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Natural Resource Stewardship and Science

Coastal Hazards & Sea-Level Rise Asset Vulnerability Assessment for Moores Creek National Battlefield

Summary of Results

NPS 324/186749, November 2022

PROGRAM FOR THE STUDY OF DEVELOPED SHORELINES

Western Carolina University

ON THE COVER
James Moore Monument at Moores Creek National Battlefield after Hurricane Florence
Photo credit: NPS

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Program for the Study of Developed Shorelines
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Executive Summary

This document presents the results of the **Coastal Hazards & Sea-Level Rise (SLR) Asset Vulnerability Assessment (VA)** completed by Western Carolina University at Moores Creek National Battlefield (MOCR) in 2021. In this VA, we evaluate the vulnerability (as a combination of exposure and sensitivity) of NPS buildings and transportation assets[1] to identified coastal hazards and climate change factors, approximately to the year 2050 (for full methodology, see Peek et al. 2022).

We assessed 17 buildings/structures (including a picnic shelter, storage, amphitheater, and monuments) and 15 transportation assets (including roads, a bridge, parking lots, and trails) at MOCR. Almost one-third (31%) of assets analyzed have high vulnerability to the evaluated coastal hazards and SLR, while the majority (56%) have minimal vulnerability (are not in any of the hazard zones). Scoring details and results for all assets evaluated at MOCR are reported in the provided Excel sheets.

Exposure Results

Exposure is a measure of the character, magnitude, and rate of changes a target may experience (e.g., from the impacts of climate change or a natural hazard influenced by climate change; NPS 2021). In this VA, we evaluate the exposure of each asset to the following coastal hazard indicators: flooding potential, shoreline change, SLR inundation, extreme event flooding, and reported coastal hazards (Table 1).

Table 1. Exposure indicators and hazard data sources used.

Exposure Indicator (Description)	MOCR Data (Citation)
Flooding potential (1% annual-chance)	Effective FEMA VE & A zones (FEMA 2019)
Shoreline change (coastal proximity)	35-m shoreline proximity buffer (Peek et al. 2022)
SLR inundation (2050)	NPS 8.5 RCP SLR model, 0.27 m rise (Caffrey et al. 2018)
Extreme event flooding (category 3 surge)	NPS storm surge inundation model (Caffrey et al. 2018)
Reported coastal hazards (historic flooding)	Questionnaire results & discussions (Peek et al. 2022)

Assets with high exposure are within at least four exposure indicator hazard zones. Assets with moderate exposure are within two or three exposure indicator hazard zones. Assets with low

[1] The NPS Facility Management Software System (FMSS) database defines assets as "...a physical structure or grouping of structures, land features, or other tangible property that has a specific service or function, such as a farm, cemetery, campground, marina, or sewage treatment plant. The term 'asset' shall also be applied to movable items, such as vehicles and equipment."

exposure are within only one exposure indicator hazard zone. The asset could still be seriously impacted by this hazard. Assets with minimal exposure are not in any exposure indicator hazard zone. This does not mean that the asset has no exposure to coastal hazards, but it is not within the exposure hazard data used in this study.

Only four (13%) assets at MOCR have high exposure to the analyzed coastal hazards: the Bridge Monument, Moores Creek Bridge, History Trail, and Negro Head Point Road Historic Trace (Table 2, and Figure 1). These assets are all located in the western portion of the unit near Moores Creek and the surrounding wetlands, and therefore have a higher exposure to flood hazards. Almost one-third (31%) of assets at MOCR have moderate exposure. In this case, most moderate exposure assets were within the FEMA AE flood zone (1% annual chance flood) and have been flooded in the past.

Table 2. MOCR exposure results. Sum of percentages may not equal 100 due to rounding.

