DEVELOPING STRATEGIES TO RE-VEGETATE THE BALD ROCK NATURAL HERITAGE PRESERVE TO MITIGATE VANDALISM

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ABSTRACT
In the Fall of 2022, a team from the South Carolina Department of Natural Resources, the Friends of Bald Rock, and Clemson's LA-Co-LAB outlined a phased approach to address the current issues of visitor behavior at the Bald Rock Natural Heritage Preserve. The team developed innovative strategies to modify how visitors engage and explore one of South Carolina's cherished natural resources to reduce vandalism and promote ecological health. A team of faculty and students from Clemson University's Landscape Architecture program began a comprehensive inventory and analysis of the existing Bald Rock Natural Heritage Preserve. After inventory and analysis, the consultant team performed a strengths, weaknesses, opportunities, and threats analysis on a series of strategies before developing a series of designed experiments to address the systemic vandalism issue on the site. Intervention strategies focused on the idea of expeditious lithosere succession. Methods were identified and tested to promote soil formation and re-vegetation: damming, planting, and patina. The team selected damming and planting plots for their favorable volumes on the rock's surface. The existing volumes on the surface were either dammed to contain organic matter, leaf litter, decomposed wood, dust, and silt deposits from rain runoff events or planted, creating vegetated islands to decrease the amount of exposed granite surface area susceptible to vandalism. The team selected patina plots for their sloped nature of the topography to create a film on the surface of the rock to increase the organic layer on the rock face to promote additional lichen and moss growth as well as decrease the amount of exposed granite area susceptible to vandalism. All three strategies reduced the exposed rock accessible to vandalism and promoted soil formation. The patina strategy was less expensive, quicker to implement, and less constrained by topographic conditions, potentially allowing for a more extensive application.

Keywords
Lithosere succession, Vandalism, Graffiti, User behavior

1 INTRODUCTION

1.1 Background

Friends of Bald Rock (FOBR), along with wildlife biologists from the South Carolina Department of Natural Resources (SCDNR), contacted Clemson's Landscape Architecture Program about a potential collaboration at the Bald Rock Natural Heritage Preserve (BRNHP) in northern Greenville County in the Summer of 2022. BRNHP is a granite outcrop with spectacular views adjacent to, and easily accessible from, Highway 276 northwest of Cleveland, SC (Figure 1). Granite domes, outcrops, and rock faces are often used for recreation and tourism (Twidale, 2000). This can result in the need for management strategies to help conserve and protect these sensitive landscapes and cultural resources.

