

ORIGINS OF THE FLORA

The flora of the Goat Island complex and the Niagara River Gorge represent a floristic anomaly within the characteristic regional vegetation of the Niagara Frontier. This is based on the high species diversity and abundance reported for the area of the falls. All vegetation in the area has been reintroduced since the last glacial period. All species became established through opportunities provided by regional and local climatic regimes, substrates, water levels, topographic variation and natural disturbance regimes within the study area favoring the establishment of a diversity of habitats supporting species with a wide assortment of different tolerances and competitive advantages.

The Niagara Reservation consists of the margin of a river and a series of islands. These two conditions alone serve to distinguish these natural areas ecologically from those of the surrounding continuous landscape. The original forest, depicted in nineteenth century and earlier pre-photographic engravings and illustrations as growing down to the river and gorge edge, would have had a boundary there. So, too, would its darkening canopy and the modification of environmental conditions within it. Life on the margin would be exposed to sunlight, to weather, to soil changes, soil textures with different nutrients, and to increases in soil moisture and the mechanical effects of the same moisture freezing in winter, fluctuations in water levels, etc. These different physical conditions would have and do create opportunities for distinctive plant communities, with species assemblages differing from those of the forest dominating the enclosing region.

As a general rule, it may be said that the organisms growing on Goat Island - and any of the other islands at the brink of the falls - derive from populations existing or which have existed in the past in the region as a whole. Day (Porter, 16 Ann Rep Comm, 1900) inferred this because no species he was able to observe growing there could not be found elsewhere in the adjacent mainland. This simply means there were no endemic species developed here and nowhere else, or that there were any bizaare elements in the flora only confined to the islands.

It may also be said that whatever broad climatological events affected the region also affected conditions on Goat Island. Whatever the preglacial regional ecosystems were, these were destroyed and the entire area was stripped of its indigenous flora and soil as the last glacier ground over it at the end of the Pleistocene over 12,000 years ago. As plants and animals recolonized the areas south of the northwardly retreating ice front, these species would have made contact with whatever land surface was available in the channel of the post-glacial river we now call the Niagara River. Conditions were sub-arctic near the ice front and became gradually ameliorated as the millennia proceeded. Communities of plants existing south of the glacier, and presently found north of the Niagara region, first pioneered and succeeded one another on the recently exposed land. The Niagara area supported tundra vegetation and isolated patches of spruce forest (Terasmae in Tesmer, 1981). Perhaps 1300 years subsequently, with ameliorating climate, the boreal forest with spruce and jack pine dominants replaced the tundra situation. Topographic stability in western New York, following the various hydrological changes corresponding with the retreat of the glacier, was achieved by around 9000 years B.P. "Residual features such as bogs, kettle holes, now-dry lowland marshy areas, etc., were major features of the landscape that would have influenced distribution of plant communities, animal habitats, and human sites" (Calkin & Miller, 1977).

Forests dominated by spruce and fir continued to colonize the land, and elements of the present eastern deciduous forest, with its beech-maple dominants, succeeded them (Zenkert, 1934). Significant pine elements were present around 9000 years ago and persisted to 6000 years ago, due to drier conditions than exist in the Niagara area today (Terasmae in Tesmer, 1981). From around 5000 years ago to the present the climate was much as it is today, promoting growth of extensive deciduous forest.

Isolated pockets and range extensions of boreal plant species continue to exist throughout glaciated western New York State, down to the southern limits of the glacier in the unglaciated area of Allegany State Park, south of Salamanca in Cattaraugus County. These species do not occur south of the old glacial boundary (Zenkert, 1934). These species continue to persist in areas of relative cold, as in the higher elevations of the Allegheny Plateau in southwestern New York, in cold bogs and along cold springs, and in areas of late snow melt. The water-charged atmosphere cooled by spray from the cataracts and the turmoil of water in the Niagara River gorge, also cold ice floes building up in the gorge from Lake Erie late in the year, together with northern exposures and the restricted angles of sunlight in the gorge, allowed northern trees, such as *Betula papyrifera* (Paper Birch) and *Thuja occidentalis* (Arbor Vitae) to extend down the Niagara Escarpment through Ontario to the north, into the Niagara gorge, which is continuous with that escarpment, and on up to Goat Island at the southern terminus or head of that gorge. It is to be expected that the historic flora of Goat Island and the Niagara Gorge flora derived from the flora of the north-facing calcareous Niagara Escarpment, of which the seven-mile gorge is a continuation. This interpretation is Zenkert's (1934) based on observations along the Niagara Escarpment, and the presence

