

An Ecological Assessment of the Long-term Survival of Ancient Populations of Eastern White Cedars on Cliff Faces of the Niagara Escarpment

Peter E. Kelly and Douglas W. Larson
Cliff Ecology Research Group, Department of Botany
University of Guelph, Guelph, Ontario N1G 2W1

Abstract

*Evidence suggests that eastern white cedar (*Thuja occidentalis*) forests persisted undisturbed on cliff faces of the Niagara Escarpment for at least 12,000 years. The introduction and expansion of recreational rock climbing in the 1950s brought humankind in contact with the cliff faces for the first time. Unfortunately small solution hollows, narrow ledges and vertical cracks on cliffs which are ideal for climbing, also provide excellent habitat for cedars. Research on the effects of rock climbing on these forests has shown that climbing disrupted the natural age structure of this forest. Tree density also declines in climbed areas and the remaining trees show increased damage. A survey is currently underway to document the location, morphology and age of the oldest trees at both climbed and unclimbed locations along the Niagara Escarpment. This will provide landowners with a baseline of data for monitoring disturbance in the future. Detailed measurements of tree morphology and site factors will also provide information on the relationship between environment and age in this species. Despite the fact that some cedars are the oldest trees in North America east of the Rocky Mountains, their small stature compared with 'typical' level-ground old-growth forests means they suffer from an image problem. Lobbying by the rock climbing community and inaction on the part of landowners and government have continued to leave the trees vulnerable to disturbance. Data gathered from scientific research in protected areas can help identify habitats sensitive to disturbance and contribute significantly to the conservation process.*

Introduction

In southern Ontario, the Niagara Escarpment is a discontinuous series of exposed cliff faces that stretch between Niagara Falls and Tobermory. These cliff faces have an important scenic value but they are also places which offer scenic views of the surrounding landscape. Traditionally, the cliff face has been viewed as a barrier or a boundary separating two places rather than a distinct place of its own. Until 1987, this 'place' had never attracted direct scientific inquiry primarily because the escarpment face has traditionally been viewed as barren and devoid of life. The Cliff Ecology Research Group at the University of Guelph has been studying the ecology of the Niagara Escarpment since this time and we have found, contrary to this perception, that the cliff face supports a large community of organisms distinct from the plateau community at the top or the talus community at the bottom. This community is comprised of at least 69 vascular plant species, 35 lichen species, 14 moss species and two species of liverworts. The cliff faces are also frequented by five species of small mammals and a higher number of forest bird species than the surrounding level-ground forests. An inventory of forest birds by Matheson

and Larson (1998) found that 21 species utilized the cliff face for nesting or foraging.

The Old-Growth Eastern White Cedars

The considerable age of the cedars on the Niagara Escarpment was first realized in 1988 during routine determination of tree ages along the cliff edge to determine the impact of trail use on forest age structure. Eastern white cedars up to 400 years in age were discovered growing along the cliff edge at this site (Larson 1990). The following year, the age structure of the cliff-face forest was determined for the entire escarpment using a random sampling design involving 50 five-metre wide transects at ten sites between Grimsby in the south and Bear's Rump Island in the north. The ages of all trees on the cliff face within each transect were determined and the age structure determined for each site as well as for the whole escarpment (Larson and Kelly 1991). The age structure of the cedars on the cliff face closely resembled the negative exponential age structure of undisturbed old-growth forests in level ground habitats. There were large numbers of trees less than 200 years in age with declining numbers of trees in every age class up to maximum ages approaching 800 years. The Niagara Escarpment was found to support an undisturbed old-growth forest at every site.

Many of the eastern white cedars were also characterized by unusual morphologies (Kelly et al. 1992). Death to portions of the root system in these trees caused death in connecting portions of the aboveground stem (Larson et al. 1993). Thus, most older cedars possess alternating longitudinal strips of living bark and longitudinal strips of barkless dead wood. In some cases, the living bark spirals around the tree. Root death also produces dead axes and dead branches which persist on the tree for many hundreds of years. Many of the trees also hang upside down with their rooting point on the cliff face at a spot higher than the tip of the main living axis. Periodic rockfall may contribute to this unusual morphology by exposing roots to dehydration and subsequent death or by creating instability in the underlying rock substrate thereby causing the tree to shift position and forcing it to readjust to optimize growth conditions. The cedars on the cliff face also grow extremely slowly, their aboveground biomass seemingly limited by the availability of rooting space and not by nutrient or water limitations (Matthes-Sears et al. 1995). This slow growth rate contributes to the highly tapered nature of the stems and the general gnarled and stunted appearance of some of the trees, especially those growing in small cracks and solution hollows on the face.

