COSEWIC
Assessment and Status Report

on the

Beach Pinweed
Lechea maritima

in Canada

SPECIAL CONCERN
2008

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

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Beach pinweed — supplied by the author.

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COSEWIC
Assessment Summary

Assessment Summary – April 2008

Common name
Beach pinweed

Scientific name
Lechea maritime

Status
Special Concern

Reason for designation
The Canadian populations have been recognized as an endemic variety of global significance. Plants are restricted to stabilized sand dunes within localized areas of coastline in New Brunswick and Prince Edward Island. The majority of the 15 populations, including the three largest, occur at elevations under 5 m above sea level. Here they are at increased risk from the impacts of severe storm surges resulting from rising sea levels and increased storm frequency and intensity predicted to occur as a consequence of climate change. A recent storm surge has already impacted a substantial portion of potential habitat at one of the New Brunswick sites. Other impacts have also been documented as a consequence of trampling, all terrain vehicle use, and successional changes to the species' habitat.

Occurrence
New Brunswick, Prince Edward Island

Status history
Designated Special Concern in April 2008. Assessment based on a new status report.

COSEWIC
Executive Summary

Beach Pinweed
Lechea maritima

Species information

Beach pinweed (*Lechea maritima*) is an herbaceous perennial in the family Cistaceae. The Canadian populations have been recognized as a unique variety, the Gulf of St. Lawrence beach pinweed (*Lechea maritima* var. *subcylindrica)*. Since this is the only variety of *Lechea maritima* in Canada, this report documents the status of the Canadian populations at the species level and only refers to the var. *subcylindrica* when necessary for clarity. The species occurs on stable coastal sand dunes. Prostrate, densely leafy basal shoots develop from the woody base, often forming a rosette, and the fruiting stems are (10) 20-35 cm tall, usually erect and strongly branched. Plants flower in mid- to late summer and develop fruit in late summer and early fall. The numerous, inconspicuous flowers (2-4 mm wide) have three short-lived, reddish-brown petals. The fruit is a round, 3-valved capsule (1.8-2.1 mm long) usually shorter than the sepals, splitting open lengthwise to the base. The seeds, generally 4-5 per capsule, are smooth and 1-1.1 mm long, and without obvious adaptations for dispersal. Beach pinweed is best distinguished from the other pinweed in its range (narrowleaf pinweed, *Lechea intermedia*) by the densely white-hairy undersides of its basal leaves and by its smooth seeds.

Distribution

Beach pinweed is globally secure and occurs primarily along the Atlantic coast from New Brunswick to North Carolina. Reports from Ontario and Quebec are unsupported and likely erroneous. Gulf of St. Lawrence beach pinweed is globally rare and endemic to New Brunswick's eastern coast and Prince Edward Island's northern shore, 370 km disjunct from the nearest occurrence of variety *maritima* in southern Maine. On Prince Edward Island, populations occur on over 41 km of shoreline, with a single occurrence 54 km west. In New Brunswick, the northern and southernmost occurrences are spread over an 87 km straight-line distance. The species' Extent of Occurrence is 176 km^2 (sum of distances between population extremities along coastal shorelines in NB and PE times 1 km width) and its Area of Occupancy is 71 km^2 based on occupied 1 km grid squares or 152 km^2 using a 2 x 2 km grid.

Habitat

Beach pinweed is restricted to large, stable barrier dune systems, usually in open, dry habitats. It is apparently unable to tolerate highly active dune sections and is typically found in comparatively sheltered sites, often with the low shrub beach heather (*Hudsonia tomentosa*), a strong indicator of potential habitat. It is also found locally in open jack pine–red pine woodland on old dunes but these populations are small and limited to the most open woodland, suggesting that this habitat may be suboptimal.

Biology

The species is perennial from a stout, woody taproot, forming rosettes of prostrate basal shoots and sending up 1-5 flowering stalks. Reproduction is by seed, and dispersal is probably primarily by wind and water. Wind pollination is suspected but insect pollination is also possible. *Lechea* has been reported as primarily self-pollinating but unconfirmed suggestions of hybridization would indicate cross-pollination. Under certain conditions it can reproduce at very small sizes in its second or perhaps its first season, but most plants appear to be significantly older. Generation time is not well known, but is estimated here at 8-10 years.

Population sizes and trends

The total population in Canada is estimated at 181,000 plants in 15 populations within five areas, with little genetic exchange likely between those five areas. There is no direct evidence on long-term trends but five historic sites, discovered between 1892 and 1932, are still extant. At least one site has experienced recent minor declines due to storm damage, and storm frequency and intensity are likely to increase with climate change. Minor losses to ATV traffic and trampling have been noted at a few sites, and succession may be an issue at the two sites with forest cover.

Limiting factors and threats

The species is naturally limited by its highly specialized habitat. Sea-level rise and climate change-induced increases in storm frequency and intensity could be a long-term threat to the species and its habitat, given that much of the population is under 5 m elevation, and storm-caused decline in habitat quality has been noted at the lowest elevation sites supporting the majority of the population. It is not possible, however, to quantify climate change - related threats with any precision. Minor losses to ATV traffic and trampling have been noted at a few sites, and succession may be an issue at the two sites with forest cover. It is relatively well-protected from shoreline development by protected areas, provincial regulation and remoteness of occurrences.

Special significance of the species

Beach pinweed, when recognized as a distinct Canadian variety, is a globally rare endemic restricted to a very limited area, and is 380 km disjunct from the variety

maritima plants from which it evolved. It is one of a number of southern species with disjunct occurrences on the relatively warm Gulf of St. Lawrence. No evidence of First Nations use of the plant or of any other human use was found.

Existing protection or other status designations

Beach pinweed has no existing legal protection, although it benefits from provincial laws and regulations governing development and limiting activity in coastal areas. Seven of 15 populations are protected in Kouchibouguac and Prince Edward Island National Parks, Portage Island National Wildlife Area, Bouctouche Dune and Cabot Beach Natural Area. Four other sites are on provincial (two Conway Sandhills populations) or federal land (two Hog Island populations, on land held in trust for the Lennox Island First Nation). The species is ranked globally as G5T1 (secure as a species but the variety is critically imperiled), although revision to G5T2 could be warranted because of recent fieldwork. It is ranked S1 (critically imperiled) and *May be at risk* in New Brunswick and Prince Edward Island, meaning it would receive consideration in provincial and federal environmental impact assessments.

In total, about 33% of the habitat containing the species is within protected areas.

COSEWIC HISTORY

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list. On June 5, 2003, the *Species at Risk Act* (SARA) was proclaimed. SARA establishes COSEWIC as an advisory body ensuring that species will continue to be assessed under a rigorous and independent scientific process.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, arthropods, molluscs, vascular plants, mosses, and lichens.

COSEWIC MEMBERSHIP

COSEWIC comprises members from each provincial and territorial government wildlife agency, four federal entities (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biodiversity Information Partnership, chaired by the Canadian Museum of Nature), three non-government science members and the co-chairs of the species specialist subcommittees and the Aboriginal Traditional Knowledge subcommittee. The Committee meets to consider status reports on candidate species.

DEFINITIONS (2008)

Wildlife Species	A species, subspecies, variety, or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus, that is wild by nature and is either native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.
Extinct (X)	A wildlife species that no longer exists.
Extirpated (XT)	A wildlife species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A wildlife species facing imminent extirpation or extinction.
Threatened (T)	A wildlife species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
Not at Risk (NAR)**	A wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances.
Data Deficient (DD)***	A category that applies when the available information is insufficient (a) to resolve a species' eligibility for assessment or (b) to permit an assessment of the species' risk of extinction.

* Formerly described as "Vulnerable" from 1990 to 1999, or "Rare" prior to 1990.

** Formerly described as "Not In Any Category", or "No Designation Required."

*** Formerly described as "Indeterminate" from 1994 to 1999 or "ISIBD" (insufficient scientific information on which to base a designation) prior to 1994. Definition of the (DD) category revised in 2006.

Environment Canada
Canadian Wildlife Service

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COSEWIC Status Report

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SPECIES INFORMATION

Name and classification

Scientific name:	*Lechea maritima* Leggett
Synonyms:	*Lechea maritima* Leggett var. *subcylindrica* Hodgdon
Species-level synonymy:	*Lechea thymifolia* Pursh
	Lechea minor L. var. *maritima* A. Gray
English vernacular names:	Beach pinweed, Gulf of St. Lawrence beach pinweed, maritime pinweed, hoary pinweed, seaside pinweed
French vernacular names:	Léchéa du Golfe Saint-Laurent, Léchéa maritime, Léchéa de la mer
Family:	Cistaceae, rock-rose family
Major plant group:	Eudicot flowering plant

Beach pinweed (*Lechea maritima*) is a member of the Cistaceae, a medium-sized family of about 200 species in nine genera. The family is composed of mesophytic and xerophytic herbs, shrubs and sub-shrubs, and reaches its highest concentrations of species in arid Mediterranean regions of the Iberian Peninsula and the Atlantic Coastal Plain of North America (Hodgdon 1938).

The genus *Lechea* L., containing 17 species (Hodgdon 1938), is restricted to the United States, Canada and northern Mexico, with the exception of one species endemic to western Cuba and two species present in southern Mexico, Belize and Guatemala. Commonly referred to as pinweeds, the species in this genus are typically perennial or biennial herbs found growing on dry sandy or rocky substrates in open and exposed habitats. Their diversity is highest on the Atlantic Coastal Plain. The genus was named by Kalm in 1751 in honor of John Leche, a Swedish botanist, and was taken up by Linnaeus in 1753 in the first edition of *Species Plantarum* (Britton 1894). As was summarized by Hodgdon (1938), it subsequently underwent several revisions in the 19th century, but variability and the often microscopic diagnostic characters led to great variations between the early treatments. The most recent and complete revision is that of Hodgdon (1938), which established the species concepts in use today.

Despite a somewhat confusing taxonomic history outlined below, beach pinweed (*Lechea maritima*) is considered distinct from all other Canadian *Lechea* species (David Lemke, author of *Lechea* account for *Flora of North America*, pers. comm.). The Gulf of St. Lawrence variety of beach pinweed (*Lechea maritima* var. *subcylindrica*) is the only variety definitively known for Canada, with reports of *Lechea maritima* var. *maritima* from Quebec and Ontario apparently erroneous, as outlined under *Canadian Range* below. Thus, although the distinctness of var. *subcylindrica* may warrant further taxonomic enquiry, at the species level *Lechea maritima* is definitely a valid unit for COSEWIC status evaluation.

