
Sharp Pencils, Fat Crayons and Fuzzy Boundaries: How to depict the Carolinian in Canada

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Abstract

The Carolinian in Canada is the small northward portion of the much larger Eastern Deciduous Forest of North America in the United States. Its 'southern' boundary is defined absolutely by the southern boundary of Canada in Ontario, from southern Lake Huron to the shore of Lake Ontario, somewhere east of Toronto. However, the critical boundary is its 'northern' extent, the definition of which has import in a number of areas, not least in any attempts at protection and/or restoration of the region's rare ecological resources. This paper explores the antecedents to and specific variables that have been incorporated in the definition of the northern boundary and its representation. Particular attention is drawn to the distinctions between a) representing the Carolinian in Canada by the very precise, detailed lines of The Big Picture Project (sharp pencil) and b) the existence of possible outliers and inliers and fuzzy boundaries of a zonal nature (fat crayon).

Keywords: *Carolinian; boundary; ecoregion; ecotone; mapping*

A Geographer's Point of View

Carolinian Canada is a non-profit coalition of over 40 government and non-government conservation groups and many individuals working to conserve the ecological diversity of Canada's most threatened natural region. The Carolinian region in Canada has recently been 'defined' by Carolinian Canada as the same as *The Big Picture Project*. However, the ecological boundaries of the Carolinian region in Canada are not represented consistently and we have encountered numerous variations in depictions of the boundaries of the Carolinian Life Zone between the Big Picture maps and other maps. The

Carolinian Life Zone lies within the Lake Erie Lowland ecoregion that is part of the Temperate Broadleaf and Mixed Forests biome and it overlies the Niagara Deciduous forest region (World Wildlife 2001). In brief, the “Big Picture” methodology is an idealized pattern of linkages of forests greater in size, and of greater habitat complexity, than exist today. The Big Picture is a plan for several centuries into the future to provide functional habitats for a sustainable natural heritage system. The objective of this paper is to provide a critical re-examination of the treatment of the linear versus zonal boundaries of the Carolinian Life Zone in Canada.

Ecological Life Zone and Ecotonal Gradients

Mapping for *The Big Picture Project* used the revised limits of the Ontario Ministry of Natural Resources Ecoregion 7E owing to reasons of the analysis for conservation planning that required finite limits (Jalava *et al.*, 2000). As a result, the Big Picture map is a classic example of a map drawn with a firm boundary, as though drawn with a sharp pencil (Figure 1A). According to Carolinian Canada (2002) “*the Big Picture maps are an excellent tool for informing ourselves and creating awareness of the importance of local decisions to the health of the entire region*”. But, for purposes of education and public awareness, it is important to portray the Carolinian Life Zone in Canada as the dynamically variable ecological life zone that it is. Multiple variables are brought together to define an ecological life zone. These include structural attributes of physiography, topography, soils and ecoclimate. The interactions of these variables, in turn, influence function and processes that affect species’ range distribution. The ecotonal gradient of the Carolinian Life Zone should be portrayed with a gradient of tones and not mapped with finite limits to illustrate better the gradual blending of ecological communities. A limit to the Carolinian in Canada has been proposed by numerous botanists and biogeographers since as early as 1859, (James Phipps, personal communication, August 29, 2005). We believe that it is essential to depict the actual extent and inherently fuzzy boundary of the limits of the Carolinian Life Zone without a fixed edge but rather with a broad stroke as with a fat crayon.

The Problem of the Boundary

Ecoregions are distinguished by regional ecological factors that include climate, physiography, vegetation, soil, water and fauna. The Canadian framework for ecological land classification characterizes this part of Ontario as the Lake Erie Lowland of the Mixedwood Plains of the Eastern Deciduous

Region (Environment Canada 2005). This ecoregion at the southern tip of Ontario extends from Windsor to east of Toronto and includes the Niagara Peninsula. The Lake Erie Lowland Ecoregion has one of the warmest climates in Canada. It is marked by humid, warm to hot summers and mild, snowy winters. The mean annual temperature is approximately 8°C with a high of 9°C in the Windsor area. The mean summer temperature is 18°C and the mean winter temperature is 2.5°C below zero. The mean annual precipitation ranges from 750 to 900 mm and is evenly distributed throughout the year (Environment Canada 2005). This regime supports a range of species not found elsewhere in Canada. Indicator species of Carolinian Canada include the plants: Tulip-tree (*Liriodendron tulipifera*), sycamore (*Platanus occidentalis*), chestnut (*Castanea dentata*), sassafras (*Sassafras albidum*), flowering dogwood (*Cornus florida*), green dragon (*Arisaema dracontium*), and butterfly weed (*Asclepias tuberosa*); and, the animals: common opossum (*Didelphis marsupialis*), southern flying squirrel (*Glaucomys volans*), red-bellied woodpecker (*Melanerpes carolinus*), Carolina wren (*Thryothorus ludovicianus*), Eastern hog-nosed snake (*Heterodon platirhinos*) and the spiny softshell turtle (*Apalone spinifera*).

