National Park Service
U.S. Department of the Interior

Mammoth Cave National Park Comprehensive Land and River Trails Plan and Environmental Assessment | Draft

October 2024

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Mammoth Cave National Park

Comprehensive Land and River Trails Plan and Environmental Assessment

Kentucky

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Draft

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CHAPTER 1: PURPOSE AND NEED

BACKGROUND

Established on July 1, 1941, Mammoth Cave National Park (the park) comprises approximately 52,830 acres in Edmonson, Hart, and Barren Counties in the Commonwealth of Kentucky. The park has two levels—reclaimed hardwood forest with winding riverways above and complex cave systems below. This plan (the trail management plan) focuses on the aboveground land and water trail networks and does not address the management of the underground cave network, which is addressed in other plans. The cultural and natural resources protected in the park are national treasures. In recognition of these world-class resources, the park has received two international designations. In 1981, the United Nations Educational, Scientific and Cultural Organization (UNESCO) designated Mammoth Cave as a World Heritage Site. In 1990, the Mammoth Cave Area International Biosphere was designated, with all park acreage included in a core 112,800-acre area. The biosphere was subsequently expanded to 909,328 acres in 1996. In addition, the park was certified as an International Dark Sky Park in 2021.

This comprehensive land and river trails plan and environmental assessment has been prepared in accordance with the National Environmental Policy Act (NEPA) of 1969 (as updated in 2023), the regulations for implementing the procedural provisions of NEPA (2022) (40 Code of Federal Regulations (CFR) Parts 1500–1508), and Director's Order 12: *Conservation Planning, Environmental Impact Analysis, and Decision-Making* (National Park Service [NPS] 2011) and its accompanying handbook (NPS 2015a).

PROJECT PURPOSE, NEED, AND OBJECTIVES

The purpose of the plan is to improve the conditions and sustainability of the aboveground land and water trail networks and to enhance the diversity and quality of visitor experiences while protecting the park's natural and cultural resources.

The plan is needed because

- inconsistent trail design and maintenance standards exist across existing trails because initial trail layouts mostly followed old road alignments prior to park establishment;
- on some trails, use is exceeding intended design standards and causing erosion, trail widening, and trail braiding that detract from trail longevity and impact both natural and cultural resources;
- visitor use conflicts and crowding on trails detract from high-quality visitor experiences; and
- limited opportunities exist for neighboring communities to access the park through multimodal transportation.

The objectives of the plan are to

- provide management guidance and direction to increase trail resiliency under changing climatic conditions and minimize maintenance needs while staying within park personnel and budgetary constraints;
- protect natural and cultural resources through sustainable trail construction and management practices;
- increase accessibility options for the park's network of trails;
- enhance partnership opportunities for trail stewardship;
- improve connectivity with neighboring community trail networks;
- provide varied trail and backcountry camping opportunities to include key points of interest north and south of the Green River;
- address facilities to support trail access (e.g., add restrooms and parking at trailheads, reduce crowding at boat launches, add hitching rails); and
- improve visitors' understanding and stewardship of resources.

RESOURCE IMPACT TOPICS

Achieving the purpose, need, and goals of this plan could result in impacts on park resources. The following section describes the level of consideration given to park resources in the context of this planning effort.

Impact Topics Retained for Further Analysis

Impact topics represent resources that could be affected, either beneficially or adversely, by implementing any of the proposed alternatives of this plan. The National Park Service used an interdisciplinary review process, existing studies and data, and public comments to determine which resources would likely be affected by this project. The following topics are carried forward for further analysis in this land and river trails plan:

- Vegetation
- Soils
- Special status mussels
- Special status bats – Indiana bat, northern long-eared bat, and tricolored bat
- Cave and karst resources
- Water quality
- Visitor use and experience
- Archeological resources
- Cultural landscapes and historic structures

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CHAPTER 2: MANAGEMENT DIRECTION

INTRODUCTION

This plan applies the Visitor Use Management Framework for best practices and guidance, as developed by the Interagency Visitor Use Management Council (IVUMC). The purpose of the IVUMC Framework is to provide cohesive guidance for managing visitor use on federally managed lands and waters (IVUMC 2016).

Articulating desired conditions is an important aspect of planning and is considered the "heart" of the IVUMC Framework. Desired conditions are statements of aspiration that describe resource conditions, visitor experiences and opportunities, and facilities and services that the National Park Service strives to achieve and maintain in a particular area. Desired condition descriptions paint a picture of what an area will look, feel, sound, and function like in the future. They do not answer the question of how conditions will be maintained or achieved.

Desired conditions may vary across the landscape of a park depending on resource types and desired experiences for visitors. A park will typically be divided into management areas or "zones" that delineate differences in management. Each of these zones should include a description of distinct desired conditions that may be arranged along a continuum or spectrum of visitor opportunities, resource conditions, and realistic levels of management and infrastructure to be provided. Zone-specific desired conditions allow for the development of meaningful guidance on the types and levels of use that may be appropriate in an area and how that use may generally be managed, including informing identification of visitor capacities where needed.

EXISTING ZONING AND DESIRED CONDITIONS

Previous planning for Mammoth Cave National Park offers some high-level guidance for desired conditions and zoning for the aboveground portions of the park. The 1983 general management plan (GMP) includes a map of "Major Resource Areas" (figure 1) that roughly divides the park into the Hilly Country, Mammoth Cave Plateau, and River Valleys. This approach is similar, though not identical, to how current park staff colloquially refer to the park's trail system in terms of the backcountry (trails north of the Green River) and frontcountry (trails south of the Green River that, currently, are concentrated in frontcountry/high visitor use areas around the visitor center).

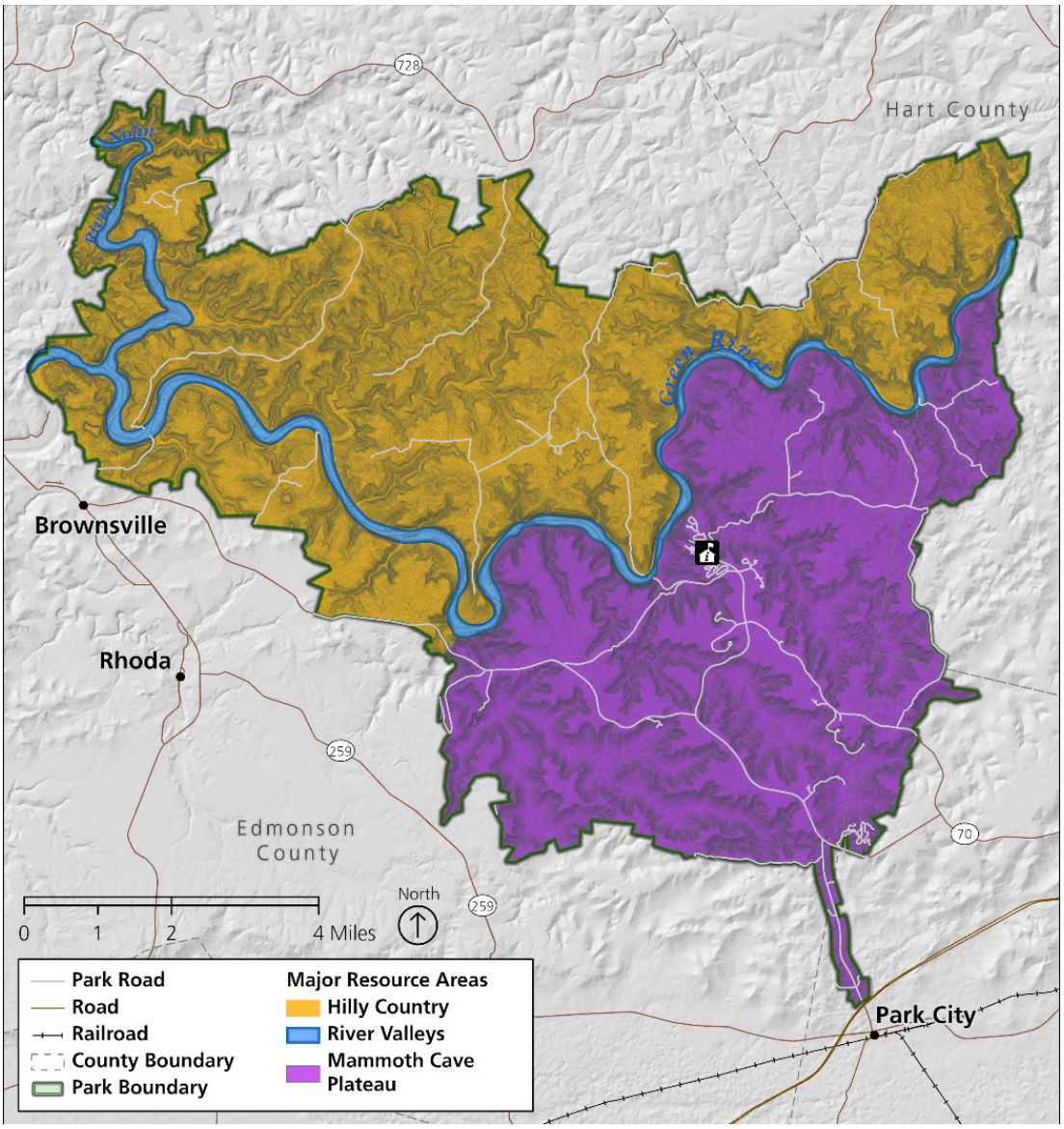

FIGURE 1. MAJOR RESOURCE AREAS (1983 GENERAL MANAGEMENT PLAN)

The general management plan also includes "management zones" for the park (figure 2). Under this zoning, the majority of the park is in the natural environment zone. Some areas in this natural environment zone "containing objects of natural wonder and of scientific importance" are included in an outstanding natural features subzone. These areas include Big Woods, basin ecosystems, Bylew Creek Valley, Virgin Forest, Goblin Knob, Turnhole Bend, Woolsey Valley, Strawberry Valley, Double Cellars Sink and Hunts Sink, Deer Park Hollow, and Ridge Tops on Mammoth Cave Plateau.

Some lands, totaling about 3 acres, are included in the historic zone under the general management plan. These lands include the Mammoth Cave Railroad's Hercules Engine and Coach #2, archeological resources in Salts Cave, the saltpeter vats, and two stone tuberculosis huts in Mammoth Cave, Floyd Collins' home, and the Crystal Cave Ticket Office.

Lastly, the general management plan includes a park development zone, which includes seven subzones: the headquarters area, residential/maintenance areas, an access/circulation subzone that includes two-way park roads, Maple Spring, a recreational subzone consisting of four riverside primitive camping sites, and a utilities subzone.

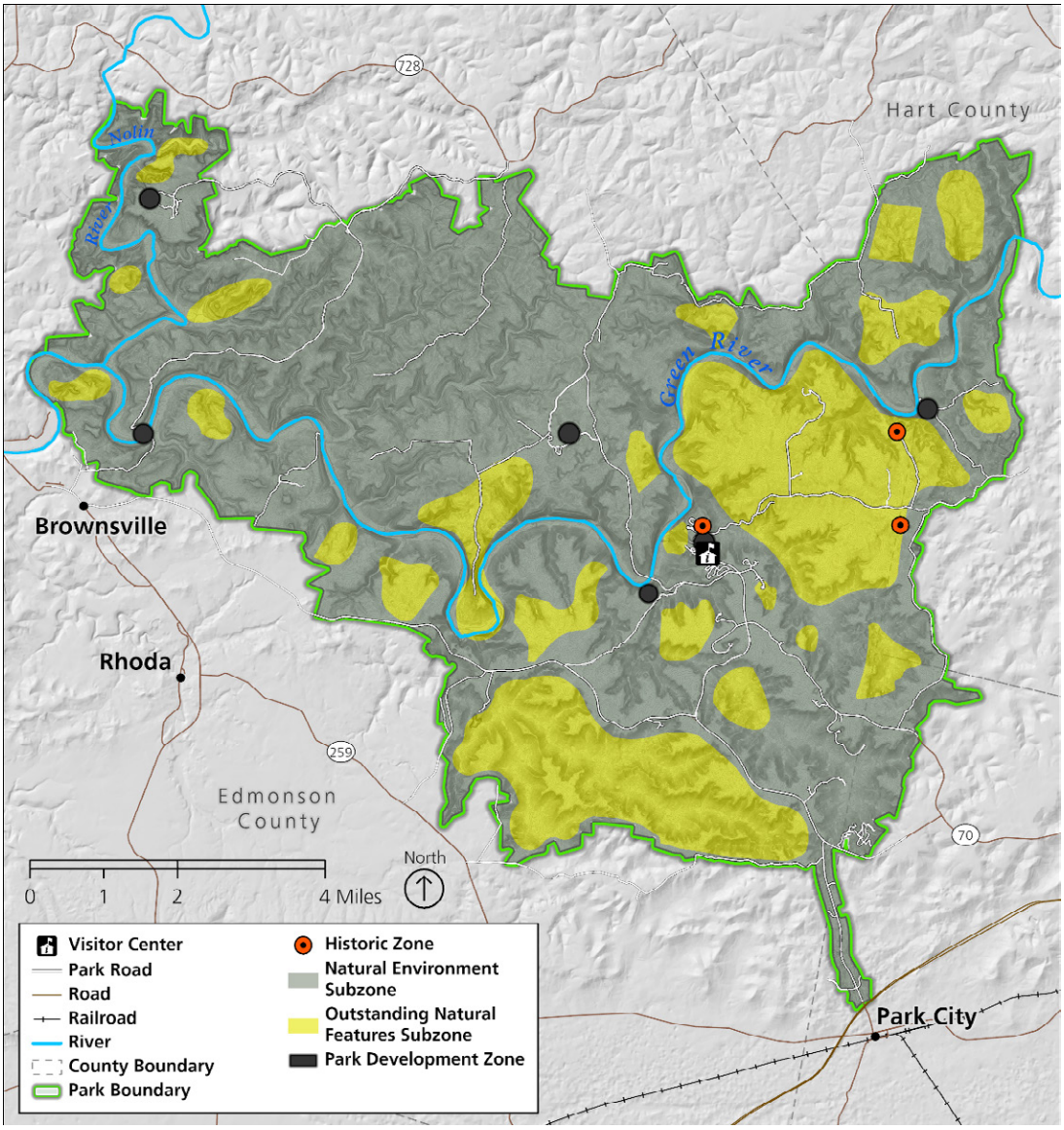

FIGURE 2. MANAGEMENT ZONES (1983 GENERAL MANAGEMENT PLAN)

Zone descriptions or definitions for each of the zones and some of the subzones described above were articulated in the general management plan and are included in table 1. However, the zones do not include detailed desired condition statements.

Table 1. Desired Conditions for Management Zones (1983 General Management Plan)

Zone	Definition
Natural zone	Most park lands are covered by this zone. Development is limited and perpetuation of the natural scene is paramount (about 51,200 acres total).
Outstanding natural features subzone	Resources of special scientific, scenic, or interpretive value, which may contain unpaved foot trails and interpretive devices (about 20,200 acres total).
Natural environment subzone	Lands managed predominantly to perpetuate natural ecosystems, but may contain environmentally compatible recreational activities, such as unpaved hiking, horse, and one-way motor nature trails, primitive campsites, and interpretive devices (about 31,000 acres total).
Historic zone	Cultural resources and their settings are identified so that they may be preserved, protected, and interpreted (about 3 acres total).
Preservation subzone	Measures are applied to sustain the existing terrain, and vegetative cover of a site and the existing form, integrity and material of an object or structure. Ongoing maintenance is expected, and the sites, objects, and structures may be interpreted. A structure may be used for contemporary purposes if that will help to perpetuate its primary historic value.
Park development zone	Places where the natural environment or the setting of historical resources have been modified to serve the needs of visitors and park management (about 500 acres total).

UPDATED DESIRED CONDITIONS AND TRAIL CATEGORIZATION

While the zoning and zone descriptions from the general management plan provide high-level guidance, park managers need greater clarity in terms of desired conditions. A clear vision for the trail systems is needed to guide management of the trails, strategy selection, visitor capacity analysis, and other key pieces of the trail management plan. For this reason, desired conditions for the entire land and water trail system were developed, as was a system of categorizing or "zoning" the trails. These trail categories will serve as a zoning scheme that applies just to the trail systems. The term "categories" is used, as they apply to each trail individually and are not necessarily geographic—trails in different categories may be adjacent or even intersect. The trail categories expand upon and do not replace the zoning from the general management plan.

Desired Conditions for the Entire Land and Water Trail System

The following sections describe desired conditions that apply to the entire land and water trail system. They are categorized by desired conditions for visitor use and experience, resource condition, trail condition and related facilities, and management and partnerships.

Visitor Use and Experience

- Park visitors are able to find the type(s) of experience they are looking for. A spectrum of opportunities is available for hikers, backpackers, horseback riders, mountain bikers, canoeists, kayakers, and other allowed land and water trail users. The park has a range of difficulty levels, from accessible and family-friendly trails to more rugged and

challenging trails. A diversity of trail lengths, varying degrees of opportunities for solitude, and a diversity of environmental settings, including ridgetops, bluffs, and hollows that are populated with forests, broken by small meadows, and prairie remnants characteristic of the park's karst topography, amplify the range of recreation available.

- Sections of the trail system provide opportunities to experience solitude and natural soundscapes, where encounters with others are minimal, providing opportunities to experience the sounds of nature, babbling brooks, rushing rivers, insects and animals, fish and amphibians, rustling or crunching leaves, splashing water, birds, wind, and "escape" from society. On other sections of the trail system, visitors hear the sounds of other visitors enjoying the park.
- Natural smells, such as the perfume of the spring green up, the pleasant petrichor after a rain, or even the distinctive musty smell of the rivers and leaf filled hollows, predominate and allow for the creation of strong nature-centric memories.
- Visitors have the information they need to confidently select appropriate trail- and river-based recreational opportunities for their skill, experience, fitness, and equipment level, as well as time availability. Visitors can choose a recreational outing that challenges them both mentally and physically and create a lasting memory.
- The land and water trail networks offer visitor access to key locations and resources of interest—including scenic vistas on ridges and bluffs, water-based access to caves and springs, and historic sites of interest—that provide opportunities for exploring park resources and moments of discovery connected to the interpretive themes of the park.
- Visitors have opportunities to learn about the cave system under their feet or in the surrounding hills. The connection between surface geology and hydrology and subsurface geology and hydrology (i.e., karst environment) is clear to visitors.
- Conflicts between and among user groups are minimized through the separation of use types, designation of dedicated trails for use types, or education about use types that may be encountered on a stretch of trail and proper trail etiquette.

Resource Condition

- Visitors have the opportunity to experience and learn about the human connection to the landscape, from precontact cultures to the homesteading period to the modern day.
- Sensitive biological resources, such as the Kentucky cave shrimp and freshwater native mussel species, are protected and minimally impacted by aboveground land and water trail activity that may impact water quality.
- Native plant species predominate and thrive along the park's trail systems. Nonnative species are minimal and mitigated when possible.
- Sensitive resources, such as archeological sites and surface features, are protected and minimally impacted during the construction, maintenance, and the use of park trails.

- Cultural resources remain in good condition, and trails do not contribute to further resource degradation. Trails may lead to cultural sites when construction and use does not degrade those sites.
- Hydrologic functions of the landscape—including streamflow, karst functions like seeps and springs, and wetland integrity—and associated water quality are maintained along the park's land and water trail systems.
- Geologic soil materials are protected through the sustainable design of the land trail system.

Trail Condition and Related Facilities

- A variety of surface types are found in the land trail system, including paved, gravel, boardwalk, and natural surface trails to provide distinct recreational opportunities.
- Land trails are sustainably constructed and well maintained and blend into surroundings as much as possible. Trail surfaces and design are appropriately matched to the type of use they receive. Where appropriate, land trails have natural surfaces to provide for less-developed settings.
- The land trail tread is built and maintained in such a way that it provides a stable surface for pedestrians and horseback riders, allowing them to be immersed in the park and unconcerned about the surface under them. Mountain bikers, who are intrinsically focused on the trail tread, find enjoyable experiences that are appropriate for their ability level. Upon leaving the trail system, visitors remember the resources that surround them and not the trail under them.
- Land trail widths accommodate room for passing on busier trails, such as those near the visitor center and the multiuse hike-and-bike trails.
- Impacts on the trail surface from use during wet weather conditions are minimized.
- Directional signage, trail markings, and mileage markers consistent with desired trail experience give visitors an accurate sense of where they are, where they are going, and how far they must go, while not introducing excessive signage into the natural setting. Trail braids and social paths are minimal to prevent visitors from becoming lost.
- Trailhead signs are consistent with accessibility standards in that they provide information about trail length, surface, width, grade, and cross slopes; the type and location of technical challenges; and potential barriers so visitors can make informed decisions. See "Appendix H: Accessibility" for more information on trailhead signage.
- A range of trail segments are improved for accessibility (e.g., from trailhead to a key destination of interest). These accessible opportunities occur across land trail types. Trail conditions are improved to be accessible per Architectural Barriers Act Accessibility Standards (ABAAS) to the extent practicable. See "Appendix H: Accessibility" for more information on accessibility.

- Trailheads and river access points have adequate parking and other facilities, which may include vault toilets and picnic tables.
- Designated campsites provide overnight opportunities for visitors along both the land and water trail system.

Management and Partnerships

- Trail users take ownership in the maintenance and stewardship of the trails. The trail community is proud of the trail system and frequently uses park trails to recreate.
- Towns and communities surrounding the park are connected to the park via the trail system to increase recreational opportunities for both visitors and residents.
- Appropriate commercial visitor services and events help to provide visitors' access and recreational opportunities so they may experience both the land and water trail systems.

Desired Conditions for All Water Trails

In addition to the desired conditions for the entire land and water trail system, the following desired conditions apply to all water trails. This additional guidance for the water trails is needed due to the unique nature and complexity of river systems.

- Visitors can feel the water splashing, the smooth, rounded river rocks, weathered driftwood, and other highly tactile aspects of river travel.
- The many natural smells of the river, from fish to native vegetation, are strong along the river. Nonnatural smells are minimized when feasible.
- Visitors not planning to float on or get into the river can still appreciate the views from the river banks with adequate land-based trails and overlooks.
- Most of the riverside is free from development, and visitors are free to enjoy sandstone cliffs, cave openings, large spring features, and clear day and night skies.
- Visitors are able to experience a valley used historically by American Indians and travel along old ferry crossings and historic structures that were once submerged.
- Visitors can expect a social atmosphere and to hear mostly anthropogenic sounds at river access points. As visitors get further away from access points, encounters become less frequent, and natural sounds predominate. Visitors seeking more solitude and natural quiet are generally able to do so by altering speeds to avoid louder groups of visitors.
- Sensitive biologic elements of river systems, including mussels and fish, continue to thrive in their natural state.
- Social activity and sounds are expected on sandbars.

- Motorboating, canoeing, kayaking, stand-up paddleboarding and similar permitted on-water uses provide visitors with a variety of ways to experience the river. Overnight camping along the river further provides visitors the chance to engage with the unique sights, sounds, and sensations the river provides.
- As a part of the national water trails system, a network of water trails open to the public to explore and enjoy, the Green and Nolin Rivers Blueway is strengthened and conserved through the mutual support and cooperation of federal, state, local, and nonprofit entities, including through river cleanup efforts. The blueway is a catalyst for protecting and restoring the health of local waterways and surrounding lands.
- The water trail is a wild river experience and is only occasionally maintained with the removal of some strainers and other obstacles.

Desired Conditions for River Access Points

Desired conditions for river access points are included below and generally align with desired conditions for trailheads found in the "developed" category for land trails. These desired conditions are based on previous or ongoing planning and compliance (Green River Ferry, Dennison Ferry, Houchin Ferry) and reflect the decisions in those processes that the river access points generally be well developed and consistent in design.

- Access points may have a high density of visitor use.
- Access points are designed to provide reasonable access to the river, along with visitor comfort and convenience. Novice river users are able to access the river successfully.
- Due to constructability challenges associated with the Green River's dynamic stream height and the river's steep banks, current and soon-to-be-constructed river access points may not be accessible to all users. However, visitors of all abilities are able to understand the river network and have a river-going experience through interpretation, photos, videos, virtual reality, and/or similar media. Accessibility information on the park website helps people understand what to expect at the river launches and plan appropriately.

Desired Conditions for Land Trail Categories

As described above, an outline of categorizing the trails is established to serve as a form of "zoning" for the park's trail system. Trails are assigned to one of the categories on a trail-by-trail basis rather than geographically. The intent of the categorization is to provide a diversity of experiences and opportunities consistent with the desired conditions for the entire trail system (see the first bullet under "Desired Conditions for the Entire Land and Water Trail System").

Detailed desired conditions have been articulated for each of four trail categories: developed trails, moderately developed trails, semi-primitive trails, and primitive trails. Desired conditions were developed for use type, visitor experience, resource conditions, and facilities and maintenance-related attributes for each of the four trail categories. The desired conditions

developed are shown in table 2 to delineate differences in how each of the trail categories will be managed so that the continuum of desired conditions is clear.

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Table 2. Desired Conditions for Each Land Trail Category

Trail Category Description	**Developed Trails** Hiking and biking trails have a high density of visitor use managed to provide a low-to-moderate degree of physical challenge and a social atmosphere. Visitors are near developed areas, and little time commitment is needed. Resources may be impacted by trail construction, and trail-related erosion risk can be more readily mitigated with infrastructure. Trail surfaces are hardened with pavement or gravel and are relatively wide and flat in many areas and include obvious trail structures like bridges, stairs, and boardwalks where needed.	**Moderately Developed Trails** Hiking, equestrian, and/or biking trails have a moderate density of visitor use managed to provide a moderate-to-high degree of physical challenge and a moderately social atmosphere. Visitors are relatively close to developed areas, necessitating some outdoor skill, and need to commit to an hour or two to visit. Trail construction may somewhat impact resources, and erosion is not tolerated due to difficulty with mitigation. Trail surfaces are hardened with gravel, moderately wide and flat to rolling and include noticeable trail structures like culverts and bridges.	**Semi-Primitive Trails** Hiking, equestrian, and/or biking trails have a low density of visitor use managed to provide a moderate-to-high degree of physical challenge and opportunities for solitude. Visitors are farther from development and immediate safety response, necessitating outdoor skill, and need to commit to a couple of hours up to a full day to visit. Resources may be impacted by trail construction and ongoing maintenance, and some erosion inevitably occurs due to use and surface type but not due to trail alignment. Trail surfaces are the natural substrate, if possible, but other engineered surfaces may be used to ensure sustainability. Trails are single-track width and flat to hilly, and trail structures like culverts are mostly unnoticeable to the average user.	**Primitive Trails** Hiking-only trails have a low density of visitor use managed to provide a moderate-to-high degree of physical challenge and ample opportunities for solitude. Visitors are farther from development and immediate safety response, necessitating outdoor skill, and need to commit to up to a full-day visit. Resources may be slightly impacted by trail construction, and ongoing maintenance and erosion are less likely on these trails due to the user type. Trail surfaces are natural substrate, single-track width, and flat to hilly. Artificial trail structures are virtually nonexistent, as logs and rocks are used for most stream crossings.
Use Type				
Is hiking allowed?	Yes	Yes	Yes	Yes
Is horseback riding allowed?	No	Yes, on designated horse trails	Yes, on designated horse trails	No
Is biking allowed?	Yes, on designated bike trails. Generally road or gravel biking.	Yes, on designated bike trails. Generally gravel or mountain biking.	Yes, on designated bike trails. Generally mountain biking.	No
Overnight backcountry camping along trail?	No	Yes	Yes	Yes
Visitor Experience				
What key experiences or opportunities will visitors find?	• Main Cave entrance and springs • Cemeteries • Scenic overlooks and points of interest • Heritage Trail • Greater perception of safety • Universally accessible opportunities to experience the trail system on some trails in this category	• Main Cave entrance and springs • Cemeteries • Scenic overlooks and points of interest • Greater perception of safety	• Feelings of remoteness and being “away from it all” • Immersion in park resources; visitors’ senses are heightened and attuned to the smells and sounds of nature • Greater perception of challenge • A high variety of natural features, flora and fauna, river bottoms, and hollows • Contemplation	• Feelings of remoteness and being “away from it all” • Immersion in park resources • Greater perception of challenge • A high variety of natural features, flora and fauna, river bottoms and hollows • Contemplation and connection with nature • Immersion in park resources; visitors’ senses are heightened and attuned to the smells and sounds of nature • At night, visitors are immersed in the dark night sky and have quality opportunities for stargazing
Level of physical challenge and aerobic exertion.	Low to moderate	Moderate to high	Can be high on some trails, but not all	Can be high on some trails but not all
Degree of adventure expected and level of skill required to visit. (Includes risk and responsibility for one’s own safety)	Low. Visitors are near development areas and park staff and other visitors. Visitors of many different abilities are able to use these trails.	Low to moderate, depending on the trail. Visitors are closer to development areas and park staff and other visitors.	Moderate to high. Visitors need to have outdoor skills, as these trails are designed to provide a high degree of challenge while still being sustainable and rustic.	Moderate to high Visitors need to be experienced in traveling on trails, as they are managed to provide a sense of

Trail Category Description	**Developed Trails** Hiking and biking trails have a high density of visitor use managed to provide a low-to-moderate degree of physical challenge and a social atmosphere. Visitors are near developed areas, and little time commitment is needed. Resources may be impacted by trail construction, and trail-related erosion risk can be more readily mitigated with infrastructure. Trail surfaces are hardened with pavement or gravel and are relatively wide and flat in many areas and include obvious trail structures like bridges, stairs, and boardwalks where needed.	**Moderately Developed Trails** Hiking, equestrian, and/or biking trails have a moderate density of visitor use managed to provide a moderate-to-high degree of physical challenge and a moderately social atmosphere. Visitors are relatively close to developed areas, necessitating some outdoor skill, and need to commit to an hour or two to visit. Trail construction may somewhat impact resources, and erosion is not tolerated due to difficulty with mitigation. Trail surfaces are hardened with gravel, moderately wide and flat to rolling and include noticeable trail structures like culverts and bridges.	**Semi-Primitive Trails** Hiking, equestrian, and/or biking trails have a low density of visitor use managed to provide a moderate-to-high degree of physical challenge and opportunities for solitude. Visitors are farther from development and immediate safety response, necessitating outdoor skill, and need to commit to a couple of hours up to a full day to visit. Resources may be impacted by trail construction and ongoing maintenance, and some erosion inevitably occurs due to use and surface type but not due to trail alignment. Trail surfaces are the natural substrate, if possible, but other engineered surfaces may be used to ensure sustainability. Trails are single-track width and flat to hilly, and trail structures like culverts are mostly unnoticeable to the average user.	**Primitive Trails** Hiking-only trails have a low density of visitor use managed to provide a moderate-to-high degree of physical challenge and ample opportunities for solitude. Visitors are farther from development and immediate safety response, necessitating outdoor skill, and need to commit to up to a full-day visit. Resources may be slightly impacted by trail construction, and ongoing maintenance and erosion are less likely on these trails due to the user type. Trail surfaces are natural substrate, single-track width, and flat to hilly. Artificial trail structures are virtually nonexistent, as logs and rocks are used for most stream crossings.
		Visitors need to have some skill on these trails, as they include a degree of challenge.	Time required for rescues may be higher due to communication challenges and distance to developed areas.	challenge and adventure and few visitor comforts are provided. Time required for rescues may be higher due to communication challenges and distance to developed areas.
Time commitment required to visit	Visitors need only 20–30 minutes to visit these trails but can spend several hours. These trails are frequently used to fill time as visitors wait for cave tours.	Visitors generally need an hour or two to visit these trails, though a half or full day could be spent on these trails in the northern portion of the park.	Visitors need at least 2–4 hours to visit these trails and could spend up to a full day on them. Overnight use is possible along these trails.	Visitors typically need a half to a full day and possibly one or two nights to visit these trails.
Likelihood of encounters with other visitors and likelihood of finding solitude or a more social atmosphere soundscape	Visitors find a social atmosphere. Visitors may encounter many other visitors except for the quiet winter season. Visitors can expect to hear mechanical noises from nearby automobiles.	Visitors find a moderately social atmosphere. Visitors may encounter some other visitors on a relatively frequent basis. Sights and sounds from other visitors, bicycles, and horses are heard at times but not at all times.	Most visitors find some opportunities for solitude at some point during their visit. Encounters with other visitors are expected but are not frequent. Sights and sounds from other visitors, bicycles, and horses are heard at times but not at all times.	Visitors have the opportunity to experience solitude. Very few other visitors are encountered during the majority of a visit. Sights and sounds from other visitors are infrequent. Natural sounds predominate, and most of the time, visitors are able to hear babbling brooks, insects and animals, rustling or crunching leaves, birds, and wind and “escape” from society.
Likelihood of encountering larger groups on trails	Large groups of hikers may be encountered, including people heading to or from cave tours.	Large groups of horseback riders and occasionally mountain bikers are encountered on these trails.	Groups of horseback riders, mountain bikers are small.	Groups of hikers are small.
Special uses and events allowed on trails	Special uses, such as group runs, walks, and similar events, may occur on trails in this category when in alignment with the Special Park Uses (SPU) program. Events occurring in this category are subject to restrictions on the total number of people involved, group size, the spacing of groups, and event duration consistent with other desired conditions. The size of events depends on the space available at trailheads used. Special events may be restricted in certain seasons to protect resources and trail surfaces.	Special uses, such as group runs, walks, trail rides, and similar events may occur on trails in this category when in alignment with the SPU program. The size, scope, and complexity of special events are managed consistent with the distance to facilities like roads and restrooms being greater, and emergency response capabilities and times are generally lower (the size of special events accommodated in this category is generally smaller than in the developed category). Events occurring in this category are subject to restrictions on the total number of people involved, group size, the spacing of groups, and event duration consistent with other desired conditions.	Special uses such as group runs, walks, trail rides, and similar events may NOT occur on trails in this category.	Special uses such as group runs, walks, trail rides, and similar events may NOT occur on trails in this category.

Trail Category Description	**Developed Trails** Hiking and biking trails have a high density of visitor use managed to provide a low-to-moderate degree of physical challenge and a social atmosphere. Visitors are near developed areas, and little time commitment is needed. Resources may be impacted by trail construction, and trail-related erosion risk can be more readily mitigated with infrastructure. Trail surfaces are hardened with pavement or gravel and are relatively wide and flat in many areas and include obvious trail structures like bridges, stairs, and boardwalks where needed.	**Moderately Developed Trails** Hiking, equestrian, and/or biking trails have a moderate density of visitor use managed to provide a moderate-to-high degree of physical challenge and a moderately social atmosphere. Visitors are relatively close to developed areas, necessitating some outdoor skill, and need to commit to an hour or two to visit. Trail construction may somewhat impact resources, and erosion is not tolerated due to difficulty with mitigation. Trail surfaces are hardened with gravel, moderately wide and flat to rolling and include noticeable trail structures like culverts and bridges.	**Semi-Primitive Trails** Hiking, equestrian, and/or biking trails have a low density of visitor use managed to provide a moderate-to-high degree of physical challenge and opportunities for solitude. Visitors are farther from development and immediate safety response, necessitating outdoor skill, and need to commit to a couple of hours up to a full day to visit. Resources may be impacted by trail construction and ongoing maintenance, and some erosion inevitably occurs due to use and surface type but not due to trail alignment. Trail surfaces are the natural substrate, if possible, but other engineered surfaces may be used to ensure sustainability. Trails are single-track width and flat to hilly, and trail structures like culverts are mostly unnoticeable to the average user.	**Primitive Trails** Hiking-only trails have a low density of visitor use managed to provide a moderate-to-high degree of physical challenge and ample opportunities for solitude. Visitors are farther from development and immediate safety response, necessitating outdoor skill, and need to commit to up to a full-day visit. Resources may be slightly impacted by trail construction, and ongoing maintenance and erosion are less likely on these trails due to the user type. Trail surfaces are natural substrate, single-track width, and flat to hilly. Artificial trail structures are virtually nonexistent, as logs and rocks are used for most stream crossings.
		The size of events depends on the space available at trailheads used. Special events may be restricted in certain seasons to protect resources and trail surfaces.		
What commercial services are allowed on trails and trailheads?	Commercial services may occur at trailheads and on trails in this category with appropriate approval by the National Park Service. An example of commercial visitor services that may be supported in this category includes the renting or delivering of bikes that visitors then use on trails (only trails that permit bikes). All new commercial services are evaluated through the commercial use authorization (CUA) review process or during concessions contract development. The location of commercial activities in this category may be permitted based on parking lot size, vehicle size, and other determining factors.	Commercial services, including guided horseback riding, guided bike touring, and guided hiking, may occur on trails in this category and at trailheads for trails in this category with appropriate approval by the National Park Service. Commercial activities are subject to conditions that manage the impact of the activity on other users. These may include restrictions on the maximum group size, timing or spacing between groups organized by the same provider, and guide-to-client ratios. Conditions may also designate specific trails open to commercial activities (i.e., not all trails in this category are necessarily open to all commercial uses). An example of commercial visitor services that may be supported in this category includes the renting or delivering of bikes or horses that visitors then use on trails (only trails that permit bikes or horses as appropriate) All new commercial services are evaluated through the CUA review process or during concessions contract development. The location of commercial activities may be limited based on parking lot size, vehicle size, and other determining factors.	No commercial services occur on trails in this category. Commercial services may occur at trailheads for trails in this category if those trailheads also serve developed and moderately developed trails.	No commercial services occur on trails in this category. Commercial services may occur at trailheads for trails in this category if those trailheads also serve developed and moderately developed trails.
Interpretive media	Educational waysides designed to teach visitors about the resources in the area are available.	Some educational waysides designed to teach visitors about the resources in the area are available.	Waysides inform visitors of what to expect, provide directions, and provide information to prepare for a visit including rules and regulations.	Small waysides inform visitors of what to expect, provide directions, and provide information to prepare for a visit including rules and regulations.

Trail Category Description	**Developed Trails** Hiking and biking trails have a high density of visitor use managed to provide a low-to-moderate degree of physical challenge and a social atmosphere. Visitors are near developed areas, and little time commitment is needed. Resources may be impacted by trail construction, and trail-related erosion risk can be more readily mitigated with infrastructure. Trail surfaces are hardened with pavement or gravel and are relatively wide and flat in many areas and include obvious trail structures like bridges, stairs, and boardwalks where needed.	**Moderately Developed Trails** Hiking, equestrian, and/or biking trails have a moderate density of visitor use managed to provide a moderate-to-high degree of physical challenge and a moderately social atmosphere. Visitors are relatively close to developed areas, necessitating some outdoor skill, and need to commit to an hour or two to visit. Trail construction may somewhat impact resources, and erosion is not tolerated due to difficulty with mitigation. Trail surfaces are hardened with gravel, moderately wide and flat to rolling and include noticeable trail structures like culverts and bridges.	**Semi-Primitive Trails** Hiking, equestrian, and/or biking trails have a low density of visitor use managed to provide a moderate-to-high degree of physical challenge and opportunities for solitude. Visitors are farther from development and immediate safety response, necessitating outdoor skill, and need to commit to a couple of hours up to a full day to visit. Resources may be impacted by trail construction and ongoing maintenance, and some erosion inevitably occurs due to use and surface type but not due to trail alignment. Trail surfaces are the natural substrate, if possible, but other engineered surfaces may be used to ensure sustainability. Trails are single-track width and flat to hilly, and trail structures like culverts are mostly unnoticeable to the average user.	**Primitive Trails** Hiking-only trails have a low density of visitor use managed to provide a moderate-to-high degree of physical challenge and ample opportunities for solitude. Visitors are farther from development and immediate safety response, necessitating outdoor skill, and need to commit to up to a full-day visit. Resources may be slightly impacted by trail construction, and ongoing maintenance and erosion are less likely on these trails due to the user type. Trail surfaces are natural substrate, single-track width, and flat to hilly. Artificial trail structures are virtually nonexistent, as logs and rocks are used for most stream crossings.
Resource Condition				
Level of tolerance for impacts from development	Resources are heavily impacted from trail construction. More mitigations are needed to match the high use of trails. Soundscape impacts from trail users are expected, and the cultural landscape may not be as intact. Areas near cave entrances, in particular, may be more developed.	Resources are somewhat impacted from trail construction. Fewer mitigations are needed due to the less impactful nature of construction and the sustainable nature of the construction. Impacts on water quality and cultural resources like archeological sites are minimal.	Resources are slightly to somewhat impacted from trail construction and ongoing maintenance. Some mitigations are needed due to the less sustainable nature of the construction, though fewer impacts from ongoing visitor use are tolerated due to relatively low levels of use. Impacts on water quality and cultural resources like archeological sites are minimal.	Resources are slightly impacted from trail construction and ongoing maintenance. Some mitigations are needed due to the less sustainable nature of the construction, though fewer impacts from ongoing visitor use are tolerated due to relatively low levels of use. Impacts on water quality and cultural resources like archeological sites are minimal.
Expectations for rehabilitation after trail construction impacts	Resources along the trail are rehabilitated, but the evidence of trail construction is still somewhat obvious.	Resources along the trail are rehabilitated, but the evidence of trail construction is noticeable but not obvious other than the trail itself.	Resources along the trail are rehabilitated, and the evidence of trail construction is difficult to discern other than the trail itself.	Resources along the trail are rehabilitated, and the evidence of trail construction is almost nonexistent other than the trail itself.
Condition of trailside vegetation	Trailside vegetation could be heavily impacted, and it may appear unnatural. Manicured grass is acceptable.	Trailside vegetation is somewhat impacted. Cultural and scenic viewsheds are maintained through vegetation trimming and occasional tree clearing.	Trailside vegetation is only minorly impacted. Cultural and scenic viewsheds are maintained through vegetation trimming and occasional tree clearing.	Trailside vegetation is generally not be impacted and appears natural. Cultural and scenic viewsheds are maintained through vegetation trimming and occasional tree clearing.
Trail-related erosion risk	Trail-related erosion risk can be more readily mitigated with infrastructure.	Trail-related erosion risk can be mitigated with infrastructure.	Some erosion on these trails is inevitable due to the use and surface type (hike or bike on native surface trails). However, trail-related erosion risk is mitigated as much as possible given the infrastructure limitations on these trails.	Erosion is less likely on these trails due to the hiker-only nature of the trails. Trail-related erosion risk is mitigated if necessary.
Facilities and Maintenance				
Primary role and function of trails	Trails provide administrative functions, connect from one site to another site, serve as a mode of transportation in busier areas of the park, provide access to interpretive sites, and provide access to major cave entrances.	Trails connect from one site to another site, provide recreational experiences, and provide access to interpretive sites.	Trails provide recreational experiences.	Trails provide recreational experiences.
Overall character of trails, including surface type	• Trails are relatively wide and flat. • Trails are hardened with pavement or gravel. • Human-made structures like boardwalks and stairs are common.	• Trails are hardened with gravel. • Human-made structures like boardwalks and stairs are uncommon.	• If possible, trail surfaces are native soil. However, some gravel, enhanced dirt, engineering features, and rock armoring is present to ensure sustainability.	• Trail surfaces are native soil. • Human-made structures are minimal, with very limited use of minor bridges, boardwalks, or stairs to protect resources.

