

Sustainable Trail Design, Not Hiker Permits, is Necessary for Environmental Preservation in New York State's Adirondack Park High Peaks

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Executive Summary: The High Peaks of the Adirondack Park in New York is home to many of the state's precious natural resources and is a favorite destination for hikers. Severe erosion on trails threatens the region's environmental health. Most conservation groups advocate for reducing the number of hikers as the primary solution to combatting erosion; however, the scientific literature indicates that reduction of foot traffic is ineffective at combatting already deteriorating trails. Instead, we recommend the state legislature and Department of Environmental Conservation pursue a plan to rebuild these trails using sustainable design principles, which more effectively ensures their longevity. We outline the research and expertise required to successfully rebuild these trails as well as a mechanism to fund this expensive endeavor.

I. Introduction

The Adirondack Park, part of New York State's Forest Preserve, is the largest protected forest in the United States. Though home to 130,000 residents, much of the park's 6.1 million acres is kept as undeveloped wilderness. The park's vast diversity of habitats, including lakes, streams, and mountains, provide outdoor recreation to twelve million visitors each year (Adirondack Council n.d.; Adirondack Park Agency 2017). Enshrined in the state constitution is a directive that these lands be "forever kept wild" ("New York State Constitution" 2014).

Within the park is the mountainous High Peaks Wilderness, a premier destination for hikers. This region is home to a 12,000-year-old alpine ecosystem that contains the greatest concentration of rare and endangered species in New York State (Robinson et al. 2010, 355). Twenty-seven species that cover an area of approximately forty acres across 19 High Peaks contribute to the pristine beauty of the summits, provide opportunities to study the

Adirondacks' ecological past, and act as a bellwether for anthropogenic climate change (Goren 2010, 9; Germino 2013, 1–30). Below the alpine zone, the forested slopes provide natural resources such as minerals and timber, and filter the precipitation feeding the region's watersheds.

Erosion, especially on hiking trails, is a major threat to the health of these resources, threatening rare alpine species, polluting the water supply, and tarnishing the immersive experience. As the High Peaks continues to see more hikers, it is easy to conflate this steady (and at some trailheads, exponential) increase with erosion and conclude that hikers are the direct cause of trail deterioration (Adirondack Council Staff 2019). Yet, most studies on soil loss on trails point to properties such as gradient, water drainage features, and surface materials as much better predictors of the rate of soil loss than foot traffic (Cole 1983; Dixon, Hawes, and McPherson 2004, 305–20; Olive and Marion 2009, 1483–93). Poor construction of trails, most of which date back

to the late 1800s, and trail misuse have jeopardized the health of these fragile natural habitats (Lynch 2016; 2019). The problem has been exacerbated by an uncoordinated plan for maintenance on a meager budget, threatening the state's moral and constitutional duty to protect the health of the Adirondack Park.

Here, we advocate the New York State Legislature to enable the Department of Conservation to rebuild the region's hiking trails using sustainable design techniques. This requires an understanding of the unique characteristics of High Peaks environment that facilitate erosion, paramount to preserving the biodiversity and natural resources in this region. This ambitious project can be funded through a self-sustaining entrance fee. These actions will ensure the longevity of the fragile lands in the High Peaks.

II. Factors impacting the longevity of High Peaks trails

i. Current management of High Peaks trails

The High Peaks Wilderness falls under the jurisdiction of the New York State Department of Conservation (DEC), who are responsible for managing and maintaining the park. Management of the park is outlined in the Adirondack Park State Land Master Plan (APSLMP), as mandated by the Adirondack Park Agency Act of 1971. The current plan, adopted in 1999, identifies various issues with the current hiking trails and offers broad guidelines on maintenance (New York State Department of Environmental Conservation 1999).

Most trails in the High Peaks remain unchanged from when they were first blazed. Hikers sought the most direct paths to the summits and the concept of trail longevity was not considered (Lynch 2016; 2019). These straight-line trails, such as those in **Figure 1**, fail to avoid dangerous obstacles, and are subject to severe erosion and damage to vegetation. The DEC acknowledges the problems on these legacy trails and identifies the need to repair or reroute them (New York State Department of Environmental Conservation 1999, 143). However, the APSLMP offers very few guidelines on the equipment, data, and personnel needed to reroute a trail; the standards to which they evaluate successfully rehabilitated trails; and the financial resources required to fund these projects.

ii. Criteria for sustainable trails

Sustainable trail design refers to practices in trail construction that ensure hiker safety, prevent soil loss from anticipated traffic, facilitate water drainage, and minimize the need for repair (Marion and Wimpey 2017, 46–57). Trails in the High Peaks generally fail to meet these criteria.