The Province's ecological classification uses a modification of the Hill's Site Region nomenclature. Ecoregions are based on the ecological subdivision of the land by a combination of climate, physiography and biological productivity (Jalava *et al.*, 2000). Finer scale refinements to the ecodistricts within the ecoregions of Ontario were made in 1999 and were based largely on physiographic criteria (Jalava *et al.* 2000). The limits of *The Big Picture Project* were the revised limits of OMNR Site Region 7E (Figures 1A and 1B).

However, the actual extent of the Carolinian Life Zone is based on biogeographic attributes and the distribution of plants and animals. Numerous questions arise in considering the representation of the limits of the Carolinian Life Zone as co-incident with the Big Picture Project maps. As examples,

1a) Why is there no extension of the Carolinian Life Zone north along the eastern shore of Lake Huron shore as would be suggested by various climatic variables (Figures 1B, 2A)?

1b) How is the use of the mid-point of the Rouge River justified as an eastern boundary when many contributing variables to the ecoregion suggest an extension along the north shore of Lake Ontario at least as far as the Bay of Quinte in Prince Edward County (Figure 1B, 2A)?

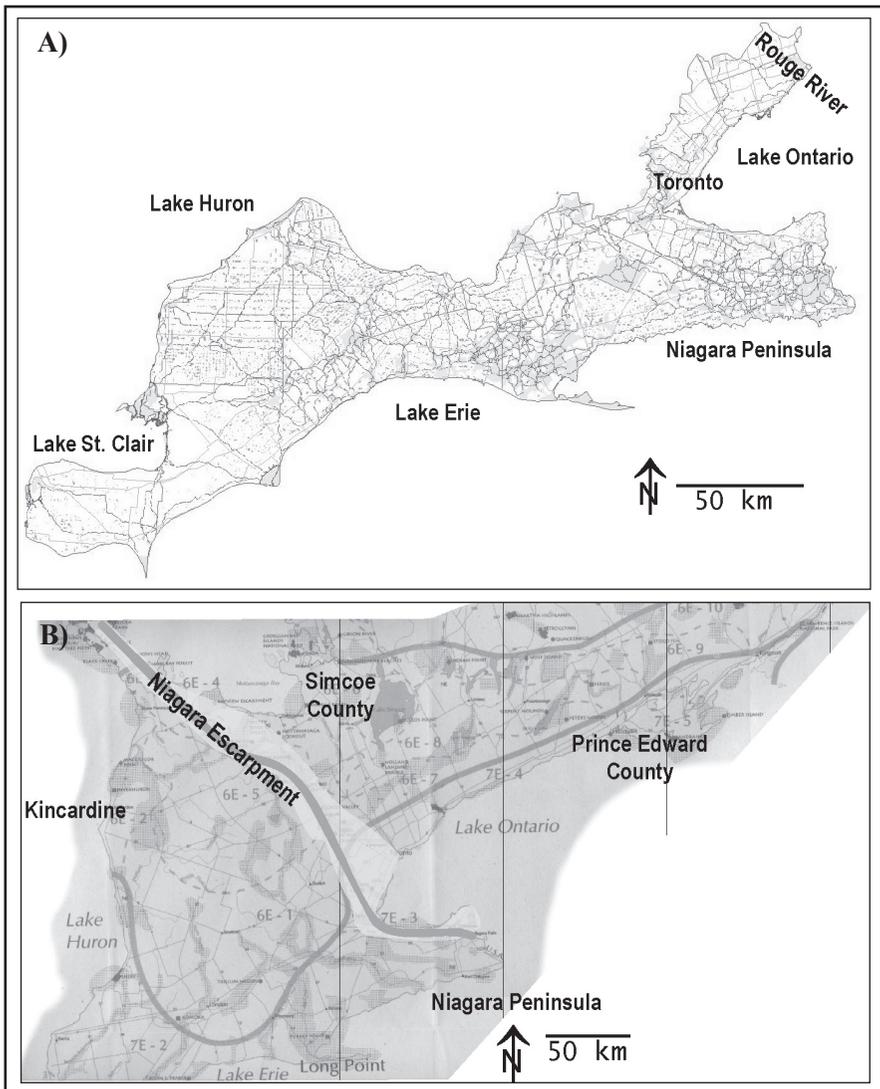
2a) How can *inliers* such as the boreal features within the Eastern Mixed Forest found at kettle bogs such as Sifton Botanical Bog in London, or the significantly fewer growing degree days along the Mount Elgin Ridge, which are presently included, be appropriately represented as NOT being a part of the Carolinian Life Zone (Figure 2A)?