Trail Category Description	**Developed Trails** Hiking and biking trails have a high density of visitor use managed to provide a low-to-moderate degree of physical challenge and a social atmosphere. Visitors are near developed areas, and little time commitment is needed. Resources may be impacted by trail construction, and trail-related erosion risk can be more readily mitigated with infrastructure. Trail surfaces are hardened with pavement or gravel and are relatively wide and flat in many areas and include obvious trail structures like bridges, stairs, and boardwalks where needed.	**Moderately Developed Trails** Hiking, equestrian, and/or biking trails have a moderate density of visitor use managed to provide a moderate-to-high degree of physical challenge and a moderately social atmosphere. Visitors are relatively close to developed areas, necessitating some outdoor skill, and need to commit to an hour or two to visit. Trail construction may somewhat impact resources, and erosion is not tolerated due to difficulty with mitigation. Trail surfaces are hardened with gravel, moderately wide and flat to rolling and include noticeable trail structures like culverts and bridges.	**Semi-Primitive Trails** Hiking, equestrian, and/or biking trails have a low density of visitor use managed to provide a moderate-to-high degree of physical challenge and opportunities for solitude. Visitors are farther from development and immediate safety response, necessitating outdoor skill, and need to commit to a couple of hours up to a full day to visit. Resources may be impacted by trail construction and ongoing maintenance, and some erosion inevitably occurs due to use and surface type but not due to trail alignment. Trail surfaces are the natural substrate, if possible, but other engineered surfaces may be used to ensure sustainability. Trails are single-track width and flat to hilly, and trail structures like culverts are mostly unnoticeable to the average user.	**Primitive Trails** Hiking-only trails have a low density of visitor use managed to provide a moderate-to-high degree of physical challenge and ample opportunities for solitude. Visitors are farther from development and immediate safety response, necessitating outdoor skill, and need to commit to up to a full-day visit. Resources may be slightly impacted by trail construction, and ongoing maintenance and erosion are less likely on these trails due to the user type. Trail surfaces are natural substrate, single-track width, and flat to hilly. Artificial trail structures are virtually nonexistent, as logs and rocks are used for most stream crossings.
	• Water crossings on land trails are made with bridges. • The hand of humans is unmistakable to the average trail user.	• Water crossings on land trails are predominately made with culverts. • The hand of humans is readily noticeable to the average trail user.	• Human-made structures are rare and only used when absolutely necessary for sustainability. • Water crossings on land trails are made with culverts. • The hand of humans are mostly unnoticeable to the average trail user.	• Water crossings on land trails are made with rocks and downed trees. • The hand of humans is much less noticeable.
US Forest Service land trail class	4–5	3	2	2
Appropriate facilities to support visitor use of trails	Visitors have access to restrooms, potable water, picnic tables, benches, trash cans, and commercial products at or near trailheads. Treated or human-made materials are appropriate for these facilities. Fences may be used to delineate boundaries. Stairs and railings are allowable with accessible bypasses.	Visitors have access to restroom facilities, picnic tables, and trash cans at or near trailheads. Potable water is a reasonable distance away. Some materials may be treated or human made, but materials for these facilities are mostly natural. Backcountry campsites have lantern poles, fire rings, and tent pads. Rock stairs and split rail fences are allowable.	Visitors do not have access to restroom facilities, potable water, or trash cans at or near trailheads. Materials for these facilities are more natural than human made. Backcountry campsites have lantern poles, fire rings, and tent pads. Rock stairs and split rail fences are allowable.	Visitors do not have access to restroom facilities, potable water, or trash cans at or near trailheads. Visitor support facilities have limited impacts and can include fire rings, signs for designated camping, and cut logs. Only natural features are used, no human-made materials are present. Backcountry campsites have limited facilities and are largely pack in, pack out.
Appropriate types of trail signage	Appropriate trail signs include educational wayside exhibits, informational signage that provides context for the trail, and wayfinding signage.	The trails signs are predominantly wayfinding signage. Kiosks and maps at the trailhead are appropriate, as is safety information and regulatory information.	The trails signs are predominantly wayfinding signage, especially at trail junctions. Signs are as visually unobtrusive as possible. No mileage signs are appropriate.	The trail signs are minimal in nature and predominantly provide wayfinding information. Most signage occurs at trailheads. Some trail markings occur along the trail when necessary, and directional signage can be found at complicated intersections. Signs are as visually unobtrusive as possible. No mileage signs are appropriate.
Level of maintenance required	As trails are made of durable materials, they require a low-to-moderate amount of maintenance but have a high replacement cost.	Trails are maintained on an as-needed basis. Ideally, these trails do not need much maintenance due to their sustainable design. Annual condition inspections are needed due to the high levels of use.	Trail maintenance needs are greater due to the less-hardened nature of the trail tread. Native soils and select hardened sections may need to be replaced on a somewhat frequent basis.	Trail maintenance needs are minimal due to the lower levels of use on these trails and their hiking only nature. Maintenance includes removing downed trees and fixing significant wash outs.
Role of partnerships in trail maintenance	Partnerships may be leveraged to connect trails to neighboring communities. Partners, including the Friends of Mammoth Cave, the Federal Highways Administration, and local governments, may assist with these connections.	Partnerships with user groups are highly likely to assist with trail construction and maintenance.	Partnerships with horse and bike user groups or other partners are essential to the viability of these trails. Partners are needed to assist with trail construction and maintenance.	Partnerships with hiking user groups or other partners may be needed to ensure the viability and sustainability of these trails. Partners may assist with trail construction and maintenance.

Trail Category Description	**Developed Trails** Hiking and biking trails have a high density of visitor use managed to provide a low-to-moderate degree of physical challenge and a social atmosphere. Visitors are near developed areas, and little time commitment is needed. Resources may be impacted by trail construction, and trail-related erosion risk can be more readily mitigated with infrastructure. Trail surfaces are hardened with pavement or gravel and are relatively wide and flat in many areas and include obvious trail structures like bridges, stairs, and boardwalks where needed.	**Moderately Developed Trails** Hiking, equestrian, and/or biking trails have a moderate density of visitor use managed to provide a moderate-to-high degree of physical challenge and a moderately social atmosphere. Visitors are relatively close to developed areas, necessitating some outdoor skill, and need to commit to an hour or two to visit. Trail construction may somewhat impact resources, and erosion is not tolerated due to difficulty with mitigation. Trail surfaces are hardened with gravel, moderately wide and flat to rolling and include noticeable trail structures like culverts and bridges.	**Semi-Primitive Trails** Hiking, equestrian, and/or biking trails have a low density of visitor use managed to provide a moderate-to-high degree of physical challenge and opportunities for solitude. Visitors are farther from development and immediate safety response, necessitating outdoor skill, and need to commit to a couple of hours up to a full day to visit. Resources may be impacted by trail construction and ongoing maintenance, and some erosion inevitably occurs due to use and surface type but not due to trail alignment. Trail surfaces are the natural substrate, if possible, but other engineered surfaces may be used to ensure sustainability. Trails are single-track width and flat to hilly, and trail structures like culverts are mostly unnoticeable to the average user.	**Primitive Trails** Hiking-only trails have a low density of visitor use managed to provide a moderate-to-high degree of physical challenge and ample opportunities for solitude. Visitors are farther from development and immediate safety response, necessitating outdoor skill, and need to commit to up to a full-day visit. Resources may be slightly impacted by trail construction, and ongoing maintenance and erosion are less likely on these trails due to the user type. Trail surfaces are natural substrate, single-track width, and flat to hilly. Artificial trail structures are virtually nonexistent, as logs and rocks are used for most stream crossings.
	As needed, such partnerships would be authorized under an appropriate NPS instrument(s) such as a general agreement (also referred to as memorandum of agreement or memorandum of understanding), intergovernmental agreement, cooperative management agreement, philanthropic partnership agreement, or volunteer agreement.	As needed, such partnerships would be authorized under an appropriate NPS instrument(s) such as a general agreement, volunteer agreement, partner design and construction agreement, or special use permit.	As needed, such partnerships would be authorized under an appropriate NPS instrument(s) such as a general agreement, volunteer agreement, partner design and construction agreement, or special use permit.	As needed, such partnerships would be authorized under an appropriate NPS instrument(s) such as a general agreement, volunteer agreement, partner design and construction agreement, or special use permit.
Cost to maintain trails	Medium	Low to medium	Medium to high	Very low
Cost to build trails	High	Medium	Low	Very low

Desired Conditions for Water Trail Categories

The park's water trails are divided into three categories: high-, moderate-, and low-density water trails. Each segment of the Green and Nolin Rivers are included in these categories, as described below. The desired conditions for each water trail category are included in table 3.

East park boundary to Dennison Ferry. This 3-mile segment is part of a larger 22-mile segment of the Green River. Due to the inaccessibility of this stretch from outside the park, it is not well used at this time. However, a new river access point that could be supported by the river's national water trail designation may change this (none is currently proposed). This segment is categorized as a "moderate-density water trail."

Dennison Ferry to Green River Ferry. This 8-mile segment is currently the busiest in the park, particularly during the summer season. This use is consistent with categorization of the river as a "high-density water trail."

Green River Ferry to Houchin Ferry. This 13-mile segment of river does not currently receive a lot of use due to the distance between access points. This segment also is slightly more challenging, as users frequently have to drag or portage their craft during low water and avoid strainers (downed trees in the river) during high water. At normal water levels, the slow flow of the river means visitors have to paddle more as this portion of the river meanders and naturally floods. However, additional access points may make this section more appealing. Due to these factors, this segment is categorized as a "high-density water trail."

Houchin Ferry to Green River/Nolin River confluence. This 24-mile segment of river currently does not receive a lot of visitor use, but it is well suited for more. For these reasons, this segment is categorized as a "moderate-density water trail."

Nolin River to confluence with the Green River. The 8-mile stretch of the Nolin River from the eponymous dam to the confluence with the Green River responds rapidly to changes in the dam's release. When the dam releases a high volume of water, the Nolin River in the park is active, with standing waves in some sections. These dynamics are unrelated to water flow on the Green River. The Nolin is also sometimes blocked by trees that completely cross the river, making it impassable by water needing a land portage. For these reasons, the Nolin River is categorized as a "low-density water trail."

Green River/Nolin River confluence to west park boundary. This 3-mile segment of river is used by any paddler on the previous two segments of river. As it accommodates the sum of users on both a moderate- and low-density water trail, it is categorized as a "high-density water trail."

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Table 3. Desired Conditions for Each Water Trail Category

Desired Condition Attributes	High-Density Water Trails	Moderate-Density Water Trails	Low-Density Water Trails
Water trail category description	River segments/conditions have a high density of visitor use and are managed to provide a moderately social atmosphere. Visitors need to have little-to-no paddling or boating skills to float successfully, as these segments generally do not provide a great degree of challenge.	River segments/conditions have a moderate density of visitor use managed to provide some opportunities for solitude. Visitors need paddling experience to float successfully, as these river segments provide a moderate degree of challenge.	River segments/conditions have a low density of visitor use managed to provide opportunities for solitude, remoteness, and connection with nature. Visitors need some paddling experience and skill to float successfully, as these river segments provide a moderate-to-high degree of challenge and a sense of adventure.
River segments in each category	• Dennison Ferry to Green River Ferry • Green River Ferry to Houchin Ferry • Green River/Nolin River Confluence to West Park Boundary	• East park boundary to Dennison Ferry • Houchin Ferry to West Park Boundary	• Nolin River from park boundary to confluence with Green River.
Level of paddling experience and physical skill required	No paddling experience is necessary to successfully float these waters. These river segments are generally forgiving from a technical perspective, and the distance to development is lower.	Some paddling experience is likely necessary to successfully float these waters; however, novice paddlers with a high degree of physical fitness may successfully float these waters. These river segments are generally less forgiving from a technical perspective or the distance required to travel is greater.	A high degree of paddling experience is necessary to successfully float these waters. These river segments or conditions may present greater technical challenges, including higher flows, fewer opportunities to get off the river, greater paddling distance, and sweepers or strainers that span the width of the river.
Time commitment required to float	Visitors generally need a half day to float these river segments.	Visitors may only need a couple of hours to float some of the segments in this category but need to prepare for a more technical float. Other segments may require three-fourths to one full day.	Visitors need three-fourths to one full day to float these river segments except under high flow conditions when the trip may become faster but more challenging.
Likelihood of encounters with other visitors and likelihood of finding solitude or a more social atmosphere	Visitors find a moderately social atmosphere. Visitors encounter other visitors on a relatively frequent basis. The likelihood of encountering larger groups on these river segments is high, owing to livery-outfitted users.	Most visitors find some opportunities for solitude at some point during their visit. Encounters with other visitors are expected but not be frequent. The likelihood of encountering larger groups on these river segments is moderate.	Visitors have the opportunity to experience solitude. Very few other visitors are encountered during the majority of a visit. The likelihood of encountering larger groups on these river segments is low, as few livery-outfitted users are on these segments.
Special uses allowed on river segments	Special uses such as large group float events may occur on river segments in this category when in alignment with SPU program. Events may not be timed (i.e., no races). Events occurring in this category are subject to restrictions on the total number of people involved and event duration consistent with other desired conditions. Commercial events are not permitted.	Special uses such as medium-sized group float events may occur on river segments in this category when in alignment with SPU program. Events may not be timed (i.e., no races). Events occurring in this category are subject to restrictions on the total number of people involved and event duration consistent with other desired conditions. Commercial events are not permitted.	Special uses such as small group float events may occur on river segments in this category when in alignment with SPU program. Events may not be timed (i.e., no races). Events occurring in this category are subject to restrictions on the total number of people involved and event duration consistent with other desired conditions. Commercial events are not permitted.
What commercial services are allowed on these river segments?	Commercial services, including livery services (rental and transportation of canoes, kayaks, and similar devices, as well as the shuttling of river users) and guided river trips may occur on river segments in this category and at river access points that serve these river segments. All new commercial services are evaluated through the CUA review process or during concessions contract development. Commercial activities are subject to conditions that manage the impact of the activity on other users. These can include restrictions on the total amount of people on a river segment at one time, maximum group size, timing or spacing between groups organized by the same provider, and guide-to-client ratios. The location of commercial service activities, including parking and temporary storage of vessels, may be directed based on parking lot size, vehicle size, and other factors.	No commercial services occur on river segments in this category (i.e., no guided river trips), but commercial services may occur at select river access points that serve river segments in this category. Commercial services may support visitor use of river segments in this category and may include livery services (rental and transportation of canoes, kayaks, and similar devices, as well as the shuttling of river users). All new commercial services are evaluated through the CUA review process or during concessions contract development. Commercial activities are subject to conditions that manage the impact of the activity on other users to achieve desired conditions. These can include restrictions on the total amount of people on a river segment at one time, maximum group size, timing or spacing between groups organized by the same provider, and guide-to-client ratios. The location of commercial service activities, including parking and temporary storage of vessels, may be directed based on parking lot size and other factors.	Commercial services, including livery services (rental and transportation of canoes, kayaks, and similar devices, as well as the shuttling of river users) and guided river trips may occur on river segments in this category and at river put ins/takeouts that serve these river segments. Guided activities are permitted here to provide visitor opportunities to experience more challenging segments of river. All new commercial services are evaluated through the CUA review process or during concessions contract development. Commercial activities are subject to conditions that manage the impact of the activity on other users to achieve desired conditions. These can include restrictions on the total amount of people on a river segment at one time, maximum group size, timing or spacing between groups organized by the same provider, and guide-to-client ratios. The location of commercial service activities, including parking and temporary storage of vessels, may be directed based on parking lot size and other factors.

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Chapter 3
Alternatives

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CHAPTER 3: ALTERNATIVES

INTRODUCTION

This section describes the current trail conditions and proposed parkwide trail management strategies and trail alignments. The current trail conditions provide a basis for which to compare and evaluate the proposed alternatives. This section identifies proposed changes to the trail system, including new trail construction and natural rehabilitation of portions of the existing system, and presents an approach to address the purpose and need for the trails plan as described in the introduction. The proposed alternatives in this section were derived from the recommendations of an interdisciplinary planning team and input from the public and stakeholders during an external civic engagement process. Table 4 summarizes the differences between alternative 1 (continuation of current management) and alternative 2 (NPS preferred alternative). Please note all values were rounded to the nearest tenth. Because of rounding, numbers presented may not add up precisely to the totals provided.

Table 4. Comparison of Existing and Proposed Trail System by Mileage

Trail Designation	Alternative 1: Current Management	Alterative 2: NPS Preferred Alternative
Land Trails		
Total miles of pedestrian-only trails	12	50
Total miles of multiuse (equestrian and pedestrian) trails	54	59
Total miles of multiuse (bicycle and pedestrian) trails	19	37
Total miles of multiuse (bicycle, equestrian, hiking) trails	0.3	0
Total land trails mileage	85	146
River Trails		
Total river trail system mileage	30	30
Associated Facilities		
Bike rack	6	16
Information kiosk	11	18
Parking lot	62	65
Restroom	9	16
Backcountry land campsite	13	20
River campsite	On islands and the river floodplain	On islands and the river floodplain plus 5 reservable designated river campsites

Trail Designation	Alternative 1: Current Management	Alterative 2: NPS Preferred Alternative
Primitive river takeout	0	3
Total number of associated facilities	101	143

NPS BICYCLE RULE

Both alternatives must comply with 36 CFR 4.30 (the bicycle rule), which describes regulations that manage bicycle use in national park system units. In 1987, the National Park Service promulgated regulations establishing a management framework for the use of bicycles in park areas. In 2012, the National Park Service revised the process in the regulations for allowing bicycles (77 FR 56117 [*Federal Register]*) to focus on park planning and environmental compliance under the National Environmental Policy Act.

The bicycle rule establishes different procedures for authorizing bicycle use on existing trails, on new trails in developed areas, and on new trails outside of developed areas. Regardless of the scenario, before the superintendent can authorize the use of bicycles, the National Park Service must prepare a compliance document that evaluates the effects of bicycle use on the specific trails where bicycles would be allowed. The compliance document must evaluate the suitability of trail surfaces and soil conditions for accommodating bicycle use, including any maintenance, minor rehabilitation, or armoring that would be necessary to upgrade the trail to sustainable condition. Lifecycle maintenance costs, safety considerations, strategies to prevent or minimize user conflict, and methods to protect natural and cultural resources and mitigate impacts also must be analyzed.

An environmental assessment or environmental impact statement must be completed that evaluates the effects of bicycle use in the park and on the specific trails where they would be allowed. An environmental assessment must provide for at least a 30-day comment period per the bicycle rule. If significant impact is not found, the superintendent must prepare and the regional director must approve a written determination stating that bicycle use on the trails is consistent with the protection of the park area's natural, scenic, and aesthetic values; that safety considerations have been made; and that management objectives and would not disturb wildlife or park resources. Bicycle use on the new trails will not occur until a final rule is promulgated allowing such use.

New trails requiring construction activities (such as clearing brush, cutting trees, excavating, or treating surfaces) must be developed and constructed in accordance with sustainable trail design principles and guidelines. A special regulation that is promulgated after notice and comment rulemaking is required for new trails and for existing trails that require construction or significant modification to accommodate bicycle use if any portion of those trails is outside a developed area. Bicycle use on new trails entirely in developed areas and on existing trails that do not require construction or significant modification to accommodate bicycles may be authorized without the need for a special regulation.

Although some existing trails at the park can continue to accommodate bicycles without construction or significant modification, if the National Park Service selects the preferred alternative, the bureau will promulgate a special regulation to designate all trails where bicycle use is authorized.

This approach will increase compliance, strengthen enforcement, and decrease public confusion and frustration about where bicycles are allowed.

ALTERNATIVE 1: NO-ACTION ALTERNATIVE (CONTINUE CURRENT MANAGEMENT)

This section describes what a continuation of current management looks like, and this serves as a baseline for comparing and considering the proposed land and river trails plan. The park has several trail-related projects that are underway but which are not yet implemented, which would continue to progress under the no-action alternative. These projects include the "Dennison Ferry Design Concept Plan," which is in the pre-NEPA stage and has not yet been implemented. As such, the preliminary design elements of the Dennison Ferry plan are included in the no-action alternative of this plan. Please see "Appendix E: Related Planning Efforts" for a complete list of projects related to this one.

Desired Conditions

Under the no-action alternative, management direction for the trail system would be limited to the high-level guidance provided in the general management plan (see chapter 2). No categorization or zoning of trails would occur.

Land Trails

Park managers would continue to manage the park's approximately 85 miles of land trails without any updated guidance since the 2007 comprehensive trail management plan. Biking would continue to be allowed on 19 miles of trails throughout the park. Throughout this document, the terms "biking" and "bicycles" refer to both traditional bicycles and electric bicycles (or e-bikes) unless otherwise specified. As per the 2021 Superintendent's Compendium, the use of e-bikes is permitted on park roads open for motor vehicle use, permitted where traditional bicycles are allowed, and prohibited where traditional bicycles are prohibited. E-bikes are subject to the same 15 mph speed limit as traditional bicycles. Equestrian use would continue to be allowed on 54 miles of trails throughout the park. Approximately 1.6 miles of trails in the park would continue to meet the technical requirements of ABAAS. Hiking would continue on all these segments continuing the mixed-use practices. Approximately 0.3 miles of trail would continue to support equestrian, biking, and hiking recreation from Maple Springs to Big Hollow.

Land trails would continue to follow old road alignments that predate the park, lack sustainable design standards, and do not connect visitors to points of interest such as waterfalls, rock formations or scenic overlooks. Trail construction, reconstruction, and restoration would occur on a case-by-case basis. The existing designated trail system would continue to be provided, and undesignated trails would continue to comprise much of the trail system; no changes in allowed trail uses would occur. Trails would continue to be managed and maintained without regard to

any specified trail class or maintenance standard. Park managers would continue to implement temporary trail closures, as needed, to protect visitor safety and park resources in accordance with the provisions of 36 CFR 1.5.

Roads

All public roads (those open to motor vehicles) in the park would continue to be open to biking and hiking use. Biking and hiking would continue to be allowed on the following administrative roads: Great Onyx Road (2 miles), Crystal Cave Admin Road (1.1 miles), Three Springs Administrative Road (0.3 miles), and Union City Administrative Road (1.2 miles). The NPS-owned sections of Ugly Creek public road would continue to be open to bicyclists and hikers. All public and administrative roads would remain closed to equestrian use per 36 CFR 2.16 (c).

River Trails

Park staff would continue to manage its approximately 30 miles of water trails. River access locations would continue to be congested during the summer months. Resource degradation would continue to occur along the riverbanks, impacting both natural and cultural resources.

Associated Facilities

The park would continue to have 62 parking facilities and 9 restroom facilities in the park. Visitors would continue to camp anywhere along the river, often in campsites that are not safe or appropriate for camping. River access would continue at the formal developed put ins at Green River Ferry, Dennison Ferry day use area, and Houchin Campground and boat ramp. Park staff have completed an environmental assessment for Houchin's Ferry Campground that includes an expanded walk-in/boat-in campground on the north side of the river across from the existing campground. This new campground has not yet been constructed at the time of this environmental assessment but is considered an existing campsite for the purposes of this plan. Park staff would continue to manage the primitive White Oak campsite across from the Dennison Ferry. The primitive camping at Houchin's Ferry would continue to be reservable. In addition, primitive river camping is currently permitted in the floodplain and on islands with a permit. These primitive river campsites do not have any facilities and are first-come, first served. The number of boats commercial operators can put on the water at one time would continue to be unlimited.

Figure 3 below shows the existing trails and associated facilities under the no-action alternative. Trail names are portrayed as map codes in the image below. See "Table 8. Resulting Trail System Mileage," for map code names.

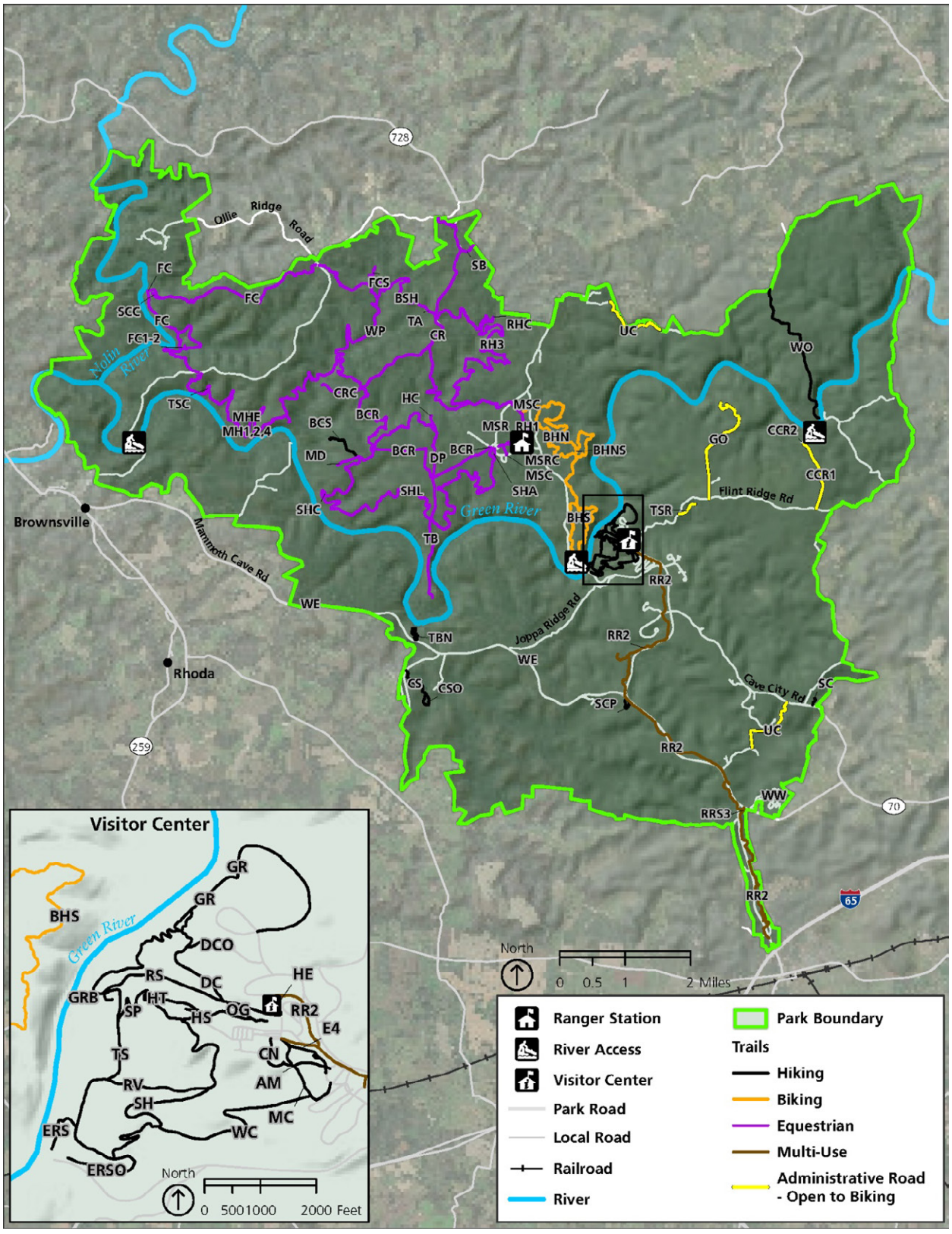

FIGURE 3. EXISTING TRAILS AND ASSOCIATED FACILITIES UNDER THE NO-ACTION ALTERNATIVE

ALTERNATIVE 2: NPS PREFERRED ALTERNATIVE

Overview

The park trail system would be redeveloped to improve its overall sustainability, protect the park's resources, and improve the visitor experience and circulation. The overall mileage of designated trails available for public use in the park would increase substantially, and a focus would be placed on improving the quality of the trails to better serve visitors and achieve greater resource stewardship. Recreation opportunities, such as hiking, walking, exercising leashed pets, wildlife watching, running, kayaking, and canoeing would continue on land and river trails. Bicycling and equestrian use would be allowed on designated trails.

Under this alternative, land trails would be designed consistent with the systemwide desired conditions described in chapter 2. Land and water trails would be placed in one of the trail categories described and managed to the associated desired conditions (table 1 and table 2).

Trails would be designed in consideration of three aspects of trail sustainability. Typically, trail sustainability has focused on the durability of the trail tread or the physical sustainability. This focus has utility, and best practices developed in the construction and maintenance of natural surface trails have served land managing agencies well. However, trails are a facility, just like a road, building, boat launch, or restroom. Facilities must be kept up to an operational standard and in a condition that can be optimally efficient for visitors. To create a sustainable trail facility, the conditions must also be analyzed not only from standpoints of physical sustainability but also social and managerial sustainability.

- **Physical sustainability.** How a trail's position on the landscape affects its ability to manage water and limit erosion would be addressed by decommissioning poorly designed trails, including trails with steep or fall-aligned gradients, and trails with very low gradients in low and flat areas. These trails would be replaced with trails that (1) allow for water drainage without causing excessive erosion by following more gradual grades and water bars, (2) are sidehill- or cross-slope-aligned (generally perpendicular to the fall line), (3) incorporate short dips in the trail called grade reversals, and (4) include an outsloped tread.

- **Social sustainability.** How visitors interact with the park and each other would be addressed by (1) improving the trail tread and access to desirable destinations, (2) generally rerouting trails into corridors better suited to recreation, (3) formalizing access to the trail system through trailheads and trail access points that connect the park with surrounding communities, (4) addressing circulation issues to decrease user conflicts, and (5) improving wayfinding and navigability through intuitive design and signage.

- **Managerial sustainability.** The ability of park staff, partners, volunteers, and contractors to manage and maintain the trail system would be addressed by (1) designing trails in alignments that require less ongoing maintenance and are, therefore, less costly to maintain, (2) defining an overarching vision for the trail system that park staff and stakeholders can work toward, and (3) outlining relative priorities for trails-related

projects to guide the limited investment of time, energy, and financial resources by park staff and partners.

While improving the physical, social, and managerial sustainability of the trail system generally means a shift away from the use of relict roadbeds and utility corridors toward more purpose-built trails, in some cases, these existing routes would continue to be used to minimize new disturbance and protect cultural resources.

Proposed Land Trails and Associated Facilities

Table 5 summarizes the proposed trails in alphabetical order, including trail name, location, use type, trail category, and mileage. Trails that include a backcountry campsite are noted as well. Because of rounding, numbers presented may not add up precisely to the totals provided.

Table 5. Proposed Trails under Alternative 2

Trail Name	Map Code	Use Type			Trail Category	Backcountry Campsite	Mileage
		Pedestrian Only	Pedestrian & Equestrian	Pedestrian & Bicycle			
Bransford Cemetery Trail	BC	✓			Moderately developed	No	0.3
Brooks Knob Lookout	BKL	✓			Moderately developed	No	0.3
Brooks Knob Road Trail (up to gate)	BK			✓	Moderately developed	No	0.2
Brooks Knob Road Trail (past gate)	BK	✓			Semi-primitive	Yes	1.0
Brooks Knob Road Cemetery Trail	BKC			✓	Moderately developed	No	0.4
Cedar Sink North Access	CSN	✓			Developed	No	0.7
Cedar Spring Ridge Trail	CSR	✓			Primitive	No	2.8
Crystal Cave Road	CCR2			✓	Developed	No	0.1
Doyle Valley Trail	DV	✓			Primitive	Yes	4
Dry Branch	DB	✓			Developed	No	0.9
East Entrance Trail	EE			✓	Developed	No	2.8
Flint Ridge Loop Trail	FR	✓			Primitive	No	6.5
Hunt Sink Connector	HSC	✓			Primitive	No	0.3
Hunts Sink Loop	HSL	✓			Developed – accessible*	No	1

Trail Name	Map Code	Use Type			Trail Category	Backcountry Campsite	Mileage
		Pedestrian Only	Pedestrian & Equestrian	Pedestrian & Bicycle			
Laurel Overlook Trail	LO	✓			Primitive	Yes	1
Lick Log Nature Trail	LL	✓			Primitive	No	2.1
Little Hope Cemetery Trail	LH			✓	Moderately developed	No	0.1
Maple Springs Road	MSR		✓		Developed	No	0.7
Maple Springs Road Connector	MSR		✓		Developed	No	0.2
McCoy Hollow	MH1		✓		Semi-primitive	No	0.9
McCoy Hollow Extension	MHE		✓		Semi-primitive	No	1.3
Orchard Trail	OT	✓			Primitive	No	0.6
Raymer Hollow	RH2		✓		Moderately developed	No	1.3
Ridge Top Trail	RT		✓		Moderately developed	No	1.2
Sandhouse Trail	SHS	✓			Primitive	No	0.02
Silent Grove Loop Trail	SG	✓			Primitive	Yes (2)	3.9
Sugar Camp Road	SCR		✓		Moderately developed	No	2.3
Sugar Sink Connector	SSC			✓	Semi-primitive	No	0.2
Sugar Sink Trail	SS			✓	Semi-primitive	No	3.8
Triple Falls River Trail	TF	✓			Primitive	No	0.3
Turnaround Trail	TA		✓		Moderately developed	No	0.4
Turnhole Bend Trail	TBD	✓			Primitive	No	0.5
Two Rivers Trail	TR	✓			Primitive	No	1.4
Valley Trail	VT	✓			Primitive	No	1.9
West Entrance	WE			✓	Developed	No	11.2
White Pine Trail	WPT	✓			Primitive	No	1.7
Wildcat Hollow Trail	WH		✓		Moderately developed	No	0.8

Trail Name	Map Code	Use Type			Trail Category	Backcountry Campsite	Mileage
		Pedestrian Only	Pedestrian & Equestrian	Pedestrian & Bicycle			
Wondering Woods Loops	WW	✓			Developed	No	1.9
Woolsey Valley Trail	WV	✓			Primitive	Yes	6.3

* Trails listed as "Developed – accessible" were designed to meet the majority of ABAAS accessible trail standards, but current conditions may vary.

In addition to the backcountry campsites on the newly proposed trails, one backcountry campsite would be added to the existing White Oak Trail.

Table 6 summarizes the proposed facilities to support land trail use. Details include facility location, type of features included, the approximate size, trails supported by the facility, and the trail categories supported by the facility. For sizing, a small facility is about 0–5 parking spaces (e.g., Park City entrance sign), a medium facility is about 5–10 parking spaces (e.g., Locus Grove/Cedar Sink), and a large facility is about 10–20 parking spaces (e.g., Green River Ferry). Facilities are listed alphabetically.

Table 6. Proposed Facilities under Alternative 2

Facility Location	Features Type				Approximate Size	Supports Trails	Trail Categories Supported by Facility
	Bike Rack	Information Kiosk	Parking	Restroom			
Brooks Knob Road	✓ (2)	✓	✓	✓	Small (gravel)	Brooks Knob Road, West Entrance Bike and Hike	Moderately developed/ developed
Cedar Sink	✓					West Entrance Bike and Hike, Cedar Sink North access	Primitive, developed
East Entrance	✓					East Entrance Bike and Hike, Sand Cave	Developed
Flint Ridge Loop		✓		✓		Flint Ridge Loop, Bransford Cemetery, Great Onyx Road, White Pine	Primitive, semi-primitive, moderately developed

Facility Location	Features Type				Approximate Size	Supports Trails	Trail Categories Supported by Facility
	Bike Rack	Information Kiosk	Parking	Restroom			
Hunts Sink Loop		✓ (2)	✓	✓	Medium (paved)	Hunt Sink Connector, Hunts Sink Loop, Valley Trail	Primitive, developed
Silent Grove	✓	✓				Silent Grove Loop, West Entrance Bike and Hike	Primitive, developed
Sloan's Crossing	✓			✓		Sloan's Crossing, Woolsey Valley Trail, Bike and Hike	Primitive, developed
South Entrance	✓					Bike and Hike	Moderately developed
Sugar Sink	✓	✓	✓	✓	Large (gravel)	Sugar Sink, Big Hollow, Maple Springs, Mill Branch	Semi-primitive, moderately developed
Turnhole Bend Nature Trail	✓			✓		Turnhole Bend Nature, Turnhole Bend, Sandhouse Trail, Western Bike and Hileq	Primitive, developed
West Entrance via Deer Park Hollow Road	✓					West Entrance Bike and Hike	Developed
Wondering Woods Loop	✓			✓		Wondering Woods Loops	Developed
Woolsey Valley Trail (west access)		✓				Woolsey Valley Trail, Cedar Sink	Primitive, developed

In addition to the newly proposed facilities listed above, the following existing parking lots would be improved as follows:

- Little Hope Cemetery parking lot: Improved drainage within existing footprint, maintain current small size
- McCoy Hollow parking lot: Improved to support horse trailer use, maintain existing small size and gravel surface

- Wildcat Hollow parking lot: Improved to support horse trailer use, maintain existing small size and gravel surface

Proposed Changes to Roads

One section of the NPS-owned Ugly Creek public road (approximately 1 mile in length) would be converted from a public road to administrative road. On this administrative section of Ugly Creek Road, only hiking and bicycling would be allowed. In addition to the current uses of biking and hiking (and driving), equestrian use would be allowed on Houchin Ferry North / Ollie Road (5.4 miles). A separate special regulation process would occur to permit this change to the roads. All other public and administrative roads would continue to remain closed to equestrian use. The limited existing bicycle use on White Oak Trail (2.5 miles in length) would be disallowed as part of this plan.

Proposed River Facilities

Two facility types would be developed along the river trail to support river use: primitive takeouts and river campsites, as described below. These designated facilities would help concentrate the impacts of use along the riverbank and increase visitor safety. For both primitive takeouts and river campsites, signs along the river trail would identify the river facilities.

- Primitive takeouts would be developed in areas determined appropriate for river access. These primitive takeouts would be minimally engineered with natural processes in mind and would blend in with the natural environment (i.e., boulders).

- River campsites would be developed in areas determined appropriate for overnight camping via river trail. These river campsites would be in high elevation areas for overnight use. These river campsites would have a campfire ring, tent pad, hook for lantern, and would be reservable in advance online.

Table 7 summarizes the proposed river facilities.

Table 7. Proposed River Facilities

River	Que	Primitive Takeout Facility	Reservable River Campsite Facility	Intersection
Green River	River left	✓		Crump Island
Green River	River left		✓	Nolin confluence
Green River	River left	✓		Turnhole Bend
Nolin River	River left		✓	Bylew Creek confluence
Nolin River	River left	✓		First / Second Creek confluence

In addition to these facilities, park staff would increase education on Leave No Trace (LNT) on river trails, especially regarding human waste. Park staff would work with CUA permit holders

to encourage boat use on the less-used river segments to reduce crowding and congestion from the Dennison day use area to the Green River Ferry.

Decommissioned Trails

Some of the park's current official trails are not sustainable and/or do not provide a desired trail experience. Under this alternative, four trail segments would be decommissioned and restored to natural conditions. Decommissioned trails would be obscured and blocked from public access to avoid continued use. Restoration would include reshaping soils to pre-trail conditions, planting or transplanting local/native vegetation, and obscuring the visual corridor. The extent of revegetation, obscuring, and blocking efforts would vary depending on the location and specific conditions for each route. In some instances, recontouring the trail may involve placing gravel or clean fill to stabilize the trail. Exposed soils would be monitored for germination and recruitment of nonnative species. Planting and seeding of nonnative species would be avoided. Water management structures would need to be created in this process to eliminate long-term, water-based erosion along these routes. Temporary educational/closure signs may also be placed to discourage use.

The following existing trails would be removed from the trail system due to the following rationale:

- **Dry Prong Trail (DP).** This 1.5-mile trail is highly eroded and extremely muddy, with a recorded average maximum incision of 4.0 inches in 2021 (Brownlee and Sharp 2022). The maximum incision is the vertical depth of a trail surface beneath its intended constructed tread surface. The trail's current use is very low (0.5% in 2021), and its condition is beyond repair. Alternate connections via Wet Prong Trail support continued use in this area. The Homestead campsite and hitching post at the end of the trail at the Homestead Campground would stay in use.

- **Maple Springs Connector (MSR).** This 0.3-mile trail would be decommissioned due to extensive visitor use conflicts (equestrian feces/urine pools on biking route, bicycles surprising horses and riders), which would be addressed by other new additions in the preferred alternative (i.e., a parking lot at the Sugar Sink trailhead to separate the uses).

- **McCoy Hollow Trail (MH1).** Two sections of the McCoy Hollow Trail would be decommissioned. These sections are from the Temple Hill parking lot to the section of McCoy Hollow along the river and from the Wet Prong Trail to the new McCoy Hollow trail connection, totaling 2.3 miles. These sections are highly eroded and extremely muddy, presenting treacherous safety conditions, with a recorded total loss of 19,147.7 cubic feet of soil and 123 informal trails in 2021 (Brownlee and Sharp 2022). By allowing equestrian use on Houchin Ferry Road, pending legislative rulemaking, loop connections in this area of the park would be maintained.

- **Mill Branch Trail (MB).** This 1.9-mile trail is highly eroded and extremely muddy, with a recorded average maximum incision of 4.5 inches and 97 informal trails in 2021 (Brownlee and Sharp 2022). The trail's current use is very low (0.3% in 2021), its condition is beyond repair, and it passes through a sensitive native plant area. Alternate

connections via Wet Prong Trail and Raymer Hollow Trail would provide other trail loops in this area.

Figure 4 shows the proposed trails and facilities under alternative 2. Trail names are portrayed as map codes in the image below. See Table 5. Proposed Trails under Alternative 2," for map code names.

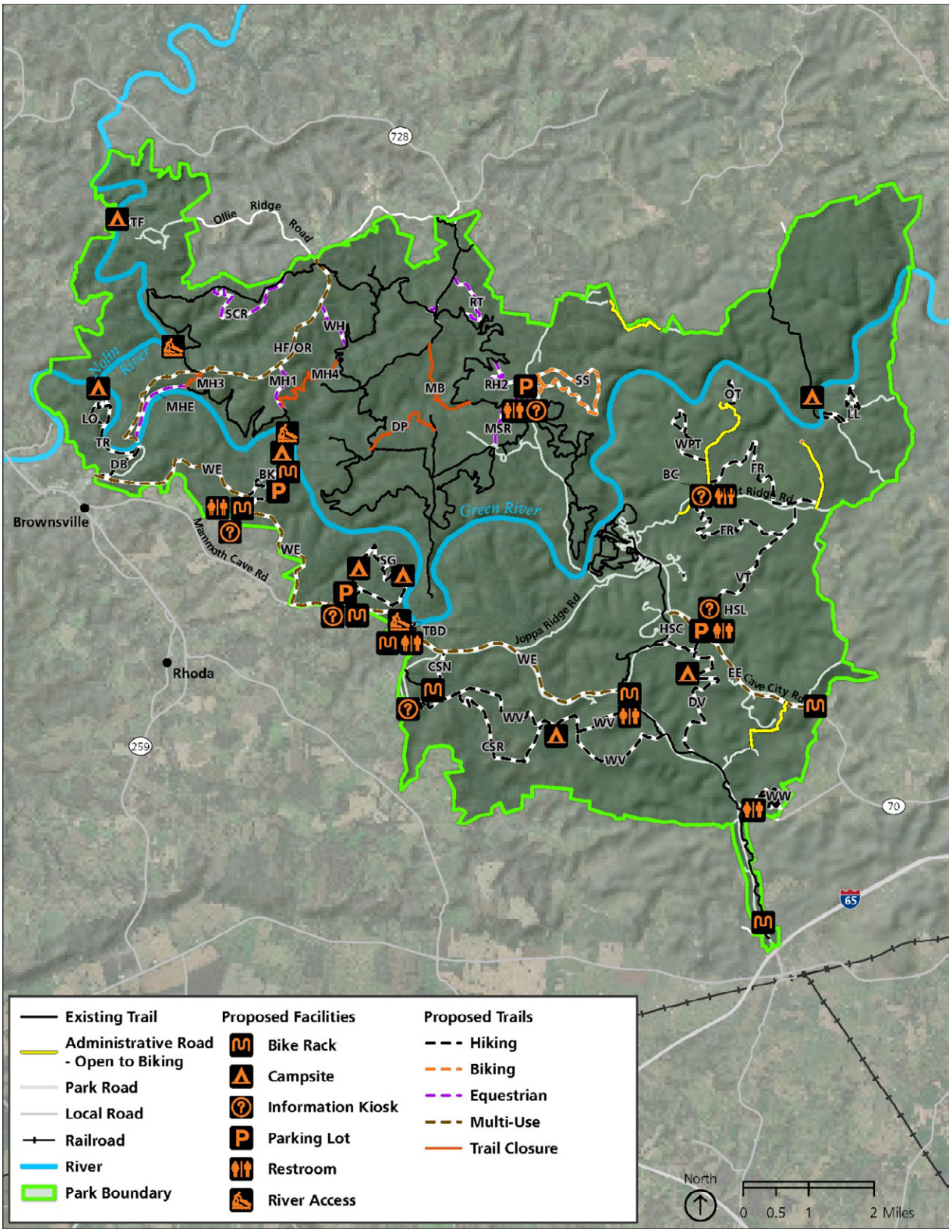

FIGURE 4. PROPOSED TRAILS AND FACILITIES UNDER ALTERNATIVE 2

Trail Rehabilitation

Some existing trails require a significant investment in one-time rehabilitation work to establish proper drainage, correct a safety concern, or remedy an extremely poor trail condition. This one-time maintenance effort could include earthwork to establish drainage ditches, grade reversals, rock armoring, additional clean fill, and brush clearing. Trails with high visitor use and erosion concerns would be prioritized for hardening. These trails would generally follow their current alignment. The Blair Springs Hollow Trail would be rehabilitated with miles of hardened sections to improve the surface and drainage. This rehabilitation would make the trail appropriate for beginner equestrians.

