Rock Climbing and Talus Vegetation on the Niagara Escarpment: Impacts and Management Implementations

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Executive Summary

Sport climbing has become a mainstream recreational activity over recent decades, but it its impacts to natural landscapes have yet to be completely understood. The goal of this report is to identify how rock climbing has impacted talus vegetation communities, and to suggest climbing stewardship strategies for currently existing climbing areas and other potential new climbing areas throughout the Niagara Escarpment. A review of currently available literature revealed that most existing studies focused on vegetation communities on the cliff face, with little information pertinent to talus vegetative communities, in particular to species listed under the Ontario Endangered Species Act.

Therefore, in summer 2014, a study was conducted in the Swamp, a climbing area originally established without authorization on Crown land in the Kolapore Uplands Resource Management Area. Talus vegetation was sampled at the base of twenty sport climbing routes, plus four unclimbed control sites, using the quadrat method. Various environmental cover measurements were recorded per 1x1m^2 quadrat (mineral soil, canopy openness, loose stone, bedrock, moss, graminoids, overall understory vegetation, dead woody debris, leaf litter). Vascular vegetation was identified, and information was recorded based on species frequency (density of stems per m^2) and relative cover.

Canonical correspondence analyses of species frequency, species relative cover and the physical environment revealed that the environment variables (i.e. distance from cliff, canopy openness and loose stone cover) explained more variation than climbing. Nonetheless, non-native plant species were found to occur more frequently at the base of cliffs, while natives grew more

commonly farther away where climbers did not go, suggesting that climbers were trampling out native species and introducing non-natives, as was found in other studies. Furthermore, by conduction a Floristic Quality Assessment (FQA), plant assemblages in unclimbed areas were revealed to be composed of more conservative plants (i.e. that were less tolerant to disturbance). This supports the necessity of including unclimbed areas in any climbing stewardship plan as an anticipatory management strategy.

The plant assemblages of three crevice areas with unique micro-climates were also compared with the main trail using the FQA system, to test their candidacy for protection. Crevices were harboured slightly more conservative species than did the main trail, but no species at risk or regionally rare species were found. There is not enough evidence to support the closure of these crevice areas from climbers over other areas within the Swamp, especially when wetter conditions already make crevice areas less appealing for climbing.

American Hart's-Tongue Fern (*Asplenium scholopendrium* var. *americanum*), a species listed in Ontario as Special Concern under the Endangered Species Act, was found along the main climbing area of the Swamp. A more thorough inventory of vegetation of the Swamp is warranted to locate and identify other species at risk particularly in areas where climbing is currently being undertaken and any future proposed areas.

In conclusion, there is evidence suggesting that climbers are trampling out native vegetation and introducing non-native species, but further research is needed to confirm this. Involving the climbing community in management should foster improved relations between climbers (e.g. Ontario Rock Climbing Access Coalition) and land managers (e.g. Ministry of Natural Resources and Forestry). Climber already show a willingness to participate in rewarding variety of stewardship actions. Education as well as consistent management throughout the entire Niagara Escarpment will be crucial in reducing confusion and increasing compliance by the climbing community.

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1 Introduction

Sport climbing is a type of rock climbing that has grown in popularity over the recent decades (Kuntz & Larson 2005; McMillan & Larson 2002; Camp & Knight 1998; Kelly & Larson 1997). Sport climbers will use gymnastic-like ability, strength and endurance to scale walls upon which have been fixed permanent anchors in the form of bolts for protection. When performed outdoors, sport climbing is typically practised in structurally complex cliff ecosystems with a diverse mosaic of small-scale microclimates that can support rare and possibly cliff-endemic species of disturbance-sensitive vegetation and specialists of extreme habitats (Müller et al. 2004).

In Ontario, Crown land is managed under the *Public Lands Act* (PLA). Under the PLA, the Free Use Policy allows the public free use of Crown land so long as recreational activities are not impactful upon the natural environment (MNRF 2004). Due to the distinctly sensitive ecosystems in which rock climbing is performed authorization from the Ministry of Natural Resources and Forestry (MNRF) is required to establish any new rock climbing areas. Throughout the Niagara Escarpment, several formal rock climbing areas have been developed, yet some have been established without authorization (Niagara Escarpment Commission 2013b). The Swamp in the Kolapore Uplands Resource Management Area (hereafter referred to simply as Kolapore) is one of these unauthorized climbing areas.

After the discovery of the Swamp by the MNRF in Summer 2010, the MNRF and the Ontario Rock Climbing Access Coalition (OAC) initiated a land manager/user group partnership. The goal of this collaboration was to get a better understanding of the impacts that rock climbing may have on the surrounding natural features within the Swamp.

A review of available academic literature was undertaken to better understand rock climbing and the potential impacts of this activity on the natural environment. As most rock climbing studies examined impacts relating to the cliff face, a study was developed and conducted to fill the gap in literature pertaining to how rock climbing may be impacting the talus at the base of cliffs. Furthermore, crevice areas within the Swamp were identified to have potentially more unique and sensitive vegetation compared with those from the main trail. Therefore, this project will also include a section in which crevice and main trail vegetation communities are compared qualitatively using the floristic quality assessment system (Oldham 1995). Efforts were also made to locate any species at risk (SAR) listed under the *Endangered Species Act* (ESA) that could potentially be present in the area. The results of the literature review, talus study, FQA analysis, and location of at-risk species will be used to inform climbing stewardship strategies in existing and other potential climbing areas within the Swamp and throughout the rest of the Niagara Escarpment.

2 Literature Review

2.1 Impacts of Rock Climbing

Many studies that compared climbed to unclimbed cliffs concluded that the activity of rock climbing negatively impacted plant communities inhabiting the cliff face (e.g. Kuntz & Larson 2005, 2006a, 2006b; Müller et al. 2004; Camp & Knight 1998; Farris 1998, to name a few). However, researchers recommended that results from prior studies should not be used to make predictions about the impacts of new climbing routes due to flaws in the methodology. Previous studies did not take into account naturally-occurring differences in micro-topography between climbed and unclimbed sites. Furthermore, these studies did not consider whether control sites adhered to climbers' selection criteria of a climbable cliff (Kuntz & Larson 2005, 2006a, 2006b). Climbers tend to select rock formation with clean, vertically steep character, with few features that will make for challenging movement. Fewer ledges, cracks (i.e. more clean faces) naturally support less vegetation, and control rock formations were not chosen with such criteria in mind (Clark 2012; Kuntz & Larson 2005, 2006a, 2006b). Newer studies that considered cliff microtopography, physical properties of cliffs such as the volume of accumulated soil (Kuntz & Larson 2005, 2006a, 2006b) and cliff angle (Clark 2012) were found to have more influence on cliff vegetation than the act of rock climbing. Finally, no studies have yet to use direct experimental approaches to test cliff biota for before/after impacts of rock climbing.

While many studies have looked into how rock climbing may impact the cliff face, few investigated how this activity may affect the base of the cliff (Kuntz & Larson 2005). The talus (i.e. slopes of rocky debris at the base of cliffs) also risks becoming adversely affected from overuse. In the Swamp, the climbing trail meanders along the cliff on talus, and climbers will hike along the talus to the specific route they intend to climb. The talus is also used as a staging area, where climbers will store their gear or belay other climbers. Healthy talus communities are important components of the cliff ecosystem, as they provide propagules that may establish on the cliff face (Farris 1998). However, the presence of recreationists has been associated with trampling of native flora (Clark 2012; Müller et al. 2004; McMillan & Larson 2002), soil compaction (Clark 2012), and introduction of alien vegetation dispersed on shoes, clothing or equipment (Müller et al. 2004; McMillan & Larson 2002). Considering the remoteness of the Swamp's climbing trail, climbers are the most likely sources of disturbance among recreationists along the talus (Figure 1).

Kolapore is located in the Town of Blue Mountains in the County of Grey, 20 km southwest of Collingwood, Ontario (Figure 2). The Niagara Escarpment transects through this 3630-ha Crown landholding, which accommodates three provincially significant Areas of Natural and Scientific Interest (ANSIs): one for earth sciences (Kolapore Uplands) and two others for life sciences (Kolapore Escarpment and Kolapore Swamp; Niagara Escarpment Commission 2013a; Riley et al. 1996). Kolapore Uplands provides an excellent representation of crevice caves and the Banks Moraine (Riley et al. 1996). Kolapore Escarpment, where one can find the Swamp climbing area, hosts excellent representations of rich Sugar Maple forests on the Banks Moraine; Niagara Escarpment cliff, crevice and talus communities; and wetlands (including rich mixed swamps; Riley et al. 1996).

The Swamp climbing area is not located in Kolapore Swamp, but in Kolapore Uplands. Kolapore's exposed dolomite limestone escarpment is composed of dry and moist open cliffs with outlier blocks forming impressive 30-m deep crevice caves (Riley et al. 1996). A richly diverse biological community inhabits the Kolapore cliffs, including 331 vascular plant species, 79 breeding bird taxa (among which include 26 forest-interior species), 19 mammalian and 19 herpetofaunal species (Riley et al. 1996). A large concentration of fern species also dwell along the escarpment, including smooth and the less common purple-stemmed cliffbrake (*Pellaea glabella* spp. *glabella*, with the Natural Heritage Information Centre subnational rank of S4; and *Pellaea atropurpurea*, S3, respectively, Bradley 2013), green spleenwort (*Asplenium trichomanes-ramosum*, S4, Bradley 2013), and the nationally and provincially rare American Hart's-tongue fern (*Asplenium scholopendrium* var. *americanum*, Riley et al. 1996; S3, Bradley 2013; listed as an Ontario species of special concern, MNRF 2014a). The ancient old-growth eastern white cedars (*Thuja occidentalis*) are arguably the most conspicuous component of Kolapore's unique flora. These trees, possibly germinated several hundreds of years ago, grow directly out of the cliff face or rim in very shallow and dry soil (Kelly & Larson 1997; Riley et al. 1996).

Kolapore has been experiencing significant recreational pressure mainly due to its proximity to the Greater Toronto Area, Collingwood and Blue Mountain Village. For instance, two climbing areas have been established within Kolapore: the unauthorized Swamp, as well as one of Ontario's oldest climbing area, Metcalfe Rock (Oates & Bracken 1997). In response to such pressures, the Niagara Escarpment Plan outlines strategies to manage the Bruce Trail, hiking, cross-country skiing, snowmobiling, hunting and fishing (Niagara Escarpment Commission 2013a). In regards to rock climbing, despite being recognized as a mainstream recreational activity formally practiced in many areas throughout the Niagara Escarpment, The Niagara Escarpment Commission only began including relevant management policies recently in the 2015 review of the Niagara Escarpment Plan (Niagara Escarpment Commission 2013b).

Management of these delicate cliff ecosystems is in itself a delicate process. Despite being avid supporters of wilderness (Monz 2009), some climbers mistrust natural resource managers (McKenney 2013) and feel treated unfairly in comparison to other recreationists (Schuster et al. 2001). While climbers felt that managers did not fully understand the activity of rock climbing, climbers also did not completely comprehend the process of management (Schuster et al. 2001). It is worth noting that Southern Ontario climbers have been formally engaged in addressing recreation and environmental sustainability challenges with land managers (Thompson & Hutson 2011; Thompson 2010). The ongoing collaboration between the MNRF and the OAC is designed to foster more positive relations between climbers and managers.

2.2 Species at Risk and Subnational Rankings in Ontario

Another gap in literature involves species at risk. The most recent studies of rock climbing on the Niagara Escarpment (Kuntz & Larson 2005, 2006a, 2006b) occurred prior to the introduction of ESA in 2007 (ESA 2007). American Hart's-Tongue Fern (*Asplenium scholopendrium var. americanum*, special concern), and Butternut (*Juglans cinerea*, endangered) are two at-risk plant species that are likely to occur within the Swamp. Hart's-tongue fern grows in moist and shady rocky habitat in deciduous forests. Threats to this species include human resource extraction activities (e.g. logging and quarrying), development, and recreation (competition from invasive species, trampling, collection for home garden transplantation; MNRF 2014b). The natural range of Butternut includes the Niagara Escarpment, within which Butternuts ae able to grow in a variety of habitat types, including deciduous forests (MNRF 2014c). The main threat to this species is the Butternut Canker fungus (*Sirococcus clavigigrenti-juglandacearum*), which have already infected and killed many butternut individuals regardless of age and size. Effective management of the Swamp and other climbing areas throughout the Niagara Escarpment should prioritize identifying and locating all at-risk species that could be present in the area. This study will focus on plants species at risk. For a list of all species at risk that are known to occur within the Town of Blue Mountains—and are thus likely to occur in Kolapore—please refer to Appendix A.

Species are assigned a provincial Subnational Rank (SRANK) by the Natural Heritage Information Centre (Table 1). This ranking system is based on estimated number of occurrences, estimated community extent, estimated range of community within the province (Bradley 2013). While not a legal designation like the ESA or the SARA, the SRANK system is a useful tool to identify rare species and susceptible populations. It was used as such in this study.

2.3 Floristic Quality Assessment System

First developed by Swink and Wilhelm for the region of Chicago (Swink & Wilhelm, 1994), the floristic quality assessment (FQA) system is now widely used to qualitatively assess a region's floral community (Landi & Chiarucci 2010; Oldham et al. 1995). According to the FQA, the quality of a natural area's vegetative community is based on native floral diversity, the degree of fidelity to specific habitats, and vulnerability to disturbance of that area's assemblage of plant species (Catling 2013; Landi & Chiarucci 2010; Oldham et al. 1995).

In Southern Ontario, native vascular plant species have been assigned a coefficient of conservatism (CC) by a panel of experts (Oldham et al. 1995). A numerical score between 0 and 10 is given based on a taxon's degree of fidelity (conservatism) to a specific habitat and tolerance to disturbance. Lower CC scores (Table 2) indicate that a plant species is more likely to invade degraded areas, as they will inherently be more tolerant to anthropogenic disturbances and display lower fidelity to a particular habitat type.

A natural area can be evaluated based on a compilation of a list of species occurring in the area, and calculating mean CC ($CC_{\bar{x}}$) for all present native plants. $CC_{\bar{x}}$ can also be used to calculate a site's floristic quality index (FQI), which incorporates native species diversity into the evaluation of a natural area (Catling 2013). Natural areas with greater FQI are considered to be higher in biodiversity.

Non-native species usually make up 20-30% of a plant community in a southern Ontario natural area. However, some species are more dominating than others. The Weediness Index (WEED) has been assigned by a panel of experts to most introduced species occurring in southern Ontario (Oldham et al. 1995). Natural areas can then be evaluated based on their total weediness value, or the mean weediness score (refer to Table 3 for a definition of weediness categories). The more negative the weediness score, the more impact these non-native species are having upon the natural area.

The FQA has been useful throughout the United States, where it is used more widely than in Canada (Catling 2013), for a variety of conservation purposes (Landi & Chiarucci 2010). The FQA system can be used to identify and compare natural areas, regardless of community type, and to monitor over the long term remnant natural areas as well as restoration efforts (Catling 2013; Oldham et al. 1995). Easily understood and applied by non-biologists, the FQA system is a useful communication tool to demonstrate how natural areas are or could potentially be disturbed from anthropogenic stresses (Catling 2013).

