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Decline of Two Open Champlain Sea Dune Systems in Eastern Ontario and Their Characteristic and Restricted Plants and Insects

PAUL M. CATLING¹, HENRI GOULET², and BRENDA KOSTIUK²

¹Agriculture and Agri-Food Canada, Environmental Health, Biodiversity, Saunders Building, Central Experimental Farm, Ottawa, Ontario K1A 0C6 Canada; e-mail: catlingp@agr.gc.ca

²Agriculture and Agri-Food Canada, Environmental Health, Biodiversity, K.W. Neatby Building, Central Experimental Farm, Ottawa, Ontario K1A 0C6 Canada

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Open sandy areas have existed for hundreds or thousands of years in eastern Ontario but they have declined to approximately 1% of their former extent over the last 60-70 years. The history and decline of this unusual habitat, and its consequences for protection of biodiversity, are explored through reference to historical documents and collections as well as current surveys using two exemplary sites: Slack Road south of Ottawa and Crystal Rock in Edwardsburgh Township north of Prescott. Planting trees to eliminate these open areas, before their biodiversity value was understood, is a primary cause of the decline, but cessation of fire, invasive species and urban development have also been contributing factors. The two exemplary areas have a very similar flora and fauna and collectively contain at least five provincially rare and 65 regionally rare species, many of which are dependent on dry, open, inland sand deposits not directly associated with rivers or lakes. Based on the present rate of decline, these sandy habitats, along with their specialized flora and fauna, may be gone in a decade or two. On the other hand, the biodiversity-rich remnants could serve as nuclei for the recolonization of a restored ecosystem.

Key Words: dunes, sand, conservation, protection, vascular plants, insects, eastern Ontario.

Dry, open sand (Figure 1) is a distinctive habitat for many unique plants and animals specially adapted to extremes of heat and drought. Among the distinctive insect fauna are moth larvae that burrow in the sand feeding on roots of sparse vegetation and emerging only at night, beetles that bury themselves in the sand during the day and forage at night, as well as hoppers and other beetles that bury themselves at night and forage during the day.

Dry open sand barrens, dry meadows and bracken grasslands occur throughout the Great Lakes region (e.g., Curtis 1959). These kinds of interior open sandy habitats, not directly associated with water, were once much more widespread in the Mixedwood Plains and Prairie ecozones of Canada (Hugenholtz and Wolfe 2005; Catling 2008) but may now be one of the most seriously threatened ecosystems in northern North America. Although climate warming will likely increase the extent of open sandhills, there may be a lag period and there is concern that deterioration may proceed before climate change reverses the trend (S. A. Wolfe personal communication; Wolfe and Thorpe 2005). One of the reasons for their loss is the decline of natural processes such as fire which leads to con-

tinual rejuvenation (e.g., Filion 1984), and without which they become overgrown with dense vegetation. However, fire may not be the only important factor in maintaining a landscape with open sand. Others may be frequent drought and drier climate conditions. Invasive alien plants such as Brome Grass (*Bromus inermis* Leyss.) and Scots Pine (*Pinus sylvestris* L.) that do well in dry conditions (Otfinowski et al. 2007; Catling and Carbyn 2004) may also play a role in eliminating open sand. Urban and agricultural development of the landscape has reduced open sandy area in some regions such as the Annapolis valley of Nova Scotia (Carbyn et al. 2006); however, a major factor in the decline of open sand in the Mixedwood Plains Ecozone of eastern Canada has been the lack of conservation action resulting from the fact that open sand and peripheral areas have not been recognized as an important and biodiversity-rich ecosystem worthy of preservation.

The decline of open sand in the prairie region (e.g., Hugenholtz and Wolfe 2005; Wolfe and Thorpe 2005) has been associated with endangerment of flora and fauna. Several species from these habitats have been recently listed under the Species at Risk Act. The endangered species include Ord's Kangaroo Rat (*Dipo-*



FIGURE 1. Sandy opening in young *Pinus strobus* – *Populus balsamifera* woodland at Crystal Rock. Small trees of *Prunus pennsylvanica* are in bloom in the centre and on the left. The lower part is dominated by *Danthonia spicata* and lichens. Open sand increases toward the middle, which is dominated by the provincially rare *Cyperus houghtonii*. The restricted Mottled Sand Grasshopper, *Spharagemon collare*, and various restricted carabid beetles, including *Anisodactylus merula*, *Cicindela formosa*, *Cicindela scutellaris lecontei*, and *Harpalus caliginosus*, occur here. The spider *Steotoda albomaculata* was abundant. Photo, early May 2007, by P. M. Catling.

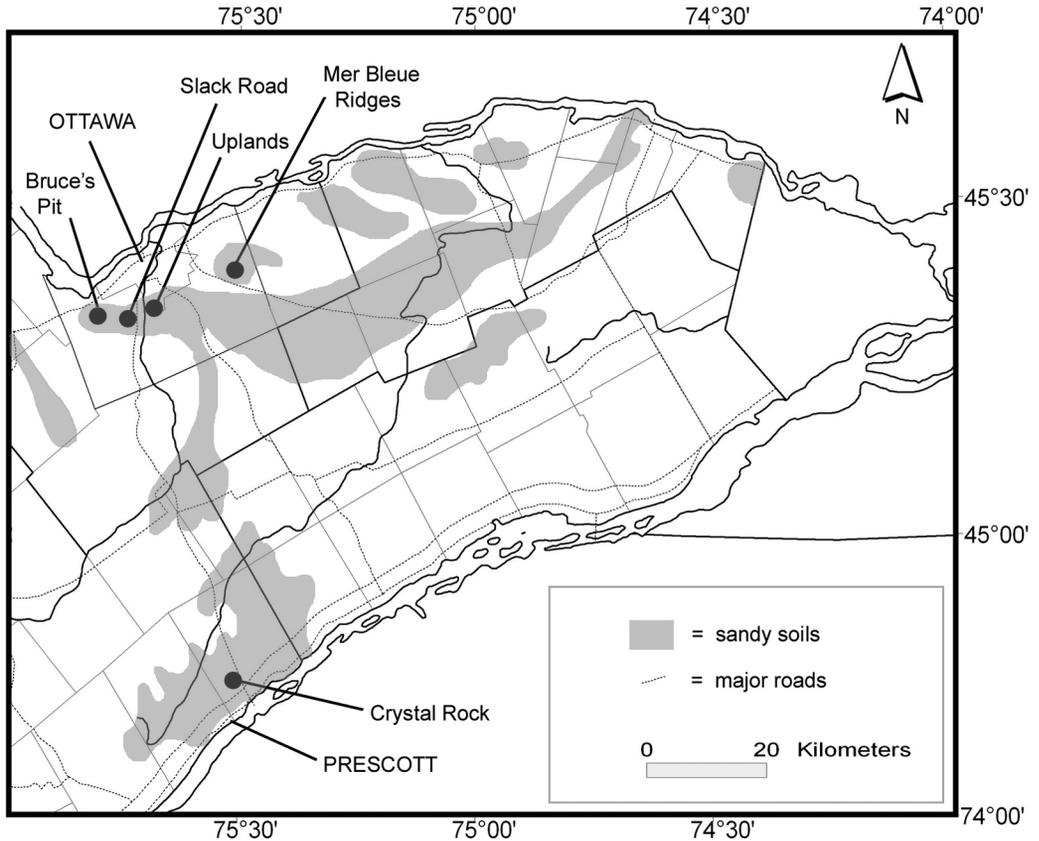


FIGURE 2. Map of eastern Ontario showing regions with sandy soils and sand plains, the higher parts of which had areas of open sand. Based on Soil Research Institute (1960*) and Chapman and Putnam (1984). Locations mentioned in the text are indicated.

domys ordii); three moths: the Dusky Dune Moth (*Copablepharon longipenne*), White Flower Moth (*Schinia bimatrix*) and the Gold-edged Gem (*Schinia avemensis*); and an endangered plant, the Small-flowered Sand-verbena (*Tripterocalyx micranthus*). In the Mixedwood Plains ecozone of Ontario and Quebec the decline is less well documented and its consequences are less clear, yet there is evidence for decline of associated and restricted flora and fauna including plants and insects (e.g., Kurczewski 2000; Stanton and Kurczewski 1999). There is also information for Ontario outlining rare and restricted plants in sand barrens habitats (Catling and Catling 1993; Carbyn and Catling 1995; Catling 2008).