Lechea maritima Leggett was first included within *L. thymifolia* Pursh in 1814. *Lechea maritima* has at times also been included under *L. thymifolia* Michaux, a name

that is properly synonymized with the present *L. minor* L. (Hodgdon 1938). Gray's work in 1890 referred to *L. maritima* as *L. minor* L. var. *maritima* A. Gray. Britton's revision of the genus in 1894 established the name *L. maritima* Leggett for *L. thymifolia* Pursh. Hodgdon (1938) described marked variants of the species, including var. *subcylindrica*, on the basis of differences in panicle shape and branching, sepal characters and seed number, with the type specimen of var. *subcylindrica* having been collected by S.F. Blake in 1913 on Portage Island, New Brunswick, and located at the Gray Herbarium. Hodgdon specifically identified all the Canadian records known at that time, from five New Brunswick sites, as variety *subcylindrica*. The distinctness of *Lechea maritima* var. *subcylindrica* Hodgdon has not been specifically investigated since that time, but the variety was retained by Fernald (1950) and Kartesz (1999) and was noted as "segregated on minor differences" in Gleason and Cronquist (1991). Hodgdon (1938) examined no specimens from Prince Edward Island, but specimens collected there in recent years key to var. *subcylindrica* (Catling *et al*. 1985, D.M. Mazerolle & C.S. Blaney, pers. obs.), with some variation in inflorescence shape.

Morphological description

The following description has been derived from Hodgdon (1938), Barringer (2004), Fernald (1950), Gleason and Cronquist (1991) and Britton (1894). Figure 1 illustrates the plant in the field.

The following description is based on *Lechea maritima* var*. subcylindrica.* Beach Pinweed is a low, herbaceous perennial arising from a woody taproot up to 10 cm long. The fruiting stems are (10) 20-35 cm long, reclining to erect and strongly branched. Prostrate to reclining basal shoots 3-10 cm long develop from the woody base, often forming a rosette. The crowded basal leaves are whorled, thick, dull green, lanceolate to elliptic-lanceolate, 5-12 mm long, 2-5 mm wide, minutely pilose above and densely white pilose below. The stem leaves are narrowly elliptic to narrowly oblanceolate, 7-25 mm long, 1.2-4 mm broad. They are scattered-pilose over the lower surface with a smooth to scattered-pilose upper surface becoming glabrous in maturity. Stem leaves are opposite or whorled, with the lowermost sometimes subopposite. Leaves on branches are alternate, often crowded and mostly persistent and are shorter and proportionately narrower. The inflorescence is a narrowly subcylindric panicle, as referenced by the varietal name, with branching beginning mostly above the middle of the stem. Numerous inconspicuous flowers are crowded in small axillary or terminal clusters of 3-6 or are arranged in racemes on short tertiary branches borne towards the secondary branch tips. Flowers are 2-4 mm broad and perfect with a superior ovary. The 3 petals are short-lived, reddish-brown and generally shorter than the sepals. Flower structures are regular except for the slightly depressed-globose persistent calyx (2 mm or slightly more in length), which is of 5 sepals in two distinct series. The inner 3 sepals are thin and membranous, obscurely keeled, pubescent, ovate-elliptic and subacute while the outer 2 are leaf-like, narrowly lanceolate to linear and shorter than or equal to the inner. Number of stamens varies, even among flowers on the same plant, from 6 to 10 or more. There are 3 fringed-plumose stigmas, either sessile or on a very short style. The fruit is an ovoid or globose 3-valved capsule (1.8-2.1 mm long) usually shorter than the calyx, splitting open lengthwise to the base. The (3)4-5(6) seeds per

Figure 1. Beach pinweed (*Lechea maritima*) with two flowering stems and basal rosette. beach pea (*Lathyrus japonicus*) and American beachgrass (*Ammophila breviligulata*) are in the right foreground.

capsule are 1-1.1 mm long, dull light brown in color, smooth and nearly equilateral with a convex dorsal surface and a convex or keeled ventral surface. They lack a membranous cover and a slender straight or curved embryo is faintly discernible through the semitransparent endosperm.

Excerpted from Hodgdon's (1938) analysis of *Lechea maritima*, the following key distinguishes var. *subcylindrica* from var. *maritima*. An additional variety, var. *virginica*, occurs in coastal southern Virginia and northern North Carolina and has been confirmed as distinct in a recent study (Sorrie and Weakley 2007).

> Panicles thick-subcylindric to broadly subpyramidal, and mostly uniformly branching at about the middle of the stems. Calyx mostly pyriform to obconic or subglobose (cuneate-obovoid), 2 mm or less in length. Outer sepals inconspicuous and much shorter than the inner. Seeds 3-4 (rarely 5). Ranging from Maine to Maryland. var. *maritima*

var. *maritima*

> Panicles slenderly subcylindric, their branches mostly from above the middle of stem. Calyx slightly depressed-globose, 2 mm or slightly more in length. Outer sepals often conspicuous and sometimes nearly equaling the inner. Seeds 4-5(6).

Restricted to Gulf of St. Lawrence coasts of New Brunswick and Prince Edward Island. var. *subcylindrica*

var. *subcylindrica*

Mature specimens with basal shoots and use of a hand lens may be necessary for positive identification of many *Lechea* species. The Canadian populations of beach pinweed are geographically isolated from other *L*. *maritima* varieties in the U.S. and are sympatric only with narrowleaf pinweed (*Lechea intermedia*), a more common and less habitat-specific species. In Canada, *Lechea maritima* and *L. intermedia* can occur in close proximity and are best distinguished by basal leaf pilosity and seed texture. In *L. intermedia*, mature seeds are conspicuously reticulate, and pubescence on the undersurface of basal leaves is restricted to the midribs and margins. In *L. maritima* var. *subcylindrica* seeds are smooth and basal leaves are pubescent over the entire undersurface.

Genetic description

David Lemke, author of the Flora of North America treatment for *Lechea*, is unaware of any chromosome counts or other genetic analysis of *Lechea maritima* or any other *Lechea* species (Lemke 2007, pers. comm. to Sean Blaney).

Designatable units

Only a single designatable unit is recognized since all of the populations occur within relatively restricted shoreline stretches within a single COSEWIC National Ecological Area (Atlantic) that encompasses the species' range in New Brunswick and Prince Edward Island.

DISTRIBUTION

Global range

Lechea maritima in the broad sense occurs from New Brunswick to North Carolina, reaching up to about 150 km inland in Massachusetts and New Hampshire, but otherwise occurring almost exclusively along the Atlantic coast. Despite its relatively restricted global range, *Lechea maritima* is considered widespread and secure (G5, NatureServe 2007). Kartesz (1999) cites Hodgdon (1938) for reports of *Lechea maritima* var. *maritima* from Ontario and Quebec, but no such reports are given in that paper and the reports are not considered valid by conservation data centre botanists Michael Oldham (Ontario, pers. comm.) and Jacques Labrecque (Quebec, pers. comm.).

The variety *subcylindrica* is endemic to the southern Gulf of St. Lawrence, where it has a very limited range on New Brunswick's eastern coast and Prince Edward Island's northern shore (Figure 2), over 370 km disjunct from the nearest occurrence of variety *maritima* in south-central Maine (Magee and Ahles 1999). On Prince Edward Island,

Figure 2. Global range of *Lechea maritima*.

almost all populations occur within 41 km of shoreline along Malpeque and Cascumpec Bays, with a single occurrence a further 54 km west. In New Brunswick, the northernmost and southernmost occurrences are spread over an 87 km straight-line distance, between Miramichi Bay and Bouctouche Bar.

Canadian range

When treated as a distinct variety, the Canadian populations are endemic to the southern Gulf of St. Lawrence and only occur on barrier sand dunes along

New Brunswick's eastern coast and Prince Edward Island's north coast (Figure 3). On Prince Edward Island, almost all plants occur within a 41 km stretch of shoreline along Malpeque and Cascumpec Bays, with a single occurrence a further 54 km west on Tracadie Bay. In New Brunswick, the northernmost and southernmost occurrences are spread over an 87 km straight-line distance, between Portage Island in Miramichi Bay and Bouctouche Bar.

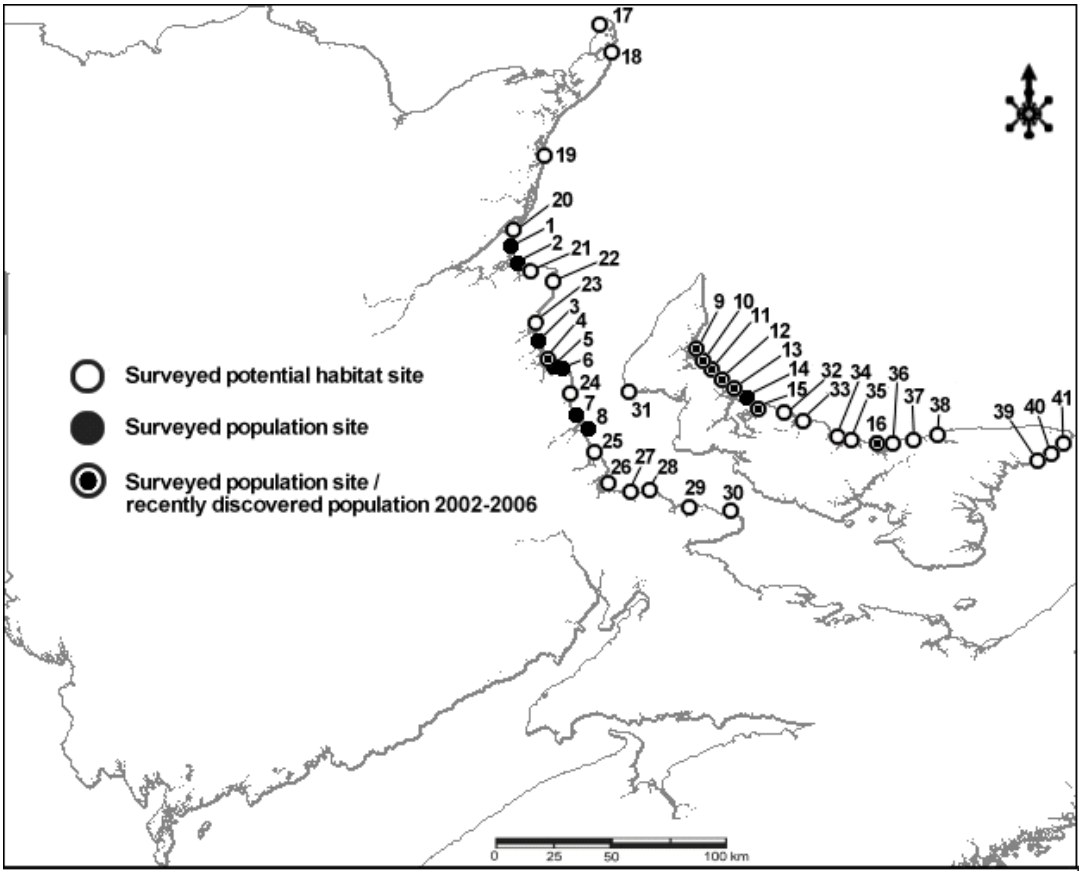

Figure 3. Canadian population sites of *Lechea maritima* and unoccupied potential habitat sites surveyed during AC CDC and Irving Eco-Centre fieldwork, 2003-06. Numbers correspond to sites listed in Table 1.