Principles of good design include:

- **Routing through soils resistant to erosion.** A soil's susceptibility to erosion principally depends on its texture, characterized by its constituent proportion of sand, silt, and clay. Soils containing high proportions of coarse sand resist erosion, while silt and very-fine sand comprise the most erodible soils (Brewer 2012; Wischmeier and Mannering 1969, 135–36; Vermont Environmental Conservation n.d.; Michigan Department of Environment, Great Lakes, and Energy n.d.). Dislodged soil can end up in waterways, disrupting the ecosystem and promoting the growth of harmful pathogens such as *Escherichia coli* and *Giardia lamblia* (Marion et al. 2016, 352–62).
- **Side-hill trails.** Trails should zigzag gradually rather than directly climb a peak. Steep slopes facilitate erosion by channeling snowmelt and precipitation directly down the trail. Furthermore, side-hill trails provide flexibility for trail designers to navigate around dangerous obstacles such as large boulders (Marion and Wimpey 2017, 46–57).
- **Proper water drainage.** Muddy surfaces incentivize hikers to avoid these obstacles, disrupting the native flora and exposing more soil to erosion. Placing wood or stone barriers across side-hill trails effectively directs water away from exposed trail, limiting soil loss (Marion and Wimpey 2017, 46–57).
- **Hardening with crushed gravel.** Mixing crushed gravel with native soil hardens trails, increasing their resistance to erosion (Aust, Marion, and Kyle 2005, 23–25).

