003	
Cedar Lake, Nictaux South	Annapolis	on or near lakeshore	550	70	Crown	L. Benjamin & T. Duke	Nov 10, 2004	only significant cedar site occurring on Crown land
Cedar Brook, Hillsburn	Annapolis	old pastures, forest	trees of all sizes observed	1000+	private	L. Benjamin	June 09, 2003	evidence of recent harvesting
Litchfield (about 2 km	Annapolis	roadside forest	?	50	private	L. Benjamin	June 09 2003	

Locality	County	Habitat	Regeneration	Population Size (reproducing individuals*)	Ownership	Observer(s)	Date Last observed	Observers Comments
west of Cedar Brook site)								
Watton Brook, Wilmot	Annapolis	brookside	6 seedlings	69	private	L. Benjamin	July 09, 2003	Hwy 101 built through population
Annapolis River above Middleton	Annapolis	riverside forest and pasture	active colonization occurring in pasture	300	private	L. Benjamin and G. Parsons	July 02, 2003	
Button Brook, near Bridgetown	Annapolis	forest	none observed	50	private	L. Benjamin et al.	July 11, 2003	limited harvesting has occurred
Daniels Brook (next brook east of Button Brook)	Annapolis	forest (former pasture)	present	1,000	private	L. Benjamin et al.	July 11, 2003	limited harvesting has occurred
Lawrencetown Lane (south of Lawrencetown)	Annapolis	dry hillside	many small trees present	100	private	L. Benjamin and Francis	July 11, 2003	limited harvesting has occurred
Ledgehill (south of Middleton)	Annapolis	mixed stand in old pasture	some regen observed	100	private	Bruce Carter	2003	
Petes Brook (west of South Williamston)	Annapolis	mixed stand along stream bank	none observed	12	private	Bruce Carter	2003	
Paradise (Hwy. 101, west of Paradise, where abandoned rr crosses highway)	Annapolis	part cutover, part pasture	approximately 20 seedlings	50	private	L. Benjamin	May 10, 2004	highway divides stand; some recent limited harvesting
Victoria Vale	Annapolis	roadside forest	seedlings present	approx. 25	private	T. Neily	2004	
Thompson Station (Trans Canada Highway)	Cumberland	forest	limited regen	174	private	R. Hall	Nov. , 2004	Hwy 104 built through stand; part of stand is adjacent to a clearcut
Racetrack Brook/Steep-bank Brook (north of Racetrack Brook)	Cumberland	forest and swamp	limited regen due to deer and hare browsing	900	part private, part Crown	R. Hall	Dec. 12, 2004	
Amherst Point Migratory Bird Sanctuary	Cumberland	in dense, mixed forest	?	?	part private, part Federal	H. Harries	Jan 24, 1991	
Dockertys Brook	Cumberland	mature, mostly softwood forest	no regen	600	private	R Hall & G. Cloney	Oct 28, 2004	some selective harvesting has occurred in the past
Eatonville	Cumberland	bog	?	12	private	B. Ells	Dec 01,	

Locality	County	Habitat	Regeneration	Population Size (reproducing individuals*)	Ownership	Observer(s)	Date Last observed	Observers Comments
							2004	
Black Lake	Cumberland	forest?	?	200	private	G. Cloney	Oct 27, 2004	
Barnes Lake	Digby	wetland	?	?	private	Maurice Comeau	2002	
Tusket River (Long Tusket Lake)	Digby	?	?	?	private	J. Lane-Cloud	Sept 4, 1917	
Hectanooga	Digby	swamp	?	4000?	private (small section is Crown)	A. Wilson & B. Wright	Aug 14, 1986	
Cedarwood Lake (near Corberrie)	Digby	?	?	?	private	P. M. Taschereau	May 02, 1970	
Cedar Lake	Straddles Digby/Yar-mouth County Line	lake edge	?	?	private (small section is Crown)	R. Muise	Dec., 2004	
Norwood Clearwater Lake	straddles Digby/Yar-mouth County Line	forest	none observed	25	private	Maurice Comeau	July 24, 2003	
Rockland	Kings	old pasture returning to forest	275	477	private	L. Benjamin	June 23, 2003	
Tremont	Kings	pasture	?	?	private	E. C. Smith et al.	July 05, 1956	
Prospect	Kings	forest	no regen present	1(a single tree in poor health)	private	L. Benjamin	June 23, 2003	site was clearcut sometime in last 50 years – one tree remaining
Bond Road, South Waterville	Kings	forest	1	0	private	L. Benjamin	June 10, 2002	
Zwickers Lake**	Annapolis	part old field and part regenera-ting cutover	no seedlings present	80		J. Mills & L. Benjamin	Sept 16, 2003	most likely trees are descendant s of planted stock that have regenerated naturally
Acaciavile**	Digby	old farm returning to forest	present	20+	private	L. Benjamin	July 07, 2003	a heavily disturbed site; cedar may have originally been transplante d to site but is now regeneratin g naturally

