Geoscience Canada

The Soil Column: Geology, Land-Use, and Conservation of the Quaternary Barrier System of Wasaga Beach, Ontario

I. P. Martini et D. W. Hoffman

Volume 3, numéro 1, february 1976

URI : https://id.erudit.org/iderudit/geocan03_01fea01

Aller au sommaire du numéro

Éditeur(s)

The Geological Association of Canada

ISSN

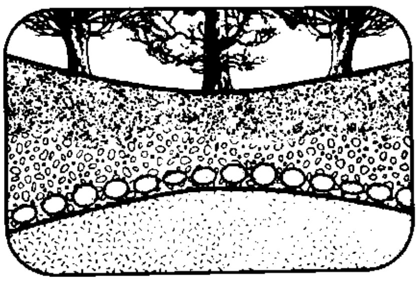
0315-0941 (imprimé)
unknown (numérique)

Découvrir la revue

Citer cet article

Martini, I. P. & Hoffman, D. W. (1976). The Soil Column: Geology, Land-Use, and Conservation of the Quaternary Barrier System of Wasaga Beach, Ontario. *Geoscience Canada*, *3*(1), 45–53.

Features



The Soil Column

Geology, Land-Use, and Conservation of the Quaternary Barrier System of Wasaga Beach, Ontario

I. P. Martini and D. W. Hoffman
Department of Land Resource Science
University of Guelph
Guelph, Ontario

Man is finally becoming aware of the limitations of his habitat on Earth. He is now striving to use natural resources without unduly disturbing or polluting the natural environment. However, increasing population requires increased development of lands for habitation and recreation. In densely populated areas, modifications of natural landscapes occur rapidly; in these areas there is an obvious need to maintain a variable and pleasant environment in which to live. Remote, inaccessible wilderness regions preserve examples of natural phenomena and act as reservoirs for living things. However, examples of natural landscapes should also be maintained in densely populated regions so that many individuals may visit them for recreation and educational purposes.

In land use planning, values that are seldom considered relate to the geological and geomorphological history of the landscape. The primary objective of this article is to contribute some information concerning the geology and geomorphology of Wasaga Beach, Ontario (Fig. 1), by stressing its unique character, the slow processes that formed it, and the necessity for careful land-use planning and conservation.

The geological system of Wasaga Beach comprises Pleistocene (Wisconsin) till sheets overlain by glacio-fluvial and lacustrine sands and gravels. A "barrier complex" was formed in the last 6800 years through accretion of spits, beaches and sub-aerial sand dunes (Martini, 1975). Similar complexes exist along the coasts of the Great Lakes, and contain much information for deciphering the history of

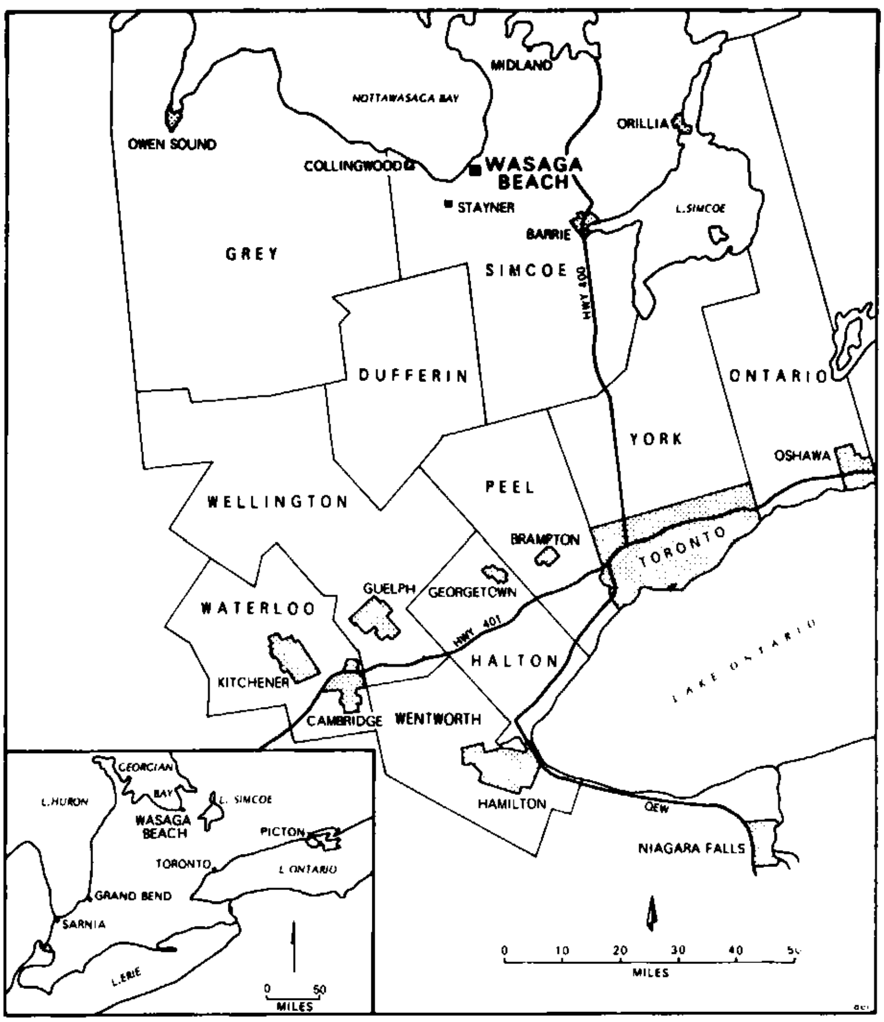


Figure 1
Location of Wasaga Beach.

formation of these features and lacustrine basins (Hester and Fraser, 1973). However, the Wasaga Beach system is unique on account of its degree of development and preservation; moreover it contains easily accessible natural exposures of its internal structures along the Nottawasaga River. From a naturalist's point of view, the location of this sandy, hilly environment at this latitude creates unique biological niches where assemblages of plants and animals, normally having more southern or northern ranges, are found together.