Eastern white cedar also decomposes very slowly in the cliff environment. The ancestral populations of the current cliff population can be found lying in the talus at the cliff base. Important paleoenvironmental and paleoecological information is preserved in the tree-ring records of these trees. It is possible, by sampling and measuring both living and dead trees and using dendrochronological techniques, to determine germination and death dates for these trees, and reconstruct the age structure, recruitment rates and mortality rates of the current forest (Kelly and Larson 1997a). These reconstructions were accomplished for one site near Milton, Ontario at 20-year intervals between 1770 A.D. and the present. While recruitment and mortality rates fluctuated, the age structure maintained its negative exponential form over this time. Tree-ring width in this species has also been shown to be

negatively correlated with summer temperature over the course of 1,397 years (Kelly et al. 1994). A 2,787-year tree-ring chronology has now been constructed using living and dead cedar from the northern portions of the Niagara Escarpment. Dead cedars have been found at the cliff base with raw tree-ring counts of over 1,000 years including two specimens with 1,555 and 1,693 tree-rings respectively. The maximum estimated age for cedars on the cliff face is now 1,890 years based on tree-rings missing due to the rot at the tree base and erosion of the outer rings in these samples.

While the frequency of natural disturbance on the Niagara Escarpment has not been measured, we have found that fire scars are rare in the cliff-face cedars. Natural disturbance is probably restricted to rockfall and severe storm events such as heavy windstorms. Despite these occasional disturbances, it has not prevented trees from reaching a maximum age of almost 1,900 years.

Impact of Rock Climbing

The only direct contact that humans have with the cliff-face community is through the sport of rock climbing. Rock climbing is an extremely popular activity particularly on the Niagara Escarpment near Milton, Ontario. In 1995, we initiated a project to assess the impacts of rock climbing on the old-growth eastern white cedars in this area (Kelly and Larson 1997b). Three unclimbed (or minimally climbed) and four climbed sites located within 12 kilometres of each other were selected for study. Five sampling transects were randomly placed along the cliff edge at unclimbed sites, while five random transects were selected from climbed cliff-face sections at climbed sites. Each transect was five metres wide and ran down the cliff face to the talus below. All trees in the plateau and within three metres of the cliff face were sampled. All trees in each transect were recorded, cored (for age determinations), measured and assessed for damage. Damage was recorded as Type 1, Type 2 or Type 3 damage. Type 1 damage was not noticeable, Type 2 damage was significant but not necessarily attributable to humans (broken branches and axes), while Type 3 damage was directly attributable to humans (eg. saw marks, axe marks)

There was a significant reduction in the density of trees on cliff faces at climbed sites, but not at cliff edges (Table 1). The density of trees was reduced for both old and young individuals. As well, the age structure of the cliff-face and cliff-edge forests at climbed sites showed a reduction in the numbers of trees in most age classes. There were also significant amounts of both Type 2 and Type 3 damage at climbed sites compared to unclimbed sites (Table 2), from which we concluded that Type 2 damage was also attributable to humans. Dendrochronological cross-dating of a random collection of 21 stumps and cut branches from both cliff edges and faces revealed that this damage had occurred in every decade since the 1950s including seven times in the 1990s and six times in the 1980s. One individual was found that had had 14 branches cut from one side of the tree including the main axis. This tree germinated in 1215 A.D. The results showed that rock climbing was clearly having a negative effect on the persistence of the old-growth forests on cliff faces the Niagara Escarpment.

Sampling Location		Number of Sites	Tree Density per 100m ²			
				All	>100 years	> 300 years
Cliff Face	Climbed	4	Mean	6.1	2.3	0.4
			Range	2.1 - 7.8	1.3 - 3.0	0 - 0.6
	Unclimbed	3	Mean	14.9	5.8	1.8
			Range	9.0 - 21.2	4.2-6.7	0.6-3.2
Cliff Edge	Climbed	4	Mean	34.6	5.8	0
			Range	5.3 - 137.3	1.3 - 25.3	0
	Unclimbed	3	Mean	36.2	9.6	0
			Range	24.0 - 109.3	6.7 - 26.7	0

Table 1: The mean density of all living sampled *Thuja occidentalis* stems, stems >100 years and stems >300 years at climbed and unclimbed sites on cliff faces and cliff edges of the Niagara Escarpment, Ontario, Canada. The difference in means between climbed and unclimbed cliff faces was highly significant ($p < .001$) for the three age classes. The differences in means between cliff edges at climbed and unclimbed sites were not significant ($p > .05$) (excluding trees >300 years).