*trees 10 cm dbh or larger

**populations suspected to have originated from planted trees

Search Effort

The majority of sites (24 out of 32) listed in Table 1 have been verified within the last three years. Recent site checks involved recording map coordinates, rough population estimates and size classification, evidence of regeneration, general observations on disturbance levels, etc.

Abundance

A rough estimate of the total number of individuals of cedar within Nova Scotia is 13,000 – 15,000. Please keep in mind that population sizes remain to be determined or in some populations as well as numbers of seedlings and saplings < 10 cm dbh .

It is estimated here based on population size numbers in Table 1, that the number of mature individuals is approximately 12,000.

Fluctuations and trends

Because cedar is long-lived, there are no short-term fluctuations in populations sizes.

Because of the extensive history of agriculture in the Annapolis Valley it is considered highly likely that populations have been lost in this part of Nova Scotia This also may apply to other parts of the province given that cedar has been documented from counties that no longer are known to have cedar today (Johnson, 1986, Hawboldt and Bulmer,1958).

Nearly all size classes of cedar have been and continue to be highly valued for a variety of uses (canoe construction, fence posts, ships knees, cedar chests, outdoor furniture, etc.) Because of this some populations have undoubtedly been harvested heavily possibly to the point of eradication over the years.

It is assumed that logging has resulted in a decrease in numbers of cedar at some locations. Highway construction has eliminated trees within three populations in recent years (Table 1).

Pasture establishment may have led to some population expansion particularly in the Annapolis Valley along the north-facing slope of the South Mountain. However there is no way of knowing if this translates into an increase in population sizes or simply a partial recovery of former populations.

Bentley & Smith (1957-58) wrote that the cedar stands in Nova Scotia have proven to be so localized and small that the species has likely gone unnoticed on many of the inland lakes and streams in the western part of the province. This reasoning has proven to be accurate over much of its current range in Nova Scotia. New populations have been documented from a number of different locations in the past year.

Rescue Effect

It is likely that cedar from New Brunswick would be adapted to survive in Nova Scotia but the Chignecto Isthmus may hinder propagule migration as most of the isthmus is open marshland and appears to be unsuitable habitat for cedar establishment. The possibility exists for accidental dispersal via waterfowl or mammals.

LIMITING FACTORS AND THREATS

Nova Scotia
In Nova Scotia, the most significant current threat to cedar appears to be clearcutting. Because many populations are small and localized, they may be cut inadvertently. This situation is compounded by the fact that recent field observations indicate that many populations exhibit low levels of regeneration (L. Benjamin, pers. comm. 2005; R. Hall, pers. comm. 2005).

Deer, snowshoe hare and rodents may be limiting factors with respect to seedling survival in Nova Scotia (R. Hall, pers. comm. 2005). Growing deer populations pose a serious threat to cedar populations in the Great Lake States of Michigan, Wisconsin and Minnesota (Miller, 1990, Johnston, 1990; Heitzman *at al*., 1997; Rooney, et al., 2002) by browsing cedar regeneration. In Nova Scotia there is no direct evidence at the moment that deer browsing posses a similar threat to cedar populations.

Cedar as a rule, displays high seedling mortality rates due mainly to drought (Johnston, 1990). Other causes cited by Johnston include smothering by sphagnum moss or logging slash, cutting or girdling by small rodents and deer browsing.

Bentley & Smith (1957-58) noted reproduction of cedar in lake-side sites to be excellent with seedlings per acre ranging from 2,400 to 20,348. There was however, a striking sparsity of young trees more than 10 years of age and less than one inch dbh at these same sites. A similar situation was reported in Maine by Curtis (1946) who suggested that high seedling mortality might be due to a lack of light, low nutrient levels, and/or to variable moisture conditions.