High-Water Closures

Currently, the Green River is closed to all use when the stream gauge exceeds 20 feet. Under the preferred alternative, the Superintendent's Compendium would be amended so that only commercial livery services would be suspended when the stream gauge exceeds 20 feet. This change would allow more experienced private paddlers to access and experience the river at higher and more dynamic stream flows while continuing to protect the safety of less experienced paddlers who often use livery services when conditions are generally unsafe for this user group. Messaging would emphasize to private paddlers that emergency response may be delayed and/or unavailable during high water.

Seasonal Closure to High-Powered Motorboats

Currently, the Green River is open to all motorboat use. Under the preferred alternative, the Superintendent's Compendium would be amended so that motorboats with a functional output exceeding 40 horsepower would be prohibited from April 15 through October 15. This change would protect the safety of nonmotorized river users during the primary paddling season by preventing large motors and accompanying wakes and speeds from occurring on the river in close proximity to high densities of nonmotorized craft.

Wet Weather Closures

Certain trails would be closed to equestrian and bicycle use in wet weather conditions to prevent erosion and protect park resources. Soil moisture data would be collected at several locations that are representative of the soil types, drainage, and aspects of the trails that would be impacted by wet weather closures. This data would be used as the determining factor for whether trails need to be closed due to soil moisture content. Wet weather conditions would be communicated online so visitors would know whether trails are open for use. Information would be available at the trailheads of trails affected by wet weather closures advising visitors to check the status of the trail online to ensure it is open for use (via an app, text-for-status system, or similar). Signs with active status would not be placed on trails due to staffing limitations. Wet weather closure trails would only be open to pedestrian use during wet weather. The following trails would be subject to wet weather closures to protect resources:

- First Creek
- First Creek Campsite 1
- First Creek Campsite 2
- Sal Hollow
- Sal Hollow campsite
- Second Creek Campsite
- Big Hollow – North Loop
- Big Hollow – South Loop
- Sugar Sink Loop
- McCoy Hollow

Unauthorized Visitor-Created Trails

Existing unauthorized visitor-created trails, or social trails, that are not designated on maps as a proposed trail would be restored to natural conditions (as described above) or designated as part of the trail system, where appropriate. One exception is unauthorized trails that access the riverbank (short "anglers' trails"), which would generally be left in place due to the impracticality of restoring them. Signage would be added to certain formal angler trails to encourage riverbank access in more stable areas (locations are reflected in appendix B).

Resulting Trail Network

Table 8 summarizes the resulting trail mileage under alternative 2. The resulting trail mileage is a summation of existing and proposed trails minus decommissioned trails. Approximately 66 miles of trails would be added to the official trail system, resulting in a 72% net increase in trail mileage. Because of rounding, numbers presented may not add up precisely to the totals provided.

Table 8. Resulting Trail System Mileage

Trail Name	Trail Code	Use Types			Trail Category	Mileage
		Pedestrian Only	Pedestrian & Equestrian	Pedestrian & Bicycle		
Existing Trails						
Amphitheater	AM	✓			Developed	0.2
Big Hollow N	BHN			✓	Semi-primitive	5.0
Big Hollow N Shortcut	BHNS			✓	Semi-primitive	0.1
Big Hollow South	BHS			✓	Semi-primitive	3.7
Blair Springs Hollow	BSH		✓		Moderately developed	1.8
Bluffs Campsite	BCS	✓			Moderately developed	0.6
Buffalo Creek	BCR	✓			Moderately developed	4.4
Cabins	CN	✓			Developed	0.2

Trail Name	Trail Code	Use Types			Trail Category	Mileage
		Pedestrian Only	Pedestrian & Equestrian	Pedestrian & Bicycle		
Cedar Sink	CS	✓			Developed	1.0
Collie Ridge	CR		✓		Moderately developed	3.8
Collie Ridge Campsite	CRC		✓		Moderately developed	0.7
Dixon Cave	DC	✓			Developed	0.4
Dixon Cave Overlook	DCO	✓			Developed	0.1
Dry Prong	DP		✓		Moderately developed	0.8
Echo River Spring Overlook	ESRO	✓			Developed	0.01
Echo River Spring Trail Paved	ERS	✓			Developed – accessible*	0.6
Engine No. 4	E4	✓			Developed	0.2
Ferguson Campsite	FCS		✓		Moderately developed	0.6
First Creek (lower)	FC		✓		Semi-primitive	4.3
First Creek (upper)	FC		✓		Moderately developed	2.0
First Creek Campsite 1	FC1		✓		Semi-primitive	0.3
First Creek Campsite 2	FC2		✓		Semi-primitive	0.1
Green River Bluffs	GR	✓			Developed	1.3
Green River Bluffs – Riverbank Spur	GRB	✓			Developed	0.04
Heritage	HT	✓			Developed – accessible*	0.5
Heritage – Sunset Lodge Access	HS	✓			Developed	0.02
Historic Entrance	RE	✓			Developed	0.2
Homestead Campsite	HC		✓		Moderately developed	0.3
Mammoth Cave Railroad Bike and Hike – North	RR2			✓	Developed	9.3
Mammoth Cave Campground	MC	✓			Developed	0.2
Maple Springs Campground	MSC		✓		Moderately developed	0.2

Trail Name	Trail Code	Use Types			Trail Category	Mileage
		Pedestrian Only	Pedestrian & Equestrian	Pedestrian & Bicycle		
Maple Springs Research Center	MSRC	✓			Moderately developed	0.04
McCoy Hollow	MH2		✓		Semi-primitive	4.1
McCoy Hollow Campsite	MHC		✓		Semi-primitive	0.2
Miles-Davis Cemetery	MD	✓			Moderately developed	0.4
Mill Branch (east)	MB		✓		Moderately developed	1.1
Old Guides	OG	✓			Developed	0.1
Old Guides Cemetery	OGC	✓			Developed	0.04
Raymer Hollow	RH1		✓		Moderately developed	1.0
Raymer Hollow	RH3		✓		Moderately developed	6.2
Raymer Hollow Campsite	RHC		✓		Semi-primitive	0.1
River Styx Spring	RS	✓			Developed	0.4
River Valley	RV	✓			Developed	0.3
Sal Hollow	SHL		✓		Semi-primitive	8.6
Sal Hollow Campsite	SHC		✓		Semi-primitive	0.1
Sal Hollow Trail Alternative Access	SHA		✓		Semi-primitive	0.1
Sand Cave	SC	✓			Developed – accessible*	0.1
Second Creek Campsite	SCC		✓		Semi-primitive	0.2
Sinkhole	SH	✓			Developed	1.0
Sloan's Crossing Pond Walk	SCP	✓			Developed – accessible*	0.4
Stables	SB		✓		Moderately developed	0.3
Sunset Point	SP	✓			Developed	0.3
Three Springs Campsite	TSC		✓		Semi-primitive	0.1
Turnhole Bend	TB		✓		Moderately developed	1.9
Turnhole Bend Nature	TBN	✓			Developed	0.5

Trail Name	Trail Code	Use Types: Pedestrian Only	Use Types: Pedestrian & Equestrian	Use Types: Pedestrian & Bicycle	Trail Category	Mileage
Two Springs Trail	TS	✓			Developed	0.6
Wet Prong	WP		✓		Moderately developed	4.6
White Oak Trail	WO	✓			Primitive	2.5
Whites Cave	WC	✓			Developed	0.6
Total mileage of existing trails: 85 miles						
Proposed Trails						
Bransford Cemetery Trail	BC	✓			Moderately developed	0.3
Brooks Knob Lookout	BKL	✓			Moderately developed	0.3
Brooks Knob Road Trail (up to gate)	BK			✓	Moderately developed	0.2
Brooks Knob Road Trail (past gate)	BK	✓			Semi-primitive	1.0
Brooks Knob Road Cemetery Trail	BKC			✓	Moderately developed	0.4
Cedar Sink North Access	CSN	✓			Developed	0.7
Cedar Spring Ridge Trail	CSR	✓			Primitive	2.8
Crystal Cave Road	CCR2			✓	Developed	0.1
Doyle Valley Trail	DV	✓			Primitive	4.0
Dry Branch	DB	✓			Developed	0.9
East Entrance Trail	EE			✓	Developed	2.8
Flint Ridge Loop Trail	FR	✓			Primitive	6.5
Hunt Sink Connector	HSC	✓			Primitive	0.3
Hunts Sink Loop	HSL	✓			Developed – accessible*	1.0
Laurel Overlook Trail	LO	✓			Primitive	1.0
Lick Log Nature Trail	LL	✓			Primitive	2.1
Little Hope Cemetery Trail	LH			✓	Moderately developed	0.1

Trail Name	Trail Code	Use Types			Trail Category	Mileage
		Pedestrian Only	Pedestrian & Equestrian	Pedestrian & Bicycle		
Maple Springs Road	MSR		✓		Developed	0.7
Maple Springs Road Connector	MSR		✓		Developed	0.2
McCoy Hollow	MH1		✓		Semi-primitive	0.9
McCoy Hollow Extension	MHE		✓		Semi-primitive	1.3
Orchard Trail	OT	✓			Primitive	0.6
Raymer Hollow	RH2		✓		Moderately developed	1.3
Ridge Top Trail	RT		✓		Moderately developed	1.2
Sandhouse Trail	SHS	✓			Primitive	0.02
Silent Grove Loop Trail	SG	✓			Primitive	3.9
Sugar Camp Road	SCR		✓		Moderately developed	2.3
Sugar Sink Connector	SSC			✓	Semi-primitive	0.2
Sugar Sink Trail	SS			✓	Semi-primitive	3.8
Triple Falls River Trail	TF	✓			Primitive	0.3
Turnaround Trail	TA		✓		Moderately developed	0.4
Turnhole Bend Trail	TBD	✓			Primitive	0.5
Two Rivers Trail	TR	✓			Primitive	1.4
Valley Trail	VT	✓			Primitive	1.9
West Entrance	WE			✓	Developed	11.2
White Pine Trail	WPT	✓			Primitive	1.7
Wildcat Hollow Trail	WH		✓		Moderately developed	0.8
Wondering Woods Loops	WW	✓			Developed	1.9
Woolsey Valley Trail	WV	✓			Primitive	6.3
Total mileage of proposed trails: 66 miles						

Trail Name	Trail Code	Use Types: Pedestrian Only	Use Types: Pedestrian & Equestrian	Use Types: Pedestrian & Bicycle	Trail Category	Mileage
Decommissioned Trails						
Dry Prong	DP		✓		Moderately developed	1.5
Maple Springs Connector	MSC		✓	✓	Semi-primitive	0.3
McCoy Hollow (segment 1)	MH3		✓		Moderately developed	0.8
McCoy Hollow (segment 2)	MH4		✓		Moderately developed	1.5
Mill Branch (west)	MB		✓		Moderately developed	1.9
Total mileage of decommissioned trails: 6.0 miles						

* Trails listed as "Developed – accessible" were designed to meet the majority of ABAAS accessible trail standards, but current conditions made vary.

Figure 5 shows the resultant trail network and facilities under alternative 2. Trail names are portrayed as map codes in the image below. See table 8 above for map code names.

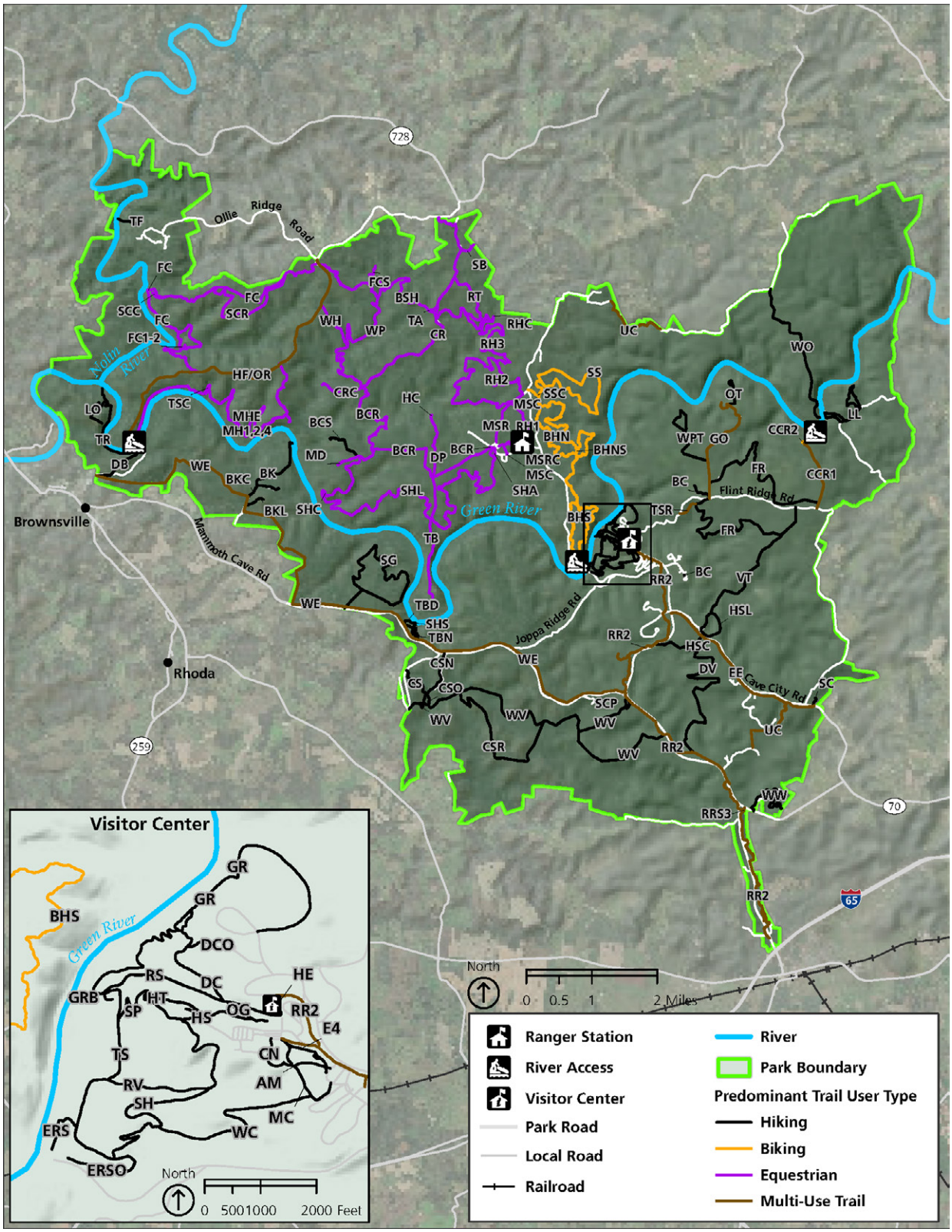

FIGURE 5. RESULTANT TRAIL NETWORK AND FACILITIES

Trail Improvements

The following improvements would apply to all existing and newly proposed trails parkwide.

Trail Names, Signs, and Markers

Trail names throughout the park would be updated as needed and formally designated for consistency. These names would be used consistently on signage, maps, and other informational materials to improve wayfinding, trip planning, and a sense of place. Trails and destinations would be clearly marked with signs. Signage located at trailheads and trail access points would be standardized and improved to (1) provide an inviting gateway to the park's trail system, (2) set appropriate expectations about the experiences visitors are likely to have, and (3) provide wayfinding information and basic rules and regulations.

Trailhead signs would provide the following information: trail type (loop or out and back), trail use (equestrian, bikes, hiking), difficulty, distance, map, grade for accessibility, and estimated time to complete the trail. Overall, wayfinding would be provided either on a physical sign or digitally through a QR code to the park website, park mobile application, or third-party trail application. Consistent with desired conditions for the trail's category, signage on the trails could provide directions and trail markers with unique color and shape combinations specific to each trail. Trail markers would be installed at trail junctions and destinations, as necessary.

Where appropriate, existing postholes and disturbed areas would be used for new sign installations.

Trail Etiquette and Leave No Trace

Educational materials (signs, information at the visitor center, social media) would be increased for appropriate trail etiquette among different recreational groups (i.e., bikers yield to pedestrians, pedestrians yield to horses and move to the side of the trail). Education on LNT principals would be increased, especially regarding human waste.

Partnerships

Existing partnerships would be expanded to take a prominent role in maintaining certain trails. In the past the Big Hollow trail loops have been maintained with the assistance of the Kentucky Mountain Bike Association and are in excellent condition as a result of this partnership. Park managers seek to expand this partnership to include the maintenance of new biking trails. Park managers also seek to create a similar type of partnership with the equestrian and hiking stakeholders to facilitate more proactive maintenance of the equestrian and hiking trails. Park managers seek to form partnerships with the neighboring towns that are connected to the park via the hike-and-bike trail as well.

Reporting Trail Issues

A method would be created for visitors to report trail issues that need to be resolved by appropriate park staff, such as downed trees and other safety concerns. The application would provide one-way communication from visitors to park staff, and park staff would determine the appropriate actions to take (if any) based on the severity and type of issue being reported.

Examples of helpful trail issues to report include a fresh tree fall that prohibits safe travel on a trail (land or river).

Accessibility

The terrain at Mammoth Cave National Park presents inherent challenges to creating and maintaining accessible trails and outdoor constructed features. Park staff are committed to exploring ways of improving trails and supporting facilities, such as parking areas, pedestrian routes, constructed features, and signage, to meet current accessibility standards and best practices. The interdisciplinary planning team is conducting a preliminary review of conditions to better understand the feasibility of accessible trail conditions for each of the trails in the preferred alternative. As trails and facilities are constructed or improved, park staff will ensure compliance with Architectural Barriers Act Accessibility Standards to the extent practicable and document all instances when qualifying conditions for exception are met. For additional information on accessibility requirements for trails, refer to "Appendix H: Accessibility."

Invasive Species Management

The management of invasive species could include a number of preventative actions, including education (e.g., LNT principles), boot brushes, approved herbicides and pesticides, bike tire cleaning stations, and encouraging weed-free feed for equestrian use.

Final Alignment for Trails

The new trail alignments shown on the maps are based on field surveys and geographic information system (GIS) analysis. The new trail alignments have been determined at the corridor level, defined as a 60-foot-wide corridor within which the new trail would be constructed. The width of the trail tread and shoulders in the corridor would be determined by the trail categories. Final trail alignments would be determined on the ground upon implementation and in consultation with park natural and cultural resources specialists, which could result in minor adjustments to the trail locations shown on the maps. If a need existed to align a trail outside of the identified corridor, the amended alignment would undergo additional review to avoid or minimize impacts on sensitive resources, and the change would be documented as an amendment to the trails management plan.

Implementation

To successfully implement this trails management plan, the National Park Service would likely hire a trail lead who would work with park staff, contractors, partners, and volunteers to implement the plan actions and conduct routine maintenance of the trail system. Qualified professional trail construction contractors may be hired to complete some of the construction or rehabilitation as needed. Individual volunteers and volunteer groups would continue to provide a valuable service by assisting park staff with trail maintenance activities, monitoring trail conditions, providing information to visitors, and protecting resources. Partnerships would continue to play a maintenance role. The trail lead and volunteer program coordinator would collaborate on implementation efforts. All trail work in the park would follow the guidance provided in the appendix C.

All trails and destinations would undergo routine maintenance activities, as funding and staffing allow, to include the repair and replacement of trail surface and trail markers and signage. Some areas may require annual or semiannual maintenance, while other areas may not require maintenance for five or more years.

New trail development and the restoration of unsustainable trails would take place as funding and staffing allow. Park staff would develop the implementation schedule after this planning effort is complete. Over time, staff could modify the implementation schedule based on funding, staffing, and equipment availability and whether user groups and organizations could partner/assist with trail development and restoration efforts.

The implementation of the preferred alternative would be subject to available funding and staff and would be done in a phased manner as resources allow. Park staff would create a strategy to guide the phased approach following this planning effort. Park staff could work with appropriate partners to raise funds for high-priority trail projects. In addition, park staff may work with partner organizations to explore opportunities for partners to provide donations (funds and in-kind donations such as supplies and materials and volunteer hours to support trail maintenance).

Visitor Use Management

This plan incorporates aspects of the IVUMC Visitor Use Management Framework (https://visitorusemanagement.nps.gov/) to develop long-term strategies for monitoring and managing visitor use in the park. Key aspects of visitor use management incorporated into the preferred alternative include the identification of indicators, as well as visitor capacities.

Indicators, Thresholds, and Objectives

Monitoring in this plan is accomplished through the establishment of indicators, thresholds, and objectives. Indicators are specific resource or experiential attributes that can be measured to track changes in conditions so that progress toward achieving and maintaining desired conditions can be assessed. Thresholds are the minimum acceptable conditions associated with each indicator. Objectives are specific, positive targets for resource conditions or visitor experiences. Indicators, thresholds, and objectives provide park managers with a monitoring framework to ensure desired conditions for resources and visitor experiences are achieved and maintained over time.

The planning team considered many potential indicators but ultimately identified five that are the most important to monitor the effectiveness of the land and river trails plan. The five issues or topics the indicators monitor include encounter rates on land trails, boats per view on water trails, the cross-sectional area of trails, trail maintenance costs, and bare ground in riparian areas. Other related monitoring of visitor concerns would also monitor conditions related to visitor conflicts and wayfinding.

Appendix A contains detailed descriptions of the indicators, as well as other related monitoring. With each indicator, a threshold or objective is identified, the rationale for selecting the indicator and identifying the threshold/objective is described, and the potential strategy for monitoring is outlined. Lastly, management strategies that may be taken in association with the

indicator are included. These strategies are divided into two groups: (1) strategies that are identified in chapter 3's description of the preferred alternative and would assist in managing within the identified threshold, and (2) strategies that may be implemented if and when monitoring reveals conditions are approaching or exceeding the identified threshold or failing to meet the objective. The impacts of these management strategies are analyzed in chapter 4.

Visitor Capacity

Visitor capacity is the maximum amount and types of visitor use that an area can accommodate while sustaining desired resource conditions and visitor experiences consistent with the purpose for which the area was established (IVUMC 2016). By establishing visitor capacities and implementing them with appropriate management strategies, the National Park Service can help ensure that resources are protected and that visitors have the opportunity for a range of high-quality experiences.

Pursuant to Director's Order 2: *Park Planning*, this plan is considered an implementation-level plan that addresses the legal requirement for general management plans (54 USC 100502 [United States Code]) to identify and implement visitor capacities for all areas of a system unit. Mammoth Cave National Park's land and water trail system has no prior identification of visitor capacity, though other parts of the park do. See appendix B for the visitor capacities that were identified for trails included in this plan, as well as a list of management strategies in the plan that implement the visitor capacities.

Adaptive Visitor Use Management

Visitor use management is an iterative process in which management decisions are continuously informed and improved through monitoring to determine the most effective way to manage visitor use. Assessing the outcome of management actions is necessary to ensure that management actions are having their intended effects and that desired conditions are maintained.

As the monitoring of conditions continues, managers may decide to modify or add indicators and/or thresholds if better ways are found to measure important changes in resource and experiential conditions. Likewise, visitor capacities may need to be adjusted over time in response to improved understanding of the relationship between visitor use and impacts on desired conditions. The rationales to adapt any indicators, thresholds, visitor capacities, or their associated management strategies would be documented appropriately, undergo any necessary additional compliance reviews, and be made available to the public.

STAFFING AND COST ESTIMATES

Implementation of the preferred alternative would be subject to available funding and staff and would be done in a phased manner as resources allow. Park staff would create a strategy to guide the phased approach following this planning effort.

Mammoth Cave National Park has a history of successful philanthropic partnerships, including collaborative projects that have funded trail construction and design. The park also relies on a dedicated and active volunteer corps to support ongoing trail maintenance. Building on the

legacy of trail-centered philanthropy and volunteerism, the park plans to work with partner and volunteer groups to fund, construct, demarcate, monitor, and maintain the trail alignments set forward in the preferred alternative. This reliance on partner resources and fundraising for trail system improvements is a basic tenant of this planning effort. Alternative 2 is a roadmap for trail system improvements in the park over the next 20 years of implementation. Neighboring trail system managers should look to the proposals of the alternative when making external connections to park trail systems. Park managers may pursue partnership opportunities with organizations using the proper partnership agreement. The costs and operation implications of the alternatives are an important consideration in comparing them and determining their advantages and disadvantages. The costs and staff needs in table 9 are estimates for comparison purposes only and are not to be used for budgetary purposes or implementation funding requests. When the actions in the land and river trails plan are implemented, actual costs would likely vary from what is presented below.

Table 9. Estimated Costs and Full-Time Employees (FTE) for 20 Years

FTE/Costs	Alternative 1 (No Action)	Alternative 2 (Preferred)
Mammoth Cave National Park FTE		
Current park FTE	126	126
Additional FTE (maintenance staff – trail crew and lead)	0	0*
Total FTE	126	126
Annual Operating Costs		
Current ONPS**	$7,341,770	$7,341,770
Additional maintenance cost***	0	$124,303
Total Annual Cost ONPS	$7,341,770	$7,466,073
One-Time Costs		
Trail construction (including facilities and trailheads)	0	$11,787,808
Total One-Time Costs	–	$11,787,808

* Park will be using three Inflation Reduction Act hires
** Operation of the National Park System
*** Including 20-year annualized average

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Chapter 4
Affected Environment and Impact Analysis

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CHAPTER 4: AFFECTED ENVIRONMENT AND IMPACT ANALYSIS

INTRODUCTION

This chapter describes the resources that could be affected and the potential environmental consequences of implementing one of the alternatives being considered.

The topics presented are those related to the key issues that could inform the NPS decision about how to manage the park's trail system. The descriptions of the resources in this chapter serve as baseline conditions against which the potential effects of the proposed actions can be compared.

Included in this analysis are vegetation, soils, special status bats, special status mussels, cave and karst resources, water quality, visitor use and experience, archeological resources, and cultural landscapes and historic structures.

VEGETATION

Affected Environment (Current and Future Conditions of Resources)

The park is located in the transitional zone between historic open grasslands and drier oak-hickory forests to the west and the moister mixed mesophytic forests to the east. The park is likewise located transitionally between the subtropical climates to the south and the colder climates to the north. The result is a mixed mesophytic forest with many of the plant species found in the park at their northern, southern, eastern, or western limits of their natural range. The park has 1,185 species (1,265 documented species, varieties, or subspecies) of vascular plants in the park (Pyne et al. 2010). The park has dry upland flats and sandstone-capped ridges, limestone exposed slopes, ravines and karst valleys, broad alluvial bottoms along the Green River, gorge-like hemlock ravines, deep sinks with exposed otherwise subterranean streams, old-growth timber, successional growth forests, barrens and savannah habitats, and wetlands.

Invasive plant species are an ongoing threat to native vegetation. Over 10% of plant species in the park are nonnative to the area. Approximately 100 of those nonnative species have been deemed to have invasive qualities or to represent a threat to native biodiversity in Kentucky or Tennessee (Pyne et al. 2010; Leech 2024). In the interior woods and forests, shrubs and vines, such as Japanese honeysuckle (*Lonicera japonica*), multiflora rose (*Rosa multiflora*), and periwinkle (*Vinca minor*), have colonized areas of the understory (Pyne et al. 2010; Leech 2024). Most of the floodplains and lower slopes in the park now have large infestations of garlic mustard (*Alliaria petiolata*), ground ivy (*Glechoma hederacea*), and Japanese stilt grass/Nepalese browntop (*Microstegium vimineum*) (Pyne et al. 2010).

Past actions in the park have resulted in ground disturbance, the removal of native vegetation, and the subsequent establishment of invasive exotic plants. Most, if not all of the entire surface of the park was logged at least once before the creation of the park. Significant portions of the upland acreage were cultivated or pastured agricultural land at the time of park establishment, and this land is today occupied by various kinds of successional hardwood or evergreen forests (Pyne et al. 2010). Additionally, the Civilian Conservation Corps undertook extensive tree

planting efforts in the park to reclaim former farmland and clearings, contributing to reforestation efforts. The construction, maintenance, and use of existing buildings, roads, and trails have created disturbed soil areas where invasive plant populations have become established. These plant populations continue to serve as sources of seed, causing persistent adverse impacts on native plants. Historic fire suppression also changed natural vegetation succession patterns across the park.

The ongoing implementation of the park's 2019 fire management plan will have long-term beneficial impacts on park vegetation by reducing nonnative plant species; enhancing the diversity, structure, composition, and integrity of fire-dependent vegetation communities; and reducing the potential for larger intense wildfires (NPS 2019). The ongoing implementation of invasive plant monitoring and control efforts will reduce the adverse impacts of nonnative plant species on native vegetation communities.

Additional threats to vegetation include trail widening and braiding, visitor-created social trails, and climate change. As visitors navigate rutted, flooded, or muddy areas on trails, they trample adjacent vegetation, causing trail widening, trail braiding, and erosion. On the north side of the Green River, trails are in a serious state of deterioration due to poor trail alignment, soil type, use levels, and erosion and have led visitors to create shortcuts or side trails around mud holes. In 2014, these illegal trails were found at more than 1,000 locations, double what was found in 2008 (Johnson 2014). These visitor-created social trails disturb native vegetation through trampling and can increase soil erosion. Trail surveys also show that trails north of the Green River, where horses are allowed, experience significant vegetation denuding and damage to trees from horse chewing at rest areas when tied to trees (Groves et al. 2021). While horse manure can contain seeds of nonnative plant species, studies show that native and nonnative plant species rarely become established on horse trails due to the harsh environmental conditions (Gower 2008). Park managers take a cautious approach to management of exotic species per the manure management regulations (36 CFR 2.16).

A high potential exists for future impacts on park vegetation communities from climate change. For example, climate change could shift the ranges of numerous tree species northward, reducing potential densities in Kentucky of sugar maple (*Acer saccharum*), red maple (*Acer rubrum*), and white oak (*Quercus alba*) (Iverson et al. 2008 in NPS 2013). Park forests will also continue to be impacted by a variety of forest pests (e.g., emerald ash borer) and pathogens, with new species likely moving into the area through inadvertent introduction, as well as through range shifts under climate change.

Impacts on Vegetation

Alternative 1: No Action (Continue Current Management)

Alternative 1, the no-action alternative, would be the continuation of current management. No new actions would occur, and impacts on vegetation would remain the same as described in the affected environment section. The current resource threats of invasive plant species, trail deterioration, and climate change would continue to occur.

Alternative 2: NPS Preferred Alternative

Under the action alternative, the construction of new trails, campsites, and facilities would require the permanent removal of approximately 28 acres of vegetation parkwide. Approximately 66 miles of new trails would create most of the impact, requiring permanent vegetation removal along new trail corridors. The total trail acreage accounts for the width of the trails and the necessary horizontal clearance of vegetation thinning and trimming needed to construct the trails, as outlined in appendix C. Trail widths and horizontal clearance are based on their trail type, also in appendix C.

Trail sustainability would be integrated into all new trail construction, as well, to rehabilitate existing trails. Specifically, physical trail sustainability measures would be used to manage water and limit erosion, such as through trail hardening and earthwork strategies to improve drainage. Attention to the trail's grade, through grade reversals and outslopes, would ensure that water can flow from the trail as frequently as possible, limiting erosion and the need for maintenance. These measures would minimize trail widening and trail braiding on new and rehabilitated trails, resulting in less vegetation trampling. The National Park Service would also implement the mitigation measures described in appendix I to minimize the impact on native vegetation during construction. New and existing trails would avoid rare and sensitive plant species and avoid the removal of healthy trees except where unavoidable when determining the final trail alignment. All healthy trees over 12 inches diameter breast height would remain. Clearing any vegetation for new trails would be coordinated with park natural resource staff to avoid sensitive vegetation communities and identify ecological restoration areas.

New backcountry campsites and facilities would result in the permanent removal of vegetation. The nine backcountry campsites would permanently remove approximately less than 0.1 acres of vegetation, while construction-related activities would temporarily impact another less than 0.1 acres of vegetation beyond the footprint of ground disturbance. The new facilities, including three parking lots and seven restrooms, would require the removal of less than 1 acre of vegetation. Construction activities for these facilities would also temporarily impact another less than 1 acre of vegetation beyond the footprints. To minimize temporary impacts on vegetation, staging areas would occur in previously developed areas or in the immediate project area to the extent possible, and mitigation measures and best management practices would be implemented, as described in appendix I. Table 10 shows the impacts on vegetation of short-term construction related activities and long-term use. Because of rounding, numbers presented may not add up precisely to the totals provided.

Table 10. Vegetation Impact by Development Type

Development	Impact in Acres
New trails	28
New backcountry campsites	0.03
New facilities	0.6
Decommissioned trails	(-) 3
Total vegetation impact	25

With the construction of new trails and facilities, the potential exists for informal spur trails to develop as visitors travel off maintained trails to reach a destination. These visitor-created trails are a concern to land managers when they result in vegetation trampling and erosion. Under the action alternative, an increase in educational materials could improve trail etiquette and deter off-trail hiking (Hockett et al. 2010; Marion and Reid 2007). Trail sustainability measures and the mitigation measures described in appendix I would also minimize this impact. Park staff would also monitor trail conditions and social trails, as outlined in appendix A.

The proposed construction activities that disturb vegetation could lead to increasing populations of nonnative invasive plants by removing established native plants that compete with noxious weeds, exposing mineral soil as a substrate for weed germination and dispersing existing or new weeds seeds or plants carried by construction equipment and trail users. To prevent the spread of invasive and nonnative vegetation, NPS staff would monitor and control nonnative invasive species in disturbed areas created by new trail construction, areas with new amenities for trails, and areas of trail restoration and would use early detection and rapid response to remove new occurrences of nonnative species.

Decommissioning four official trails due to alignment and sustainability issues and restoring the trails to natural conditions would result in a positive impact of up to approximately 3 acres of vegetation. In addition, restoring existing unauthorized visitor-created trails to natural conditions would reduce current adverse impacts on vegetation on these visitor-created trails. These areas would be positively impacted by the reduction of soil compaction, vegetation trampling, and introduction of invasive plant species.

Under the action alternative, educational materials and community stewardship would encourage behaviors that would reduce impacts on vegetation. Specifically, wet weather closures would be communicated to equestrians and bicyclists when soil moisture probes indicate wet soil conditions to prohibit use on wet trails and, therefore, reduce impacts such as trail widening, the creation of mudholes, and other damage to wet and malleable trail surfaces. Additional educational materials on trail etiquette and LNT practices would remind visitors to reduce their impact on vegetation. Lastly, existing partnerships would be expanded to encourage stakeholders to take ownership of maintaining certain trails, which could improve trail conditions and reduce off-trail vegetation trampling.

Under the action alternative, biking would be allowed on approximately 18 miles of new trail in addition to the existing 19 miles of bike trails. The increase of multiuse trails allowing biking is not anticipated to impact vegetation more than the impacts of constructing the new trails alone. In addition, impacts on vegetation from traditional biking are either equivalent or less than that caused by hiking (Marion and Olive 2006). Finally, studies show that the impacts on vegetation are the same for bikes and e-bikes (IMBA 2015).

In total, when accounting for the acreage of restored trails, the action alternative would result in permanent adverse impacts on approximately 25 acres of vegetation. Mitigation measures and best management practices listed in appendix I would be implemented to reduce adverse impacts on vegetation from these actions. These impacts account for a small portion of the park: 25 acres of permanent impacts compared to the 52,830 total acres of the park or less than 0.05%.

Therefore, the actions proposed under the action alternative would not be expected to impact the stable trends and long-term viability of vegetation in the park.

Conclusion

Under the no-action alternative, impacts on vegetation would remain the same as described in the affected environment section. Actions proposed under the NPS preferred alternative would result in the permanent removal of approximately 25 acres of vegetation. Construction on the new trails and facilities would have minor short-term impacts during construction and minor long-term impacts on the vegetation in the project area. Overall, the removal of vegetation would account for the small percentage of less than 0.05% total impact on vegetation across the park. The restoration of existing unsustainable trails, the improved trail sustainability of new and existing trails, and the increase in educational materials would have long-term positive impacts on vegetation. With the implementation of mitigation measures outlined in appendix I and trail construction guidelines in appendix C, the effects on vegetation would be minor, as the areas would be surveyed before ground disturbance to ensure that final trail alignment avoids areas with high-quality and highly diverse vegetation and healthy trees.

When the impacts of the action alternative are combined with the impacts of past, ongoing, and reasonably foreseeable future planned actions described in the affected environment section, the overall cumulative impacts on vegetation would be adverse in the short term but would result in overall beneficial impacts in the long term. In the short term, trail widening and braiding, visitor-created social trails, climate change, pests, and invasive species would continue to adversely impact the park's vegetation. Implementing the action alternative would contribute beneficial effects over the long term, as it directly addresses trail-related degradation by alleviating trail widening, braiding, and reducing visitor-created social trails through more sustainable trail placement, alignment, and construction. Furthermore, additional planned actions, such as the fire management plan, would contribute to controlling nonnative plant species and mitigating the effects of climate change on native vegetation.

SOILS

Affected Environment (Current and Future Conditions of Resource)

The park's climate is humid and temperate. Because the soils are not dry or frozen for long periods, the processes of soil formation are active throughout the year (NPS 2008). Many soluble bases and clay minerals have leached to lower horizons, and in some instances, out of the soil. As a result, many of the soils in the park are acidic, have a loamy surface layer, and a have subsoil that has accumulated clay from upper horizons (NPS 2008).

Soils in the park have been subdivided into the following primary soil map units that define broad areas with unique patterns of soil, relief, and drainage: Wallen-Caneyville-Bledsoe, Wellston-Clarkrange, and Lily-Jefferson-Riney. Soils in the park range from young to old. The youngest soils are on alluvial positions, with indistinct soil horizons and little evidence of profile development; some soils that formed on stream terraces are older and exhibit a more mature horizon of development (NRCS 2010). The oldest, most mature soils in the park formed in

stable landscape position in a variety of residual materials; they are deeply weathered and have developed argillic (clay) horizons (NRCS 2010).

Since the establishment of Mammoth Cave National Park, soils have been impacted by the construction of roads and facilities to accommodate park visitors and operations. Most of these projects have occurred within or adjacent to existing developed areas, as well as along the 85 miles of existing trails in the park. Soils have been damaged by trail construction and high concentrations of people, causing compaction and erosion in visitor use areas. Trail surveys show serious soil deterioration on trails north of the Green River where horses travel on unsustainable trail alignments, resulting in significant soil loss (Groves et al. 2021). This survey also showed that human-created social trails doubled in number from 2009 to 2014, resulting in soil compaction (Groves et al. 2021). These impacts affect soil resources in many ways, including damaging soil ecosystems; altering the soil profile and removing soil organic matter; affecting soil structure; and affecting nutrient cycling processes. Ongoing and planned future trail maintenance will reduce adverse impacts from trails by addressing drainage issues and minimizing conditions (i.e., puddles or muddy areas) that cause users to use the side of the tread and widen the exposed soil of the tread.

A high potential exists for future impacts on park soils from climate change. Increasing temperatures will cause an increase in evaporation, particularly during the summer, potentially leading to decreased soil moisture and loss of productivity. The projected increase in heavy rain events may contribute to increased soil erosion rates over current levels, particularly when the trails become muddy, have puddles, or are not draining correctly.

Impacts on Soils

Alternative 1: No Action (Continue Current Management)

Alternative 1, the no-action alternative, would be the continuation of current management. No new actions would occur, and impacts on soils would remain the same as described in the affected environment section. The current resource threats of trail deterioration, visitor-created trails, and climate change would continue to occur.

Alternative 2: NPS Preferred Alternative

Under the action alternative, the construction of new trails, campsites, and facilities would result in permanent adverse impacts on approximately 28 acres of undisturbed soil parkwide. Approximately 66 miles of new trails would be the most impactful, requiring soil disturbance and compaction. The total trail acreage accounts for the width of the trails and the necessary horizontal clearance of vegetation thinning and potential soil loss needed to construct the trails, as outlined in appendix C. Trail widths and horizontal clearance are based on their trail type, also in appendix C.

New backcountry campsites and facilities would result in permanent adverse impacts on soils. The nine backcountry campsites would permanently impact approximately less than 0.1 acres of soil, while construction-related activities would temporarily impact another less than 0.1 acres of soil beyond the footprint. The new facilities, including three parking lots and seven restrooms, would permanently reduce soil productivity on less than approximately 1 acre.

Pavement and gravel overlays would cause permanent compaction and loss of soil productivity. Construction activities for these facilities would temporarily impact approximately less than one acre of soils. To minimize temporary impacts on soils, staging areas would occur in previously developed areas or in the immediate project area, and mitigation measures and best management practices would be implemented as described in appendix I.

Initial trail and facility construction would cause soil compaction and loss through erosion. In some areas, up to 6–8 inches of topsoil would be removed to create trail facilities such as information kiosks, bike racks, and backcountry campsites. Implementing the mitigation measures listed in appendix I would reduce these impacts on soil from construction. The recreational use of the trails, campsites, and facilities would cause continued adverse soil impacts, including the loss of organic litter and soil compaction, rutting, and erosion. In addition, trail widening or braiding may result in soil compaction and erosion on either side of new trails. However, implementing the strategies listed under the action alternative, such as improving signage, rehabilitating old system trails, and restoring visitor-created trails, would reduce off-trail travel and lessen adverse impacts from hiking on the trail corridors and adjacent areas.

All new trails would be built in accordance with the trail sustainability measures outlined in appendix C. Specifically, physical trail sustainability measures would be used to manage water and limit erosion, such as through trail hardening and earthwork strategies to improve drainage. Attention to the trail's grade, through grade reversals and outslopes, would ensure that water can flow from the trail as frequently as possible, limiting erosion and the need for trail maintenance. These trail sustainability measures would also reduce soil compaction on newly constructed trails. Well-designed trails would further minimize the conditions that cause visitors to travel off trail and widen the intended exposed soil of the tread. Additionally, wet weather closures and educational materials would encourage visitors to mitigate their impact, preventing erosion and protecting soil resources during wet weather conditions.

With the construction of new trails and facilities, the potential exists for informal spur trails to develop as visitors travel off maintained trails to reach a destination. These visitor-created trails are of concern to land managers when they become areas of soil erosion and compaction. However, implementing management strategies listed in chapter 3, such as improving signage, rehabilitating visitor-created trails, and adding educational materials on trail etiquette and LNT principles, would reduce off-trail travel and minimize adverse impacts.