Wasaga Beach offers extensive sandy shores, and is a preferred weekend and summer resort for the inhabitants of central and southwestern Ontario. The cottage-town of Wasaga Beach has sprawled to cover all but the tip of the recent spit (Fig. 2). During the last decade, the rapid rate of increase of population in the Great Lakes region and the introduction of contemporary recreational activities, such as snowmobiling, cross-country skiing, all-terrain vehicles, horseback riding, and camping has increased the pressure for development in the area to the point that maintenance of the natural ecosystem is difficult. To prevent disruption of the protective plant cover and subsequent accelerated erosion and deposition of sand, proper planning of human activities should be undertaken.

Planning requires inputs from several disciplines. This article makes no attempt to bring together representatives from all disciplines interested in the conservation of the unique natural ecosystem at Wasaga Beach. Instead, it concentrates on some aspects of the physical environment which have a strong bearing on the potential of the area for certain forms of development.

The work reported herein is of a general nature. More detail and quantification can be found in referenced work. It should be noted that this is ongoing research and hopefully additional information will be available at a later date.

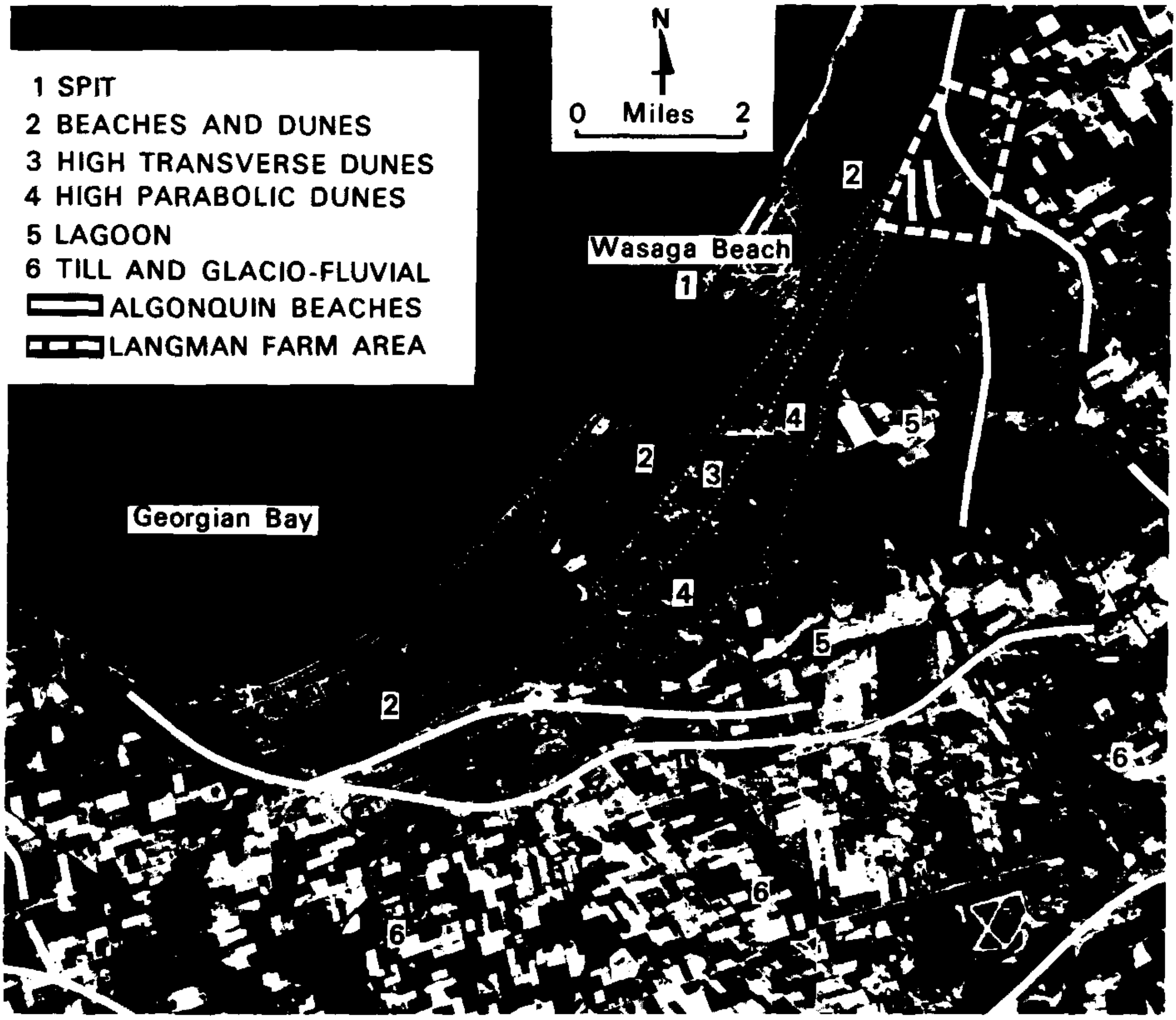


Figure 2
Geomorphological provinces of the barrier system of Wasaga Beach.