To date, the species has been observed on 11 dune systems in five areas. From these observations, a total of 15 populations are identified, each separated from other occurrences by at least one km of unsuitable habitat. Populations within the identified regions are separated from their next nearest population within a region by no more than 7 km (the two populations on Bouctouche Dune), while each of the five identified regions of occurrence are isolated from any of the other regions by at least 19 km. Table 1 lists the populations and identifies the regions and dune systems with which they are associated. The four populations over roughly 21 km of the Kouchibouguac-Richibucto barrier system in New Brunswick support an estimated 66% of the total population of the species. The other area of extensive occurrence is Prince Edward Island's Cascumpec-Malpeque barrier system that extends over about 41 km and includes a total of 7 identified populations.

Table 1. Sites surveyed for beach pinweed populations. For sites where pinweed was found, the region and dune system are noted. Sites are mapped in Figure 3. Note that there is no site number 11 because it was combined with site 10.

Surveyed Sites	Found?	Region	Dune System
1. Portage Island, NB	X	Miramichi Bay	Portage Island
2. Fox Island, NB	X	Miramichi Bay	Fox Island
3. South Kouchibouguac Dune, NB	X	Kouchibouguac-Richibucto	South Kouchibouguac
4. North Richibucto Dune, NB	X	Kouchibouguac-Richibucto	North Richibucto
5. South Richibucto Island, NB	X	Kouchibouguac-Richibucto	South Richibucto
6. South Richibucto Dune, NB	X	Kouchibouguac-Richibucto	South Richibucto
7. Bouctouche Dune, north section, NB	X	Bouctouche	Bouctouche
8. Bouctouche Dune, south section, NB	X	Bouctouche	Bouctouche
9. Cascumpec Sandhills, PE	X	Cascumpec - Malpeque Bays	Cascumpec Sandhills
10. Conway Sandhills, north section, PE	X	Cascumpec - Malpeque Bays	Conway Sandhills
12. Conway Sandhills, south section, PE	X	Cascumpec - Malpeque Bays	Conway Sandhills
13. Hog Island, north section, PE	X	Cascumpec - Malpeque Bays	Hog Island
14. Hog Island, southern section, PE	X	Cascumpec - Malpeque Bays	Hog Island
15. Cabot Beach Provincial Park, PE	X	Cascumpec - Malpeque Bays	Cabot Beach–Darnley
16. Blooming Point, PE	X	Tracadie Bay	Blooming Point
17. Grande Plaine, NB			
18. Chiasson Lighthouse, NB			
19. Île-au-Cheval, NB			
20. Neguac Dune, NB			
21. Preston Beach, NB			
22. Escuminac Beaches, NB			
23. North Kouchibouguac Dune, NB			
24. Chockpish Beaches, NB			
25. Cocagne Island, NB			
26. Shediac Island – Grande Digue, NB			
27. Cap-Brûlé – Cap-Bimet, NB			
28. Aboiteau Provincial Park, NB			
29. Grants Beach, NB			
30. Cape Jourimain Natl. Wildlife Area, NB			
31. Cedar Dunes, PE			
32. Campbells & Cousins Ponds, PE			
33. Cavendish Beach, PE			
34. Rustico Island, PE			
35. Brackley Beach, PE			
36. Deroche, PE			
37. Crowbush, PE			
38. Cable Head, PE			
39. Black Pond, PE			
40. Basin Head, PE			
41. South Lake, PE			

Extent of Occurrence, calculated as the distance between northern and southern New Brunswick populations plus distance between eastern and western Prince Edward Island populations, is 176 km^2. Using a 1 x 1 km grid, Area of Occupancy is 71 km^2. Using a 2 x 2 km grid, 38 grid squares are occupied yielding an Area of Occupancy of 152 km^2. The actual land area occupied by plants is under 5 km^2.

HABITAT

Habitat requirements

In Canada, the species is strictly coastal, occurring on large and relatively stabilized barrier dune systems. It usually grows in open habitats on sandy substrates with little or no soil profile development, limited moisture and low nutrient content. The species is apparently unable to tolerate conditions on highly active dune sections. Most known populations occur on sites rarely or never subjected to overwash and offering some protection from the full intensity of onshore winds, salt spray and storm-related sand deposition. Typical locations include the landward slopes of foredunes, stable secondary dune crests, and dry interdune and backdune swales and plains. These habitats are often distinguished by the presence of low shrubs, especially beach-heather (*Hudsonia tomentosa*) and bearberry (*Arctostaphylos uva-ursi*), with these species often exceeding 40% cover while adjacent areas are more thoroughly dominated by the more disturbance-tolerant American beachgrass (*Ammophila breviligulata*). Fieldwork indicates that beach pinweed's association with beach heather is particularly strong. In most populations, most plants were found growing with or near beach-heather, where the low shrub forms locally dominant and sometimes extensive patches. The herbaceous layer of beach pinweed sites is usually sparse, generally composed of American beachgrass with species such as sea-beach sedge (*Carex silicea*), shaved sedge (*Carex tonsa*), beach pea (*Lathyrus japonicus*), New-Belgium American aster (*Symphyotrichum novi-belgii*), Baltic rush (*Juncus balticus*) and seaside goldenrod (*Solidago sempervirens*), often with significant lichen cover.

Beach pinweed habitat differs on Portage and Fox Islands in New Brunswick's Miramichi Bay. There, beach pinweed occurs in open woodland on old dunes well back from the shore and dominated by Jack pine (*Pinus banksiana*) and red pine (*Pinus resinosa*) with white pine (*Pinus strobus*), grey birch (*Betula populifolia*) and trembling aspen (*Populus tremuloides*) and with an understory of beach heather, bearberry and lichens. Populations on these sites are smaller than other New Brunswick sites, and the fact that plants are limited to the most open areas of forest suggests that this habitat may be suboptimal because of competitive exclusion mediated by partial shading by tree cover.

Evidence of competitive exclusion on open dunes was found on Hog Island, Prince Edward Island, where extensive areas are dominated by dense cover of broom-crowberry (*Corema conradii*) in combination with bearberry. These areas appear to be a more advanced successional stage of unusually old or stable dunes that is not found on other beach pinweed dunes. The beach pinweed associate beach-heather was restricted to the

margins of occasional sandy blowouts in the broom-crowberry community and beach pinweed was entirely absent. There was also an apparent association between moderate levels of disturbance and greater seed germination at a few sites. A dune slack apparently subjected to a single storm surge event on Hog Island about two years prior to the site visit supported thousands of tiny but fertile pinweed plants, and the margins of an infrequently used ATV trail through open forested dune on Fox Island supported dozens of small plants. The ability of the small plants to survive in these areas and therefore their significance to the species' persistence at the sites was not clear.

Habitat trends

Coastal zones are dynamic environments, changing over time in location and in features, in response to long-term processes (e.g. isostatic adjustments, global water levels) (Forbes *et al.* 2006) and shorter term events (e.g. wave energy, storm surges). (O'Carroll *et al.* 2006). The current trends along the coast of the Northumberland Straight reflect the interaction of globally increasing water levels (due to ice melt and thermal expansion) and regional land subsidence (following the initial post-glacial rebound). Against this background of coastal retreat, there is potential for additional strong influences through the possible increase in the frequency of intense storms and the predicted reduction in the extent of winter ice formation, and its buffering function, during winter storms (Parkes *et al.* 2006).

The local expression of these complex processes is determined by the patterns of erosion, transport and deposition of sediment, as influenced by the local sediment budget, composition and height of the existing coastal features (e.g. cliffs, dunes), slope, orientation or exposure to wave action, fetch length and breaker-zone width, extent of shoreline structures or *hardening* of the shore, and nature of adjacent marine environment (e.g. water depth, currents) (O'Carroll *et al* 2006). In the case of dune systems, the outcome of the interaction of erosion and deposition may take several forms: landward migration of the dune, breaching or infilling, over-wash, destruction followed by eventual reconstitution, overall reduction or disappearance, or reshaping with parts of the dune appearing to grow while other parts are reduced (O'Carroll *et al*. 2006).

Recent increases in the frequency of severe storm events, potentially associated with human-caused climate change, have had an impact on coastal dunes supporting Canadian populations of beach pinweed, causing increased extent of flooding, erosion and breaching (Environment Canada 2006). A study of the evolution of southeastern New Brunswick coastal habitats immediately south of the pinweed occurrences shows a net decrease in the total area of beaches and dunes from 1944 to 2001 (O'Carroll *et al.* 2006a). Severe storm events have led to the opening of breaches and have left certain heavily affected areas devoid of vegetation and with lower topography. About 25% of the northern Bouctouche population has been affected by recent overwash events, with some portion of that 25% already lost (D.M. Mazerolle, pers. obs.). Information is insufficient to assess impacts on other sites but many sections of the Kouchibouguac barrier system including the South Kouchibouguac, North Richibucto and South Richibucto dunes have been notably modified in recent years (D.M. Mazerolle, pers. obs.).