2b) How can *outliers* such as the sheltered environments of the Bayfield

Figure 1. Variations in the limits of Carolinian Canada.

A) Cores and Corridors (Carolinian Canada, 2002).

B) Protecting Ontario's Endangered Spaces (Cundiff *et al.*, 1996).

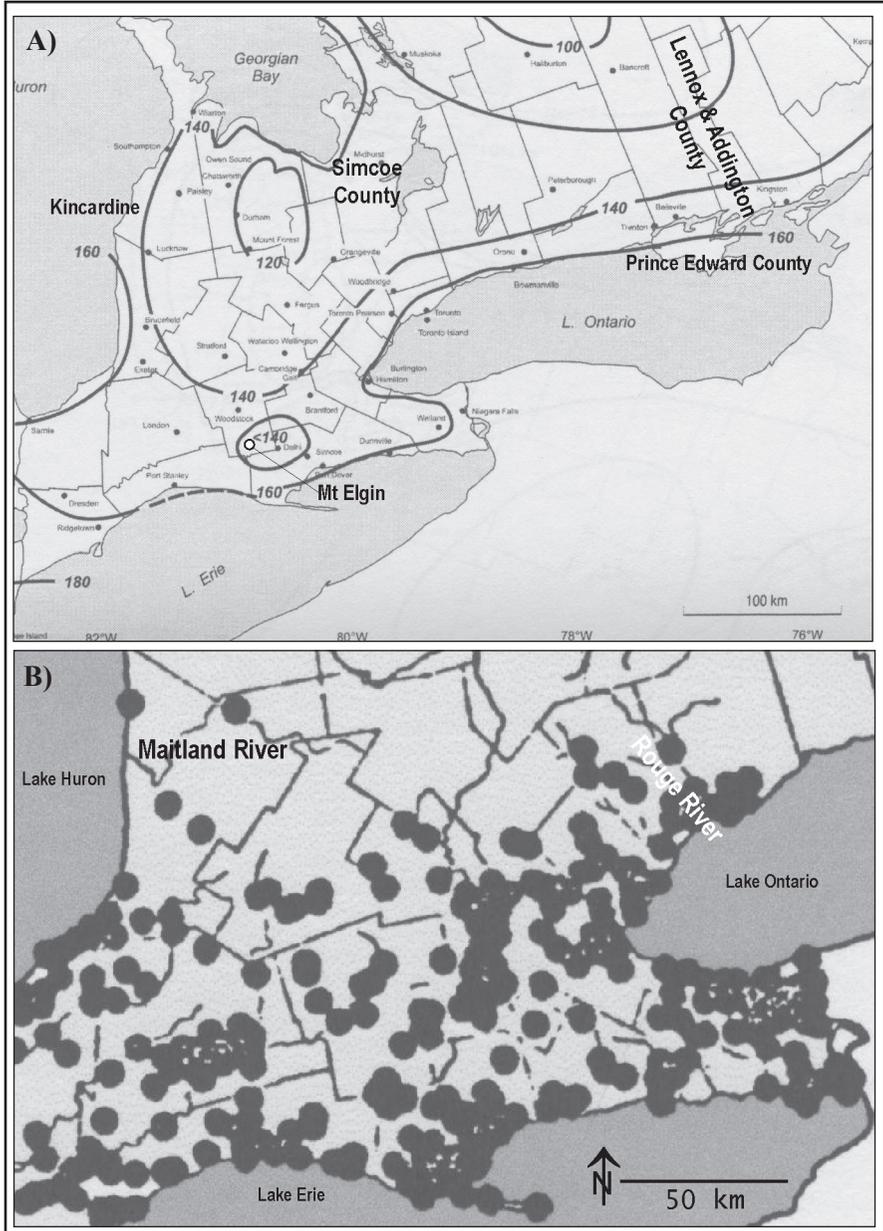


and Maitland River valleys, which are presently excluded, be represented as BEING part of the Carolinian Life Zone (Figure 2B)?

Figure 2. Inliers, Outliers and Transecting Ecotones.

A) Growing Degree Days, (Sanderson, 2002).