Geology and Land Use

The information available on the geological history of the present day Lake Huron and its glacial precursors, Lake Algonquin and Lake Nipissing, indicates that the fluctuations of the water level were related to an inter-play of retreating ice sheets, a differential isostatic rebound of the land that affected also the elevation of outlets, and a progressive erosion and deepening of the outlets themselves (Fig. 3) (Dreimanis, 1958; Lewis, 1969, 1970). Much of this key information is locked in the geological-geomorphological provinces that make up Wasaga Beach (Fig. 2, 4). The major provinces are the Pre-Algonquin till sheets, the Algonquin glacio-fluvial sediments and raised beaches, and the Nipissing post-Nipissing "barrier complex", which can be subdivided further into a lagoon, high parabolic dunes, raised beaches and transverse dunes. The Recent provinces comprise an alluvial plain, a sand spit, with beaches and a shallow shelf with well-developed subaqueous bars. Each one of these areas was formed and is being modified by specific processes or different power-states of similar processes. As a consequence, each unit is unique in terms of its sediments, geomorphology and living biota, and each one responds differently to intensive land use (Martini, 1974; McHarg, 1969). Optimum planning for development can be achieved only through diversification and matching of activities to landscape in order to minimize damages to the ecosystems (Fig. 4).

Till Plain. During the Pleistocene glaciations, glaciers advanced into the Wasaga Beach area from the Lake Huron basin and from the Shield north of Lake Simcoe. Paleozoic shales and limestones eroded from the basin, mixed with some Precambrian material derived from the Shield, constitute the makeup of the tills. Two till-sheets were deposited during the latest Wisconsin period and have been preserved (Burwasser, 1974). The younger sheet is highly calcareous, clay rich and contains few pebbles. It is found in limited areas and is capped by gravels and sands. The second and older till is sandy and stony, and contains a few large Precambrian boulders. Sand filled frost cracks provide a record of an early post-glacial

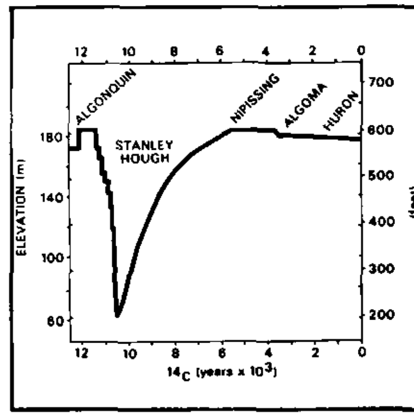


Figure 3
Variations in lake levels in the Lake Huron Basin (after Lewis, 1970).

permafrost condition (Martini, 1974). This till is present on the surface and in the sub-surface throughout the Wasaga Beach area. During Algonquin times, it constituted islands around which gravelly beaches were formed. During Nipissing times, it formed promontories from which the initial spits of the system grew. This till was the major source of the materials that were reworked into the coastal environments. At the present time, the sandy and stony till forms gently fluted high grounds (Fig. 2), with

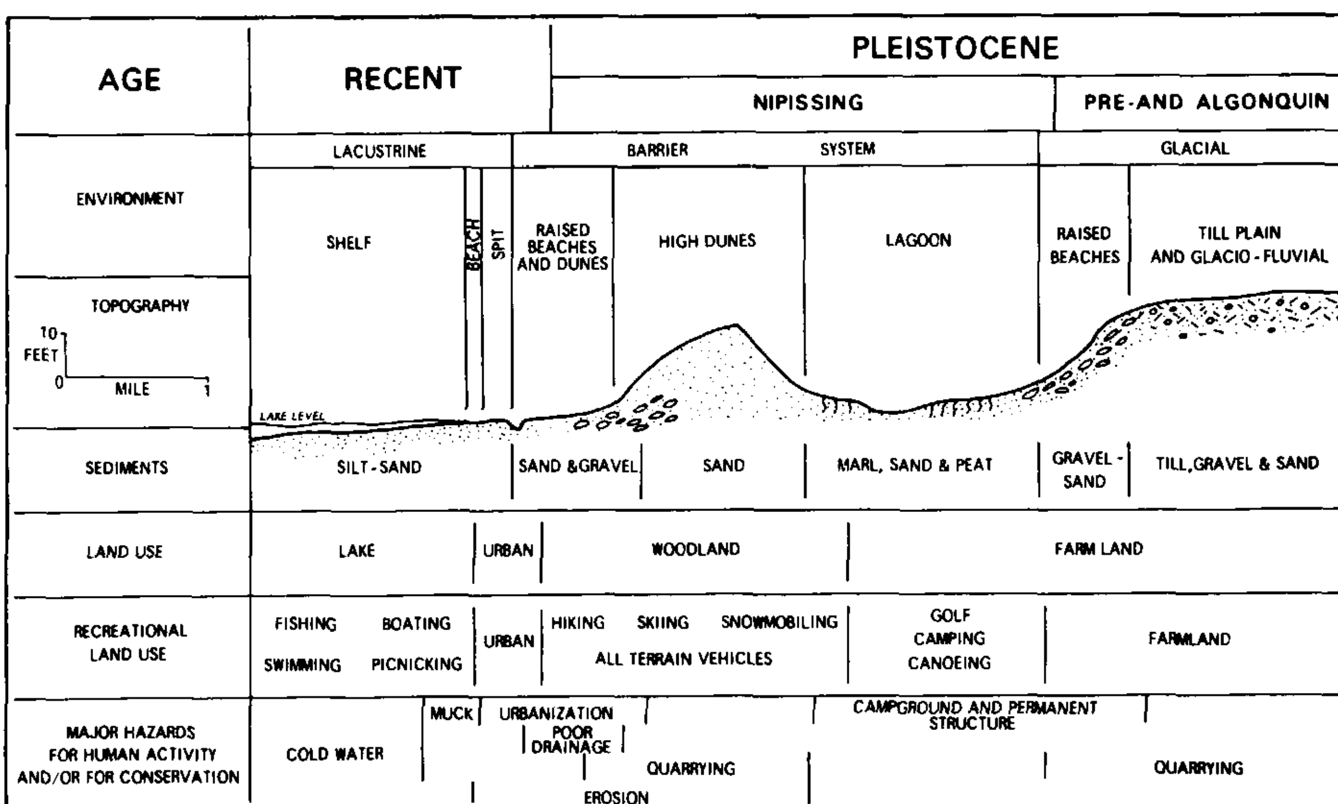


Figure 4
Schematic cross-section of barrier system of Wasaga Beach.

soils of the Gray Brown Luvisol group *developed on it. The soils are* characterized by a silty loam texture, slight to very stony, imperfect drainage, smooth, rolling topography with approximately three percent slopes, and no, or very little, erosion (Hoffman *et al.*, 1962). The till plains are open, poorly protected by arboreal vegetation, and *tend to experience cold winters.* The land is used predominantly for dairy and livestock farming.