In well established old-pasture cedar stands, Bentley & Smith (1957-58) found that reproduction was sparse whereas in the younger, more open stands, it tended to be higher. Also, in the younger, open stands, trees size class < 1 inch dbh were commonly present, but in the more mature stands these were rare or absent.

Other perhaps less imminent threats to cedar in Nova Scotia include larger, knot-free individuals being targeted for canoe, sauna, closet or chest construction; highway construction (at least three populations have had highways built through them); land-clearing for agriculture; harvesting for fence posts (L. Benjamin, pers. comm. 2005; R. Hall, pers. comm. 2005).

Heavy damage to trees by bears has been observed on several occasions (L. Benjamin, pers. comm. 2005; R. Hall, pers. comm. 2005).

Bentley and Smith (1957-58) reported cedar to be a poor competitor in Nova Scotia occurring in habitats where there is minimal competition.

Dr. G. W. I. Creighton, a former Deputy Minister of the Nova Scotia Department of Lands and Forests, attributes the rarity of cedar in Nova Scotia to soil pH. He feels that Nova Scotia's soils are simply too acidic to sustain cedar populations (pers. comm. 2005).

General
Limiting factors and threats described by Johnston (1990) in the Silvics of North America include the following:

- Porcupines sometimes kill cedar trees or lower their growth and timber quality by feeding heavily on foliage and by girdling stems and branches
- Red squirrels frequently clip branchlets with flower buds and cone clusters, and thus may significantly reduce the supply of seed available for reproduction
- The relatively shallow root system makes cedar susceptible to uprooting where trees are exposed to the wind
- Short trees and regeneration are often over-browsed by deer and hare
- Impeded drainage caused by road construction in northern Minnesota, has killed or reduced growth of white cedar and associated species on thousands of acres of organic soil
- Beaver damming can also negatively impact cedar stands by altering drainage patterns
- Natural gas and petroleum pipelines have the potential to alter drainage patterns
- The roots of cedar are easily exposed due to their shallowness and thereupon can be trampled by animals as well as subjected to drying from fluctuating water tables
- The roots are readily damaged in a fire due to their shallowness
- Cedar has only a moderate tolerance of deicing salts. Branches exposed to salt spray along highways commonly suffer severe dieback
- The bark is very thin and has high oil content and as such is susceptible to fire damage.

Moisture is a critical factor with respect to white cedar in a swamp. Abnormally high water levels, or slow-moving ground water, or stagnant ground water restricts aeration, tends to reduce the rate of growth and in some cases kills the entire stand (Johnston, 1990)

Compared to other tree species, cedar is relatively free of insect pests and diseases. According to Johnston (1990), the most common insect pests are carpenter ants, both the black (*Camponotus pennsylvanicus*) and red carpenter ant (*C. ferrugineus*) and leafminers (*Argyresthia thuiella* and *Coleotechnites thujaella*). Trees growing on poor sites may be more susceptible to an insect infestation. Cedar has few serious diseases as a forest tree. In cultivation it is subject to several seedling and foliage diseases. Several root- and butt-rot fungi attack cedar but these mainly attack old or damaged trees. The most common outward

sign of rot is woodpecker holes.

Farrar (1995) states that although the dry wood is resistant to decay, the living trees are subject to heart-rot, hence, many trees have hollow trunks.

In Ontario, cedar is susceptible to drought, salt-damage, animal browsing in winter, and flooding caused by beaver damming or road construction (Ontario Landowner Resource Centre, 2005).

SPECIAL SIGNIFICANCE OF THE SPECIES

Cultural
Cedar has played and continues to play a fairly significant role in the lives of Nova Scotia's First Nations People, the Mi'kmaq.

It is an important ceremonial plant. In smudging ceremonies the smoke from burning sweet grass, cedar, or sage, is brushed toward one's body to cleanse the spirit (Mi'kmaq Resource Centre, Oral Histories, 2005).

Because cedar wood is lightweight and easily split, it was utilized in the construction of canoes. Cedar slats were used for the inside lining of the canoe as well as for the ribs. It may also have been used for the gunwales.

Cedar was also used to make arrow shafts and the shredded outer bark and the wood were used to start fires.