Nevertheless, the FQA system is not without limitations. Landi and Chiarucci (2010) question its reliability in human-managed ecosystems (i.e. in areas "with a long history of human exploitation, where it is difficult to distinguish between natural and human derived habitats", such as Italy where their study took place; Landi & Chiarucci 2010). Moreover, the process of CC assignment is subjective and susceptible to be conducted using limited ecological knowledge of certain species (Matthews et al. 2015; Landi & Chiarucci 2010). However, Matthews and colleagues (2015) found through their study that CC values of some species were useful at predicting those of co-occurring species within the plant assemblage. Therefore, Matthews et al. (2015) concluded that, despite subjectivity and susceptibility to species-specific imprecisions and biases, CC values are still very powerful and informative, and can still be useful in evaluating natural areas.

3 Methodology

3.1 Talus Experiment

3.1.1 Sampling Design

The rock climbing portion of Kolapore is referred to as "The Swamp" within the climbing community. An inventory of all climbing routes within the Swamp was completed in July 2014. Location of each route was recorded as UTM coordinates using a Garmin Montana 650 GPS unit (Figure 1). Routes were classified according to climbing difficulty using the Yosemite Decimal System by a local climber who was personally involved in the establishment of the Swamp climbing area. Within the Swamp, there are a total of 100 climbing routes stationed along the main climbing trail, most of which were designated for sport rock climbing (Table 4). Furthermore, climbing routes were grouped into four difficulty classes based on those used by Clark (2012): Beginner (5.6-5.8), Intermediate (5.9-5.10d), Experienced (5.11a-5.12b), and Expert (5.12c-5.13+).

There were several types of climbing routes in the Swamp. "Sport" climbs were defined by the permanent bolts installed within the rock all along the route. Alternatively, traditional (or "trad") climbs were devoid of permanent bolts and followed a crack to bolted anchors at the top of the climb. "Project" routes refer to those sport climbs that remain unfinished, identified by a red tag on the lowest bolt or a line of bolts that stop midway up the cliff face. Finally, "mixed" routes incorporated elements of both trad and sport climbing. Only sport climbs were included in this study. Dichotomously divided routes that separated into two different climbing difficulty classes were excluded. Alternatively, sport routes that branched into a project route were still considered, under the assumption that the project vein remained unclimbed. Finally, traverse routes that ascend the cliff over an unusually wide horizontal distance were excluded from this study. Additional exclusions involved unbranching routes that changed difficulties partway along the cliff.

Vegetation communities in association with route cliff face and talus were highly variable even within a few meters. Often, the nearby forest vegetation did not reflect that growing at the base of the cliff. Talus communities were sorted as open, shrubby or treed, according to modified definitions of the Ecological Land Classification for Southern Ontario (ELC; Lee et al. 1998; Table 5; Figure 3).

3.1.2 Sampling of talus communities

In August 2014, talus vegetation was sampled at the base of twenty sport climbing routes along the main trail, plus four unclimbed control locations off-trail. Routes were randomly and proportionally selected based on climbing difficulty and talus ELC. One control site at the base of an unclimbed cliff was sampled per talus ELC type (Table 6; Figure 4).

Quadrats (1×1 m^2), segregated into 25 cells (20×20 cm^2; Figure 5), were used to sample the base of the cliff. Each site was sampled at four distances increasing perpendicularly from the cliff base: a) at the base (0-1 m), directly below the lowest bolt; b) 2-3 m out perpendicularly from the cliff base, often associated with the trail edge; c) 4-5 m from the cliff base, completely off the walking trail; and d) in an undisturbed area, usually 9-10 m (at least 8 m if farther was not possible) beyond the cliff. Photographic records were taken of each quadrat.

Various cover measurements were recorded per quadrat. Firstly, species richness and abundance (density and cover) were recorded for all vascular plant species, in a manner similar to that employed by McMillan & Larson (2002). Density was calculated by recording the number of stems per cell, while percent cover was established by counting the number of cells in which foliage of a particular species occurred. Unknown species were either photographed or collected and dried for future identification. Only percent cover was recorded for graminoids and mosses, regardless of species. Additional cover information was recorded for overall extent of vegetation, mineral soil, loose stone, surface rock, coarse woody debris (of at least 2 cm in diameter), and leaf litter. Canopy cover (vegetative or rocky in nature) was evaluated with a moosehorn crown closure estimator.

Nomenclature follows Bradley (2013). References mainly used in identification of vascular plants include Owen Sound Field Naturalists (1999) and Cobb (1963) for ferns; and Newcomb (1977) and Peterson & McKenney (1968) for wildflowers.

3.1.3 Statistical Analysis of Talus Communities

Statistical analysis was conducted in RStudio, using the Vegan statistical (Oksanen 2014; Oksanen et al. 2014) and Sciplot graphical (Morales 2012) packages. To analyze the variables predicting the physical talus environment (Table 7), a canonical correspondence analysis (CCA) was conducted comparing a matrix of biotic variables with another matrix with abiotic variables. Significance of each “term” (constraining biotic or abiotic variable) was tested using an ANOVA-like permutation tests, with 200 permutations per test. Tests were first performed including all terms; non-significant terms were subsequently removed until only significant variables were left. Finally, by referring to the “accumulated constrained eigenvalues” through the “summary” function, one was able to understand the proportion explained by each axis. Talus ecotype was used as a covariate. Only significant ($P<0.05$) and moderately significant ($P<0.10$) abiotic environmental variables were included in the final CCA results.

In the analysis of talus species frequency (stems per square metre; Table 7), another CCA with 200 permutation tests was conducted comparing a physical environment matrix that included both abiotic and biotic environmental variables with a matrix of the 20 most common understory vascular species. The number 20 was chosen as this was a rounded-up number that included all species that appeared in at least 15% of all quadrats (18 species; the 19th and 20th most common species appeared in 13% and 12% of all quadrats). Non-significant terms were again eliminated, leaving only significant constraining variables in the model. Talus ecotype was used as a covariate.

A third CCA (200 permutation tests) was conducted for species relative cover (Table 7), using the 21 most widespread species. Twenty species were used to stay consistent with the number of species used for species frequency, and an extra was included in the analysis as the 20th and 21st most widespread species shared the same relative coverage. Once again, only significant terms were left in the final analysis, with talus ecotype was used as a covariate.

3.2 Crevice Communities

The three crevice communities (Figure 6) were sampled by completing an overall vegetation inventory of vegetation growing on the ground and along the cliff face. Inventory was conducted from the ground; cliff species were spotted and identified as best as possible using binoculars. Vascular vegetation was also identified along the main climbing trail and just outside of the crevice areas. The list of species found along the main trail is not exhaustive. However, it can be useful to compare vegetative communities between more closed-off crevice areas and the more open main trail.

3.3 Floristic Quality Analysis

A list of species and their respective FQA and weediness ratings was obtained from the Natural Heritage Information Centre (Oldham et al. 1995). Through this list, each native and non-native taxon was assigned a coefficient of conservativeness (CC) and corresponding wetness index, weediness index and physiognomy type. These values were used to calculate mean CC ($CC_{\bar{x}}$, Equation 1), mean floristic quality index (FQI; Equation 2), total WEED score ($WEED_T$, Equation 3) and mean WEED index ($WEED_{\bar{x}}$, Equation 4) of any given area. For the talus portion of this project, mean indices were determined per quadrat, then averaged (± standard error) with other quadrats of similar variables (i.e. distance, climbing status, talus ecotype). For the crevice portion, mean indices were calculated for each crevice (and the main climbing trail), then an average values (± standard error) were calculated for all three crevices together. Based from these averaged FQA values, one is able to qualitatively and intuitively compare vegetative communities.

Calculations were conducted using Microsoft Excel software. First and foremost, native (N) and non-native (or adventive, A) plants occurring within an area were counted and identified. These numbers and species were then used to calculate FQA indices.

Equation 1 $$CC\bar{x} = {}^{\sum CC}/_{N}$$

Equation 2 $$FQI = CC\bar{x} \times \sqrt{N}$$

Equation 3 $$WEEDt = \sum WEED$$

Equation 4 $$WEED\bar{x} = {}^{WEEDtot}/_{A}$$

3.3.1 Statistical Analysis of Floristic Quality Assessment Values

Statistical analysis was conducted in RStudio, and graphs were constructed using the Sciplot graphical package. FQA indices for all quadrats ($CC_{\bar{x}}$, FQI, $WEED_T$, $WEED_{\bar{x}}$), absolute number of native and non-native species, and relative proportion of non-native species were analysed using analyses of variance (ANOVAs). Distance (1 m, 3 m, 5 m, 10 m), climbing treatment (0: no climbing; 1: climbing) and talus ecotype (0: open; 1: shrubby, 2: treed) were used as grouping variables. Similar statistical testing was conducted for the crevices and the main trail.

4 Results

4.1 Obvious Signs of Anthropogenic Damage

There are several cedar stumps scattered throughout the Swamp. At some unknown point in time, these many small and large cedars were cut down in order to make room for the climbing trail or to install a climbing route. A staircase was also installed, although this could have been done to serve the double purpose of a retaining wall (to prevent erosion) and to narrow the trail width (reducing area to be trampled by hiking climbers an erosion-prone area). There were also signs of fire, as many burnt logs could be found in several locations just off the main climbing trail.

4.2 Species at Risk in Ontario

American Hart's-Tongue Fern was found just off the main climbing trail, growing in an area where it can be trampled on. There were no other sightings of at-risk species.

4.3 Vegetative Communities

A total of 44 species were identified in the talus study, among which 34 (77%) were native and 10 (23%) were non-native (Appendix B). Most native species had SRANKs of S4 or S5, with only one S3-ranked species: Early Meadow-Rue (*Thalictrum dioicum*).

Along the main trail, 55 species were identified, among which 47 (85%) were native and 8 (15%) were non-native (Appendix C). The majority of native plants were ranked S5, with a few designated as S4.

Among the 34 species identified in the crevice areas, 29 (85%) were native and 5 (15%) were non-native (Appendix D). Most native species were ranked S5, with a few as S4.

4.4 Impact of Rock Climbing on Talus Communities

4.4.1 Physical environment

The first two CCA axes explained 75.2% and 24.2% of total variance, respectively (Figure 7). The physical environment is composed of abiotic and biotic constraining variables, which are explained below.

4.4.1.1 Abiotic

The first axis explains much variation due to distance (ANOVA, $F_{1,90}$=14.630, P=0.001), canopy openness (ANOVA, $F_{1,90}$=7.091, P=0.005) and loose stone cover (ANOVA, $F_{1,90}$=3.552, P=0.038). Quadrats with greater cover of loose stone were located closest to the cliff base, and were also associated with more open overstory canopies. The second axis best associates with variation related to bedrock cover (ANOVA, $F_{1,90}$=4.944, P=0.014) and climbed status (ANOVA, $F_{1,90}$=4.192, P=0.016), demonstrating that climbed quadrats were linked with less exposed bedrock.

4.4.1.2 Biotic

Quadrats with greater cover of understory vegetation (and other related biotic variables such as species richness and number of native and non-native species) were more likely accompanied by climbing activity and less bedrock exposure. Alternatively, mosses and graminoids covered greater area in unclimbed quadrats that also had more exposed bedrock.

Native species tended to occur more commonly in quadrats located off the climbing trail and into the adjacent forest with a more closed overstory canopy. Meanwhile, non-native species were more commonly found closer to the cliff base, where occurred a greater amount of talus rubble and open overstory canopies.

4.4.2 Species Frequency

The first two axes explained 86.4% (47.4% and 39.0%, respectively) of total variance in frequency of the 20 most common vascular species in the understory (Figure 8). Environmental variables such as distance (ANOVA, $F_{1,73}$=4.685, P=0.001), leaf litter cover (ANOVA, $F_{1,73}$=3.811, P=0.045) and total understory vegetation cover (ANOVA, $F_{1,73}$=2.795, P=0.077) best explained this variation. Many species are associated with the vegetation cover vector, possibly because these species dominate the understory and make up most of the vegetation cover (e.g. RUBU-SP or *Rubus sp.*, and CYSTBUL or *Cystopteris bulbifera*).

Most non-native species occurred in the north-west quarter of Figure 8, meaning that these species occurred most often at the foot of the cliff in areas with lower amounts of leaf litter. Meanwhile, most native species were more numerous in quadrats farther from the staging area, in locations with greater accumulations of leaf litter.

4.4.3 Species Relative Cover

The first two axes explained 76.9% (44.5% and 32.4%, respectively) of total variance in relative cover of the 21 most widespread vascular species (Figure 9). Distance (ANOVA, $F_{1,73}$=3.992, P=0.001), leaf litter (ANOVA, $F_{1,73}$=2.368, P=0.053) and understory vegetation cover (ANOVA, $F_{1,73}$=2.099, P=0.027) were again important environmental factors in explaining this variance. However, unlike with species frequency, moss cover (ANOVA, $F_{1,73}$=2.018, P=0.033) became a significant environmental variable in predicting species relative cover. Many species are associated with the vegetation cover vector, possibly because these species dominate the understory and make up most of the vegetation cover (e.g. RUBU-SP or *Rubus sp.*, and CYSTBUL or *Cystopteris bulbifera*).

Again, quadrats with greater relative cover of non-native species were commonly found closer to the staging area, where little leaf litter or moss occurred. On the other hand, native species covered a greater relative area in quadrats father away from the cliff base with a greater cover of moss and leaf litter.

4.4.4 Floristic Quality Assessment of Talus

4.4.4.1 Native and Non-Native Species

Quadrats closest to the base (0-1 m) had moderately fewer native plant (Figure 10; ANOVA, $F_{3,92}$=2.590, P=0.058; TukeyHSD, 1 m versus 10 m, P=0.038), more non-native species (Figure 11; ANOVA, $F_{3,92}$=4.408, P=0.006; Tukey HSD, 1 m versus 10 m, P=0.006; 3 m versus 10 m, P=0.053) than those farther away (9-10 m). In addition, the proportion of non-native plants were also significantly greater closer to the base (Figure 12; ANOVA, $F_{1,94}$=9.781, P=0.002 P, 1 m versus 10 m, P=0.010).

Shrubby taluses had significantly more native (Figure 10; ANOVA, $F_{2,93}$=7.938, P>0.001; TukeyHSD, shrubby versus open, P=0.001; shrubby versus treed, P=0.003) and non-native (Figure 11; ANOVA, $F_{2,93}$=6.318, P>0.003; TukeyHSD, shrubby versus open, P=0.083; shrubby versus treed, P=0.002) species than open and treed taluses. However, this significant difference was not detected when looking at the relative proportion of non-native species (Figure 12; ANOVA, $F_{1,94}$=2.144, P=0.147). This suggests that shrubby taluses are simply more biodiverse with a greater number of species.