These lands have limited natural resources for recreation (class 5 or lower, Table I), but have high ratings (class 2 or 3) for urban growth. The lands that are closer to the town of Wasaga Beach would constitute optimum sites for building indoor or outdoor recreational facilities. Intense development here would not necessarily conflict with conservation principles, *neither would it seriously harm the* marginal farming activities. On the other hand, it would relieve some of the development pressure presently directed toward other geomorphological provinces that have more fragile ecosystems, much higher natural capability for recreation, and unique *historical and geological values.*

Algonquin Glacio-Fluvial and Lacustrine Sediments. At different times, Lake Algonquin discharged eastward from Wasaga Beach through Lake Simcoe into the St. Lawrence Lowlands (Deane, 1956). This ancient re-entrant, and the pathways of the outlets are well-defined by glacio-fluvial sediments, raised erosional shorelines and beaches, and other lacustrine sediments deposited around till islands, and on flat, low-lying *till plains. The glacio-fluvial and deltaic* deposits are composed of poorly sorted sandy gravel deposits of braided outwash, and locally, of sand filling of deep deltaic channels that were entrenched into coastal beaches and dunes during lowering stages of the water level of the lake. The fills are *characterized by cross-bedded,* "fining upward sequences" (Reineck and Singh, 1973) of fairly well-sorted medium to coarse sand, with the lower coarser portion mixed with clay pebbles derived from local ancient ponds.

Three major types of Algonquin beaches were formed around till islands or along spits that grew from till aprons (Martini, 1975). One contains sorted sand and gravel, and resembles the Nipissing beaches that will be described

Table 1: *Soil Capability for Urbanization (top values) and Recreation (bottom values) (after Hoffman, 1972; MacDonald and Richards, 1973).*

Soil and Site Factors	Capability Classes				
	1	2	3	4	5
Depth to Bedrock (ft) (1 foot = 0.3048 m)	>20 / > 5	8-20 / > 5	< 8 / >5	<8 / >5	<8 / >5
Depth to Water Table (ft)	>20 / Below surface	>20 / Below surface	8-20 / Below surface	<8 / Below surface	<8 / Below surface
Natural Drainage	Good / Good	Moderate / Moderate	Imperfect / Very good (rapid)	Poor / Poor	Very poor / Very poor
Depth of one or more Impermeable Layers (ft)	None / None	>3 / >3	2-3 / 2-3	1 / 1-2	<1 / <1
Time Between Floodings (wks)	No Flood / No Flood	No Flood / >10	50 years / 6-10	10 years / 3-5	5 years / <2
Slope (percent)	0-6 / 0-30	7-12 / 3-30	7-12 / >30	13-20 / 0-2	>20 / 0-2
Variability in Slope	Moderate / High	Moderate / Moderate	High to Moderate / High to Moderate	High / Low	High / Low
Erosion	None / None	None / None	None to slight / None to slight	Moderate / Moderate	Severe / Severe
Texture	Clay to sandy loam / Silty loam	Sandy loams to clays / Sandy to clay loams	Gravels to silty loams / Gravels to clays	Silt and / sands	All textures of wet / locations
Stoniness	Few or stone-free	Few or stone-free	Moderately stony	Very stony	Exceedingly stony

later. Another type is characterized by well-sorted sand deposited in inclined beds that show rhythmic sedimentation in the form of plane beds alternating with thicker intervals of ripple-marked sand. High rates of sedimentation and possible near-deltaic environments of deposition are suggested for these sequences by the stratigraphic position, and the preservation of thick layers with ripple marks and occasional ripple-drift. Characteristics of the third type of beach are fairly to poorly sorted gravels with rounded and subspherical pebbles which are mainly carbonate in composition. Their poor sorting relates to short distances from tills of the islands that constituted their source, the generally low energy of the depositing environment, and the relatively short time that the beach processes were allowed to rework the sediments. These deposits are typified by gently inclined accretionary beds, by the overall coarsening upward trend of the sediments, where the coarser sediments were piled at the top of the beach during storms, and by superimposed minor cycles consisting of small to medium scale cross-beds and erosional surfaces and/or thin plane beds.

The soil types formed on the glacio-fluvial, deltaic, and beach sands vary from well-developed Humo-Ferric Podzol to Gray Brown Luvisol and Humic Gleysols (Hoffman *et al.*, 1962). Melanic Brunisol soils characterize the sandy-gravelly deposits. All, except the poorly-drained Gleysols, have good drainage. The topography is generally smooth, except in restricted areas where some steep slopes exist. These lands are poor for farming, but good (class 2 or 3) for recreation and cottage building. Proper planning is required to exploit the sand and gravel resources, and afterwards, to reclaim the area for forestry and recreation.

Intense, well-planned activities on these deposits do not conflict necessarily with conservation principles, except for a small parcel of land on the northeast side of the Wasaga Beach system around the Langman Farm (Stanley, 1936), where three Algonquin beaches at different elevations, are well preserved (Fig. 2). The lowest beach, the Payette beach, lies 624 feet above sea level and it records an Algonquin water level that is lower than the Nipissing Lake level (elevation 634 feet above sea level) (Stanley, 1936). This Algonquin beach was not destroyed by the advancing Nipissing waters because of the build-up of the barrier which protected it from strong waves. This geological record of Wasaga Beach is a rare one, and it is very important for understanding the geological history of the Great Lakes, and in particular, the Wasaga Beach system. As such, it should be preserved as a small open space to be used only for non-destructive agricultural or recreational activities.