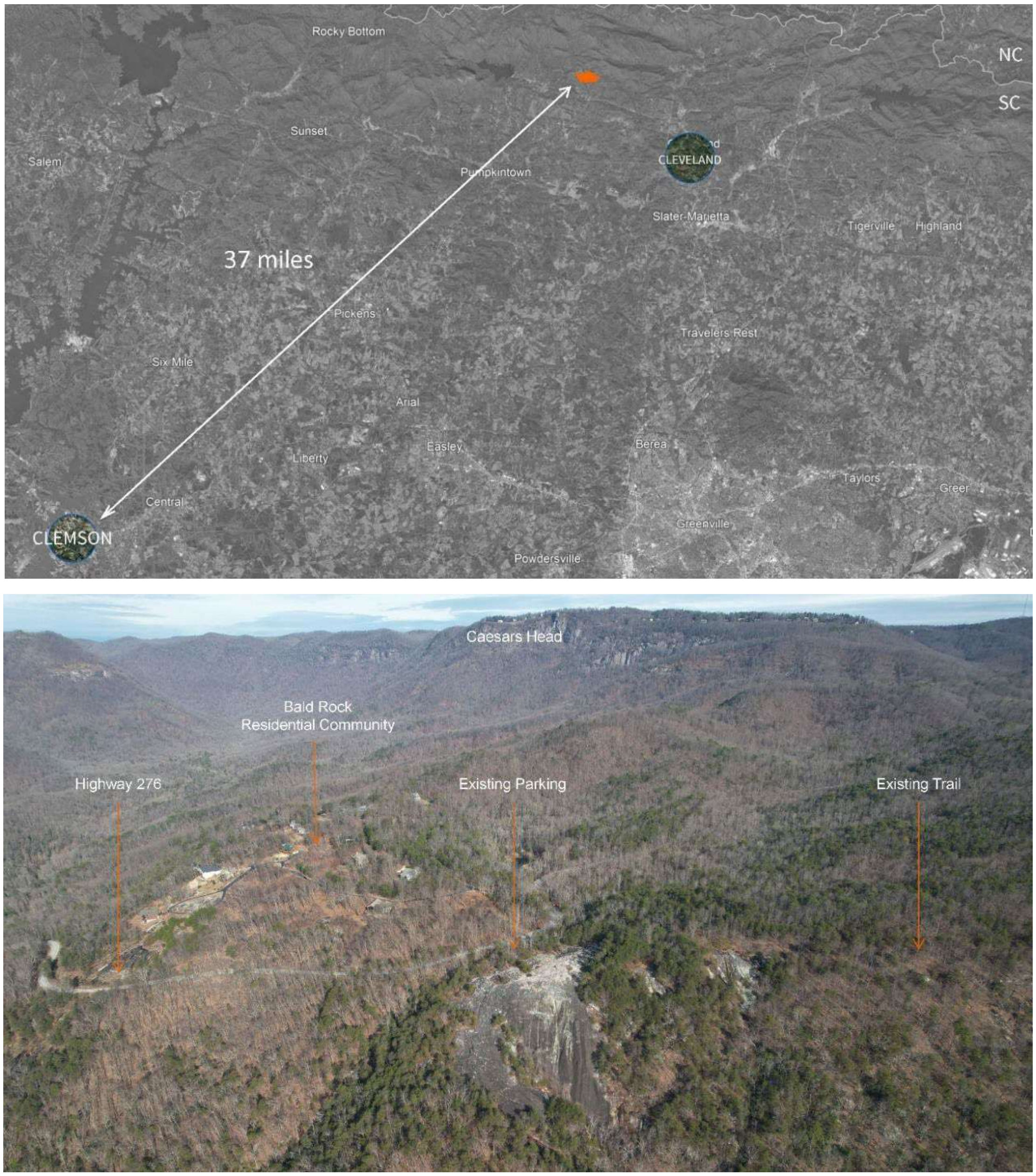

Figure 1: BRNHP Context Map- Diagram and image by Annie Steele and Will Nickles, 2023

The following Fall and Spring, the Landscape Architecture Collaborative Studio, LA-Co-LAB, learned about the Bald Rock Natural Heritage Preserve and the extent of the property owned and managed by the SCDNR. In the initial discussions, the SCDNR representatives requested recommendations and strategies on how best to manage the sensitive ecologies of the site while balancing a high volume of daily visitors. Additionally, the FOBR desired clarity on how best to direct volunteers in efforts to restore, preserve, and cherish the cultural asset the community knows as Bald Rock. Through the Fall of 2022 and Spring of 2023, the team from SCDNR, the FOBR, and Clemson's LA-Co-LAB organized and outlined a phased approach to address the current issues and challenges facing BRNHP, including opportunities to capitalize and engage less accessible portions of the property, develop innovative strategies to mitigated vandalism and begin to change the culture that has persisted in the community for decades.

In the Fall of 2022, a team of faculty and students from Clemson's Landscape Architecture program began a comprehensive site investigation, inventory, and analysis of the existing BRNHP. The initial investigations focused on visitor activity and behavior, infrastructure and circulation (Figure 2), topography and vegetation, and a concise ownership history of the site and previous land use. Through a series of local peer precedent project studies, the LA-Co-Lab team investigated how other signature natural attractions handled issues of high visitor volume, vandalism, wayfinding and access, and general overuse. The team developed a series of Strength, Weakness, Opportunity, and Threat analyses (SWOT), laying the groundwork for the site's conceptual strategies. These strategies investigate ways to mitigate vandalism by reducing the available surface area on the rock face. We tested approaches to reduce the exposed rock area by promoting and accelerating lithosere succession.