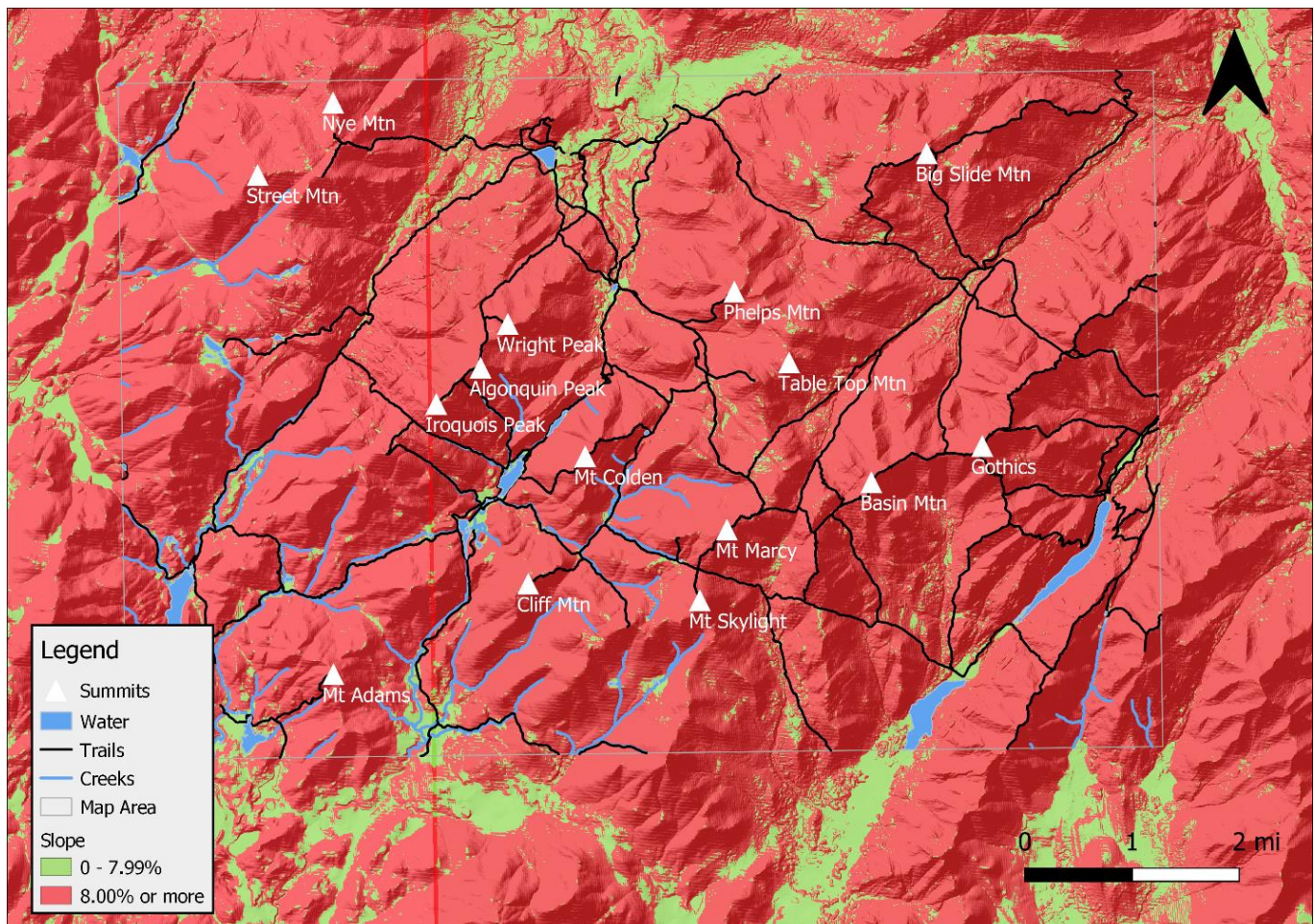


Figure 1. Slope map of the central Adirondack High Peaks. Slopes at or above eight percent, shown in red, exceed the threshold for erosion. Map created using QGIS 3.12 with publicly available sources (U.S. Geological Survey 2019b; 2019a; 2020a; 2020b; Ballston Emergency Management Committee 2018; OpenStreetMap Contributors n.d.).

Most trails in the High Peaks are in desperate need of rerouting and rebuilding. The map of the central High Peaks in **Figure 1** shows the slopes of High Peaks trails that exceed an 8% grade, a commonly accepted threshold for erosion (Marion and Wimpey 2017, 46–57). Based on a study done by the Adirondack Council, we estimate 200 miles of trails are unacceptably steep (Lynch 2019; Adirondack Atlas, LLC 2019; Adirondack Council 2019).

This study does not consider efficiency of water drainage, surface materials, soil composition, or locations of dangerous obstacles, suggesting this number is substantially higher. Runoff from these trails may also have contributed to unacceptable levels of *Escherichia coli* in the waterways near the trails (Ausable River Association n.d.). Furthermore, twenty of the forty-six High Peaks have multiple informal routes haphazardly carved after decades of

hiking, that suffer from severe damage to delicate vegetation (see in **Figure 1**, trails to Table Top and Nye Mountains are not delineated) (Wimpey and Marion 2011, 1012–22; Barros and Marina Pickering 2017, 57–68; Martin and Butler 2017, 354–67). The DEC does not consider these paths as part of the network of trails under its jurisdiction, thus devoting few resources to their maintenance (New York State Department of Environmental Conservation 1999, 72).

Yet, the DEC continues to remedy only their aesthetics, neglecting the underlying problems inherited by these century-old trails. It operates these efforts on a meager budget estimated to be ~\$87,000 when adjusted for inflation (\$55,000 in the 1998 budget published in the APSLMP; the DEC has not published expenditure figures for subsequent years). Much of the work is outsourced to conservation

groups, who themselves face budgetary and personnel constraints (New York State Department of Environmental Conservation 1999, 98). For example, in 2017, the Adirondack Mountain Club spent \$564,000 on trail and facility maintenance projects which spanned the entirety of New York State, relied mainly on volunteers, and generally took less than a week (Adirondack Mountain Club 2017). In the High Peaks, trail crews removed fallen trees and installed rock steps on muddy sections (Adirondack Mountain Club 2018; 2019). These actions may discourage hikers from wandering off-trail, but do not aid in drainage or hardening. The approach to trail maintenance taken by the Adirondack Mountain Club and other groups lack the dedicated budget, personnel, and discrete milestones within a master plan required to sufficiently rebuild High Peaks trails.

III. Proposed policies

The consensus among Adirondack conservation advocates is that overuse primarily drives trail deterioration and that a permit program to limit the number of hikers is a potential remedy (Levine 2019; Gibson 2019; Amato 2018; Adirondack Mountain Club 2020). Yet most studies on trail conditions suggest that proper trail design contributes more to longevity (Cole 1983; Dixon, Hawes, and McPherson 2004, 305–20; Olive and Marion 2009, 1483–93) than a reduction of visitor traffic (Farrell and Marion 2001, 31–59).