Decommissioning four existing trails due to poor alignment and sustainability issues and restoring the trails to natural conditions would result in a positive impact on up to approximately 3 acres of soil. In addition, restoring existing unauthorized visitor-created trails to natural conditions would reduce current adverse impacts on soil on these visitor-created trails. These areas would be positively impacted by the reduction of soil compaction and a return to natural soil conditions and processes.

Under the action alternative, biking would be allowed on approximately 18 miles of new trail in addition to the existing 19 miles of bike trails. The increase of multiuse trails allowing biking is not anticipated to impact soils more than the impacts of constructing the new trails alone. The amount and severity of anticipated soil erosion due to class 1 e-bikes and e-mountain bikes is

similar to that of traditional bikes (IMBA 2015; Nielsen et al. 2019). Implementing the design standards outlined in appendix C would mitigate the risks of increased soil erosion due to biking and, in particular, the increased soil displacement from the heavier weight of e-mountain bikes in grade changes and turns (IMBA 2015). Relevant design standards include appropriate grading, banking, trail alignment, the assessment of soil suitability, and the temporary closure of trails during wet weather closures. Per the design standards described in appendix C, soil suitability, the minimization of user-caused soil displacement, infrastructure, and clear sight lines on multiuse trails would all reduce the adverse impacts on soils on newly constructed trails. In addition, the mitigation measures listed in appendix I, such as using USDA NRCS soil survey data, conducting site evaluations, and considering soil conditions when determining the final layout of a trail, would reduce the adverse impacts on soils on these newly constructed trails.

In total, when accounting for the acreage of decommissioned trails, the action alternative would result in permanent adverse impacts on approximately 25 acres of soil. Mitigation measures and best management practices listed in appendix I would be implemented to reduce adverse impacts on soils from these actions. These impacts account for a small portion of the park: 25 acres of permanent impacts compared to the 52,830 total acres of the park, less than 0.5%. Therefore, the actions proposed under the action alternative would not be expected to impact the long-term viability of soils in the park.

Conclusion

Under the no-action alternative, impacts on soils would remain the same as described in the affected environment section. The NPS preferred alternative would result in adverse impacts on approximately 25 acres of undisturbed soils. Construction of the new trails and facilities would have minor short-term impacts during construction and minor long-term impacts on the soils in the project area. The restoration of existing trails and visitor-developed trails would have long-term positive impacts on soils. The rehabilitation of existing trails would result in an increase in sustainable trails that would reduce soil loss. Overall, the impact on soils would account for the small percentage of less than 0.05% total impact on soils in the project area. Implementing the mitigation measures outlined in appendix I and following the trail construction guidelines in appendix C would help reduce the negative impacts on soils.

When the impacts of the action alternative are combined with the impacts of past, ongoing, and reasonably foreseeable future planned actions described in the affected environment section, the overall cumulative impacts on soils would be in the short term but would result in overall beneficial impacts in the long term. In the short term, soil compaction, soil loss, erosion, and deterioration would continue on poorly aligned trails and social trails throughout the park. Additionally, climate change would continue to impact the productivity of soils. Implementing the action alternative would contribute beneficial effects over the long term, as it directly addresses trail-related degradation by alleviating trail widening, braiding, and reducing visitor-created social trails through more sustainable trail placement, alignment, and construction.

SPECIAL STATUS BATS

Affected Environment (Current and Future Conditions of Resources)

Bats are critical components of surface and subsurface ecosystems. Cave-roosting bats import organic matter into the nutrient-deficient cave environment in the form of guano (Culver and Pipan 2009), and this supports highly specialized communities of cave invertebrates. Outside the cave, bats play a critical role in controlling nocturnal insects and serve as a major asset to pest management in agricultural and forest settings (Thomas 2015). The bat species that occur in the park are exclusively insectivores, and their consumption of insects is of great benefit to surface ecosystems (Thomas and Toomey 2017). Mammoth Cave historically housed one of the largest hibernating (winter hibernation) colonies of bats yet identified, with an estimated 9–13 million bats (primarily *M. sodalis* and *M. grisescens*). The abundance of hibernating bat populations declined after settlers in the 1700s and 1800s discovered large deposits of nitrates or saltpeter, essential for making gunpowder, and began year-round mining operations in some of the major hibernacula. By the 1820s, tourism had become lucrative at several major hibernacula and increased rapidly over the next 100 years. Of the 21 federally protected species, the Indiana bat, northern long-eared bat, and tricolored bat have been carried forward for analysis. Table 11 provides details on these three species. Descriptions of these species are provided below.

Table 11. Federally Endangered, Threatened, and Candidate Bat Species That May Occur in Mammoth Cave National Park (as of March 2024)

Common Name	Scientific Name	Federal Status	Potential for Species or Habitat in Planning Area	Proposed or Designated Critical Habitat Present in Planning Area
Indiana bat	*Myotis sodalis*	E	Yes	Yes
Northern long-eared bat	*Myotis septentrionalis*	E	Yes	No
Tricolored bat	*Perimyotis subflavus*	PE	Yes	No

E = endangered; PE = proposed endangered

Indiana Bat

The Indiana bat (*Myotis sodalis*), federally listed as endangered, is a temperate, insectivorous, migratory bat. The Indiana bat is distributed throughout much of the eastern United States and is located across Kentucky. The Indiana bat annual cycle includes four major phases: winter hibernation, spring migration, pup rearing, and fall migration and swarming. During winter, large colonies of Indiana bats hibernate in caves or abandoned mines known as hibernacula. The non-hibernation season, which includes spring emergence, migration, birth/rearing of pups, and fall swarming, varies depending on the sex and location but generally lasts from April through mid-November. Indiana bats are usually found roosting beneath the exfoliating bark of live or dead trees. In spring, reproductive females migrate and form maternity colonies where they bear

and raise their young in wooded areas (USFWS 2007). Summer habitat requirements for the species include the following:

- dead or live trees and snags with peeling or exfoliating bark, split tree trunk and/or branches, or cavities, which may be used as maternity roost areas
- live trees (such as shagbark hickory and oaks), which have exfoliating bark
- stream corridors, riparian areas, and upland woodlots, which provide forage sites

The first evidence of reproductive success for this species at the park occurred in 1995 when females and juveniles were captured among cave and upland habitats. A later study tracked the species to 17 roost trees, where the majority of roost trees were snags (82.4%), and only a few roosts (17.1%) were found in live trees (Foster et al. 2007). Two primary roosts for Indiana bats were identified in the park, including a chestnut oak on the upland margins of Sal Hollow, which was split into two trunks, one living and one dead. Many bats were found under the peeling bark of the dead trunk. The other primary roost was in a shellbark hickory (*Carya laciniosa*), located in close proximity to the roosting chestnut oak. A modest number of Indiana bats were reported hibernating in Colossal Cave, Lee Cave, Wilson Cave, Bat Cave, and the historic entrance to Mammoth Cave, and upwards of 1,000 bats were reported in Dixon and Long Cave (Thomas and Toomey 2017). The most substantial hibernaculum for Indiana bats in the park is in Dixon Cave. Overall, recent winter counts (2015 and 2017) showed decreased abundance of this bat in all sites. Several factors have contributed to the decline of the Indiana bat, including the loss and degradation of suitable hibernacula, human disturbance during hibernation, pesticides, and the loss and degradation of forested habitat, particularly stands of large, mature trees. Fragmentation of forest habitat may also contribute to declines.

Northern Long-Eared Bat

The northern long-eared bat *(Myotis septentrionalis)* is federally listed as endangered. The northern long-eared bat is found throughout most of North America and is present year-round in Kentucky, where it exhibits statewide distribution. Northern long-eared bats have similar habitat requirements as the Indiana bat. Like Indiana bats, northern long-eared bats hibernate in caves or mines during winter and migrate to roosting habitats during spring. This species is known to roost underneath bark, in cavities, or in crevices in live or dead trees during the summer, either alone or in maternity colonies (Caceres and Barclay 2000). Males and nonreproductive females may also roost in cooler places, like caves and mines (USFWS 2022). Most females in a maternity colony give birth around the same time, which may occur from late May or early June to late July (USFWS 2022). Northern long-eared bats spend winters hibernating in caves and mines. They typically use large caves or mines with large passages and entrances, constant temperatures, and high humidity with no air currents (USFWS 2022).

A study recorded numerous long-eared bats in 2004–2005 at multiple locations, including Cedar Hill Church Road, Maple Springs Pond, Buffalo Trail Pond, and Triangle Pond (Foster et al. 2007). Summer distribution of the species (pre-white-nose syndrome) was fairly well known in the park (the species was captured by netting in numerous locations). Recent summer capture records (2015 and 2017) suggest a catastrophic decline of the species in the park and the potential for extirpation from the park due to white-nose syndrome (WNS). White-nose

syndrome is a devastating disease that was first detected in the park in 2013. White-nose syndrome has led to unprecedented numbers of sick, dying, and dead bats in and around caves and mines. White-nose syndrome spreads on bats' muzzles and other parts of their bodies. The park, in cooperation with the US Fish and Wildlife Service, has implemented stringent protocols to prevent the introduction and spread of white-nose syndrome in bats and has established an educational outreach program for park visitors. The primary factor influencing the viability of the species is white-nose syndrome; other primary factors include wind energy mortality, effects from climate change, and habitat loss (USFWS 2022).

Tricolored Bat

The tricolored bat *(Perimyotis subflavus)* is proposed to be federally listed as endangered. The tricolored bat is widespread across the eastern United States and Canada and commonly occurs in Kentucky throughout the year. The life history characteristics and habitat requirements of tricolored bats are similar to those of the bat species described above. The primary characteristic that distinguishes tricolored bat from other bat species is that it frequently roosts in live trees during summer months, rather than snags. Tricolored bats have also been observed roosting during summer among pine needles; in artificial roosts like barns; and beneath porch roofs, bridges, concrete bunkers, and, rarely, in caves (USFWS 2021). During the spring, summer, and fall, tricolored bats primarily roost among live and dead leaf clusters or live or recently dead deciduous trees (USFWS 2021). During the winter, tricolored bats primarily hibernate in caves and mines (USFWS 2021).

A study recorded 100 individuals during the 2004–2005 inventory, mostly from Long Cave (Foster et al. 2007). The historic entrance to Mammoth Cave continues to be a year-round roosting site for tricolored bats, with many often found hibernating in Dixon Cave since the mid-1980s (Thomas and Toomey 2017). Observations from cavers and data from the park's Lesser Cave inventory indicated that this species was very widespread (present in hundreds of caves in the park in small numbers) at the park before the arrival of white-nose syndrome. Post-white-nose syndrome, this species remains distributed throughout various caves in the park but is observed less often. Several factors have contributed to the decline of the tricolored bat, including white-nose syndrome; wind energy projects; loss of roosting, foraging, and commuting habitat; and changing climatic variables (USFWS 2021).

The overall condition of these three bat species populations is poor. All three species have experienced a significant decline (>50%) in the park (Groves et al. 2021). Capture rates for tricolored and northern long-eared bats declined by 82.5% to 99.1% from 2004 to 2017 (Thomas 2018). Biennial counts at colonial caves for Myotis hibernation sites in 2015 showed declines near 80% for Indiana bats (Groves et al. 2021). Bats exhibit low reproductive rates, produce few offspring per event, and reach reproductive maturity later in life, rendering them particularly vulnerable to population declines (Groves et al. 2021). White-nose syndrome has been documented in seven of eight cave-dwelling bat species that occur in the park (Groves et al. 2021). The impact of white-nose syndrome continues, and the overall loss in terms of numbers and diversity is not yet known. As there is no known cure for the disease, the only course of action land managers can take is to attempt to mitigate further exposure, control access to sensitive areas, and educate park visitors of the critical ecosystem services provided by bats and the potential loss of such services that may occur by spreading white-nose syndrome to

unaffected areas. The decline of several Myotis species may impact other bat species that are less affected by white-nose syndrome by altering niche partitioning of bat species in a forest community.

In addition to white-nose syndrome, anthropogenic modifications to cave bat habitat threaten the species. The cave-roosting bats that occur in the park and elsewhere face a variety of challenges, including human use and disturbance in caves, physical changes to the cave environment, surface land use issues (including wind energy development), and disease. Modifications, such as passage enlargement or installation of cave gates, have altered cave microclimates so that these areas no longer provide suitable roosting environment for some bat species (Thomas and Toomey 2017).

Cave modifications that affected the thermal regime of the cave in the past may have affected the suitability of the cave to support hibernating Indiana bats include alterations to accommodate tourists, the erection of physical barriers (e.g., doors, gates) to control cave access, and saltpeter mining. Entrance gates caused significant modification of the airflow and climate in the cave, which, in turn, profoundly affected quality of the cave as a roost for bats and also physically restricted the access of bats to the cave, which may have resulted in direct mortality. Restrictive entrance gates were in place until 1990, when an open-grid gate was installed at the historic entrance. The negative effects of cave modifications were compounded by physical disturbance of hibernating bats during commercial, recreational, scientific, or educational purposes. Because the bats congregate in large numbers, these species have been inherently vulnerable to the loss or degradation of hibernation habitat. Ongoing WNS education and mitigation will help reduce the impacts on bats.

Impacts on Special Status Bats

Alternative 1: No Action (Continue Current Management)

Alternative 1, the no-action alternative, would be the continuation of current management. No new actions would occur, and impacts on special status bats would remain the same as described in the affected environment section. The current resource threats of white-nose syndrome, habitat loss, wind energy projects, and climate change would continue to occur.

Alternative 2: NPS Preferred Alternative

Under the action alternative, vegetation and tree removal related to the construction of approximately 66 miles of new trails and associated facilities could degrade summer habitats for the Indiana bat, northern long-eared bat, and tricolored bat. Specifically, the removal of suitable roost snags and trees would result in a loss of or reduced quality of summer habitat conditions. Under the action alternative, approximately 25 acres of vegetation would be permanently impacted for the development of new trails and facilities. To avoid bat mortality and impacts on roosting bats, construction would be scheduled to occur outside of the fall swarming, spring emergence, and summer maternity period, when bats are hibernating. Where possible and not a safety hazard, dead or dying trees would be left undisturbed. To further minimize adverse impacts on bats from the proposed action, mitigation measures described in appendix I would be implemented. For example, new and existing trails would avoid sensitive areas where a rare and/or endangered plant or animal species or its known habitat exist, and trail alignments would

be designed such that native vegetation would be retained as much as possible. Additionally, studies have found that small-scale habitat disturbance, such as the creation of small cutblocks and small-scale timber harvesting, have had minimal impacts on bat species and in some cases benefit bats by creating a mosaic of different habitats (Sheets et al. 2013; Grindal and Brigham 1998). Therefore, vegetation clearing under the action alternative would have a minimal negative impact on bat habitat.

The new trails and facilities would create more opportunities for humans to potentially disturb bat populations. The action alternative would not change the human use of caves but may increase the number of visitors and associated noise near natural cave entrances. The proposed Dry Branch trail, for example, would be located close to a maternity colony, but since the cave is gated, there is little concern that bats would be disturbed. In addition, new multiuse trails in forested areas near summer roosts may cause an increase in disturbance. Under the action alternative, biking would be allowed on approximately 37 miles of trails, an increase of approximately 18 miles when compared to the no-action alternative. The increase of multiuse trails allowing biking may contribute to increased disturbance to bats, although this disturbance is not anticipated to be greater than the disturbance to bats caused by hikers, as biking and hiking have been found to disturb wildlife in similar ways (Marion 2016). Mitigation measures described in appendix I would be implemented to minimize adverse impacts from disturbance to the species. For example, care would be taken not to disturb sensitive wildlife species found nesting or hibernating, trails would avoid seasonal roosting areas, and a review of site conditions where sensitive habitats may exist in the trails planning area would be conducted with the park biologist and, if necessary, the US Fish and Wildlife Service. Additionally, bat-friendly cave gates would be added to caves that experience increased levels of bat disturbance. Lastly, an increase in LNT and trail etiquette educational materials would remind visitors to respect bats and their habitat.

Surface activities affect water infiltrating into caves and homes to bats. Chemicals and other toxins occurring in cave water adversely affect underground aquatic life and fauna that drink the water, including the three special status bat species. Dye traces have shown a direct hydrologic link between parking lot runoff and certain cave passages, which may have led to contamination of cave drip water in the past (NPS 2009). Under the action alternative, the three new parking lots and other proposed facilities could result in an increased risk of cave drip water contamination and subsequent impacts on bats. Parking lot filters have been found to reduce parking lot contaminants from entering the cave drainage systems (NPS 2009) and would be used in the new paved parking lots to mitigate this risk. Drainage from construction impacts and runoff from new trails could contribute to clogging the natural cave drainage systems, impacting the three special status bat species. However, mitigation measures and best management practices described in appendix I, such as silt fences and sedimentation controls, would be used to mitigate erosion during construction and reduce this risk.

Decommissioning four official trails and restoring the trails to natural conditions would result in beneficial impacts on the three bats species. Restoring existing unauthorized visitor-created trails to natural conditions would also positively impact the bats. These efforts would provide additional habitat for the bats and bat prey species while reducing habitat fragmentation. Trail

sustainability measures and the mitigation measures described in appendix I would minimize the potential for new spur trails to develop, which would ensure that these benefits persist.

White-nose syndrome has resulted in significant declines in numbers of Indiana bats, northern long-eared bats, and tricolored bats. As there is no known cure for the disease, the only course of action land managers can take is to attempt to mitigate further exposure, control access to sensitive areas, and educate park visitors of the critical ecosystem services provided by bats and the potential loss of such services that may occur by spreading white-nose syndrome to unaffected areas. Under the action alternative, LNT educational materials would result in increased awareness of white-nose syndrome and mitigation strategies. Additionally, these educational materials could result in a reduction in vegetation impacts, which would improve summer habitat for bats and habitat for bat prey species.

Overall, when accounting for habitat fragmentation, disturbance, construction-related impacts, trail restoration, and educational materials, the three special status bats and their habitat would experience minor long-term negative impacts. These negative impacts are anticipated to be insignificant upon implementation of the mitigation measures described in appendix I, including scheduling construction outside of fall swarming, spring emergence, and the summer maternity seasons, avoiding seasonal roosting areas, and prioritizing retaining dead and dying trees.

Conclusion

Under the no-action alternative, impacts on the special status bats would remain the same as described in the affected environment section. Actions proposed under the action alternative would result in a slight decrease in possible summer habitat (.05%) in the forest, of which not all trees are suitable habitats, and park managers would do their best to avoid the removal of possible habitat and human disturbance to the special status bat species. Constructing the new trails and restoring existing trails would have minor short-term impacts during construction and insignificant long-term impacts on special status bat species in the project area.

When the impacts of the action alternative are combined with the impacts of past, ongoing, and reasonably foreseeable future planned actions described in the affected environment section, the overall cumulative impacts on special status bats would be insignificant. The current conditions of the three bat species are poor. The major past and current impacts on bat species are white-nose syndrome and the loss of habitat. The actions proposed under the preferred alternative do not significantly impact WNS transmission or the impacts white-nose syndrome has on bats. Additionally, any tree removal would be minimal and only done between November 15 and March 31, when the listed bat species are expected to be hibernating in caves and not present on the landscape, per the park's USFWS-approved section 7 programmatic agreement (USFWS 2012). Employing the mitigation measures outlined in appendix I would reduce the overall impact on the Indiana bat, northern long-eared bat, and tricolored bat. Continued implementation of stringent protocols to prevent the introduction and spread of white-nose syndrome in bats and educational outreach program for park visitors would mitigate further exposure.

SPECIAL STATUS MUSSELS

Affected Environment (Current and Future Conditions of Resources)

The Green River and its tributaries support one of the most diverse assemblages of mussel fauna in North America. The Nolin River has not received the same degree of intensive survey as the Green River. The entirety of the segment of the Nolin found in the park was impounded by Lock and Dam 6 until recently, and it has several kilometers still impounded by Lock and Dam 5, creating habitat that has not been shown to support mussels. In addition, the other end of the Nolin River is an US Army Corp of Engineers (USACE)-regulated dam, so it is not free flowing on either end. Overall, there are 70 species of freshwater mussels in the park. Of these 70 mussels, 3 are federally listed as threatened and 11 are federally listed as endangered. Table 12 provides details on these 14 species.

Table 12. Federally Endangered, Threatened Mussel Species That May Occur in Mammoth Cave National Park (as of March 2024)

Common Name	Scientific Name	Federal Status	Potential for Species or Habitat in Planning Area	Proposed or Designated Critical Habitat Present in Planning Area
Clubshell	*Pleurobema clava*	E	Yes	No
Fanshell	*Cyprogenia stegaria*	E	Yes	No
Northern riffleshell	*Epioblasma - rangiana*	E	Yes	No
Pink mucket (pearlymussel)	*Lampsilis abrupta*	E	Yes	No
Purple cat's paw (=purple cat's paw pearlymussel)	*Epioblasma obliquata*	E	Yes	No
Rabbitsfoot	*Quadrula cylindrica* -	T	Yes	CH
Rayed bean	*Villosa fabalis*	E	Yes	No
Ring pink (mussel)	*Obovaria retusa*	E	Yes	No
Rough pigtoe	*Pleurobema plenum*	E	Yes	No
Sheepnose mussel	*Plethobasus cyphyus*	E	Yes	No
Snuffbox mussel	*Epioblasma triquetra*	E	Yes	No
Spectaclecase (mussel)	*Margartifera monodonta*	E	Yes	No
Longsolid	*Fusconaia subrotunda*	T	Yes	CH
Round hickorynut	*Obovaria subrotunda*	T	Yes	CH

CH = critical habitat; E = endangered; T = threatened

These mussel species can be found in the free-flowing segments of the Green River and Nolin River. The Upper Green River supports a great biodiversity of fish, macroinvertebrates, and freshwater mussels, many of which exist only in this part of the watershed. Mussel habitat is generally upstream of the majority of the current trail system in the park. In addition, the Green River serves as habitat for one mussel endemic to Kentucky (Kentucky creekshell) and 28 mussel species identified as Species of Greatest Concern Network (Groves et al. 2021).

The Unionid family of freshwater mussels is believed to provide critical ecosystem services, including producing nutrients, processing particulates, and mixing sediments. Freshwater mussels also serve as indicator species for stream health, as they are filter feeders with limited mobility. Knowledge of freshwater mussel distributions and abundances can be used to make certain inferences about water quality in a particular area and applies directly to the park's water resource management efforts.

The overall condition of the federally listed mussel species in the park is stable and showing signs of improvement. While mussel species richness has declined over time (from 79 species historically to 27 species in 2017 survey) and composition of the mussel assemblage is not evenly distributed among species, current surveys show fairly stable population levels and, in some cases, increasing levels. Several species that were once common in the park are now rare or extirpated, suggesting these organisms may be highly sensitive to habitat degradation, such as changes in composition of channel substrate and water temperature associated with impoundment of the Green River or other issues related to deterioration of water quality. The lifecycle of mussels is dependent on fish, as some mussels can only reproduce using specific species of fish; poor water quality or expiration of these fish species can directly affect the presence and population levels of dependent mussel species. Because mussels are negatively impacted by alluvial sedimentation, the current trail alignments and maintenance practices resulting in erosion into the rivers negatively impacts the mussel species. Lastly, current floodplain camping can result in litter entering the water and the improper disposal of human waste. Fecal matter in the river and visitors handling mussels both contribute negatively to mussels and their habitat.

Freshwater mussels are particularly negatively impacted by the presence of dams, because the dams disrupt the natural flow patterns of both rivers, resulting in negative impacts on fish, mussels, and other river species and on the cave systems in the park. Beyond the park boundary, freshwater mussels in North America are experiencing significant declines. The removal of Lock and Dam 6 and the partial removal of Lock and Dam 5 have contributed to improved conditions and increased habitat for mussel species. The planned removals of Lock and Dams 4 and 5 are expected to continue to contribute to overall river health, fish movement, and mussel habitat by reestablishing more natural river flow.

Impacts on Special Status Species Mussels

Alternative 1: No Action (Continue Current Management)

Alternative 1, the no-action alternative, would be the continuation of current management. No new actions would occur, and impacts on the special status mussel species would remain the

same as described in the affected environment section. The current resource threats of alluvial sedimentation from trail erosion and impacts from dams would continue to occur.

Alternative 2: NPS Preferred Alternative

Although most of the critical mussel habitat is upstream of the proposed trails, the construction of new trails and associated facilities would likely have a short-term impact on the special status mussels. Construction would result in soil disturbance and an increase in alluvial sedimentation in the Green River and Nolin River. As described in appendix I, erosion mitigation measures would be used during and after construction until disturbed areas are stabilized by new vegetative growth. Mitigation measures include silt fences and other runoff control measures to prevent alluvial sedimentation.

A survey of streams north of the Green River revealed higher levels of sedimentation downstream from trail crossings compared to stream sites not in proximity to a trail (Johnson 2017). Recreational use of the current and new trails, therefore, would likely cause minor adverse soil impacts, including erosion and rutting, which would result in alluvial sedimentation. Increased levels of alluvial sedimentation from trail use may negatively impact the special status mussel species in the long term. To mitigate these impacts, all new trails would be built in accordance with the trail sustainability measures outlined in appendix C. Specifically, physical trail sustainability measures would be used to manage water and limit erosion, such as through trail hardening and earthwork strategies, to improve drainage. Attention to the trail's grade, through grade reversals and outslopes, would ensure that water can flow from the trail as frequently as possible, limiting erosion and sediment loading.

Under the action alternative, biking would be allowed on approximately 18 miles of new trail in addition to the existing 19 miles of bike trails. The increase of multiuse trails allowing biking may contribute to increased soil erosion, which would lead to negative impacts on the special status mussel species. The amount and severity of anticipated soil erosion due to class 1 e-bikes is similar to that of traditional bikes (IMBA 2015; Nielsen et al. 2019). Implementing design standards outlined in appendix C would mitigate the risks of increased soil erosion due to biking. Relevant design standards include appropriate grading, banking, trail alignment, the assessment of soil suitability, and the temporary closure of trails during wet weather closures. Per the design standards described in appendix C, considering soil suitability, the minimization of user-caused soil displacement, and clear sight lines on multiuse trails would all reduce the adverse impacts on soils on newly constructed trails and limit alluvial sedimentation in the Green and Nolin Rivers. In addition, the mitigation measures listed in appendix I, such as using USDA NRCS soil survey data, conducting site evaluations, and considering soil conditions when determining the final layout of a trail, would reduce the chance for high levels of erosion on newly constructed trails, thus reducing impacts on special status species mussels.

Under the action alternative, four trails would be decommissioned due to poor alignment and sustainability issues and restored to natural conditions. Unauthorized social trails would also be restored to natural conditions, and some existing trails in extremely poor condition would be rehabilitated. These actions would reduce erosion across the trail system, resulting in lower levels of alluvial sedimentation in the Green and Nolin Rivers. Since the special status mussel

species are negatively impacted by alluvial sedimentation, these trail improvements would enhance preferential habitat for the mussels.

Under the action alternative, none of the river recreation improvements on the Green River or Nolin River would impact the bed or the flow of the rivers. Therefore, the action alternative would not negatively impact critical habitat for any mussels with designated critical habitat in the park. Water recreation activities, such as canoeing and kayaking, have minimal impacts on the special status mussel species. River users can inadvertently crush the mussels while recreating (NPS 2015b). The action alternative would increase LNT educational materials to remind visitors to the Green and Nolin Rivers not to disturb the mussels, dispose of waste properly, and give the mussels space while recreating.

Under the action alternative, amending the Superintendent's Compendium so that motorboats exceeding 40 horsepower would not be allowed during the primary paddling season would have a positive impact on special status mussels. The horsepower restriction would reduce the potential for large wakes eroding the shoreline and contributing to water turbidity, positively impacting the mussel's ability to feed and reproduce.

Overall, when accounting for temporary impacts due to construction, long-term minor alluvial sedimentation impacts, and benefits from decommissioning and rehabilitating trails, the special status mussels would likely experience limited negative impacts. Per the mitigation measures described in appendix I, prioritizing physical trail sustainability, applying sustainable practices during construction, and increasing educational materials would beneficially impact the mussel species in the long term.

Conclusion

Under the no-action alternative, impacts on the special status mussels would remain the same as described in the affected environment section. Actions proposed under the action alternative would result in an increase in short-term alluvial sedimentation due to construction activities; however, employing trail sustainability and mitigation measures along with decommissioning and rehabilitating poorly aligned trails would reduce overall impacts on the special status mussels and potentially improve their habitat overall in the long-term. When the impacts of the action alternative are combined with the impacts of past, ongoing, and reasonably foreseeable future planned actions described in the affected environment section, such as the removal of Lock and Dams 6 and 5, which have improved mussel habitat by reestablishing more natural river flow, and the planned removals of Lock and Dams 4 and 5, the overall cumulative impacts on special status mussels would be beneficial.

CAVE AND KARST RESOURCES

Affected Environment (Current and Future Conditions of Resources)

The Mammoth Cave System (consisting of the interconnected Mammoth Cave, Flint Ridge, and Roppel Cave systems) is a primary focus of the park. At more than 426 miles of surveyed cave passages, Mammoth Cave is the longest cave in the world (NPS 2019). In addition to the Mammoth Cave, there are more than 300 smaller caves throughout the park (NPS 2006b). The lowest—and hence newest—passages in Mammoth Cave are still flooded at the level of the

Green River, but the higher and older passages have stabilized and are largely dry except for small, localized areas of seepage. At the present water table, cave passages are still being formed. Cave passages contain evidence of present and past flow regimes, such as canyons, vertical shafts, passages, and domes. The larger passages are classic examples of karst tubular passages. Tubular passages originate by solution along partings or jointed beds at or below the water table. They tend to be relatively gently sloped and are often partially filled with cave sediment. The cave passages include speleogens, which are cave surfaces that formed by solution and abrasion. Speleogen features, such as small pits, domes, and scallops, record conditions during primary cave development. Other solutional features include flutes, anastomoses, solution pockets, and scours.

Mechanical deposition is responsible for many of the mineral-based sediment deposits found in Mammoth Cave (excluding organic-based deposits, such as guano). These sediments were either carried into the cave by underground streams and redeposited or are the result of mechanical and chemical breakdown of the limestone cave matrix. Sediments deposited through stream action consist of gravel, sand, silt, clay, and sandstone pebbles and contain a record of surface and subsurface events. Most of these sediments were derived originally from surface contexts resulting from the weathering of insoluble materials such as shale, sandstone, and conglomerates. Most of the mineral sediments deposited in the cave passages were deposited between about 1 million and 6 million years ago. However, sediment deposition has been an ongoing process in the lower levels of the cave systems and is still continuing. Sand, silt, and clay are deposited in lower levels during flooding events. Breakdown consists of slabs, blocks, or chips of rock that have detached from the cave ceilings or walls due to chemical weathering of joints in the rock matrix and the eventual effects of gravity. Following the deposition of these materials, they are subject to further changes through physical, chemical, and biological processes.

Mammoth Cave is a nonrenewable resource that lacks natural regenerative processes; therefore, impacts are cumulative, and some may be permanent. Damage to irreplaceable cave features occurred during the early periods of cave use, including graffiti and smoke deposits from torches and fires. Later impacts include the physical degradation of cave formations, such as speleothems, and cave surfaces from the construction of cave trails and other Civilian Conservation Corps-era structures. Visitation throughout the cave has caused and continues to cause both inadvertent and deliberate damage to speleothems and other cave features. Some speleothems are extremely fragile. In one example of protecting a cave feature, park staff installed a grate around fragile speleothems located immediately adjacent to the trail on the Frozen Niagara route to prevent damage. Human presence in the cave results in the deposition of a small amount of detritus consisting of hair, skin cells, and lint from clothing. Human travel then stirs up fine sediments that settle onto adjacent cave surfaces. This redistributed dust can build up over time and affect cave aesthetics and damage delicate speleothems.

A high potential exists for future impacts on cave and karst resources from climate change. While caves are semi-closed systems that buffer fluctuations in air temperature (Mammola et al.), over longer periods, they reflect mean annual surface temperature (Sánchez-Fernández et al. 2016) in temperate areas. Due to the “chimney” effect at Mammoth Cave, changes in temperature, particularly in winter months, may affect airflow through the cave (Šebela, Baker,

and Luke 2019). The changes in temperature due to climate change can be problematic because caves are home to organisms that exhibit low tolerance to climatic perturbations and may have little adaptive capacity due to their evolution in a stable environment.

Impacts on Cave and Karst Resources

Alternative 1: No Action (Continue Current Management)

Alternative 1, the no-action alternative, would be the continuation of current management. No new actions would occur, and impacts on cave and karst resources would remain the same as described in the affected environment section. The current resource threats of recreation impacts and climate change would continue to occur.

Alternative 2: NPS Preferred Alternative

Surface activities affect water infiltrating into the caves at the park. Runoff from erosion can clog the natural cave drainage systems and impact physical cave and karst resources and the organisms that inhabit them. Under the action alternative, initial trail and facility construction would cause soil loss through erosion and could lead to short-term impacts on the cave drainage systems. Mitigation measures and best management practices, such as silt fences and other runoff control measures, would be implemented during construction to minimize erosion, as described in appendix I.

The use of new trails and facilities would cause adverse soil impacts, including erosion and rutting, which would impact cave drainages. However, all new trails would be built in accordance with the trail sustainability measures outlined in appendix C. Specifically, physical trail sustainability measures would be used to manage water and limit erosion, such as through trail hardening and earthwork strategies to improve aboveground drainage, which would limit impacts on the cave drainage systems. Additionally, decommissioning four existing trails due to poor alignment and sustainability issues and restoring the trails to natural conditions would result in less erosion and a reduction of negative impacts on cave drainages. Restoring existing unauthorized visitor-created trails to natural conditions and rehabilitating trails with poor alignment would further reduce negative impacts on cave and karst resources.

Under the action alternative, biking would be allowed on approximately 18 miles of new trail in addition to the existing 19 miles of bike trails. The increase of multiuse trails allowing biking is not anticipated to increase soil erosion more than the impacts of constructing the new trails alone. The construction of new multiuse trails may contribute to increased soil erosion, which could impact cave drainages. The amount and severity of anticipated soil erosion due to class 1 e-bikes is similar to that of traditional bikes (IMBA 2015; Nielsen et al. 2019). Implementing design standards outlined in appendix C would mitigate the risks of increased soil erosion due to biking. Relevant design standards include appropriate grading, banking, trail alignment, the assessment of soil suitability, and the temporary closure of trails during wet weather closures. Per the design standards described in appendix C, soil suitability, the minimization of user-caused soil displacement, infrastructure, and clear sight lines on multiuse trails would all reduce the adverse impacts on soils on newly constructed trails and, therefore, reduce potential adverse cave impacts.

Dye traces have shown a direct hydrologic link between parking lot runoff and certain cave passages, which may have led to contamination of cave drip water in the past (NPS 2009). Under the action alternative, the three new paved parking lots and other proposed facilities could result in an increased risk of cave drip water contamination. Parking lot filters have been found to reduce parking lot contaminants from entering the cave drainage systems (NPS 2009) and would be used in the new parking lots to mitigate this risk and reduce negative impacts on cave and karst resources.

The action alternative would not change any cave trails but the new aboveground trails may bring visitors closer to cave entrances. This would increase the risk of human caused disturbance and damage to the cave and karst resources through inadvertent and deliberate damage, such as vandalism and recreational impacts. However, because the new trails do not lead visitors directly to cave entrances, implementing strategies listed under the action alternative, such as improving signage, rehabilitating old system trails, and restoring visitor-created trails, would reduce off-trail travel and reduce the adverse impacts on sensitive cave resources. Additionally, an increase in educational materials, such as LNT information and trail etiquette reminders, would further reduce off-trail travel while reminding visitors to protect cave and karst resources. Lastly, implementing the mitigation measures listed in appendix I, such as installing a cave gate if the cave experiences degradation over time, would minimize negative impacts on cave and karst resources.

Overall, when accounting for the impacts on the cave drainage systems and human-caused disturbance and damage, the cave and karst resources would experience minor short-term negative impacts. Per the mitigation measures described in appendix I, an emphasis on physical trail sustainability and parking lot filters would reduce the negative impacts on the cave and karst resources and may improve long-term conditions by reducing erosion from poorly aligned trails.

Conclusion

Under the no-action alternative, impacts on the cave and karst resources would remain the same as described in the affected environment section. Actions proposed under the action alternative would result in an increased risk of impacts on the natural cave drainage systems and physical damage from recreation and vandalism, resulting in minor impacts on the cave and karst resources. Employing the mitigation and physical trail sustainability measures outlined in chapter 3 and appendix I would reduce the adverse impacts on cave and karst resources and improve conditions over the long term. When the impacts of the action alternative are combined with the impacts of past, ongoing, and reasonably foreseeable future planned actions described in the affected environment section, the overall cumulative impacts on cave and karst resources would be adverse in the short term during trail construction. Implementation of the action alternative would contribute to beneficial effects over the long term, as it directly addresses trail-related degradation and would reduce erosion through physical trail sustainability measures, including sustainable trail placement, alignment, and construction.

WATER QUALITY

Affected Environment (Current and Future Conditions of Resources)

Surface water resources at the park are dominated by the Green River and its major tributary, the Nolin River, which flows from the north to join the Green River in the western part of the park. These rivers have significant tributaries flowing on clastic rocks to the north of the Green River, including First, Second, and Bylew Creeks in the Nolin drainage and Buffalo and Ugly Creeks flowing to the Green River. South of the Green River, flow in the park is generally underground in the limestones of the karst aquifer, although there are a few short sections of surface flow where cave streams emerge at springs to flow across the bottoms of karst depressions to sink again on the other side.

Flow through the Mammoth Cave karst aquifer can be very rapid. Water can flow similarly to surface streams, traveling thousands to tens of thousands of feet per day. In addition, as in a surface stream, contaminants are not diluted substantially when a spill occurs. However, unlike surface flows, one cannot see where contaminants go or what they impact. Contaminants entering the karst aquifer can thus be rapidly transported unaltered through the conduit system. The karst aquifer is dynamic; that is, it responds nearly instantaneously to rainfall. Aquifer levels can rise tens of feet in a matter of hours. In addition, chemical and bacteriological properties of the groundwater can change dramatically following rainfall events. These rises in water level can activate high-level overflow routes between groundwater basins and thus direct flow in different directions, depending upon aquifer conditions.

Water quality monitoring from 1990 to 2012 showed that nitrate levels in groundwater were frequently above the drinking water standard of 10 milligrams per liter, with a trend of increasing nitrate concentrations over time (Groves et al. 2021). With a few exceptions, the waters were well oxygenated and both pH and specific conductance well within the range that should be expected for waters in a well-developed carbonate rock aquifer (Groves et al. 2021). Fecal bacteria were the most pervasive contaminant in groundwater, with highly variable levels. Researchers observed that in the Cave City subbasin of the Turnhole Spring basin, a storm pulse caused the bacteria loading in to rise from near zero to about 2 million bacteria colonies per second (Groves et al. 2021).

Trail impacts can also affect water quality. Assessing water quality parameters and benthic macroinvertebrates, whose population structures can provide insights into stream health, Johnson (2017a, 2017b) found that impacts of trails were noted both from visual evidence of sedimentation and changes in species composition. Mill Creek, for example, has had visible sedimentation for at least 30 meters downstream from the stream crossing with the Good Springs Trail along with negative benthic macroinvertebrates impacts.

In June 2021, researchers at the Crawford Hydrology Lab at Western Kentucky University began a study to quantitatively evaluate the potential impacts of trail use on groundwater quality in Mammoth Cave National Park (Singer et al. 2023). Four groundwater basins with different types of trail use were selected for a comparative study; the Great Onyx basin, with no established visitor trails and wholly within the park boundaries, was selected as the control site, and the other three basins, Running Branch, Ganter Bluehole, and Buffalo Creek, was selected

for each basin's combination of trail use and surface activities with the potential to impact water quality through surface erosion and/or fecal bacteria contamination. Between the control site and the other three basins, the researchers found that trail use did not result in observable increases in turbidity and/or specific conductance resulting from trail erosion. Any differences in trail use at the drainage basins scale were small compared to the influences of natural processes. Phosphate was not present in measurable concentrations at any location or time; nitrate was at or below five parts per million, which is within the federal drinking water standard.

Consistent with NPS water quality monitoring results, researchers at Western Kentucky University also found that groundwater contamination by human and/or animal fecal waste is ubiquitous at the park, and the data showed impacts from trail use (Singer et al. 2023). Every water sample analyzed in the study was positive for both total coliform bacteria and *E. coli*. Using highly sensitive molecular source tracking technology, results showed that fecal contamination sources include humans, wildlife, horses, and in the Buffalo Creek basin that extends beyond the park, agriculture (cows, sheep, and/or goats). The waters from the Running Branch basin showed contamination by horse-derived fecal bacteria, even though established horse trails are absent in this part of the park. Subsequent investigation by NPS personnel identified illegal horse trails in the Running Branch basin.

A high potential exists for future impacts on water quality from climate change. Overall precipitation, the frequency and intensity of severe thunderstorms, and extreme precipitation events are all projected to increase at the park (NPS 2020b), likely leading to an increase in the number of spikes in *E. coli* levels. In addition, increased soil erosion from heavy rainfall events may increase turbidity and reduce dissolved oxygen levels during those events.

Impacts on Water Quality

Alternative 1: No Action (Continue Current Management)

Alternative 1, the no-action alternative, would be the continuation of current management. No new actions would occur, and impacts on water quality would remain the same as described in the affected environment section. The current resource threats of fecal bacteria contamination, trail-related impacts, and climate change would continue to occur.

Alternative 2: NPS Preferred Alternative

Because of the close relationship between surface and groundwater throughout the park, impacts on surface water quality also contribute to groundwater quality impacts (Singer et al. 2023). As such, this section describes impacts on both groundwater and surface water quality as general water quality impacts. Under the action alternative, the construction of approximately 66 miles of new trails and associated facilities would result in erosion and the introduction of sediment into water systems, which would have temporary adverse impacts on water quality. As described in appendix I, mitigation measures and best management practices, such as silt fences and other runoff control measures, would be implemented during construction to minimize erosion and prevent adverse impacts on water quality.

Studies in the park have revealed that trails can negatively impact water quality by introducing sediment into nearby streams and changing the composition of macroinvertebrate species (Johnson 2016a, 2016b). An increase in the mileage of trails could result in more sedimentation across a larger geographic area. However, all new trails would be built in accordance with trail sustainability measures outlined in appendix C. Specifically, physical trail sustainability measures would be used to manage water and limit erosion, such as through trail hardening and earthwork strategies to improve drainage. Attention to the trail's grade, through grade reversals and outslopes, would ensure that water can flow from the trail as frequently as possible, limiting erosion and reducing sedimentation. Restoring existing unauthorized visitor-created trails to natural conditions and rehabilitating trails with poor alignment would also reduce adverse impacts on water quality from soil erosion and sedimentation. Additionally, educational materials would encourage visitors to mitigate their impact, preventing erosion and, therefore, protecting surface and groundwater resources. The mitigation measures described in appendix I, such as adding gates around springs as needed, would also reduce local water turbidity.

Surface water and groundwater contamination by human and animal fecal waste is ubiquitous in the park and impacted by trail use. New trails and backcountry campgrounds could increase contamination from fecal waste throughout the park. The addition of seven restrooms at trailheads throughout the park would help reduce human waste. Under the action alternative, an increase in educational materials on trail etiquette and LNT practices would provide visitors with information on how to properly manage human waste and reduce water contamination from human waste.