In Ontario, extensive non-littoral sandy areas with dry openings are scattered and largely restricted to the upper Ottawa valley, eastern Ontario (Figure 2), Simcoe County, Norfolk County, and the region of the Oak Ridges moraine. Sand barrens are ranked as S1 or S2 by the Ontario Natural Heritage Information Centre (Lee et al. 1998*, NHIC 2007*), meaning that they are rare or extremely rare with currently less than

20 significant occurrences in the province. They are also significant in surrounding regions, for example S3 and tracked in New York State (Edinger et al. 2002*).

The purpose of the present work is to demonstrate the extreme decline in a small subset of Canada's open sandy habitats, the open (non-forested) dunes of the Champlain Sea in eastern Ontario (Figure 2), and to indicate some of the characteristic and restricted species of flora and fauna. As well as documenting biodiversity, it is hoped that this will contribute to the protection and maintenance of these and other sites. The remnants are species-rich and provide nuclei from which recolonization may occur if the landscape is managed appropriately.

Methods

Two regions of sandy deposits in eastern Ontario were studied (Figure 2): (1) the Slack Road dune system extending from Uplands (45.3366°N, 75.6807°W) west to Slack Road (45.3215°N, 75.7325°W) and Bruce's Pit (45.3240°N, 75.8006°W) on the south side of Ottawa, and (2) the Crystal Rock area in the

Edwardsburgh Sand Hills in Edwardsburgh Township north of Prescott, including dunes scattered over a broad area but particularly at Crystal Rock (44.7845°N, 75.5049°W). To evaluate decline of the open sand and dry meadows at Slack Road and Crystal Rock, aerial photographs were obtained from the National Air Photo Library of Natural Resources Canada. Those for Crystal Rock were photo A5670-045 taken 25 August 1937 and A28056-242 taken 13 May 1994 and for Slack Road were HA72-030, 73-006, 007, 019, 032, taken 5 June 1925, and A31788-087, taken 12 May 1999.

Historical information concerning the character of the landscape in pre-settlement times was obtained from early survey records (Ontario Ministry of Natural Resources, Land Information Ontario, Crown Surveys), historical reports and publications, and interviews with local historians.

At both Crystal Rock and Slack Road, plants were collected and deposited in the National Collection of Vascular Plants maintained by Agriculture and Agri-Food Canada, Ottawa (acronym DAO). Insects were also collected by active searching and use of pitfall traps. Approximately 50 visits were made to Slack Road by H. Goulet and others during the 1980s and 1990s and, for two years, sampling for hymenoptera was conducted on a weekly basis. Bruce's Pit was visited several times by P. M. Catling between 2000 and 2007, and P. M. Catling and B. Kostiuk made 10 visits to the Crystal Rock site in 2007. Information on past collections from the Slack Road region was obtained from Agriculture Canada's Canadian National Collection of Insects (CNCI). While the survey of vascular plants is considered relatively complete, that of insects is very incomplete and favours groups well known to the authors (butterflies and moths, beetles, grasshoppers) or for which experts were readily available to assist with identification (spiders, wasps, bees, flies). Notes on other organisms are incidental.

The status of plants and insects as well as other organisms was determined using the collections and articles listing rare and restricted taxa. Restriction refers to confinement to dry sandy habitats and is based on literature (e.g., Lindroth 1961 to 1969b; Layberry et al. 1982, etc.) personal observation and information from the Canadian National Collections (CNCI, DAO). Restricted species are actually a subset of regionally rare species, some of which may or may not be habitat-restricted. Regional rarity refers to eastern (east of 75.5°W) Ontario and is defined as known to occur in less than five locations (1 km apart) in the region. Provincial rarity status for plants is derived from the Ontario Rare Plant Atlas (Argus et al. 1982-1987). Scientific names preceded by one asterisk (*) indicate regionally rare and restricted species whereas names preceded by two asterisks (**) indicate provincially rare species.

The scientific and common names and authorities used for vascular plants are mostly those of Kartesz

and Meachum (1999) and are included in Appendix Table 1 with only the Latin names appearing in the text. Since most insect species lack common names, there is no separate appendix list and the authorities are included in the text. The sources of names of insects are indicated where appropriate.

Results

Origin of the Dunes

The Champlain Sea was a deep embayment of the Atlantic Ocean. It occupied a depression created by the continental glacier. From approximately 13000 to 10000 years ago it gradually receded due to isostatic rebound of previously ice-covered landscape (Parent and Occhietti 1988). After 10000 years ago it became the smaller freshwater Lake Lampsilis (Elson 1969) and receded to the present Ottawa and St. Lawrence Rivers. Sand dunes, sandy outwash and marine fossils were left to indicate its former area, which extended from west of Ottawa, south to Lake Champlain and east of Montreal (Kindle 1918; Terasmae 1959; Harrington 1971, 1981, 1988; Anderson 1988; Gadd 1988). The dunes were a consequence of the action of wind and water carrying sand left by the glacier into the sea by major rivers and streams cutting through the glacial deposits.

In Edwardsburgh Township from the north side of the town of Prescott to a point 15 km NNW (in Limerick Forest), winds blowing across the Champlain Sea off the ice sheet about 9000 years ago were dominant, the winds from the west being developed later and reduced by forest. The onshore winds from the east resulted in characteristic parabolic dunes growing from the shore westward into the conifer forest (Terasmae and Mott 1959; Filion 1987; David 1988). The highest crests of the dunes evidently return to forest very slowly after forest removal by fire. The parabolic shape of the dune crests was evident to Terasmae and Mott (1959) because the lower parts of the dune fields had become revegetated leaving the curved white dune crests clearly evident on an otherwise dark photograph. Although dune activity (movement) apparently ceased several thousand years before present (David 1988), the higher parts of the sandy deposits were probably prone to fire and drought and may have remained as open sand, sandy grassland and scrub for thousands of years as islands in a largely forested landscape. Supporting this view, Filion (1987) reported minor eolian erosion of Champlain Sea dunes at Rivière-du-Chêne, Quebec, as a result of wildfire 1250 years before present.

Recent History (pre-settlement to early or mid-1900s)

(1) Crystal Rock, Edwardsburgh Township

The Sand Hills of Edwardsburgh Township and part of Augusta Township north of Prescott are part of an extensive sandy area designated as Rubicon sand in the county soil survey (Richards et al. 1949; Figure 2) that may have been more or less open (unforested)

for thousands of years. This could have been a consequence of both natural fires and fires set to improve hunting by native peoples, including the Paleo Indians followed by the Archaic cultures, both hunters and gatherers. However, a far more significant trend in opening the landscape was the establishment of the Woodland culture, which began after 1000 B.C. during which time the hunters and gatherers were replaced by the agricultural and well-organized Iroquois. At least six major Iroquoian villages have been documented in the Sand Hills area (Pendergast 1966), the first of which was reported in 1854 (see Leavitt 1972), including the multi-pallisaded Roebuck site (Wintenburg 1936). Agriculture was well developed at this and the other sites. It included corn, beans, sunflowers, tobacco, and squash (Wintenburg 1936). Three to six square miles of cultivated land surrounded the villages of at least one to two thousand inhabitants and beyond that were areas where wood was collected for cooking, heating, and construction of longhouses and repair of 30-foot high pallisades. The open land created around villages would probably be in the order of hundreds of km² (J. V. White, personal communication). Exhaustion of supplies of firewood was a primary reason for the abandonment of Iroquoian villages (J. V. Wright, personal communication). Consequently, villages like the Roebuck site moved from place to place over periods of several decades undoubtedly creating extensive treeless areas in various stages and rates of succession back to forest. The impact of the Iroquois may have lasted until 1500 A.D. They had disappeared from the region by 1535 when Jacques Cartier arrived (Pendergast 1995).

In Grenville County, without exception, the Iroquoian villages were located on the sandy deposits of the Champlain Sea, and the Crystal Rock dunes were the site of a well-known pre-Columbian village (Pendergast 1962). Charred corn and pipes were abundant at the site, suggesting the cultivation of at least corn and tobacco. Although there was evidence for at least three longhouses, there is a possibility that the Crystal Rock village was a smaller, periodically occupied, farm village associated with one of the major villages (Pendergast 1962).

Although aboriginal activity may have opened up sandy areas and maintained open sandy areas, the rates of vegetation succession and lack of sufficient effective wind may have prevented any significant dune activity, as occurred elsewhere in Canada (Wolfe et al. 2007). This may explain the fact that the primary active dune pattern on the landscape dates back to the Champlain Sea.