There were no discernible differences in number of native (Figure 10; ANOVA, $F_{1,94}$=0.552, P=0.459), non-native species (Figure 11; ANOVA, $F_{1,94}$=1.537, P=0.218), nor were there detectible differences in relative proportion of non-native species (Figure 12; ANOVA, $F_{1,94}$=0.031, P=0.862) between climbed and unclimbed areas.

4.4.4.2 Coefficient of Conservatism and Floristic Quality Index

Mean coefficients of conservatism, for the most part, remained within the 4-6 range. This indicates that the Swamp is populated by primarily by plants that associate with a specific habitat type (most likely that of cliffs) and are able to tolerate moderate disturbances. The exception to this general pattern is the plant assemblage in unclimbed taluses, in which mean coefficient of conservatism just grazes the 7-8 range (plants in advanced successional stage that tolerate mild disturbances).

Unclimbed quadrats had more conservative plant assemblages (Figure 13; ANOVA, $F1_{,73}$=7.838, P=0.007), but this did not translate into differences in floristic quality index (Figure 14; ANOVA, $F_{1,73}$=0.262, P=0.611).

Meanwhile, shrubby taluses had significantly greater floristic quality (Figure 14; ANOVA, $F_{2,72}$=4.462, P=0.015) than open taluses (TukeyHSD, P=0.012) but not more than treed ones, but talus ecotype assemblages did not statistically differ in conservatism (Figure 13; ANOVA, $F_{2,72}$=1.457, P=0.240). The increased floristic quality of shrubby taluses is probably reflective of the higher number of species found in these quadrats.

Comparison of plant assemblages according to distance did not reveal any statistical differences in conservatism (Figure 13; ANOVA, $F_{3,71}$=2.146, P=0.102) or in floristic quality (Figure 14; ANOVA, $F_{3,71}$=0.805, P=0.495).

4.4.4.3 Total and Mean Weediness

No significant differences could be detected among total weediness scores and mean weediness indices. While shrubby taluses had greater total weediness scores, these were not statistically significant (Figure 15; ANOVA, $F_{2,45}$=2.281, P=0.114). Distance and climbing treatments also did not seem to have any statistical effect upon total weediness (Figure 15; ANOVA, $F_{3,44}$=0.55, P=0.983; $F_{2,45}$=2.281, P=0.114; respectively). Furthermore, mean weediness index varied little from -2, regardless of distance from cliff base, climbing treatment or talus ecotype (Figure 16; ANOVA, $F_{3,44}$=0.851, P=0.474; $F_{1,46}$=0.324, P=0.572; $F_{2,45}$=1.694, P=0.195; respectively). Most introduced species have the potential to cause problems in a localized manner.

4.5 Crevices and Main Trail

4.5.1 Floristic Quality Assessment

4.5.1.1 Native and Non-Native Species

The main trail had significantly more native and non-native plants than did crevice areas, but the relative proportion of non-native species were not significantly different (Figure 17; ANOVA, $F_{1,2}$=120.020, P=0.008; $F_{1,2}$=64.000, P=0.015; $F_{1,2}$=2.586, P=0.249; respectively).

4.5.1.2 Coefficient of Conservatism and Floristic Quality Index

Again, coefficient of conservatism remained within the 4-6 range. Crevice plant assemblages were significantly more conservative (Figure 18; ANOVA, $F_{1,2}$=22.321, P=0.042), while those of the main trail were greater in floristic quality (Figure 18; ANOVA, $F_{1,2}$=49.484, P=0.020). This superiority in floristic quality for the main trail is probably reflective of the fact that more species were found, and that the main trail transects through a higher diversity of different habitat types.

4.5.1.3 Total and Mean Weediness

Total and mean weediness were not significantly different, with mean weediness index averaging at -2, like in the talus section above (Figure 19; ANOVA, $F_{1,2}$=0.75, P=0.478; $F_{1,2}$=0.008, P=0.667; respectively).

5 Discussion

Climbing seemed to have less of an impact on vegetative communities in the Swamp than were environmental factors, as demonstrated in other studies (Kuntz and Larson 2005, 2006a, 2006b; Farris 1998). Species frequency and relative cover were more influenced by distance, cover of understory vegetation, and—to a lesser extent—leaf litter and moss. While climbing does play a role in the composition of the physical environment, the variance explained by climbing is dwarfed by that explained by factors such as distance from cliff, canopy openness and loose stone cover. However, impacts related to distance may also be related to climbing, considering how climbers are more likely to stay within the staging area (up to 3 m from the cliff base).

Yet, the floristic quality assessment system revealed some other interesting patterns. Ontario natural areas are typically composed of 20-30% non-native species (Oldham et al.1995). At a broad scale, the general frequency of non-natives found throughout the Swamp (main trail and crevice communities) just fringed over the lower end of this weediness range. However, a more focused scale (i.e. 1x1m^2 quadrat), the relative proportion of non-native well surpassed this 20-30% average. Non-native species populated up to 80% of quadrats at the base of cliffs. The lowest small-scale proportion of non-native species were found at 9-10 m from the cliff base (approximately 20%). There are more non-native plant species in areas where climbers are.

In addition, unclimbed areas were occupied by more conservative species with lower tolerance to disturbance and a higher degree of fidelity to a narrow range of habitat characteristics. Considering how some control plots were located along the trail between the main climbing trail and the parking lot, this suggests that the access trail may be more sensitive to disturbances than the actual climbing area.

The greater frequency of non-native species at the base of cliffs within the staging area suggests that climbers may be introducing these plants as they hike along the cliff base or while they climb. Alternatively, these non-native species could be simply filling an empty niche that would otherwise be left void from native species that are less tolerant to disturbance (trampling, falling rocks). This is difficult to confirm without conducting an enclosure study. However, this study provides evidence that the presence of climbers is trampling out the native vegetation and introducing non-native species, thus confirming the results from other studies (Clark 2012; Müller et al. 2004, McMillan & Larson 2002).

There is evidence that American Hart's-Tongue Fern grows in the area, however this species was only sighted in one place. The quadrat method of sampling plant communities was not effective in locating at-risk species. A more thorough inventory of vegetation within the Swamp needs to be conducted in order to confirm the existence and location of other species at risk.

In terms of crevices, they harbour a slightly more conservative plant population, but this difference is not great. No special species were found. Wetter conditions within the crevices already make these areas less appealing for climbing, but climbers will often walk through on warm days to cool off. More research is needed to determine whether these areas should be closed to climbers. However, as it is, the evidence is not strong enough to warrant closure.

The greater proportion of climbed routes established upon open taluses may reflect the preference climbers share in choosing to establish climbing routes where it is easiest to access the cliff (i.e. open taluses). However, it is difficult to discern whether these open taluses would remain open if climbing were to stop. If climbers prefer more open areas with easier access to the cliff wall, would the presence of climbers impede regeneration of large-bodied biota such as shrubs and trees? Through the act of trampling upon regrowth, would climbers be maintaining the openness of these taluses?

Much like Farris (1998) and Nuzzo (1996), it was very difficult to find open control taluses at the base of tall, vertical walls that had no evidence of being climbed. The difficulty in finding ideal climbing sites without any signs of climbing may demonstrate: 1) the presence of climbers may be impeding regeneration, or 2) climbing has become so prevalent throughout the Swamp that every accessible wall has already been claimed. The remains of cedar stumps near the base of the cliff suggests that climbers have been taken to cutting down trees in order to access the rocky wall behind. However, this is again difficult to confirm without further research.

Environmental factors were demonstrated to have a greater impact on vegetative communities than did climbing, as was found in previous studies. Nevertheless, the presence of climbing closer to the cliff base was associated with more non-native plant species. Also, unclimbed areas were shown to be populated by more conservative plant assemblages. However, results from this report only reflect the vegetative patterns of a single month within a single growing season.

6 Management Recommendations

Future monitoring must be conducted in order to better understand the impacts that rock climbing may be having on the talus in the Swamp and elsewhere throughout the Niagara Escarpment. Easy to use and understand (even by non-biologists), the FQA system will be a very valuable tool for future monitoring. Nonetheless, the FQA is not without limitations and should be supplemented with other evaluation tools (Oldham et al. 1995).

More in-depth inventories of the vegetation within the Swamp must be conducted in order to locate special plant communities that may also include species at risk (plant or animal). This information can help improve the design of trails so as to avoid these special plant communities (Holzman 2013). Kuntz and Larson (2005) recommend that trails should cut to the cliff base only when necessary. Considering how the cliff talus is a rare vegetation type, disturbance to it should be minimally implemented.

Improved design of trails partnered with temporal and spatial closures would result in improved protection of special plant communities and species at risk (Holzman 2013; McMillan & Larson 2002). However, area closures must be minimal. Recreationists can respond by moving their activities to previously undisturbed areas (McMillan and Larson 2002). When closures are employed as a management strategy, land managers should make it a priority to contact the climbing community through the OAC and explain the reasons for these restrictions. Climbers are more likely to abide by these closures if they understand the ecological rationale behind them (McMillan and Larson 2002). Temporal closures should occur during noteworthy time throughout the year such as in the spring or during significant flowering periods (Holzman 2013). Future monitoring efforts should reveal ideal locations and times that warrant protection.

Enclosure studies that prevent entrance of climbers could help to reveal whether climbers are the source of disturbance that may be preventing the recovery of talus vegetation. Appropriate signage and education must accompany these temporary closures to inform the climbing community of the reasons for closures.

Climbers should also be educated on the potential impacts that they may have on the trail they hike between the climbing area and the parking lot. Management need not solely concentrate upon the climbing area. Kuntz and Larson (2005) recommend that managers put in place anticipatory management strategies to protect currently unclimbed areas. If inventories are taken of these unclimbed areas, this could provide the basis for before-and-after studies should new climbing routes be established in these zones. If the Niagara Escarpment is managed consistently throughout its entirety, this would reduce confusion and increase compliance by the climbing community (Kuntz & Larson 2005).

Signage is another useful method of disseminating ecological information to the climbing community. Again, this strategy should be used minimally, as it may reduce the natural experience of outdoor climb. At most, signs should be installed at the entrance of the general climbing area and just outside of area closures.

Climbers in southern Ontario, including at the Swamp, already demonstrate many stewardship best practices that need to be recognized. They actively participate in leaving no trace, by picking up their trash and that left behind by others. Further, through the OAC, climbers work with managers across Ontario engaged in initiatives such as invasive species removal, climbing permit creation, and land acquisition and donation for conservation (to name a few). Meanwhile, MNRF can be invaluable to the climbing community as a source of information and other resources that could help to create a more effective stewardship strategy moving forward. The ongoing collaborations between the MNRF and the OAC appear valuable in putting stewardship strategies into action, especially from a long-term perspective.

Tables

Table 1. Subnational ranking system by Natural Heritage Information Centre. Obtained from Bradley (2013).

SRANK	Definition
SH	Possibly extirpated (Historical). Species occurred historically and there is some possibility that it may be rediscovered. Its presence may not have been verified in the past 20-40 years.
S1	Extremely rare in Ontario; <5 occurrences in province, or less than a couple remaining hectares.
S2	Very rare in Ontario; usually 6-20 occurrences in province, or only a few remaining hectares.
S3	Rare to uncommon in Ontario; usually 21-80 occurrences in province; may have fewer occurrences, but with some extensive examples remaining.
S4	Considered to be common in Ontario. It denotes a species that is apparently secure, with over 80 occurrences in the province.
S5	Indicates that a species is widespread in Ontario. It is demonstrably secure in the province
?	A question mark following the rank indicates that there is some uncertainty with the classification due to insufficient information.
S2S3	Indicates that an element (species) is rare, but insufficient information exists to accurately assign a single rank
SNR	Unranked -- conservation status Not Ranked.
SNA	Not Applicable -- a conservation status rank is not applicable because the species is not a suitable target for conservation activities (i.e. invasive, introduced).
SX	Indicates that an element is extirpated from the province.
SU	Indicates that the status is Uncertain due to insufficient information.
SHY	Indicates that the species of a Hybrid origin.

Table 2. Coefficient of Conservatism Categories and definitions (from Oldham et al. 1995).

CC	Definition
0 to 3	Plants found in a wide variety of plant communities, including disturbed sites.
4 to 6	Plants that tolerate moderate disturbance, but still associate with specific habitat types.
7 to 8	Plants in communities in an advanced successional stage that has undergone minor disturbance.
9 to 10	Plants with high degrees of fidelity to a narrow range of undisturbed habitat.

Table 3. Weediness categories and definitions (from Oldham et al. 1995).

Weediness	Definition
-1	Plants with little or no impact on natural areas. Most southern Ontario non-native plants fall into this category.
-2	Species that sometimes cause problems, but only relatively infrequently or in localized areas.
-3	Introduced species that can become serious problems in southern Ontario natural areas. These species have the potential of becoming serious weeds. E.g. Garlic Mustard and Purple Loosestrife.

Table 4. Types of climbing routes found along the main climbing trail within the Swamp.

Route Types	No.
Sport - Single	58*
Sport - Single (Shifting Difficulty)	3
Sport - Branching (2 Difficulties)	1
Sport - Branching (Sport & Project)	1*
Sport - Branching (Same Difficulty)	3*
Sport - Traverse	2
Traditional	11
Project	19
Mixed (Sport & Traditional)	2
Total Considered for Study	62
Grand Total	100

* Routes included in study.

Table 5. Definitions of talus ELC types, modified from Lee et al. (1998, p.44).

Talus Type	Definition
Open	Bare rock surfaces predominate; Substrate availability limited. Cover patchy and barren.
Shrub	Intermediate proportions of bare rock surfaces and substrate available. Within 1 m of the cliff base, cover varies from patchy/barren to continuous thicket.
Tree	Greater availability of substrate accumulated between rocks. Within 1 m of cliff base, cover varies from patchy/barren to more closed in nature.

Table 6. Sport climbing routes along the main trail in the Swamp that were included in study, stratefied according to difficulty and talus ELC type. Total number of routes per classification indicated first; number of routes sampled per classification in parenthases. Not included are control sites (one for each talus ELC type).

Difficulty	Talus ELC Types			Total
	Open	Shrub	Tree	
Beginner	0 (0)	0 (0)	1 (0)	1 (0)
Intermediate	11 (3)	5 (1)	6 (3)	22 (7)
Experienced	15 (5)	8 (3)	3 (1)	26 (9)
Expert	9 (3)	3 (1)	1 (0)	13 (4)
Total	35 (11)	16 (5)	11 (4)	62 (20)

Table 7. Variables included in initial CCA computations.