Equestrian use has been found to have a larger adverse impact on water quality compared to foot traffic or bicycle use due to heavier weight loads, which generates more sediment, along with a higher prevalence of fecal contamination (Cooke and Xia 2020). Decommissioning four existing equestrian trails due to poor alignment and sustainability issues and restoring the trails to natural conditions would reduce erosion and result in positive impacts on water quality from less equestrian use. However, under the action alternative, the mileage of equestrian trails would increase by 5 miles, which could increase adverse impacts on water quality. As described above and in chapter 3, these new trails would integrate physical trail sustainability measures to manage water and limit erosion, which would mitigate the adverse impact on water quality. Additionally, under the action alternative, keeping all horse trails north of the Green River would contain impacts geographically to those water basins.

Under the action alternative, biking would be allowed on approximately 18 miles of new trail in addition to the existing 19 miles of bike trails. Very little research exists that specifically examines the impacts on water quality from biking and e-biking; however, research shows that the amount of soil erosion (which could contribute negative impacts on water quality) is the same from biking as it is from hiking. (IMBA, 2015; Nielsen et al. 2019). Increased soil erosion and impacts on water quality typically occur during initial trail construction (regardless of whether the trail is for hiking only or for multiuse recreation) and then levels out over time. Implementing the design standards outlined in appendix C would mitigate the risks of increased soil erosion due to biking. In addition, the mitigation measures listed in appendix I, such as using USDA NRCS soil survey data, conducting site evaluations, and considering soil conditions when

determining the final layout of a trail, would reduce erosion on newly constructed trails and, therefore, mitigate adverse impacts on water quality.

Under the action alternative, amending the Superintendent's Compendium so that motorboats exceeding 40 horsepower would not be allowed during the primary paddling season would have a positive impact on water quality. The horsepower restriction would reduce the potential for large wakes eroding the shoreline and contributing to water turbidity, positively impacting water quality.

In total, when accounting for construction-related sedimentation, erosion from trail use, and fecal waste, surface water and groundwater quality would experience minor short- and long-term impacts. An emphasis on trail sustainability, an increase in educational materials, and the mitigation measures described in appendix I would reduce the adverse impact on water quality.

Conclusion

Under the no-action alternative, impacts on water quality would remain the same as described in the affected environment section. Actions proposed under the action alternative would result in an increase in sedimentation from construction and trail use, as well as a minor but contained increase in fecal waste contamination, resulting in minor adverse impacts on water quality. Employing the mitigation and trail sustainability measures outlined in chapter 3 and appendix I would reduce the adverse impacts on water quality. When the impacts of the action alternative are combined with the impacts of past, ongoing, and reasonably foreseeable future planned actions described in the affected environment section, the overall cumulative impacts on water quality would be adverse in the short term during trail construction but would result in overall beneficial impacts in the long term due to more sustainable trail placement, alignment, and construction.

VISITOR USE AND EXPERIENCE

Affected Environment (Current and Future Conditions of Resources)

Mammoth Cave's surface trail system provides park visitors with a wide variety of recreational opportunities, both on land and on the Green and Nolin Rivers. Land-based activities include hiking, trail running, biking, horseback riding, camping, birding/wildlife watching, photography, and wildflower viewing. River-based activities include kayaking, canoeing, fishing, camping, and exploring islands and the two open entry caves—Pike Spring and Sand House Caves—when the river levels allow. A diversity of natural settings is found along the trails, including woodlands, rivers and streams, waterfalls and cascades, wildflowers, dramatic bluffs, and historic landscapes. Experiences along the trails range from highly social gatherings with medium-to-large groups to more solitary pursuits.

The collective surface trail system at Mammoth Cave National Park is the result of numerous historical processes and isolated planning efforts. The system was never holistically designed. For example, many of the trails follow old road alignments that served utilitarian purposes rather than recreational purposes and do not connect visitors to points of interest, such as waterfalls, rock formations, or scenic overlooks. The system lacks clear guidance about how different trails should be managed and what experiences are available there.

A 2022 study reported that most visitors were from Kentucky (45.5%), Tennessee (7.58%), Indiana (7.49%), or Ohio (6.49%), with many Kentucky visitors coming from Bowling Green in Warren County (28%) (Brownlee et al. 2022). The park has a mix of repeat or frequent visitors and one-time visitors, with approximately 9.1% of respondents visiting the park once a month to recreate and 53.3% of respondents visiting the park for the first time (Brownlee et al. 2022).

Visitor Access and Circulation

Currently, 85 miles of trail are on land. Most existing trails in the park lack sustainable design elements such as cross-slope alignment, outsloping drainage, and grade reversals. Many of these trails contain some segments that are muddy or badly eroded. The 2022 study found that as much as 17% of the length of some backcountry trails are highly muddy, and depending on the trail, 10%–86% of their lengths are highly eroded. These conditions harm the quality of the visitor experience, as trail users must navigate through or around mudholes, ruts, and washouts. These conditions appear to be worsening, as the 2022 study found most park trails became wider, more deeply incised, and more eroded and muddy, between 2014 and 2021 (Brownlee et al. 2022). In some cases, conditions have deteriorated to the point that park management implements temporary closures to protect visitor safety consistent with 36 CFR 1.5.

In addition to the designated trail mileage, many unauthorized user-created trails exist throughout the park. In some areas, these unauthorized trails are very common, with 123 found along McCoy Hollow Trail, 97 along Mill Branch, and 53 along Blair Springs Branch in 2021 (Brownlee et al. 2022). Many of these unauthorized trails have become so well established that visitors are not able to distinguish between designated trails and undesignated ones. These unauthorized trails, along with sometimes inconsistent signage, mapping, and trail marking, can lead to wayfinding challenges for visitors.

Approximately 30 miles of trail are on the Green and Nolin Rivers combined, a national water trail blueway. Within the park boundary on the Green River, there are developed canoe/kayak ramps at Dennison Ferry, Green River Ferry, and Houchin Ferry. Access to the Nolin River occurs outside of the park boundary on USACE land, which is also a developed ramp. Many of these river access points become congested during the summer months, with bottlenecks often occurring as visitors park, prepare their watercraft, launch, takeout, trailer, and depart in these areas.

Visitors travel to the park primarily by passenger vehicle, but also on foot, by bicycle, and by boat. Those arriving by motor vehicle can access the trail system by parking in designated trailhead parking areas. Bicyclists can use bicycle parking racks along trails and at trailheads. Currently, one vehicle ferry operates in the park, the Green River Ferry. This ferry serves as the primary north-south vehicular route from the core visitor services area on the south side and the north side of the park along with communities outside the north side.

Visitor Opportunities

Many recreational opportunities are available on both land trails and the rivers. They are described in the two sections that follow.

Land Trails

The majority of land trails are north of the Green River, with minimal trails located on the south side of the Green River. Hikers can enjoy all 85 miles of land trails in the aboveground trail system, including 12 miles that are open to pedestrians only and 1.6 miles that meet the technical requirements of ABAAS. Equestrian trail users can enjoy 54 miles of trail that are open to equestrians and pedestrians. Bicyclists can enjoy 19 miles that are open to bicycles and pedestrians. A 0.2-mile section of trail connecting Maple Springs to Big Hollow is open to bicyclists, equestrians, and hikers, though this suboptimal mixture of use is necessary to provide access from the trailhead parking to the Big Hollow bike trail.

About a quarter of hiker trail opportunities are clustered near the visitor center area. These scenic trails feature ridgetops, river views, sinkholes, cave-fed springs, cemeteries, a historic train engine, the accessible Heritage Trail, and views of the historic entrance to Mammoth Cave and Dixon Cave. These trails tend to have higher use levels, shorter distances, and more development. Most can be hiked in under an hour and are useful for those looking to spend some time in the park before, after, or in between cave tours. The remaining three-quarters of hiker trail opportunities are north of the Green River. These trails traverse forest ridges, valleys, and scenic rivers vistas and tend to have lower use levels, longer distances, and less development.

Equestrian trail opportunities range from family friendly to rustic and challenging. Private equestrians can access trails by parking private horse trailers at horse trailer parking lots, such at First Creek Trailhead or Maple Springs Trailhead, or through commercial operators with businesses just outside of the park boundary. Guided outings are also available through authorized commercial operators. All of the equestrian opportunities are north of the Green River.

Bicycle trail opportunities are almost evenly split between mountain biking and road biking opportunities. The Big Hollow Trail, which is about 9 miles, was purpose-built for mountain biking and is popular with that user group, as it consists of mostly native tread single-track trail with rolling terrain and occasional moderately technical features. The trail offers a more intermediate loop (North Loop) and more advanced loop (South Loop). Another 9 miles of biking opportunities can be found along the Mammoth Cave Railroad bike-and-hike multiuse trail. This wide, hardened trail connects from the park's southern boundary near Park City.

For overnight backcountry users along the land trails, there are 13 designated backcountry campsites that are accessible only by hiking or horseback. These sites are rugged, with only a fire ring and horse hitching posts available, though nearby water is generally available. Permits are required for backcountry camping, and reservations can be made online.

River Trails

The Green and Nolin Rivers in the park provide opportunities for both day paddles and overnight trips. Paddlers can fish, view wildlife and scenic river bluffs and explore springs. Camping is allowed on islands and in the floodplain with a backcountry permit or at the Houchin Ferry Campground. The 25 miles of the Green River in the park are considered flat-water, but the current can still be very swift (around 4.5 knots or 5 miles per hour). The 7 miles

of the Nolin River in the park can be accessed from the Tailwater Recreation Area, managed by the Army Corps of Engineers, and floated through the park to the confluence with the Green River. Downstream of the confluence and just outside the park, Lock and Dam 6 was recently removed, which led to lower water levels and swifter currents on the Nolin River and enhanced the paddling experience on the Green River when water levels are adequate.

Both rivers are known for water levels that can change rapidly due to weather (i.e., rise 20–50 feet in the hours and days after a rain event) or due to water release schedules from the Nolin River and Green River Dams. Hazards such as submerged trees, rocks, and drifting debris can be present. Due to the increased hazards associated with high water, currently launching of all paddle craft is prohibited when the river exceeds 20 feet.

Visitors may paddle the rivers on their own private boat or rent canoes and kayaks from authorized commercial liveries (currently three) based outside of the park. The livery services rent boats and related equipment and shuttle visitors to launch and takeout locations. The most popular section of the river is the Dennison Ferry to Green River Ferry segment, approximately 8 miles or a 2.5-hour to 4-hour float, depending on the river level and an individual's pace. The second most popular trip is from Green River Ferry to Houchin Ferry. This trip is 12 miles and can take 4 to 6 hours to paddle. The 11-mile Nolin River Dam to Houchin Ferry segment, 4-mile Houchin Ferry to Brownsville segment, and more than 20-mile segment upstream from the Dennison Ferry are all less popular, largely due to the difficulty of access and length of the segments.

The kayak/canoe ramp at Green River Ferry was recently improved to support boating access to the river, and the kayak/canoe ramps at the Dennison Ferry and Houchin Ferry are slated for similar improvements in the near future. Once improved as planned, all three river access locations will offer kayak and canoe staging areas to aid in boat storage and shuttling associated with paddling.

Visitation Trends

Overall visitation to the park has increased by 25% over the last 10 years. In 2014, the park had over 520,000 recreational visits, and by 2023, this number increased to over 650,000 annual recreational visits. This increase has been somewhat steady except for a drop in annual visitation during the COVID-19 pandemic in 2020 (figure 6). While trail use is only a small proportion of overall visitation, parkwide visitation is indicative of the overall recreational demand in the area.

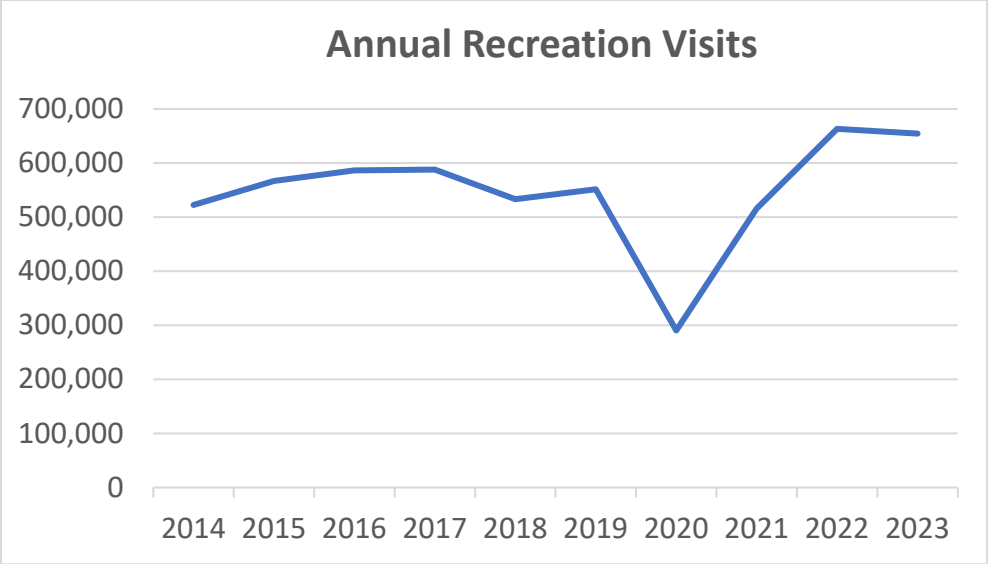

FIGURE 6. PARKWIDE ANNUAL RECREATIONAL VISITS, 2014–2023

Peak annual visitation to the park occurs from the months of June through August each year (figure 7).

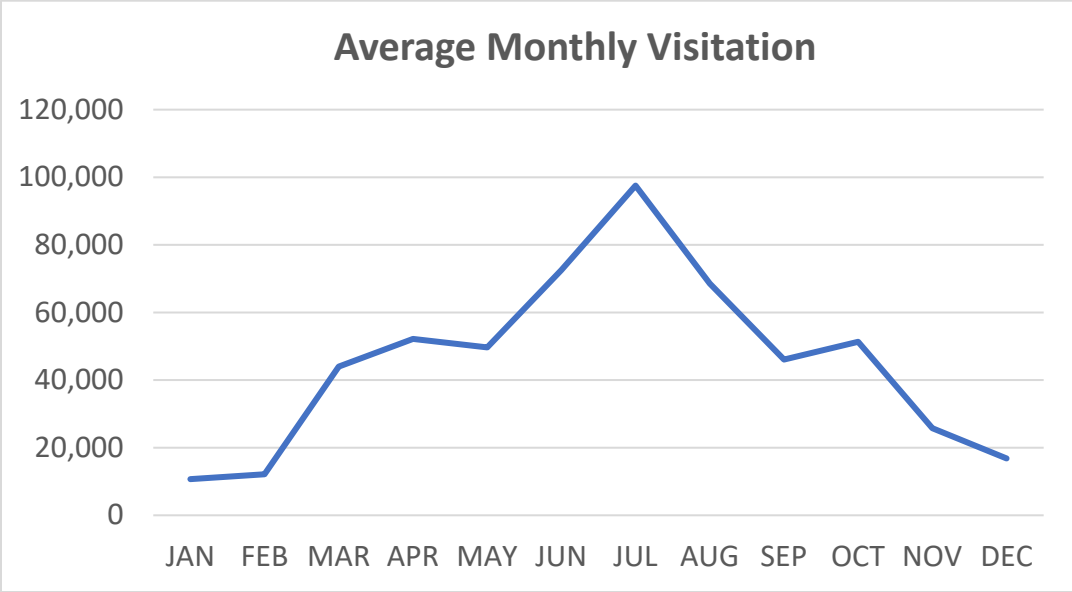

FIGURE 7. PARKWIDE AVERAGE MONTHLY VISITATION, 2014–2023

A 2022 study showed that 52.3% of visitors using the trail system do not visit the visitor center and instead start their trip at backcountry trailheads (Brownlee et al. 2022). One-day trips are more common (45%) than two-day overnight trips (21.7%) (Brownlee et al. 2022). Most visitors recreate at the park in pairs, with larger groups being more common for on-river paddling and horseback riding (Brownlee et al. 2022).

Spatially, visitors show a variety of route patterns for all backcountry trails, and the Maple Springs area is a popular area for all land-based user groups. The majority of respondents to the

2022 study stated that day hiking (38%) and backcountry camping (23%) were their primary recreational activities. The study found the following breakdown of recreational groups: day hikers (38%), backcountry/overnight campers (23%), mountain bikers (13%), horseback riders (12%), frontcountry campers (7%), and paddlers (7%).

Detailed information about the timing, amount, and distribution of visitor use on the park's land and river trail systems is included in the "Existing Direction and Knowledge" sections of appendix B.

Trail Management Trends

Land trails at the park are generally maintained on an as-needed basis, where safety concerns and downed trees take priority. Many land trails in the park are improved by placing loose gravel on the trail to improve tread in muddy areas. This management technique has proven to be unsustainable, as the gravel washes down trails and gullies into the river system.

Expected Future Conditions

Overall, the visitor use and experience on the park's surface trail system is expected to deteriorate if visitation trends and current trail management continues. The deterioration of trails from erosion and use, combined with the piecemeal approach to trail improvements, would mean that trails become wetter, muddier, and more rutted, making them less enjoyable to use. The expected continued increase in trail use would exacerbate these issues. Increasingly heavy use of the trails would also cause more erosion and potentially increase the frequency of trail closures related to resource and safety concerns. These reactive closures would reduce visitors' access, as they would have fewer areas to visit, and fewer locations would offer a particular type of use or experience that may be of interest.

In addition, anticipated increases in visitor use would also contribute to more social experiences on both the land and river trails, making solitude and connection with nature more challenging to achieve. As trailhead parking lots begin to fill more frequently and potentially become overwhelmed, visitors could face the uncertainty or inability to find parking, thus preventing them from visiting certain portions of the trail system. Full parking lots may also lead to increased informal parking, which causes safety and resource concerns.

Impacts on Visitor Use and Experience

Alternative 1: No Action (Continue Current Management)

Alternative 1, the no-action alternative, would be the continuation of current management. No new actions would occur, and impacts on visitor use and experience would remain the same as described in the affected environment section. Park management would continue to lack clear guidance and desired conditions for managing trails, land trails would continue to follow historic road alignments that lack sustainable design elements and fail to access points of interest, shared use and associated conflicts would continue on the Maple Springs Connector, visitor access would occasionally be limited by temporary trail closures to protect safety, and river access locations would continue to be congested during summer months. Many of these conditions could worsen over time due to increased use, the cumulative toll of erosion, and lack of maintenance.

Alternative 2: NPS Preferred Alternative

Land Trails and Roads — Under the preferred alternative, approximately 66 miles of land trails would be added to the Mammoth Cave trail system. This 72% increase in designated trail miles available for public use would mean many more opportunities for hiking, horseback riding, and bicycling. The preferred alternative includes increased trail mileage and associated opportunities for each of these user groups. Pedestrian-only trail mileage would increase from 13 to 52, with much of this mileage adding new opportunities away from the visitor center where pedestrian trails are currently clustered. Equestrian/pedestrian trail mileage would increase modestly from 54 to 59, and bicycle/pedestrian trail mileage would increase from 24 to 37.

Upon implementation of the preferred alternative, trail mileage available for each primary terrestrial user group would more closely align with user types currently using the trail system, as day and overnight hikers (61% of users) would have access to 100% of the system, bicyclists (13% of users) would have access to 26% of the system, and equestrians (12% of users) would have access to 38% of the system. Overall, the substantial increase in trail mileage and recreational opportunities for all users would be beneficial to visitor use and experience.

Under the preferred alternative, some individual trail segments would be decommissioned. However, in each case, this adverse impact would be mitigated by the presence of an existing alternative, the construction of an alternative, or the designation of an alternative. Additionally, use levels on these decommissioned trails is currently very low, so few visitors would be impacted (Brownlee et al. 2022). Specifically, the 1.5-mile Dry Prong Trail would be decommissioned, but equestrian and pedestrian users could still traverse the same ridgetop using the existing and adjacent Buffalo Creek Trail. The Dry Prong Trail is the primary trail used by 0.5% of visitors. The 2.3-miles of the McCoy Hollow Trail would be decommissioned, but equestrian and pedestrian users could still complete a similar loop by using the proposed McCoy Hollow extensions, proposed Wildcat Hollow trail, and Houchin Ferry Road, which would be newly designated for equestrian use. The McCoy Hollow Trail is the primary trail used by 2.2% of visitors. The 1.9-mile Mill Branch Trail would be decommissioned, but the nearby Raymer Hollow Trail would provide similar opportunities to traverse Dry Prong. The Mill Branch Trail is the primary trail used by 0.3% of visitors. The 0.3-mile Maple Springs Connector would be decommissioned, but an alternative would be provided with the new parking lot at the Big Hollow Trailhead. This new connection via Sugar Sink to the Big Hollow bicycle and pedestrian trails would eliminate any shared use between horses and bikes, reducing opportunities for conflict between user types.

The changes in allowable visitor use on Ugly Creek and Houchin Ferry North Roads, as well as the White Oak Trail, would impact the visitor experience in several ways. Visitors would no longer be able to drive on the 1-mile section of Ugly Creek Road, but hiking, biking, and equestrian use would continue to be allowed. Currently, there is little public vehicular use of this road, so only a small number of visitors would be adversely impacted by this change. Similarly, the White Oak Trail is used by very few bicyclists, so the closure to bikes would not impact many visitors. Allowing equestrian use on the 5.4 miles of Houchin Ferry Road would improve the equestrian user's experience by providing multiple opportunities for longer loop rides, and a new opportunity to ride to the river and back from the northern boundary of the park. Conflicts

between vehicles, equestrian users, hikers, and bicyclists are not expected on Houchin Ferry Road North since there is such little use on this road.

Under the preferred alternative, there would be more support infrastructure for recreation, including new bike racks, information kiosks, parking areas, and restrooms. This infrastructure would provide for improved access and experiences, as visitors' basic needs will be taken care of once they hit the trail. One more backcountry land campsite would be available, which would mean more overnight camping possibilities.

Beyond merely providing more opportunities in terms of trail mileage and support infrastructure, the preferred alternative would improve the diversity of experiences possible on trails. This improvement would occur through the clear delineation of four land trail categories, each with varying levels of development, use density, physical exertion or challenge, time required to visit, and degree of adventure. This categorization and communication of the types of experiences available on the different trail categories would allow more trail users to find trail experiences aligned with their expectations and motivations, greatly improving the quality of their experiences. The trail systemwide desired conditions would also provide a benefit to visitors by defining clear goals to guide trail maintenance and management. For example, the desired condition that visitors can become more immersed in their surroundings (and less concerned with trip hazards) would help to focus maintenance on improving the quality of the trail tread to better serve visitors.

Another on-trail benefit of the preferred alternative is that many more of the trails would lead to desirable destinations, such as scenic viewpoints, rock formations and outcrops, and water features. This benefit would add interest and purpose to trail users' experience beyond the exercise, meditation, and relaxation opportunities that currently exist.

The accessibility actions in the preferred alternative would both provide an additional mile of trail to the park's system that meet the technical requirements of ABAAS and allow trail users with a variety of abilities to make informed decisions about whether the remaining trails may suit their interests and needs.

Addressing circulation issues to decrease user conflicts and improving wayfinding and navigability through intuitive design and signage would generally benefit the visitor experience. Improved signage, trail markers, and educational materials regarding trail etiquette would also improve wayfinding and reduce conflict.

An adverse impact would occur from the closures of trails associated with trail rehabilitation, as well as the associated noise and visual impact from these activities; however, these closures would be occasional and short term and unlikely to impact most trail users due to scheduling, noise abatement, visual screening, and directional signage to avoid construction.

Occasional adverse impacts would occur on visitor use and access from the six trails that would be subject to wet weather closures for bikes and horse use when soil moisture levels are too high. A perceived inequity could occur stemming from the differential treatment of user types. However, this differential treatment is supported by the need to limit rutting and erosion caused by horses and bikes that generally do not occur with pedestrian use. In addition, all users experience an overall net benefit that stems from the trails being in better condition when they

are dry. Importantly, the occasional wet weather closures would only affect a few select trails, and the vast majority would remain open to all users regardless of weather conditions.

Water Trails — Under the preferred alternative, five designated reservable campsites would be established with a campfire ring, tent pad, and hook for lantern. For visitors who prefer to plan ahead, the reservable nature of these sites would have beneficial impacts, as it would provide assurances that a high-quality, safe, campsite with basic infrastructure would be available to those who want it. Meanwhile, continuing to allow undesignated, unreserved camping on islands and the floodplain would preserve opportunities for spontaneous visits for those who prefer shorter trip planning windows.

The primitive river takeouts included in the preferred alternative at Crump Island and Turnhole Bend would provide more options for shorter river trips along the Green River Ferry to Houchin Ferry segment of the river. Currently, this 12.4-mile segment is underused by visitors, largely due to the long time commitment (4–6 hours) required to float that section of river. Under the preferred alternative, river users would be able to explore sections in shorter chunks. This change may also distribute use away from the busy Dennison Ferry to Green River Ferry section (7.6 miles), decreasing congestion at those boat launches and boats per viewscape along that stretch, improving the quality of access and experience. Park staff believe this section gets elevated use due to its shorter associated time commitment (2.5–4 hours). In a similar vein, the preferred alternative includes actions to encourage CUA permit holders to use the less-busy river segments (e.g., Green River Ferry to Houchin Ferry, Houchin Ferry to confluence, confluence to west park boundary) to reduce congestion at the takeouts and quality of the on-river floating experience. While this would generally be a beneficial impact, too much dispersal could harm desired condition achievement on the moderate- and low-density water trails, which are managed for more opportunities for solitude.

Under the preferred alternative, the Superintendent's Compendium would be amended so that self-supported paddlers could still launch on the water trails in the park, even when the stream gauge exceeds 20 feet. Commercial livery services would continue to be suspended at high water. This change would have both beneficial and adverse impacts on visitor use and experience. The beneficial effect would be that paddlers who are not supported by commercial liveries would be able to access and experience the river at higher and more dynamic stream flows, ensuring continual access throughout the season and potentially more exciting on-water experiences. While there is an increased risk to visitor safety due to paddling during higher water, this risk is relatively small, as visitors who can provide their own watercraft tend to be more experienced paddlers. Education around the risks and the potential for delayed or unavailable emergency response would also mitigate this adverse effect.

The access for visitors using commercial livery services is unchanged from current conditions, so there is technically no effect; however, the differential treatment of user groups could create a perception of inequity. This differential treatment is supported by a legitimate safety concern for novice paddlers using the river with rented watercraft during hazardous conditions— a concern that is grounded in years of search and rescue experience by park staff. Additionally, it does not appear that paddlers are an economically disadvantaged group or group with environmental justice concerns, as the demographics of paddlers mimics that of visitors to the park overall. Twenty-two percent of paddlers make less than $50,000 per year, while 19% of all visitors make

less than $50,000. While 92% of paddlers are white, 86% of all visitors are white (Brownlee et al. 2022). The difference in demographics between commercially supported and unsupported paddlers is unknown.

Under the preferred alternative, the Superintendent's Compendium would be amended so that motorboats exceeding 40 horsepower of functional output would not be allowed during the primary paddling season. This change would have both beneficial and adverse impacts on visitor use and experience. The beneficial impact would be experienced by nonmotorized paddlers who would not have to contend with high speeds and large wakes created by larger boats and high-powered motors. The adverse impacts would be experienced by motorized users who would otherwise be able to use their watercraft during this high-use season. Since very few motorboats currently use the river (an average of three boats per day during a busy month), these impacts would be experienced by very few individuals, many of whom likely live locally and have suitable motorboating alternatives in the region.

Bicycle Use and NPS Bicycle Rule — Under the preferred alternative, additional bicycling opportunities would be available on the Sugar Sink Trail, West Entrance Trail, and East Entrance Trail. These trails are shared with pedestrians but notably would not be shared with equestrians. The potential for conflict between bicyclists and pedestrians is relatively low on these new bicycle routes since most are wide, developed, and hardened. These routes provide plenty of room for passing, mitigating collision concerns. The one exception, the Sugar Sink Trail, would be constructed adjacent to the park's existing mountain bike trail system at Big Hollow. Information shared in park publications, online, and at the trailhead currently highlights that these are mountain bike trails, and they would continue to do so. Hikers electing to use this trail system, which is self-contained and isolated from the rest of the park's trail system, would be doing so on their own volition.

Indicators, Thresholds, and Objectives — The management strategies that may be implemented if conditions approach thresholds would generally be beneficial, as they help ensure desired conditions are achieved. This benefit includes minimizing encounters on land trails, minimizing boats per view on water trails, ensuring trails are in good condition for users, and ensuring that complaint-worthy items are minimized and addressed when needed.

Conclusion

Under the no-action alternative, impacts on visitor use and experience would remain the same as described in the affected environment section. Actions proposed under the preferred alternative would result in many more miles of recreational opportunities for all terrestrial user types and a commensurate increase in support facilities and access to scenic points of interest. While some individual trail segments would be lost, they all have comparable or superior substitutes under the preferred alternative. On the water trails, the reservable campsites would provide predictable access, and the primitive takeouts would increase options and distribute river use more evenly to decrease crowding on the water and congestion at the takeouts. Allowing use during high water would expand opportunities for experienced self-supported paddlers with minimal associated increase in risk. The expansion of bike use to new areas would be of minimal concern due to the wideness of the trails, and the potential for visitor use conflict overall would be low due to the avoidance of shared use on trails.

Overall, the preferred alternative would introduce a clear vision and desired conditions to the trail system and help achieve those desired conditions. When the impacts of the action alternative are combined with the impacts of past, ongoing, and reasonably foreseeable future planned actions described in the affected environment section, the overall cumulative impacts on visitor use and experience would be beneficial.

ARCHEOLOGICAL RESOURCES

Affected Environment (Current and Future Conditions of Resources)

Much of Mammoth Cave National Park has been subjected to varying degrees of archeological survey. Based on GIS data, it is estimated that approximately 5% to 10% of the park has had pedestrian surveys completed and 1% to 5% has been subject to subsurface testing (shovel, post-hole, or auger). More than 1,100 archeological sites are found within the park boundaries, ranging in age from the Late Paleoindian Period (8,500 BP), continuously through to the historic era of the early 19th to 20th centuries and leading up to the establishment of the park. One site, Salts Cave Archeological Site, was listed in the National Register of Historic Places in 1979.

Many of Mammoth Cave's archeological resources show the connection that Indigenous peoples have had to these lands since time immemorial. These resources include cave sites, rock shelters, settlements along river terraces, and upland campsites on the ridges. The cave environment minimizes the decomposition of sensitive organic materials, practically preserving the remains of seeds, rivercane, gourds, reeds and other fibers, paleofeces, and other organic matter indefinitely; many of these resources can still be found on the landscape.

The land on which the park sits was once home to over 500 families who held farmsteads, logging camps, quarries, stores, and churches and buried their deceased in nearby cemeteries, many located within the current park boundary. Several of the park's current trails are located on homestead roads, effectively limiting access to the richer and more scenic cultural sites.

As use levels for hiking, mountain biking, and horseback riding increase, direct, adverse impacts on the physical condition and the integrity of archeological resources occur. Social trailing results in damage to archeological sites, mainly due to erosion and soil compaction, looting, and littering. Social trails to waterfalls, rock shelters, and other areas with archeology encourage more visitors to visit those sites, and their isolation from the formal trail network can increase the surface looting of material and even result in subsurface looting. Changing climate conditions could also cause impacts on archeological resources. Increased global temperatures are projected to cause faster deterioration of newly exposed artifacts and sites, as well as accelerate the decay of organic materials. More precipitation and/or heavier precipitation could cause archeological site erosion from overflow and new flood channels. Soil destabilization/shifting could also take place (Rockman et al. 2016).

Impacts on Archeological Resources

Alternative 1: No Action (Continue Current Management)

Under alternative 1, current management activities would continue. The current threats of erosion, soil compaction-induced impacts, looting, and littering would remain. No new actions

would be implemented, and as a result, there would be no impacts on archeological resources under this alternative beyond what is described in the affected environment section.

Alternative 2: NPS Preferred Alternative

Alternative 2, the NPS preferred alternative, would redevelop the park's trail system, with an emphasis on sustainability and the protection of park resources. Under this alternative, the land trail mileage in the system would increase from the existing 85 miles to 146 miles (river trail mileage would remain at 30 miles.) Many of the new trails would direct visitors near areas in the park that contain known archeological resources, including rock shelters. The phased programmatic agreement would be used and archeological surveys would be completed as part of the preferred alternative to ensure that direct impacts on archeological resources from new trail development would be avoided. Indirect visitor use impacts, including trampling, would likely increase due to visitors leaving established trails. As part of the sustainability measures that would be implemented (outlined in appendix C), the new trails that would be constructed would minimize the risk of erosion by following sustainability guidelines such as grade reversals and outslopes. Existing trails would be used differently, or closed altogether, where damage is beyond repair, and select trails would be temporarily closed during wet weather closures, thus preventing the trails from being expanded laterally and minimizing impacts on archeological resources in these areas. Park staff anticipate that increased visitor presence in the rock shelter areas would help reduce the looting of these resources due to higher visitor presence and social pressure to behave appropriately. Trails that are being rerouted would avoid archeological resources or would mitigate existing impacts on archeological resources. Improvements to existing trails, including minor realignments, are not anticipated to adversely impact archeological resources, as surveys to identify archeological sites would be conducted, leading to better, more protective trail placement and alignments.

Conclusion

Under the no-action alternative, impacts on archeological resources would remain the same as described in the affected environment section. The development of new trails under the action alternative would result in ground disturbance impacts on archeological resources. Surveys completed prior to constructing new trails would increase the knowledge of the park's archeological resources. New trail development under the action alternative would avoid direct adverse impacts on archeological sites. By following sustainability guidelines such as grade reversals and outslopes, the risk of erosion impacts at archeological sites in the vicinity of new trails would be minimized. With the implementation of mitigation measures outlined in appendix I and trail construction guidelines in appendix C, the effects on archeological resources would be minor as the areas would be surveyed prior to ground disturbance to ensure that final trail alignment avoids areas where archeological resources are present. When the impacts of the action alternative are combined with the impacts of past, ongoing, and reasonably foreseeable future planned actions described in the affected environment section, the overall cumulative impacts on archeological resources would be adverse.

CULTURAL LANDSCAPES AND HISTORIC STRUCTURES

Affected Environment (Current and Future Conditions of Resources)

Cultural landscapes at Mammoth Cave National Park include both natural and human-made environments, and the park's historic structures represent a wide variety of sites and structure types Four historic districts, and eleven individual structures, are listed in the National Register of Historic Places. Cultural landscape reports were completed for the Mammoth Cave Historic District and the core visitor services area in 2021 and 2015, respectively.

Historic churches are found in different parts of the Mammoth Cave area. Many of them began as rustic log buildings. As congregations and communities grew, there was a need to construct buildings dedicated specifically for holding church services. In many instances, however, these churches often doubled as schools to avoid the labor and expense of separate buildings. In addition to regularly held worship services, the churches were a gathering place for weddings and homecomings, as well as a comforting sanctuary for funeral mourners. Three separate churches are listed in the National Register of Historic Places—the Joppa Missionary Baptist Church, Good Spring Baptist Church, and Mammoth Cave Baptist Church—and are among the park's structures listed in the historic structures in the Cultural Resources Inventory System.

The buildings of Mammoth Cave National Park have a history of their own. Some of the most iconic buildings are older than the park itself. Before its establishment in 1941, the park was being prepared for the public with construction projects that included lodging, workshops, warehouses, utility structures, and comfort stations. The designs of these buildings were inspired by the early 20th-century architecture of other national parks. These designs focused on the harmony of materials and form with the surrounding landscape. Materials like hand-cut native sandstone and exposed lumber frames on the exterior of the buildings integrated into the surrounding landscape. Forested ridgelines and exposed sandstone and limestone bluffs surround many of these structures today, giving the illusion that these buildings could have grown out of the ground or formed directly from the rocky outcrops. Other notable structures, including the Superintendent's Residence, were constructed in 1941 or after.

The effects of climate change could pose challenges to the park's cultural landscapes and historic structures. Increased global temperatures could lead to a commensurate increase in stress (e.g., desiccation, warping, and cracking) on constructed landscape features. More precipitation and/or heavier precipitation could lead to swelling and distortion of wooden building materials and architecture features due to wetness and dampness. An increased risk of rot and fungal/insect issues in the structures and falling trees from storms could also increase (Rockman et al. 2016.) More immediately, the current limited staffing makes it difficult to proactively monitor the historic structures. Park staff do their best to respond to condition-related issues with the current resources when the issues are brought to their attention. Floyd Collins's House and Crystal Cave Ticket Office includes wells within its boundary. Not all the wells are covered, making it possible for visitors to fall into them.

Impacts on Cultural Landscapes and Historic Structures

Alternative 1: No Action (Continue Current Management)

Under alternative 1, current management activities would continue. The current threats, including the uncovered wells at the Floyd Collins House and Crystal Cave ticket office, would remain. Reactive monitoring of these and the other cultural landscapes and historic structures would continue to take place. No new actions would be implemented, and as a result, there would be no impacts on cultural landscapes and historic structures under this alternative beyond what is described in the affected environment section.

Alternative 2: NPS Preferred Alternative

As proposed in alternative 2, the NPS preferred alternative, the development of new trails would avoid direct impacts on the park's cultural landscapes. New trails would, however, direct visitors to areas close to many of the park's historic structures. Access to the Three Springs Pumphouse, the Floyd Collins House and Crystal Cave ticket office, and the Bransford Spring Pumphouse would all increase under this alternative. Historic churches, including Joppa, and several cemeteries provide parking for trail users, and visitor use is expected to increase in these areas. No direct impacts on these and the park's historic structures would occur from proposed trail development, be it the construction of a new trail or the rerouting of an existing trail. Historic structures could suffer wear and tear from increased visitation, but monitoring the carrying capacity of the structures could result in the imposition of visitation levels or constraints that would contribute to the stability or integrity of the resources without unduly hindering interpretation for visitors. Unstaffed or minimally staffed structures could be more susceptible to vandalism, but continued ranger patrol and emphasis on visitor education regarding the significance and fragility of such resources and how visitors can reduce their impacts on the structures would discourage vandalism and inadvertent visitor impacts, minimizing adverse impacts.

Conclusion

Under the no-action alternative, impacts on cultural landscapes and historic structures would remain the same as described in the affected environment section. The lack of active monitoring at the Floyd Collins House and Crystal Cave ticket office would perpetuate the visitor safety issues at this location, namely the risk of falling into an uncovered well. The development of new trails under the action alternative would result in visitors having increased access to the park's historic structures, including the Three Springs Pumphouse, the Floyd Collins House and Crystal Cave ticket office, and the Bransford Spring Pumphouse. New trail development under the action alternative would avoid direct adverse impacts on the cultural landscapes and historic structures. An increased number of people in the vicinity of the historic structures could reduce the likelihood of visitor-caused damage to the resources due to the resources acquiring greater visibility. With the implementation of mitigation measures outlined in appendix I and the trail construction guidelines in appendix C, the effects on cultural landscapes and historic structures would be minor. When the impacts of the action alternative are combined with the impacts of past, ongoing, and reasonably foreseeable future planned actions described in the affected environment section, the overall cumulative impacts on cultural landscapes and historic structures would be minor and largely beneficial.

Chapter 5
Consultation and Coordination

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CHAPTER 5: CONSULTATION AND COORDINATION

PUBLIC INVOLVEMENT

Civic engagement began in 2022 to inform the trails management plan. During this time, park staff met with specific trail user and community groups. These preliminary conversations shaped the early development of this plan. From July 25 to August 25, 2023, the general public and key stakeholders were invited to submit written comments via the Planning, Environment, & Public Comment (PEPC) online interface (https://parkplanning.nps.gov/mammothtrails). The purpose of this civic engagement period was to obtain public feedback on preliminary management strategies to assist with the development of the plan. The comments received from this process informed the creation of preliminary strategies.

Two in-person public meetings were held to discuss the trails plan and answer questions about the project on August 1, 2023 (4:00 p.m. to 6:00 p.m. CDT), and on August 3, 2023 (4:00 p.m. to 6:00 p.m. CDT). During the public meetings, NPS staff explained the plan process, showcased methods for public comment, and answered participants' questions.

A summary of public feedback was presented in the summer of 2023 and posted on the PEPC website. A total of 64 correspondences were received during the civic engagement period. The public shared input on their definition of a dream trail network, support for expanding the trail network, and opposition to decommissioning select trails and provided specific ideas on new trail ideas. The draft comprehensive trails management plan reflects the suggestions, ideas, and concerns shared by the public in the last round of civic engagement to the extent practicable.

CONSULTATION WITH AGENCIES AND TRIBES

During preparation of this land and river trails plan, members of the planning team met and/or consulted with various entities.

Tribal Consultation

Mammoth Cave National Park initiated Tribal consultation for the comprehensive land and river trails plan and environmental assessment on April 30, 2024. The National Park Service sent letters to the following Native American Tribes affiliated with Mammoth Cave National Park inviting consultation:

- Absentee Shawnee Tribe (Absentee-Shawnee Tribe of Indians of Oklahoma)
- The Chickasaw Nation
- Cherokee Nation
- Eastern Band of Cherokee Indians,
- Eastern Shawnee Tribe of Oklahoma
- The Osage Nation

- Shawnee Tribe
- United Keetoowah Band of Cherokee Indians in Oklahoma

State Historic Preservation Office

In accordance with section 106 of the National Historic Preservation Act, Mammoth Cave National Park staff initiated consultation with the state historic preservation office about the comprehensive land and river trails plan and environmental assessment in a letter dated April 19, 2024. As of October 2, 2024, park staff had not heard back from the state historic preservation office.

Mammoth Cave National Park staff also developed a phased programmatic agreement to guide the treatment of cultural resources in the different project areas identified in the Comprehensive Land and River Trails Plan. The draft programmatic agreement was shared with the state historic preservation office on July 25, 2024.

US Fish and Wildlife Service

Via the US Fish and Wildlife Service's Information for Planning and Consultation website, the National Park Service requested the most recent list of species and their designated critical habitat protected under the federal Endangered Species Act that may be impacted by projects in Mammoth Cave National Park in March 2024. This action served as a record that the National Park Service had initiated informal consultation with the US Fish and Wildlife Service pursuant to the requirements of the Endangered Species Act and NPS management policies. Park staff sent the US Fish and Wildlife Service a letter on October 2, 2024, to get concurrence on the species list and determinations.

Appendixes

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APPENDIX A: INDICATORS, THRESHOLDS, AND OBJECTIVES

INTRODUCTION

Visitor use management monitoring associated with this plan would be accomplished through "indicators" and "thresholds." The development of these components follows the guidance of the Interagency Visitor Use Management Council's Visitor Use Management Framework (IVUMC 2016) and monitoring guidebook (IVUMC 2019a).

Monitoring is the process of routinely and systematically gathering information or making observations to assess the status of specific resource conditions and visitor experiences (IVUMC 2019b). Monitoring is designed and implemented to provide usable data for periodically comparing existing and desired conditions, evaluating the efficacy of ongoing management actions, and assessing the need for additional management actions. Monitoring is an integral component of visitor use management, and it allows managers to objectively evaluate whether desired conditions are being achieved and maintained.

"Indicators" translate the desired conditions of the plan into measurable attributes that, when tracked over time, evaluate change in resource or experiential conditions from visitor use. The indicators are considered part of the preferred alternative.