It is probable that the pine forests found in the Sand Hills region noted by the first settlers in early 1800s (Cameron 1994) developed gradually on mesic and drier sand after departure of the Iroquois. In the early 1800s these forests were probably at least 100 years old (large enough to provide masts for ships) and

their presence indicates open areas around 1700. Extensive pine stands called "pineries" were characteristic of previously open sites because the young pines favour open areas with exposed mineral soil for establishment. The pineries often developed on the landscapes previously occupied by native people (Day 1953). These pineries were also prone to fire, which burned in a mosaic leaving a patchwork of openings. Mohawks and fur traders moved into the area during the 1700s and there was likely at least some of the traditional burning to improve hunting (Day 1953) which likely also contributed to the perpetuation of openings during this brief period of decreased human impact. The St. Lawrence River was a highway to the wilderness of the Great Lakes from 1684 to 1720, at which time Johnstown (then called La Galette) was one of a number of trading posts around which open areas were maintained by tree cutting.

The removal of woody vegetation began on a grand scale during the European settlement period of the 1800s, but not only for heating, cooking and construction. The large pines were cut along the "Mast Road" north of Johnstown to provide masts and wood for ship building (Newman 1967 and personal communication). Subsequently, cordwood was cut for the many steam-powered boats operating along the major transportation route of the St. Lawrence River. Throughout the Sand Hills region, but especially around Crystal Rock, wood was also cut for burning limestone in pits and later in kilns to produce lime. Illustrations of the open dunes are included in some of the historical documents (Cameron 1994; Woodhead 1995). The subsistence agriculture of the late 1800s and early 1900s utilized the landscape almost completely for a variety of crops, but in the sand hills region especially for rye to supply the distillery in Prescott. Livestock was prevalent, including horses, dairy cattle, sheep and pigs (Newman 1967; Edwardsburgh Centennial Committee 1967). The intensive agricultural use of the landscape destroyed most of the natural habitat but some of the sand areas may have been spared due to extreme dryness and drifting sand making them unsuitable for most kinds of agriculture. Attempted agriculture in some dry areas resulted in wind erosion and loss of soil. The drifting sand and any sandy ground were regarded as a landscape damaged by poor agricultural practices rather than as a special ecosystem. In the 1920s and 1940s there were extensive areas of open sand as well as areas of sparse shrub and grassland (Woodhead 1995, page 2; Cameron 1994, page 5; Figure 3).

(2) *Slack Road, Ottawa-Carleton*

Although the Slack Road area of Ottawa-Carleton was beyond the northern limit of extensive Iroquoian settlements, there is evidence that it was used historically by native people who required wood and game and thus would have reduced forest cover. Artifacts have been found in the area (Jameson 1989*) and in adjacent areas along the Rideau River where it cuts

through sand deposits. The area is recognized for its archaeological resource potential (Laliberté 1998*), although evidence of extensive and continuous settlement is lacking.

The survey of McDonnell and McDonald (1820*) of the first concession of Gloucester Township (now in the regional Municipality of Ottawa-Carleton but then Carleton County) recorded trees in 21 of 26 lots with a total of 75 tree records involving 14 tree species and 3.57 species recorded per lot. Pine was recorded in only five of the 21 lots and of these, three of the five records were from the adjacent lots 5, 6 and 7 corresponding to the Slack Road sand deposits. Elsewhere along the concession survey line hemlock, maple, basswood, ash and Yellow Birch were frequent. Clearly the three adjacent lots were anomalous and the presence of pine and birch (Lot 5) suggests early succession on sandy soils (since pine often germinates only on mineral soil in open conditions). This compared with climax forest suggested by the presence of hemlock, maple and Yellow Birch elsewhere. Consequently the reports of the first surveyor suggest that the Slack Road area had been open and sandy during the late 1700s and prior to the arrival of the first European settlers in the region (Philomen Wright's settlement in 1800 on the north side of the Grand (Ottawa) River at what later became Hull).

Similarly for the area of Bruce's Pit in the same sandy deposits 5 km to the west of the Slack Road remnants, Landon's (1824*) survey of Nepean Township indicated "pine land" on four contiguous lots on the line between Concessions 2 and 3, and the only "pine land" in 35 lots between Concessions 1 and 2 was in Lot 33. Thus there seems to be little doubt that the sandy deposits on the south side of Ottawa had been open prior to European settlement.

(3) General Observations

Considering the preceding historical information, the sandy ground in both the Slack Road and Crystal Rock regions may have been unforested with open sand and dry meadow for thousands of years as a consequence of drought and natural fire. This is supported by: (1) observations of pines and pineries by the first land surveyors and the earliest settlers; (2) the observation that in some of the drier sites today the invading cedars and poplars have died so that the driest openings can persist for long periods which is also supported by the open parabolic dune crests evident in aerial photographs taken in the 1950s; (3) a long history of open sandy habitats (for Edwardsburgh) in connection with Iroquoian agriculture; and (4) post-settlement wood harvesting for a variety of purposes that would have maintained the open habitats until several decades ago when wood declined in importance.

It has been suggested that the dunes in eastern Ontario became active only during post-European settlement times because of the absence of buried soil horizons (e.g., Johnson quoted in Porsild 1941) but this is



FIGURE 3. Drifting Sand Ridge photographed in 1920 between Crystal Rock and Prescott (Lot 30, Concession 1, Edwardsburgh Township, Grenville County, Ontario). Courtesy of the Canadian Geological Survey. Photo 48125 by J. Keele.

contrary to Filion's (1987) observation and the subject has not been studied extensively. Regardless, open sandy areas can exist without dune activity.

DOCUMENTATION OF RECENT HABITAT DECLINE

(1) Tree planting

The open sandy habitats throughout eastern Ontario declined for a number of reasons, but planting with both native and introduced pines played an important role everywhere, and in some places such as the Constance Bay Sand Hills, it is the major cause of habitat loss (White 1979; Wilson 1984). For decades in the past, open sandy areas were considered to be a very serious problem of soil erosion and such areas were subject to reduced property values. Tree planting was recommended for all open sandy areas to prevent erosion, redevelop soil cover and create value in terms of harvestable timber (e.g., Richards et al. 1949). The provincial government provided young established trees that could survive the dry conditions whereas their earlier seedling stage in nature could not. The strong reliance on wood in earlier times made this seem an appropriate use of the landscape. Biodiversity and its association with successional habitats were poorly understood during this period. Since open conditions may have persisted for many hundreds or thousands of years, tree planting was not necessarily restoring original conditions, although this was assumed to be the case at the time. Pines were planted in every open place that did not produce much hay or was unsuitable for crops. Later the densely planted trees became a dense monoculture with rich organic duff leading to a low-diversity forested community altogether unlike the open sand. Many areas that were not planted were rapidly invaded by ecosystem, altering invasive alien species such as Smooth Brome (*Bromus inermis*) and Scots Pine (*Pinus sylvestris*).

(2) Edwardsburgh Township and Crystal Rock Sand Dunes

The Crystal Rock dunes (Figure 4) were but one of several extensive open sandy dune areas that existed in Edwardsburgh Township 100 years ago. Even 50 years ago, many of these sandy areas were still present,



FIGURE 4. Aerial photographs of the Crystal Rock sand dunes (centre of photo at 44.7845°N, 75.5049°W). Left, photographed on 25 August 1937 (photo number A5670-045). Right, photographed on 13 May 1994 (photo number A28056-242). National Air Photo Library of Natural Resources Canada.

according to local inhabitants, and extensive sand at Crystal Rock is seen in early photographs such as Figure 3 (also reproduced in Woodhead (1995)), and the ca. 1950 oblique aerial view in Pendergast (1962). The open sandy areas of Edwardsburgh Township persisted for a few decades after 1940, but woody cover increased for three reasons: (1) fire was no longer a natural process on the landscape; (2) the need for wood declined as electricity became available for heating in the 1940s and 1950s and coal oil and propane also replaced wood for heating and cooking resulting in reduced tree cutting; and (3) much of the area was planted with pine and spruce during and after the 1930s and the well-established saplings were able to cope with the drought so that plantations developed rapidly. Invasive alien species capable of growth in dry places such as Smooth Brome, Flat-stem Blue Grass (*Poa compressa*) and Scots Pine became established in many of the open areas. By 2000 only a few very compromised patches of native sandy habitat remained (e.g., Figure 1). The 1937 aerial photograph (Figure 4) shows 103 hectares of sand and dry meadow at Crystal Rock, whereas the corresponding 1994 aerial photograph shows less than 3.5 hectares and most of this is associated with a few sand quarries. Invasive alien Scots Pines have taken over much of the dune area. Much sand was removed for construction of Highway 416 that dissected the dune system. Natural succession also reduced the open areas.