Sampling Location		Size Class	Percent Damaged (Living and Dead)		
			Type 3	Type 2	Total
Cliff Face	Climbed	All	17.0	11.3	28.3
	Unclimbed	All	2.5	1.9	4.4
	Climbed	>2.0 cm. B.D.	21.4	16.1	37.5
	Unclimbed	>2.0 cm. B.D.	2.3	2.3	4.7
Cliff Edge	Climbed	All	10.8	10.3	21.1
	Unclimbed	All	3.0	5.3	8.3
	Climbed	>2.0 cm. B.D.	20.2	16.3	36.5
	Unclimbed	>2.0 cm. B.D.	4.3	7.8	12.1

Table 2. The percentage of *Thuja occidentalis* stems (entire population and population > 2 cm basal diameter) with Type 3 (obvious human impact) and Type 2 (probable human impact) damage on sampled climbed and unclimbed cliff faces and cliff edges of the Niagara Escarpment, Ontario, Canada.

Prospects for Long-Term Survival

The Current State of Rock Climbing in Southern Ontario

Rock climbing in southern Ontario began in the late 1950s when small groups of climbers developed many of the classic climbing routes along the Niagara Escarpment near Milton, Ontario. The popularity of rock climbing as a recreational activity increased in the 1970s but has experienced an exponential increase in growth in the late 1980s and 1990s. The numbers of individuals entering the sport may be slowing recently, but at an elevated level compared with just five years ago. Climbing has also entered the realm of popular culture with climbing being featured in advertisements on television and in the print media. Most cities support one or two indoor rock climbing gyms and rock climbing is taught by both indoor gyms and outdoor instructional schools.

The areal extent of climbing along the Niagara Escarpment has also expanded considerably. While Rattlesnake Point, Kelso and Mount Nemo Conservation Areas remain the most popular climbing locations, climbing has expanded to cliffs along the entire escarpment, in some cases onto properties where the landowners are unaware of these activities. Some climbers continue to search out new routes in new areas. This expansion has occurred as a response to overcrowding at popular sites and the desire on the part of elite climbers to establish first ascents and increasingly difficult routes.

Rock climbers have also organized access committees, in part, to ensure continued access to the climbing resource. In the United States, the Access Fund is a wealthy and influential agency established to solve access issues for climbers and to open climbing areas threatened with 'unnecessary restrictions or closures'. Fortunately, the Access Fund and the Access Committee of the Alpine Club of Canada have been forced to address the concerns of landowners, thus environmental awareness is increasing within the organized climbing community. We have been approached by members of the climbing community to provide information on cliff ecology for a climbing guide, an access web page and for an interpretive sign. The Alpine Club of Canada seems particularly concerned about the impact of climbing.

Unfortunately, most climbers do not belong to climbing organizations such as the Alpine Club of Canada. They learn climbing from their friends or from indoor climbing gyms or outdoor instructional schools. Terri Newman of the University of Waterloo conducted a survey of the Ontario Rock Climbing Association (which oversees the certification of instructors in Ontario) and various instructional schools to determine the amount of ecological information incorporated into climbing instruction. Her results indicate that most schools do not have a policy on environmental education and that it is left up to the discretion of the individual instructors, and that there was virtually no mention of the old-growth forests on the cliff faces during instructional sessions. Some schools felt that environmental education was not their responsibility but rather the responsibility of Halton Region Conservation Authority or the Ontario Rock Climbing Association. Other companies felt that there was a need for environmental education but felt that they would appear to be preaching to the students which would lessen their enjoyment of the experience. One company omitted environmental issues from their climbing manuals because they felt that everyone knew all the issues. They continued to use the cedars as anchors on the rock face because they believed that the problem was not as bad as it seemed.

Recommendations and Possible Solutions

The education of the general public and the climbing community is an important step towards the conservation of these ancient forests. Clearly, the ancient forests of the Niagara Escarpment suffer from an image problem. Most people picture the temperate rain forests of British Columbia as typical old-growth forest where the oldest trees are also the largest. It is difficult to change peoples' perceptions to realize that trees with maximum heights of only 10-12 metres and basal diameters up to 50 centimetres can also be very old. We feel that if these trees were much larger but of equal age, and were being removed in southern Ontario as the result

of a recreational activity, that effective management of this resource would already be in place.