The interdisciplinary planning team considered the central issues driving the need for the plan and developed related indicators that would help identify when the level of impact becomes cause for concern and management action may be needed. The indicators described below were considered the most critical, given the importance and vulnerability of the resource or visitor experience affected. The planning team also reviewed the experiences of other park units with similar issues to help identify meaningful indicators for the park's trail system, as follows:

- encounter rates on land trails
- boats per view on water trails
- trail cross-sectional area
- trail maintenance costs
- bare ground in riparian areas

"Thresholds" represent the minimum acceptable condition for each indicator and were established by considering the desired conditions for the plan, data on existing conditions, visitors' stated preferences and tolerances based on survey data, the professional judgment of staff from management experience, and other factors. Although defined as "minimally acceptable," thresholds still represent acceptable conditions. Establishing thresholds does not imply that no action would be taken prior to reaching the threshold. Thresholds identify when conditions approach unacceptable levels and accordingly serve as a "line in the sand," letting managers and the public know that corrective action must be taken to maintain acceptable conditions.

"Objectives" are specific, positive targets for resource conditions or visitor experiences. Unlike a threshold, an objective is defined as a specific result that an agency aims to achieve within a specified time frame.

Together, indicators, thresholds, and objectives provide park managers with a monitoring framework to ensure desired conditions for resources and visitor experiences are achieved and maintained over time.

The indicators identified in this document do not represent an exhaustive list of all monitoring that is currently and will continue to be conducted at Mammoth Cave National Park. Visitor use management is an iterative process in which management direction is continuously informed by new information and improved. Indicators are monitored, and adjustments are made as appropriate. As monitoring of conditions gets underway, park managers may decide to modify or add indicators if better ways are found to measure important changes in resource and experiential conditions. In recognition that not all monitoring relevant to this plan can be described with an indicator and threshold, some "other related monitoring" related to visitor concerns has also been included.

The following sections include detailed descriptions of the indicators and other related monitoring. With each indicator, a threshold or objective is identified, as is the rationale for selecting the indicator and identifying the threshold/objective and the potential strategy for monitoring. Lastly, management strategies that may be taken in association with the indicator are included. These strategies are divided into two groups: (1) strategies that are identified in chapter 3's description of the preferred alternative and would assist in managing within the identified threshold and (2) strategies that may be implemented if and when monitoring reveals conditions are approaching or exceeding the identified threshold or failing to meet the objective.

ENCOUNTER RATES ON LAND TRAILS

Indicator

Number of hiking parties (either an individual or group) encountered per hour on selected primitive and semi-primitive trail segments

Thresholds

No more than 3 hiking parties encountered per hour 85% of the time on primitive trail segments

No more than 5 hiking parties encountered per hour 85% of the time on semi-primitive trail segments

Rationale for Indicator and Thresholds

This indicator measures visitors' opportunity for solitude on trail types that are managed for that desired condition—the primitive and semi-primitive trails. While the indicator directly measures the number of times hikers meet, pass, or get passed along the trail, it is effectively

measuring the presence of "gaps" or breaks between encounters. In those gaps, visitors can experience solitude.

The desired conditions for the trail management plan state that there should be "sections of the trail system with opportunities to experience solitude and natural soundscapes, where encounters with others are minimal, providing for opportunities to experience the sounds of nature . . . and 'escape' from society." Specifically, the primitive trails in the park should provide "ample opportunities for solitude," while on the semi-primitive trails, "most visitors will find some opportunities for solitude at some point during their visit. Encounters with other visitors will be expected, but will not be frequent." On the developed and moderately developed trails, visitors can generally expect to find social atmospheres and encounter many other visitors. Since these trail types are not managed for solitude, this indicator, which measures opportunities for solitude, does not apply. This indicator is focused on primitive and semi-primitive trails.

This indicator is known to be reliable and sensitive to change based on experience in other park units. For low- or medium-volume trails, encounter rates are a common and appropriate indicator of visitor experience. This indicator is also thought to be reasonable as long as the number of trails monitored for encounter rates and the frequency they are monitored with is kept at a manageable level. Indirect monitoring of this indicator through the use of trail counters may be used as a proxy in intervening years. As the relationship between trail counts and encounter rates becomes better understood, trail count triggers may be established that would indicate a need for greater encounter rate monitoring.

While park managers do not have any historical data on encounter rates in the park, anecdotal evidence suggests that encounter rates on primitive and semi-primitive trails are currently very low. This evidence is supported by park trail counter data showing that trail counts on semi-primitive trails at peak times are between 1 and 4 people per hour (see appendix B). This indicator was carried forward not to address an issue that is currently of great concern but rather to warn park managers before it does become an issue. In this sense, it is a proactive indicator. Therefore, thresholds were identified above current levels, at volumes consistent with other trails managed for solitude across the National Park Service. Consistent with desired conditions for "ample opportunities for solitude," the threshold for primitive trails allows for 20 minutes of gap, on average, between encounters. Consistent with desired conditions for "some opportunities for solitude at some point," the threshold on semi-primitive trails allows for 12 minutes of gap, on average, between encounters.

These thresholds are well below levels of encounters visitors would find to be unacceptable, indicating that these levels of encounters would be consistent with desired conditions for solitude. A 2022 visitor use survey looked at the visitor preferences for the number of encounters with other people in a one-hour period on a trail (Brownlee et al. 2022). The study found that visitor acceptability of conditions decreases as the number of encounters increases (figure A-1). Assuming an average group size of 3 (Brownlee et al. 2022), 3 parties encountered per hour would equate to 9 people encountered per hour, while 5 parties would equate to 15 people encountered per hour. These encounter rates represent "moderately acceptable" to "slightly acceptable" encounter rates (roughly 1 to 2 on an acceptability scale from 4 to -4), according to the survey.

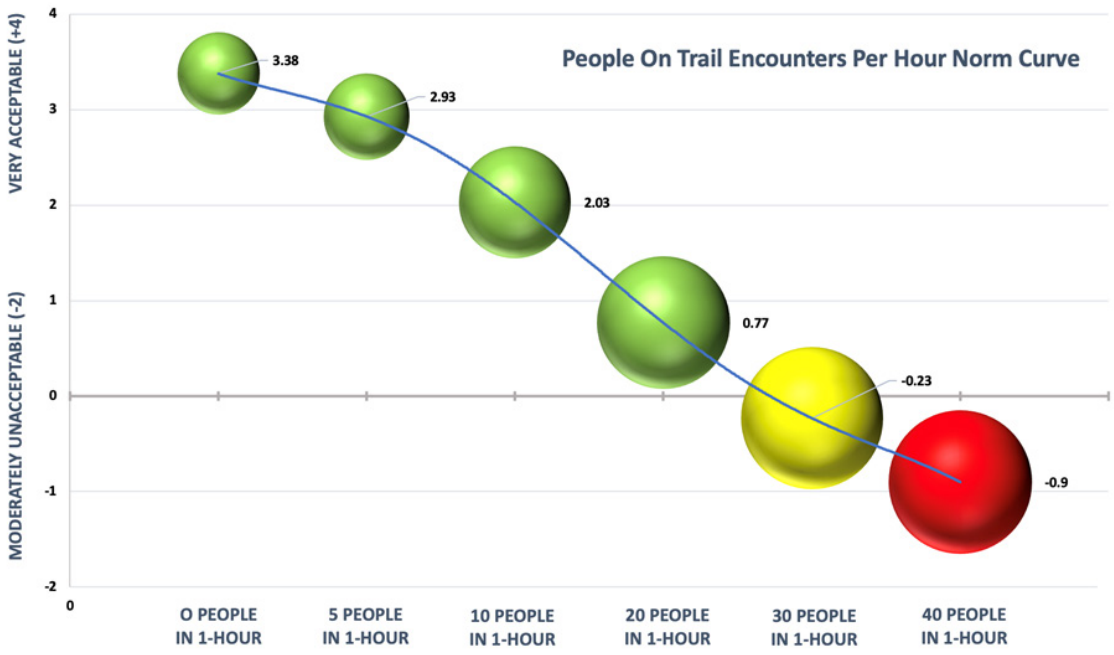

FIGURE A-1. PEOPLE ENCOUNTERED ON TRAILS PER HOUR NORM CURVE

Monitoring Strategy

The park's Science & Resource Management division staff would lead monitoring efforts with support from Facilities Management division staff. Park staff may leverage trained volunteers, interns, or university partners to assist with monitoring.

Monitoring would follow best practices for monitoring encounter rates in solitude-focused settings, such as Broom and Hall's guide to monitoring encounters. Generally, this involves walking the length of a trail while simulating the pace of a typical hiker and counting the number of discrete parties encountered. This can be considered "direct monitoring." This form of direct monitoring would establish the true encounter rate and directly monitor the presence of gaps and opportunities for solitude. Direct monitoring would be supplemented by the use of trail counter data. By collecting encounter rates and trail counts concurrently, park staff can understand the regression relationship between the two, and assuming the relationship is strong, rely on trail counts in years when encounter rate monitoring does not occur. Once the relationship between encounter rates and trail counts is understood, direct encounter rate monitoring may only occur every five years to test the long-term stability of the counter-encounter relationship.

Monitoring would generally include a sampling approach to get a range of conditions; however, monitoring would generally be done on days and times of year when visitor use of trails is likely to be higher. Encounter rate monitoring would occur on primitive and semi-primitive trails that represent the range of use levels, such as the Flint Ridge, Woolsey Valley, Big Hollow, Sal Hollow, McCoy Hollow, First Creek, Silent Grove, Cedar Spring, Doyle Valley, and White Oak Trails.

Management Strategies

The following management strategies are identified in chapter 3's description of the preferred alternative and would assist in managing within the identified threshold:

- Expand the number of primitive and semi-primitive trails in the park managed for solitude.
- Increase educational materials on appropriate trail etiquette among different recreational groups. Increase education on LNT principals.

The following management strategies may be implemented if and when monitoring reveals conditions are approaching or exceeding the identified threshold:

- Use public information and orientation to direct use away from trails that exceed the threshold at peak times.
- Provide appropriate trip planning information to visitors based on motivation. Direct visitors seeking solitude to primitive and semi-primitive trails, while others should be encouraged to use developed and moderately developed trails.
- Identify and enforce group size limits.
- Increase public education efforts to encourage voluntary redistribution of use to off-peak times.
- Use public information efforts before historically crowded weekends to inform the public to be prepared for higher-use levels.
- Enforce parking lot capacities and prevent overflow parking, as these parking lots were sized consistent with the desired conditions for the area.

BOATS PER VIEW ON WATER TRAILS

Indicator

Number of boats per view on the Green River 0.75-mile upstream from the Green River Ferry

Threshold

No more than 12 boats in the viewshed 80% of the time (boats include kayaks, canoes, paddleboards, inflatable vessels, and other small human-powered watercraft)

Rationale for Indicator and Threshold

For purposes of this indicator, the number of boats per viewshed is defined as the number of watercraft one would perceive if they stood on the river edge looking down river. Paddlers on the Green River through Mammoth Cave should be afforded a unique opportunity to engage in a social setting while recreating near river access amenities and find a sense of solitude once further down river. Desired conditions for water trails state that:

Visitors can expect a social atmosphere and to hear mostly anthropogenic sounds at river access points. As visitors get further away from access points, encounters would become less frequent and natural sounds would predominate. Visitors seeking more solitude and natural quiet generally can do so by altering speeds to avoid louder groups of visitors . . . Social activity and sounds are expected on sand bars.

This indicator monitors the quality of the visitor experience and, specifically, the degree to which the desired condition that encounters with others are "less frequent" and "can be avoided by altering speeds" away from access points is achieved. The monitoring of this indicator is considered reasonable, as it only includes monitoring at one viewshed. This indicator is also considered to be reliable based on its demonstrated use at other national park sites, such as Cuyahoga Valley.

A 2022 visitor use survey looked at the visitor preferences for the number of people within view at popular river locations (Brownlee et al. 2022). The study found that visitor acceptability of conditions decreases as the number of boats per viewscape increases. This demonstrated relationship between boats per viewscape and the quality of the visitor experience points to the importance of this indicator to desired conditions. According to the study, the number of boats per view becomes unacceptable for the average visitor when there are 12 boats per view (figure A-2). As conditions become unacceptable for the average visitor at 12 boats per view, park management identifies this number as the threshold, or minimally acceptable condition.

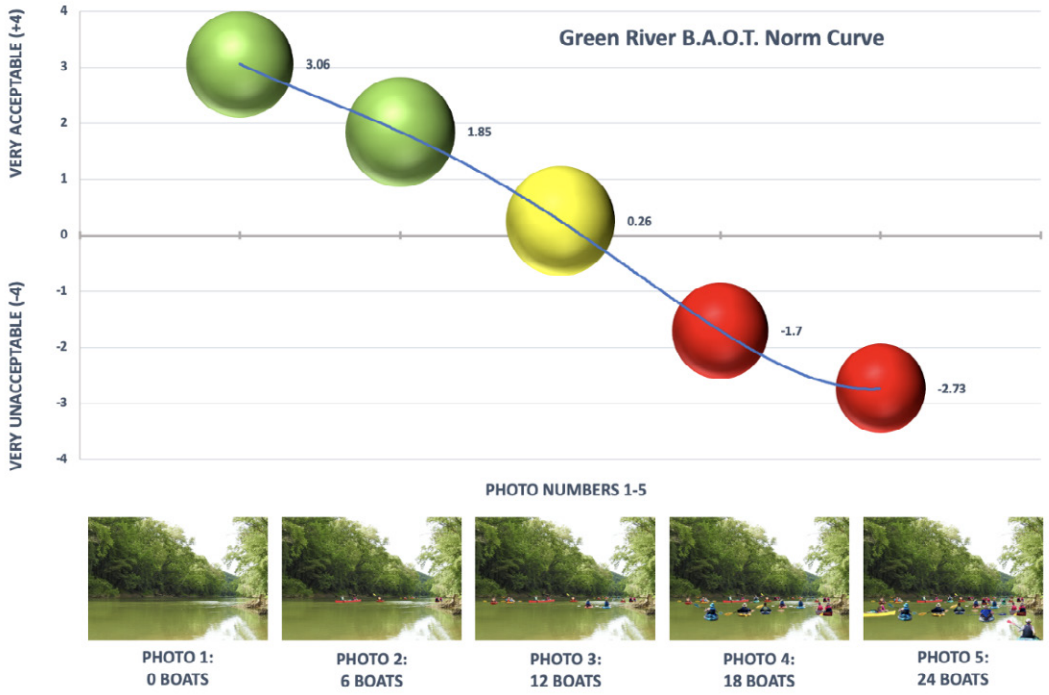

FIGURE A-2. SOCIAL NORM CURVE DEMONSTRATING DECREASING VISITOR ACCEPTABILITY OF CONDITIONS AS PEOPLE PER VIEWSCAPE INCREASES. NOTE THAT CONDITIONS BECOME UNACCEPTABLE AT 12 BOATS PER VIEW (BROWNLEE ET AL. 2022)

Monitoring Strategy

The park's Science & Resource Management staff would lead monitoring efforts with assistance from the park's facilities manager. Game cameras can be used for this monitoring to ease the staff time burden; however, in-person monitoring may be used as well.

The primary location for monitoring is approximately 0.75 miles upriver from the Green River Ferry. This location was selected as it is along the busiest stretch of river (Dennison Ferry to Green River Ferry), and, therefore, it is at greatest risk of approaching or exceeded the threshold. This specific location was chosen because it is far enough from the Green River Ferry to avoid the potential confounding effects of activity at the river launch while being close enough to be easily accessed by park staff. This location has a clear view downstream that does not include the river launch.

If the monitoring location is close enough to the path of paddlers and a game camera is used, the camera can be set to be motion activated; otherwise, the camera can be programmed to take photos at set intervals. Monitoring should be done during peak paddling season, between May and August. If used, cameras will be securely mounted to a tree or structure. They will be mounted at an angle that captures paddlers heading downstream. Camera equipment should be checked periodically during the monitoring period to ensure vegetation is cleared, batteries are functional, and memory card is not full. Postprocessing at the end of each season can be done by hand count or possibly with artificial intelligence technology. If in-person monitoring is used, standard protocols would be established to ensure the comparability of data collected by different staff, volunteers, and interchangeability with camera-collected data.

A secondary monitoring location could be added directly at the Green River Ferry boat launch, though this would be focused on parking activity more than boats on the river.

Management Strategies

The following management strategies are identified in chapter 3's description of the preferred alternative and would assist in managing within the identified threshold:

- None identified

The following management strategies may be implemented if and when monitoring reveals conditions are approaching or exceeding the identified threshold:

- Encourage visitors to launch earlier or later in the day to avoid periods of peak use.
- Identify a maximum group size for river parties.
- Actively manage the amount, timing, and distribution of CUA livery-supported boats at all boat launches within the park boundary.

TRAIL CROSS-SECTIONAL AREA

Indicator

Percent change in average cross-sectional area of selected trails as measured every five years

Threshold

Each monitored trail segment would experience no more than a 1% increase in a cross-sectional area from previous monitoring (every five years).

Rationale for Indicator and Threshold

The average cross-sectional area is the average tread width (measured in inches) multiplied by the average max incision (measured in inches). In effect, this indicator is a measurement that includes both the trail depth and trail width. For example, a trail with an average tread width of 60 inches and an average max incision of 5 inches would have an average cross-sectional area of 300 square inches. Monitoring the change in an average cross-sectional area gives trail managers an overall sense of how the trail is changing and how quickly it is eroding.

The average cross-sectional area is closely related to many issues related to trail condition, including trail widening, incision or cupping, braiding, muddiness (muddy trails tend to widen as users redirect around muddy areas), downed trees (similar to muddiness), the erosion of geologic soil, and runoff (which can affect sensitive resources with stream turbidity and infill of riparian habitat).

This indicator monitors the achievement of several desired conditions for the trail management plan, including that "land trails are sustainably constructed and well-maintained," "trail surfaces and design are appropriately matched to the type of use they will receive," "the land trail tread will be built and maintained in such a way that will provide a stable surface for pedestrians and horseback riders," and "impacts on the trail surface from use during wet weather conditions is minimized."

This indicator is closely connected to visitor use, as higher trail use, particularly during wet conditions, contributes to higher average cross-sectional areas. Visitor behaviors, such as walking two or more abreast and walking around muddy spots, also contribute to increases in a cross-sectional area. This indicator is considered a standard metric for trail monitoring that is well established in literature and considered to be reliable (Marion, Wimpey, and Park 2011). Multiple efforts that collected data on this indicator in 2009, 2014, and 2021 point to the reasonable, efficient, and proven nature of this indicator to monitor without complicated analysis and also provide baseline data for comparison. While it is considered sensitive to change, it often takes five years to see a change in comparative data.

The threshold identified operationalizes a low tolerance for change in this indicator. This tolerance for change is much lower than the 10% to 60% increase in cross-sectional area experienced on trails between 2014 and 2021. Park staff have deemed the rate of change seen in recent years unacceptable, closely related to a large spike in use and changing use types, and cite it as a primary reason this planning effort was initiated. A 1% increase every five years is more consistent with acceptable tolerances in trail management (Marion, Wimpey, and Park 2011).

Monitoring Strategy

The park's Science & Resource Management staff would lead monitoring efforts with support from the Facilities Management staff. Park managers may leverage trained volunteers, interns, or university partners to assist with monitoring.

Monitoring would follow trail assessment procedures outlined in the park's Trail Monitoring Manual, which is based on techniques developed by Marion, Wimpey, and Park (2011). Park managers would focus monitoring efforts on the trails for which baseline condition information exists, including Blair Springs Ranch, Buffalo Creek Trail, Dry Prong, Good Springs West, First Creek North, McCoy Hollow, Mill Branch, Sal Hollow East, Sal Hollow West, Turnhole Bend North, and the Wet Prong-McCoy Hollow Connector. Additional trails may be added to the monitoring regime over time, though not all trails in the park would be assessed. Monitoring on any given trail would occur no more frequently than every five years, as changes are hard to detect on shorter time scales. To keep the annual monitoring load manageable, park staff may use a rotation to monitor 20% of the selected trail segments each year so that each selected trail segment would be monitored every five years.

Management Strategies

The following management strategies are identified in chapter 3's description of the preferred alternative and would assist in managing within the identified threshold:

- Decommission and restore unsustainable trails to natural conditions.
- Rehabilitate existing trails to establish proper drainage using drainage ditches, grade reversals, rock armoring, adding clean fill, and brush clearing.
- Harden trails with higher levels of visitor use consistent with the trail categorization described in chapter 2.
- Close certain trails to equestrian and bicycle use in wet weather conditions to prevent erosion.

The following management strategies may be implemented if and when monitoring reveals conditions are approaching or exceeding the identified threshold:

- Encourage the use of trails with more sustainable alignments, and direct use away from trails that exceed the threshold.
- Identify and enforce group size limits.
- Expand the wet weather trail closures to additional trails that exceed the threshold.
- Seasonally close trails that exceed the threshold to prevent overuse during times of year when the trails are particularly susceptible to erosion.
- Alter trail categorization and designated use types to less impactful use types on trails that exceed the threshold.

TRAIL MAINTENANCE COSTS

Indicator

Annual dollar amount spent on labor and materials to maintain individual trail segments

Threshold

The annual dollar amount spent on individual trail segments will not exceed an amount 5% (adjusted for inflation) above baseline expenditures (established by five-year average).

Rationale for Indicator and Threshold

The amount of money spent annually on trail maintenance speaks to the financial sustainability of the trails program and is indicative of the physical sustainability of the trail system. Tracking the costs of maintaining individual trail segments is important so that the overall costs of the park trail maintenance program do not become unsustainable. Tracking expenditures provides insight into how frequently a trail segment is rehabilitated. Frequent rehabilitation indicates that a particular trail segment may have unsustainable design, unsustainable use, or a combination of the two. Trail substrates, drainage, and alignment all contribute to the sustainability of a trail's design, in addition to type and amount of use. The costs of trail maintenance include staff and volunteer labor hours, as well as the costs of materials.

This indicator monitors the achievement of the desired conditions that "land trails are sustainably constructed and well-maintained," "trail surfaces and design are appropriately matched to the type of use they will receive," and "impacts on the trail surface from use during wet weather conditions are minimized."

Maintenance costs that are factored into this indicator include work to address trail depth, trail width, social trails, braided trails, and mudholes. Maintenance costs incurred due to weather-related incidents, such as downed trees, are not factored into this indicator. The construction of new trails or bringing a trail up to the appropriate standard upon the implementation of this plan are also not factored into this indicator.

This indicator is reasonable, as it relies on data that are already being collected and stored in NPS databases. This indicator would be sensitive to change and connected to visitor use since increased trail use leads to trail damage, which requires repair and maintenance.

Monitoring Strategy

Monitoring will require data collection and input from the park's administrative officer, Facilities Management staff, and the volunteer coordinator. The administrative officer will work with Facilities Management staff to track and report trail maintenance costs per trail segment. The Science & Resource Management volunteer coordinator will support the tracking of volunteer labor hours. Volunteers need to be specially trained in trail maintenance.

Facilities Management staff will determine expected cost to maintain/manage trail segments based on money expended over the last five years. The administrative officer will gather data from NPS databases, including the Administrative Financial System, the Financial and Business

Management System, and the Planning, Environment & Public Comment System, for costs expended on different trail projects. The volunteer coordinator will provide the number of volunteer trail crew workhours and training hours to provide equivalent costs. Once the data are compiled to form a larger picture of the cost to maintain trail segments, these findings will be presented to the management team. A template for recording data should be developed for consistent tracking. The assessment of the compiled data should be done annually during the first quarter of the fiscal year (before December 31) to inform work planning for future years.

Management Strategies

The following management strategies are identified in chapter 3's description of the preferred alternative and would assist in managing within the identified threshold:

- Redesign trails for sustainable alignment, possible hardening consistent with designated trail categories.
- Close certain trails to equestrian and bicycle use in wet weather conditions to prevent erosion.
- Rehabilitate trail alignments to allow additional grade reversals.
- Provide education on proper trail etiquette, including signage and on the website/app.

The following management strategies may be implemented if and when monitoring reveals conditions are approaching or exceeding the identified threshold:

- Seasonally close trails that exceed the threshold to prevent overuse during times of year the trails are particularly susceptible to erosion.
- Establish wet weather closures on additional trails.
- Consider fully decommissioning trails with rapidly increasing maintenance costs.

BARE GROUND IN RIPARIAN AREAS

Indicator

Change in the amount of anthropogenic bare ground in identified riparian habitats over a five-year time

Objective

Bare ground is decreased by at least 10% at each five-year monitoring period until fully restored.

Rationale for Indicator and Objective

The degradation of natural resources in riparian habitats of Mammoth Cave due to off-trail visitor use has been identified as a threat to achieving desired conditions for natural resources. Specifically, the desired conditions state that

Sensitive biological resources . . . are protected and minimally impacted by aboveground land and water trail activity that may impact water quality,

Native plant species will predominate and thrive along the park's trail systems, and

Hydrologic functions of the landscape . . . and associated water quality are maintained along the park's land and water trail systems.

Bare ground in riparian areas is indicative of off-trail travel and can lead to erosion, as well as impacts on water quality both in major streams and smaller tributaries. The amount of bare ground in riparian habitats shows a clear impact on sensitive resources that are directly caused by visitor use.

Riparian health is important, as it has far-reaching impacts that affect sensitive species in water and can contribute to water quality and turbidity. Additionally, quality native vegetation is needed to maintain stability of soil, which speaks to the desired condition that "Geologic soil materials are protected through sustainable design of the land trail system."

This indicator is considered sensitive to change, as it is quite noticeable when visitors trample river crossings. The indicator's reasonable and reliable nature is demonstrated by its current us as part of an ongoing monitoring protocol.

Monitoring Strategy

This indicator is currently being monitored by the Cumberland Piedmont Inventory and Monitoring Network as part of existing national monitoring protocol and can further be supported by Science & Resource Management staff and park volunteers.

Monitoring would occur at all riparian areas including stream crossings, seeps, springs, wetlands, riverbanks, and areas proximal to trails that could be indicative of off-trail travel. These areas would be monitored on a five-year cycle to align with the trail monitoring protocol. The first year of monitoring would establish a baseline of current conditions. Monitoring could be done from hiking trails or from the river.

Management Strategies

The following management strategies are identified in chapter 3's description of the preferred alternative and would assist in managing to achieve the identified objective:

- Define water corridor crossings with enhanced natural edges (trees alongside trail).
- Increase education on trail etiquette by installing "stay on trail" signage, using interpretive waysides, the park website, and social media.
- Increase enforcement and targeted outreach to visitors who are not adhering to regulations.
- Use game cameras or volunteers to monitor areas and assess behavioral causes of damage.

The following management strategies may be implemented if and when monitoring reveals conditions are not achieving the identified objective:

- Trail closures during rehabilitation efforts or during wet seasons

OTHER RELATED MONITORING: VISITOR CONCERNS

Monitoring

Number of visitor concerns received related to poor wayfinding and/or user conflicts

Rationale

Visitors to Mammoth Cave occasionally provide feedback to park staff through comment cards at park visitor centers, by phone call, or by e-mail or letters. While most of this feedback is positive, some of it is critical and can be used to understand what visitors are concerned about.

Park managers are particularly concerned about visitor concerns that relate to wayfinding on the park's trail system (i.e., getting lost or confused), and user conflicts (i.e., frustration about the behavior or impacts for other users, often an entire user group). Park managers are aware that poor signage can lead to visitors becoming lost, as evidenced by frequent calls to dispatch and the visitor center, social media complaints, and field inquiries. User conflicts are often asymmetrical and can be deeply detrimental to the quality of some visitors' experience.

This monitoring is intended to measure achievement of desired conditions for the trail system, including that "visitors have the information they need to confidently select appropriate trail- and river-based recreational opportunities …" that "conflicts between and among user groups are minimized …" and that "directional signage, trail markings, and milage markers … give visitors an accurate sense of where they are, where they are going, and how far they must go."

While this metric is undoubtedly connected to visitor use and desired conditions, park staff question its reliability and sensitivity to change. Park staff would have difficulty knowing if a change in the number of complaints received was truly an indicator of a changing condition or if it was related to some other factor, such as the availability of comment cards, a coordinated feedback campaign, or similar. For this reason, it was identified for "other related monitoring," and no threshold was identified.

Monitoring Strategy

Interpretation & Visitor Services division staff would be primarily responsible for tracking the annual number of visitor concerns received by e-mail, US mail, and on-site visitor comment forms. Staff would track this number alongside visitor concerns related to cave tour size and crowding per the *Mammoth Cave National Park Cave and Karst Management Plan / Environmental Assessment* (NPS 2019).

Management Strategies

The following management strategies are identified in chapter 3's description of the preferred alternative and would assist in managing visitor concerns:

- Address circulation issues to decrease user conflicts.
- Improve wayfinding and navigability through intuitive design and signage.
- Restore existing unauthorized visitor-created trails, or social trails, in the park to natural conditions (as described above) or designate as part of the trail system where appropriate.
- Name and designate trails throughout the park formally. These names would be used on signage, maps, and other informational materials to improve wayfinding, trip planning, and a sense of place.
- Cleary mark trails and destinations marked with signs.

The following management strategies may be implemented if and when monitoring reveals conditions are trending away from desired conditions:

- Provide appropriate trip-planning information to visitors based on motivation.
- Identify and enforce group size limits.
- Increase public education efforts to encourage voluntary redistribution of use to off-peak times.
- Consider separating use types and directional trail designations further.

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APPENDIX B: VISITOR CAPACITY

Visitor capacity is a component of visitor use management defined as "the maximum amount and types of visitor use that an area can accommodate while sustaining desired resource conditions and visitor experiences consistent with the purpose for which the area was established" (IVUMC 2019b). By identifying and implementing visitor capacities, the National Park Service can help ensure that resources are protected and that visitors have the opportunity for a range of meaningful and enjoyable experiences.

In addition to being an effective management tool, identifying visitor capacities addresses the legal requirement of the National Parks and Recreation Act of 1978 to identify and implement commitments for visitor capacities for all areas of a park unit (1978 NPRA; 54 USC 100502). This appendix includes visitor capacities for the park's land- and water-based trail systems. Visitor capacities for other areas are beyond the scope of this planning effort and have either already been identified—in the case of cave areas, see the *Mammoth Cave National Park Cave and Karst Management Plan/Environmental Assessment* (NPS 2019)—or would be identified in future planning.

Visitor capacities are management decisions based on the best available data and other factors, including professional judgment, staff experience and expertise, lessons learned, and public input. Visitor capacity identifications, like other management decisions, provide direction. Visitor capacities can be adjusted with appropriate environmental compliance as new information becomes available through further study, analysis, and monitoring.

PROCESS

The analysis is based on the principles described in the Interagency Visitor Use Management Council's Visitor Use Management Framework and Visitor Capacity Guidebook. These documents and associated background material are available on the council's website at https://visitorusemanagement.nps.gov/. The principles include the following four guidelines:

1. Determine the analysis area.
2. Review existing direction and knowledge.
3. Identify the limiting attribute.
4. Identify visitor capacity.

Determine the Analysis Area

To analyze visitor capacity in a meaningful way, the planning team analyzed visitor capacities for the river segments and the land trails. The analysis areas include all resulting trails under the NPS preferred alternative.

Review Existing Direction and Knowledge

The existing direction and knowledge section of each analysis area reviews known information about the amount, type, timing, and distribution of visitor use that is specific to each analysis area, as well as key information about the desired conditions for the area, which are described in chapter 2.

Sources of Knowledge

The known information about the amount, type, timing, and distribution of visitor use comes principally from three sources.

The first source is the park's monthly visitation statistics as reported on the National Park Service Visitor Use Statistics website at https://irma.nps.gov/Stats/Reports/Park/MACA (NPS 2023b). These statistics include monthly counts of canoe and kayak use by the park's authorized livery services, infrared trail counts on select trails, assumptions about the ratio of equestrian to hiker use, assumptions about the ratio of private to commercially supported river use, and other sources. This data source is particularly useful for understanding long-term trends on both land and river trails and general use levels on the river trails.

The second source is the "Visitor Use Study: Recreation & Trails Report" prepared by researchers at Clemson and Kansas State Universities. This study was a "three-year, mixed methods research effort to gather and bolster park information about visitors, their recreation experiences on trails, and environmental impacts of recreation on trails." The study provides comprehensive information about user types (who uses the trails and how they use them), visitor satisfaction with their experiences, and information intended to inform visitor capacities. The study used on-site and online survey sampling, as well as voluntary GPS tracking to inform visitor use and experiential data. The survey data, in particular, were helpful in understanding differences in how different user groups use the trails and the perceptions trail users had about the acceptability of different user densities (Brownlee et al. 2022, "the 2022 study," or similar in this plan).

The third source is trail count data from 16 infrared trail counters that NPS staff deployed from August 2023 through August 2024 along the park's land trails (NPS 2024c). These data include trail use data on the monthly, weekly, daily, and hourly scale. This information informed a baseline understanding of current conditions related to the amount, timing, and distribution of trail use.

On a simplistic level, the visitor capacity analysis can be described as evaluating the current conditions from visitor use statistics and trail counters and then considering the visitor perceptions from the visitor use study to identify an appropriate visitor capacity.

Parkwide Visitor Use

Some of the known information about the amount, type, timing, and distribution of visitor use applies parkwide and does not vary from analysis area to analysis area. Information that applies parkwide is summarized below. Information that applies to just one analysis area is included with the respective analysis area.

Overall, annual recreational visits to the park have increased 25% over the last decade (figure B-1).

FIGURE B-1. MAMMOTH CAVE NATIONAL PARK ANNUAL RECREATION VISITS, 2014–2023

Visitation to the park tends to be much higher in the summer months of June, July, and August, when monthly visitation is about 70,000 or greater. The park has pronounced shoulder seasons in March, April, May, September, and October, when average monthly visitation hovers between 40,000 and 50,000. November through February tends to be much less busy in the park, with average monthly visitation typically below 25,000. Figure B-2 demonstrates this month-to-month pattern.

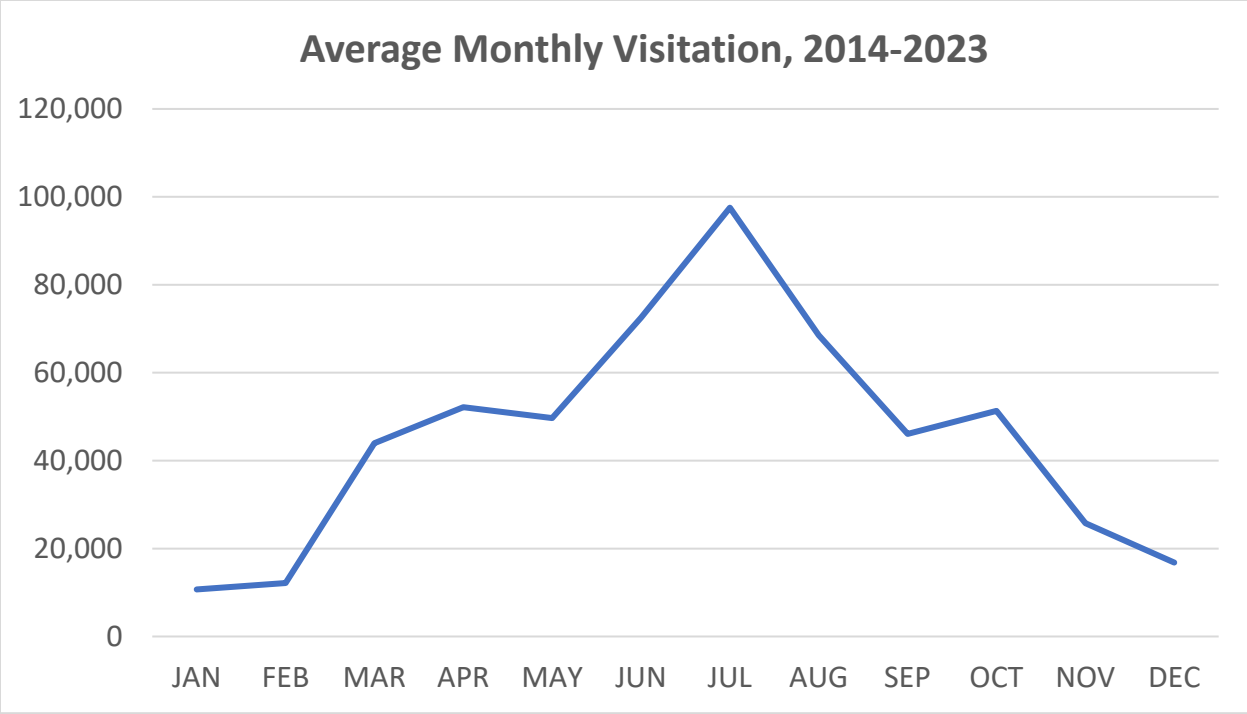

FIGURE B-2. AVERAGE MONTHLY VISITATION TO MAMMOTH CAVE NATIONAL PARK

These parkwide data are heavily influenced by counts of visitors taking cave tours in the park (NPS 2021b). Since visitors taking cave tours represent the majority of overall recreation visitation to the park, this parkwide trend and volume data may not necessarily be representative of trends on the park's aboveground trail systems. However, the parkwide trend data are useful for understanding overall context of visitor use in the park. More detailed analysis of visitor use on the river and the land trails is included in the respective analyses.

Identify the Limiting Attribute

The limiting attribute is the condition of concern, threshold, or issue that most constrains an analysis area's ability to accommodate visitor use while achieving and/or maintaining desired conditions. For example, a limiting attribute might be encounters with other groups traveling along a trail, a historic bridge's structural integrity and ability to accommodate a volume of trail uses, or trampled vegetation. The limiting or constraining attribute varies from analysis area to analysis area. Identification of the limiting attribute is an important step, as it connects the most important resources and visitor experiences to on-the-ground conditions with the identified visitor capacity.

Identify Visitor Capacity

Visitor capacity contains two parts. First is the identification of the visitor capacity (maximum amounts and types of use) and second is the identification of management strategies and/or actions that could be taken to implement visitor capacity to ensure the amount of visitor use is managed to achieve and maintain desired conditions.

Maximum Amounts and Types of Use

To identify the appropriate amounts and types of use for each of the analysis areas, the previous steps were reviewed to understand current conditions and how they compare to desired conditions for the area. Based on the desired conditions, a visitor capacity number is identified.

Visitor capacities are not use level goals but rather a maximum amount of visitor use that is consistent with desired conditions. Supporting infrastructure such as parking lots may not be built to accommodate visitor capacity use levels if current or projected use doesn't warrant such construction, the cost is prohibitive, or other factors make it infeasible. In addition, alternative means of arrival (i.e., liveries and shuttle services) may make larger supporting infrastructure unnecessary.

Implementation Strategies

Due to the relationship of current use levels and identified visitor capacities, no additional management strategies are needed to manage within visitor capacities. The management strategies identified in the description of the preferred alternative (chapter 3), as well as in association with the indicators and thresholds (appendix A), would be sufficient to manage visitor use consistent with the visitor capacities.

Notable management strategies from chapter 3 that assist park managers in managing visitor use consistent with visitor capacities include the following:

- Construct additional trails and support facilities to disperse visitor use.
- Construct additional river access points to better disperse use.
- Decommission and restore unsustainable trails to natural conditions.
- Harden trails with higher levels of visitor use consistent with the trail categorization described in chapter 2.
- Rehabilitate existing trails to establish proper drainage using drainage ditches, grade reversals, rock armoring, adding clean fill, and brush clearing.
- Close certain trails to equestrian and bicycle use in wet weather conditions to prevent erosion and protect park resources.
- Address circulation issues to decrease user conflicts.
- Improve wayfinding on trails through naming and trail signage.
- Increase educational materials on appropriate trail etiquette among different recreational groups.
- Increase education on Leave No Trace principals.
- Expand the number of primitive and semi-primitive trails in the park managed for solitude.

- Improve wayfinding and navigability through intuitive design.

Notable management strategies from appendix A that assist park managers in managing visitor use consistent with visitor capacities include the following:

- Use public information and orientation to direct use away from overused trails that approach thresholds during peak times.
- Provide appropriate trip planning information to visitors based on their motivation for more social or solitude based experiences.
- Identify and enforce group size limits.
- Increase public education efforts to encourage voluntary redistribution of use to off-peak times.
- Use public information efforts before historically crowded weekends to inform the public to be prepared for higher use levels.
- Enforce parking lot capacities and prevent overflow parking, as these parking lots were sized consistent with the desired conditions for the area.
- Encourage visitors to launch on the rivers earlier or later in the day to avoid periods of peak use.
- Identify a maximum group size for river parties.
- Manage the amount, timing, and distribution of CUA livery-supported boats actively at all boat launches within the park boundary.
- Encourage the use of trails with more sustainable alignments.
- Close trails seasonally that exceed thresholds to prevent overuse during times of year the trails are particularly susceptible to erosion and degradation.
- Consider the additional separation of use types and directional trail designations.

VISITOR CAPACITY IDENTIFICATION

Each analysis area is discussed below, including a review of existing direction and knowledge, the limiting attribute, and visitor capacity identifications and associated rationale.

River

Analysis Area

This analysis area includes the full length of the Green and Nolin rivers within the park, approximately 30 miles of water trail in total. Individual capacity identifications are included for each of the six river segments.

Existing Direction and Knowledge

Visitor use on the Green and Nolin rivers is predominantly by CUA livery-supported canoe and kayak users. However, there are some self-supported paddlers on the rivers, as well as some motorboat users. The number of private canoeists and kayakers is estimated as 20% of all paddlers (NPS 2021b). Motorboats are allowed on the rivers as well, though their use tends to be low and concentrated during one or two months of the year when conditions are favorable. A busy month of motorboating may equate to an average of three boats per day, while a quiet month of motorboating may equate to fewer than one boat per day on average (NPS 2023b). As such, this use is not discussed further as a separate motorboat allocation would not be warranted.

The warmer months are the most popular for paddling, with May through August typically being the busiest. Monthly river use peaks in July, with just over 3,000 paddlers on average over the last three years (NPS 2023b). Much of this use is concentrated in the middle of the day due to the logistics involved with launching and retrieving boats on the rivers.

Currently, the Dennison Ferry to Green River Ferry segment (Dennison to Green) is by far the most used. The Green River Ferry to Houchin Ferry segment (Green to Houchin), Houchin Ferry to Green River/Nolin River confluence segment (Houchin to confluence), Nolin to Green River confluence (Nolin to confluence), Green River/Nolin River confluence to west park boundary (confluence to boundary) and east park boundary to Dennison Ferry (boundary to Dennison) all receive much lower use. For example, in July 2023, there were just under 2,000 commercially supported paddlers on the Dennison to Green segment and just under 100 on the Green to Houchin segment in July 2023, according to monthly CUA reporting from the liveries. The liveries did not support any users on the other segments during that particular month. For a broader view, shows the average monthly use on the different river segments over the past two years. Additional information about the type, timing, amount, and distribution of visitor use on the river can be found in the description of the affected environment section for visitor use and experience in chapter 4.