Beach pinweed habitat at most other sites beyond those mentioned above has probably not yet had extensive storm impacts, because of higher elevations of foredunes. Thus climate change impacts are primarily a future threat to habitat. Future changes in climate and accelerated sea-level rise coupled with natural land subsidence are expected to exacerbate impacts on coastal habitats, increasing the likelihood of massive overwash and breaching and leading to destabilization and rapid landward dune migration (Shaw *et al*. 2001, O'Carroll *et al.* 2006a). Although habitat modification through storm disturbance is normal in coastal environments such as barrier dunes, a rise in the frequency and severity of disturbance could tend to change current pinweed habitat into much less suitable American Beachgrass-dominated dune or to bare sand. This issue is discussed in greater detail under *Limiting Factors and Threats* below.

Aside from the above-mentioned storm effects, change in habitat quantity and quality in occupied sites has likely been relatively minor within the last three pinweed generations (estimated to equal 24-30 years). Succession could be causing declines in the Fox and Portage Island sites, the only ones where pinweed occurs under tree cover. Local residents indicate that Portage Island has become substantially more wooded over the past 40 years and the same situation likely applies to Fox Island. Populations at these sites are relatively low and could be lost over time.

New Brunswick and Prince Edward Island have seen a considerable increase in development within coastal areas during the late twentieth century (NBDELG 2002, Prince Edward Island DAF 2003), resulting in habitat loss and fragmentation (Stewart *et al.* 2003). During fieldwork, numerous areas of potential habitat were found to have been impacted by construction of roads, houses, cottages, boardwalks and access ramps. This has, however, had minimal direct impact on known pinweed sites, and current land management and development guidelines will likely limit future direct impacts of development.

Coastline modification, where it hardens shorelines or alters currents, can have an indirect effect on pinweed habitat by impeding the longshore transport of sand, potentially creating a negative sediment budget for beaches and dunes (Stewart *et al.* 2003), which could be especially significant under conditions of rapidly rising sea-levels. Additionally, development can bring a rise in pedestrian traffic and recreational activities such as all-terrain vehicle (ATV) use. Beach pinweed habitat at South Richibucto Dune has been noticeably altered by vehicle traffic, with several well-worn vehicle tracks passing through pinweed patches, eliminating vegetation in certain areas and causing blowouts. Several other populations (especially those on the Bouctouche Dune and in Kouchibouguac and Prince Edward Island National Parks) are situated in prime summer recreational areas and minor trampling impacts were found at the former two sites.

Habitat protection/ownership

Five populations occur on federal land. In New Brunswick, the South Kouchibouguac Dune and North Richibucto Dune sites are situated within Kouchibouguac National Park and the Portage Island occurrence is within the Portage Island National Wildlife Area. In

Prince Edward Island, the Blooming Point population is within Prince Edward Island National Park and the two Hog Island populations are on federal land held in trust for the Lennox Island First Nation.

The two Bouctouche Dune populations are on private land owned by the forestry company J.D. Irving Ltd. This 10 km sand spit is presently identified under J.D. Irving's Unique Areas Program and is the site of an interpretive centre focusing on coastal ecology and a 2 km dune boardwalk that has been open to the public since 1997. J.D. Irving retains the right to alter management of its Unique Areas sites, but as a very publicly visible site, protection of the Bouctouche Dune is unlikely to change through the foreseeable future.

The Cabot Beach Provincial Park population and most individuals in the two Conway Sandhills populations (with a minority possibly occurring on a small parcel of private land) are on Prince Edward Island provincially owned land. Prince Edward Island's provincial parks are managed by the Department of Tourism, often with minimal consideration for biological diversity, but the dunes of Cabot Beach are also identified as a provincial Natural Area by the Department of Environment, Energy and Forestry under the *Natural Areas Protection Act*, and that designation prohibits activities detrimental to the dune.

The remaining populations, Fox Island, South Richibucto Dune and South Richibucto Island in New Brunswick and Cascumpec Sandhills in Prince Edward Island are on private land. All population sites, including those on private lands, are in theory afforded protection through provincial laws regulating development in coastal areas. The New Brunswick *Trespass Act*, administered by the Department of Justice, prohibits the driving of motorized vehicles and construction of roads on sand dunes, although enforcement of the act is difficult. The province's recent Coastal Areas Protection Policy limits most development on dunes but allows the construction of structures that provide access and certain structures and habitations within an adjacent 30 m buffer zone. In Prince Edward Island, the *Planning Act*'s Subdivision Development Regulations, Section 40(1) state that "No person shall develop or construct a road on any primary, secondary, or baymouth barrier sand dunes." All Prince Edward Island *Lechea* habitats are all barrier baymouth dunes and are therefore protected from development. Prince Edward Island's *Environmental Protection Act* specifies that development adjacent to sand dunes requires an impact assessment and prohibits vehicular traffic that interferes with natural dune succession.

BIOLOGY

Very few studies exist on the reproductive biology of Cistaceae species and little specific information is available on the biology of *Lechea maritima* var. *subcylindrica* or *Lechea maritima* more broadly. Most information found refers to the plant family or genus in general with that information augmented here by field observations.

Life cycle and reproduction

Beach pinweed is a low herbaceous perennial with mostly erect fruiting stems and prostrate basal shoots growing from a woody taproot. The species reproduces by seed, flowers in mid- to late summer, and produces fruit in early fall. Flowers open only for a short time (Hodgdon 1938, Fernald 1950), typically in bright sunshine (Britton 1894). They are reddish-brown, perfect flowers and are borne in panicles (Hodgdon 1938). The stamens first become exerted and pollen is shed once the ovary has grown as long as the sepals and the three red feathery stigmas have become receptive (Barringer 2004). A variety of pollination biology or breeding systems have been documented in Cistaceae taxa, including obligate outbreeding, selfing and cleistogamy (Talavera *et al*. 1992) and the occurrence of reduced cleistogamous flowers has been reported in *Lechea* (Herrera 1992, Nandi 1998). Although *Lechea maritima* has been referred to as being self-fertilized (Kearney 1901), Hodgdon's (1938) suggestion of frequent hybridization between species would imply outbreeding to some extent. Although the small flowers and red petals could indicate pollination by small Diptera or Lepidoptera species, flower morphology (exerted stamens and feathery stigmas), preference for open habitat and an apparent lack of nectar production suggest wind pollination (Barringer 2004).

Basal shoots appear after flowering in late summer or early fall and their leaves fully develop in fall (Britton 1894). These basal shoots last through the winter then either die back in late spring and summer or shoot up from the tip to form erect fruiting stems (Barringer 2004). Fruiting shoots frequently remain erect through the winter months and into the following spring, which likely allows seed dispersal by wind over snow and ice. Some seeds were found to be remaining on old flowering stalks in mid-February 2007.

There is limited information on longevity in pinweeds, although Hodgdon (1938) did note a greater frequency of biennial plants and occasional production of limited fruit after one growing season toward the northern edge of the range. A few cases of beach pinweed plants producing a limited number of flowers at very small sizes, apparently within two years of germination (C.S. Blaney, pers. obs. at Fox and Hog Islands, 2005) were found. These small plants had only tiny taproots about 1mm wide and no basal shoot development, compared to the thick (>5mm), woody taproots and dense basal rosettes of the more typical larger plants observed. It seems reasonable to assume that these much larger plants are considerably older than two years, and an estimate of 8-10 years is probably a conservative one for generation time (average age of reproductive individuals).

Herbivory

No signs of substantial herbivory were detected during field surveys and no mention of this was found in the pertinent literature. Historically, the sites of certain populations have been used as pasture for livestock and the species could have been subjected to grazing at that time.

Dispersal

As observed in other Cistaceae (e.g., Talavera *et al.* 1992), seed dispersal in *Lechea* most likely occurs via the shaking of branches by wind and precipitation. In a study of seed dispersal in *Cistus* species, seed density in the soil was shown to reach its peak beneath the plant canopy, indicating that seeds are mostly dispersed over very short distances (Bastida and Talavera 2002). According to Thanos *et al.* (1992), there seems to be no specialized mode of dispersal in Cistaceae species and seeds presumably disperse in the vicinity of the mother plant. Seeds might be carried over greater distances by water or by high winds, especially over ice and snow. The stalks, which often remain erect for a year after flowering, were found to retain some seeds into mid-February. No evidence of animal-mediated dispersal was found in the literature reviewed for this report, though it might occur through wet seeds sand sticking to animal fur, feathers or feet.

Interspecific interactions

Studies indicate that most Cistaceae form symbiotic relationships with either specific or aspecific root mycobionts (Giovannetti and Fontana 1982, Malloch and Thom 1985, Comandini *et al.* 2006). In an investigation of North American genera, Malloch and Thorn (1985) confirm that both *Lechea* and *Hudsonia* species show evidence of ectomycorrhizae with unidentified fungi. Generally, such relationships are very beneficial to the host plant, facilitating water and nutrient absorption from the soil and increasing resistance to drought and soil-borne pathogens, thus improving the capacity to withstand harsh conditions such as those found in dune habitats. It is unclear whether availability of compatible fungi could limit beach pinweed distribution. An interesting line of speculation in this regard involves the fungus *Leccinum arenicola*, originally described from coastal dunes in New Brunswick as a presumed mycobiont of beach heather (*Hudsonia tomentosa*) (Redhead and Watling 1979). If Canadian plants of *L. maritima* and *Hudsonia tomentosa* formed mycorrhizal relationships with the same fungus species, it could explain why these two plants frequently occur in association.

Hodgdon's (1938) field observations and morphological analysis of herbarium specimens suggested that *L. maritima* can occasionally hybridize with *Lechea villosa*, *L. minor* and *L. intermedia*; however, Hodgdon (1938) and David Lemke (pers. comm.), author of the upcoming *Flora of North America* treatment for the genus, believe the taxa are all good species. Beach pinweed's range overlaps only with *L. intermedia*, which is also found in New Brunswick and Prince Edward Island in a variety of dry and disturbed habitats. Although the two species were seen in fairly close proximity at three sites, no hybrids were detected during field surveys and the species were clearly separable morphologically and ecologically.