The decline of open sand at Crystal Rock has been paralleled by a similar, or even greater, decline in open sandy areas that existed previously throughout the townships of Edwardsburgh and Augusta. For example, the open dune crests in the photo published by Terasmae and Mott (1959), approximately centred on 44.8462°N, 75.6383°W, are now closed in (personal observation, August 2007).

3. Slack Road Sand Dunes

The Slack Road dunes (Figure 5) were one of a number of extensive open sandy areas extending in a broad east-west band about 3 km in length crossing the Rideau River at Uplands and Merivale on the south side of Ottawa. The extensive open sandy areas were used for pasture, leading to increased erosion, or they were quarried or developed into housing and industrial parks. Those not developed were planted with conifers or gradually grew in with invasive Scots Pines, buckthorn and native woody plants. Up until the 1980s the sandy areas at Slack Road, which is part of the Pinhey Forest Reserve (National Capital Commission), were considered to be abandoned agricultural land rather than remnants of former open and semi-open natural habitats (e.g., Mosquin and Gillet 1984*). Fortunately Mosquin and Gillet (1984*, p. 51) did recommend that the remaining open sandy areas not be planted in trees.

The once extensive sandy areas at Uplands are essentially gone, leaving only remnants at Slack Road

and Bruce's Pit, these being a fraction of a percentage of what was once present. An aerial photo of the Slack Road section in 1937 (Figure 5) shows 24 hectares of open sand reduced to 0.67 hectares by 1999. The open sand and associated dry meadow included 64.7 hectares in 1937 but it is now less than 1 hectare (Figure 5 and personal observation, 2007). The Slack Road system (Figure 5) was replaced by housing (upper left), pine plantations (right centre), and succession to forest, including invasive species (throughout the remainder).

FLORA AND FAUNA

The flora (see Appendix Table 1 for common names and authorities)

(1) General Vegetation

A number of very similar natural plant associations were present at both Slack Road and Crystal Rock. The surface ranged from open sand to mostly sand with scattered vegetation to half sand and half vegetation cover to a dense covering of vegetation so that the sandy substrate was not visible. The following description is based on vegetation at some of the least disturbed sites and those with the least number of invasive alien species.

Sparse vegetation on open sand includes *Cyperus houghtonii* (Figure 6) and/or *Sporobolus cryptandrus* and/or *Carex houghtoniana* and/or *Carex siccata*. *Polygonella articulata* (possibly recently introduced) occurs at Slack Road. In more stabilized sand the dominant vegetation is *Danthonia spicata* and *Pteridium aquilinum* sometimes with extensive lichen mats and *Polytrichum* moss, often referred to as Bracken Grasslands (e.g., Curtis 1959). Other characteristic species of this more climax association and the intermediate stages include *Anemone cylindrica*, *Calystegia spithamea*, *Carex cumulata*, *Carex merritt-feraldii*, *Carex pensylvanica*, *Carex tonsa* var. *rugosperma*, *Carex tonsa* var. *tonsa*, *Dichanthelium depauperatum*, *Dichanthelium acuminatum* var. *fasciculatum*, *Diphasiastrum digitatum*, *Diphasiastrum tristachyum*, *Fragaria virginiana*, *Monarda fistulosa*, *Panicum virgatum*, *Physalis heterophylla*, *Poa pratensis*, *Rubus allegheniensis*, *Rudbeckia hirta*, *Selaginella rupestris*, *Solidago juncea*, *Solidago nemoralis*, *Vitis riparia*, and other less frequent species (see Appendix Table 1).

The predominant shrubs present were *Prunus virginiana*, *Juniperus communis*, *Spiraea tomentosa*, *Amelanchier stolonifera*, *Amelanchier laevis*, and the surrounding trees included *Prunus pensylvanica*, *Pinus strobus*, *Pinus resinosa*, *Populus balsamifera*, *Populus tremuloides*, and *Thuja occidentalis*. In some remnants, *Picea glauca*, *Betula populifolia* and *Pinus banksiana* (just Slack Road region) surround sandy clearings.

Among the frequent introduced species *Hieracium piloselloides*, *Poa compressa* and *Silene vulgaris* are common on open sand; *Bromus inermis* occurs everywhere but dominates mesic sites. *Rumex acetosella* is frequent. *Pinus sylvestris* is frequent on edges and invades drier areas more successfully than native pines.

In Edwardsburgh Township, an area formerly owned by the Grand Trunk Railway west of Prescott, near Blue Church, is on the well-drained sandy soil. This entire area may have included sand barren vegetation at one time based on the relicts that exist around the pits formerly used to obtain substrate for railway construction and to provide water for steam engines. As a result of this use the area escaped the intense agricultural activity in the surrounding area, and parts of it evidently retained the original vegetation which was dominated by *Danthonia spicata* and *Carex siccata* with *Quercus rubra* and *Pinus strobus* (personal observation). A number of restricted species occurred here including *Ceanothus americanus*, *Cirsium discolor*, *Corylus americana*, *Desmodium canadense*, *Helianthus divaricatus*, *Helianthus strumosus*, *Lespedeza capitata*, *Lespedeza hirta*, *Maianthemum canadense*, *Monarda fistulosa*, and *Oryzopsis asperifolia* (Dore 1961 and personal observation). There is a possibility that some of these plants were introduced with railway ballast but the lack of extreme disjuncts and the usual railway flora (including the prairie grasses), and the occurrence of these species up to a kilometer from the tracks suggest that they are native.

The absence of any western prairie grasses (*Andropogon*, *Schizachyrium*, *Sorghastrum*) is interesting. It may in part be due to the sharp transition from very dry sandy blowouts to forest. Most places where these prairie grasses occur in the region are periodically damp due to spring flooding or brief rain retention by limestone rock. It is also of interest that a long-lasting scrub or heathland associated with a diverse flora, including many localized species such as existed on the Constance Bay Sand Hills on the Ottawa River northwest of Ottawa (Porsild 1941; Breitung 1957; White 1979), is not present on the Slack Road and Crystal Rock dunes. Both the extremes and high water table may have contributed to this situation resulting in open sand or forest without an intermediate long-lasting stage. Additionally intensive agriculture involving a variety of livestock could have reduced floristic diversity, since smaller subsistence farms in the early 1900s used even marginal landscapes very completely.

The most persistent sandy areas and those that remain today are the driest; these are the subject of this article. However, after fires there were also shorter-lived moist and mesic sandy habitats (personal observation). These would likely have supported the flora that is now most often associated with pond shores in sand pits and interdunal meadows on Great Lakes shores including such conspicuous plants as *Gentianopsis crinita* (Froel.) Ma (Greater Fringed Gentian), *Agalinis tenuifolia* (Vahl) Raf. (Slender-Leaf False Foxglove) and *Spiranthes cernua* (L.) Rich. (Nodding Ladies-tresses), along with *Equisetum variegatum* Schleich. ex F. Weber and D.M.H. Mohr (Variegated Scouring-Rush) and *Danthonia spicata*, sometimes associated with more unusual and local species such as *Polygala sanguinea* L. (Purple Milkwort, particularly eastern