B) Combined distributions of 36 genera of restricted range in southern Ontario (Soper 1962 in Bowles 2004)..



Inliers, Outliers and Disjuncts

Variations in the mapping of the Carolinian abound. Climatically and physiographically areas along the east shore of Lake Huron or the north shore of Lake Ontario support Carolinian species. Yet, various maps from the Ministry of Natural Resources, such as “Ontario’s Provincial Parks” and “Southern Deciduous Forest Region” differ in this respect. The map “Ontario Parks” excludes the north shore of Lake Ontario while other MNR maps show varying extension along Huron shore as parts of the Carolinian Life Zone.

As indicated in Figure 2A, the Bay of Quinte and Kincardine each have more than 160 Growing Degree Days (GDD) but are typically excluded as part of the Carolinian. In contrast, the inlier of Mount Elgin Ridges has less than 140 GDD and consequently does not support some species characteristic of the Carolinian.

A different kind of inlier is the Sifton Botanical Bog in London and the Delhi Kettle Bog. These bogs are the most southerly bogs in Canada with an open bog mat ringed with black spruce (*Picea mariana*), tamarack (*Larix laricina*) and leatherleaf (*Chamaedaphne calyculata*); such plants are typical for the boreal rather than the Carolinian.

Outliers of the Carolinian can be inferred from Soper (1962, in Bowles 2004) for the combined distributions of 36 plant genera of restricted range in Southern Ontario (Figure 2B). Also, the known range of the odonate blue-tipped dancer (*Argia tibialis*) is now known to extend to Simcoe County, an area well beyond the Carolinian zone (Catling, Brownell and Pratt 2001).

In addition, disjunct populations of poverty grass (*Aristida dichotoma*), Englemann’s spike-rush (*Eleocharis engelmannii*) or bear-oak (*Quercus ilicifolia*) has been found in the granite barrens of Lennox and Addington County, well to the east of the current boundaries. Poverty grass and Englemann’s spike-rush were previously known from the Carolinian zone of extreme southwestern Ontario (Brownell, Blaney and Catling 1996).

Transecting Ecotones

Northern affinity plants that are present in the Carolinian Life Zone include black spruce, yellow birch (*Betula alleghaniensis*), and Eastern hemlock (*Tsuga canadensis*). Southward affinity species found beyond the Carolinian include blue-beech (*Carpinus caroliniana* ssp. *virginiana*), Southern arrow-wood (*Viburnum recognitum*), and Carolina rose (*Rosa carolina*).

These few examples plus many others that can be listed for the distribution of Carolinian species illustrate the biodiversity and porosity of the edge of the Carolinian Life Zone, particularly in the areas of the Niagara Escarpment and the Frontenac Axis (Figures 1B).

Finding the Northern Boundary

Given these complexities is there any way to find the northern boundary of the Carolinian Life Zone? Graham (1995) sought to find an objective determination of the northern boundary by using a Mesoscale Bioclimatic model constructed of a composite of eight variables from precipitation, temperature and growing degree day data plus a digital elevation model to predict the potential distribution of three species of high conservatism. The co-efficient of conservatism (CC) is a peer-reviewed assessment of the narrowness of the habitat requirements for a species where 10 suggests a very specific niche and 0 suggests no limits to where you might predict to find, for instance, black-eyed susan (*Rudbeckia hirta*). Graham tested his model based on the congruence of the model predictions with actual biological data and species distribution data for three rare or uncommon Carolinian species each with a CC of 10: pawpaw (*Asimina triloba*), cucumber magnolia (*Magnolia acuminata*) and blue ash (*Fraxinus quadrangulata*). The outcomes for each plant represented their distribution limit as colour gradations assigned by standard deviations of the confidence of the predicted range. Figure 3A presents Graham's example for pawpaw. The model effectively demonstrates the dynamic edge of the distribution of Carolinian species based on the statistical confidence for the limits of their range. Taken together with the issues of inliers, outliers and disjuncts the conclusion must be that the northern boundary is indeterminate.