The Mi'kmaq made bags and mats out of cedar bark along with a number of other natural items such as reeds, grasses and cattail leaves (Nova Scotia Museum, 2005).

Van Wart (1948) states that the Mi'kmaq used cedar to make a poultice to treat swollen hands and feet. Moerman (1998) describes the following medicinal uses by the Mi'kmaq of *Thuja occidentalis*: analgesic (stems used for headaches); burn dressing (inner bark, bark, and stems used for burns; cough medicine (inner bark, bark, and stems used for coughs); orthopedic aid (leaves used for swollen feet and hands); toothache remedy (gum used for toothaches; tuberculosis remedy (inner bark, ark, and stems used for consumption).

The Mi'kmaq of Maine make a traditional basket of split cedar as well as wooden flowers out of strips of cedar (Aroostook Band of Micmacs, 2005).

Construction Industry
Cedar wood, because it is highly resistant to decay is valued for log home construction, poles, posts, shingles, canoes, outdoor furniture, hottubs, etc.

Medicines, household cleansers, personal care products, etc.
"Cedar leaf oil" is distilled from boughs and used in medicines and perfumes. However caution seems highly appropriate as the leaf oil is reported to be toxic and has caused fatalities is some cases (Foster and Duke, 2000). The essential oil is also used in cleansers, disinfectants, hair preparations, insecticides, liniment, room sprays and soft soaps.

Wildlife
With respect to wildlife, deer, snowshoe hare, porcupine and small rodents have all been reported to browse this species throughout its North American range. In some areas cedar regeneration has been virtually eliminated due to deer browse. It is unknown whether deer, hare, porcupine and/or rodent browsing pose significant threats to Nova Scotia's cedar populations.

Mature stands of cedar provide important winter cover for white-tailed deer in parts of its range. Cedar stands in Nova Scotia probably do not play a significant role in terms of providing winter cover for wildlife due to the limited number of stands present.

Pileated woodpeckers have been reported to feed on carpenter ants that, in turn, nest in and feed on cedar heartwood. In Nova Scotia, interactions between cedar and other species such as described in the previous sentence are likely opportunistic for the most part due to the limited distribution of cedar within Nova Scotia.

Seeds are eaten by redpolls and pine siskins.

Horticultural Industry
Thuja occidentalis is widely utilized in ornamental silviculture (more than 120 cultivars have been named and used as ornamental trees and shrubs).

Historical
Cedar is believed to be the first North American tree introduced into Europe (about 1566) (Chambers, 1993).

It is thought to be the tree that saved the crew of Jacques Cartier from scurvy. Native people showed the scurvy ridden French explorers how to prepare a tea from the foliage and bark of a tree. This tea was high in Vitamin C. The king of France subsequently named the tree "l'arbre de vie" or tree of life. Arborvitae is Latin for "tree-of-life".

EXISTING PROTECTION OR OTHER STATUS DESIGNATIONS

Thuja occidentalis is designated as a Red species in Nova Scotia (Nova Scotia's General Status Ranks, 2005). A "red" designation indicates a species known to be, or that is thought to be at risk. Because cedar is not listed under the Nova Scotia Species at Risk Act, it has no legislated protection.

The population located within the Amherst Point Migratory Bird Sanctuary is not protected

by virtue of being located within the sanctuary, i.e., there are no provisions for habitat protection in migratory bird sanctuaries. However, because this particular sanctuary is located within the Chignecto National Wildlife Area, cedar at this location is protected under the regulations of the Canada Wildlife Act which prohibits any person from damaging vegetation within NWA boundaries (A. Kennedy, pers. comm. 2005).

Cedar has a global status rank of G5 (demonstrably secure globally), a Canadian national status rank of N5 (secure) and a provincial status rank of S1S2 (ACCDC, 2005). A S1S2 ranking means that there is some uncertainty as to the exact rank with S1 being extremely rare and S2 being rare.

In the rest of Canada, *Thuja occidentalis* is ranked as S4 (apparently secure) in Manitoba, SNR (provincial conservation status not yet assessed) in New Brunswick and Newfoundland, and S5 (secure) in Ontario, Prince Edward Island and Quebec.

In the United States, cedar has a national status of N5. Within the individual states it is assessed as indicated in the table below (Table 2).

Table 2. NatureServe sub-national status ranks for *Thuja occidentalis* for individual states in the United States.