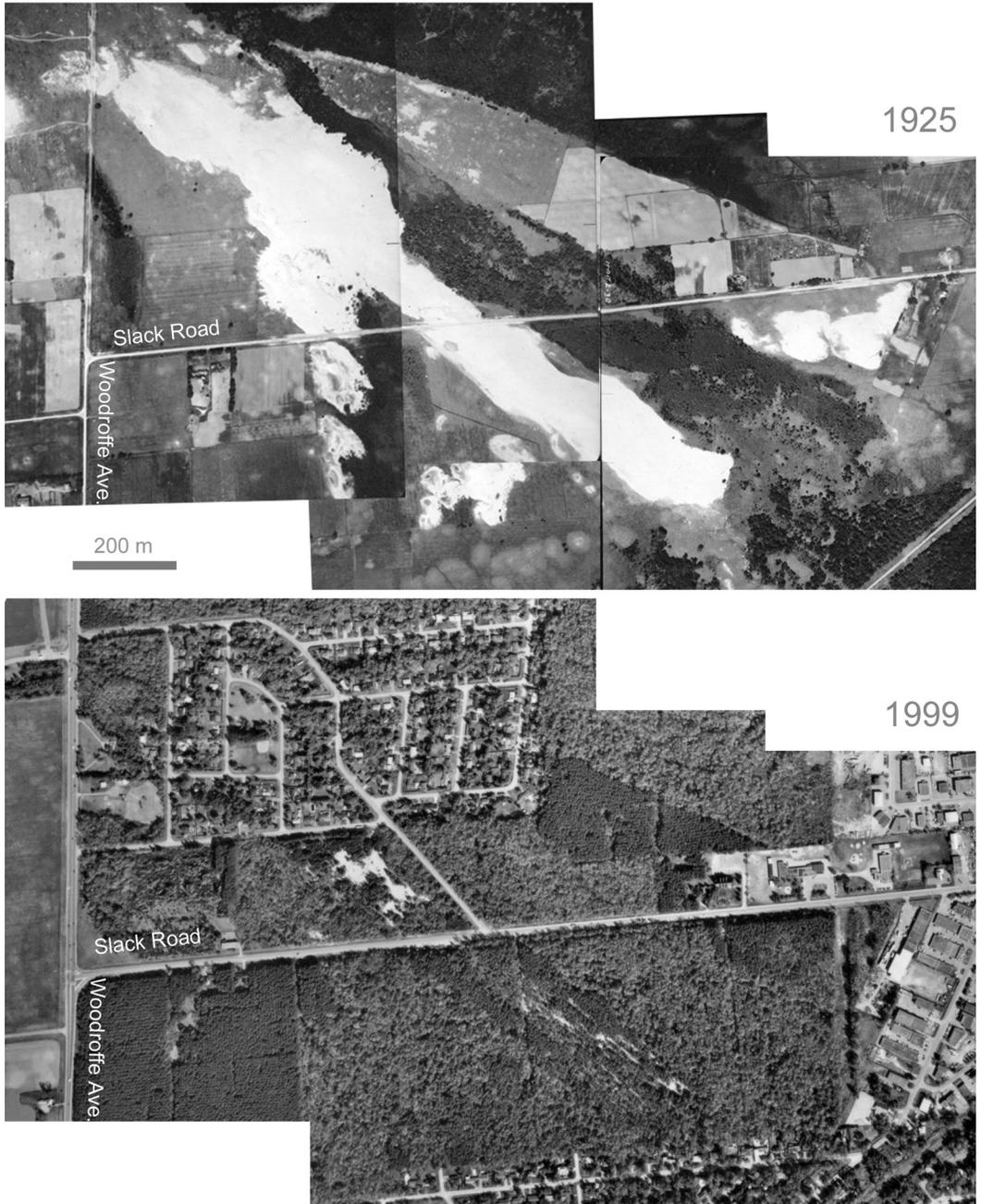


FIGURE 5. Aerial photographs of the sand dunes at Slack Road (centre of photo at 45.3215°N , 75.7325°W). Above, photographed on 5 June 1925 (photo numbers HA72-030, 73-006. 007, 019, 032). Below, photographed on 12 May 1999 (photo number A31788-087).



FIGURE 6. Inflorescence of the provincially rare Houghton's Flat Sedge (*Cyperus houghtonii*). Photo by B. Kostiuk from Crystal Rock, August 2007.

Ontario, see Reddoch 1972), **Polygala verticillata* L. (Whorled Milkwort), ***Juncus greenei* Oakes and Tuckerman (Greene's Rush) and *Drosera rotundifolia* L. (Round-Leaf Sundew). Prior to 1980, associations of this type were not unusual on bulldozed or burned sites on the sand plateaus east of Ottawa around Mer Bleue and near Casselman, but also occurred near Kemptville. These associations of mesic sandy sites may be relatively short-lived, possibly lasting for less than a few decades after initial disturbances. Introduced grasses such as *Phalaris arundinacea* and *Bromus inermis* may contribute to their short duration and general decline.

(2) Other plants and fungi

Sand barrens are rich in lichens in species of *Cladina* and *Cetraria*, but **Cladina rangiferina* predominates. It is widespread northward and in open places on the Canadian Shield but in eastern Ontario is confined to open sandy sites. The predominant mosses include several species of *Polytrichum* as well as *Tortula ruralis*. Some of these appear to be restricted but studies are incomplete. A number of fungi are associated with sandy, open sites. **Tulostoma* sp. (stalked puffballs)



FIGURE 7. The stalked puffballs (*Tulostoma* sp.) that grow in dry and open sandy places in the remnants of the Crystal Rock Sand Barrens are a complicated group of species, the classification of which is still unclear. Photo by P. M. Catling. The specimen illustrated is in the Agriculture and Agri-Food Canada Collection (Crystal Rock Barrens, 2007-05-12, P. M. Catling, DAOM (National Collection, Agriculture Canada, Ottawa)).

grow in dry and open sandy places at Crystal Rock Sand Barrens (Figure 7).

(3) Floristic significance

About 70 native vascular plant species exist in dry open areas of the Edwardsburgh and Slack Road sand hills (Appendix Table 1) and most of these (the characteristic species noted above) occur at both sites. There are two provincially rare plants present and 27 regionally rare plants, most of which are restricted to dry sand. In addition some of the mosses, lichens and fungi present are probably regionally rare.

Insects

(a) Butterflies and Moths

A number of butterflies are present as a result of abundance of their foodplants, including *Danaus plexippus* L. (Monarch), **Hesperia leonardus* Harris (Leonard's Skipper), **Callophrys niphon* (Hübner) (Eastern Pine Elf), *Coenonympha tullia inornata* Müller (Inornate Ringlet). The young *Pinus strobus* around the remnant openings at Crystal Rock are one of the few places for *Callophrys niphon* in eastern Ontario where young pine groves have become scarce.

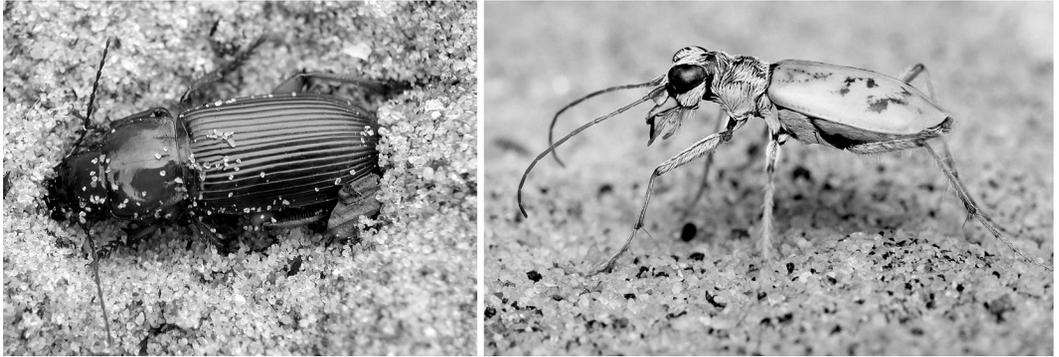


FIGURE 8. *Harpalus erraticus* (left) and *Cicindela lepida* (right). Both beetles are restricted in eastern Ontario to declining areas of open sand. Left photographed at Burnt Island, Manitoulin Island on 8 August 2003. Right photographed at Slack Road, south side of Ottawa, 9 September 2007. Photos by H. Goulet.

The most notable butterfly and one restricted to the dry sandy soils, often over limestone, in the region, is **Chlosyne gorgone* (Hübner) (Gorgone Checkerspot), the larvae of which feed on *Rudbeckia hirta* L. var. *pulcherrima* Farw. (Black-eyed-Susan). This foodplant is sometimes considered a recent introduction in Ontario, but in eastern Ontario it occurs in natural habitats with native species and likely occurred as a weed in Iroquian fields along with cultivated sunflowers, which are also a larval foodplant of *M. gorgone*. The butterfly is currently known in Ontario only from the sandy areas of Edwardsburgh Township north to Kemptville and is disjunct from the far west (Catling and Layberry 1996, 1997, 1998). **Atrytone logan* W. H. Edwards ssp. *logan* (Delaware Skipper) is also present at some Edwardsburgh Township sites.

**Euxoa detersa* and **Agrotus vestuta* are common moths in the western prairie region but local and confined to sandy soils in the east. The larvae of both species burrow in the sand in open sandy sites at Crystal Rock where they feed on the roots of a variety of plants. *Euxoa albipennis*, *E. scandens* and *E. quebecensis*, present at Crystal Rock, are also associated with sand but occur in less open sites.