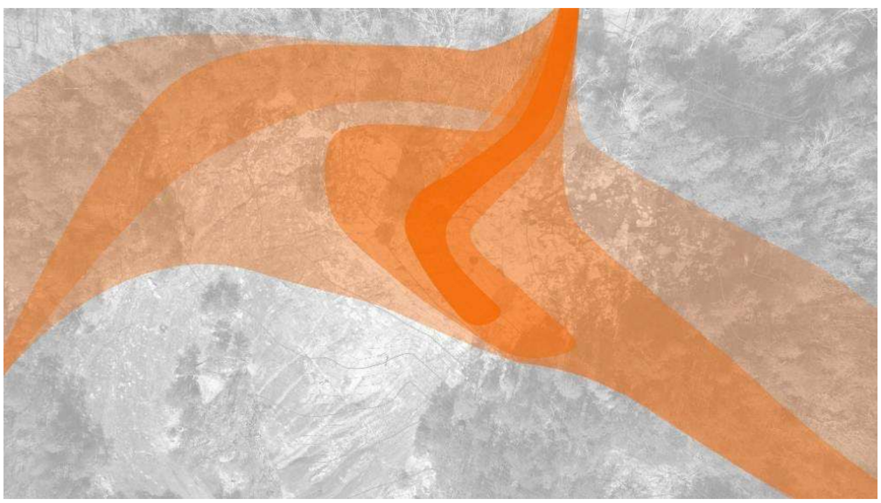

Figure 2: BRNHP Visitor Use Heat Map - Diagram by Annie Steele and Will Nickles, 2023

1.2 Site conditions

The current access to Bald Rock is an informal pull-off on Highway 276 adjacent to the exposed rock outcrop and provides a short and relatively easy approach for able visitors to walk on the rock and enjoy the vast view (Figure 2). There is ample room for 8-10 cars to park on the informal shoulder of the road, as indicated by an existing wood barrier. SCDNR has provided a footbridge connecting visitors from the "parking area" across the stream to a clearing in the woods where the exposed face of the rock begins.

However, there are safety hazards and concerns with Highway 276 access. The parking area located in a blind bend in the road makes it treacherous to turn into and out of the current Bald Rock access point. Traffic traveling south on Highway 276 from Caesar's Head State Park must make a dangerous left turn into the tight parking area and risk a highway collision from traffic moving down the mountain. Additionally, after turning off the road there is an abrupt and steep grade change from the asphalt road to the gravel parking area, making for an uneven surface. Erosion has exacerbated the uneven parking conditions and creates a potentially hazardous walking condition for unsteady pedestrians. The high volume of vehicular traffic has caused the existing parking zone to creep in both the northern and southern directions of the access area. While the existing parking area remains adequate for

6-8 vehicles, there is a need for more parking that is safer to enter and exit. The design team has provided alternatives for addressing the Highway 276 Bald Rock access. Solutions range from eliminating all vehicular and pedestrian access from Highway 276 to developing a safer and more formalized access, parking, and enhanced visitor experience for the Bald Rock visitors.

The rock face at BRNHP consists of east-facing exposed granite with naturally occurring “islands” or weathering pits of mostly native vegetation. The uneven surface from the bridge access point gently grades down about 175 feet before steeply dropping to the valley below. The relatively flat area is covered with graffiti and signs of vandalism, including paint, fire pits, litter, discarded clothing, carved trees, and cut-down trees (Figure 3). Visitors to the site use the cut-down trees for make-shift shelters and firewood. When the site was accessible to vehicles, cars were pushed off the ledge to the ravine below, where they remain.

Figure 3: Blad Rock Face with Graffiti- Image by Annie Steele and Will Nickles, 2023

1.3 Environmental conditions

Diverse herbaceous species have colonized BRNHP due to a slow transformation of unprotected rock to habitable soils, known as lithosere succession. Mineral weathering of the rock occurs physically and is influenced by wind, water, and topography (Lybrand & Rasmussen, 2018). Over time, water infiltrates microfractures on the rock face and creates weathering pits. These depressions in the rock face begin to collect debris from the surrounding area. Recent evidence also suggests that in addition to deterioration of the rock face and debris collection, a significant amount of the soil is contributed from dust captured by water at the bottom of the weathering pits (Meyer, 2021). Lichen, algae, cyanobacteria, and physical weathering accelerates the rock-to-soil transformation. Crustose lichen is most suited for the initial harsh conditions of the unsheltered rock face (Budel & Scheidegger, 1996). They collect vital nutrients and resources from the air, relieving them of the need for soil. During their life cycle, they chemically and physically erode the rock they are adhered to and release mineral byproducts (Marathe & Chaudhari, 1975; Chen, 2000). As the colonies of crustose lichen die, nutrient and mineral-rich humus are left behind.