	High Exposure		Moderate Exposure		Low Exposure		Minimal Exposure		Total
Assets	**#**	**%**	**#**	**%**	**#**	**%**	**#**	**%**	**#**
Buildings	1	6%	7	41%	0	0%	9	53%	17
Transportation	3	20%	3	20%	0	0%	9	60%	15
All Assets	4	13%	10	31%	0	0%	18	56%	32

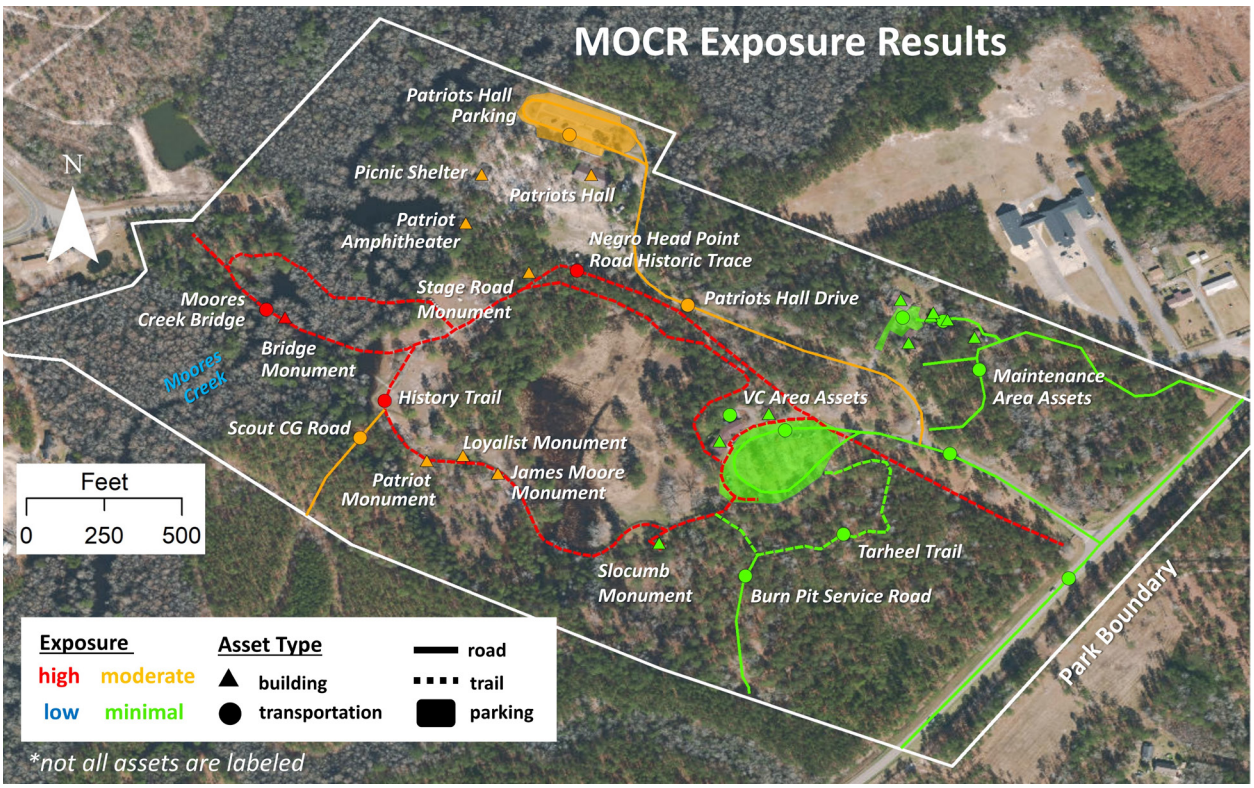

Figure 1. MOCR exposure results summary. Only select assets and areas are labeled. Background map is ESRI streaming imagery

Over half (56%) of all assets have minimal exposure using this protocol. For MOCR, the lower exposure is primarily due to the park's distance from the coast (approximately 25 miles inland from the ocean). A significant portion of these assets are also situated in the eastern portion of the park (away from Moores Creek), outside all exposure hazard zones.