Barrier System. The barrier complex of Wasaga Beach was developed during the last 6800 years and is still being moulded by modern processes (Martini, 1975). The sedimentary provinces of this system can be found interfingering with each other in sections exposed along the Nottawasaga River. The lower and older sedimentary sequences in the centre-southwestern part of the barrier consist of sandy-gravelly beaches that developed over the eroded surface of tills. These initiated the formation of the spit during the rising water level stages of the very early Lake Nipissing, 5800-7000 Radiocarbon years ago (Fig. 3).

The spit grew into a barrier. Lagoons formed behind it with the subsequent deposition of silts, clays and peats interstratified with sand carried in during storms by wind or by waves breaking through the barriers. This lagoonal sequence formed just landward from the gravelly beaches and below the overlying high parabolic dunes, and was deposited, from about 5336 ± 62 to 4642 ± 60 years ago (Carbon-14 dating), at a net deposition rate of approximately 0.7 cm per year.

The glacial Nipissing Lake remained at its highest water level until approximately 3700 Radiocarbon years ago. Afterward, the lake level dropped, and during this last regression the geological-geomorphological characteristics of the area, the available Carbon 14 dates and archaeological data suggest that the bulk of the high parabolic back-dunes were formed and migrated lagoonwards approximately 3000 to 2500 Radiocarbon years ago. From that time on, the retreating lake shores were marked on the northwest side of the system by well preserved raised strom beaches capped by thin, parallel dunes (Fig. 2).

Lagoon. The ecosystems of the lagoonal area (Fig. 2) vary considerably. They comprise (a) forested sandy floodplain of the Nottawasaga River, (b) the recent marshy, lacustrine habitat of Marl Lake where organic matter composed predominantly of grass, sedge and mollusk remains, are being deposited, (c) a rim area at the back of the high dunes and around the raised Algonquin beaches, covered by a thin, shallow, lacustrine sand layer and (d) the central area of the ancient lagoon that is underlain by marly clay. A Humic Gleysol soil has developed in the topographically level area underlain by poorly drained marly sediments (Hoffman *et al.*, 1962). Present day land use consists of mixed farming, woodlots, and increasing recreational activities such as golfing, horseback riding, camping, hunting in Marl Lake, and fishing and canoeing along the river. The land capability of the area ranges between classes 3 or 4 (Table I). Its ecosystems are robust and sheltered enough to be able to withstand future intensive development, although several parts should be maintained as open natural spaces because they are integral parts of the barrier complex, and thus have geological-geomorphological, naturalistic, historical, educational and recreational significance.

Beaches and Dunes. The sandy, gravelly beaches that formed the original spit and underly the main sandy section of the barrier complex are composed of several types of sand-free gravel layers, gravels with infiltrated sand, gravelly sand, and erosional remnants of well-sorted sands. Some of the sand lenses contain large concentrations of heavy minerals, up to 95 per cent. More commonly the sands are quartz rich with concentrations of dark minerals in laminae. Sedimentary structures typical of these beaches are inclined accretionary beds, cut and fill, cross-beds, and large, coarsening upward sequences related to storm deposits. Various minor depositional rhythms are superimposed over the major storm cycles. They show coarsening upwards and downwards sequences which were formed at different stages during storms or during fair weather. In particular, cycles which include thin beds of openwork granules mark the migration of the ancient swash lines along the shore faces during falling storm stages.

The gravelly deposits grade laterally and vertically into beaches composed of well sorted sands, which are well exposed along the Nottawasaga River, in sand pits, and road cuts. They are characterized by: a) inclined laminae with superimposed ripple marks alternating with plane beds and erosional surfaces; b) some concentrations of heavy minerals in laminae; and c) in younger beaches, thin layers of shells and thin accumulations of partially decomposed vegetal matter ("muck") similar to that being deposited along recent shores.

Covering these sequences are parallel dunes which range in thickness up to five feet (2 m). In the southwestern portion they have been modified by high transverse dunes and deflation basins, and they have been partially buried under high [up to 1000 feet (30 m)] parabolic dunes (Fig. 2). The wind blown sediments are characterized by fine to medium, well-sorted quartz-rich sand, medium to large scale cross-beds, and some slump features. Locally, the sedimentary structures of the upper five to nine feet (2 to 3 m) of the deposit are partially obliterated by plant roots and associated pedological processes.

The sands of the barrier complex have weakly developed Podzolic soils. Drainage is rapid in the high dunes, where some steep slopes exceed 30 degrees. Poor drainage characterizes the swales of the raised beach province. The whole area is forested, locally with plantations or covered by prairie ecosystems. The different biological communities relate to slope and aspects of land. In these variable environments microclimates range from well-ventilated comfortable conditions to some sheltered, forested areas where peak summer temperatures can reach 130°F (54°C) in open areas and often exceed 110°F (38°C). Except for the most exposed highlands, a good snow cover is available everywhere during winter.