Foliose and fruticose lichen slowly colonize the site as they take advantage of the mineral-rich humus. These lichens are less scale-like, boasting leaf and foliage-like forms. Larger bodies require more water and can capture more environmental particles, such as soil in water runoff and dust from the atmosphere. In harsh environments, these soil particles and dust capture moisture and act as a substrate for plant growth (Lybrand & Rasmussen, 2018). Mosses take advantage of the increasingly moist and supportive soil conditions, accelerating retention (Booth, 1941). The team collected multiple moss samples from independent small moss islands littering BRNHP's face to the edges of the larger tree-bearing vegetative islands. The team photographed samples in-situ and then stored the samples in coffee filters to prevent molding during storage.

The life cycle of the mosses leaves behind organically rich soil that allows the growth of herbaceous plant life. Pioneering seeds are distributed to these locations and successfully germinate. Studies on the volcanic island of Surtsey, Iceland, demonstrated soil formation and plant growth occurring as quickly as one year on a rock face (Fridriksson, 1987). As grasses establish themselves, their roots penetrate the shallow soil to the rock face below, leaching acid and further chemically weathering rock hidden from the elements. Increased stability provided by moss and grassroots further accelerates succession until the area can support large herbaceous species such as shrubs and trees.

The existing plant communities associated with the plant species found on the property include the Central Interior- Appalachian Seepage Swamp, Central Appalachian Northeast Oak Forest and Woodland, and the Piedmont-Blue Ridge Springhead Seepage Swamp Forest (NatureServe Explorer).

1.4 SWOT analysis

After inventory and analysis of the site, the consultant team developed five conceptual strategies to help mitigate the vandalism at the BRNHP. These strategies can be categorized as reactive, protective, and proactive. Reactive strategies refer to removing or covering graffiti after it has occurred (Huntington, 2018). These strategies include washing the surface, painting over the surface, blasting the surface with an abrasive substrate, or using a chemical or biological product to remove the graffiti (Huntington, 2018; Sanmartin & Bosch-Roig, 2019). Protective strategies refer to applications that prevent graffiti elements from directly contacting a surface, thus making removal more efficient (Huntington, 2018). These strategies can be permanent, semi-permanent, or sacrificial and take the form of waxes, nanoparticles, polyurethanes, silicones, or other chemical polymers (Amrutkar, 2021). The team also studied strategies that utilize non-pathogenic microbes to bioclean the graffiti. However, the biotechnology has yet to be developed to the point where it is actionable on a large scale and, therefore, was not considered (Sanmartin & Bosch-Roig, 2019). Proactive strategies attempt to prevent or mitigate graffiti by changing the area's environment or culture. This includes environmental design and landscaping (Huntington, 2018). Several states utilize environmental design to prevent graffiti on transportation corridor surfaces. For example, they plant hedges in front of sound barrier walls (Teng, 2012). Additionally, studies in urban areas have found that environmental and landscape design around buildings reduces property crimes (Kuo & Sullivan, 2001). These broad strategies are often applied to prevent graffiti on vertical surfaces in more developed locations. However, these valid techniques can be applied to the horizontal and rural conditions at BRNHP. These strategies are site and situationally specific and need to be evaluated for their potential success, benefits, and burdens.

The team performed a SWOT analysis for six strategies: do nothing, clean the rock face (reactive), restrict access (proactive), change behavior (proactive), patina (protective) and re-vegetate the rock face (proactive). The SWOT analysis considered ease of implementation, initial cost, maintenance cost, potential outcomes, safety, labor requirements, time horizon, cultural implications, ecological implications, and experiential implications (Table 1). This study will observe the strategies *do nothing, power wash, patina,* and *re-vegetate*.