Sensitivity Results

Sensitivity reflects the degree to which a resource is affected by exposure (NPS 2021). In this VA, we assess the following sensitivity indicators: flood damage potential/elevated, storm resistance and condition, historic damage, and protective engineering. In general, assets with high sensitivity have unfavorable determinations for 3 or 4 of these indicators, moderate-sensitivity assets have unfavorable determinations for 2 indicators, and low-sensitivity assets have unfavorable determinations for 0 or 1 indicator. Assets with minimal exposure are not analyzed for sensitivity (this is the case for 18 assets at MOCR).

All assets analyzed at MOCR have high or moderate sensitivity to coastal hazards and SLR (Table 3). Two assets, Patriot Monument and Bridge Monument, received unfavorable ratings for all sensitivity indicators. In most cases, the assets with moderate sensitivity (as opposed to high) scored favorably for the condition indicator. None of the assets analyzed have low sensitivity.

Table 3. MOCR sensitivity results. Sum of percentages may not equal 100 due to rounding.

	High Sensitivity		Moderate Sensitivity		Low Sensitivity		Total Analyzed	Excluded*
Assets	**#**	**%**	**#**	**%**	**#**	**%**	**#**	**#**
Buildings	5	63%	3	38%	0	0%	8	9
Transportation	4	67%	2	33%	0	0%	6	9
All Assets	9	64%	5	36%	0	0%	14	18

*Minimal exposure assets were excluded from the sensitivity analysis; total number analyzed is different for sensitivity.

Vulnerability Results

Vulnerability is a measure of the degree to which park resources and assets are "susceptible to harm from direct and indirect effects of climate change, including variability and extremes" (NPS 2021). In this VA, we evaluate the vulnerability of infrastructure assets as a simple combination of exposure and sensitivity ratings. It should be noted that the vulnerability of any asset can change with time (e.g., due to adaptation actions or the result of geomorphic change).

Almost one-third (31%) of assets analyzed at MOCR have high vulnerability to the evaluated coastal hazards, while the majority have minimal (56%) vulnerability (Table 4, and Figure 2). Three assets have both high vulnerability and a high asset priority index (API = 80, as reported in FMSS). This includes one structure, the Patriot Monument, and two transportation assets, Moores Creek Bridge

and Negro Head Point Road Historic Trace. Additional high vulnerability assets at MOCR include the Patriot Amphitheater, Patriots Hall, Picnic Shelter, Bridge Monument, Patriots Hall Parking Area, History Trail, and Scout Campground Service Road.

Table 4. MOCR vulnerability results. Sum of percentages may not equal 100 due to rounding.

	High Vulnerability		Moderate Vulnerability		Low Vulnerability		Minimal Vulnerability		Total
Assets	**#**	**%**	**#**	**%**	**#**	**%**	**#**	**%**	**#**
Buildings	5	29%	3	18%	0	0%	9	53%	17
Transportation	5	33%	1	7%	0	0%	9	60%	15
All Assets	10	31%	4	13%	0	0%	18	56%	32

Although over half of the assets at MOCR have minimal vulnerability to the evaluated hazards, areas of the park adjacent to Moores Creek are commonly flooded. Hurricanes Matthew (2016) and Florence (2018) both caused significant flooding and impacts to infrastructure, including Patriots Hall. In 2017, portions of this structure were rebuilt with flood-resistant construction materials and the HVAC/electrical systems were elevated above Matthew flood levels. Unfortunately, this building was flooded again during Hurricane Florence, when flood heights exceeded those recorded during Matthew by nearly five feet.