Physiology/Adaptability

As with most other Cistaceae, the majority of seeds in a given *Lechea maritima* seed bank generally have a hard, impermeable coating and only a small fraction are

capable of germinating over the short term (Thanos *et al.* 1992). Seeds can therefore remain dormant for extended periods of time, until the seed is scarified, creating openings in the seed's surface layer and allowing water absorption and germination. Together with a small seed size which facilitates penetration and accumulation in the soil (Fenner 1985) and opportunistic germination in a wide range of temperature and light conditions (Thanos *et al.* 1992), this type of primary seed dormancy is part of an adaptive strategy that allows plants to persist in difficult environments and effectively recolonize areas affected by heavy disturbance. Such adaptations make the species well suited to dune habitats that may be subjected to storm overwash and severe drought. Tests have shown that *Lechea maritima* seeds initially exhibit a low germination rate (6%) but can reach a high germination rate (75%) following abrasion (Thanos *et al.* 1992).

POPULATION SIZES AND TRENDS

Search effort

All known populations were visited by the authors between 2003 and 2006, although portions of several sites were not visited. An additional 25 potential sites were surveyed for the preparation of this report and through other AC CDC and Bouctouche Dune Irving Eco-Centre (IEC) fieldwork (Figure 3). Survey efforts to date have included a wide variety of dune habitats but have mainly focused on large stabilized dune systems along New Brunswick's eastern coast and Prince Edward Island's northern coast. In New Brunswick, search efforts have been extensive, addressing almost all potential habitat. Unsurveyed dunes in northeastern New Brunswick consist of less suitable narrow and relatively unstabilized barrier dunes. Available information can thus be considered to reliably represent the species' distribution in the province. Although the larger and more stable dune systems on Prince Edward Island have been surveyed, many smaller dunes are unsurveyed and there remains a small chance that other occurrences will be found.

It has been suggested that the species could occur on the Magdalen Islands in Quebec, where coastal habitats have many similarities to those in Prince Edward Island and eastern New Brunswick. However, the Magdalens have been extensively surveyed by botanists. Nova Scotia offers a limited potential for additional beach pinweed occurrences. Dunes on the north coast of mainland Nova Scotia and elsewhere in the province are generally not as well developed as those in New Brunswick and Prince Edward Island and are therefore less suitable for the species. This is demonstrated by the fact that the species most closely associated with beach pinweed occurrence (beach heather - *Hudsonia tomentosa*) is limited in Nova Scotia to only two dune systems near Antigonish. No fieldwork was conducted on Nova Scotia dunes, but specimens of *Lechea intermedia* potentially from dunes in the major Nova Scotia herbaria were examined, and no specimens of *L. maritima* were found.

Abundance

The total known Canadian population of beach pinweed is estimated to be 181,000+ plants. This is a rough estimate and is likely somewhat conservative due to unsurveyed portions of suitable habitat adjacent to known sites and to difficulty finding every plant within the surveyed areas at the more extensive sites. Table 2 lists populations with population size estimates and details of first discovery and most recent observation. Population sizes in New Brunswick are highly variable, ranging from small scattered patches in the northern populations at Portage and Fox Islands to denser and much more extensive populations of tens of thousands in the Kouchibouguac and Richibucto dune system. The four population sites located there collectively comprise 65% of the population. Prince Edward Island population sizes are more consistent, with the exception of the large occurrence on Hog Island's southern section, where an estimated 35,500 individuals were observed.

Fluctuations and trends

Information gathered prior to 2003 is insufficiently detailed to determine if populations have undergone growth or decline. There is no literature evidence suggesting large fluctuations in *Lechea maritima* populations. The dense population (~20,000 estimated) of uniformly aged young plants apparently responding to a single disturbance event at the Hog Island South population, as well as similar observations in *Lechea intermedia* (C.S. Blaney, pers. obs.), do suggest that fluctuations could occur over multiple years. Aside from such localized events, it seems likely that the total population has been relatively stable over the past three generations (24-30 years). All five historic records (Portage Island, Fox Island, Kouchibouguac, South Richibucto and Bouctouche), discovered between 1892 and 1932, are now known to be extant, as is the 1984 record of P.M. Catling *et al*. from southern Hog Island. Where recent losses have been noted due to storm overwash, ATV use and trampling, effects to date are small and localized relative to the populations affected. Succession could be causing declines in the Fox and Portage Island sites, the only ones where pinweed occurs under tree cover. Early records from the sites do not indicate abundance but local residents indicate that Portage Island has become substantially more wooded over the past 40 years and the same situation likely applies to Fox Island. Populations at these sites are relatively low and, especially at Fox Island where no plants were found in open habitats, could be lost over time. Search efforts between 2002 and 2006 have doubled the number of known populations and significantly increased the total number of individuals known to exist, but this likely represents a search effort effect rather than an actual population increase.

The potential for future decline is where concern arises, due to the effects of climate change-induced sea-level rise coupled with natural land subsidence and increased storm frequency and severity. Good information on projected long-term sea-level rise is available, but accounting for the future movement of dune habitats and thus estimating future population loss is not possible. Roughly 25% of the northern Bouctouche Dune occurrence has experienced recent overwash, with declines in plant

Table 2. Population size, area, and length of occurrence for each Canadian population of beach pinweed, with details of first and last observations. Site numbers correspond to those in Figure 3. [1]Area figures, where calculated, represent a sum of size estimates for actual patches observed.

Site #	Site name and province	Pop. size	Area[1], length of occurrence & notes	First & most recent observations
1	Portage Island, NB	250-500	5 patches observed, one ~continuous over 0.15km, others very small; scattered over 3km. *Note: Plants harder to find at this site in forest, likely more plants present though definitely uncommon*	First: Blake 1913; Last: Blaney, *et al.* 2004
2	Fox Island, NB	~220	1,375 m^2 observed occupied, discontinuous over 0.28km + single point occurrence. *Note: South 4.3km of island, which may not support pinweed, was not surveyed*	First: J. Fowler 1892 Last: Blaney & Goltz 2005
3	South Kouchibouguac Dune, NB	>50,000	280,000 m^2 observed occupied, ~continuous over 4km	First: Blake 1913 Last: Mazerolle 2004
4	North Richibucto Dune, NB	>50,000	210,900 m^2, ~continuous over 7.5km	First: Mazerolle 2002 Last: Mazerolle 2004
5	South Richibucto Island, NB	>10,000	125,000 m^2 observed occupied, ~continuous over 1.3km	First: Blake 1913 Last: Mazerolle 2005
6	South Richibucto Dune, NB	~8,000	16,000 m^2 observed occupied, ~continuous over 4km	First: Blake 1913 Last: Mazerolle 2004
7	Bouctouche Dune (north section), NB	~5,000	55,000 m^2 observed occupied, ~continuous over 1km	First: Marie-Victorin 1932 (N vs. S not specified); Last: Mazerolle 2004
8	Bouctouche Dune (south section), NB	~5,000	110,000 m^2 observed occupied, ~continuous over 3km	First: Mazerolle 2003 Last: Mazerolle 2004
9	Cascumpec Sandhills, PE	~250	Discontinuous over 0.06km. *Note: Northern 3.3km of island, which may not support pinweed, was not surveyed*	First & Last: Blaney 2005
10	Conway Sandhills (north section), PE	~5,000	Discontinuous over 4.9km & ~continuous over 1.5km. *Note: A segment of 2.8km, likely supporting pinweed, was not surveyed*	First: Blaney 2003 Last: Blaney & Curley 2005
11	Conway Sandhills (south section), PE	>3,500	~Continuous over 1.5km	First & Last: Mazerolle & Curley 2006
12	Hog Island (north section), PE	~740	Discontinuous over 1km. *Note: Northern 3.2km of island, likely supporting pinweed, not surveyed*	First & Last: Blaney, Mazerolle & Curley 2006
13	Hog Island (south section), PE	35,500+	~Continuous over 1.1km + 0.7km. *Note: Population value includes very dense occurrence of young but reproductive plants; South 2 km of island, likely supporting pinweed, not surveyed*	First: P.M. Catling *et al*. 1984 Last: Blaney & Curley 2005
14	Cabot Beach Provincial Park, PE	~1,500	~Continuous over 0.18km + discontinuous over 0.16km	First: Vander Kloet 2005 Last: Blaney & Mazerolle 2006
15	Blooming Point, PE	~6,000	~Continuous over 0.4km	First & Last: Mazerolle 2006
Total estimated number of individuals : 181,000+				

density and local habitat loss observed within the affected zone. A large portion of the South Kouchibouguac, South Richibucto, North Richibucto and Bouctouche sites, representing 71% of the known population, are situated between 3 and 4 m elevation behind foredunes less than 5 to 6 m. Much of the remaining population is at similar elevations, though often behind higher dunes. This elevation range is presently affected only very rarely by storm events, but is projected to see the greatest increase in frequency of storm impacts. Sites at 3.1m, 3.2m and 3.3m elevations are projected to be impacted by storm disturbance 4.5, 5.5 and 3.8 times more often by 2100 (Parkes *et al.* 2006). Field observations suggest that ideal beach pinweed habitat is flooded by storms very infrequently and it seems quite likely that the changes noted above could change beach heather–beach pinweed communities to American beachgrass-dominated or bare sand communities that are much less suitable for pinweed. Storm erosion effects are also not necessarily limited to those areas subjected to direct flooding, as erosion at lower elevations can destabilize the dune crests above and change their plant communities. A more detailed analysis of potential climate change effects is given below in *Limiting Factors and Threats.*

Rescue effect

As a Canadian endemic, the Gulf of St. Lawrence variety (var. *subcylindrica*) of beach pinweed, can have no rescue from populations outside of Canada.

At the species level, rescue effect through the natural dispersal of plants from the United States is unlikely. The nearest occurrence of var. *maritima* is in south-central Maine, roughly 115 km from the Canadian border near St. Stephen, New Brunswick. Suitable dune habitat is very limited on the Bay of Fundy shore in New Brunswick, and with Fundy waters being much colder than the Gulf of St. Lawrence, a climatic limitation could exist. It is roughly 370 km from south-central Maine to the nearest area of the Gulf of St. Lawrence coast. While northern United States plants of var. *maritima* might be adapted to Gulf of St. Lawrence conditions and habitat is likely not limiting, such a dispersal event would probably be extremely infrequent.