Table 1: BRNHP Preliminary SWOT Analysis

STRATEGY	STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
DO NOTHING	• Low cost • Cultural identity remains • Support from existing community	• Eye sore remains • Pollution continues • Unsupported by community	• Cultural representation • Brings community to site • Can be icon	• Promotes deleterious activities • Prevents natural succession • Danger to health, safety, and welfare
POWER WASH	• Existing strategy • Removes graffiti somewhat quickly • Relatively easy to implement	• Labor intensive • Diminishing returns • Does not solve problem	• Teaching moment- community service? • Test various cleaning strategies • Can create designated zones for expression	• Removes natural patina • Potential to pollute • Reduces biodiversity
RESTRICT ACCESS	• Low cost • Graffiti fades over time • Deleterious activities are reduced	• Exclusionary • Hard to enforce • Unused cultural resource	• Ecologies can be returned • Environmental change can be studied • Change in cultural perception	• Backlash from community • Community stops caring • Less eyes on the ground- more dangerous?
CHANGE BEHAVIOR	• Lasting change • Lower cost over time? • Less invasive intervention	• Labor intensive • Requires multiple strategies/ efforts • Requires consistent commitment	• Teaching moment • Increase community engagement • Change in cultural perception	• Strategies increases deleterious activity • Nothing changes • Leads to site over use
PATINA	• Potentially prevents graffiti • Graffiti is easier to clean • Low profile	• Labor intensive • Potentially high cost • May require consistent application	• Research applications • Potentially scalable • Could promote biodiversity	• May reduce coefficient of friction on rock • Artificial applications may pollute • Potentially hard to remove if unsuccessfully
RE-VEGETATE	• Lasting change • Creates visual interest • Promotes zones of activity	• High initial investment • Requires consistent expert engagement • Long time frame	• Potential for ecological monitoring • Promotes biodiversity • Change in cultural perception	• Doesn't work quickly enough • Eventually obscures rocks and views • May require interventions with/ on rock

1.5 Research objectives

This research evaluates strategies to mitigate vandalism by reducing areas perceived as available for graffiti. We analyzed strategies for success in reducing vandalism in the short-term, the ability to scale the strategy to continue to reduce vandalism in the future, and to promote ecological health and biodiversity on the rock face.

2 METHODS

The research team selected five test plots measured at 20' x 20' (Figure 4). We surveyed and documented each plot using drone photography beginning in January 2023 and ending in April 2023 (Figure 5). The plots received the following treatments: control (observation only), power wash, patina, damming, and planting. We divided the strategies into two sets. The first set, *APPLY,* involves applying a substrate that adds or removes elements to or from the granite surface and can be broadcast more broadly. These strategies are reactive and protective. The second set, *PLACE*, requires placing material onto the surface of the rock face. These proactive strategies are more site-specific and sensitive to microecologies, geologies, and topography.

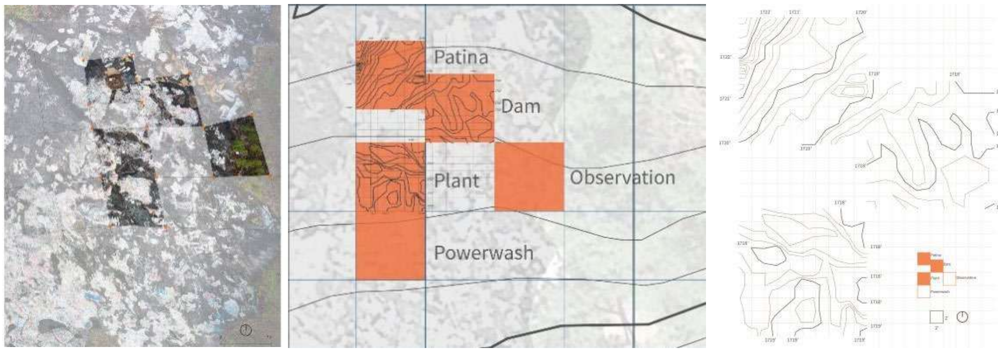

Figure 4: BRNHP Test Plot Locations- Diagrams by Annie Steele and Will Nickles, 2023

2.1 Plot selection and strategies

Control : The control plot consisted of partially exposed rock and is partially covered in existing vegetation, including various mosses and lichens, native grasses, and sapling Virginia Pines. During the observation period, no intervention occurred on the control plot. The design team selected the control plot to have approximately half exposed rock and the other half vegetation. With a zero-interference policy, we could track the growth of established plants, the markings on the rock face, and the boundary line between both (Figure 5).