continuation. This interpretation is Zenkert's (1934) based on observations along the Niagara Escarpment, and the presence of northern species in cool, shaded habitats in the Niagara gorge, such as Miterwort (Mitella nuda) and Oak Fern (Gymnocarpium dryopteris). Arbor Vitae, or Northern White Cedar, is commonly found to the north but is quite characteristic of the margins of the Great Lakes, to which many place names testify. It is near the southern margins of its range in our area and tends to persist on bedrock pavements (especially of calcareous rock).

The flora of western New York may be said to represent a transitional zone between the great northern boreal-coniferous and the more southerly deciduous forests of today. This transition expresses itself floristically in a "macromosaic-like arrangement with pure deciduous forest on favorable habitats with good soil, and pure coniferous forest on less favorable habitats with poor soils" (Walter, 1973), although this latter condition is difficult to see in western New York due to a history of logging and agricultural clearing (Zenkert, 1934). Pinus strobus (White Pine) is the conifer species indicative of this transition zone in the Great Lakes, with Tsuga canadensis (Hemlock) elements (Walter, 1973). Transitional forest areas may also be composed of "a few coniferous species (mainly pine) and a few deciduous species" (Walter, 1973). In southeastern forests, Juniperus virginiana (Red Cedar) is indicative of a transition between forest types.

A corridor of Broadleaf Deciduous Forest, reaching from southern Michigan and the Great Lakes region south to Texas, extends up the north and southern boundaries of the Erie and Ontario Lake plain, perhaps following climatically the modifying influence of these lakes. This forest corresponds to Kuechler's Beech-Maple Forest of tall broadleaf deciduous trees (No. 102): Sugar Maple (Acer saccharum) and Beech (Fagus grandifolia) are the dominants, co-dominants include White Ash (Fraxinus americana), Black Walnut (Juglans nigra), Tulip Tree (Liriodendron tulipifera), Black Cherry (Prunus serotina), Northern Red Oak (Quercus rubra), Basswood (Tilia americana), American Elm (Ulmus americana) and Slippery Elm (Ulmus rubra) (Kuechler, 1963), all present on Goat Island. This Beech-Maple Forest zone as mapped by Kuechler extends along the Lake Erie lake plain from Cleveland to Buffalo, north through Grand Island and east to the vicinity of Rochester.

The northern tip of Grand Island and the rest of Niagara County, including Goat Island, however, is covered by the Northern Hardwood (mixed broadleaf and conifer) Forest (No. 106) (Kuechler, 1963). This forest, in New York State, exists south of the lake plain flora with its southern affinities, and continues on east into central New York State. The Beech-Maple Forest corridor inserts itself within the surrounding region of Mixed Broadleaf and Conifer Forest associated with Middle latitudes - the transition forest mentioned above (Bartholomew, 1963). The southern Ontario portion of this corridor is referred to as the Carolinian Floristic Zone, more common south of the border with the United States, and is the only representation of this vegetation type in Canada - rather like Florida and other portions of the Caribbean coast have the only tropical vegetation type in the continental United States, (Kuechler, 1963).

The Mixed Broadleaf and Conifer Forest is Kuechler's Northern Hardwoods Forest (No. 106) of tall, broadleaf deciduous trees with some needle-leaf conifers such as Hemlock (Tsuga canadensis) and White Pine (Pinus strobus). The dominants are Sugar maple, Yellow birch (Betula lutea), Beech and Hemlock. Other components of these forests include Striped Maple (Acer pensylvanicum), Red Maple (A. rubrum), Mountain Maple (A. spicatum), White Ash (Fraxinus americana), White Pine, Black Cherry, Ground Hemlock (Taxus canadensis), Basswood, and American Elm. This forest type extends into New England, across New York State into northern Pennsylvania, and surrounds the northern Great Lakes region to northern Michigan and Wisconsin.