NatureServe Subnational Status Rank*	Explanation of Status Rank	State
S1	Critically imperiled	Illinois, Indiana, Maryland, Massachusetts, New Jersey
S2	Imperiled	Connecticut, West Virginia
S2S3	Uncertainty exists as to whether or not the rank should be S2 or S3	Kentucky
S3	Vulnerable	Ohio, Tennessee
S5	Secure	Maine
SNA	Not applicable (species not considered a suitable target for conservation activities)	Iowa, North Carolina,
SNR	Unranked (conservation status not yet assessed)	Michigan, New Hampshire, New York, Rhode Island, Vermont, Virginia, Wisconsin
SU	Currently unrankable due to lack of information	South Carolina

*NatureServe, 2005

TECHNICAL SUMMARY

Thuja occidentalis

Northern White Cedar cèdre, balai

Range of Occurrence in Nova Scotia: Yarmouth, Digby, Annapolis, Kings and Cumberland Counties

Extent and Area Information	
• *Extent of occurrence (EO)(km²)*	2,804 km²
• *Specify trend in EO*	long-term decline, currently stable?
• *Are there extreme fluctuations in EO?*	no
• *Area of occupancy (AO) (km²)*	7.63 km²
• *Specify trend in AO*	declining
• *Are there extreme fluctuations in AO?*	no
• *Number of known or inferred current locations*	30 (excluding 2 sites thought to be introductions)
• *Specify trend in #*	stable?; # of known locations likely to increase with more field effort
• *Are there extreme fluctuations in number of locations?*	no
• *Specify trend in area, extent or quality of habitat*	declining

Population Information	
• *Generation time (average age of parents in the population)*	unknown
• *Number of mature individuals*	~12,000
• *Total population trend:*	declining
• *% decline over the last/next 10 years or 3 generations.*	unknown
• *Are there extreme fluctuations in number of mature individuals?*	no
• *Is the total population severely fragmented?*	yes
• *Specify trend in number of populations*	probably declining
• *Are there extreme fluctuations in number of populations?*	no

- List populations with number of mature individuals in each:
  - Eel Weir Brook – 32
  - West Paradise – 300
  - Cedar Lake/Nictaux South – 70
  - Cedar Brook, Hillsburn – 1000+
  - Litchfield – 50
  - Watton Brook – 70
  - Annapolis River (Middleton) – 300
  - Button Brook (Bridgetown) – 50
  - Daniels Brook (Bridgetown) – 1000
  - Lawrencetown – 100
  - Ledgehill (Middleton) – 100
  - Petes Brook (South Williamston) – 12
  - Paradise – 50
  - Victoria Vale – 25
  - Thompson Station – 174
  - Racetrack Brook/Steepbank Brook – 900
  - Amherst Point Migratory Bird Sanctuary - ?
  - Dockertys Brook – 600
  - Eatonville – 12
  - Black Lake – 200
  - Barnes Lake - ?
  - Long Tusket Lake -?
  - Hectanooga – 4000?
  - Cedarwood Lake - ?
  - Cedar Lake (Digby/Yarmouth County line) - ?
  - Norwood Clearwater Lake – 25
  - Rockland - 477
  - Tremont - ?
  - Prospect – 1
  - Bond Road (South Waterville) – 0

The following two sites are thought to have originated from planted trees:

- Zwickers Lake – 80
- Acaciaville – 20+

Threats (actual or imminent threats to populations or habitats)

Clearcutting is probably the main threat to Nova Scotia's cedar populations.

Rescue Effect (immigration from an outside source)

- *Status of outside population(s)?*
  New Brunswick: common mainly in calcareous areas (Hinds, 2000)
  [other jurisdictions or agencies]

• *Is immigration known or possible?*	seems unlikely
• *Would immigrants be adapted to survive in Nova Scotia?*	probably
• *Is there sufficient habitat for immigrants in Nova Scotia?*	yes
• ***Is rescue from outside populations likely?***	no

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Taylor, Barry. Associate Professor and Curator of Herbarium, Department of Biology, St. Francis Xavier University, Antigonish, NS.

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COLLECTIONS EXAMINED

The following herbarium collections were consulted:

- E.C. Smith Herbarium (ACAD)
- Nova Scotia Museum of Natural History (NSPM)
- Chignecto Herbarium, Mount Allison University
- Herbarium, St. Francis Xavier University