Summary

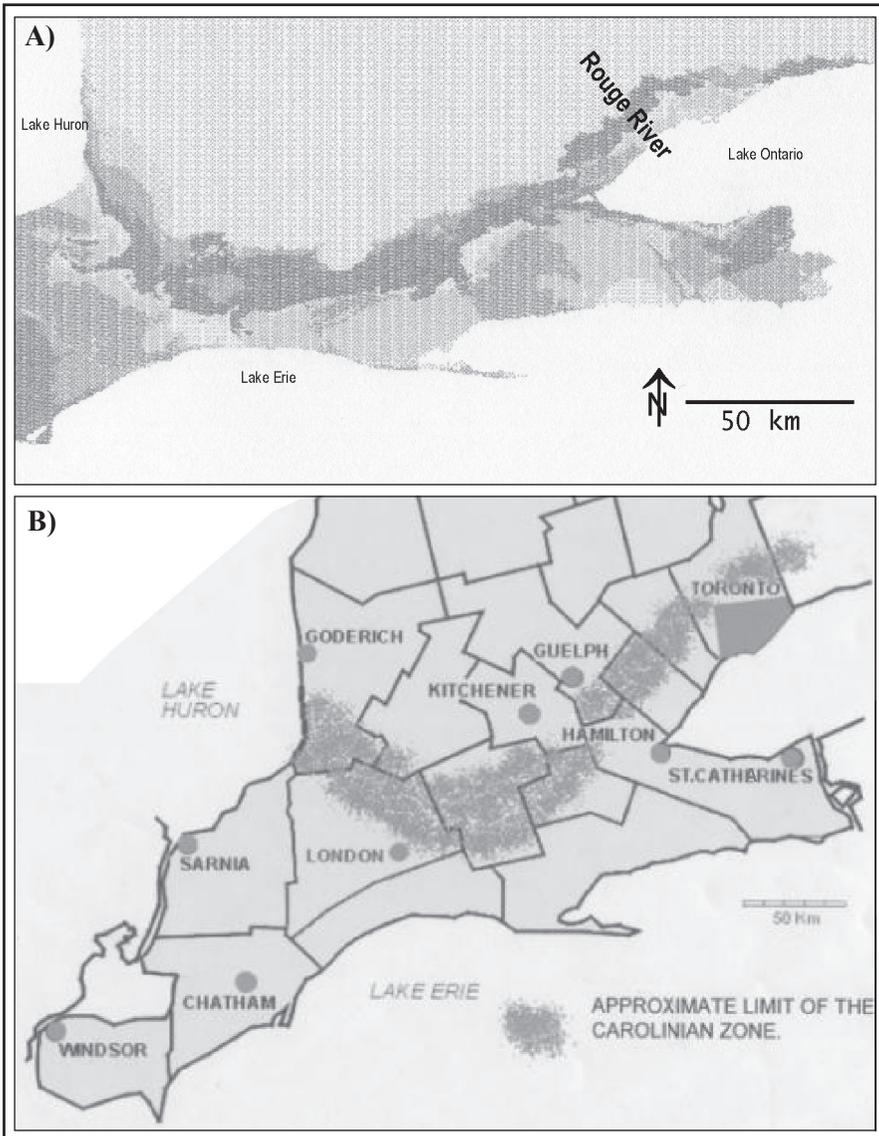
The extent of the variables physiography, topography, soils and ecoclimate overlap and give rise to ecotones that are transitional between two adjacent ecological communities. At the southern limit of the Carolinian Life Zone in Canada, the shorelines of the Great Lakes form an abrupt and sharp boundary line. The extensions, exclusions, inliers, outliers and transecting ecotones raise questions about an appropriate cartographic representation of the indeterminate character of the Carolinian Life Zone. Since the northern and eastern edges change gradually and are transitional zones of overlapping ecotones (in our terms, fuzzy boundaries), the boundary of the Carolin-

ian Life Zone is best represented as a diffuse band (Figure 3B). Transecting ecotones, such as along the Niagara Escarpment or the Frontenac Axis, can be represented as tonal gradients to portray the anomalies of northward and southward affinity species (Figure 1B).

Figure 3. Fuzzy Boundaries of the Carolinian Zone.

A) Predicted range of the Pawpaw (Graham 1995).

B) Approximate limits of the Carolinian (Bowles 2004).



The boundary of the Carolinian biome is ecotonal in structural and functional terms. Terminating the Carolinian Life Zone at the mid-line of the Rouge River has no basis in the sense of ecotonal boundaries. Ecotonal boundaries are composites of multiple variables and, unlike political or latitudinal lines, cannot be precise. Much of the promotional literature associated with Carolinian Canada in the past six years has been modelled on the mapping for *The Big Picture Project* (Figure 1A). Literature used in education and public awareness by Carolinian Canada can better represent the ecotonal nature of the rich variation and diversity of the Carolinian Life Zone by using soft edges rather than sharp lines. Displaying a zonal/tonal limit to the fuzzy boundaries of the Carolinian Life Zone should be the norm (Figure 3B). Sharp pencils are out; fat crayons are in.

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