Since Kuechler did not map the northern limits of the forest types existing in the United States as they occur in Canada (Ontario), the areal relationships between the Beech Maple southerly forest and the Northern Hardwoods forests in adjacent Ontario and their relationship with the study area are obscured. Literature probably exists regarding the distribution of forest types in southern Ontario, but time constraints prevented its examination for this report.

The range of each forest vegetation type represents migration routes for species entering the area from regions north and south of the Great Lakes area of which the vicinity of Niagara Falls is a part. The Broadleaf Forest Corridor, associated with limestone pavements and climate modifications along the lake boundaries represents areas in New York and southern Ontario of plant species rare in the State and Province and with plains affinities.

The history of hydrological relations in areas south of the retreating ice-front are very complex, with lake enlargements and disappearances, impoundments and shifting east-west drainages of the watershed system to the west (Tesmer, 1981).

Exposed bedrock ledges or pavements with shallow soils along old lake and river drainage routes support a distinctive flora contrasting with that of the surrounding region. A coastal plain floristic element in the Great Lakes flora, of which Niagara is a part, has been described by Peattie (1922) and House (1925) wherein species native to areas east of the Appalachian elevations migrated westward and inland along temporarily connected shorelines of the receding glacial lakes. Examples of plants with this association and found or were once found on Goat Island include Saururus cernuus (Lizard's Tail), once on Terrapin Point, and Juncus articulatus (Jointed Rush), one of the most common of the rushes on Goat Island (Zenkert, 1934). Other Coastal Plain taxa may be found in the associated flora of the Niagara River gorge (Eckel, in prep.).

The source of certain species migrating into the Niagara area after the Wisconsin glaciation derived from elevations in the

Ozark Mountains in the present Missouri-Arkansas area. These species survived there during the period of glaciation, and recolonized areas to the north as the glaciers retreated. The Bur Oak (*Quercus macrocarpa*), present on Goat Island, and the abundantly represented Black Maple (*Acer nigrum*) are representative of this Ozarkian element, as are Bladdernut (*Staphlea trifoliata*), New Jersey Tea (*Ceanothus americanus*) and Rue Anemone (*Anemonella thalictroides*), present in the Niagara River gorge (Curtis, 1959).

During the thousands of years succeeding the end of the Pleistocene, the warming of the climate has not been uniform. Several times conditions were significantly warmer than at present with the result that elements of floras to the west and south of our region were sustained, although later, as at present, cooler, moister conditions prevailed, favoring a different suite of plant species - those that are presently more typical of western New York and southern Ontario. Gordon (1940) referred to the literature on the subject of a Xerothermic period (Gleason, 1922; Sears, 1932; Transeau, 1935) extending "thousands of years following the disappearance of glacial ice" when there occurred "a prolonged period of deficient rainfall, which may have lasted for a couple of centuries." This period is placed between 1400 and 1200 B.C. "A more severe dry period occurred about 650 A.D. A later period of drought ... reached its worst in the thirteenth century (Huntington, 1924). The effect of such climatic changes ... was to bring about death ... to mesophytes and hydrophytes, favoring the spread of xerophytes from the western prairies and plains" (Gordon, 1940). Openings in the Beech-Maple in western New York forests were dominated by oak and hickory, or oak and native chestnut trees and "prairie species" the survivors of "this migration are found today on shallow soils over limestone ..." and other habitats (Gordon, 1940). Most of the rare species of New York State growing on Goat Island and in the adjacent Niagara River Gorge are at the eastern limits of their ranges. They are more characteristic of lands to the west of us, and most grow and once grew on soil on the barren, wet limestone pavements on the south side of Goat Island (see rare plant section). It is also interesting that here is also where the rarer alien species introductions have presently been found. Artificial and natural openings in the forest and brush covers mimic meadows and pastures which in turn mimic prairie conditions.