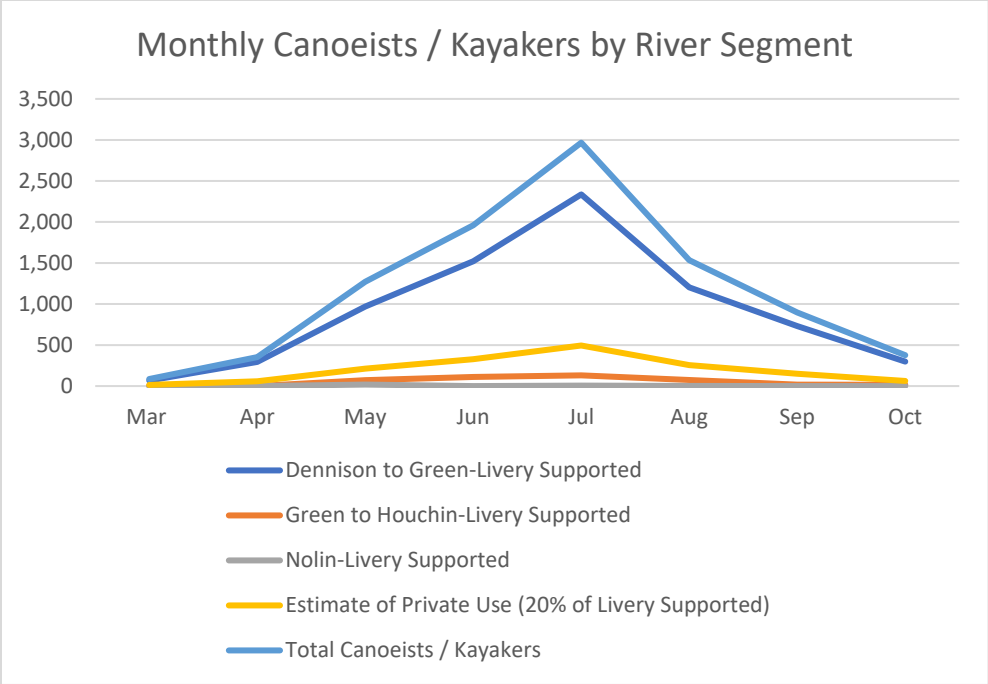

FIGURE B-3. MONTHLY CANOEISTS/KAYAKERS BY RIVER SEGMENT. FIGURES SHOWN ARE AVERAGES OF 2022 AND 2023 VISITOR USE DATA.

Note: The estimate of private use includes users on all segments, including those without livery supported use such as Houchin to confluence.

The key guidance related to visitor use on the river is the following desired condition:

> *Visitors can expect a social atmosphere and to hear mostly anthropogenic sounds at river access points. As visitors get further away from access points, encounters would become less frequent and natural sounds would predominate. Visitors seeking more solitude and natural quiet generally can do so by altering speeds to avoid louder groups of visitors . . . Social activity and sounds are expected on sand bars.*

In addition, guidance for the river segments includes the designation of each within one of three water trail categories, as follows:

- High-density water trails, including the Dennison to Green, Green to Houchin, and confluence to boundary segments, are managed for a "high density of visitor use managed to provide a moderately social atmosphere." On these segments, "visitors will encounter other visitors on a relatively frequent basis," and "the likelihood of encountering larger groups on these river segments is high, owing to livery outfitted users."

- Moderate-density water trails, including the boundary to Dennison and Houchin to confluence segments, are managed for a "a moderate density of visitor use managed to provide some opportunities for solitude." On these segments, "most visitors will find some opportunities for solitude at some point during their visit. Encounters with other

visitors will be expected, but will not be frequent." Relatedly, "the likelihood of encountering larger groups on these river segments is moderate."

- The low-density water trail in the park is the Nolin to confluence segment. The segment is managed for "a low density of visitor use managed to provide opportunities for solitude, remoteness, and connection with nature." On this segment, "visitors will have the opportunity to experience solitude. Very few other visitors will be encountered during the majority of a visit." Relatedly, "the likelihood of encountering larger groups on these river segments is low, as few livery outfitted users will be on these segments."

Recent and planned improvements to the three primary river access points at Dennison Ferry, Green River Ferry, and Houchin Ferry are expected to alter visitor use patterns to some degree (as described under alternative 1). Specifically, improving the Houchin Ferry access point is expected to make the Green to Houchin segment, and to a lesser degree the Houchin to confluence and confluence to boundary segments, more attractive to livery supported paddlers. Similarly, the addition of two primitive river access points along the Green to Houchin segment (as described under alternative 2) is expected to make this segment more appealing to private paddlers, who can use these access points to make shorter trips. While no current plans are proposed, a new river access point outside the park's east boundary could be supported by the river's national water trail designation, making this segment more appealing to those looking for a day float. Despite current use levels and patterns, these recent, future, and foreseeable increases in access support respective designations of the Green to Houchin segment as a high-density water trail alongside the currently well-used Dennison to Green segment, and the designation of the Houchin to confluence and boundary to Dennison segments as moderate-density water trails.

The primary management concerns on the river include achieving a better distribution of visitor use across the river segments to achieve desired conditions and visitor safety. Related to the former concern, park managers have identified a boats-per-view indicator as a priority for monitoring (see appendix A). If the number of boats per view exceeds the threshold of 12 greater than 20% of the time, park managers may begin to employ strategies to improve the distribution of use on the river, including encouraging launching earlier or later in the day; identifying a maximum group size; and/or actively managing the amount, timing, and distribution of livery supported use.

Related to the visitor safety concern, under alternative 2, park managers intend to continue the practice of closing the Green River to livery supported use when the stream gauge exceeds 20 feet, though private (and typically more experienced) users would be able to access the river during those times. Also related to visitor safety, under alternative 2, park managers would close the river to motorboats with a functional output exceeding 40 horsepower from April 15 through October 15.

Limiting Attribute

The ability to achieve the experiential desired conditions on each segment of water trail is the attribute that most constrains the river segments' ability to accommodate use. Specifically, increased visitor use, if high enough, could threaten desired conditions for a "moderately social atmosphere" on high-density water trails, "some opportunities for solitude" on moderate-

density water trails, and "opportunities for solitude, remoteness, and connection with nature" on low-density water trails. Across all water trail categories, as the density of boating use on the river increases, the key desired condition that "encounters would become less frequent and natural sounds would predominate" as visitors get further away from river access points may no longer be achieved, and it may become more difficult for "visitors seeking more solitude and natural quiet" to do so by "altering speeds to avoid louder groups of visitors."

Visitor Capacity

For the high-density water trails, the experiential desired conditions (limiting attribute) are quantified by the boats-per-view threshold of 12. Due to the winding nature of the rivers, a view on the river (including the section identified for monitoring the boats per view indicator) is typically no longer than 0.75-miles downriver. Therefore, it is possible to calculate the maximum number of boats that can be on the different segments of river at one time without exceeding the threshold of 12 boats per view in a 0.75-mile segment. For Dennison to Green (8 miles), visitor capacity equates to approximately 130 boats at one time. For Green to Houchin (13 miles), visitor capacity equates to approximately 210 boats at one time. For confluence to boundary (3 miles), visitor capacity equates to approximately 48 boats at one time.

While no boats-per-viewshed threshold is established for the other water trail categories, some assumptions about the acceptable number of boats per view in the moderate- and low-density water trails can be inferred by visitors' stated preferences for the number of boats per view included in the 2022 study of Mammoth Cave river users (Brownlee et al. 2022). For moderate-density water trails, 6 boats per view is assumed to achieve desired conditions that "most visitors will find some opportunities for solitude at some point during their visit … encounters with other visitors will be expected, but will not be frequent." The average visitor finds seeing 6 boats per view to be "moderately acceptable" or 1.85 on an acceptability scale from -4 to 4. For low-density water trails, 0 boats per view from one's party is assumed. This condition of typically seeing no other boats within .075 miles (other than one's own party, assuming an average group size of 4 boats) is assumed to achieve desired conditions for "solitude, remoteness, and connection with nature … Very few other visitors will be encountered during the majority of a visit." The average visitor finds seeing 0 boats per view to be "acceptable" or 3.06 on an acceptability scale from -4 to 4.

Though river paddling times do vary based on effort levels and river flow rates, a typical paddling speed of 2.5 river miles per hour is assumed based on park staff experience. The resulting "typical boats per hour" calculation can help managers implement and monitor this capacity as needed. This calculation represents the maximum number of boats that could launch on each river segment each hour during typical river flows without exceeding the maximum boats per view (assuming relatively even distribution within the hour). Table B-1 summarizes the visitor capacities in terms of boats at one time per river segment, as well as the typical number of boats launching per hour to manage within that visitor capacity.

Table B-1. Visitor Capacities by River Segment

Segment	Water Trail Density Category	Max Boats Per View	River Miles	Boats at One Time (visitor capacity)	Typical Boats per Hour
Dennison to Green	High	12	8	130	40
Green to Houchin	High	12	13	210	40
Confluence to boundary	High	12	3	48	40
Boundary to Dennison	Moderate	6	3	24	20
Houchin to confluence	Moderate	6	2	15	20
Nolin to confluence	Low	0*	8	40	12

* 0 boats per view represents groups spread at least .075 miles between groups so that no other boats beyond those in one's party are viewed. An average group size of 4 is assumed based on staff experience.

For comparison, park managers considered a typical busy day on the river. July 22, 2023, saw 212 livery supported paddlers launch on the Dennison to Green segment of the river, with another 42 (20%) private paddlers assumed, for a total of 254 paddlers on the day (NPS 2021b). Two-thirds of paddlers are estimated to have been using 2-person craft (i.e., typical canoe) and one-third are estimated to be using 1-person craft (i.e., typical kayak). This yields a sum of 170 boats on the river segment for the day. Assuming most of these boats launch during the core daylight hours of 10:00 a.m. to 3:00 p.m., there are roughly 34 boats launching per hour on the typical busy summer day. As the capacity is identified at a level that would equate to roughly 40 boats launching per hour, the capacity is understood to be 15% greater than the current typical busy summer day, therefore providing some room for growth.

Implementing the visitor capacities for some of the river segments in this analysis would necessitate a collaborative partnership with the U.S. Army Corps of Engineers and Edmonson County if and when active management of group size for river parties or the management of the amount, timing, and distribution of CUA livery-supported boats becomes necessary.

Land Trails

Analysis Area

This analysis area includes the entire resulting land trail system proposed in chapter 3. It includes existing and proposed trails in each of the four land trail categories: developed, moderately developed, semi-primitive, and primitive.

Existing Direction and Knowledge

Visitor Use on Land Trails

To develop a more refined understanding of trail use in the park, 16 infrared trail counters were deployed from August 2023 through August 2024 along the park's land trails. Unless stated

otherwise, trail use data presented in this appendix are from these counters. Limited trail-specific data are available from before this time frame, so long-term trail-specific trends are not well understood.

Data collected by these trail counters indicate that trail use is spread much more evenly across the park's busy months of March through October than the parkwide visitor use (figure B-4). Trail use was highest in April when over 12,000 counts were made across the 10 trail counters with reliable data throughout the year. Use tapered gradually through the summer months but hovered near or above 10,000 counts through October. Similar to the parkwide visitation trend, land trail use is lowest during the winter months of November through February.

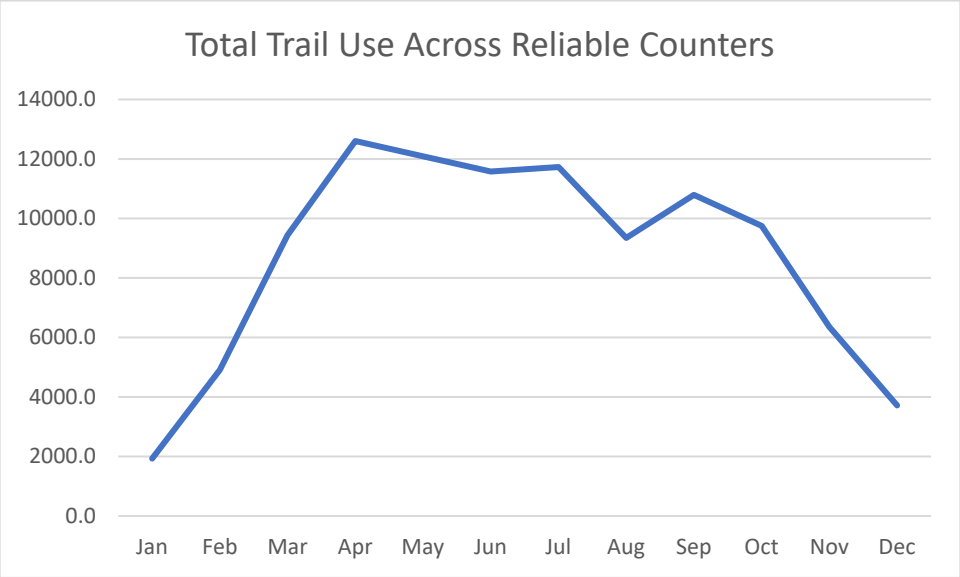

FIGURE B-4. TOTAL MONTHLY TRAIL COUNTS ACROSS 10 COUNTERS WITH RELIABLE DATA FOR THE FULL YEAR*

Note: *This graphic is included to show the month-to-month trend. It is not a census of overall trail use per month.

The seasonal trail use pattern does not appear to vary substantially between user types. Counters along the hike-and-bike trail, the Big Hollow Trail (a common mountain bike trail), common horse trails, and hiker-only trails all recorded similar trends, with steady use from March through October and relatively low use November through February (figure B-5).

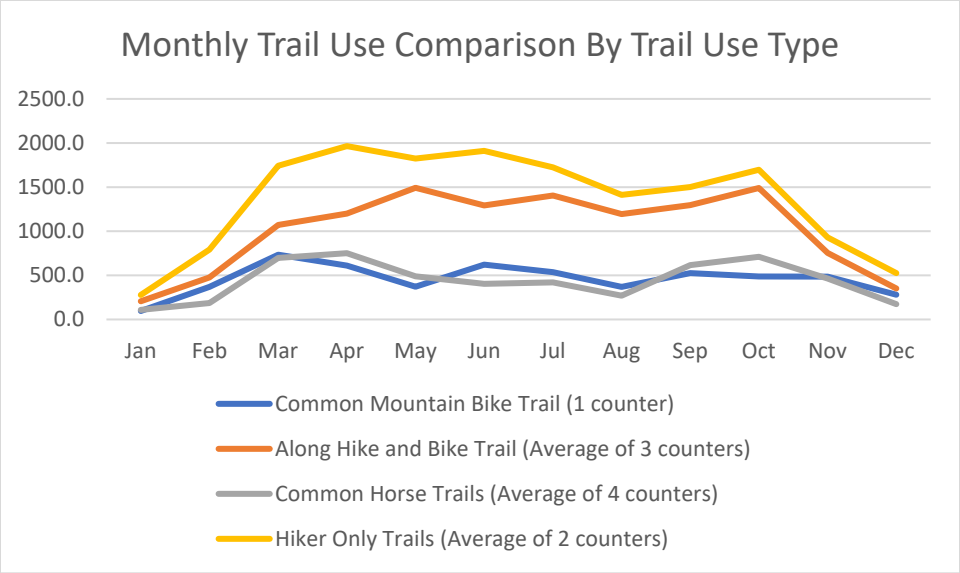

FIGURE B-5. MONTHLY TRAIL USE COMPARISON BY USE TYPE. THE MOUNTAIN BIKE TRAIL COUNTER IS ON THE BIG HOLLOW TRAIL*

Note: *The "Along Hike and Bike" number represents an average of counts at Carmichael, Locust Grove, and Sloan's Pond. "Common Horse Trails" represents an average of counts at Collie Ridge, First Creek, Maple Springs, and McCoy Hollow. "Hiker Only Trails" represent an average of counts at Turnhole Bend and Echo River. This information is included to show the month-to-month trend. It is not a census of overall trail use by user type per month.

These trail counter data provide additional insight into the timing of visitor use. Saturday was the busiest day on the trails at all counter sites but one (Locust Grove on the hike-and-bike trail, where Sunday was slightly busier). Saturdays accounted for 24.5% of use on the trails, while Sundays accounted for 19.3%, and Fridays accounted for 13.4%. The remaining four weekdays each accounted for between 10% and 12% of use (figure B-6).

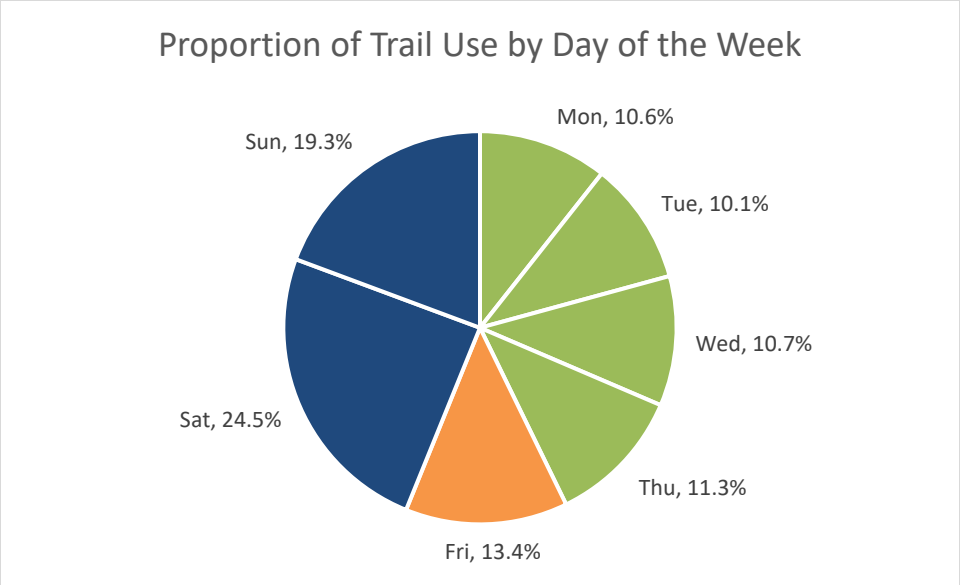

FIGURE B-6. PROPORTION OF TRAIL USE BY DAY OF THE WEEK

In terms of time of day, the trail counters indicate that use increases steadily from 6:00 a.m. to 11:00 a.m. The period between 11:00 a.m. and 3:00 p.m. is the busiest, as trail use generally peaks during this four-hour period and is fairly evenly distributed across the four hours. Trail use decreases steadily from 3:00 p.m. to around 7:00 p.m. (figure B-7).

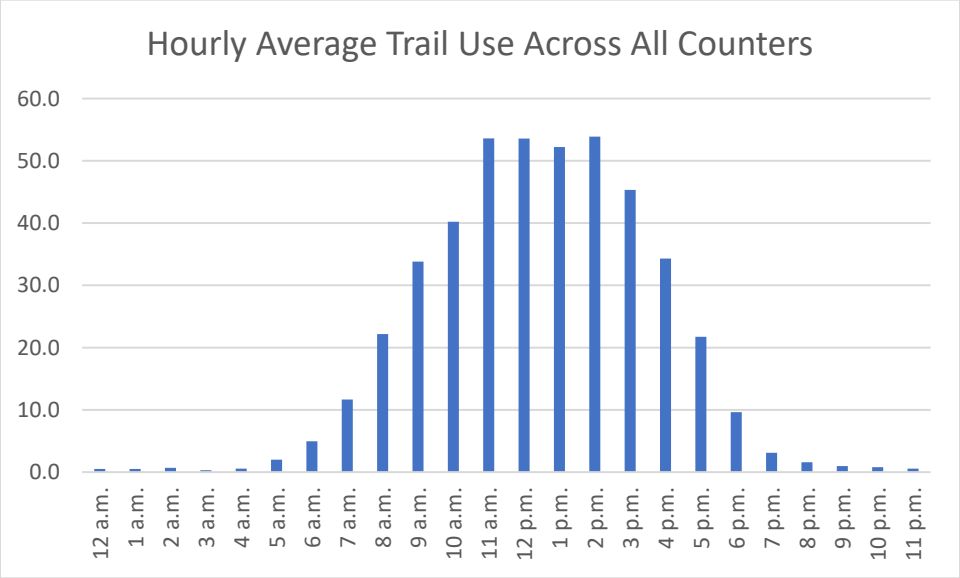

FIGURE B-7. HOURLY AVERAGE TRAIL USE ACROSS ALL COUNTERS*

Note: *The total number represents use across all 16 trail counters. It is not a census of all trail use.

Slight differences exist between the time-of-day patterns for different trail counters. While the hike-and-bike trail counters typically mimic the systemwide pattern closely, the trails north of the river (Big Hollow, First Creek, Maple Springs, McCoy Hollow, and Collie Ridge) tend to see peak use levels a bit earlier in the day (10:00 a.m.), while the hiker-only trails south of the river

(Echo River, Turnhole Bend, and Cedar Sink) tend to see peak use sustained until later in the day (4:00 p.m. or 5:00 p.m.).

To gain a sense of the relative spatial distribution of trail use and the types of use that are occurring, the average daily trail use at each of the 12 counter locations can be compared (figure B-8). In general, hiker-only trails south of the Green River had the highest average daily trail use, with Sand Cave, Echo River, and Cedar Sink tallying 91, 76, and 53 average daily trail use, respectively. The Turnhole Bend hiker-only trail also registered 13 average daily trail use. The hike-and-bike trail is typically the next-busiest type of trail with trail counters at Carmichael, Sloan's Pond, and Locust Grove, registering 43, 31, and 26 average daily trail use, respectively. Multiuse trails north of the Green River typically see less use, with Collie Ridge, Maple Springs, Big Hollow, First Creek, and McCoy Hollow seeing 27, 18, 15, 8, and 5 average daily trail use, respectively. These trail counter figures and the use types they indicate are generally consistent with the 2022 study of Mammoth Cave recreational visitors (Brownlee et al. 2022), which found day hikers account for 38% of recreationists; backcountry/overnight campers, 23%; mountain bikers, 13%; and horseback riders, 12%.

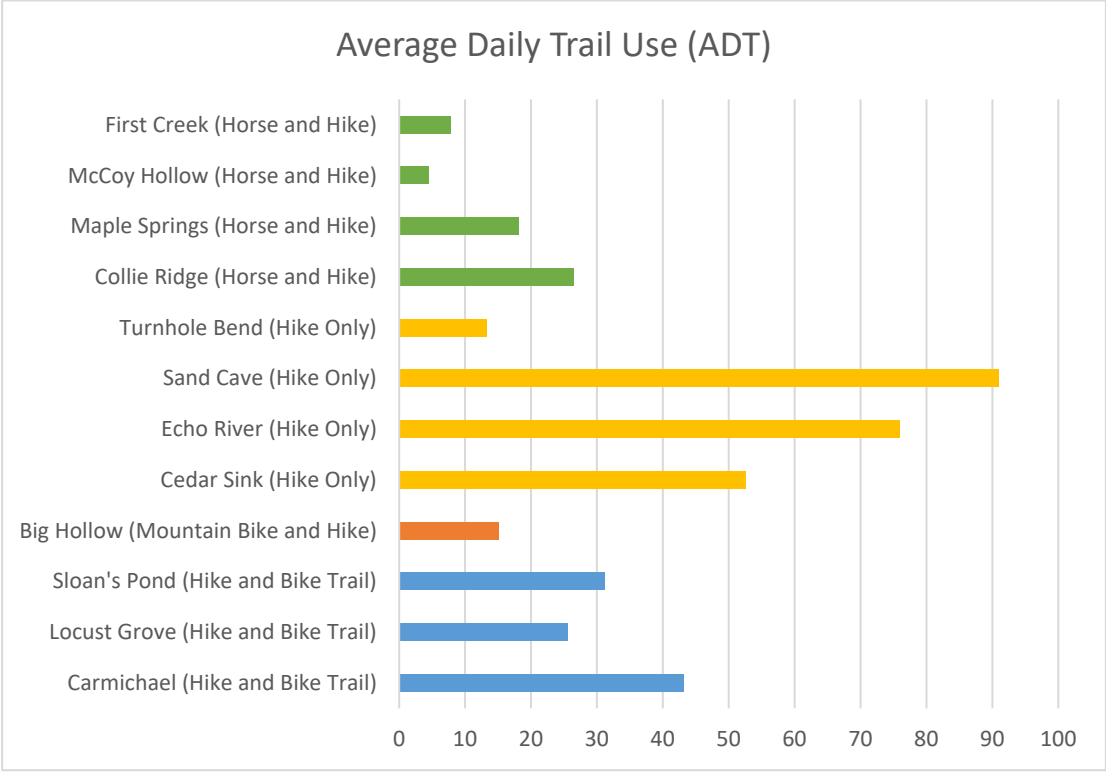

FIGURE B-8. AVERAGE DAILY TRAIL USE AT EACH OF THE PARK'S 12 TRAIL COUNTER LOCATIONS

Trail counters were also used to analyze the proportion of trail users who were riding horses on multiuse trails (the counters are not able to distinguish between bike and hike use). The data indicate that, depending on the trail, equestrian use accounts for 24% to 48% of overall use on trails where horses are allowed (table B-2). This proportion is substantially lower than is assumed in the park's visitor use counting procedures, which assume that 95% of use on these trails is equestrian. A similar assumption is made about the Big Hollow Trail, where bike use is assumed to account for 95% of trail use. This assumption's accuracy is unknown, and the 2022

study found that a "high density of visitors focused their day-hiking on Maple Springs and the North Loop of Big Hollow" (Brownlee et al. 2022). Given this uncertainty, allocations of user types are not included in the visitor capacity. Even if the proportion of users were known with more certainty, use type allocation would likely be unnecessary given that the separation of use types on dedicated trails is a primary management strategy of the plan.

Table B-2. Total Average Daily Trail Use (ADT) and Horse ADT at each of the Park's Four Trail Counter Locations That Allow Horses

Counter Location	Total ADT	Horse ADT	Percentage of Trail Users Riding Horses
Collie Ridge	26.5	12.7	47.9%
Maple Springs	18.1	5.3	29.2%
McCoy Hollow	4.5	1.3	28.8%
First Creek	7.8	1.9	24.0%

Current Use Levels on Different Land Trail Categories

As described above, use levels on trails vary widely depending on the trail, the month of the year, the day of the week, and the time of day. The busy season for Mammoth Cave's trails is March through October; the busiest days are Saturdays and Sundays, and 11:00 a.m. to 3:00 p.m. is the busiest time. By looking at hourly trail use volumes during those months, on weekends from 11:00 a.m. to 3:00 p.m., typical use at busy times on the trail becomes evident. By averaging across this season and time frame, the analysis avoids finding the "absolute peak" and instead focuses on "typical busy times." The average hourly trail use during this typical busy time is included in table B-3.

Table B-3. Average Hourly Trail Use During Typical Busy Times

Trail Counter Location	Trail Category	Average Hourly Trail Use During Typical Busy Times
Sand Cave	Developed	18.8
Echo River	Developed	17.4
Cedar Sink	Developed	12.7
Hike and Bike at Carmichael	Developed	10.5
Hike and Bike at Sloan's Pond	Developed	8.0
Hike and Bike at Locust Grove	Developed	4.3
Turnhole Bend	Developed	2.5

Trail Counter Location	Trail Category	Average Hourly Trail Use During Typical Busy Times
Collie Ridge	Moderately developed	10.4
Big Hollow	Semi-primitive	3.7
Maple Springs	Semi-primitive	2.7
First Creek	Semi-primitive	1.5
McCoy Hollow	Semi-primitive	1.0

For the purposes of this visitor capacity analysis, the average hourly trail use during typical busy times is also referred to as the "current use level."

Notably, there are no known current use levels on primitive trails, as only one existing trail is designated as primitive (White Oak Trail), and it does not have a trail counter.

Desired Conditions

The key guidance related to visitor use on the land trails is the following desired condition:

> *Sections of the trail system provide opportunities to experience solitude and natural soundscapes, where encounters with others are minimal, providing opportunities to experience the sounds of nature, babbling brooks, rushing rivers, insects and animals, fish and amphibians, rustling or crunching leaves, splashing water, birds, wind, and "escape" from society. On other sections of the trail system, visitors hear the sounds of other visitors enjoying the park.*

In short, the trail system should provide a range of experiential opportunities, from solitude to more social settings. This range of opportunities is reflected in the desired conditions guidance for the land trails, which includes the designation of each within one of four trail categories. Figure B-9 shows the location of each of the trails in these categories. The trail categories and the selected desired conditions for experiential opportunities are as follows:

- **Developed trails** are managed for a "high density of visitor use managed to provide a low-to-moderate degree of physical challenge and a social atmosphere." On these trails, "visitors find a social atmosphere," and "may encounter many other visitors except for the quiet winter season." Relatedly, "large groups of hikers may be encountered, including people heading to or from cave tours." Key experiences on developed trails include access to main cave entrances and springs, cemeteries, scenic overlooks and points of interest, and universally accessible opportunities.
- **Moderately-developed trails** are managed for a "moderate density of visitor use managed to provide a moderate-to-high degree of physical challenge and a moderately social atmosphere." On these trails, "visitors find a moderately social atmosphere," and "visitors may encounter some other visitors on a relatively frequent basis." Relatedly,

"large groups of horseback riders and occasionally mountain bikers are encountered on these trails."

- **Semi-primitive trails** are managed for a "low density of visitor use managed to provide a moderate-to-high degree of physical challenge and opportunities for solitude." On these trails, "visitors find some opportunities for solitude at some point during their visit," and "encounters with other visitors are expected but are not frequent." Relatedly, "groups of horseback riders and mountain bikers are small."
- **Primitive trails** are managed for a "low density of visitor use managed to provide a moderate-to-high degree of physical challenge and ample opportunities for solitude." On these trails, "visitors have the opportunity to experience solitude," and "very few other visitors are encountered during the majority of a visit." Relatedly, "groups of hikers are small."

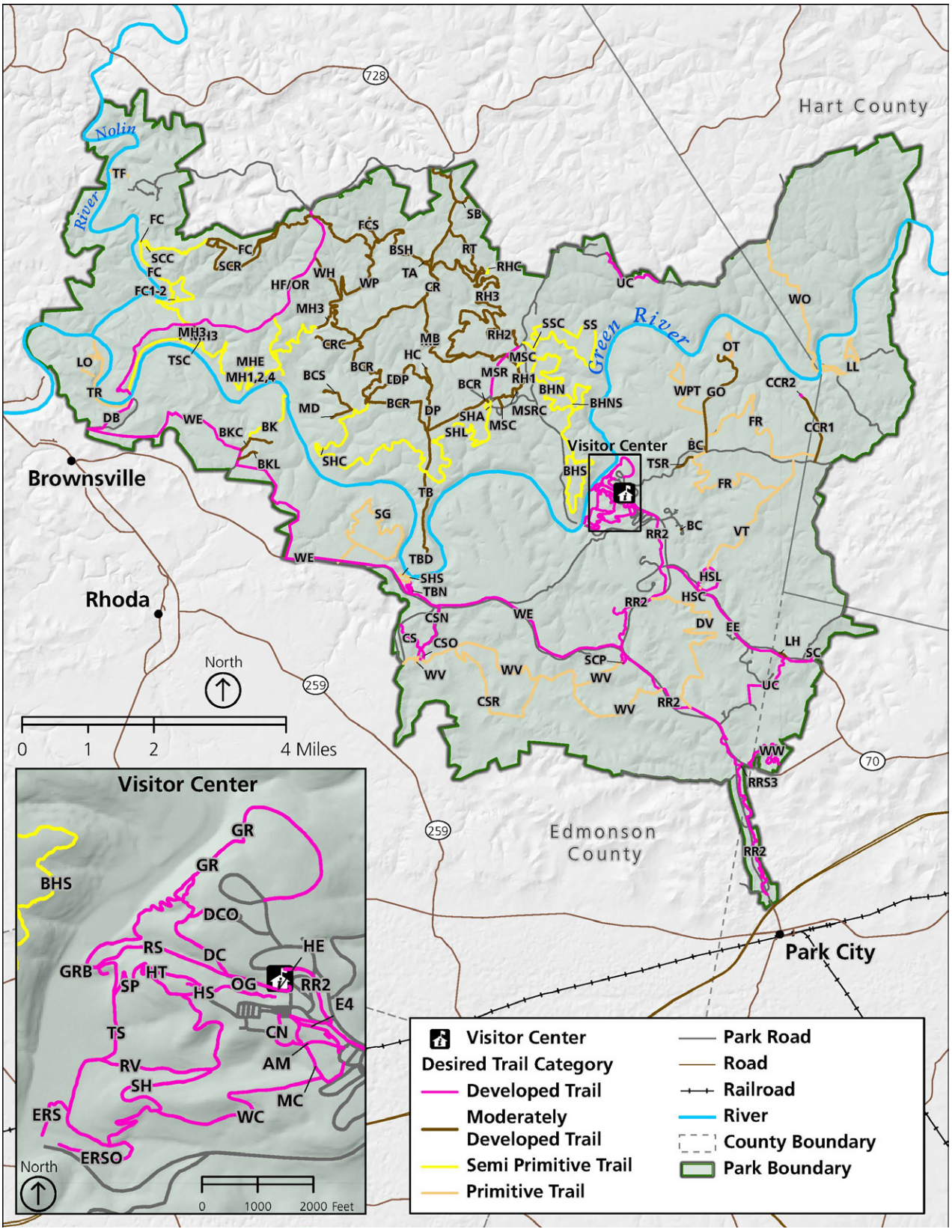

FIGURE B-9. MAP SHOWING THE LOCATIONS OF THE FOUR LAND TRAIL CATEGORIES

Management Concerns and Related Indicators

The primary management concerns on the land trails include the density of visitors on trails and the potential for perceptions of crowding, conflicts between different user groups, erosion, and trail widening due to people passing one another. Many of the indicators included in appendix A would monitor conditions related to these concerns, including the encounter rates on land trails, trail cross-sectional area, trail maintenance costs, and bare ground in riparian areas.

Limiting Attribute

The ability to achieve the experiential desired conditions of each land trail category is the attribute that most constrains the trails' ability to accommodate use. That is, visitor use levels, if high enough, could threaten desired conditions for experiential opportunities on the trails. Specifically, increased use may prevent visitors from experiencing "ample opportunities for solitude" on primitive trails or "some opportunities for solitude at some point during their visit" on semi-primitive trails. On the moderately developed trails, excessive levels of visitor use could lead to visitors experiencing near-constant encounters with others rather than the "relatively frequent" encounters described by the desired conditions. Even on the developed trails, where visitors can expect a "high density of visitor use," a "social atmosphere," and "encounters with many other visitors," excessive visitor use levels can make it difficult for visitors to appropriately experience cemeteries, scenic overlooks and points of interest, and universally accessible opportunities.

While this limiting attribute is chiefly concerned with perceptions of crowding, it is closely related to the other primary management concerns. Conditions that may make trail users perceive crowding may also lead to conflicts between user groups. Crowded conditions may also lead to trail widening and erosion as visitors pass one another on the trails and seek space away from one another. Of these, the perceptions of crowding are most readily quantified in terms of use associated use levels.

Visitor Capacity

For the primitive and semi-primitive trails, the experiential desired conditions (limiting attribute) are quantified by the encounter rates on land trails thresholds of 3 hiking parties encountered per hour on primitive trails and 5 hiking parties encountered per hour on semi-primitive trails. Assuming an average group size of 3 (Brownlee et al. 2022), the group encounter rate thresholds of 3 and 5 can be converted to 9 and 15 people encountered per hour, respectively.

In practice, encounter rates and trail counts are not equivalent metrics. The former typically measures the number of people an average trail user would meet while travelling along the trail (i.e., a moving point observation), while the latter measures the number of people that pass a certain point on the trail (i.e., a fixed-point observation). The key substantive differences are that (1) an encounter rate largely measures people moving in one direction (i.e., opposite the observer) while a trail counter will equally measure people moving in both directions, and (2) an encounter rate observer is moving against the flow of traffic they are primarily counting and,

therefore, will count more people per hour in that direction than a fixed point observation, which does not move in relation to the traffic it counts.

While these two distinctions can make a substantial difference between the metrics in practice for an individual hour, when looked at across time, they are two ways of measuring the same use level. Therefore, for the purpose of visitor capacity analysis, which is focused on the identification of a maximum use level consistent with desired conditions, both metrics would capture that peak use. For this analysis, it is reasonable to assume (given what is known about the nature of the trail and trail users) roughly equal numbers of trail users traveling in either direction and travelers moving at generally the same speed. Given these assumptions, the effect of the first substantive difference would halve encounter rates compared to trail counts (since they generally only count users going in one direction), while the second substantive difference would double encounter rates compared to trail counts (since they are moving against the flow of users they are counting). Based on the assumptions of equal speed and directionality, the net effect would be that the two metrics would be roughly equal.

With the understanding that encounter rates and trail counts can be assumed to be analogs for this analysis, the 9 encounters per hour on primitive trails can also be understood as a visitor capacity of 9 people passing a given point along the trail per hour. This is rounded to 10 people per hour. Likewise, the 15 encounters per hour on semi-primitive trails can also be understood as a visitor capacity of 15 people passing a given point along the trail per hour. These visitor capacities are consistent with the desired conditions for a low-density of visitor use on both trail categories, "ample opportunities for solitude" on primitive trails, and "some opportunities for solitude" on semi-primitive trails.

While no encounter rate threshold is established for the other trail categories, some assumptions about the acceptable number of encounters on developed and moderately developed trails can be inferred by visitors' stated preferences for encounter rates per hour included in the 2022 visitor use study (Brownlee et al. 2022). For the developed trails, 30 people encountered per hour is assumed to achieve desired conditions for a "high density of visitor use managed to provide … a social atmosphere" where visitors "may encounter many other visitors." The average visitor finds 30 people per hour to be just "slightly unacceptable" or -0.23 on an acceptability scale from -4 to 4. The visitor capacity for developed trails is therefore 30 people per hour past a given point on the trail.

For moderately developed trails, the desired conditions call for a "moderate density of visitor use" with encounters on a "relatively frequent basis." Given these desired conditions for slightly less density and fewer encounters than is prescribed on the developed trails but much greater density than is found on the semi-primitive trails, a visitor capacity of 25 people per hour past a given point on the trail is identified.

Table B-4 summarizes the visitor capacities in terms of people per hour that pass a given point on the trail in each trail category.

Table B-4. Visitor Capacities and Key Desired Conditions for Each Land Trail Category

Trail Category	Desired Conditions for Visitor Density, Setting, and Encounters	Visitor Capacity (People Per Hour Past a Point on the Trail)
Developed	• high density of visitor use • social atmosphere • may encounter many other visitors	30
Moderately developed	• moderate density of visitor use • moderately social atmosphere • may encounter some other visitors on a relatively frequent basis	25
Semi-primitive	• low density of visitor use • visitors find some opportunities for solitude at some point during their visit • encounters with other visitors are expected but are not frequent	15
Primitive	• low density of visitor use • ample opportunities for solitude • very few other visitors are encountered during the majority of a visit	10

Table B-5 compares the visitor capacities identified above with current use levels (i.e., average hourly use during typical busy times). As demonstrated in the table, the identified visitor capacities provide substantial room for growth in trail use from current use levels. This is consistent with the finding that under current use levels, the average visitor on the land trails feels only "slightly crowded," or 2.94 on a scale of 1 to 9, with 1 being "not crowded," 5 being "moderately crowded," and 9 being "extremely crowded" (Brownlee et al. 2022).

Table B-5. Comparison of Identified Visitor Capacities and Current Use Levels on Each of the Four Land Trail Categories

Trail Category	Visitor Capacity (people per hour past a point on the trail)	Current Use (people per hour past a point on the trail)*
Developed	30	2.5 – 18.8
Moderately developed	24	10.4
Semi-primitive	18	1.0 – 3.7
Primitive	18	No data

* Range represents the highest and lowest average hourly trail use during typical busy times for trails in this category (see table B-3).

APPENDIX C: SUSTAINABLE TRAIL GUIDELINES

SECTION 1. INTRODUCTION AND PURPOSE

Introduction

The trail management plan provides an opportunity to step back and review the current trail system and evaluate its sustainability for user enjoyment, resource protection, and park management operations. To ensure that the trail management plan is implemented successfully, park managers have created these sustainable trail guidelines. The guidelines serve as a roadmap for trail construction, maintenance, and management in the park and focus on the following topics to incorporate the best planning, design, and management practices for trail sustainability:

- **Trail design.** The guidelines outline the basic principles and practices to administer during the site assessment and design phases of trail development. Guidance includes the trail development process for trails in Mammoth Cave National Park; identifying trail classes and types and their design and management criteria; site assessment and site design best practices; and program guidance for the development of trail facilities, signage, and accessibility and mobility that is suitable to each trail's individual site conditions.
- **Trail construction.** The guidelines establish basic principles and best practices to administer during the physical construction and maintenance of a trail.
- **Management, maintenance, and monitoring.** The guidelines recommend management actions that will sustain park trails for future generations. Guidance is provided on annual and long-term maintenance, trail closures, trail management for special use permit events, and trail monitoring.

Purpose

This document intends to formalize existing practices and provide guidance on trail design, management, construction, and maintenance specific to Mammoth Cave National Park. The objectives of trail guidelines are to (1) ensure a consistent look without compromising local initiative, (2) ensure a high standard of quality without overbuilding, (3) ensure a basic level of safety without removing all risk, (4) maximize accessibility without compromising the character of the trail, and (5) ensure environmental and resource protection throughout the entire process.

Sections

The trail guidelines are divided into five primary sections:

- Section 1. Introduction and Purpose – This section provides an overview and defines the purpose of sustainable trail guidelines at Mammoth Cave National Park.

- Section 2. Trail Types and Reclassifications – This section outlines a general trail classification system that would be used by Mammoth Cave National Park for design and management.
- Section 3. Trail Design – This section outlines the basic principles, steps, and practices to administer for the site assessment and design of a trail.
- Section 4. Trail Construction – This section outlines basic principles and practices to administer during the physical construction of a trail.
- Section 5. Management, Maintenance, and Monitoring – This section presents guidance for trail management that would sustain park trails for future generations. The guidance includes annual and long-term maintenance, trail closures, trail management for special use permit events, and trail monitoring.

SECTION 2. TRAIL TYPES AND RECLASSIFICATIONS

Four types of trails are identified in the Mammoth Cave National Park trail management plan. Each trail type has a distinctive use that informs design criteria and guidelines recommended for each trail type. These guidelines provide a range of design specifications based on the user type, intended experience, and conditions in specific trail locations. An overview of the four types is provided below and is followed by specific design guidelines for each trail type. Under each trail type description, the recommended design guidance is provided for each applicable trail class. The park's four trail types are as follows:

- Type 1 – Developed trails (pedestrian and bicyclist)
- Type 2 – Moderately developed trails (pedestrian, bicyclist, equestrian, and overnight backcountry camping)
- Type 3 – Semi-primitive (pedestrian, bicyclist, equestrian, and overnight backcountry camping)
- Type 4 – Primitive (pedestrian and overnight backcountry camping)

Detailed desired conditions have been articulated for each of the four trail categories in chapter 2. Desired conditions were developed for use type, visitor experience, resource conditions, and facilities and maintenance-related attributes for each of the four trail categories.

Trail Type 1 – Developed Trails

Design criteria: The tread is wide, firm, stable, and generally uniform. Tread would be relatively wide and flat in many areas and include obvious trail structures like bridges, stairs, and boardwalks where needed. The trail tread width and surface would generally meet Architectural Barriers Act (ABA) Standards to the extent feasible and provide access to the widest range of user abilities.

Materials: Trail surfaces may be hardened with pavement or gravel. Constructed features are frequent and substantial and trailside amenities may be present.

Table C-1. Trail Type 1 – Developed Trails

Trail Features	Description
Trail width	6 feet
Trail construction buffer	3 feet (one side)
Trail user	Pedestrians and bicyclists
Tread surface/material	Native or imported materials; commonly hardened with crushed gravel, asphalt, or other imported materials
Horizontal clearance	1–2 feet
Vertical clearance	8 feet
Longitudinal slope	Varies; typically does not exceed 30%
Cross-sectional slope	2% typical; not to exceed 5.5%
Special structures	Structures can be frequent and substantial, typically constructed of imported materials. Bridges as needed for resource protection and user convenience. Trailside amenities may be present.
Signage	A wide variety of signing is likely present. Informational signs are likely and interpretive signs are possible. Route identification signing at junctions and as needed for user reassurance. Regulatory and resource protection signing common.
Trailheads	Trailhead signage should include the length of the trail or trail segment, type of trail surface, typical and minimum trail tread width, and typical and maximum trail grade; typical and maximum trail cross-slope. Temporary conditions and hazards would also be communicated when necessary.
Trail maintenance	Routine annual maintenance. Targeted high level of accessibility. Trail prepared for the earliest opportunity to use in season. Maintenance in response to reports of unusual resource problems requiring repair/resource protection/trail safety. Maintenance of universal access trails to be prioritized over other classes. Seasonal and other temporary conditions and potential hazards would be clearly communicated to the public at the trailhead and other related public information platforms. Repairs to trail tread would maintain a firm and stable surface where applicable.