Test	Matrix 1 (species)	Matrix 2 (environment)	Condition/Covariate
Physical environment	Biotic Environmental Variables: Vegetation Cover Species Richness Native Species Non-Native Species Moss Cover Graminoid Cover	Abiotic Environmental Variables Distance* Climbed Status* Canopy Openness* Mineral Soil Cover Loose Stone Cover* Bedrock Cover* DWD Cover Leaf Litter Cover	Talus Ecotype
Species Frequency	Stem density of 20 most common species	Abiotic and Biotic Environmental Variables Distance* Climbed Status Canopy Openness Mineral Soil Cover Loose Stone Cover Bedrock Cover DWD Cover Leaf Litter Cover* Vegetation Cover* Moss Cover Graminoid Cover	Talus Ecotype
Species Relative Cover	Relative cover (%) of 20 most widespread species	Abiotic and Biotic Environmental Variables Distance* Climbed Status Canopy Openness Mineral Soil Cover Loose Stone Cover Bedrock Cover DWD Cover Leaf Litter Cover* Vegetation Cover* Moss Cover* Graminoid Cover	Talus Ecotype

* Variables from Matrix 2 that were included in final CCA for results due to their significance (P<0.1).

Figures

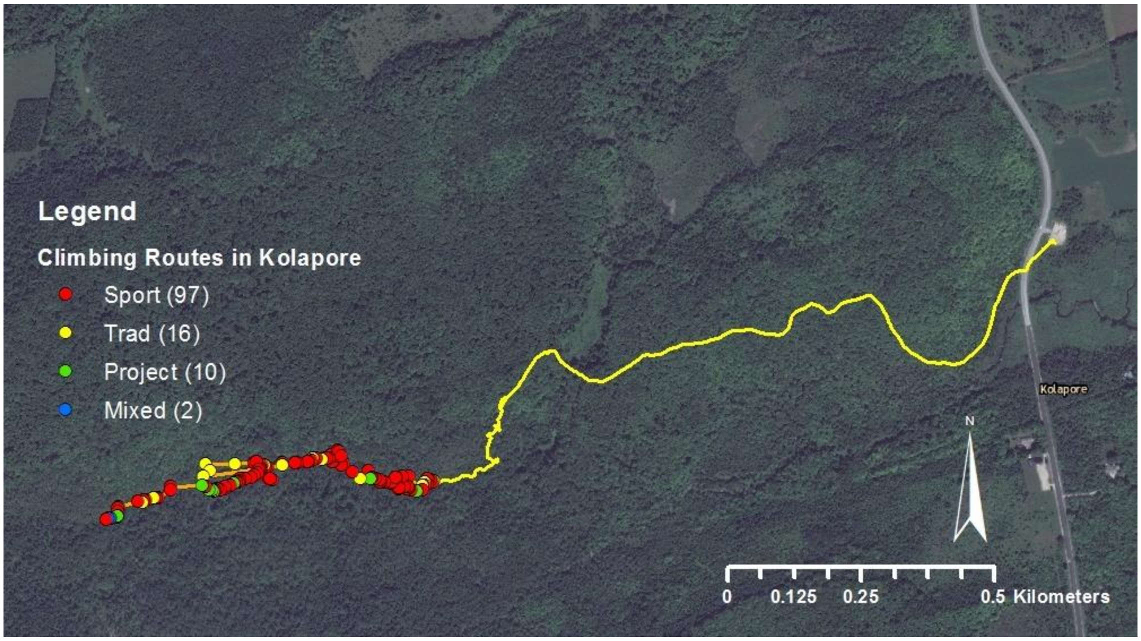

Figure 1. Map depicting the trail hiked between the parking lot to the climbing trail, as well as the location and style of each climbing route (coloured circles). Map created using ArcMap.

Figure 2. Kolapore Uplands Resource Management Areas is located in the town of Blue Mountains in Grey County, 20 km southwest of Collingwood and 60 km southeast of Owen Sound. Two climbing areas have been established within Kolapore: Metcalfe Rock and the Swamp. Map created using ArcMap.

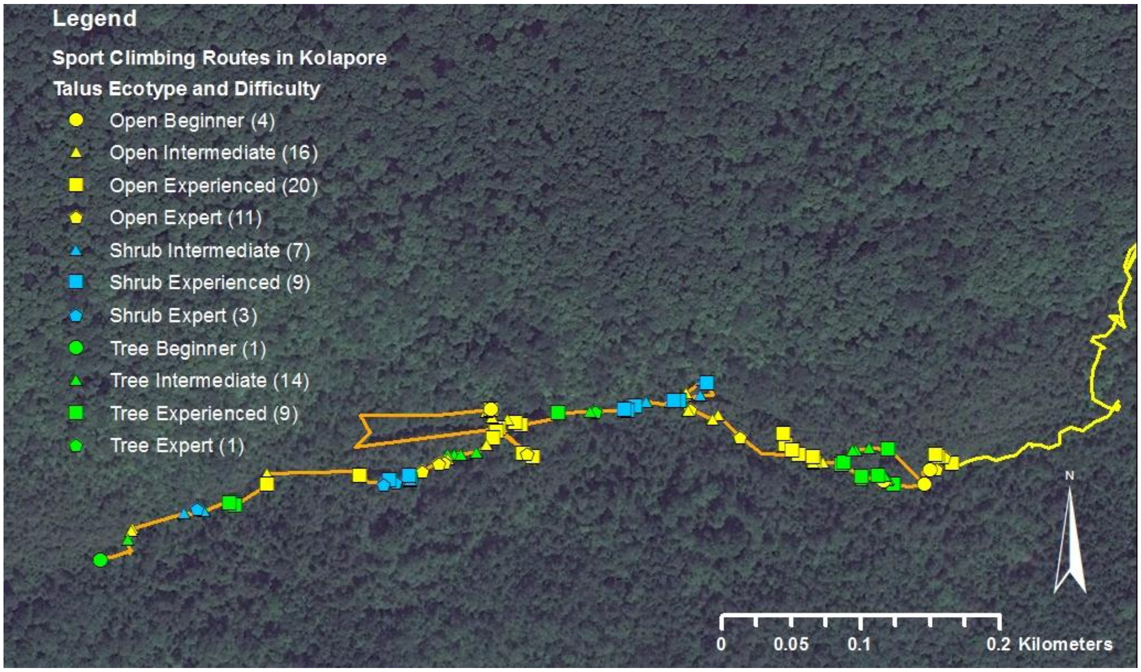

Figure 3. All climbing routes located within the Swamp, labeled according to talus ecotype (Open = Yellow, Shrub = Blue, Tree = Green) and difficulty (Beginner = Circle, Intermediate = Triangle, Experienced = Square, Expert = Pentagon), with number of routes per type indicated in parentheses. Orange line represents the climbing trail, and yellow line represents the trail that was hiked from the parking lot. Map created in ArcGIS.

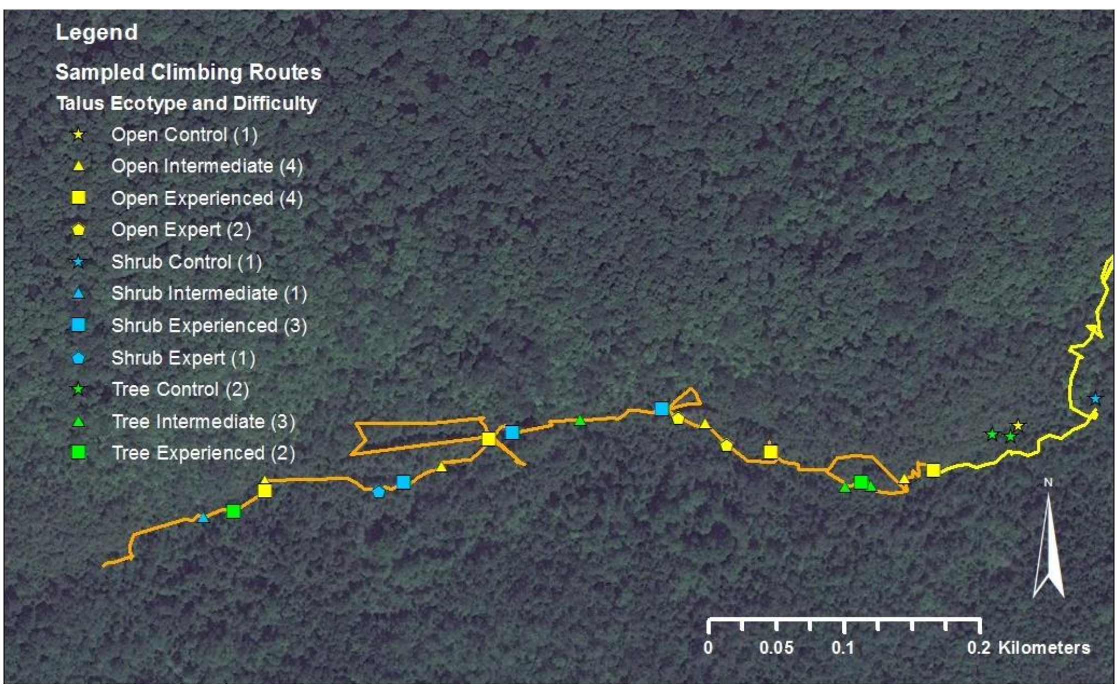

Figure 4. Sampled climbing routes located within the Swamp, labeled according to talus ecotype and difficulty, including four control sites (stars), with number of routes per type indicated in parentheses. Orange line represents the climbing trail, and yellow line represents the trail that was hiked from the parking lot.

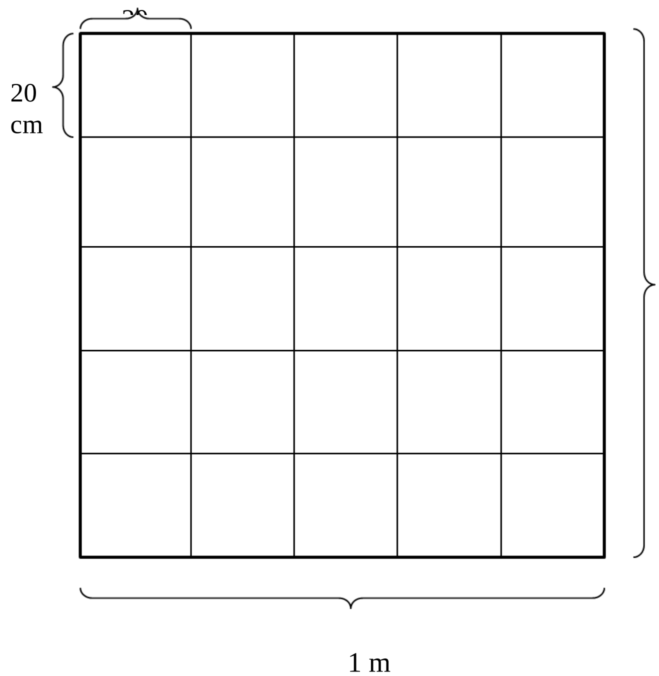

Figure 5. Sampling quadrat to measure vascular species richness and abundance (density and cover), and cover of moss, graminoids, overall vegetation, mineral soil, loose soil, surface rock, coarse woody debris and leaf litter. Each 1-m^2 quadrat is divided into 25 20x20-cm^2 cells.

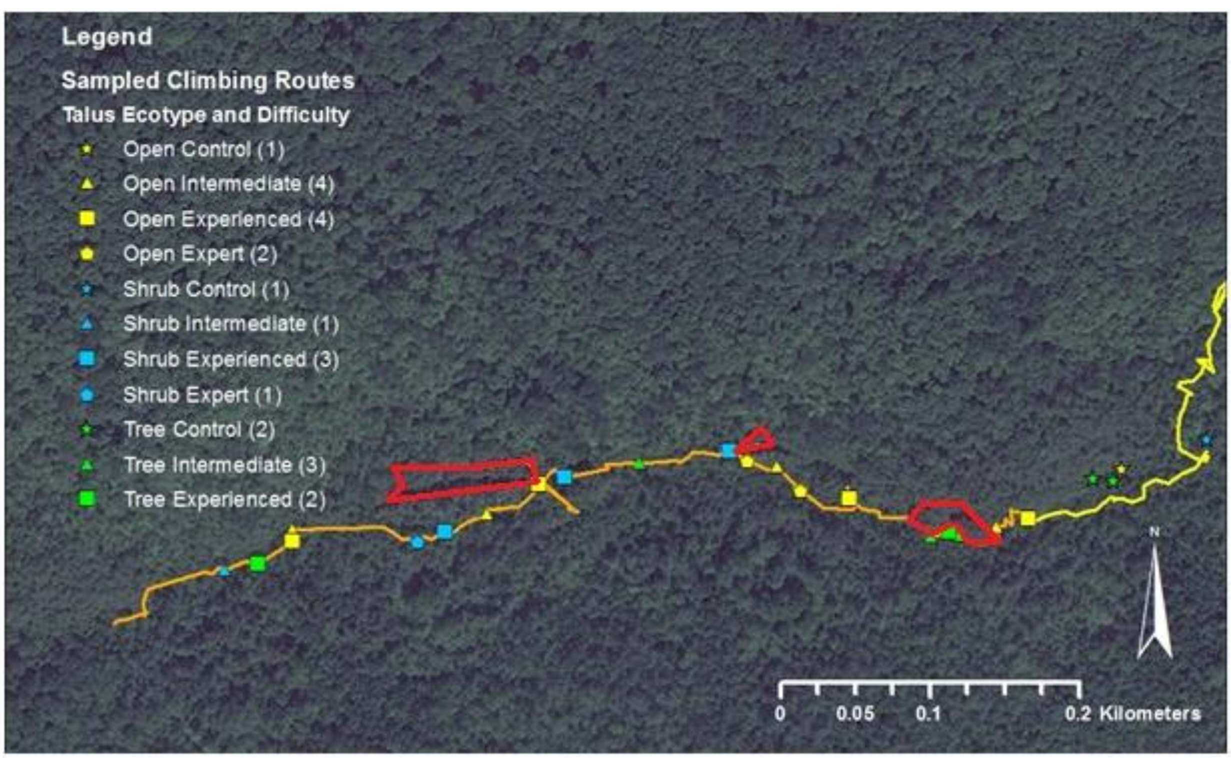

Figure 6. Three crevice areas (outlined in red) in reference to main climbing trail (orange) and hiked trail from road (yellow).