Although not explored for the purposes of this study, more detailed examination of regional climatic regimes which reach their eastern limits in western New York State in association with lowland areas along Lakes Erie and Ontario may suggest conditions favoring continuation of biotic characteristics of regions west of Niagara into the Niagara area. The distribution of some western birds may parallel this climatic extension, and some fauna such as the Fox Squirrel (*Sciurus niger*).

Limestone may intensify this climatic boundary of, at least, greater warmth for plant species.

An alternative accounting for the existence of Oak-Hickory, Oak-Chestnut openings in the area as well as habitats supporting western plants relies on the existence of calcareous outcroppings with shallow, immature soils or no soils at all, perhaps in addition to warmer temperatures than elsewhere in New York State. The presence of Oak-Hickory elements in the Niagara forests was observed in the eighteenth century: the country around Niagara "though extremely sandy, is covered with oak, chestnuts, and fine hickory trees, and such parts, as are better watered, bear ... ash and maple-trees" (Liancourt, 1799).

Shallow soils and rocky bedrock pavements occur from New York State, in the area of Lakes Ontario and Erie, west to Michigan and Wisconsin (Tesmer, 1981), well developed along the Niagara Escarpment west to Manitoulin Island and east of Niagara in places along the northern margin of Lake Ontario in the Province of Ontario. In New York State limestone pavements along Lake Ontario into the St. Lawrence Seaway near the city of Watertown have recently been found to support an unusual flora with a plains affinity (H. Faber in New York Times, Sept. 18, 1988).

Exposed limestone has edaphic characteristics which promote dryness and warmth, mainly by characteristic fracturing through which rain is quickly dispersed. The presence of habitats of calcareous exposure with an east-west trend extending to the plains, which is also calcareous as to bedrock and soil derivation, may give a competitive advantage (due to possible adaptations to the physical conditions of this substrate) to calcareous-loving species, and provide avenues of dispersal or migration. This "biological highway" of calcareous substrates, in interaction with xerothermic periods, probably contributes to the intrusion of the western flora this far east.

The occurrence of rare eastern plants with a "western affinity" was thought by Wynne-Edwards (1937) to be "better explained as resulting from their lime-loving nature rather than from differences in their Pleistocene history" (Scoggan, 1978). For discussion of how, after the xerothermic period mentioned above, western prairies were artificially maintained eastward of their typical range at the expense of forest communities due to the hunting activities of early native peoples, see the work of Gleason and Cronquist (1964). This hunting tactic involved setting fire to the countryside to herd native animal populations. Zenkert (1934) furnished additional information on openings or "prairies" in the Erie County portion of the Niagara region, aligned in an east-west direction on thin soils "some ten miles south of the limestone ledge" (the Onondaga escarpment) a portion of which was called the "Buffalo Plains" (Rogers & Zander, 1977).

Examples of the calcareous flora at Goat Island, based on past and present reports, and which are typical of calcareous substrates, include the following (after Zenkert, 1934):

Amelanchier sanguinea ROUND-LEAVED JUNE BERRY.

Anemone cylindrica LONG-FRUITED ANEMONE.
Aquilegia canadensis WILD COLUMBINE.
Arabis canadensis SICKLE-POD.
Asplenium trichomanes MAIDENHAIR SPLEENWORT.
Aureolaria flava SMOOTH FALSE FOXGLOVE.
Carex aurea GOLDEN-FRUITED SEDGE.
Carex eburnea BRISTLE-LEAVED SEDGE.
Carex normalis LARGER STRAW SEDGE.
Carex rosea ROSE SEDGE.
Celastrus scandens CLIMBING BITTERSWEET.
Cornus rugosa ROUND-LEAVED DOGWOOD.
Cystopteris bulbifera BULBLET BLADDER FERN.
Erigeron pulchellus ROBIN'S PLANTAIN.
Hepatica americana BLUNT-LEAVED HEPATICA.
Linaria vulgaris BUTTER-AND-EGGS.
Penstemon hirsutus HAIRY BEARD-TONGUE.
Polypodium vulgare COMMON POLYPODY.
Quercus macrocarpa BUR OAK.
Quercus prinoides var. acuminata YELLOW OAK.
Rhus typhina STAGHORN SUMAC.
Saxifraga virginensis EARLY SAXIFRAGE.
Triosteum perfoliatum var. aurantiacum ORANGE HORSE GENTIAN.
Viburnum rafinesquianum [var. affine] WESTERN ARROW-WOOD.