Many parts of these provinces rate highly (class 1 or 2, Table I) for recreation both in summer and winter and for cottage building. However, the landscapes, particularly the parabolic dunes are fragile and, if the protective vegetation is reduced, remobilization of the sand may occur. The importance of this biological and geomorphological system requires very careful planning for the types of activities, and for the time of year during which recreational activities may be performed. Similarly, although the dunes can be a good source of sand and the underlying beaches of gravel, the historical,

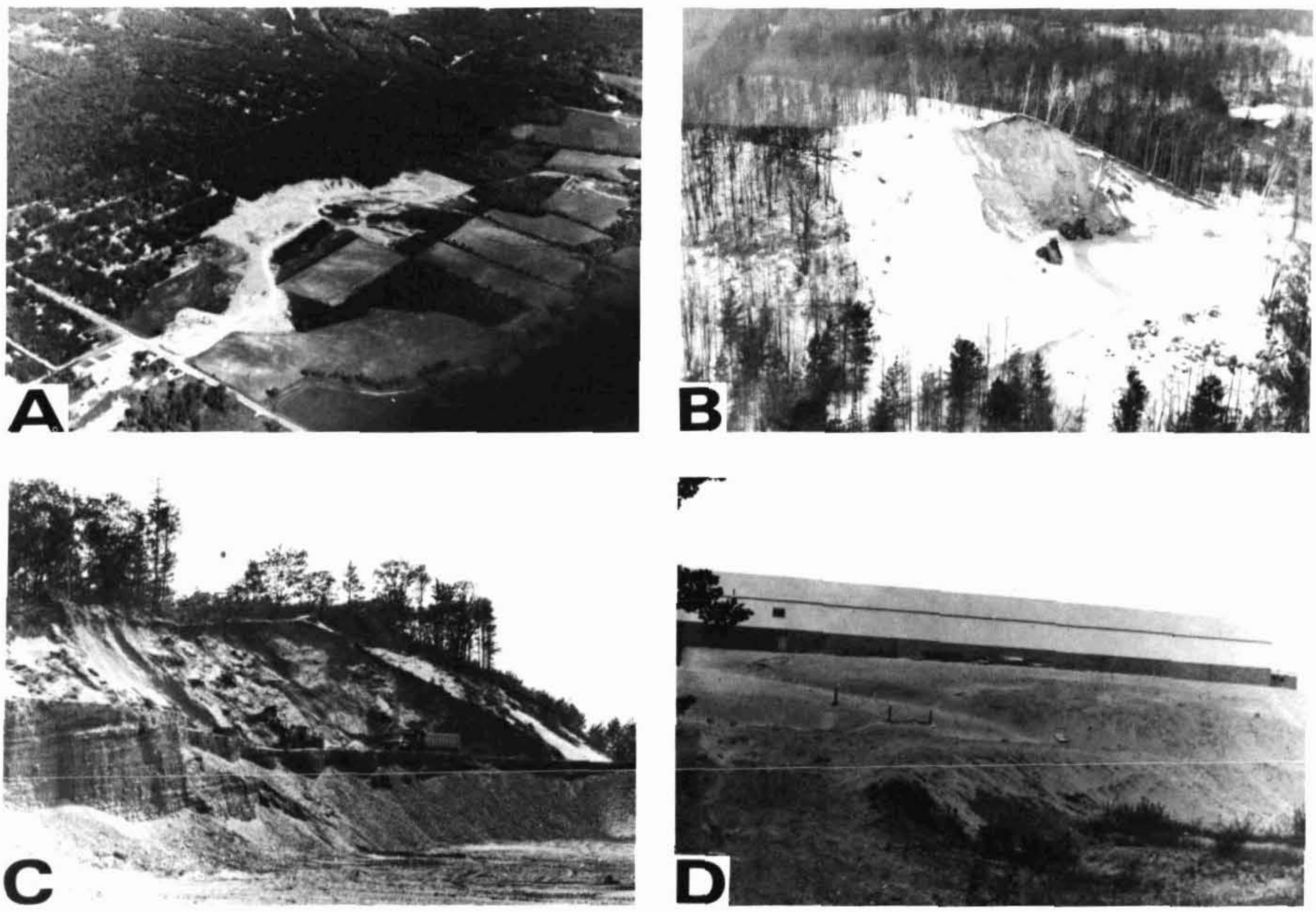


Figure 5
Disruptive land use in the barrier system:
A. Large sand and gravel pit in the southwest end of the barrier: the lagoon is to the right, Georgian Bay to the left;
B. Sand pit in high dune along the Nottawasaga River;
C. Detail view of A, showing gravel beaches overlain by sand of high dunes;
D. Skating rink built on top of dunes in the northern part of the barrier.

biological, visual and recreational importance of the landscape is too great to be destroyed (Fig. 5). Alternative sources for aggregates are potentially exploitable in nearby Algonquin and pre-Algonquin terrains.

Recent Sandy Environments. Blowouts in the high dunes, the spit, beaches, and shelf constitute the most active, recent sandy environments. A few observations will suffice to stress the relation between their sedimentology and land use planning.

The shelf of Georgian Bay is underlain by sand and silt showing a regular, fining-offshore trend. This shelf has both beneficial and detrimental effects upon the resort value of the shore. It constitutes a large reservoir of sand that is piled up onto the beaches and foredunes during fair weather and eroded off during storm conditions. In the sub-aqueous environment the sand moves in sets of three to five bars that trend parallel to the shore. These bars adjust their position in accordance with energy conditions of the lake, they tend to be unstable, to migrate toward shore, and to merge with the beach. The presence of these bars may create minor problems for young swimmers because of variations in water depth. A more important and expensive effect of the shallow shelf relates to the process of accumulation of vegetal matter ("muck") on the beaches (Fig. 6C). Grab samples from the shallow areas and along the shelf and offshore show little algal growth in the recent lake. The bulk of the organic matter is derived from inland marshes and forests, is transported by Nottawasaga River and is redistributed and stored in troughs