Inaction on the part of all parties involved with rock climbing in southern Ontario will eventually lead to the demise of the old-growth eastern white cedar forests along much of the Niagara Escarpment. Education must start at the grass-roots level and be incorporated into climbing instruction particularly in outdoor settings. Through the media and public presentations, we have found that the general public has been very interested in the ancient forests of the Niagara Escarpment. Contrary to the opinions of some climbing school owners, we believe that beginning climbers would be extremely receptive to this type of information and we feel it could only heighten their climbing experience. The Ontario Rock Climbing Association must also take a proactive stance on the issue and include ecological information as part of their certification process for instructors. Landowners such as Halton Region Conservation Authority must also take a proactive stance and insist that ecological information be incorporated into lessons by climbing schools using their property for instruction. The inclusion of this type of information need not take a lot of time, perhaps five minutes out of an entire day. Since most students at any given time are not climbing on the cliff face, it would be a perfect opportunity for instructors to educate those students waiting in the talus for their opportunity to climb. Furthermore, Halton Region Conservation Authority does not have one interpretive sign at any of their climbing areas to inform people that the oldest trees in Canada east of British Columbia are growing on the cliffs right in front of their eyes!

We also feel that an inventory of the oldest trees will help define the spatial extent of this resource and provide landowners detailed information on the age, location and morphology of individual ancient trees. We have started The Niagara Escarpment Ancient Tree Atlas Project to provide this kind of information which will enable landowners to monitor individual trees for disturbance. We feel that this project is an important step to ensuring the long-term protection of these ancient trees.

Conclusions

The ancient forests of the Niagara Escarpment cliff face represent one of the last undisturbed ecosystems in southern Ontario and support trees over 1,000 years in age. Rock climbing has introduced human disturbance to this system for the first time. A study of the impact of rock climbing on the old-growth forest has shown that significantly large numbers of trees have been removed or damaged in climbed areas. The long-term survival of this forest is dependent on the education and cooperation of many different landowners and climbing organizations. The climbing community needs to recognize that they are the only humans who come in direct contact with these trees. They are the sometimes unwilling stewards of the Niagara Escarpment old-growth forests whether they accept the responsibility or not. What they do with this responsibility is up to them. A proactive stance by the rock climbing community towards educating their peers is required to ensure the long-term survival of this ancient forest.

References

- Kelly, Peter E., Cook, Edward R. and Douglas W. Larson. 1992. Constrained growth, cambial mortality, and dendrochronology of ancient *Thuja occidentalis* on cliffs of the Niagara Escarpment: an eastern version of bristlecone pine? *International Journal of Plant Sciences*. 153 (1): 117-127.
- Kelly, Peter E., Cook, Edward R. and Douglas W. Larson. 1994. A 1397-year tree-ring chronology of *Thuja occidentalis* from cliff faces of the Niagara Escarpment, southern Ontario, Canada. *Canadian Journal of Forest Research*. 24 (5): 1049-1057.
- Kelly, Peter E. and Douglas W. Larson. 1997a. Dendroecological analysis of the population dynamics of an old-growth forest on cliff-faces of the Niagara Escarpment, Canada. *Journal of Ecology*. 85 (4): 467-478.
- Kelly, Peter E. and Douglas W. Larson. 1997b. Effects of rock climbing on populations of presettlement eastern white cedar (*Thuja occidentalis*) on cliffs of the Niagara Escarpment, Canada. *Conservation Biology*. 11 (5): 1125-1132.
- Larson, Douglas W. 1990. Effects of disturbance on old-growth *Thuja occidentalis* at cliff edges. *Canadian Journal of Botany*. 68 (5): 1147-1155.
- Larson, Douglas W. and Peter E. Kelly. 1991. The extent of old-growth *Thuja occidentalis* on cliffs of the Niagara Escarpment. *Canadian Journal of Botany*. 69 (7): 1628-1636.
- Larson, Douglas W., Matthes-Sears, Uta and Peter E. Kelly. 1993. Cambial dieback and partial shoot mortality in cliff-face *Thuja occidentalis*: evidence for sectorial radial architecture. *International Journal of Plant Sciences*. 154 (4): 496-505.
- Matheson, Jeffrey D. and Douglas W. Larson. 1998. Influence of cliffs on bird community diversity. *Canadian Journal of Zoology*. 76 (2): 278-287.
- Matthes-Sears, Uta, Nash, Caedmon H. and Douglas W. Larson. 1995. Constrained growth of trees in a hostile environment: the role of water and nutrient availability for *Thuja occidentalis* on cliff faces. *International Journal of Plant Sciences*. 156 (3): 311-319.