Further investigation into other plant groups present in the Niagara area, including the Goat Island complex, may reveal interesting patterns of past floristic conditions. Bryophytes (mosses and liverworts) may be particularly instructive regarding evidence of floristic origins (Sharp, 1939; Crum, 1952, 1972). These and other smaller organisms "have the ability to survive in microhabitats in areas where many vascular plants may have been unable to survive" (Anderson, 1971). The fact that the Goat Island complex lies along the continuous inland coastline of the Great Lakes and its feeder streams, rivers and straits may account for the presence of a number of plant species in the Goat Island shoreline flora. Insofar as there is a distinctive Great Lakes floristic region, the Niagara area is a part of it as it shares many similar physical conditions: the area was glaciated, is characterised by calcareous substrates and has thin or no soils, its climate is moderated by the influence of the water masses in the lakes, it is part of a great shoreline corridor of swamp or marsh, or rocky stream-river margins whereby flora and fauna peculiar to these habitats may migrate up or downstream. The only station for Kalm's St. John's Wort in New York State was reported from Goat Island stations. This species is characteristic of calcareous soil, "mostly on moist sands along the Great Lakes" (Gleason and Cronquist, 1963). Other species, such as Burning Bush, or Wahoo (Euonymus atropurpureus) may attain the northern limits of their range in the Great Lakes watershed, growing "on river banks and floodplain forests" associated with the lakes in Michigan (Voss, 1985). Goat Island appears to have once supported an extensive population of this species (see species catalogue).

Weedy shore species introduced into the St. Lawrence Seaway have come upstream against the current, probably in association with migratory waterfowl. Flowering Rush (Butomus umbellatus), becoming abundant off the south shore of Goat Island along the Three Sisters and flats islands, is a "handsome European plant, introduced into America in the St. Lawrence valley only about 50 years ago [at the turn of the century and] was first noticed on the Lake Erie Islands [in the western half of that lake] on June 21, 1939. It occurs near the water level on gravelly or muddy shores and by means of its abundant seeds and numerous small basal bulblets, broken off by wave action, has rapidly spread throughout the [Erie] island group" (Core, 1948).

In the present flora, one may assume the dynamics of diaspore dispersal is as continuous as it has been for centuries: the wind, the river current, migrating birds and mammals, and new sources, such as associated with vehicles from all over North America that come onto the island. The Tomato (Lycopersicon esculentum) has been established from restaurant refuse behind the Terrapin Point restaurant. The majority of new and alien species, noted in the species catalogue, derive from "garden soils" around root balls of young trees and in horticultural treatments in the islands, and from the establishment and maintenance of extensive lawns. One interesting grass species, Wood Bluegrass (Poa nemoralis) is "archaeological" in the sense it was established probably in the early days of the Reservation "when it was recommended to seed lawns in shady areas" (Dore and McNeill, 1980, see species catalogue). Other odd alien species which have rare or non-existent distributions elsewhere in western New York are Chapman's Blue-grass (Poa chapmaniana), Gamma Grass (Tripsacum dactyloides), and a tiny Chickweed (Cerastium semidecandrum) whose source and mechanism of dispersal

might be more difficult to explain, or that the Goat Island complex provides special conditions for their establishment seldom found elsewhere.

It may be assumed that today the best source for the natural introduction of native (or alien) species is from birds - a good justification for developing cover for them on Goat Island throughout the diversity of habitats present. Preparing additional habitats, such as substrates: logs, stone surfaces, and creating topographic irregularity would increase the likelihood of "capturing" species additional to the Goat Island flora, or allowing populations already present to expand.