The above observations are supported by commonly accepted principles of trail design. Poor trail design results in trail widening as hikers, avoiding roots and rocks exposed by erosion, seek easier surfaces on which to walk (Hammit and Cole 1998, 118). Trails that climb steep slopes and fail to divert surface water are subject to accelerated soil erosion with or without visitor use (Hammit and Cole 1998, 124). Erosion is more distinct in shallow soils, soils high in silt and fine sand, areas with little vegetation cover and areas where concentrated runoff occurs (Hammit and Cole 1998, 45).

Well-built trails deteriorate minimally over time (Hammit and Cole 1998, 208), effectively mitigate and manage problems associated with high use (i.e., soil erosion, trail widening), and provide sensitive alpine vegetation with time to recover from trampling (New York State Department of

Environmental Conservation 1999, 44). Methods such trail hardening with gravel to reduce the displacement of small sand and silt particles (New York State Department of Environmental Conservation n.d.; USDA Natural Resources Conservation Service n.d.; Marion and Wimpey 2017, 46–57; Aust, Marion, and Kyle 2005, 14–15) can even protect fine sandy soils in the High Peaks (New York State Department of Environmental Conservation 1999, 72), which are highly susceptible to erosion. Therefore, sustainable reconstruction of poorly designed trails, rather than a quota on hikers, will more effectively limit erosion in the High Peaks.

Thus, we advocate for the DEC to reroute or rebuild existing trails in accordance with sustainable design principles as the optimal management strategy. A master plan outlined below details the personnel required, the necessary planning for these efforts, and a mechanism through which these projects are funded.

i. Coordinate essential personnel and the public

The DEC outsources most trail repairs to conservation groups composed mostly of volunteers who lack formal training in sustainable trail design techniques (New York State Department of Environmental Conservation 1999, 144). The requirements of large-scale rerouting projects spanning >200 miles of trails necessitate more coordination, planning, and dedication than a few groups of volunteers, though well-intentioned, can provide.

The DEC must gather a team of dedicated, full-time employees that includes:

- Agronomists (soil scientists) to evaluate soil characteristics and water drainage patterns to determine the best routes and develop criteria to prioritize trails
- Surveyors and engineers to ensure paths are designed as side-hill trails
- Full-time trail workers trained in sustainable design techniques
- Construction workers with proper equipment to deliver materials to remote patches of wilderness

Even as it becomes more active in trail rebuilding, the DEC should maintain its partnerships with the public,

with conservation groups playing an integral role. Volunteer trail crews should work alongside DEC teams in accordance to the latter's priorities and milestones. DEC funding for grants that the Adirondack Mountain Club and others currently receive for trail maintenance (Adirondack Mountain Club 2018; Brosseau 2019) should be increased, with the stipulation that these increases are directed towards fulfilling the DEC's High Peaks trail goals.

Additional outreach activities can continue to foster public-private partnerships through education and engagement. Environmental science students can learn sustainable trail design and construction alongside these professional teams through internship and volunteer opportunities. For the general public, the DEC should incorporate the history of the Adirondacks and trail design demonstrations in its outreach curriculum (New York State Department of Environmental Conservation n.d.). The DEC can even institute a citizen science initiative, encouraging hikers to submit photos and GPS coordinates of waterlogged or eroded sections of trail. This will help ease the burdens of planning and surveying (see next policy proposal).

The time between hiring essential personnel and physical work on trails may be lengthy. Suitable office space, whether in Albany or near the High Peaks, must be acquired. Public hearings and negotiations with conservation groups and other stakeholders are required to organize a list of priorities based on susceptibility. Finally, insurance fees and wages may increase as wilderness work requires traveling to and living in remote, primitive conditions for extended periods of time. Even with these hurdles, a team with the appropriate expertise and driven by clearly defined milestones will more efficiently tackle >200 miles of trails than underfunded conservation groups that focus their efforts on short-term projects.

ii. Research environmental factors in the High Peaks that impact trail design

The DEC must devote appropriate funds and personnel into research of biotic and abiotic factors as a crucial step of trail redesign. Biotic considerations include locating rare alpine species in order to plan routes around them. Interpretation of slope, soil, hydrology, and vegetation data using Geographic Information Systems (GIS) is essential to inform planning decisions for trail work in the region.