Rescue effects between populations within the five regions of occurrence identified in Table 1 are plausible, with several populations separated only by marginal or unsuitable habitat on the scale of a few kilometres. As noted under *Isolation and fragmentation* below, there is a very limited chance for rescue effects between the five regions of occurrence.

LIMITING FACTORS AND THREATS

Climate change and sea-level rise

There is now a general scientific consensus that human-caused climate change is occurring and will result in increased global temperature, causing sea-level rise and increased storm frequency and severity (Houghton *et al.* 1996, Shaw 2001, Kont *et al.*

2003, Environment Canada 2006). Parkes *et al.* (2006) document a statistically significant increase in severe windstorms in the southern Gulf of St. Lawrence since the 1980s with impacts including more frequent flooding as well as increased erosion and breaching of coastal barrier dunes (Environment Canada 2006). O'Carroll *et al.* (2006a) have documented a net decrease in the amount of beach and dune habitat on New Brunswick's southeast coast during the period 1944 to 2001 (though that analysis did not include any beach pinweed sites). Data is not available for Prince Edward Island dune systems, but anecdotal evidence suggests many barrier dunes are narrowing as the seaward face is moving inland (R. Curley, PEI Department of Environment, Energy and Forestry).

Field observations show that ideal beach pinweed habitat is flooded by storms very infrequently. Increased storm frequency and severity combined with higher sea levels would likely change some beach heather–pinweed communities to American beachgrass-dominated communities that are less suitable or unsuitable for pinweed. Storm erosion effects are also not necessarily limited to those areas subjected to direct flooding, as erosion at lower elevations can destabilize the dune crests above and cause changes their plant communities.

Several beach pinweed sites have already been notably modified in recent years by heavy storm activity, with some loss of pinweed habitat and population observed. The northern section of the Bouctouche Dune and many sections of the South Kouchibouguac, North Richibucto and South Richibucto dunes were affected by very high tides and significant storm surges in October and January 2000 (Shaw 2001, Environment Canada 2006). Erosion by wave action opened breaches, locally eliminated vegetation and lowered foredune topography. Affected areas have become more susceptible to storm overwash and many have been further modified nearly every subsequent year (D.M. Mazerolle, pers. obs.). On the northern section of the Bouctouche Dune, pinweed density declined over roughly 25% of the population area and some patches were lost under sand deposition caused by overwash flooding (D.M. Mazerolle, pers. obs.). A tendency towards lower density was also observed on the North Richibucto Dune in sections having recently been subjected to storm disturbance (D.M. Mazerolle, pers. obs.).

Relevant projections of future relative sea level (factoring both sea level rise and natural land subsidence) and storm surge frequency are available only for southeastern New Brunswick pinweed populations, which happen to be among the most susceptible because of their lower dune heights. Projections suggest that sites at 3.1m, 3.2m and 3.3m elevations will be impacted by storm disturbance 4.5, 5.5 and 3.8 times more often by 2100 (Parkes *et al.* 2006). Environment Canada (2006) used digital elevation maps (DEMs) to determine areas flooded by storm surges of 4 m above *current* sea levels [note also that sea level rise by 2100 is projected at 53-60cm $\pm$ 30 cm (Forbes *et al.* 2006)]. The areas that would be flooded represented roughly 90% of the Bouctouche pinweed population and roughly 50% of the South Richibucto and South Kouchibouguac populations. Sediment budget calculations also show that the Bouctouche Dune has an especially limited capacity to counter effects of erosion and is therefore the most threatened by climate change-related impacts (O'Carroll *et al*. 2006). Most pinweed populations away from southeast New Brunswick are at slightly higher elevations or are protected by higher foredunes and would likely be less affected.

Dunes are naturally dynamic systems, and all dune plant species are adapted to some extent to cope with dune movement and sand deposition. It is not possible for coastal geomorphologists to predict total dune area through the future, even on the best-studied dunes in the region (Dominique Bérubé, NB DNR, pers. comm.) and it is impossible to rule out the possibility that beach pinweed habitat and populations will simply move with shifting dune locations caused by sea level rise. However, significant portions of existing southeastern New Brunswick occurrences are within an elevation range that could see pinweed habitat loss or degradation due to increased storm frequency and intensity within 90 years. The extent to which impacts will be felt over the next 30 years, representing the upper estimate for generation time multiplied by three, is not possible to determine.

Limited habitat/habitat specialization

Beach pinweed in the Gulf of St. Lawrence has a very restricted geographic range and only occurs in a very specific habitat type on large, stabilized dune systems. Habitat specificity likely plays the largest role in the rarity of this taxon. Barrier dune habitats occupy a total of 3,377 ha in Prince Edward Island, representing only 0.6% of the province (Prince Edward Island DAF 2003). The proportional total for New Brunswick is much smaller. Surveys indicate only a small portion of dune area offers suitable habitat for the species, and the known population sites represent the majority of areas containing suitable habitat in the southern Gulf of St. Lawrence.

Off-road vehicle and pedestrian traffic

The recreational use of all-terrain vehicles (ATVs) in natural areas is undergoing rapid growth throughout North America (see Groom *et al.* 2007), with the number of recreational riders now approaching 45,000 in New Brunswick alone (NBATVF 2001). ATV use in coastal ecosystems such as dunes and wetlands is prevalent in New Brunswick and Prince Edward Island despite prohibitive laws and other deterrents. On dunes, new trails can quickly develop after just a few passes of an ATV and even the more remote island sites can be accessed by ATVs over ice in winter. Thus ATV impacts are a potential threat to most beach pinweed populations.

Recently used off-road vehicle trails were observed, however, in beach pinweed populations only at the South Richibucto Dune and one of two portions of the Fox Island population. At Cabot Beach, a single ATV trail crossed the width of the dune near pinweed populations but did not appear to affect any plants. Old vehicle tracks are evident within both Bouctouche Dune populations and at South Richibucto Island, but ATV access to these areas is now limited because of the interpretive centre and boardwalk opened at Bouctouche in 1997 and a deep channel that split the South Richibucto Dune in 1995.

ATV impacts were most notable at the South Richibucto Dune population, a popular destination for camping, hunting and recreational ATV use where traffic is common on the foredune and interdune areas. Here vehicle tracks passed through

several large patches of beach pinweed and have caused several blowouts. Beach pinweed plants were observed at the edge of tracks but were generally absent within them, indicating a loss of individuals (D.M. Mazerolle, pers. obs. 2003). Even at South Richibucto Dune, however, overall ATV impacts at present are still quite small relative to the whole population. It is also important to note that in some situations, such as on Fox Island and at the southernmost edge of the South Richibucto Dune population, beach pinweed is present in and on the immediate periphery of vehicle tracks where vehicular disturbance seems to create suitable microsites for germination.

Pedestrian trampling causing destruction of beach pinweed plants was observed at the South Kouchibouguac Dune and Bouctouche Dune populations, both very popular beach destinations, but overall effects on these populations appear very small relative to the entire populations. Most other sites except for Cabot Beach Provincial Park are likely too remote and infrequently visited for trampling to be a significant factor, although occasional camping or unauthorized construction of cabins could certainly affect individual occurrences. Beach heather–pinweed habitats are sometimes selectively targeted for camping and cabin sites because they have a lower density of tall, rough, American beachgrass.

Isolation and fragmentation

New Brunswick and Prince Edward Island populations are separated by more than 55 km of open water and unsuitable habitat, so genetic interchange between the provinces seems very unlikely. Each of the five regions of occurrence identified in Table 1 are isolated from any of the other regions by at least 19 km, thus making a rescue effect unlikely between regions. Genetic interaction between the populations within a region of occurrence is much more plausible, with a number of populations separated only by short distances of unsuitable or marginal habitat on the scale of a few kilometres. There is no information on the population genetics of beach pinweed, but reduced gene flow in small, isolated populations can lead to genetic drift, inbreeding depression and loss of genetic variability (Karron 1991, Newman and Tallmon 2001, Oostermeijer *et al.* 2003) potentially leaving populations at greater risk of extinction (Barrett and Kohn 1991).

Anthropogenic and natural (but climate-change influenced) disturbance may be increasing fragmentation of pinweed populations through breaching of barrier dunes, loss of suitable habitat and conversion of marginal American beachgrass habitat to even less suitable bare sand overwash areas. At the South Richibucto Dune population, a combination of ATV traffic and storm disturbance caused the opening of a massive breach and led to the formation of the “South Richibucto Island” (Éric Tremblay, Kouchibouguac National Park, pers. comm., Dominique Bérubé, NB DNR, pers. comm.). The plants on this newly created island are now separated from other occurrences by approximately one kilometre of open water and unsuitable habitat and it is uncertain to what extent propagule exchange is possible.

Hybridization

Hybridization can increase competitive pressure on both parent species and lead to increasingly diluted genomes (Levin *et al*. 1996). According to Hodgdon (1938), *L. maritima* commonly hybridizes with other pinweeds including narrowleaf pinweed, which is also found in New Brunswick and Prince Edward Island in a variety of open, dry habitats. Hybrids produced may appear as intermediates or bear close resemblance to either parent plant and are frequently hard to detect (Hodgdon 1938). The two species were in fairly close proximity on Hog Island, Cabot Beach Provincial Park and on the northern section of the Bouctouche Dune, but no evidence of hybridization was found. There is thus no direct evidence of a threat posed by hybridization.

Development

New Brunswick and Prince Edward Island have seen a considerable increase in the development of coastal areas during the late twentieth century (NBDELG 2001, Prince Edward Island DAF 2003), resulting in habitat loss and fragmentation (Stewart *et al.* 2003).

Although the encroachment of residential development in coastal areas does affect dune habitat in New Brunswick (D.M. Mazerolle, pers. obs.), pinweed population sites are for the most part in protected and/or relatively inaccessible areas and are not likely to be at risk. High levels of recreational activity during summer months do pose a problem for some populations, as the beaches and dunes of protected areas are often a primary focus for regional tourism. Pedestrian trampling of pinweed patches was observed, for example, on the South Kouchibouguac Dune and on the Bouctouche Dune (D.M. Mazerolle pers. obs.), and is a potential issue at Cabot Beach.