Apply-Power Wash: Reactive Strategy: Before the intervention, the power wash plot exhibited a dull organic patina and areas of existing graffiti. Portions of the plot had limited lichen and moss growth in damp cracks and crevices. The initial plot was free of herbaceous or woody species. Following the initial observation and documentation of the power wash plot, we “cleaned” the plot using a pressure washer. The process removed the existing natural patina and portions of the loose granite from the outcrop surface. We could remove the majority, but not all, of the existing graffiti during the power wash application. Following the completion of the wash, there was a clear and distinct contrast between the “cleaned” granite plot and the adjacent condition (Figure 5, POWER WASH). The 400 sq. ft. plot required 240- 280 gallons of water applied over a 2-hour session. The research team power washed the 400 sq. ft plot twice during this project. We conducted the second wash several weeks after the first application due to observed vandalism.

Apply-Patina: Protective Strategy: We selected the patina plot for the sloped nature of the topography. The intervention created a film on the rock's surface, increasing the organic layer to promote additional lichen and moss growth and decrease the amount of exposed granite surface area available for graffiti (Figure 5, PATINA). The application applied a mud and organic slurry to the rock surface. This strategy was also adapted from personal experience, where a moss/mud slurry was applied to rocks to promote moss growth on a private residence project site. We manually applied the slurry to the surface with a broom and bucket application. The team harvested the slurry from an existing creek on the site. The 400 sq. ft. plot required 10 gallons of mud and 15 gallons of water and took 30 minutes to collect and apply.

Place-Dammed: Proactive Strategy: The research team selected the damming plot because of the favorable volumes and naturally forming cavities or weathering pits on the rock's surface. The existing volumes on the surface contained organic matter, leaf litter, decomposed wood, and signs of silt deposits from rain runoff events (Figure 5, DAMMED). The damming creates a natural substrate film on the exposed surface of the rock. The intention of the substrate is twofold: one, to increase the amount of organic matter on the rock face, which promotes the growth of lichens and moss, and two, to reduce the appeal to vandalize a vegetated surface. The intervention includes constructing an organic dam using mud, decomposing organic matter, twigs, branches, and pine needles on the downhill side of the naturally occurring rock vessel. A dam constructed from branches, leaf litter, and mud took two hours to construct.

Place-Planted: Proactive Strategy: The research team selected the planting plot for the favorable volumes and naturally forming cavities on the rock's surface. The existing volumes or weathering pits on the surface were initially free of debris, plants, or organic matter. We created planted islands to decrease the exposed granite surface area available for vandalism (Figure 5, PLANTED). The team collected native soil stockpiled from a previous road construction project and deposited the native soil in three cavities on the rock surface. The team then transplanted native lichens, mosses, grasses, wildflower species, and pine saplings. We watered the newly established plants. We planted a 140 sq. ft. area with 28 cu. Ft. of soil over 3 hours.