Trail design also requires knowledge of abiotic factors in the High Peaks, many of which lack extensive documentation. A systematic study to identify and evaluate proposed trail routes must include factors such as soil properties, drainage patterns, and vegetation. Characterizing soil texture, percent composition of fine sands, and soil permeability on- and off-trails at intervals much finer than those in USDA databases is imperative in determining the most suitable redesign strategy (Wilson and Seney 1994, 78-79; Rangel et al. 2019). During wet seasons, (November 1-December 15; April 1-May 15) (New York State Department of Environmental Conservation 1999, 115), access to trails that experience ponding must be restricted.

Crucially, physical work on a section of a trail cannot commence until these environmental assessments are completed, as the poor resolution of publicly available data is insufficient even for planning. Inclement weather, including heavy snowfall that blankets the region for much of the year ("NY State Average Annual Snowfall Data" n.d.; Adirondack Daily Enterprise Staff 2020), and the presence of hikers in the summer months further inhibit progress. It will take time for the DEC team to determine a threshold for an adequate rate of progress and the optimal number of employees to complete them in a timely manner. Restricting access to trails can facilitate this work at the expense of convenience to some hikers.

iii. Raise revenues through park entrance fees

The cost of rebuilding the High Peaks trails is estimated to be \$4,000,000 (approximately \$20,000 per mile). We estimate the project to span 10 years (20 miles and \$400,000 per year). The total cost, based on a 2005 study published by the U.S. Forest Service and adjusted for inflation, includes material and labor (Aust, Marion, and Kyle 2005, 15). Salaries for four agronomists and engineers totals \$280,000 per year, on par with other engineers and biologists hired by the DEC (Department of Environmental Conservation 2018).

To fund these projects, the DEC should charge an entrance fee to visitors entering the High Peaks Wilderness. Despite the Adirondack Park receiving 12.4 million visitors in 2017, the DEC does not impose entrance fees as a mechanism to raise valuable revenues (Adirondack Council n.d.). The number of