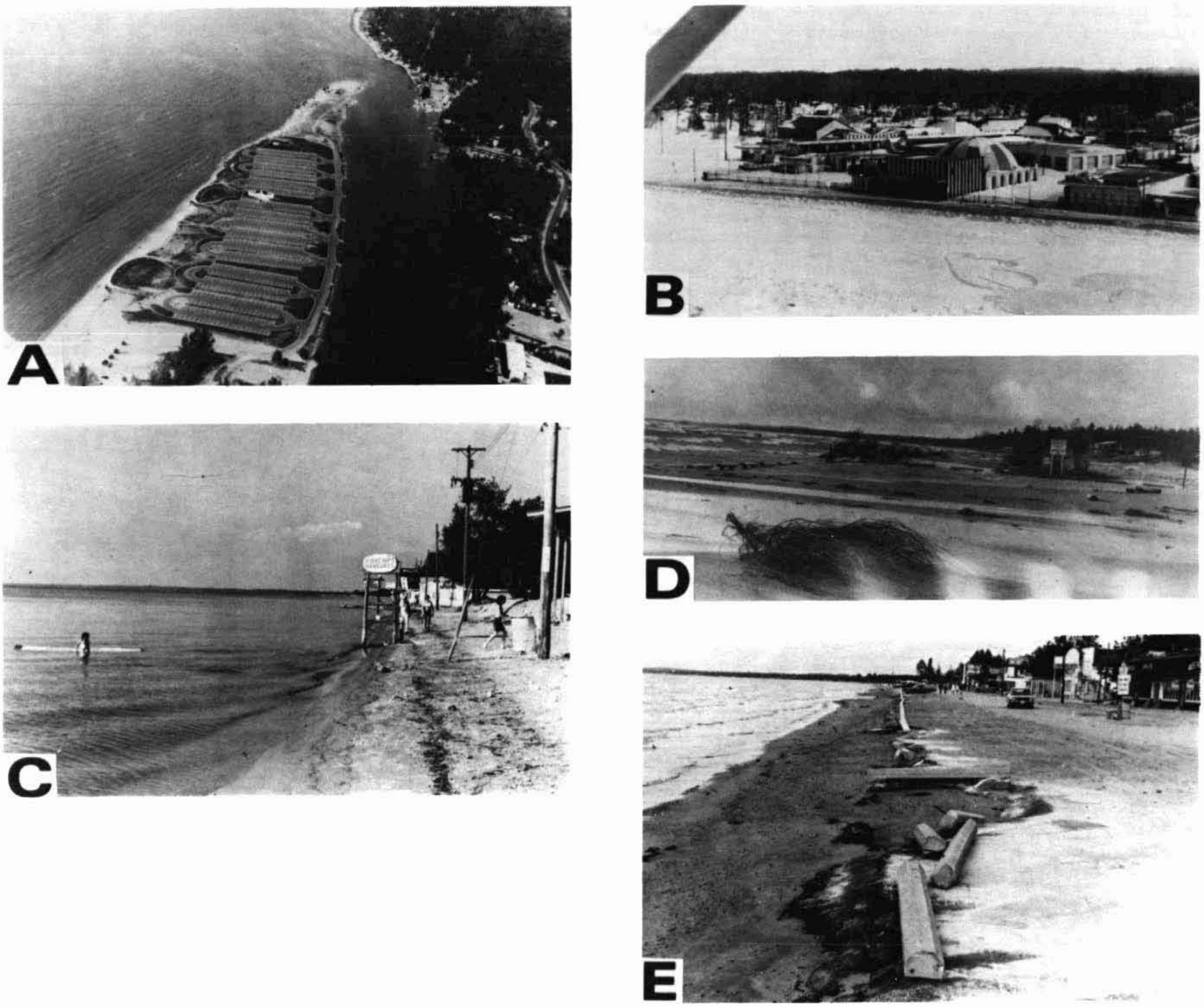


Figure 6
Modern coastal environments of Wasaga Beach:
A. Parking lots on the tip of the coastal spit: Nottawasaga River is to the right. Note indentations at the tip of the spit, which are formed by washover during storms (see D);
B. Central area of town during winter time. In foreground there is the frozen surface of Georgian Bay;
C. Beach of Wasaga Beach during high waters. Note swash lines marked by accumulation of muck;
D. During storms, washover cut across the tip of the spit, erosion occurs in the lake side and deposition in washover-fans into the river (see A);
E. Road built directly on the beach. It is not protected by foredunes and it is damaged during storms.

between the bars and ripples. During storms, the partially decomposed matter is suspended and later deposited on the shores. It creates costly management problems because the beaches must be cleared during tourist seasons.

Preliminary studies indicate that other management problems relate to sand transported in a closed circuit over the spit. Sand transported from the shelf on to the beach is carried further onshore by wind. There, it is entrapped by vegetation and piled up on foredunes. This subaerial movement of sand is not continuous, rather, it is most effective during storms and during low water stages of the lake. The sand which has not been trapped in the dunes migrates landwards and eventually falls into the river that acts as a barrier. These sands are mixed with other fluviatile sediments, carried into the lake, and redistributed once again on the shelf. This transport circuit of sand is very active at the tip of the spit where the area is only partly vegetated and no urban development has occurred except for the building of parking lots (Fig. 6A). Similar public parking lots are being built all along the water-front of Wasaga Beach. They are open to the lake and are not protected behind foredunes, whose growth has been stopped rather than enhanced by human activities. Management problems occur, firstly because each year parking lots and unprotected town roads must be cleared of sand, and secondly because the absence of foredunes has enhanced destructive shoreline erosion during storms (Fig. 6B, 6D, 6E).

Summary and Conclusions

A barrier system is located at Wasaga Beach, Ontario. It is a well developed example of a coastal landscape, and its geology is well exposed in cuts along the Nottawasaga River that cross the system.