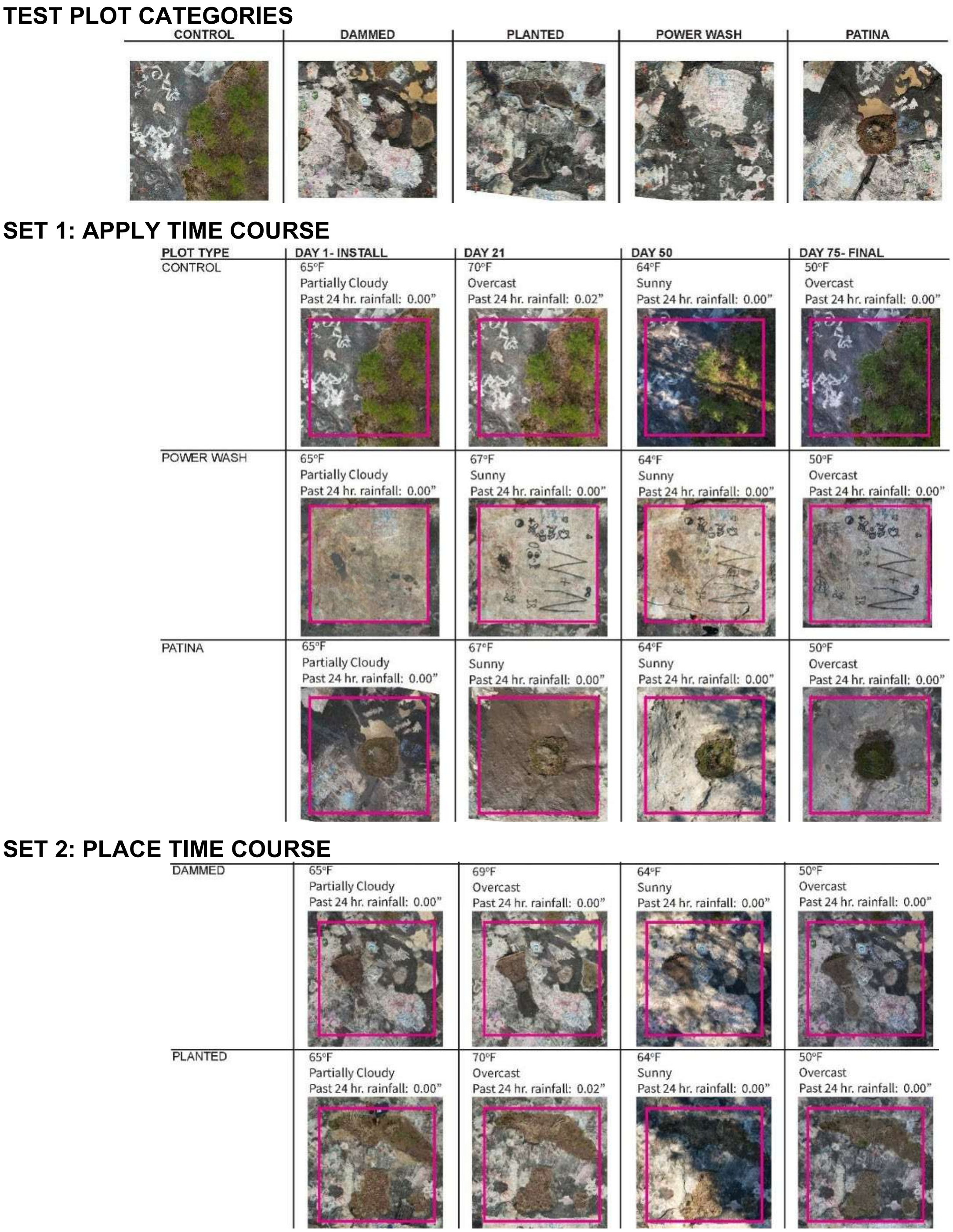

Figure 5: BRNHP Test Plots - Images by Annie Steele and Will Nickles, 2023

The design team visited the site and observed the test plots approximately once a week from January 23, 2023, through April 24, 2023. We documented the plots using drone aerial photography. Before observation, we recorded the average high and low temperature, rainfall, and humidity from the previous week. We also recorded the general weather characteristics, temperature, and rainfall over the past 24 hours before observation (Figure 5).

3 RESULTS

We observed that the *APPLY* strategies had the broadest impact on the rock face. The *power wash* application removed the graffiti from the rock's surface and the naturally occurring patina (Figure 6, Day 1). The newly exposed rock face stood in contrast to the surface containing a naturally occurring organic patina. Interestingly, during the study, the only vandalism in the form of graffiti observed on a test plot occurred on the *power wash* test plot (Figure 5, Day 21). Halfway through the observation period, the team power washed the plot again. We observed that the graffiti was more challenging to remove when painted on the newly exposed rock face (Figure 5, Day 50).