SPECIAL SIGNIFICANCE OF THE SPECIES

Canadian populations of beach pinweed are of a variety endemic to the southern Gulf of St. Lawrence and have a very limited geographic range. Only 15 populations in five regions of occurrence are known to exist on New Brunswick's eastern coast and Prince Edward Island's north coast. These populations are unique in representing the northern and eastern limit of *Lechea maritima* range and are approximately 370 km disjunct from the closest occurrence in Maine's Hancock County. Having presumably become disjunct from the species' main range following glacial retreat, Gulf of St. Lawrence populations have differentiated to the point of taxonomic recognition. The genetic distinctness of this variety is undocumented and should be further investigated. The effects of isolation, genetic drift and natural selection can produce genetic, ecological, and morphological divergence in peripheral populations, giving those populations a disproportionate significance to the species as a whole (Lesica and Allendorf 1995, Garcia-Ramos and Kirkpatrick 1997).

Lechea maritima is one of a distinct suite of southern coastal species, mostly of estuaries, having disjunct populations along the relatively warm Gulf of St. Lawrence coast, including the COSEWIC species eastern lilaeopsis (*Lilaeopsis chinensis,* discovered during 2006 AC CDC fieldwork) and "Bathurst" aster (*Symphyotrichum subulatum*). In a broad sense, the species shares its dune habitat with two species designated as endangered by COSEWIC; the Piping Plover (*Charadrius melodus*) and the Gulf of St. Lawrence aster (*Symphyotrichum laurentianum*), as well as a substantial number of provincially rare species of dunes.

No evidence of aboriginal traditional knowledge or use of this or other pinweed species was found (Lennox Island, PE and Elsipogtog and Burnt Church, NB bands contacted), or of any other human use of any pinweed. The only on-line reference to the genus *Lechea* in medicine refers to frostweed (*Helianthemum canadense*), a member of the Cistaceae formerly called *Lechea major* (Grieve 1931).

EXISTING PROTECTION OR OTHER STATUS DESIGNATIONS

Beach pinweed, in Canada, has S-ranks and General Status ranks of S1 and *May be at risk* in both New Brunswick and Prince Edward Island. It has been assigned N1 and *May be at risk* ranks for Canada and is considered G5T1 at a global level, although revision to N2 and G5T2 could be warranted because of recent field data outlined in this report. The S1 provincial ranks mean it would receive some consideration in provincial and federal environmental impact assessment screening. The variety *virginica* is globally uncommon (G5T3) and is Threatened in North Carolina.

Although the plant is not protected federally or provincially, it does benefit from provincial laws and regulations governing development and limiting activity in coastal areas. These include the New Brunswick government's *Trespass Act* and Coastal Areas Protection Policy as well as the Prince Edward Island government's *Environmental Protection Act* and *Planning Act*.

Of the 15 distinct populations described in the present report, seven are situated on protected land; one in the Portage Island National Wildlife Area, two in Kouchibouguac National Park, two on the Bouctouche Dune, one in Cabot Beach Natural Area and one in Prince Edward Island National Park. The populations in Kouchibouguac National Park represent two of the largest known occurrences. The Hog Island occurrence is also on federal land held in trust for the Lennox Island First Nation. The level of impacts within these protected areas is low. In total, about 33% of the habitat containing the species is within protected areas.

TECHNICAL SUMMARY

Lechea maritima
beach pinweed léchéa maritime
Range of Occurrence in Canada :New Brunswick, Prince Edward Island

Demographic Information

Generation time (average age of parents in the population)	Estimated at 8-10 years
Population trend and dynamics	
Observed percentage of reduction in total number of mature individuals over the last 3 generations.	<2%
Projected percentage of reduction in total number of mature individuals over the next 3 generations.	uncertain but potentially significant
Observed percentage reduction in total number of mature individuals over any 10 years period, over a time period including both the past and the future.	Unknown
Are the causes of the decline clearly reversible?	Unknown
Are the causes of the decline clearly understood?	Unknown
Are the causes of the decline clearly ceased?	No
Observed trend in number of populations Some fluctuation but overall seemingly relatively stable.	Stable
Are there extreme fluctuations in number of mature individuals?	No
Are there extreme fluctuations in number of populations?	No

Number of mature individuals in each population

Population	N Mature Individuals
Grand Total	At least 181,000

Extent and Area Information

Estimated extent of occurrence (km²) *[calculated as sum of distances between population extremities for NB and PE times 1km width]*	176 km²
Observed trend in extent of occurrence	Stable
Are there extreme fluctuations in extent of occurrence?	No
Estimated area of occupancy (km²)	71 km²
Observed trend in area of occupancy	Stable
Are there extreme fluctuations in area of occupancy?	No
Is the total population severely fragmented?	No
Number of current locations	15
Trend in number of locations	Stable
Are there extreme fluctuations in number of locations?	No
Observed trend in quality of habitat	Decline

Quantitative Analysis

Threats (actual or imminent, to populations or habitats)

1. Habitat degradation and loss through climate change-induced increases in sea level and storm frequency and severity. This could affect portions of most populations, but especially a large portion of the 71% of known population on low dunes in southeast NB.
2. All-terrain vehicle use
3. Trampling (minor effects in two sites)
4. Succession to more closed forest (potentially affecting only two small populations)

Rescue Effect (immigration from an outside source)

Status of outside population(s)? USA: The variety is endemic to Canada. The species is globally secure, although the variety virginica is globally uncommon (G5T3) and Threatened in North Carolina.	
Is immigration known or possible? The taxon is endemic. Immigration of var*. maritima* over 370+ km to Gulf of St. Lawrence coast unlikely. Immigration to Bay of Fundy coast of NB (minimum ~115 km) perhaps more plausible, but dune habitat very limited there.	No
Would immigrants be adapted to survive in Canada? Not applicable	
Is there sufficient habitat for immigrants in Canada? Not applicable	
Is rescue from outside populations likely?	**No**

Current Status

COSEWIC: Special Concern 2008 – April 2008.

Status and Reasons for Designation

Status: Special Concern	**Alpha-numeric code:** None

Reasons for Designation:

The Canadian populations have been recognized as an endemic variety of global significance. Plants are restricted to stabilized sand dunes within localized areas of coastline in New Brunswick and Prince Edward Island. The majority of the 15 populations, including the three largest, occur at elevations under 5 m above sea level. Here they are at increased risk from the impacts of severe storm surges resulting from rising sea levels and increased storm frequency and intensity predicted to occur as a consequence of climate change. A recent storm surge has already impacted a substantial portion of potential habitat at one of the New Brunswick sites. Other impacts have also been documented as a consequence of trampling, all terrain vehicle use, and successional changes to the species' habitat.

Applicability of Criteria

Criterion A: (Decline in Total Number of Mature Individuals): Not applicable. Declines well below threshold levels
Criterion B: (Small Distribution Range and Decline or Fluctuation): Not applicable. Although AO and EO are well below threshold levels, the species is not severely fragmented, comprises >10 populations and does not undergo extreme fluctuations in mature individuals.
Criterion C: (Small and Declining Number of Mature Individuals): Not applicable. The population exceeds threshold levels and no significant decline has been documented and the magnitude of inferred future declines are difficult to predict.
Criterion D: (Very Small Population or Restricted Distribution): Not applicable. Population size is too large and the Area of Occupancy is > 20km^2 and there are 15 sites
Criterion E: (Quantitative Analysis): None available

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INFORMATION SOURCES

Atlantic Canada Conservation Data Centre (AC CDC). New Brunswick and Prince Edward Island vascular plant ranking data. Web site: www.accdc.com [accessed January 2007].

Barringer, K. 2004. New Jersey pinweeds (*Lechea*, Cistaceae). Journal of the Torrey Botanical Society 131(3):261-276.

Barrett, S.H. and J.R. Kohn. 1991. Genetic and evolutionary consequences of small population size in plants: implications for conservation. Pp. 3-30 in Falk, D.A. and K.E. Holsinger (Eds.). 1991. Genetics and Conservation of Rare Plants. Oxford University Press, Oxford. 304 pp.

Bastida, F. and S. Talavera. 2002. Temporal and spatial patterns of seed dispersal in two *Cistus* species (Cistaceae). Annals of Botany 89(4):427-434.

Bérubé, D. 2007. Pers. comm. Telephone conversation with D.M. Mazerolle and C.S. Blaney. January and February 2007. Coastal Geomorphologist, New Brunswick Department of Natural Resources. Minerals Office, Bathurst.

Britton, N.L. 1894. A revision of the genus *Lechea*. Bulletin of the Torrey Botanical Club 21:244-253.

Catling, P.M., D.S. Erskine, R.B. MacLaren. 1985. Introduction to the Plants of Prince Edward Island, Second Edition, with New Records, Nomeclatural Changes, and Corrections and Deletions. Research Branch Publication 1798. Agriculture Canada, Ottawa.

Comandini, O., M. Contu and A.C. Rinaldi. 2006. An overview of *Cistus* ectomycorrhizal fungi. Mycorrhiza 16:381-395.

Curley, F.R. 2007. Pers. comm. Telephone conversations with D.M. Mazerolle and C.S. Blaney. January and February 2007. Species at Risk Biologist, Prince Edward Island Department of Environment, Energy and Forestry, Conservation and Management Division, Charlottetown.

Environment Canada. 2006. The impacts of sea level rise and climate change on the coastal zone of southeastern New Brunswick. (Daigle, R., project lead). Environment Canada. 611 pp.

Fenner, M. 1985. Seed Ecology. Chapman and Hall, London. 151 pp.

Fernald, M.L. 1950. Gray's Manual of Botany. 8th edition. D. van Nostrand, New York. 1632 pp.

Fernald, M.L. 1950. Gray's Manual of Botany. 8th edition. American Book Company, New York. 1632 pp.