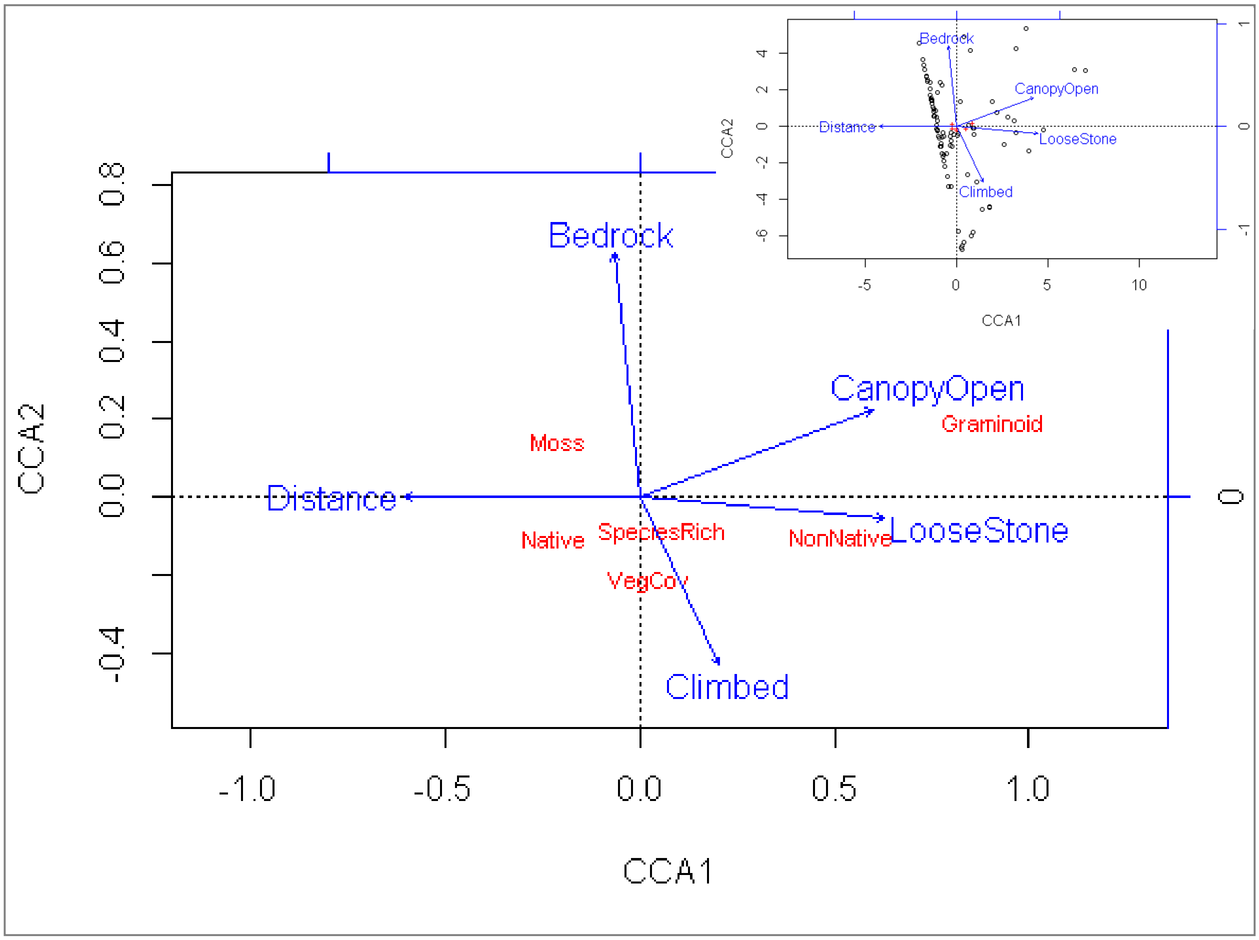

Figure 7. Canonical correspondence analysis (CCA) centered around 96 quadrat sites (black dots, see inset) and their respective biotic environmental characteristics (red text). Only significant abiotic variables were displayed as vectors (P>0.05).

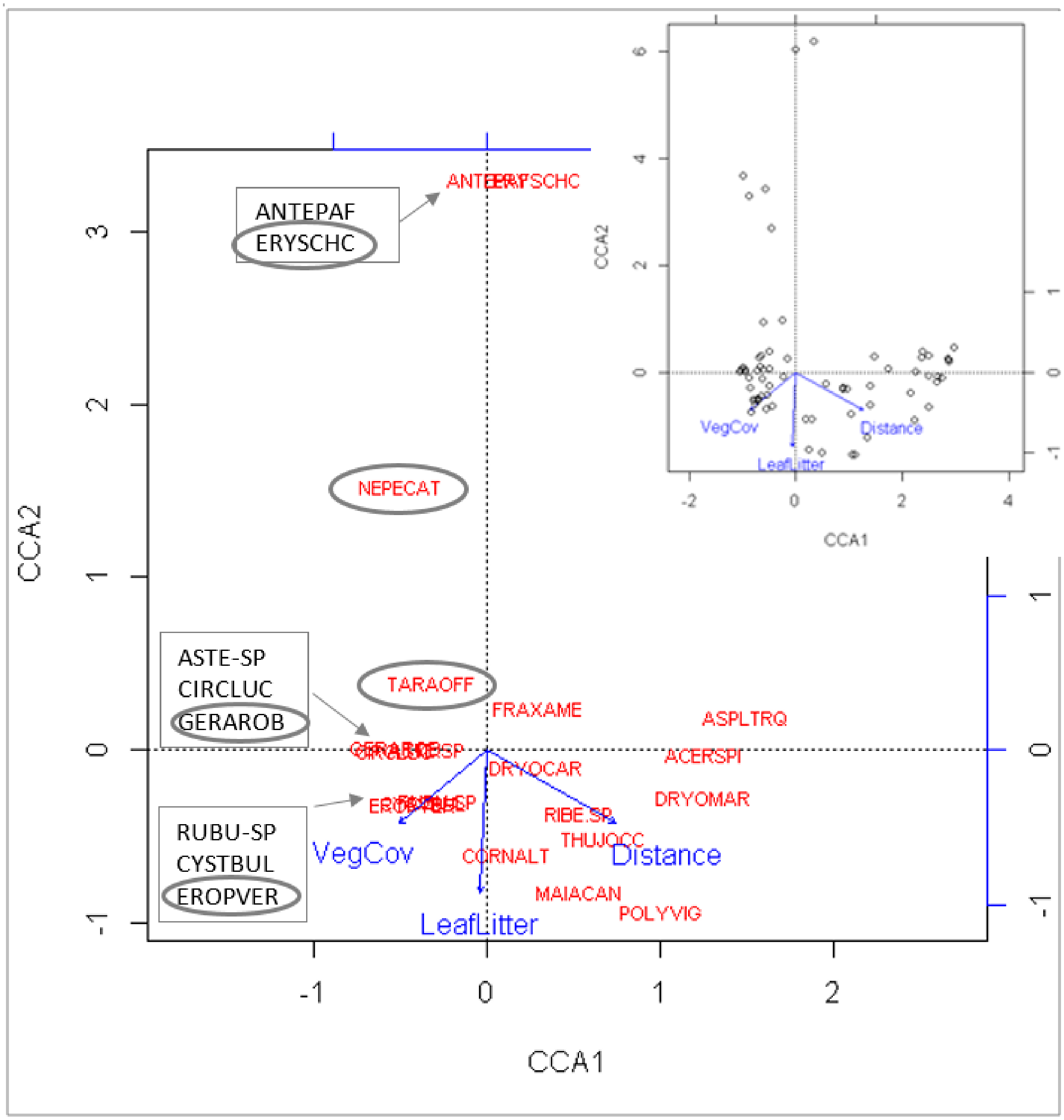

Figure 8. CCA centered around 77 quadrat sites (black dots, see inset) and 20 most frequent species composing the understory vegetative community (red text). Non-native species are circled. Only significant ($P \geq 0.05$) and moderately significant ($P \geq 0.10$) biotic and abiotic variables are shows as blue vectors. See Appendix A for a list of species abbreviations.

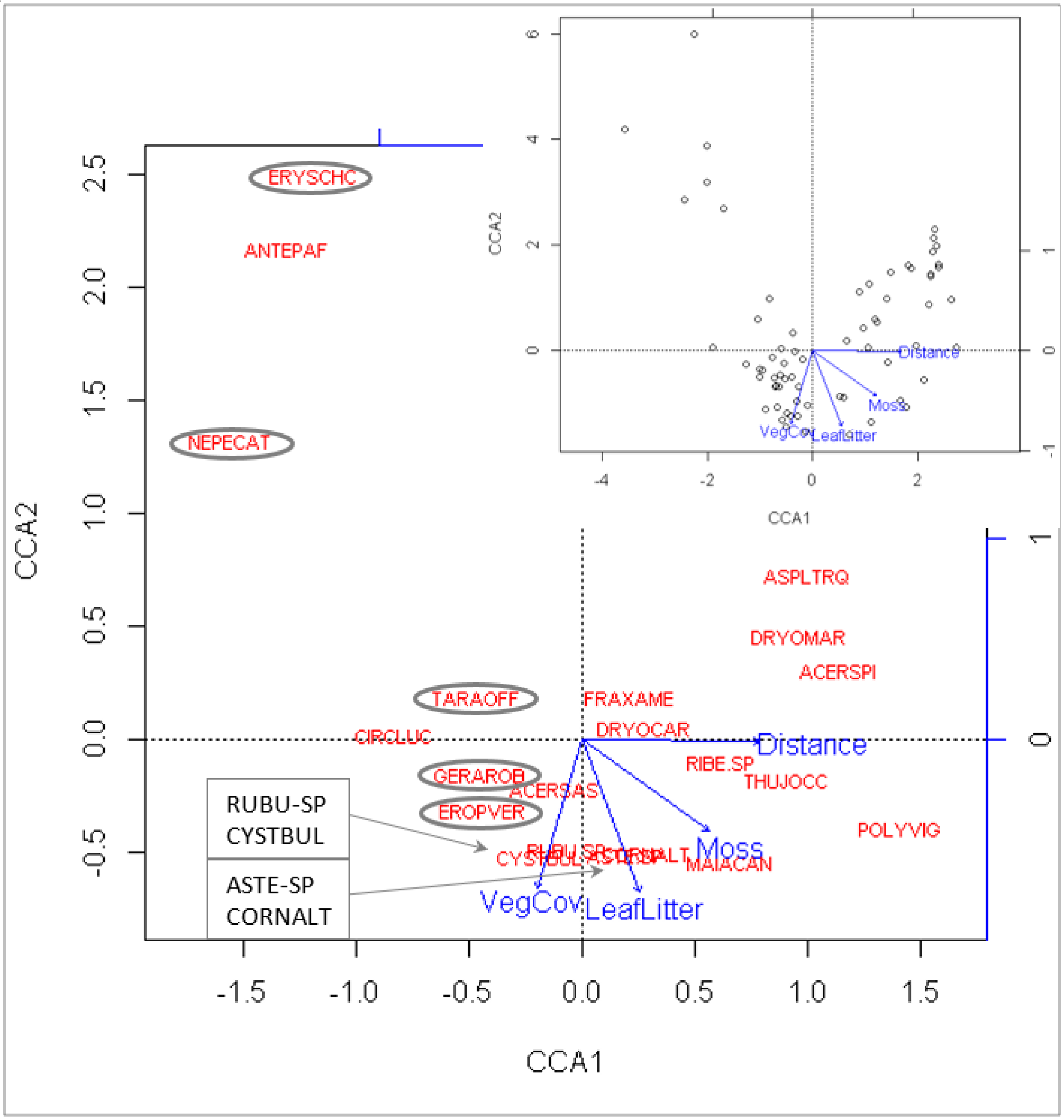

Figure 9. CCA centered around 78 quadrat sites (black dots, see inset) and 21 understory vegetative species covering the most area (red text). Non-native species are circled. Only significant ($P \geq 0.05$) and moderately significant ($P \geq 0.10$) biotic and abiotic variables are shows as blue vectors. See Appendix A for a list of species abbreviations.

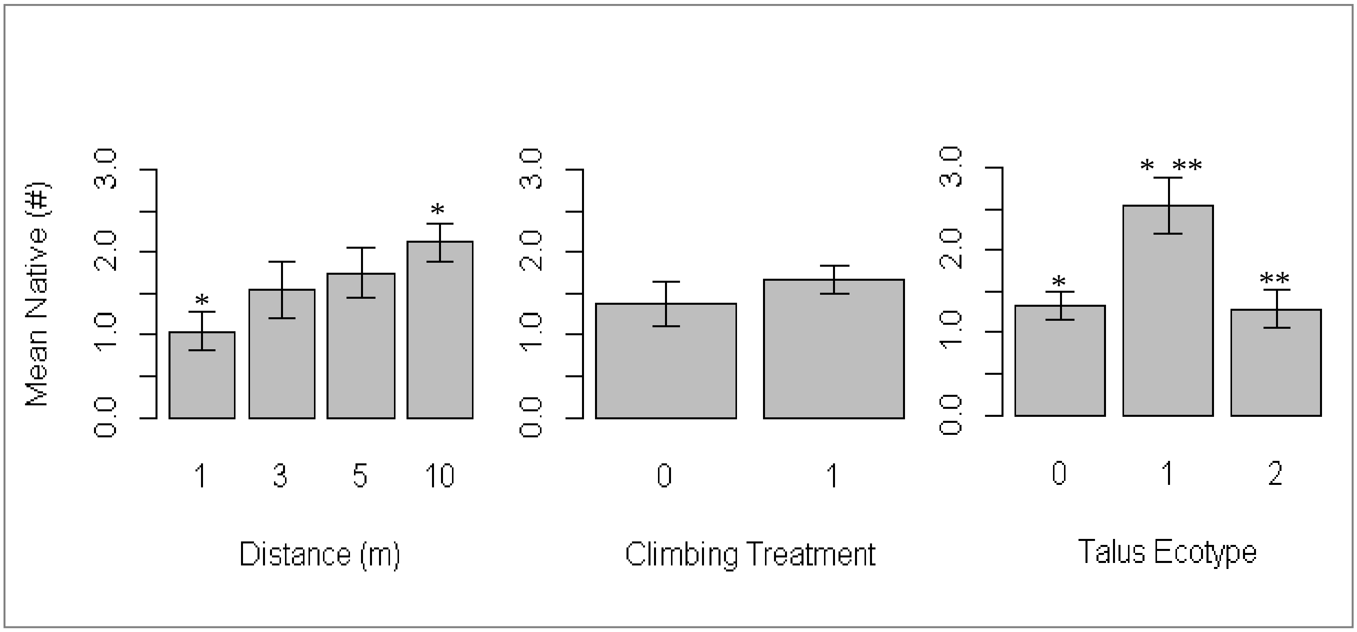

Figure 10. Number of native species (mean ± standard error) in taluses according to distance (1 m, 3 m, 5 m, and 10 m), climbing treatment (0: unclimbed, 1: climbed), and talus ecotype (0:open, 1: shrubby, 2: treed). Asterisks indicate means that are statistically different, double asterisk are included when there are two significantly different relationships.