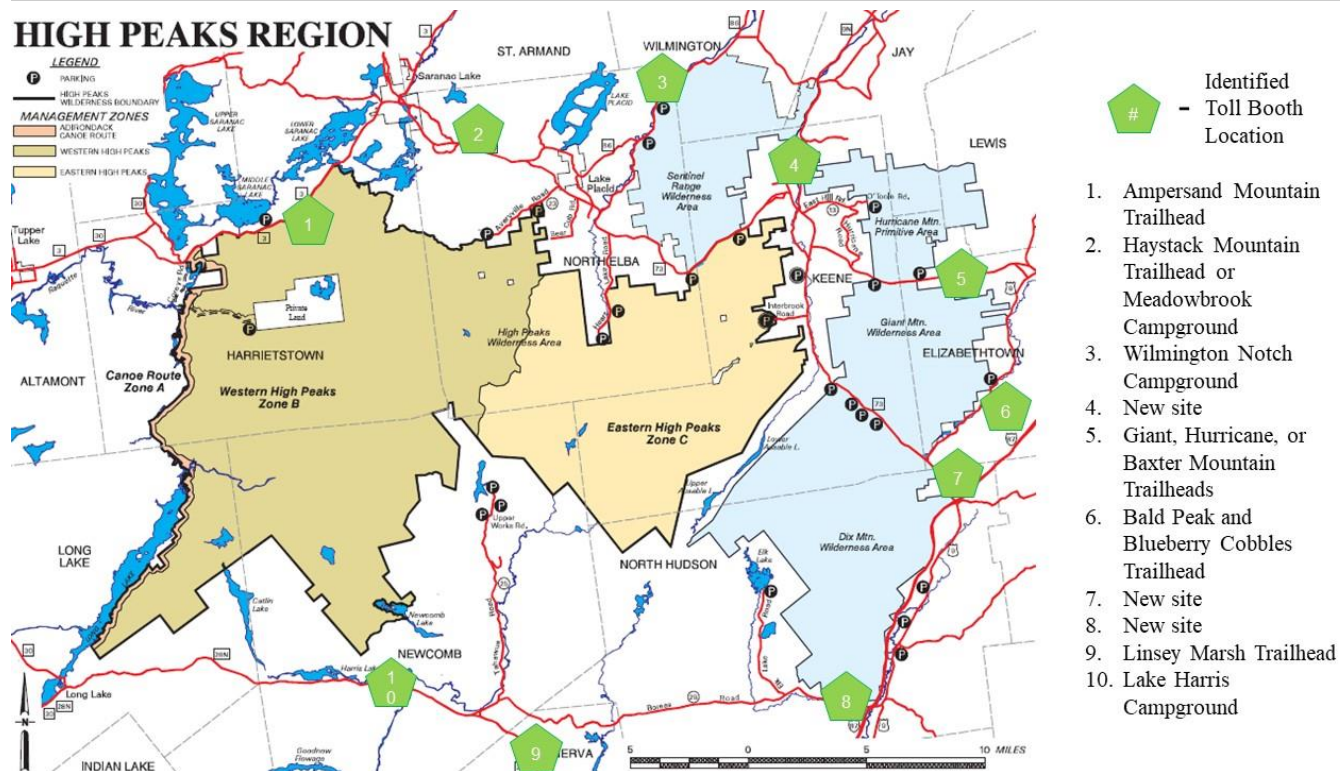


Figure 2. Potential sites for entrance toll booths for the Adirondacks High Peaks. Most locations are by trailheads or campgrounds operated by the DEC, while three new sites need to be acquired. Map altered and published with permission from NYS DEC (New York State Department of Environmental Conservation n.d.).

visitors to the High Peaks was estimated to be ~150,000 in 1998 (likely to be much higher in 2020, though the DEC has not compiled more recent usage data) (New York State Department of Environmental Conservation 1999, 47; Beier and Larkin 2014).

Most entrances to the High Peaks contain state campgrounds or trailheads near which toll booths can be constructed, with the DEC needing to acquire three new sites (**Figure 2**). As such, many booth operators can be campground workers, and can be supplemented by 20 additional workers for a total per annum wage of \$600,000. Construction of each booth is estimated to cost \$10,000, with an additional \$1,000 in maintenance costs (Guardian Booth n.d.).

A \$10 per visit entrance fee would raise the requisite amount of money over 10 years to fund sustainable trails and booths, while providing surplus for conservation efforts in other areas in the park. Stipulating that entrance fees can only be directed towards conservation efforts within the Park creates a self-sufficient revenue stream that circumnavigates potential budgetary squabbles in the state legislature. A park entrance fee is preferable to a hiker permit

system, which is more difficult to enforce due to the vastness of the park and remoteness of many trails. Furthermore, the entrance fee seeks to raise revenue for the park without limiting the number of hikers through arbitrary quotas, especially since the number of hikers is not well-documented (New York State Department of Environmental Conservation 1999, 46–49; Beier and Larkin 2014). A similar scheme implemented in White Mountain National Forest in New Hampshire has already been effective, generating \$748,133 from recreation fees in 2017 (USDA Forest Service n.d.; United States Department of Agriculture 2017).

Other indicators suggest the public would be amenable towards this funding strategy. According to a 2018 survey administered by the Adirondack Council to High Peaks hikers, 75% of hikers support additional funds for the DEC (Adirondack Council 2018). The Council’s executive director has expressed a belief that the vast majority of hikers would support paying an access fee for the High Peaks as long as the fees supported trail work (Figura 2019).

Alternate funding sources for conservation groups that help rebuild trails include the Environmental Protection Fund administered by the Office of Parks, Recreation and Historic Preservation (Parks & Trails New York n.d.). Rather than allocating ~\$1.5 million to fund shuttle busses to trailheads (Adirondack Almanac Editorial Staff 2020), which counters these groups' views against increasing hiker accessibility, funds should be instead dedicated to trail work. It is possible that the proposed entrance fees can be reduced if the shuttle bus funds can be reallocated.

IV. Recommended policy options

Even though the policies outlined above are designed to be self-sustaining, they require initial investments for the new hires, office space and materials, and construction of the toll booths. As part of the next Fiscal Year Executive Budget passed by the state

legislature, appropriations to the DEC for the explicit use on High Peaks trail redesign must be made. Once the revenue collection from entrance fees becomes profitable, the DEC must pay back to the state the initial investments.

V. Conclusions

The Adirondack High Peaks is home to rare alpine species, an abundance of natural resources, and opportunities for recreation. The State Legislature and the DEC must employ a hands-on conservation plan outlined here with haste. Neglecting our ethical duty to protect the Adirondacks will deprive future New Yorkers the opportunity to appreciate our state's unique ecological history. We must recognize that once these resources disappear, so too will our ability to keep them forever wild.

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Disclaimer

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