Forbes, D.L., G.S. Parkes and L.A. Ketch. 2006. Sea-level rise and regional subsidence. Pp. 34-94 in Environment Canada. 2006. The impacts of sea level rise and climate change on the coastal zone of southeastern New Brunswick. Environment Canada. 611 pp.
Garcia-Ramos, G. and M. Kirkpatrick. 1997. Genetic models of adaptation and gene flow in peripheral populations. Evolution 51(1):21-28.
Giovannetti, G. and A. Fontana. 1982. Mycorrhizal synthesis between Cistaceae and Tuberaceae. New Phytologist 92:533-537.
Gleason, H.A. and A. Cronquist. 1991. Manual of Vascular Plants of Northeastern United States and Adjacent Canada. The New York Botanical Garden. Bronx, New York. 910 pp.
Grieve, M.1931. A Modern Herbal. 1971 reprint. Dover Publications, New York. 919 pp. (2 vols.). On-line version at www.botanical.com [accessed February 2007].
Groom, J.D., L.B. McKinney, L.C. Ball and C.S. Winchell. 2007. Quantifying off-highway vehicle impacts on density and survival of a threatened dune-endemic plant. Biological Conservation 135:119-134.
Herrera, J. 1992. Flower variation and breeding systems in the Cistaceae. Plant Systematics and Evolution. 179:245-256.
Hodgdon, A.R. 1938. Taxonomic study of *Lechea*. Rhodora 40:29-69, 87-131.
Houghton, J.T., L.G. Meira Filho, B.A. Callander, N. Harris, A. Kattenberg and K. Maskell (Eds.). 1996. Climate change 1995: the science of climate change, contribution of working group 1 to the Second Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press. Cambridge, UK. 572 pp.
Intergovernmental Panel on Climate Change (IPCC). 2002. Climate change and biodiversity: IPCC technical paper. V. Gitay, H, A. Suarez, D.J. Dokken and R. Watson (Eds.). Geneva, Switzerland. 77 pp.
Karron, J.D. 1991. Patterns of genetic variation and breeding systems in rare plant species. Pp. 87-98 in Falk, D.A. and K.E. Holsinger (Eds.). 1991. Genetics and Conservation of Rare Plants. Oxford University Press, Oxford. 304 pp.
Kartesz, J.T. 1999. A Synonymized Checklist and Atlas with Biological Attributes for the Vascular Flora of the United States, Canada, and Greenland. First Edition. In: Kartesz, J.T., and C.A. Meacham. Synthesis of the North American Flora, Version 1.0. North Carolina Botanical Garden, Chapel Hill.
Kearney, T.M. 1901. Report on a botanical survey of the Dismal Swamp. Contributions from the U.S. National Herbarium 5:321-550.
Kont, A., J. Jaagus and R. Aunap. 2003. Climate change scenarios and the effect of sea-level rise for Estonia. Global and Planetary Change 36:1-15.
Labrecque, J. 2002. Pers. comm. Conversation with C.S. Blaney, 2002. Botanist, Ministère de l'Environnement et de la Faune, Centre de Données sur le Patrimoine Naturel du Québec, Québec.
Lemke, D. 2007. Pers. comm. to S. Blaney. Professor of Botany and *Lechea* author for *Flora of North America*, Texas State University, San Marcos, TX.
Levin, D.A., J. Francisco-Ortega and R.K. Jansen. 1996. Hybridization and the extinction of rare plant species. Conservation Biology 10(1):10-16.

Lesica, P. and F.W. Allendorf. 1995. When are peripheral populations valuable for conservation?. Conservation Biology. 9:753-760.
Magee, D.W. and H.E. Ahles. 1999. Flora of the Northeast: A Manual of the Vascular Flora of New England & Adjacent New York. University of Massachusetts Press, Amherst. 1213 pp.
Malloch, D. and R.G. Thorn. 1985. The occurrence of ectomycorrhizae in some species of Cistaceae in North America. Canadian Journal of Botany 63:872-875.
Michaux, A. 1803. Flora Boreali-Americana. Caroli Crapelet, Paris and Strasbourg.
Nandi, O.I. 1998. Floral development and systematics of Cistaceae. Plant Systematics and Evolution 212:107-134.
NatureServe. NatureServe Explorer database. Web site: http://www.natureserve.org/ [accessed January 2007].
New Brunswick All-Terrain Vehicle Task Force (NB ATVTF). 2001. Working together towards a safer future: a report of the New Brunswick All-Terrain Vehicle Task Force. New Brunswick Department of Public Safety. 88 pp.
New Brunswick Department of the Environment and Local Government (NB DELG). 2001. A coastal areas protection policy for New Brunswick. Sustainable Planning Branch, Department of the Environment and Local Government. 15 pp.
Newman, D. and D.A. Tallmon. 2001. Experimental evidence for beneficial fitness effects of gene flow in recently isolated populations. Conservation Biology 15:1054-1063.
O'Carroll, S., D. Bérubé, A. Hanson, D.L. Forbes., J. Ollerhead and L. Olsen. 2006a. Temporal changes in beach and dune habitat in southeastern New Brunswick, 1944-2001. Pp. 421-436 in Environment Canada. 2006. The impacts of sea level rise and climate change on the coastal zone of southeastern New Brunswick. Environment Canada. 611 pp.
O'Carroll, S., D. Bérubé, D.L. Forbes, A. Hanson, S. Jolicoeur and A. Fréchette. 2006b. Coastal Erosion. Pp. 325-401. in Environment Canada. 2006. The impacts of sea level rise and climate change on the coastal zone of southeastern New Brunswick. Environment Canada. 611 pp.
Oldham, M. 2002. Pers. comm. Conversation with C.S. Blaney, 2002. Botanist, Ontario Ministry of Natural Resources, Natural Heritage Information Centre, Peterborough.
Oostermeijer, J.G.B., S.H. Luijten and J.C.M. den Nijs. 2003. Integrating demographic and genetic approaches in plant conservation. 113:389-398.
Parkes, G.S., G.K. Manson, R. Chagnon and L.A. Ketch. 2006. Storm-surge, wind, wave and ice climatology. Pp. 95-262 in Environment Canada. 2006. The impacts of sea level rise and climate change on the coastal zone of southeastern New Brunswick. Environment Canada. 611 pp.
Prince Edward Island Department of Agriculture and Forestry. 2003. 2000/02
Prince Edward Island corporate land use inventory, land use and land cover summary. Resource Inventory and Modeling Section, Department of Agriculture and Forestry, Charlottetown. 12 pp.
Pursh, F. 1814. Flora Americae Septentrionalis. White, Cochrane and Co, London.
Redhead, S.C. and R. Watling. 1979. A new psammophilic *Leccinum*. Canadian Journal of Botany 57:117-119.

Shaw, R.W. and the Climate Change Action Fund (CCAF A041) project team. 2001. Coastal impacts of climate change and sea-level rise on Prince Edward Island, synthesis report. Prepared for Environment Canada, Natural Resources Canada and Fisheries and Oceans Canada, Dartmouth, Nova Scotia. 74 pp.
Sorrie, B.A. and A.S. Weakley. 2007. Notes on *Lechea maritima* var. *virginica* (Cistaceae). Bot. Res. Inst. Texas 1(1): 367 – 368. 2007
Stewart, P.L., R.J. Rutherford, H.A. Levy and J.M. Jackson. 2003. A guide to land use planning in coastal areas of the maritime provinces. Department of Fisheries and Oceans, Maritimes Region, Dartmouth, Nova Scotia. 165 pp.
Talavera, S., P.E. Gibbs and J. Herrera. 1992. Reproductive biology of *Cistus ladanifer* (Cistaceae). Plant Systematics and Evolution 186:123-134.
Thanos, C.A., K. Georghiou, C. Kadis and C. Pantazi. 1992. Cistaceae: a plant family with hard seeds. Israel Journal of Botany 41:251-263.
Toner, M. 2007. Pers. comm. Telephone conversation with D.M. Mazerolle, February 2007. Species at Risk biologist, New Brunswick Department of Natural Resources, Fish and Wildlife Branch, Fredericton.
Tremblay, É. 2007. Pers. comm. Telephone conversation with D.M. Mazerolle. February 2007. Park Ecologist, Parks Canada, Kouchibouguac National Park.

BIOGRAPHICAL SUMMARY OF REPORT WRITERS

David Mazerolle completed an undergraduate degree at the Université de Moncton with a major in biology and a minor in geography. He then went on to complete a master's degree in environmental studies at the Université de Moncton, where he studied the geography of exotic vegetation in Kouchibouguac National Park and created a strategy for the management of the park's exotic invasive flora. David Mazerolle presently works as an assistant botanist for the Atlantic Canada Conservation Data Centre. Prior to this he was coordinator for rare plant survey and monitoring projects at the Bouctouche Dune Irving Eco-Centre from 2003 to 2006, where his work focused on the rare coastal plants of New Brunswick's Northumberland Coast. An accomplished field botanist, he has over seven years' experience working on various research, survey and monitoring projects and has authored and coauthored several technical reports pertaining to rare plants in Atlantic Canada.

Sean Blaney is the Botanist and Assistant Director of the Atlantic Canada Conservation Data Centre (AC CDC), where he is responsible for maintaining status ranks and a rare plant occurrence database for plants in each of the three Maritime provinces. Since beginning with the AC CDC in 1999, he has conducted an extensive fieldwork program across the Maritimes region, discovering dozens of new provincial records for vascular plants and documenting several thousand rare plant locations. Sean is also a member of the COSEWIC Vascular Plant Species Specialist Committee, the Nova Scotia Atlantic Coastal Plain Flora Recovery Team, and has co-authored several COSEWIC and provincial status reports. Prior to employment with AC CDC, Sean received a B.Sc. in Biology (Botany Minor) from the University of Guelph and an M.Sc. in Plant Ecology from the University of Toronto, and worked on a number of

biological inventory projects in Ontario as well as spending eight summers as a naturalist in Algonquin Park, where he co-authored the second edition of the park's plant checklist.

COLLECTIONS EXAMINED

Specimens were examined from the Connell Memorial Herbarium, University of New Brunswick (UNB) and the New Brunswick Museum (NBM). Information on New Brunswick specimens had already been compiled for the Gray Herbarium, Harvard University (GH), Agriculture and Agrifoods Canada, Ottawa (DAO) and the National Museum (CAN). Ruth Newell of the E.C. Smith Herbarium, Acadia University (ACAD) and Marian Munro of the Nova Scotia Museum of Natural History (NSPM) examined collections of *Lechea intermedia* at their institutions and communicated results to us.