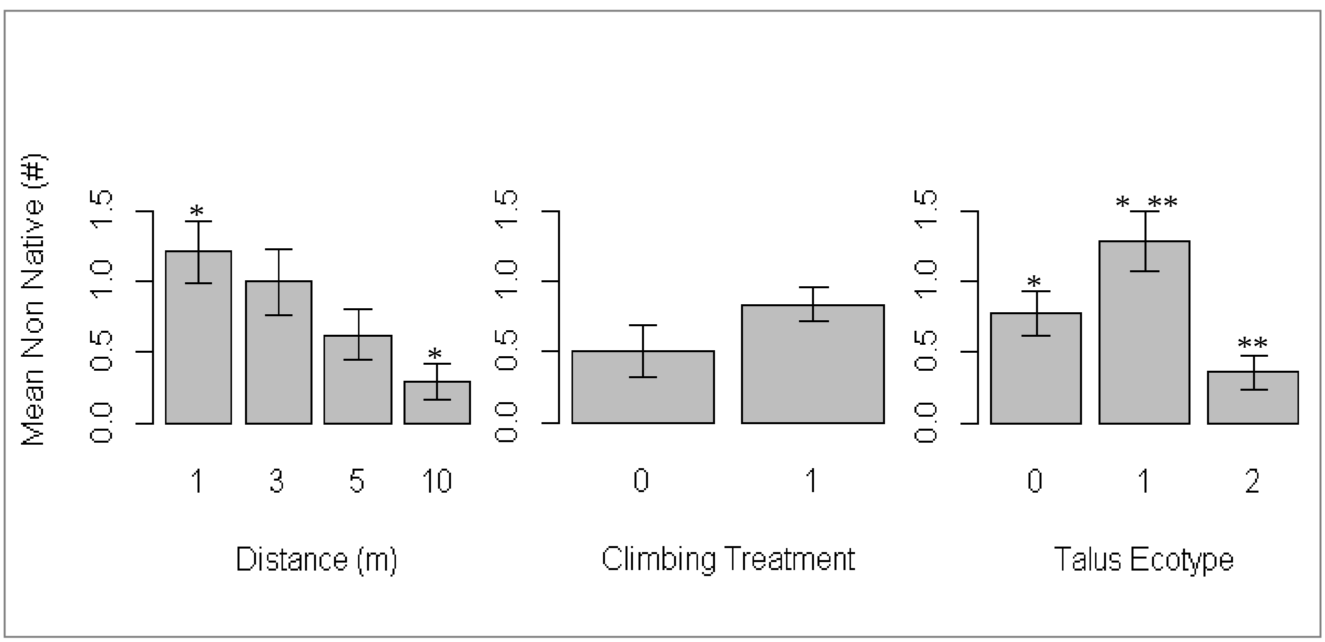

Figure 11. Number of non-native species (mean ± standard error) in taluses according to distance (1 m, 3 m, 5 m, and 10 m), climbing treatment (0: unclimbed, 1: climbed), and talus ecotype (0:open, 1: shrubby, 2: treed). Asterisks indicate means that are statistically different, double asterisk are included when there are two significantly different relationships.

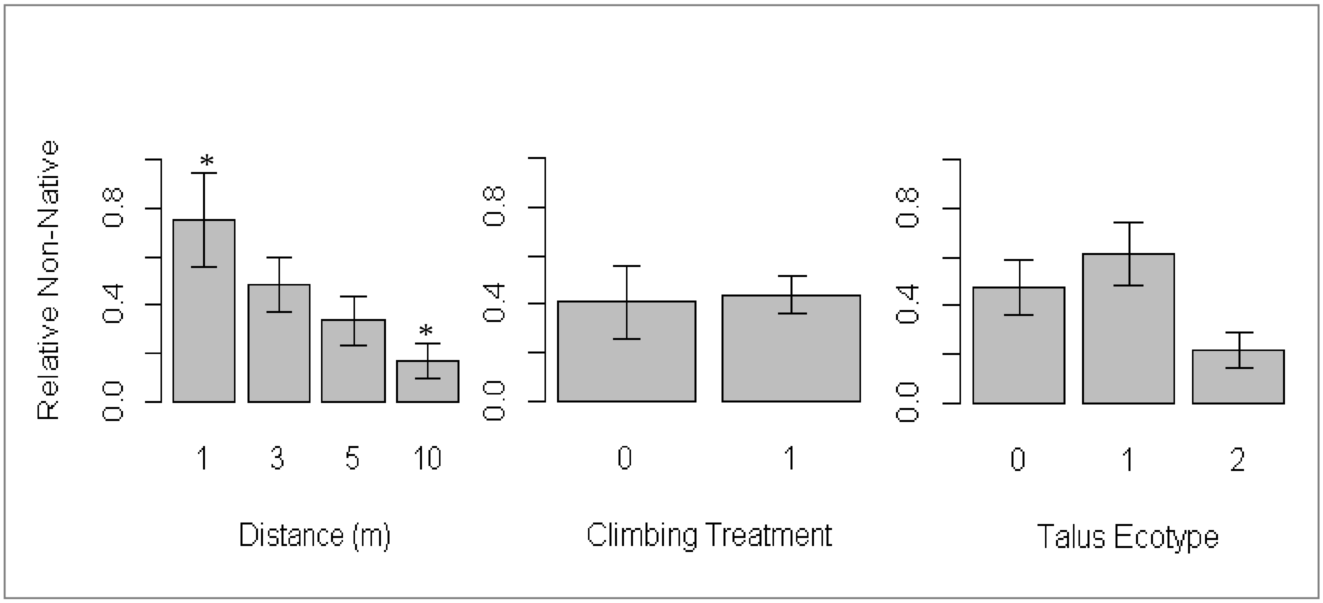

Figure 12. Relative proportion of non-native species (mean ± standard error) in taluses according to distance (1 m, 3 m, 5 m, and 10 m), climbing treatment (0: unclimbed, 1: climbed), and talus ecotype (0:open, 1: shrubby, 2: treed). Asterisks indicate means that are statistically different.

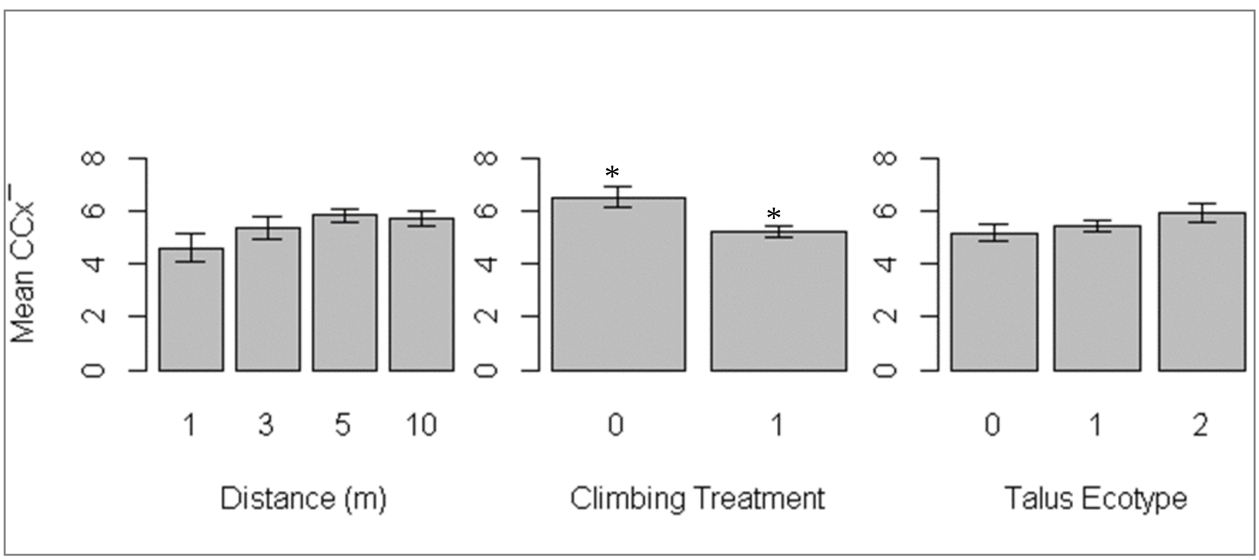

Figure 13. Coefficient of Conservatism (mean ± standard error) in taluses according to distance (1 m, 3 m, 5 m, and 10 m), climbing treatment (0: unclimbed, 1: climbed), and talus ecotype (0:open, 1: shrubby, 2: treed). Asterisks indicate means that are statistically different.

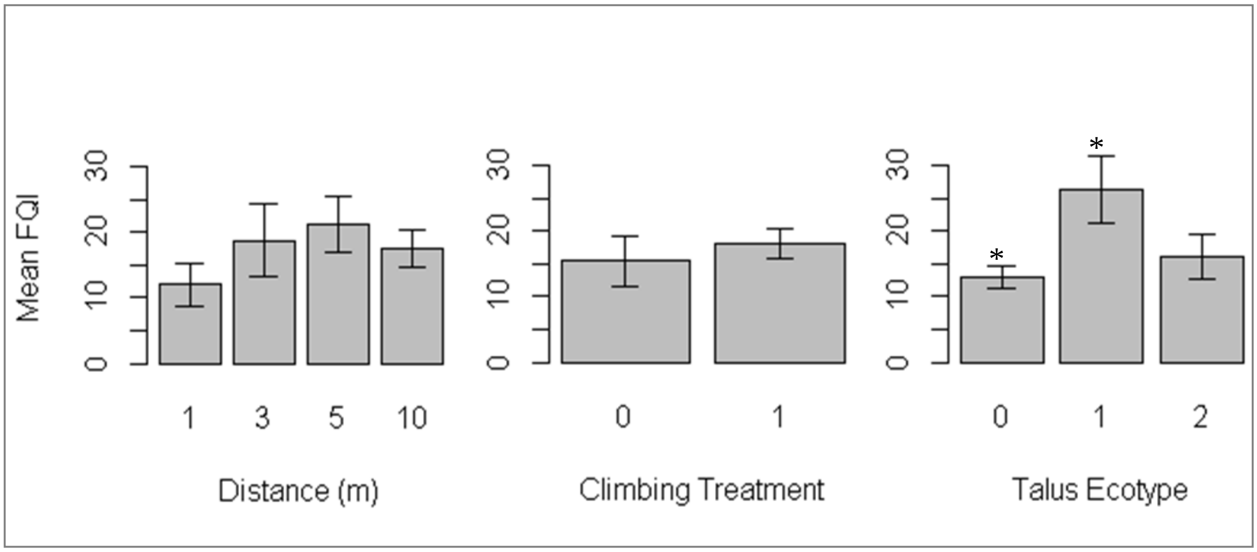

Figure 14. Floristic Quality Index (mean ± standard error) in taluses according to distance (1 m, 3 m, 5 m, and 10 m), climbing treatment (0: unclimbed, 1: climbed), and talus ecotype (0:open, 1: shrubby, 2: treed). Asterisks indicate means that are statistically different.

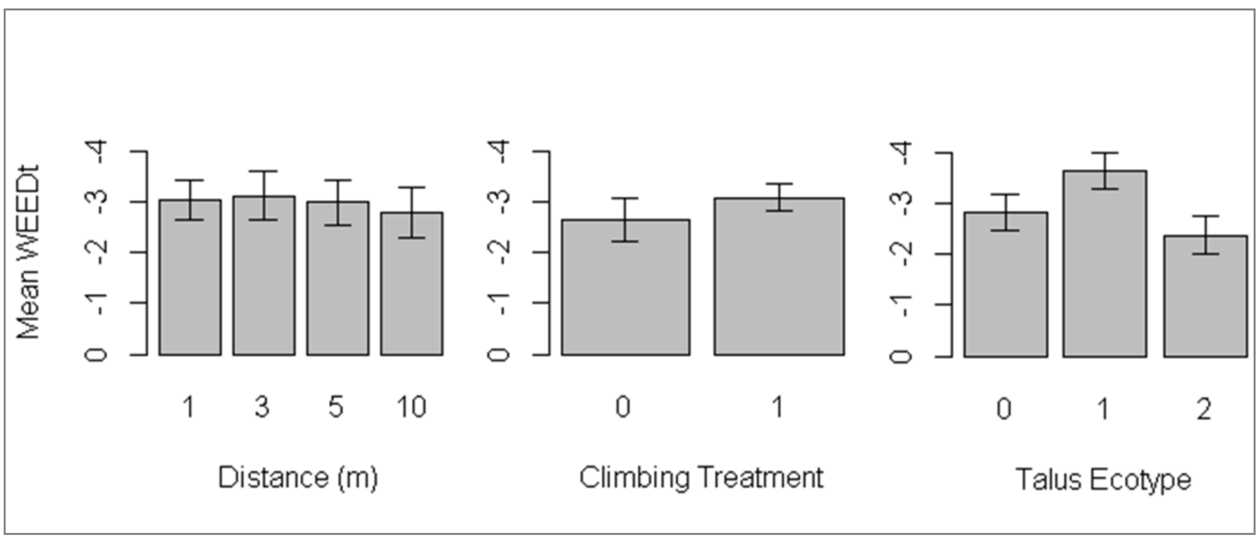

Figure 15. Total Weediness Score (mean ± standard error) in taluses according to distance (1 m, 3 m, 5 m, and 10 m), climbing treatment (0: unclimbed, 1: climbed), and talus ecotype (0:open, 1: shrubby, 2: treed). No significantly different relationships were detected.

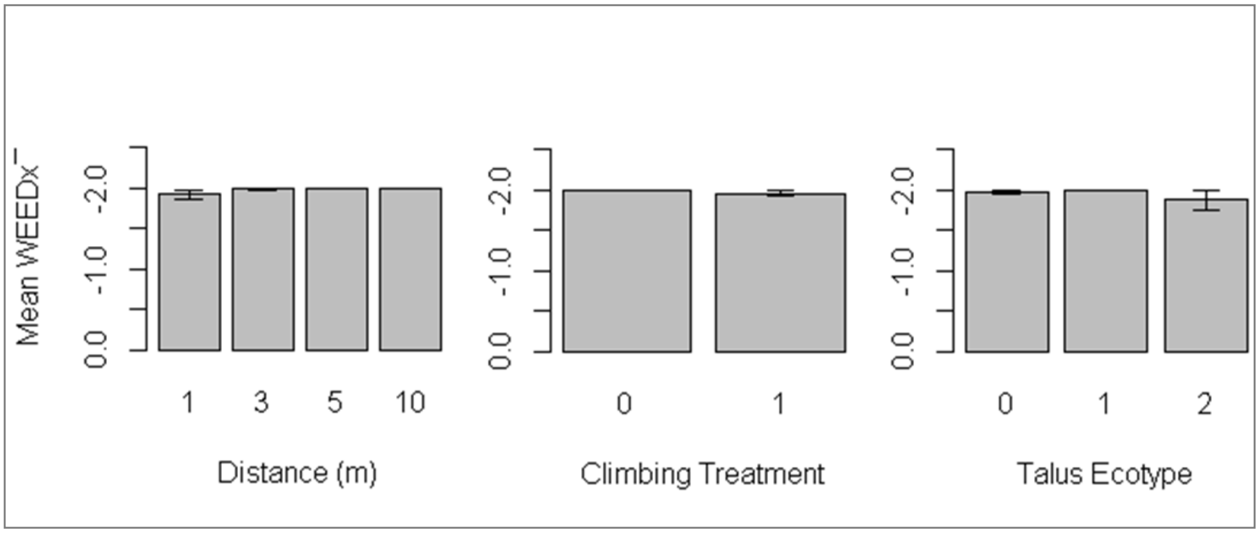

Figure 16. Weediness Index (mean ± standard error) in taluses according to distance (1 m, 3 m, 5 m, and 10 m), climbing treatment (0: unclimbed, 1: climbed), and talus ecotype (0:open, 1: shrubby, 2: treed). No significantly different relationships were detected.