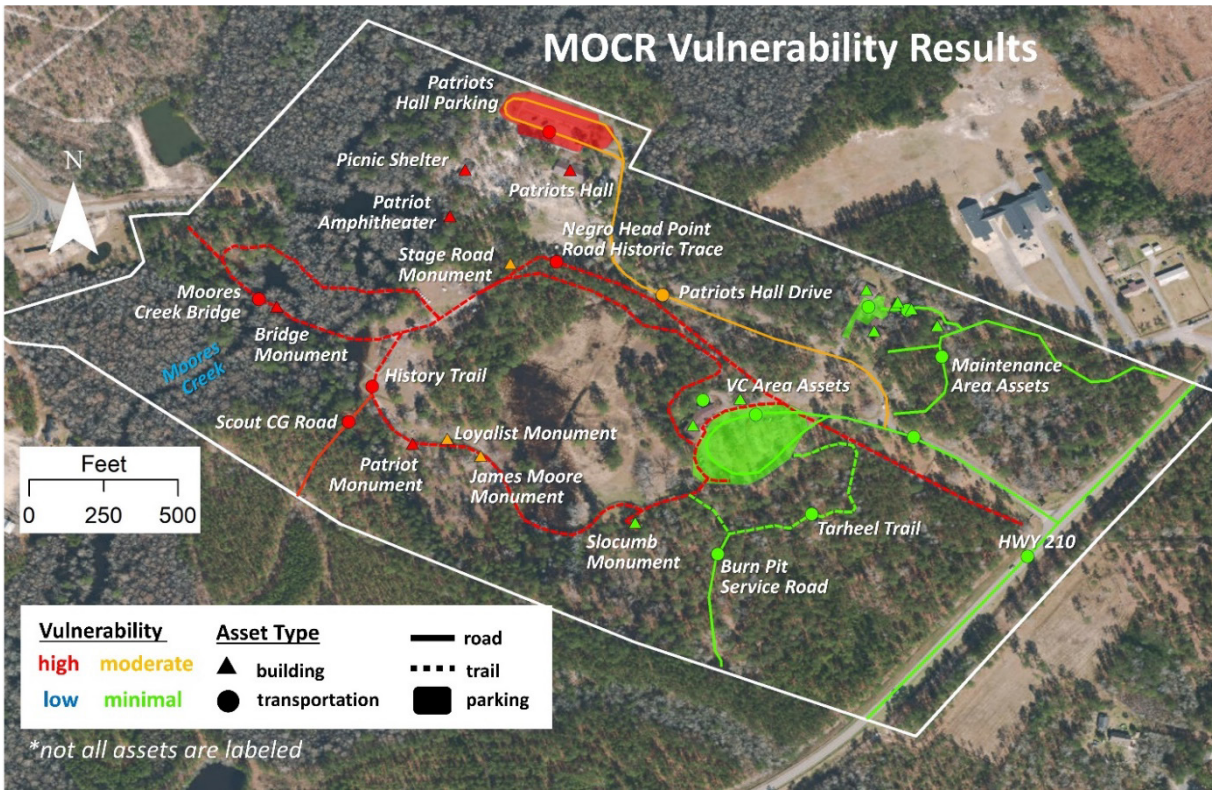

Figure 2. MOCR vulnerability results summary. Only select assets and areas are labeled. Background is ESRI streaming imagery.

Access to MOCR depends on transportation corridors that are not owned by NPS, including Highway 210, the only road that leads to the park entrance. Minimal vulnerability assets in the park could be safe from flooding but rendered inaccessible by damage or closures along these routes. During Hurricane Florence, Highway 210 collapsed in two locations nearby (over 100 linear feet) impacting access to the park for several months.

MOCR Unique Considerations

Shoreline change: Moores Creek, a tributary of the Black River, is the only major body of water that runs through the park. The creek is surrounded by marshy wetlands and meanders near the park's western boundary. Due to the small size and location of the creek, we assumed there are no major coastal erosion hazards impacting assets at MOCR (all assets were scored as outside this exposure hazard zone).

SLR data: We used the 2050 8.5 RCP SLR projection (0.27 m rise) and inundation model (Caffrey et al. 2018) developed specifically for NPS units to score exposure for this indicator. However, we also provided alternate scores using the 2100 4.5 SLR projection (0.61 m rise) for comparison (see Peek et al. 2022).

Linear assets: Due to the small geographic footprint of MOCR (< 90 acres), the NPS-owned roads and trails are also relatively short (most are less than half a mile in length). These linear features were not segmented, and therefore have only one score for exposure, sensitivity, and vulnerability. Any statistics or estimates of value represent the entire road, even if only a small portion has high exposure or vulnerability.

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