(b) Beetles

Particularly notable at Crystal Rock were the carabid beetles, including **Anisodactylus merula* (Germar), **A. rusticus* (Say), **Harpalus erraticus* Say (Figure 8, left), ***H. fuscipalpis* Sturm, ***H. lewisii* LeConte, and **H. plenalis* Casey, all restricted to dry, open sand. The *Anisodactylus* species and *Harpalus erraticus* were particularly abundant with hundreds of each observed. The three tiger beetles **Cicindela formosa generosa* Dejean, **C. scutellaris lecontei* Haldeman, and ***C. lepida* Dejean (Figure 8, right) are restricted to dry, open sandy habitats and are very localized in eastern Ontario (personal observation). *Cicindela tranquebarica* Herbst was also present at Slack Road. *Cicindela lepida* (Figure 7), strongly associated with

fine, open sand with which it blends well, has a short midsummer flight season and is generally rare throughout its Canadian range. Recent observations have suggested that this species is declining (e.g., Stanton and Kurczewski 1999). Other carabid species characteristic of the sandy sites at Crystal Rock, but less restricted include *Amara quenseli* (Schönherr), *Cicindela punctulata* Oliver, *Harpalus compar* LeConte, *H. herbivagus* Say, and *H. opacipennis* (Haldeman). The large **Harpalus caliginosus* (Fabricius), although less restricted to open sand in the southern parts of its range, is rare at its northern range limit in eastern Ontario.

(c) Grasshoppers and their relatives

**Spharagemon collare* (Scudder) (Mottled Sand Grasshopper, Figure 9) was common locally in the dry, open sandy areas dominated by the graminoid plants *Sporobolus cryptandrus* and *Cyperus houghtonii* in both regions. It often persists in isolated pockets of open sand less than $\frac{1}{10}$ the size of a Canadian football field (approx. 596 m²). It is a species restricted to dry, open sand. Also restricted, but tolerant of less open sand **Spharagemon bolli bolli* Scudder (Boll's Grasshopper) was present in both areas. **Melanoplus keeleri luridus* (Dodge) (Keeler's Grasshopper), associated with dry habitats, and **Melanoplus punctulatus punctulatus* (Scudder) (Pinetree Spurthroat Grasshopper), an arboreal species associated with *Pinus strobus* are also noteworthy. A characteristic species of dry, open woodland, **Chloea conspersa* Harris (Sprinkled Broad-winged Grasshopper) was common in dry *Danthonia spicata* grasslands. The widespread *Melanoplus sanguinipes sanguinipes* (Fabricius) (Migratory Grasshopper) was very abundant. Other grasshoppers less common in the area included widespread species: *Dissosteira carolina* (Linnaeus) (Carolina Grasshopper), *Melanoplus femurrubrum* (DeGeer) (Redlegged Grasshopper), and *Chortophaga viridifasciata* (De Geer) (Greenstriped Grasshopper).

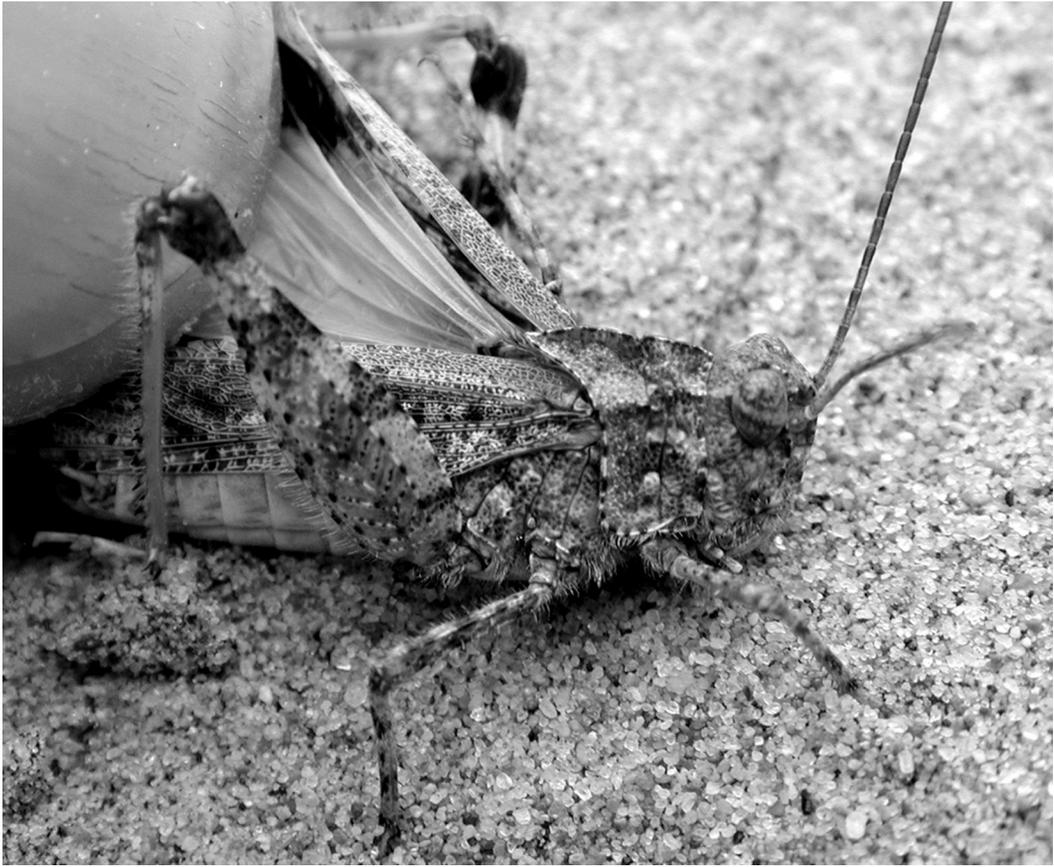


FIGURE 9. One of the band-winged grasshoppers (pale yellow wings with a black border), *Spharagemon collare* (Mottled Sand Grasshopper) strongly resembles sand. Photographed early August 2007 at Crystal Rock by P. M. Catling. Specimen in CNCI (Canadian National Collection of Insects, Agriculture Canada, Ottawa).

The small cricket **Allonemobius griseus griseus* was extremely abundant at Crystal Rock. This species is only found in dry, open sandy areas. The ubiquitous *Gryllus pennsylvanicus* (Common Cricket) was also abundant. *Oecanthus quadripunctatus* Beutenmüller (Fourspotted Tree Cricket) was frequent on *Rubus allegheniensis* and *Oecanthus fultoni* T. J. Walker (Snowy Tree Cricket) was also present.

(d) Wasps and Bees

At Crystal Rock the most notable sand inhabitant was the spheciform wasp **Microbembix monodonta* (Say), a scavenging wasp which excavates nesting and sleeping burrows in loose colonies in areas of open sand (Figure 10). Two much larger, related species of *Bembix*, **B. americana spinolae* Lapeletier and **B. pallidipicta* F. Smith, also sand burrowers, have been collected at the sites under study, but the latter only at Edwardsburgh. Three species of *Ammophila* that are likely more or less restricted to areas with open

sand have been collected at both sites: *A. kennedyi* (Murry), *A. harti* (Fernald) and *A. urnaria* (Menke).

Among the newly reported (for Ontario) spheciform wasps that nest in sand and are known in the Ottawa area from the Merivale, Slack Road, Uplands and Bruce's Pit sand system are ***Diploplectron peglowi* Krombein, which is rare in the east, as well as **Miscophus americanus* Fox, and **Plenoculus davisii* Fox (Buck 2003). The biology of ***Cerceris nitidoides* Ferguson, collected in Ontario only at Slack Road, is unknown but related species nest in sand.

Small parasitic Hymenoptera in the family Scelioidea are mostly (95%) undescribed in North America. Two undescribed species in the *Trimorous ninus* group, parasitic on the eggs of the localized tiger beetles (*Cicindela* spp.) are known from Slack Road. An undescribed species of *Idris*, parasitic on spiders' eggs is known only from Slack Road and the state of Nebraska. Another undescribed species of *Idris* has never been found at Slack Road but is common at Crystal

Rock It is estimated that 20-25 species of undescribed scelionid wasps occur in the Slack Road and Crystal Rock sand areas (L. Masner, personal communication).

The bee **Colletes inaequalis* Cresson was excavated from burrows in the sand at Crystal Rock. It is one of approximately 50 bees in eastern Ontario that use loose open sandy areas to produce burrows containing brood cells (in this case lined with a waterproof, cellophane-like material that retards decomposition of stored nectar). Another bee at Crystal Rock, **Lasioglossum vierecki* (Crawford), is also dependent on open sand and has a restricted distribution in southern Ontario.

(e) Flies

Two flies of the family Therevidae occur on both the Slack Road and Crystal Rock sands: **Cyclotelus rufiventris* Loew and **Spiraverpa senax* Walker. Both are restricted to open areas where the larvae burrow through the sand preying on fossorial arthropods. A fly belonging to the Bombyliidae, **Exoprosopa fascipennis* (Say), that only parasitizes the sand burrowing *Bembex* wasps has been found at Slack Road. Several flies of the family Asilidae are strongly associated with sand and among these **Proctacanthus milberti* Macquart and **Cyrtopogon falso* Walker occur in both dune regions studied. Hundreds of other species of flies not restricted to sandy areas were also present.