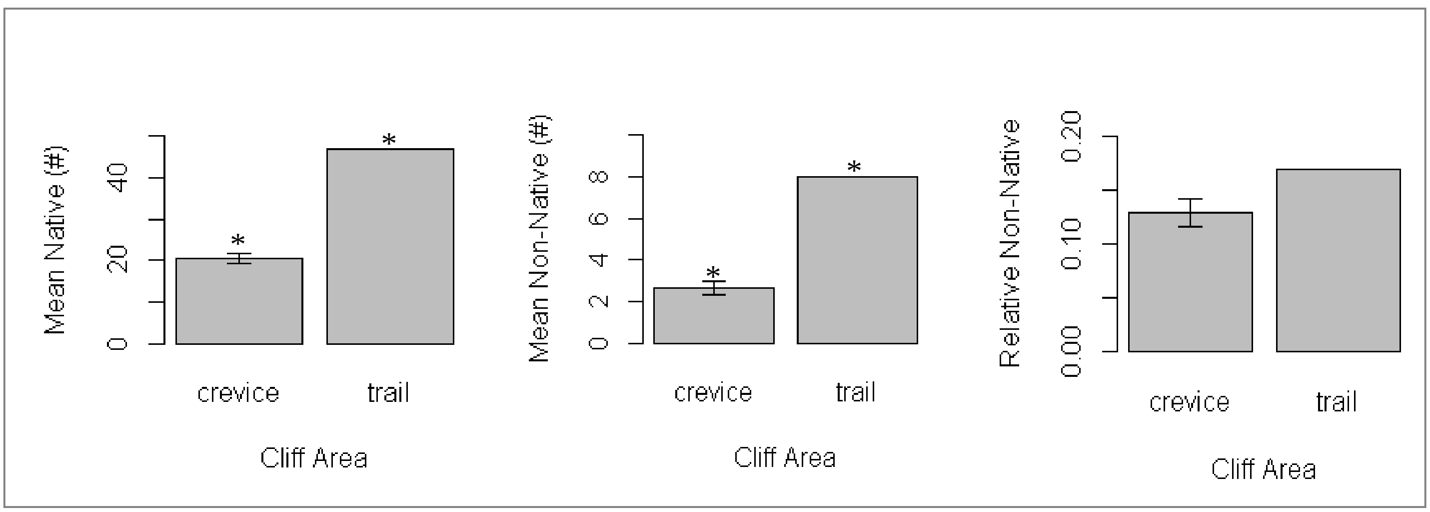

Figure 17. Number of native, and number and relative proportion of non-native species (mean ± standard error) in crevice areas and along main trail. Asterisks indicate means that are statistically different.

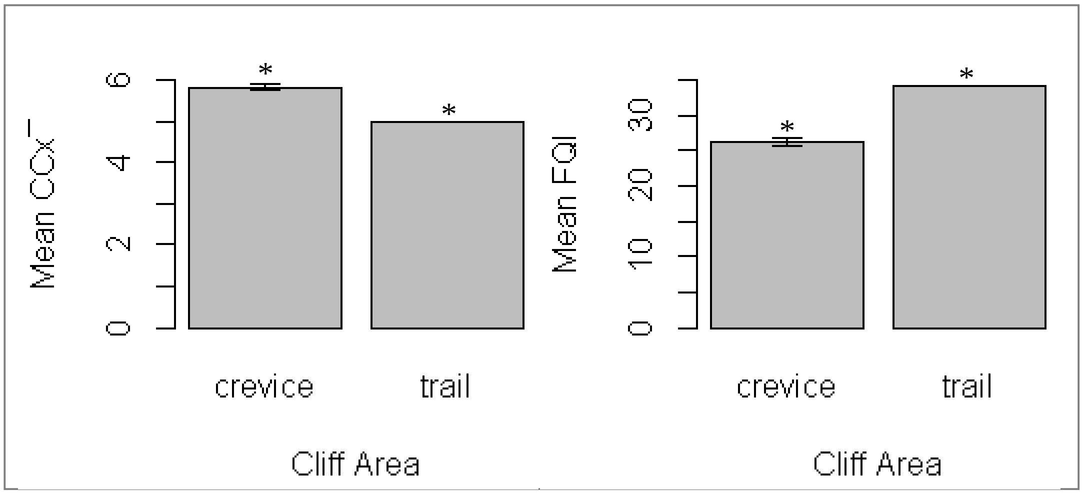

Figure 18. Coefficient of Conservatism and Floristic Quality Index (mean ± standard error) in crevice areas and along main trail. Asterisks indicate means that are statistically different.

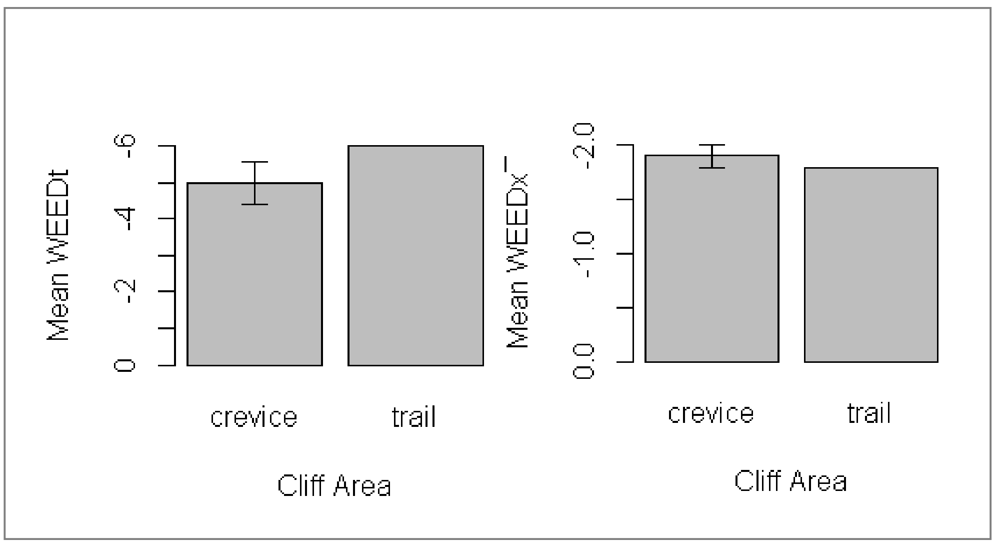

Figure 19. Total Weediness Score and average Weediness Index (mean ± standard error) in crevice areas and along main trail. No significantly different relationships were detected.

References

Bradley DJ (2013). Southern Ontario vascular plant species list. Ontario Ministry of Natural Resources, Science & Information Branch, Southern Science and Information. SIB SSI SR-03, 78p.

Camp RJ & Knight RL (1998). Effects of rock climbing on cliff plant communities at Joshua Tree National Park, California. *Conservation Biology*. 12(6): 1302-1306.

Catling PM (2013). Using Coefficients of Conservatism and the Floristic Quality Index to assess the potential for serious and irreversible damage to plant communities. *Canadian Field-Naturalist*. 127: 295-288.

Clark PW (2012). *Cliff ecology: Extent, biota, and recreation of cliff environments in the New River George, WV*. MA. Thesis. West Virginia University: USA.

Cobb B (1963). *A field guide to the ferns and their related families of northeastern and central North America.* Boston: Houghton Mifflin.

Endangered Species Act (2007). S.O. 2007, Chapter 6, Retrieved on 13 December 2014 from <http://www.e-laws.gov.on.ca/html/statutes/english/elaws_statutes_07e06_e.htm>.

Farris MA (1998). The effects of rock climbing on the vegetation of three Minnesota cliff systems. *Canadian Journal of Botany*. 76(12): 1981-1989.

Holzman R (2013). *Effects of rock climbers on vegetative cover, richness and frequency in the Boulder Front Range, Colorado*. Thesis. University of Colorado Boulder: USA.

Kelly PE & Larson DW (1997). 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.

Kuntz KL & Larson DW (2005). The relative influence of microhabitat constraints and rock climbing disturbance to vegetation on Ontario's Niagara Escarpment. In: *2005 PRFO Proceedings*. pp. 295-308.

Kuntz KL & Larson DW (2006a). Influences of microhabitat constraints and rock-climbing disturbance on cliff-face vegetation communities. *Conservation Biology*. 20(3): 821-832.

Kuntz KL & Larson DW (2006b). Microtopographic control of vascular plant, bryophyte and lichen communities on cliff faces. *Plant Ecology*. 185(2): 239-253.

Landi S & Chiarucci A (2010). Is floristic quality assessment reliable in human-managed ecosystems? *Systematics and Biodiversity*. 8: 269-280.

Lee HT, Bakowsky WD, Riley J, Bowles J, Puddister M, Uhlig P & McMurray S (1998). *Ecological land classification for Southern Ontario: First approximation and its implications.* Ontario Ministry of Natural Resources, Southcentral Science Section, Science Development and Transfer Branch. SCSS Field Guide FG-02.

Matthews JW, Spyreas G & Long CM (2015). A null model of Floristic Quality Assessment: Are plant species' Coefficients of Conservatism valid? *Ecological Indicators*. 52: 1-7.

McKenney KM (2013). *Rock climbers in the New River Gorge: Attitudes toward management actions and trust of park managers.* M.A. Thesis. West Virginia University: USA.

McMillan MA & Larson DW (2002). Effects of rock climbing on the vegetation of the Niagara Escarpment in Southern Ontario, Canada. *Conservation Biology*. 16(2): 389-398.

Ministry of Natural Resources and Forestry (2004). *Free Use Policy*. PL 3.03.01. Retrieved on 7 October 2014 from <https://www.ontario.ca/environment-and-energy/free-use-policy-pl-30301>.

Ministry of Natural Resources and Forestry (2014a). Species at risk in Ontario list: The official list of endangered, threatened, special and extirpated animals and plants in Ontario, including their status. Accessed 7 October 2014 from <http://www.ontario.ca/environment-and-energy/species-risk-ontario-list>.

Ministry of Natural Resources and Forestry (2014b). "Hart's-tongue Fern." Ministry of Natural Resources and Forestry. Queen's Printer for Ontario, 30 July 2014. Retrieved on 3 December 2014 from <https://www.ontario.ca/environment-and-energy/harts-tongue-fern>.

Ministry of Natural Resources and Forestry (2014c). "Butternut." Ministry of Natural Resources and Forestry. Queen's Printer for Ontario, 30 July 2014. Retrieved on 3 December 2014 from <https://www.ontario.ca/environment-and-energy/butternut>.

Monz CA (2009). Climbers' attitudes toward recreation resource impacts in the Adirondack Park's Giant Mountain Wilderness. *International Journal of Wilderness*. 15(1): 26-33.

Morales M (2012). Sciplot: Scientific graphing functions for factorial designs. Retrieved in November 2014 from <http://cran.r-project.org/web/packages/sciplot/index.html>.

Müller SW, Rusterholz HP & Baur B (2004). Rock climbing alters the vegetation of limestone cliffs in the northern Swiss Jura Mountains. *Canadian Journal of Botany*. 82(6): 862-870.

Niagara Escarpment Commission (2013a). *The Niagara Escarpment Plan: Office consolidation*. Ontario Ministry of Natural Resources. Halton Hills, ON.

Niagara Escarpment Comission (2013b). *Niagara Escarpment Plan Review 2015: Draft Discussion Paper -- Phase I*. Ontario Ministry of Natural Resources and Forestry. Halton, ON.

Newcomb L (1977). *Newcomb's wildflower guide: An indigenous new key system for quick, positive field identification of the wildflowers, flowering shrubs and vines of Northeastern and North Central North America.* Boston: Little, Brown.

Niagara Escarpment Commission (2013). *The Niagara Escarpment Plan: Office consolidation*. Ontario Ministry of Natural Resources. Halton Hills, ON.

Nuzzo VA (1996). Structure of cliff vegetation on exposed cliffs and the effect of rock climbing. *Canadian Journal of Biology*. 74: 607-617.

Oates C & Bracken M (1997). *A sport climbers guide to Ontario limestone.* Borealis Press, Toronto.

Oksanen J (2014). Vegan: An introduction to ordination. Retrieved in November 2014 from <http://cran.r-project.org/web/packages/vegan/vignettes/intro-vegan.pdf>.

Oksanen J, Blanchet G, Kindt R, Legendre P, Minchin PR, O'Hara RB, Simpson GL, Solymos P, Stevens MHH, Wagner H (2014). Vegan: Community ecology package. Retrieved in November 2014 from <http://cran.r-project.org/web/packages/vegan/index.html>.

Oldham MJ, Bakowsky WD & Sutherland DA (1995). *Floristic quality assessment system for Southern Ontario*. Natural Heritage Information Centre: Peterborough, ON, 11 pp.

Owen Sound Field Naturalists (1999). *A guide to the ferns of Grey and Bruce Counties, Ontario.* Owen Sound, ON: Owen Sound Field Naturalists.

Peterson RT & McKenny M (1968). *A field guide to wildflowers of Northeastern and North-Central North America*. Boston: Houghton Mifflin.

Riley JL, Jalava JV & Varga S (1996). *Ecological survey of the Niagara Escarpment Biosphere Reserve*. Ontario Ministry of Natural Resources, Southcentral Region. Peterborough, ON.

Schuster RM, Thompson JG & Hammitt WE (2001). Rock climbers' attitudes toward management of climbing and the use of bolts. *Environmental Management*. 28(3): 403-412.

Swink FA & Wilhelm GS (1994). *Plants of the Chicago Region*. 4th Ed. Indiana Academy of Science, Indianapolis. 921 pp.

Thompson J (2010). Climbers' perceptions toward sustainable bouldering at the Niagara Glen Nature Reserve. Unpublished Master's Thesis, Brock University: St. Catharines, Canada.

Thompson J & Hutson G (2011). Sustainable bouldering at the Niagara Glen. Paper presented at the Niagara Escarpment Leading Edge Conference, St. Catharines, Ontario. Retrieved on 12 January 2015 from <http://issuu.com/niagaraescarpmentcommission/docs/ontario_access_coalition_presentation_-_thompson_a?e=3367022/3375098>.

Appendices

Appendix A. List of species at risk in the Town of Blue Mountain, as of November 2013. List obtained from MNRF Midhurst District. This list of species is based on known occurrences and may not be completely exhaustive. Sorted by taxon, each species at risk is listed along with their current Species at Risk in Ontario (SARO) status (endangered, threatened, special concern), a description of habitat used by that species, along with whether these habitats are protected under the Endangered Species Act (ESA).