Because Wasaga Beach is close to major urban centers, it is a favourite summer and winter resort. The increased use of the land for recreational purposes, requires a proper land-use plan to balance activities, and to match possible developments with the carrying capacity of the various landscape units (provinces). A few general comments can be made.

a) Areas of possible intense development are present to the east of the barrier system itself. These lands are underlain by tills, glacio-fluvial and coarse beach sediments. Except for a small parcel of land to the north (around the Langman farm; Stanley, 1936), which has great geological significance, the sand and gravel resource can be exploited first, and the whole land can be reclaimed afterwards for intense land use and construction. The carrying capacity of the area is high and the soils are suitable for construction.

b) Along the modern spit and coastline of the Georgian Bay intense urbanization has occurred. The beach is the major attraction of the area. The natural enviroment has been strongly modified by man, and the best that can be done, is a sound management of the coast to avoid expensive maintenance of parking lots and removal of muck from beaches.

c) The cottage town of Wasaga Beach has outgrown the spit area, and it is sprawling to the east of the river into the "raised beached and dunes" province. Areas of this province should be maintained at their present natural status because they contain important geomorphological and biological features. To do this, however, only a moderate degree of construction can be allowed, and sound land-use planning is required because of the strong conflicts between development and conservation principles. For example, to develop the area properly, an extensive drainage system must be built to lower the water table. This may destroy the natural plant assemblage of any area that is planned as park or reserve, if these areas are not sufficiently extensive and properly located.

d) A second province of the barrier system where moderate development can occur, is the lagoon. The lagoon is crossed by the Nottawasaga River and its shores are attractive for people interested in fishing and canoeing. There, the land is flat and in many areas it is underlain by marly deposits which may reduce its suitability for construction of septic tanks. The lagoon is an integral part of the geologic-geomorphologic system and parts of it should be maintained as open park spaces.

e) The high dunes constitute the most fragile environment of the barrier system. They are covered by pine and oak forest and by prairies and recently stabilized heath. The ground cover is highly susceptible to traffic, and exposed sand is easily remobilized by wind erosion in open spaces and spring runoff in open trails in the forested areas. No development of the area should be undertaken, except for the establishment of controlled nature trails to exploit the physical and biological educational values of the area.

Concluding, it may be stated that the Wasaga Beach landscape is unique in the Great Lakes region. Some of its features such as sand dunes are fragile and can easily be remobilized; others are found only in very restricted areas, for example, the set of three raised Algonquin beaches in the northeastern side of the system. Development of these areas should be carefully planned with prime emphasis being given to conservation and non-destructive recreational activities. Alternative areas exist that are located close to the present town and are capable of supplying all necessary building materials at comparable costs, and where permanent structures can be built without violating conservation principles.

Acknowledgements

The authors are grateful for grants from the Ontario Ministry of Natural Resources and National Research Council making this research possible. We are indebted to Dr. B. D. Fahey whose helpful comments improved the manuscript.

References

Burwaser, G. J., 1974, Quaternary Geology of the Collingwood-Nottawasaga Area, Southern Ontario: Ont. Div. Mines, Prelim. Map, p. 919 Geol. Series, scale 1:50,000.

Deane, R. E., 1956, Pleistocene Geology of the Lake Simcoe District, Ontario: Geol. Surv. Can., Memoir 256, 108 p.

Dreimanis, A., 1958, Beginning of the Nipissing Phase of Lake Huron: Jour. Geol., v. 66, p. 591-594.

Hester, N. C. and G. S. Fraser, 1973, Sedimentology of a Beach Ridge Complex and Its Significance In Land Use Planning: Environmental Geological Notes, no. 63, Illinois State Geol. Survey, 24 p.

Hoffman, D. W., R. E. Wicklund and N. R. Richards, 1962, Soil Survey of Simcoe County, Ontario: Rep. No. 29, Ontario Soil Survey (Canada Department of Agriculture), 109 p.

Hoffman, D. W., 1972, University of Guelph, unpublished data.

Lewis, C. F. M., 1969, Late Quaternary History of Lake Levels in the Huron and Erie Basins: *in* Proceedings of the 12th Conference of Great Lakes Resources: Ann Arbor, University of Michigan, Great Lakes Res. Div., p. 250-270.

Lewis, C. F. M., 1970, Recent Uplift of Manitoulin Island, Ontario: Can. Jour. Earth Sci., v. 7, p. 655-675.

MacDonald, D. A. and N. R. Richards, 1973, Land Inventory Interpretation for *Resource Use for the Pickering*, Uxbridge, Markham Area: Dept. Land Resource Science, Univ. Guelph, Guelph, Ontario, 33 p.

McHarg, I. L., 1969, Design with Nature: New York, Natural History Press, 198 p.

Martini, I. P., 1974, Wasaga Beach: A Quaternary Classic Landscape, Its Geological History and Biological Carrying Capacity of the Sand Dunes: Univ. Toronto Press, York Universtiy Series, Geographical Monographs, v. 5, p. 61-77.

Martini, I. P., 1975, Sedimentology of a Lacustrine Barrier System at Wasaga *Beach, Ontario, Canada; Sedimentary* Geology, in press.

Reineck, H. E. and I. B. Singh, 1973, Depositional Sedimentary Environments; New York, Springer-Verlag, 439 p.

Stanley, G. M., 1936, Lower Algonquin Beaches of Penetanguishene Peninsula: Geol. Soc. Am. Bull., V. 47, p. 1933-1960.

MS received October 27, 1975.

Last Notice for The Stockwell Symposium

A symposium on "*The Hudsonian Orogeny and plate tectonics*" is to be held in Ottawa, March 4th and 5th, 1976, in the auditorium of the National Library on Wellington Street. Meetings will begin at 8:55 a.m. and continue until 5:30 p.m. each day. The symposium is being organized under the auspices of the Canadian Geodynamics Subcommittee and is in honour of C. H. Stockwell, of the G.S.C., who has contributed so much to our understanding of the Canadian Shield. There will be 30 papers covering geology, geophysics and metallogenesis in the Churchill and Bear Provinces and Precambrian occurrences in the USA. The meetings are open to all who are interested. Participants are expected to make their own travel and accommodation arrangements. The National Library is conveniently situated near any downtown hotel. Neither registration nor registration fees are required. Enquiries to J. G. Tanner, Earth Physics Branch, EMR Ottawa, 613-994-5242.