The *patina* plot did not observe any vandalism. The organic slurry effectively and efficiently was applied to the rock surface (Figure 5, Day 21). Rain did remove some of the slurry and distributed it downstream of the test plot (Figure 5, Day 50). Multiple applications created resistance to weather events (Figure 5, Day 75).

The *PLACE* strategies observed minor scale impacts on the rock face. We did not observe any appreciable vandalism on these test plots. The *dammed* strategy did observe an increase of about 25% of the covered surface (Figure 5, DAMMED). The *planted* plots maintained soil mass, but we did not see an increase in surface coverage (Figure 5, PLANTED).

4 DISCUSSION

While well intended, the current power washing practices at BRNHP appear ineffective in reducing or eliminating vandalism. This effort requires tremendous volunteer hours, exhausts resources, and may have long-term detrimental effects on the rock's surface and the ecosystem. Through observation, it is clear that portions of the cleaned rock, at best, do not prevent vandalism and, at worst, become a blank canvas attracting new graffiti. This phenomenon is similar to the counter-intuitive observation that lights in low-traffic areas can promote graffiti as they highlight the surface (Weisel, 2009). As mentioned earlier, power washing has diminishing returns as it becomes harder to remove the paint once the natural patina below the graffiti is removed. In addition, it is time-consuming, labor-intensive, and more expensive than other strategies from this study.

During the testing and observation phase of the project, the three strategies of planting, damming, and applying organic patina effectively prevented vandalism. Each strategy discourages graffiti and does not appear to affect the environment or ecosystem adversely. While each intervention is labor intensive, the design team believes each application has merit separately or applied together to prevent vandalism. The organic patina strategy offers the most benefits as it is low cost, easy to apply, and can cover a large surface area with less attention to the topography. The essence of this strategy is protective. However, it has proactive characteristics as it can direct traffic and, over time, leave less rock face available for graffiti. Additionally, since the substrate is soil collected on-site, it does not have the harmful environmental and cost properties of traditional commercially available polymer-based-chemical applications. The design team recommends regularly implementing the three strategies of *planting*, *damming*, and *patina* through volunteer groups, SCDNR resources, or alternative grant funding.

Additional recommendations include exploring alternative ways to mass broadcast organic patina on the rock face and more efficient ways to deposit native soil for future or naturalized plant zones. We recommend future studies and observation of the various proactive strategies, including interpretation, access, circulation, and educating the regional community to change the culture of vandalism towards a culture of stewardship. The design team recommends developing short and long-term goals regarding the maintenance, management, and long-term development of BRNHP. Goals should be achievable and aspirational while supporting the missions of SCDNR and FOBR and aligning with the collective strategic plan.

5 CONCLUSION

Changing an ingrained culture of vandalism at the BRNHP is a challenging prospect. To begin the process and reduce the current rate of vandalism, the research team tested strategies to reduce the surface area of the rock face available to graffiti. These strategies looked at removing and preventing graffiti through physical applications by promoting and accelerating lithosere succession.

Observations revealed that the current strategy of removing graffiti by power washing is attracting graffiti and preventing lithosere succession. The most effective strategy, *patina*, requires 'painting' the exposed granite with an organic soil slurry gathered from on-site. This slurry can be economically and efficiently broadcasted by utilizing volunteers. The process can be scaled to cover a large portion of the exposed area on BRNHP. Additionally, this protective application can be removed if vandalized through the addition of water or naturally over time by rain. We observed no vandalism on the test plot with the applied *patina*, and it had the added benefit of depositing soil downstream after rain events. The *damming* and *planting* strategies were also successful in promoting lithosere succession. These strategies require more physical labor, expertise, and materials than the *patina* strategy. Therefore, these strategies should supplement the *patina* application.

The design team recommends implementing the *patina* strategy on a larger scale, and observation over a more significant time horizon is advised. An extended implementation and observation period can reveal a more robust understanding of physically and chemically accelerated lithosere succession. Monitoring plant colonization can also present valuable information that can assist in the remediation of disturbed sites in the lower Appalachian Mountains region.

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