Taxon	Species	Status	Description of Habitat Used	Protection*
Amphibian	Jefferson Salamander	THR	Woodlands and vernal pools plus adjacent areas primarily along the Niagara Escarpment.	Regulated
Birds	Barn Swallow	THR	Nests on ledges/walls in/outside of barns and other man-made structures including buildings and bridges, may also use natural cliffs and caves.	General
Birds	Bobolink	THR	Grassland habitats, hayfields and some crop lands.	General
Birds	Canada Warbler	SC	deciduous and coniferous forests, usually wet forest types with a well-developed, dense shrub layer	N/A
Birds	Cerulean Warbler	SC	Forest-interior birds that require large, relatively undisturbed tracts of mature, semi-open deciduous forest.	N/A
Birds	Chimney Swift	THR	In and around urban settlements where they nest and roost in chimneys and other manmade vertical structures, will also nest in hollow trees, often near water.	General
Birds	Common Nighthawk	SC	Open areas with little to no ground vegetation, such as forest clearings, rock barrens, peat bogs, lakeshores and logged or burned over areas.	N/A
Birds	Eastern Meadowlark	THR	Native grasslands, pastures, agricultural fields especially in alfalfa and hay, old fields, meadows.	General
Birds	Golden-winged Warbler	SC	Areas of early successional vegetation, found primarily on field edges, hydro or utility right-of-ways, or recently logged areas.	N/A
Birds	Louisiana Waterthrush	SC	Steep, moist, forested ravines with fast flowing streams along Niagara Escarpment.	N/A
Birds	Peregrine Falcon	SC	Tall, steep cliff ledges adjacent to large water bodies.	N/A
Birds	Red-headed Woodpecker	SC	Nests in cavities in dead/mature trees in open woodland/woodland edges, especially in oak savannahs/riparian forest/habitats which contain high density of dead trees.	N/A
Birds	Whip-poor-will	THR	Open woodlands or openings in mixed forests, rock or sand barrens with scattered trees, savannahs.	General
Insects	Monarch Butterfly	SC	Wherever there are milkweed plants and wildflowers, often found in old fields, abandoned farmland and roadsides.	N/A
Mammal	Little Brown Myotis	END	Roost in trees or buildings during the day, often select attics, abandoned buildings and barns for summer colonies. Hibernate in caves and abandoned mines.	General
Mammal	Northern Myotis	END	Roost under loose bark and in the cavities of trees, hibernate in caves or abandoned mines.	General

Taxon	Species	Status	Description of Habitat Used	Protection*
Plants	American Hart's-Tongue Fern	SC	Mostly on Niagara Escarpment in rocky areas, particularly on limestone rock outcrops in maple-beech forest.	N/A
Plants	Butternut	END	Found in variety of sites, commonly in forest openings, old fields, hedgerows, on floodplains, stream sides or gradual slopes.	General
Reptiles	Eastern Ribbonsnake	SC	Usually found in vegetated areas close to water bodies, such as marshes, swamps, bogs, ponds, and edges of streams.	N/A
Reptiles	Milksnake	SC	Wide range of habitats, especially old fields and farm buildings.	N/A
Reptiles	Snapping Turtle	SC	Very aquatic species, spend most of their lives in water, prefers shallow water in wetland habitats.	N/A

* Protection types: General (all areas in which species carry out life processes are protected), Regulated (species-specific habitat regulations); N/A (habitat for species of special concern are not protected, but are considered as potential significant wildlife habitat).

Appendix B. List of vascular vegetative species from main trail for talus study. Also included are relevant FQA rankings such as status as a native (N) or non-native/adventive (A) species, coefficient of conservativeness (CC), weediness index (WEED), as well as Ontario subnational rank (SRANK). Scientific names of non-native species are written in capital letters.

Acronym	Scientific Name	Common Name	N/A	CC	WEED	SRANK
ACERSAS	*Acer saccharum*	Sugar Maple	N	4		S5
ACERSPI	*Acer spicatum*	Mountain Maple	N	6		S5
ACTARUB	*Actaea rubra*	Red Baneberry	N	5		S5
ANTEPAF	*Antennaria parlinii*	Smooth Pussytoes	N	2		SU
ARALRAR	*Aralia racemosa*	Spikenard	N	7		S5
ASPLTRI	*Asplenium trichomanes-ramosum*	Green Spleenwort	N	10		S4
ASPLTRQ	*Asplenium trichomanes*	Maidenhair Spleenwort	N	8		S5
ASTE-SP	*Aster sp.*	Aster Sp.				
ATHYFIA	*Athyrium filix-femina*	Lady Fern	N	4		S5
BETUPAP	*Betula papyrifera*	Paper Birch	N	2		S5
BRAS-SP	*Brassica sp.*	Mustard Species				
CAULTHA	*Caulophyllum thalictroides*	Blue Cohosh	N	6		S5
CIRCALP	*Circaea alpina*	Small Enchanter's-Nightshade	N	6		S5
CIRCLUC	*Circaea lutetiana*	Enchanter's-Nightshade	N	3		S5
CORNALT	*Cornus alternifolia*	Alternate-Leaved Dogwood	N	6		S5
CYSTBUL	*Cystopteris bulbifera*	Bulblet Fern	N	5		S5
DIERLON	*Diervilla lonicera*	Bush Honeysuckle	N	5		S5
DRYOCAR	*Dryopteris carthusiana*	Spinulose Woodfern	N	5		S5
DRYOINT	*Dryopteris intermedia*	Intermediate Woodfern	N	5		S5
DRYOMAR	*Dryopteris marginalis*	Marginal Woodfern	N	5		S5
EPIPHEL	*EPIPACTIS HELLEBORINE*	Helleborine	A	*	-2	SNA
EROPVER	*EROPHILA VERNA (DRABA V.)*	Whitlow-Grass	A	*	-2	SNA
ERYSCHC	*ERYSIMUM CHEIRANTHOIDES*	Wormseed Mustard	A	*	-1	SNA
FRAGVEA	*Fragaria vesca*	Woodland Strawberry	N	4		S5
FRAXAME	*Fraxinus americana*	White Ash	N	4		S4?
GALI-SP	*Galium sp.*	Bedstraw Species				
GERAROB	*GERANIUM ROBERTIANUM*	Herb Robert	A	*	-2	S5
HIER-SP	*Hieracium sp.*	Hawkweed Species				
IMPA-SP	*Impatiens sp.*	Jewelweed Species				
LONI-SP	*Lonicera sp.*	Honeysuckle Species				
MAIACAN	*Maianthemum canadense*	Canada Mayflower	N	5		S5
MEDILUP	*MEDICAGO LUPULINA*	Black Medick	A	*	-1	SNA
MITEDIP	*Mitella diphylla*	Bishop's Cap	N	5		S5
MITENUD	*Mitella nuda*	Naked Miterwort	N	6		S5
MYOS-SP	*Myosotis sp.*	Forget-Me-Not Species				
NEPECAT	*NEPETA CATARIA*	Catnip	A	*	-2	SNA
POLYLON	*Polystichum lonchitis*	Northern Holly-Fern	N	9		S4
POLYVIG	*Polypodium virginianum*	Common Polypody	N	6		S5
PRUNSER	*Prunus serotina*	Wild Black Cherry	N	3		S5

Acronym	Scientific Name	Common Name	N/A	CC	WEED	SRANK
RIBE-SP	*Ribes sp.*	Currant Species				
RUBU-SP	*Rubus sp.*	Bramble Species				
SOLADUL	*SOLANUM DULCAMARA*	Bittersweet Nightshade	A	*	-2	SNA
SOLIPTA	*Solidago ptarmicoides*	Upland White Goldenrod	N	9		S5
SOLI-SP	*Solidago sp.*	Goldenrod Species				
TARAOFF	*TARAXACUM OFFICINALE*	Common Dandelion	A	*	-2	SNA
THALDIO	*Anemonella thalictroides*	Rue Anemone	N	8		S5
THALTHA	*Thalictrum dioicum*	Early Meadow-Rue	N	5		S3
THUJOCC	*Thuja occidentalis*	Eastern White Cedar	N	4		S5
TILIAME	*Tilia americana*	Basswood	N	4		S5
TRIFREP	*TRIFOLIUM REPENS*	White Clover	A	*	-1	SNA
TSUGCAN	*Tsuga canadensis*	Hemlock	N	7		S5
VEROOFF	*VERONICA OFFICINALIS*	Common Speedwell	A	*	-2	SNA
VIOLREN	*Viola renifolia*	Kidney-Leaved Violet	N	7		S5
VIOLSOR	*Viola sororia*	Common Blue Violet	N	4		S5

Appendix **C**. List of vascular vegetation species from the main trail. Also included are relevant FQA rankings such as status as a native (N) or non-native/adventive (A) species, coefficient of conservativeness (CC), weediness index (WEED), and SRANK. Scientific names of non-native species are written in capital letters.

Scientific Name	Common Name	N/A	CC	WEED	SRANK
Abies balsamea	Balsam Fir	N	5		S5
Acer saccharum ssp. saccharum	Sugar Maple	N	4		S5
Acer spicatum	Mountain Maple	N	6		S5
Actaea pachypoda	White Baneberry	N	6		S5
Actaea rubra	Red Baneberry	N	5		S5
Aquilegia canadensis	Wild Columbine	N	5		S5
Aralia nudicaulis	Wild Sarsaparilla	N	4		S5
Arisaema triphyllum	Jack-In-The-Pulpit	N	5		S5
Asarum canadense	Wild-Ginger	N	6		S5
Asplenium rhizophyllum	Walking Fern	N	9		S4
Asplenium trichomanes	Maidenhair Spleenwort	N	8		S5
Asplenium trichomanes-ramosum	Green Spleenwort	N	10		S4
Carex eburnea	Sedge	N	6		S5
Carex pedunculata	Sedge	N	5		S5
Caulophyllum thalictroides	Blue Cohosh	N	6		S5
CHRYSANTHEMUM LEUCANTHEMUM	Ox-Eye Daisy	A	*	-1	SNA
Cinna latifolia	Wood Reedgrass	N	7		S5
Circaea alpina	Small Enchanter's-Nightshade	N	6		S5
Clinopodium vulgare	Wild Basil	N	4		S5
Clintonia borealis	Bluebead-Lily	N	7		S5
Cornus alternifolia	Alternate-Leaved Dogwood	N	6		S5
Cystopteris bulbifera	Bulblet Fern	N	5		S5
Cystopteris fragilis	Fragile Fern	N	7		S5
Diervilla lonicera	Bush Honeysuckle	N	5		S5
Dryopteris intermedia	Intermediate Woodfern	N	5		S5
Dryopteris marginalis	Marginal Woodfern	N	5		S5
EPIPACTIS HELLEBORINE	Helleborine	A	*	-2	SNA
ERYSIMUM CHEIRANTHOIDES	Wormseed Mustard	A	*	-1	SNA
Eupatorium rugosum	White Snakeroot	N	5		S5
GERANIUM ROBERTIANUM	Herb Robert	A	*	-2	S5
Glyceria striata	Fowl Manna Grass	N	3		S5
Hystrix patula (Elymus hystrix)	Bottlebrush Grass	N	5		S5
Impatiens capensis	Spotted Touch-Me-Not	N	4		S5
LEONURUS CARDIACA	Motherwort	A	*	-2	SNA
Lonicera canadensis	American Fly Honeysuckle	N	6		S5
Maianthemum canadense	Canada Mayflower	N	5		S5
NEPETA CATARIA	Catnip	A	*	-2	SNA
Oryzopsis asperifolia	Rough-Leaved Rice-Grass	N	6		S5
Pellaea glabella	Smooth Cliff-Brake	N	10		S4

Scientific Name	Common Name	N/A	CC	WEED	SRANK
Poa compressa	Canada Bluegrass	N	0		SNA
Polypodium virginianum	Common Polypody	N	6		S5
Prunus serotina	Wild Black Cherry	N	3		S5
Ranunculus abortivus	Small-Flowered Buttercup	N	2		S5
Rosa blanda	Wild Rose	N	3		S5
Sambucus canadensis	Elderberry	N	5		S5
SOLANUM DULCAMARA	Bittersweet Nightshade	A	*	-2	SNA
Solidago canadensis	Canada Goldenrod	N	1		S5-S4?
Solidago nemoralis	Old-Field Goldenrod	N	2		S5
TARAXACUM OFFICINALE	Common Dandelion	A	*	-2	SNA
Taxus canadensis	Canadian Yew	N	7		S4
Thuja occidentalis	Arbor Vitae	N	4		S5
Tilia americana	Linden	N	4		S5-SNR
Ulmus americana	White Or American Elm	N	3		S5
Veronica serpyllifolia	Thyme-Leaved Speedwell	N	0		SNA
Viola conspersa	Dog Violet	N	4		S4S5

Appendix D. List of vascular vegetation species from the crevice areas. Also included are relevant FQA rankings such as status as a native (N) or non-native/adventive (A) species, coefficient of conservativeness (CC), weediness index (WEED), as well as Ontario subnational rank (SRANK). Scientific names of non-native species are written in capital letters.

Scientific Name	Common Name	N/A	CC	WEED	SRANK
Acer spicatum	Mountain Maple	N	6		S5
Aquilegia canadensis	Wild Columbine	N	5		S5
Arabis hirsuta ssp. pycnocarpa	Hairy Rock Cress	N	8		S5
Aralia racemosa	Spikenard	N	7		S5
ARCTIUM MINUS	Common Burdock	A	*	-2	SNA
Arisaema triphyllum	Jack-In-The-Pulpit	N	5		S5
Asplenium trichomanes	Maidenhair Spleenwort	N	8		S5
Asplenium trichomanes-ramosum	Green Spleenwort	N	10		S4
Carex eburnea	Sedge	N	6		S5
Cinna latifolia	Wood Reedgrass	N	7		S5
Circaea alpina	Small Enchanter's-Nightshade	N	6		S5
Cornus alternifolia	Alternate-Leaved Dogwood	N	6		S5
Cystopteris bulbifera	Bulblet Fern	N	5		S5
Dryopteris carthusiana	Spinulose Woodfern	N	5		S5
Dryopteris intermedia	Intermediate Woodfern	N	5		S5
Dryopteris marginalis	Marginal Woodfern	N	5		S5
Eupatorium rugosum	White Snakeroot	N	5		S5
Fraxinus americana	White Ash	N	4		S4?
GERANIUM ROBERTIANUM	Herb Robert	A	*	-2	S5
Impatiens capensis	Spotted Touch-Me-Not	N	4		S5
Impatiens pallida	Pale Touch-Me-Not	N	7		S5
Maianthemum canadense	Canada Mayflower	N	5		S5
MYOSOTIS ARVENSIS	Field Scorpion-Grass	A	*	-1	SNA
Oxalis stricta	Yellow Wood-Sorrel	N	0		S5
Pellaea glabella	Smooth Cliff-Brake	N	10		S4
Polypodium virginianum	Common Polypody	N	6		S5
Prunella vulgaris ssp. lanceolata	Heal-All	N	5		S5
Ranunculus abortivus	Small-Flowered Buttercup	N	2		S5
Ribes cynosbati	Prickly Or Wild Gooseberry	N	4		S5
Sambucus canadensis	Elderberry	N	5		S5
SOLANUM DULCAMARA	Bittersweet Nightshade	A	*	-2	SNA
Solidago rugosa	Rough Goldenrod	N	4		S5-SU
TARAXACUM OFFICINALE	Common Dandelion	A	*	-2	SNA
Thuja occidentalis	Eastern White Cedar	N	4		S5