(d) Spiders

The most abundant spider in pitfall traps at Crystal Rock was *Steotoda albomaculata* (DeGeer). This species (Figure 11) was not strongly associated with open sand but characteristic of very dry, open places where it occurred under bark, under the cover of sedge clumps and in lichen mats. Ten other species of spiders were recorded, including *Agelenopsis potteri* (Blackwall), *Castianeira longipalpa* (Hentz), *Gnaphosa parvula* Banks, *Phidippus purpuratus* Keyserling, *Schizocosa avida* (Walckenaer), *Schizocosa saltatrix* (Hentz), *Tibellus oblongus* (Walckenaer), *Trochosa terricola* Thorell, *Xysticus triguttatus* Keyserling and *Zelotes hentzi* Barrows. Some of these are likely restricted, but information on occurrence is incomplete.

(e) Other insects

The larvae of **Myrmeleon immaculatus* DeGeer (Ant Lions – Neuroptera) require open sand to develop pitfall ant traps and are consequently restricted to open, sandy sites (issue cover). These insects were found at Slack Road but have yet to be seen at other sandy areas of eastern Ontario. A number of ant species and representatives of several other insect groups present at the two sites may have been restricted to open sand, but occurrence data are presently insufficient to draw conclusions.

OTHER FLORA AND FAUNA

The small size of existing remnants is limiting to larger animal species, but ***Common Nighthawks* (*Chordeiles minor* (Forster)) nested on a larger rem-



FIGURE 10. A sphacid wasp, *Microbembix monodonta* (Say) at entrance to burrow in open sand. Photographed late August 2007 at Crystal Rock by P. M. Catling. Specimen in CNCI.

nant at Crystal Rock in the 1980s and **Clay-coloured Sparrows* (*Spizella pallida* (Swainson)) were present during the breeding season. Pine Warblers (*Dendroica pinus* A. Wilson) have been present in the pine stands at Crystal Rock and although pine stands are widespread in eastern Ontario today, young stands have become quite scarce. **Grasshopper Sparrows* (*Ammodramus savannarum* (Gmelin)) have been observed on the dry grasslands at Uplands.

The early reports of ***American Badgers* (*Taxidea taxus*), which are associated with sandy ground, at Crystal Rock seem unlikely since the easternmost reports are otherwise from southwestern Ontario. However, Cameron (1994) noted on the authority of the Newmans, who lived on the south side of the sand hills, that the badgers around Crystal Rock “were not only dangerous, but would attack other animals and steal chickens ... Badgers were nearly eradicated.” They recalled the bears (presumably **American Black Bears* (*Ursus americanus* Pallas)) and badgers in the early days which would have been ca. 1875 (T. Cameron, personal communication). Although badgers may disperse over 100 km within a year, eastern Ontario is at least 400 km east of the main range in southwestern Ontario (Lintack and Voigt 1983; Newhouse and Kinley 1999*) and the lack of material evidence makes the records doubtful.

Open sandy areas, where sufficiently extensive, are important habitats for reptiles. Even when greatly



FIGURE 11. The spider *Steotoda albomaculata* (DeGeer), abundant on dry and hot sandy ground, generally hiding under bark, lichen mats and under foliage. Photographed in late June 2007 by P.M. Catling at Crystal Rock. Specimen in CNCI.

reduced, they retain significance as nesting sites for turtles. The Crystal Rock sites have been used extensively by *Blanding's Turtles* (*Emydoidea blandingii* (Holbrook)).

Decline of flora and fauna in sandy areas

Although there is little quantitative information on declines of plants and insects in Slack Road and Edwardsburgh Township sand deposits, the continuous trapping of parasitic wasps at Slack Road has strongly suggested a very substantial decline. During the 1980s the numbers of individuals and species declined by 50% and further decline has continued to the present. It is believed that these declines are a consequence of a variety of factors, including loss of habitat and spraying with pesticides, especially to control mosquitoes in adjacent pine plantations.

Several plant species appear to have been extirpated on the dry open sandy areas of Edwardsburgh Township; at least they are now extirpated in their only known locations. Included here are *Lespedeza capitata* and *L. hirta*. Several beetles and plants including *Monarda fistulosa* were eliminated when sandy areas at Uplands were replaced with urban development. Others including the Mottled Sand Grasshopper (*Spharagemon collare*) were extirpated when dry, open sand

grew in with invasive Glossy Buckthorn (*Frangula alnus*) and other woody vegetation.

Other sand dunes of the Champlain Sea

Other extensive dry areas occurred elsewhere on the borders of the Champlain Sea in New York state and southwestern Quebec and elsewhere in the lower Ottawa valley. It appears that all of these sites have in common (1) a similar dominant and restricted flora and fauna; (2) some species unique to the site; and (3) a substantial decline in areas of open sand and unforested area over the last 100 years. A few examples follow.

The only other area of sand associated with the Champlain Sea that is fairly well known in Ontario is the Constance Bay Sand Hills (Porsild 1941; Breitung 1957). Information on the decline of this biodiversity-rich site is available in White (1979 and Wilson (1984).

The Bourget Barrens west of Bourget and north of Casselman were planted with conifers or have grown in or became part of urban or agricultural developments. Vestiges of these sandy areas and others to the west, in vicinity of Mer Bleue and on the ridges in Mer Bleue (near 45.3938°N, 75.5092°W), existed until the 1990s. They were very similar to the Slack Road and Crystal Rock sites but had a higher water table

and were more prone to filling in with trees without fire. Natural succession and invasion of Glossy Buckthorn (*Frangula alnus*) have eliminated most of these habitats.

Rare species are documented at a number of sites on Champlain Sea sand deposits in Quebec. A few provincially and regionally rare plants occur in the shrinking sandy openings at Cazaville near Saint-Anicet (Boudreault and Brisson 1994; Barbeau and Brisson 2004*). Andre Castagnier, who grew up on the site of the sand barren at Saint-Anicet, southwest of Valleyfield in Quebec, noted that the open sandy area was far more extensive 50 years earlier. This area, very similar to Crystal Rock, has open sandy ground with scattered *Danthonia spicata*, *Rubus alleghaniensis*, *Carex tonsa* var. *rugosperma*, *Dichantheium depauperatum*, *D. acuminatum* var. *fasciculatum* and *Pteridium aquilinum* but is best known for the relatively large population of *Monarda punctata* in the open sand (Barbeau and Brisson 2004*), this being the only site in Quebec. Also present are *Aristida basiramea* (see Allen 2002*), *Ambrosia psilostachya* and *Hedeoma hispida*. The open area is growing in with *Populus tremuloides*, *Acer rubrum*, and *Pinus strobus*, and introduced *Bromus inermis* and *Rumex acetosella* appear to be increasing on the site (personal observation). Barbeau and Brisson (2004*) thought it likely that natural fires maintained open sandy areas in the pine forests of the region. Of course this makes sense because the pine forests found in the region by the early settlers would have required open sand to develop.

Other naturally open or semi-open sandy areas in Quebec are mapped by Filion (1987) and David (1988) and noted by Larochelle (1975) in a list of sites where *Cicindela lepida* occurs which he searched for specifically and which is confined in Quebec to the region of the former Champlain Sea (including Lachute, St. Phillippe, Lanoraie, Pointe-du-Lac, Choisy, Como, Hudson, Rigaud, Ste-Marthe, and St. Lazare; more precise locations are provided by Larochelle (1975)). These areas occur on both sides of the St. Lawrence River and include sand deposits several km south of Rigaud. These sites are disappearing and have not been inventoried in depth but they include characteristic and restricted flora and insects such as the grasshopper *Psinidia fenestralis*, among others.

Conclusions

Open sandy areas that existed for hundreds or thousands of years in eastern Ontario have declined to approximately 1% of their former extent over the last 60 to 70 years due to tree planting, invasion of alien plants, destruction for urban developments and natural succession to woodland in the absence of fire. This is supported by both historical information and a persisting rich assemblage of rare and restricted species of open sand. The sandy areas dependent vascular plants and insects have declined not just due to habitat

loss but they also apparently have been influenced by invasive species and use of pesticides in adjacent areas. Although climate change may increase activity of shoreline dunes in southern Ontario (e.g., Wolfe and Nickling 1997), it is less likely to cause expansion of sandy areas in eastern Ontario inland dunes that have always probably been dependent on natural fire and other disturbances. At the Slack Road and Crystal Rock dune study sites, the regionally rare and restricted species include 29 vascular plants and 36 insects, most of these dependent upon dry, open sand habitats, but the numbers of restricted species are likely much higher because insects, lichens and mosses at these sites require much more study. The recent survey suggests that most of the restricted species still exist in these areas despite substantial loss of habitat and local extirpation. However, based on the present rate of decline, these and other sandy habitats in the Champlain Sea region, along with their specialized flora and fauna, may disappear within a few decades. On the other hand, the biodiversity-rich remnants could serve as nuclei for the recolonization of a restored ecosystem. Appropriate management would require cutting woody plants and removal of invasive species as well as bulldozing or other disturbance to expand and maintain open sandy areas for colonization.

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APPENDIX 1

List of plants occurring in open sandy area of the Slack Road region (SR) and/or the Crystal Rock and nearby sandy areas (CR) in Edwardsburgh township. ** = provincially rare in Ontario; * = regionally rare in eastern Ontario (east of Ottawa); + = introduced.

- Amelanchier arborea* (Michx. f.) Fern. var. *arborea*, Downy Service-Berry (CR,SR)
Amelanchier laevis Wieg., Allegheny Service-Berry (CR,SR)
Amelanchier stolonifera Wieg., Running Service-Berry (CR,SR)
Anaphalis margaritacea (L.) Benth., Pearly-Everlasting (CR,SR)
Anemone cylindrica Gray, Long-Head Thimbleweed (CR,SR)
Apocynum androsaemifolium L., Spreading Dogbane (CR,SR)
Asclepias syriaca L., Common Milkweed (CR,SR)
Betula papyrifera Marsh., Paper Birch (CR,SR)
Betula populifolia Marsh., Gray Birch (CR)
+ *Bromus inermis* Leyss., Smooth Brome (CR,SR)
* *Calystegia spithamea* (L.) Pursh ssp. *spithamea*, Low False Bindweed (CR,SR)
* *Carex cumulata* (Bailey) Fern., Clustered Sedge (CR,SR)
* *Carex houghtoniana* Torr. ex Dewey, Houghton's Sedge (CR,SR)
* *Carex merritt-feraldii* Mackenzie, Merritt Fernald's Sedge (CR,SR)
Carex pennsylvanica Lam., Pennsylvania Sedge (CR,SR)
* *Carex siccata* Dewey, Dry-Spike Sedge (CR,SR)
Carex tonsa (Fern.) Bickn. var. *rugosperma* (Mackenzie) Crins, Shaved Sedge (CR,SR)
* *Carex tonsa* (Fern.) Bickn. var. *tonsa*, Shaved Sedge (CR,SR)
* *Ceanothus americanus* L., New Jersey-Tea (CR)
Cirsium discolor (Muhl. ex Willd.) Spreng., Field Thistle (CR)
* *Corylus americana* Walt., American Hazelnut (CR)
Corylus cornuta Marsh. var. *cornuta*, Beaked Hazelnut (CR,SR)
** *Cyperus houghtonii* Torr., Houghton's Flat Sedge (CR,SR)
Danthonia spicata (L.) Beauv. ex Roemer and J.A. Schultes, Poverty Wild Oat Grass (CR,SR)
* *Desmodium canadense* (L.) DC., Showy Tick-Tefoil (CR,SR)
Dichanthelium acuminatum (Sw.) Gould and C.A. Clark var. *fasciculatum* (Torr.) Freckmann, Tapered Rosette Grass (CR,SR)
* *Dichanthelium depauperatum* (Muhl.) Gould, Starved Rosette Grass (CR,SR)
Diphasiastrum complanatum (L.) Holub, Northern Running-Pine (CR,SR)
Diphasiastrum digitatum (Dillenius ex A. Braun) Holub, Southern Running-Pine (CR,SR)
* *Diphasiastrum tristachyum* (Pursh) Holub, Blue Ground-Cedar (CR,SR)
Equisetum hyemale L., Tall Scouring-Rush (CR,SR)
Fragaria virginiana Duchesne ssp. *virginiana*, Virginia Strawberry (CR,SR)
+ *Frangula alnus* P. Mill., Glossy Buckthorn (SR)
Gaultheria procumbens L., Eastern Teaberry (CR,SR)
* *Helianthus strumosus* L., Pale-Leaf Woodland Sunflower (CR)
* *Helianthus divaricatus* L., Woodland Sunflower (CR)
+ *Hieracium piloselloides* Vill., Tall Hawkweed (CR,SR)
+ *Juniperus communis* L. var. *depressa* Pursh, Common Juniper (CR,SR)
* *Lespedeza capitata* Michx., Round-Head Bush-Clover (CR)
* *Lespedeza hirta* (L.) Hornem. ssp. *hirta*, Hairy Bush-Clover (CR)
Lycopodium clavatum L., Common Club-Moss (CR,SR)
Lycopodium dendroideum Michx., Prickly Tree Club-Moss (CR,SR)
* *Lycopodium lagopus* (Laestadius ex C. Hartman) G. Zinserling ex Kuzeneva-Prochorova, One-Cone Club-Moss (CR,SR)
Lycopodium obscurum L., Flat-branched Tree Club-Moss (CR,SR)
Maianthemum canadense Desf., False Lily-of-the-Valley (CR,SR)
Maianthemum stellatum (L.) Link, Starry False Solomon's-Seal (CR,SR)
* *Monarda fistulosa* L. ssp. *fistulosa*, Oswego-Tea (CR,SR)
Muhlenbergia mexicana (L.) Trin., Mexican Muhly (CR,SR)
Oryzopsis asperifolia Michx., White-Grain Mountain-Rice Grass (CR,SR)
* *Panicum virgatum* L., Wand Panic Grass (SR)
Physalis heterophylla Nees var. *heterophylla*, Clammy Ground-Cherry (CR,SR)
Picea glauca (Moench) Voss, White Spruce (CR,SR)
* *Pinus banksiana* Lamb., Jack Pine (SR)
* *Pinus resinosa* Ait., Red Pine (also planted) (CR,SR)
Pinus strobus L., Eastern White Pine (CR,SR)
+ *Pinus sylvestris* L., Scots Pine (CR,SR)
+ *Poa compressa* L., Flat-Stem Blue Grass (CR,SR)
Poa pratensis L., Kentucky Blue Grass (CR,SR)

APPENDIX 1 (continued)

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- ** *Polygonella articulata* (L.) Meisn., Coastal Jointweed (possibly introduced in the Merivale area based on late collections) (SR)
- Populus balsamifera* L. ssp. *balsamifera*, Balsam Poplar (CR,SR)
- Populus tremuloides* Mich., Trembling Aspen (CR,SR)
- * *Potentilla arguta* Pursh ssp. *arguta*, Tall Cinquefoil (CR,SR)
- Prunus pensylvanica* L. f., Fire Cherry (CR,SR)
- Prunus virginiana* L., Choke Cherry (CR,SR)
- Pseudognaphalium obtusifolium* (L.) Hilliard and Burt., Blunt-leaf Rabbit-Tobacco (CR,SR)
- Pteridium aquilinum* (L.) Kuhn var. *latiusculum* (Desv.) Underwood ex Heller, Bracken (CR,SR)
- * *Pycnanthemum virginianum* (L.) T. Dur. and B.D. Jackson ex B.L. Robins. and Fern., Virginia Mountain-Mint (CR)
- * *Quercus rubra* L., Northern Red Oak (CR)
- Rosa acicularis* Lindl. ssp. *sayi* (Schwein.) W.H. Lewis, Prickly Rose (CR,SR)
- Rosa blanda* Ait., Smooth Rose (CR,SR)
- Rubus allegheniensis* Porter, Allegheny Blackberry (CR,SR)
- Rudbeckia hirta* L., Black-eyed-Susan (CR,SR)
- + *Rumex acetosella* L., Common Sheep Sorrel (CR,SR)
- * *Selaginella rupestris* (L.) Spring, Ledge Spike-Moss (CR)
- + *Silene vulgaris* (Moench) Garcke, (*S. cucubalus*) Maiden's-Tears (CR,SR)
- Solidago juncea* Ait., Early Goldenrod (CR,SR)
- Solidago nemoralis* Ait. var. *nemoralis*, Gray Goldenrod (CR,SR)
- * *Spiraea tomentosa* L., Steeplebush (SR)
- * *Sporobolus cryptandrus* (Torr.) Gray, Sand Dropseed (CR,SR)
- Thuja occidentalis* L., Eastern Arborvitae [White Cedar] (CR,SR)
- * *Viola adunca* Sm., Hook-Spur Violet (CR,SR)
- Vitis riparia* Michx., River-bank Grape (CR,SR)
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