Trail Type 2 – Moderately Developed Trails

Design criteria: The tread is continuous and obvious and smooth with few irregularities. The trail tread width and surface would meet the technical requirements of ABAAS, to the extent feasible, and provide access to a range of user abilities.

Materials: Native or imported materials are used for tread, and it may be hardened in places with gravel.

Table C-2. Trail Type 2 – Moderately Developed Trails

Trail Features	Description
Trail width	4 feet
Trail construction buffer	2 feet (one side)
Trail user	Pedestrians, equestrians, bicyclists, and overnight backcountry campers
Tread surface/material	Natural native soils, surfaced as needed for hardening with natural native materials such as stone, rock, or wood
Horizontal clearance	3–4 feet
Vertical clearance	8 feet
Longitudinal slope	Varies, typically does not exceed 30%
Cross-sectional slope	2% typical, but not to exceed 5.5%
Special structures	Trail structures are uncommon. Trail bridges as needed for resource protection and appropriate access. Boardwalks; drainage; bridges, puncheons, and armoring as needed for resource protection.
Signage	Trails signs are predominantly wayfinding signage. Kiosks; loops and trails marked at intersections. Limited interpretive signage.
Trailheads	Visible trail markings/signage; caution signs at trail crossings or technical sections.
Trail maintenance	Routine annual maintenance. Maintain clearance for user convenience/recreational experience. Maintenance in response to reports of unusual resource problems requiring repair/resource protection/trail safety.

Trail Type 3 – Semi-Primitive Trails

Design criteria: The tread is narrow and rough. The width accommodates one-lane travel, with occasional allowances for passing.

Materials: The trail surface would be native soils with limited grading. Some gravel, enhanced dirt, engineering features, and rock armoring may be present to ensure sustainability.

Table C-3. Trail Type 3 – Semi-Primitive Trails

Trail Features	Description
Trail width	2–3 feet
Trail construction buffer	1 foot (one side)
Trail user	Pedestrians, bicyclists, equestrians, and overnight backcountry campers
Tread surface/material	Natural native soils, surfaced as needed for hardening with natural native materials, such as stone, rock, or wood, as well as gravel, enhanced dirt, engineering features, and rock armoring
Horizontal clearance	3–4 feet

Trail Features	Description
Vertical clearance	8 feet
Longitudinal slope	Varies; typically does not exceed 30%
Cross-sectional slope	2% typical but not to exceed 5.5%
Special structures	Structures are rare and only used when absolutely necessary for the sustainability and protection of resources, including boardwalks, stairs, and foot bridges.
Signage	Trail signs are predominantly wayfinding signage. Kiosks; loops and trails marked at intersections and with difficulty. Limited interpretive signage.
Trailheads	Visible trail markings/signage
Trail maintenance	Routine annual maintenance. Maintenance in response to reports of unusual resource problems requiring repair/resource protection/trail safety, such as storm damage creating heaving large numbers of downed trees.

Trail Type 4 – Primitive Trails

Design criteria: The tread is narrow and rough and has few or no allowances for passing.

Materials: The trail surface would be native soils with limited grading.

Table C-4. Trail Type 4 – Primitive Trails

Trail Features	Description
Trail width	2–3 feet
Trail construction buffer	1 foot (one side)
Trail user	Pedestrians and backcountry campers
Tread surface/material	Natural native soils, surfaced as needed for hardening with natural native materials such as stone, rock, or wood
Horizontal clearance	3–4 feet
Vertical clearance	8 feet
Longitudinal slope	Varies; typically does not exceed 30%
Cross-sectional slope	2% typical but not to exceed 5.5%
Special structures	Structures where protection of resources are needed, including boardwalks, stairs, and foot bridges
Signage	Trail signs are minimal in nature and predominantly provide wayfinding information. Kiosks, loops, and trails marked at intersections and with difficulty. Limited interpretive signage.
Trailheads	Visible trail markings/signage

Trail Features	Description
Trail maintenance	Trail maintenance needs would be minimal. Maintenance in response to reports of unusual resource problems requiring repair/resource protection/trail safety, such as storm damage creating heaving large numbers of downed trees.

Definitions of Trail Reclassifications in This Plan

Beyond the identification of the four trail types for park trails, the trail management plan classifies some existing trails for "rehabilitation" or "restoration."

Rehabilitation. This trail class entails the one-time reconstruction of an existing trail in which the new trail would follow the existing alignment. Trails were tagged with this class when the current trail had a safety concern, serious recurring water issues (i.e., drainage), or extremely poor trail condition. Types of work expected to occur in this trail class include earthwork (e.g., establishing a drainage ditch), reversing slopes (i.e., grade reversals), rock armoring, and heavy brush clearing.

Restoration. Roads, trails, recreation areas, and river crossings that are not part of the designated system would be restored to predisturbed conditions. Before implementation, park staff would determine the exact restoration strategy needed based on factors such as the likelihood that vegetation would naturally recover and the extent of the existing human impacts. Restoration would be contingent on funds and staff availability, may be subject to additional compliance (particularly section 106 of the National Historic Preservation Act), and may be phased over time.

The restoration of trails, as proposed in the trail management plan, is critical to achieving the desired conditions and visitor experiences intended for the plan. Furthermore, trails and their use impact wildlife through fragmentation and the loss of habitat, so new trail construction would minorly be offset by restoration of unsustainable trails in other areas of the park.

Active Restoration. The intention of active restoration is to reconstruct the natural spacing, abundance, and diversity of native plant species as much as possible. Active revegetation may require implementation-level compliance and is broken down into the following two categories:

1. Major ecological improvements: This category of restoration is the most intensive in terms of time, money, and required equipment. Major ecological improvements would involve substantial earthwork, including using heavy machinery (i.e., grubbing, recontouring, obliterating tread), and would result in a significant improvement to the landscape.
2. Minor ecological improvements: This category of restoration is less technically complex, involves minimal tools, and could be completed by volunteers. Minor ecological improvement techniques would involve replanting (using native species seed), fencing, or similar methods.

Passive Restoration. Passive restoration allows surrounding vegetation to colonize the abandoned trail. This method is appropriate in areas that are likely to fill in if left alone. The

process works when erosion has been stopped and the trail has been scarified, allowing adjacent vegetation to spread and grow rapidly. This modest level of restoration would involve placing barriers on trails, scarifying the trail tread, and allowing the plants to revegetate on their own.

SECTION 3. TRAIL DESIGN

The general planning and site design process applies to new trail construction, as well as reroutes for the rehabilitation and restoration of existing trails. Please refer to chapter 3 of the trail management plan for the route corridors.

Trail Design Process

This phase of development begins with the selection of a trail construction corridor identified in this trail management plan and approved by the superintendent. Upon this selection, the following planning steps are recommended for all trail projects in the park:

Step 1. Establish a Trail Design Team. A project manager from the park would be assigned at the initiation of a trail project. The project manager would complete any necessary compliance for project implementation using a designated trail design team, otherwise known as an interdisciplinary team. The team would serve as advisors and reviewers during the trail planning, design, and construction process. The team can consist of the park facility manager, park biologist, hydrologist, environmental protection specialist, accessibility coordinator, outdoor recreation planner, and communications/public affairs specialist, as deemed necessary to the trail location and conditions. Based on the conditions of the proposed trail, additional trail design team members, including user group representatives and nonprofit partners, may be involved.

1.1 Determine Intent of Trail — The trail design team would review the trail management plan, including the trail type from section 2 of this appendix, to determine the design parameters and establish the trail intent. Corridors for new trails would follow alignments identified in the trails management plan.

Step 2. General Site Assessment for Trail Alignment. A site visit would be conducted at the potential trail corridor to identify challenges and opportunities for the general alignment. The assessment would identify an implementation alignment in the corridor proposed by the trail management plan. The trail design team would identify sensitive areas and pertinent issues. Compliance requirements would be identified by the trail design team.

2.1 Site and Trail Plan — The project manager would develop an initial site and trail plan based on general site assessment and field conditions, surveys, consultation with the trail design team, and discussions with resource management and maintenance staff.

2.2 Flagging the Trail Alignment Corridor — The project manager would flag the proposed trail layout in the field. The project manager would coordinate with the interdisciplinary team and management team at the park before flagging materials being placed to ensure public awareness of the activity.

2.3 Conduct Implementation Level Compliance for Trail Construction (as necessary) — The trails management plan and its associated programmatic agreement for the treatment of cultural resources require that before any new construction or active restoration of trails, an archeological survey would be carried out in previously unsurveyed corridors and that any archeological sites encountered would be evaluated for eligibility in the National Register of Historic Places. Impacts on eligible properties would be avoided through the modification of the trail alignments or minimized in consultation with the state historic preservation office and Tribes.

2.4 Natural Resource Surveys and Wetlands Delineations (where available) — These delineations are also expected in advance of ground-disturbing activities. The park's database of sensitive species should be consulted before trail construction or active restoration and as necessary, in consultation with the park's resource managers and the park's biological survey to identify species of concern. Wetlands statements of finding may be required before finalizing a plan for trail work. Additional surveying may be needed.

Step 3. Finalize Construction Plan. The project manager would refine the site plan based on the results of resource surveys and with input from the trail design team, which would result in a final layout, cost estimates, construction techniques, staging locations, and equipment guidance.

3.1 Pre-Approved Maintenance Plan — Before construction, the park superintendent should be provided with an approved maintenance plan for the trail that outlines how the new asset would be maintained through park staff or volunteer labor.

Step 4. Construct Trail. See "Section 4. Trail Construction" below and the "Mitigation Measures Applied to Alternative 2 (NPS Preferred Alternative)" section in appendix I of the trails management plan.

Step 5. Formalize Management, Maintenance, and Monitoring Plan. See "Section 5: Management, Maintenance, and Monitoring" below.

General Guidance for Trail Design

This section provides general guidance for trail design, as well as the supporting amenities. The guidance set forth aligns with the procedures described above for the Mammoth Cave National Park trail planning process.

Physical design. Establishing baseline design principles for every trail, whether it be rehabilitating and restoring existing trails or developing a new trail, would be essential for the long-term sustainability of the trail system, minimizing its impact on park resources, and providing a safe and enjoyable experience for the park visitor. These general design principles have been compiled from other recent NPS trail plans and guided by past work and publications on sustainable trail development throughout the United States. These principles should be considered part of the design development and construction practices for every trail in the park and reviewed during step 2 of the Mammoth Cave National Park trail planning process. The trail design team should also consult any updated trail guidance from NPS policy once a trail corridor has been established and approved.

Accessibility. The National Park Service strives to ensure that all people have the highest level of accessibility that is reasonable to NPS programs, facilities, and services in conformance with applicable regulations and standards, as outlined in Director's Order 42: *Accessibility for Visitors with Disabilities in National Park Service Programs and Services*. The National Park Service intends to provide accessibility to the extent practicable on all trails and facilities in the park. Each trail and its associated facilities would be evaluated on its conditions to determine the practicability of accessible design and the extent to which accessible features are provided. For additional information on accessibility, including accessible trail design, see appendix H.

Equity in design guidance. Historically underserved communities, including, but not limited to, low-income, people of color, people with physical or intellectual disabilities, seniors, and people with limited English proficiency, may feel unwelcome or unsafe due to racial profiling and stereotyping; a lack of visibly diverse populations in rural parks; legacies of racism in how recreational spaces were founded and managed; or imagery and language in marketing materials that prioritize particular types of users. Additionally, historically underserved communities may be prevented from using trails due to physical barriers or poorly maintained surfaces. The National Park Service strives to advance equity through various efforts as outlined in Executive Order 13985, "Advancing Racial Equity and Support for Underserved Communities Through the Federal Government" (2021) and Executive Order 14096, "Revitalizing our Nation's Commitment to Environmental Justice for All." To confront inequities in trail access, understanding these barriers can help inform trail development to best serve all populations. To promote equity in trail design, teams can consider the following suggestions from the US Department of Transportation's *Trails as Resilient Infrastructure Guidebook* (USDOT 2023):

- Grade trails and selecting and locating amenities such as seating and bike racks to support people with limited mobility.
- Provide design treatments that assist in navigation or greater interaction with spaces for people with low vision or blindness.
- Design more intentionally for minority populations. Consult resources on designing spaces that feel secure and support diverse recreational and social needs, such as including lighting where appropriate.
- Consider equity in the design of marketing materials, signage, art, and websites.
- Find ways to offer free or inexpensive options if trails require fees or equipment rental for certain uses. Consider partnering with organizations to provide free or reduced prices.

Trail location. The most sustainable trails are located along the sides of hills and follow the elevation contours providing undulation for drainage. Following this design assists with water drainage from the trail and keeps users on the trail, preventing widening.

Trail alignment. Sustainable trails traverse slopes rather than directly descending a hillside. A trail traversing a slope allows for sheet runoff of water, which causes less erosion and minimizes the creation of gullies. Because of poor soils at Mammoth Cave National Park, creating trails

that follow the fall line or move perpendicular to contours is unsustainable. Such fall line trails degrade over time, eroding soils and requiring consistent maintenance.

The following design principles are a set of sustainable principles that should be used when engaging in the trail planning process as it relates to step 2:

- **The half rule.** The grade of a trail should not exceed half of the grade of the sidehill on which it is located. Exceptions to the half rule occur when soils in the location of the trail are prone to erosion, in which case the maximum sustainable trail grade may be considerably less than half of the grade of the sidehill. Except in rare and limited situations, the maximum grade of a trail should not exceed 15%.

- **Sustainable grade.** The overall average grade of the trail should be generally 10% or less. An average grade of 10% or less can decrease the impacts of erosion. For mountain bike-specific trails, beginner trails should range from 0% to 5% average grade, intermediate trails range from 5% to 7% average grade, and advanced trails average 7% to 9% (or higher) grade (IMBA 2015). Although soil dependent, the maximum grade should be around 15%–20%. The maximum grade is the steepest section of the trail that is more than 10 feet in length. These grades can be exceeded if trail reinforcement techniques such as rock armoring are used (IMBA 2015).

- **Grade reversals.** A grade reversal is a brief change in elevation where the trail drops subtly before rising again. Incorporating the use of grade reversals in trail design would assist in water drainage and minimize the potential for erosion. Prior guidance for trail construction included the use of both rock and log waterbars; however, using grade reversals rather than these built features would result in less cyclic maintenance over time. Grade reversals every 20–100 feet would ensure water can flow from the trail as frequently as possible.

- **Outslope.** Trails should be built with a slight tilt (about 5%) of the trail tread toward the low side of the trail. Where outslope is difficult to implement, the use of grade reversals should be implemented before and after that section to reduce the amount of water accumulation.

Design with natural and cultural resources. Park trails would be designed to avoid sensitive natural and cultural resources. When avoidance of a resource is not feasible, designing the trail to minimize its impact would be required. Best practices and sustainable design methods that minimize impacts on cultural resources and complement natural features would be used. The following guidance pertains to trail design in park resources:

- **Alignment outside of buffer zones.** Ensure that trail alignment design is outside of buffer zones identified during site assessment for sensitive natural resources and cultural resources, and/or implement management and design measures for those areas where the trail must cross through established buffer zones. The US Environmental Protection Agency recommends a protected buffer of 50 feet around wetlands and streams where siting of campsites, parking areas, or other structures should be avoided. In addition to wetlands and streams, natural resources, including certain plant and animal species/communities, granite outcrops, wetlands, seeps, and springs, should all be

buffered when possible. The park's database of sensitive species should be consulted before trail alignment, construction, and maintenance to locate and avoid sensitive areas and sensitive species. In addition, surveys should be conducted to inventory and identify these resources of concern before any new trail construction so that they may be avoided. Trails would seek to achieve a minimum buffer of 50 feet around sensitive resources, but buffers may be increased based on the sensitivity of the resource.

- **Archeological and historical site protection.** Archeological inventories covering the project area must be complete before starting any new trail construction or restoration project. Historic properties would be avoided where possible through minor reroutes of trails. If avoidance is not possible, measures would be taken to limit or mitigate impacts on cultural sites. Reference the programmatic agreement under development for this trails management plan for guidance on the completion of compliance associated with cultural resources when implementing this trails management plan.

- **Drainage.** Design methods to manage stormwater and trail runoff naturally through dissipation and infiltration should be identified and developed as part of the overall design of the trail to reduce runoff velocity, erosive conditions, and stream head cutting. Additional infrastructure required to meet drainage requirements should also be identified on the site plan.

- **Stream crossings.** When a stream crossing is the only viable option, it should be designed and constructed at no greater than an 8% grade. Crossings should be located on gradually sloping stream banks to minimize impact (IMBA 2004). Trails should not parallel a stream for an extended distance. If the trail should need to travel along a waterway, it should be aligned so that it moves toward and away from the waterway at intervals that are determined appropriate for the size of the river or stream and the existing riparian habitat conditions. Crossings for streams should span the channel of the stream, and any posts or fill should be kept above the ordinary high-water mark of stream channels.

- **Wetland boardwalks.** If a trail is constructed in a wetland, a boardwalk system is recommended. The boardwalk design should provide a layout that minimizes the width of the boardwalk tread and the number and size of pilings (helical piers) needed for excavation and uses best practices that minimize the area of excavation. Additionally, trails or boardwalks in or near wetlands should be constructed during winter, if feasible, and the width of temporary access roads for construction should be minimized to reduce impacts on aquatic resources. Any impacts or changes to identified wetlands require a Clean Water Act 404 permit through the Army Corps of Engineers and permits by the Kentucky Department for Environmental Protection.

Soil suitability. Sustainable trails consider the soil conditions and user patterns to identify design measures required for long-term sustainability. Since the soils at Mammoth Cave National Park are identified as poor, the following measures should be addressed in the trail planning process:

- **Minimize user-caused soil displacement.** Design trails that avoid abrupt corners and sharp hills, when feasible. Design trails that incorporate consistent flow, insloped turns, and the use of trail hardening practices in areas that are susceptible to soil displacement.
- **Determine infrastructure.** Once a general trail alignment is determined in step 2, further layout of infrastructure would be identified. The determination of the type of infrastructure, costs, and general design would need to be assembled during the site design phase. When necessary, budget for trail hardening measures before construction to avoid soil erosion problems.
- **Create clear sightlines for multiuse trails.** Avoiding abrupt stops and the use of braking would create less erosion issues for bicyclists and preserve trail tread.

Climate resilience. Climate change is having a clear impact on weather patterns and landscapes, causing flooding, extreme heat, drought, and wildfire. Trails can be particularly vulnerable to climate impacts, and changing weather patterns and landscapes can cause physical impacts on trails. A trail's vulnerability to climate change and extreme weather can be seen as a function of a trail's or trail network's exposure, sensitivity, and adaptive capacity, as follows:

- **Exposure** depends on whether a trail or trail network is located in an area experiencing direct effects of climate variability and extreme weather events.
- **Sensitivity** refers to how the trail or trail network responds to or is affected by climate stressors.
- **Adaptive capacity** is the trail or trail network's ability to adjust, repair, or flexibly respond to damage caused by existing climate variability or future climate impacts.

Assessing a trail's vulnerability to climate change can help plan to mitigate risk. Vulnerability assessments for trails are a relatively new concept, and there are few available best practice examples. Consider reviewing the USDOT (2023) *Trails as Resilient Infrastructure Guidebook* and the NPS (2021) *Planning for a Changing Climate: Climate-Smart Planning and Management in the National Park Service* on how to develop an assessment and adapt to climate change as appropriate.

Trail Facilities

The park's trail system contains support facilities to provide access and amenities for visitors. The design and types of facilities are an important aspect of the management and use of park trails. The park's general management plan includes descriptions of appropriate facilities by zone, and the trail-related facilities would conform to allowable infrastructure by GMP zone.

Sustainable design and climate friendly practices. All new improvements to existing trail facilities should be designed and developed recognizing the character of the park and aim to meet NPS Climate Friendly Program and sustainable design guidelines (NPS 2024a, 2024b). Using low-impact design standards should be considered where applicable, such as Leadership in Energy and Environmental Design, sustainable sites, building guidelines, the use of recycled

materials, the Environmental Protection Agency's WaterSense program, the park's environmental management program, and other similar programs.

Trail Amenities

The trails management plan describes two types of access points: trailheads and river access points. Public access to the park's trail system and connection to local communities would be facilitated by this system of access points. Modifications to parking and supporting trail infrastructure would be handled on a case-by-case basis. Please reference chapter 2 under the action alternative for further descriptions. Following are trail amenities for trailheads and river access points.

Trailheads. Trailheads are places that serve as a starting or ending points along a trail that provide information and, potentially, facilities at varying levels of services to the trail user and park visitor. Trailheads are developed areas on federally owned/leased and NPS-managed lands that include a parking lot, trail access signage, and trail access. Trailheads may also include other facilities, as outlined in the trails management plan and can vary based on the designated zoning. Refer to the maps and tables in chapter 2 for locations of trailheads and associated facilities.

- **Restrooms.** New and/or improved restroom facilities should be designed using NPS sustainable design guidelines and NPS Climate Friendly Program guidance. Types, quantity, and locations for restrooms would be based upon zoning, trail access classification, and maintenance requirements.

- **Bike racks.** Bike racks may be installed at designated trailheads where bicycle use is authorized. The design and placement of the bike racks should reflect and maintain the character of the park and its resources. Materials for bike racks should provide minimal additional maintenance when installed.

- **Information kiosk.** Information kiosks are used to share information and raise awareness. They should be set up at trailheads to increase the chance of capturing a broad spectrum of trail users and visitors while also maintaining the character of the park and its resources. Materials for information kiosks should provide minimal additional maintenance when installed.

- **Parking lot.** New and/or improved parking lots should be designed using NPS sustainable design guidelines and NPS Climate Friendly Program guidance. Types, quantities, and locations for parking lots would be based on zoning, trail access classification, and maintenance requirements.

- **Benches.** Benches would be located along trails and at trailheads, where applicable. Benches should fit the character of trail type and would adhere to the bench standards currently in place at the park.

- **Picnic tables.** Picnic tables would be limited to designated picnic areas of the park and generally not located on trails.

River access points. River access points are places that serve as start or end points along water trails and provide information and, potentially, facilities at varying levels of services to the trail user and park visitor. River access points may not fully meet the technical requirements of ABAAS due to topography and resource constraints. River access points may also include the same facilities listed under trailheads above.

Trail Signage and Markers

Trail and trailhead naming. Trailheads and trail access points throughout the park would be formally named and designated, as would some popular trail routes. These names would be used on signage, maps, and other informational materials to improve wayfinding, trip planning, and sense of place.

Signage. Trails and destinations would be clearly marked with signs. Signage located at trailheads and both primary and secondary trail access points would be standardized. Trail markers would be installed at trail junctions and destinations, and mile markers could be considered for use along certain trails when necessary. Please see "Trail Improvements" in chapter 3 for additional information and locations.

Trail information. A variety of trail information should be available to trail users through trailhead signage, on-trail information, trail maps, and the use of digital media at trailheads and through mobile applications (e.g., NPS mobile app). Trail characteristics and condition information are required at all trails, including:

1. length of the trail or trail segment
2. type of trail surface
3. typical and minimum trail tread width
4. typical and maximum trail grade
5. typical and maximum trail cross-slope
6. types of users permitted on the trail
7. hazards such as rocks and roots on the trail
8. temporary hazards and seasonal conditions such as flooding, surface maintenance needs, or intruding vegetation

SECTION 4. TRAIL CONSTRUCTION

This section outlines general guidance for construction, including the rehabilitation and restoration of existing trails and the development of new trails. Collaboration during the trail design process with maintenance and resource management disciplines at the park, and trained volunteers are the cornerstones for the successful construction of the trail, long-term sustainability, and minimal maintenance.

Using the best management practices to construct a new trail or improve an existing trail is critical to its future maintenance and management. The following general guidelines are

recommended for basic activities and methods to use during trail construction. The park's trail guidelines and practices should stay updated to trail industry standards, nationally and regionally, that are beneficial to the trail user and park resources. Information in this section is adapted from the trail guidance manuals cited in the "References" section of this document but primarily from the National Park Service, US Forest Service, Minnesota and Michigan Departments of Natural Resources trail guidelines (MDMR n.d.; Public Sector Consultants 2021), the International Mountain Biking Association's Trail Solutions manual (IMBA 2004), and the USDOT *Trails as Resilient Infrastructure Guidebook*.

Guidance on Trail Construction Practices

Trail clearing. Clearing vegetation for any new trail would be coordinated with park staff consisting of disciplines in or equivalent to planning and design, plant ecology, biology, and trail construction and maintenance during Step 2.2 Flagging the Trail Alignment Corridor. For protection against erosion and to maintain resource integrity, native vegetation should be retained when possible.

The amount of trail clearing needed would be based on the category of trail type and the GMP zone within which it is identified. Trail clearing should be made as narrow as possible.

Healthy trees of any size should not be removed except where they interfere with trail traffic and/or the trail cannot be relocated to eliminate the interference. Healthy trees over 12 inches in diameter breast height should remain, and the trail should be routed to avoid being placed in the area directly under the outer circumference of the tree branches (i.e., the dripline). When branches extend over the trail, the corridor would follow the vertical trail clearance standards. Considerations for wildlife movement and habitat connectivity should be included to ensure that trail construction and any associated structures do not adversely affect local fauna.

Base construction. Construction of sidehill trails usually requires grading the bed for the trail, but if the existing surface is flat and provides a suitable tread, leave it undisturbed. This practice would reduce erosion and maintenance. On level ground, form the trail base by building up rather than cutting down. On equestrian trails, ensure the base is stable and prevents the spread of materials due to traffic, such as by using geotextiles or larger aggregate sizes in the base course. Remove all duff before making cuts or fills for the tread. Start grading on the upper slope and carry it down to the finished grade. The usual procedure is to "scratch" a continuous line along the upper slope using a Pulaski or McLeod. Remove any excess duff at this time. Begin excavation along this line using the appropriate equipment for the trail. The depth, width, and material of surfacing are determined by the quality of the native material and the class of the trail, as specified in these guidelines. As a standard of practice, do not add material or fill to the trail on these contour trails; rather, create a full bench.

Drainage. Proper drainage is a key component to the sustainability of any trail. Drainage control on a trail relates to two primary types of water control: surface and subsurface water.

- **Surface drainage.** Methods to manage surface drainage include outslope, grade reversals, drain dips, varying the trail grade, and armored crossings.

- **Outslope.** Establishing an outslope to a trail would allow water to sheet across and off the trail instead of funneling down its center. Outslope design should exceed the running slope to be effective. If loose soil is present, the incorporation of grade reversals is recommended.

- **Grade reversals/drain dips.** A drain dip provides subtle grade changes to a trail, allowing water to exit the trail at intervals. This process reduces the volume and erosive power of water runoff along a trail corridor. Drain dips should be located where they would be most effective. Features such as natural contours, side slopes, and trail grade must be studied closely to determine where the largest volume of water can be intercepted. Soil conditions, vegetative cover, and downslope steepness must also be considered when selecting a drain point and outflow location. Ideally, drain dips should be located where natural swales or drainageways bisect the trail. A drain dip begins on the up-trail side of a normal outslope. The outslope is gradually increased (4%–10%) as the trail grade is cut and lowered to the trough and drain point. The terrain and volume of water encountered usually determines the length and the degree of outslope used on a trail. Generally, steep terrain and higher flows require longer drain dips with more outslope. The trough is dug across and down the trail at a 30-degree angle and should also be dug with a 15% downslope to ensure adequate drainage and sediment transport. From the trough, the down-trail side sharply rises to the original grade and outslope. This angle must not be too steep or this portion of the trail would be worn down or scuffed into the trough by trail users. Below the drain point, a ditch or drainage channel must be provided to allow water to escape from the trail and fill the slope without creating undue erosion. This channel is sized according to the volume of water generated by the drain dip. This channel may also require armoring with native rock to reduce scouring and bank erosion. When a trail cannot support enough drainage dips to meet its drainage needs, knicks, and rolling grade dips can be a practice to evaluate as an option. These options feature an outsloped depression in the tread, followed by a long, gentle dirt ramp. The ramps are typically long, at 10–20 feet from tip to tail and outsloped at 5%. The total length of a rolling grade dip varies widely depending on the steepness of the trail tread, but it is typically 15–30 feet.

- **Armoring the tread.** When natural drainage and/or use types create conditions that prevent the maintenance of a natural tread and no other locations are available, the use of hardening material is recommended. Hardening the tread would minimize maintenance, stabilize the surface, and minimize erosion and drainage impacts on adjacent natural resources. Armoring techniques to consider include steppingstones and rocks.

- **Mixed aggregate.** Mixed aggregate is typically used on trails located on flat terrain with poor drainage and where the use of dips and reversals is not feasible. Aggregate mix material comprising 0.75-inch crushed gravel with the crusher fines is recommended for this application and used to build up the trail tread. This mix keeps a dry surface for visitors to traverse, reducing off-trail travel.

- **Turnpike.** Turnpike construction is used in areas where the trail tread remains wet and no relocation options are available. Turnpiking builds up the trail tread higher than the water. Turnpikes are used in short intervals (not in wetlands) where trails cross over seasonal drainages or low-lying areas. Turnpikes would be made of applicable/approved aggregate based on usage type to elevate the trail. Turnpikes would only be used if diverting water around the trail with available materials or under a trail using culverts.

- **Edge protection.** Where a trail travels along a side slope, drainage, and erosion issues can arise due to trail user patterns. Edge protection techniques should be evaluated and considered in some locations to assist with stabilizing the trail and reducing maintenance. Techniques to consider include curbing; establishing a vegetative shoulder; installing a constructed barrier, such as a low wall or fencing; or visitor education and enforcement. Site conditions, trail use, trail type, and desired trail experience should be factors in determining the best technique.

- **Tread watersheds.** A tread watershed consists of the tread surface plus any uphill area where runoff flows onto the trail and down to a dip between two crests of a grade reversal. This design approach limits erosion on the trail by reducing the amount of water on the given trail segment. Designing the trail with a rolling grade with crests and dips would assist in creating tread watersheds.

Trail climbs. To maintain sustainable grades but meet the topographic terrain that exists in the park, trails require direction changes or placement at sustainable grades to help gain the elevation at a consistent and sustainable rate. Tread climb relates to the steepness and length of a trail overall and between individual tread crests and dips. In general, tread climbs should not exceed one-fourth to one-third of the fall line or the direct drainage paths of the natural terrain. Fall line climbs should be avoided when possible. If the trail needs to meet the fall line climb, ensuring proper grade reversals on the upslope side of the trail is imperative to reduce erosion and water runoff.

- **Climbing turns.** Climbing turns should be used on grades that do not exceed 7%. Turn radii should be wide, generally 20 feet or more. Incorporating a grade reversal just above the turn is recommended. Armoring the fall line section of the turn and adding a choke point to slow users before the turn would reduce user-caused erosion. If possible, use a natural feature as a visual guiding point for trail users to anticipate the climbing turn and to appropriately determine their speed if cycling or running, which would help reduce erosion.

- **Switchbacks.** Switchbacks are sharp, directional changes on a trail to gain elevation in limited space. Switchbacks should be avoided if possible. When switchbacks are necessary, construct the turns as flat as possible. On side slopes of less than 30%, treat the switchback as a climbing turn. If this results in the center line grade being steeper than is desirable, shorten the radius and design a step section. Provide 15–30 feet of barrier back from the turning point to prevent trail users from crosscutting inside the switchback. A gutter-type ditch, 8 inches deep and 12 inches wide across the top, should be constructed along the bottom of the cut bank to extend from the spill point upgrade for 20 feet. The trail tread paralleling the ditch should have a 10% inslope that would

drain water from the tread into the ditch. The tread surface, down grade from the crown line for 20 feet, should be constructed with a 10% outslope that would drain water off the trail. A traffic control barrier should be constructed by placing large rocks along the outer edge of the upgrade trail section, forming a continuous barricade. The barrier should be a minimum of 14 inches high and extend from the crown line on the turn section upgrade for a minimum distance of 15 feet. Consideration of handrails should be made where applicable and necessary where steep grades or drop-offs exist.

- **Turning approaches.** The upper and lower 20-foot approach sections extend away from the turning point, and the turn section should be constructed to have no less than the trail tread width. The tread on the approach sections and on the turn section should not exceed the prevailing grade of the trail and have no surface rocks over 2 inches in diameter or solid rock protrusions above the trail bed.

Drainage crossings. Crossings of streams can have significant impacts on resources if not implemented properly. At all times, avoiding drainage and stream crossings is the preferred option. If crossings are unavoidable, the following drainage crossing options would need to be evaluated and considered to determine the best option for a specified trail area. The determination of the best methods for drainage crossings should be evaluated in compliance with Director's Order 77: *NPS Benefits Sharing*. Drainage crossing design should consider the characteristics of the trail, level of use, and level of development of the trail.

- **Direct crossing.** If drainage flows are intermittent, the installation of a primitive crossing should be considered. The use of the trail, type of trail, and resource conditions would influence this consideration. If a direct crossing begins to alter the drainage flow, then other crossing options would need to be installed.

- **Hardened tread crossing.** Hardened tread crossings should only be used where water depths during high flow are less than 3 feet, water velocities are low, trail use is low, and water quality conditions would not significantly change. Hardening techniques include the use of stones, gravel, and cobble to fortify the trail tread. These materials should be used at sizes appropriate for the stream conditions and trail type.

- **Culverts.** Elevated crossings are preferred over culverts, as culverts can alter the water quality and stream functions significantly depending on the drainage size. Culverts should only be used when other natural water management methods are not feasible for site conditions.

- **Bridges/boardwalks.** Bridges and boardwalks are the preferred methods for drainage crossings when avoiding waterway crossings is not possible. The scale, width, and materials for structures should be compatible with trail use, trail experience, GMP zone, and the minimization of resource impacts. Staff would ensure consistency in bridge design across park units based on the trail type and GMP zone with the goal of establishing a distinct NPS visual identity. Bridge spans should aim not to install piers or footers into waterways. Spans greater than 24 feet should examine materials other than wood to establish long-term sustainability. A minimum bridge width should match the width of the trail. Bridge and boardwalk materials, railings, and styles should be

considered for the level of use, proximity, and characteristics of the trail and must meet the technical requirements of ABAAS. Materials should be selected based on structural integrity and site appropriateness. Pressure-treated lumber is recommended for all boardwalks/bridges and matches what the park typically uses for these structures. Cultural landscapes and historic characteristics of the area should also be considered during design.

Other structures. Trails may require additional structures to protect the resource and provide a safe trail corridor for its users. These structures include but are not limited to the following:

- **Retaining walls.** Retaining walls are structures of wood or stone designed to stabilize the trail base on a side slope. Native logs should be used only if rock is not readily available, and the native logs should be peeled before placement to ensure a longer life expectancy and reduce replacement. A solid foundation on earth or rock is required to obtain a rigid, safe retaining structure, and the removal of water behind the wall is necessary for its design.

- **Steps.** Steps should be discouraged to minimize infrastructure, maintenance, and accessibility restrictions. Steps are recommended only as a safety feature where the physical conditions prohibit the alignment of a trail with the natural topography.

- **Berms.** Berms are mountain biking-specific trail features consisting of specialized insloped turns that are built up shaped like a bowl. Berms require a larger/wider turning radius than standard hiking trails (IMBA 2023).

- **Technical trail features.** Sections of mountain bike-specific trails may contain technical trail features. Technical trail features are constructed to challenge a rider's skill set and can be constructed or naturally occur. Technical trail features are typically made from rock or wood and include features such as rock gardens, drops, rock-overs (rocks you ride up and over), ledges, and skinnies (narrower sections of trail that require focus and balance) (IMBA 2023). See the IMBA publication, *Mountain Bike Trail Development Guidelines for Successfully Managing the Process* (2023) for specifics on these features.

Trail restoration. Once a trail has been designated closed or a section relocated, the closed or old trail would be restored to a natural condition consistent with the location's surrounding resources (see Section 2. Trail Types and Reclassifications for more information on passive and active restoration).

Recommended steps to take in reverting the trail to a natural condition and avoiding the continuing use of the trail include the following:

1. Till or scarify the retired tread so that new plants can seed themselves.
2. Plant or transplant from old route native species to avoid invasive plant issues.
3. Disguise and block the corridor with natural material to eliminate the visual corridor and the risk of continual use on the closed section of the trail.

4. Install "restoration in progress" signage to inform trail users to stay off of the restored area.

5. Approve all soil brought in for trail construction or maintenance through compliance to ensure it is free of weed seeds is crucial to protect the local ecosystem.

Construction practices to reduce diesel emission impacts. Best practices, where applicable, to reduce diesel emission impacts during trail construction or restoration should be followed as recommended by the US Environmental Protection Agency for areas in the nonattainment of National Ambient Air Quality Standards.

SECTION 5. MANAGEMENT, MAINTENANCE, AND MONITORING

A critical step often forgotten in the trail development process is a strategy for the management, maintenance, and monitoring of a trail after its construction. This section provides recommendations for three management actions: (1) trail management, (2) basic trail maintenance practices, and (3) methods for trail assessment and monitoring.

Trail Management

General trail operating levels. Park managers would use three trail operation levels, as follows. Condition benchmarks under specific resource conditions for each operating level are described in the sections below.

- **Trail open/fully operating**. The trail is operating as currently permitted with no restrictions for use or trail modifications required.

- **Trail seasonal/temporary closure.** The trail is temporarily closed on a seasonal basis or other temporary purpose for a resource condition. A notice would be provided on the reason for the closure.

- **Full permanent closure.** Trail conditions cannot be sustained to meet the goals and principles set forth in the trail management plan. Upon exceeding monitoring triggers or thresholds from the trail management plan (see appendix A and chapter 2), the superintendent would determine trail closures. Upon the superintendent's decision, park staff would proceed with the trail closure and site restoration.

Trail operating benchmarks for resource protection. Park managers have established benchmarks on specific park resource conditions to assist in determining the operational level of a trail.

- **Trail open/full operating.** The trail is in good condition and is open for use. No major obstacles or repairs are underway. The trail tread is 75% dry and with no significant mud.

- **Trail seasonal/temporary closures.** Seasonal closures are prescribed to designated trails to protect park resources and to meet the goals of a sustainable trail system in the park. Seasonal closures would reduce impacts on park resources, minimize the risk of tread widening, reduce annual maintenance costs to high-risk areas, and provide an

improved visitor experience during the drier seasons of the year. Natural resource-related seasonal closures would address three primary conditions: wet/muddy conditions, flood events, and annual nesting activities. Park managers may identify additional resource issues that require seasonal trail closures. Seasonal closures would occur when the following resource issues are observed:

  - **Wet/muddy conditions.** Trails that are susceptible to wet, muddy conditions due to seasonally wet conditions and have high load or high use conditions would be subject to seasonal closures. Park managers can close additional trails as wet conditions arise. Park managers can also open the seasonally closed trails if the annual wet season is dry.

- On moderately developed trails, bicycle and equestrian use is not allowed within 24 hours after a rain event. Park staff would maintain a text-for-status program for local bicyclists to check on the operating status of these trails before visiting.

  - **Flood conditions.** A flood event covers a trail or trail facility at a level as determined in the park's flood incident plan and in which access is prohibited. Trails subject to flooding would be listed on the park website, and visitors would be advised to monitor local weather as a precaution before hiking to avoid flood conditions.

  - **Annual nesting.** Seasonal closures would occur in designated areas of the park where annual nesting activities occur. These areas would be identified on an annual/seasonal basis with the park biologist and the conditions of trail restrictions for the seasonal closure.

- **Trail rehabilitation, reroutes, and permanent closures.** Through the trails management plan, the planning team has made every effort to reconfigure the park's trail system along sustainable routes by following contours, creating positive drainage, and other best practices. However, over time, conditions may change that affect the overall sustainability of certain sections of the trail. For example, some trails may become unsustainable due to shifts in the area's hydrology, changing climate, or other factors. Furthermore, resource conditions may change, such as colonization of the area by sensitive, threatened, or endangered species. As these conditions change, park management may need to rehabilitate or reroute sections of the trail and, in some cases, permanently close them altogether. Restoration methods outlined in Section 4. Trail Construction would be followed where closures occur.

The trail conditions indicators (see appendix A) would be actively monitored. If thresholds are exceeded on a particular trail, it may be rerouted or permanently closed if other management strategies are not effective at bringing the indicator back to consistency with the threshold.

If a trail is impacting a sensitive plant or animal species, a buffer distance around that species would be determined based on the individual species' sensitivity. If the species' presence is long-term in nature, the trail may be rerouted or permanently closed. Sensitive species are defined as those critical to the park's resource integrity, as well as threatened and endangered species, that are adversely impacted by human presence along the trail.

Event special use permits. When special use events are requested for trail use, the event applicant would be required to submit with its permit request an event sustainable trail plan. The plan (conditions of the permit) would require the permittee to outline how the trail would be protected and maintained before, during, and after the completion of the event. The plan would adhere to the principles set forth in the LNT stewardship program and specify that exceptional damage due to use and day-of-event conditions is addressed in adherence to the requirements under the special use permit. Park staff would review the plan as part of the permit approval process.

Trail Maintenance

Maintenance. Sustainable trails aim to require less maintenance and fewer resources to maintain their intended use. However, cyclic maintenance is still necessary to preserve the life of the trail tread and reduce costly major maintenance projects. The maintenance of trails should work to keep the original design of the trail and use sustainable techniques to respond to problem areas (IMBA 2023).

General maintenance. A level of general maintenance for each trail type and their respective trail class has been identified in Section 2. Trail Types and Reclassifications. General maintenance activities assist in providing a safe and consistent trail surface for visitors and minimizing long-term resource impacts. Specific maintenance activities should be developed that align with the designated trail type. General primary maintenance activities that would be conducted for all trails in the park would include the following:

- tread maintenance
- pruning
- pathway clearing
- clearing culverts
- replacing faded/missing trail signage

Staff from the Facilities Management and Science & Resource Management divisions would establish the conditions and practices for each maintenance activity. This collaborative approach ensures minimal impacts on specific park resources while maintaining a safe and sustainable trail. Levels and types of maintenance would also need to be determined in relation to NPS management systems for recurring and cyclic maintenance, preventive maintenance, component renewal, deferred maintenance, and operations.

An annual schedule is recommended for maintenance activities that would occur during a one-year seasonal cycle. The annual maintenance schedule would assist park managers in prioritizing areas of concern based upon use levels, the lifecycle of a trail, resource conditions, and park priorities and would identify priority tasks for the trail volunteer program.

Existing trail management. Beyond general trail maintenance, trails would need to be maintained to sustain their structural integrity and changes related to visitor use and park resource conditions. Tread conditions that include the degree of muddiness, drainage control,

erosion, and vegetation cover are structural condition factors that exist in the park. In addition, the structural integrity of trail features, such as bridges, drainage components, railings, and other trail facility structures, would need to be assessed and maintained over time. The maintenance of these structural elements of the park's trails would be conducted annually for drainage structures and reviewed every 2–5 years for other trail structural components and their conditions. Maintenance schedules would be predicated on the capacity of park operations, including park staffing and trail volunteers available to conduct the work.

- **Brushing.** On semi-primitive and primitive trails, the shoulders/corridor should be mowed minimally only as needed, but on high-use trails, more often as needed. On all trail types, the corridor should be trimmed of branches following the criteria for each trail type set forth in section 2 of these guidelines. Tree trimming should be done so that branches are cut flush with the main branch or trunk of the tree.

- **Tread surface maintenance**

    - *Aggregate tread maintenance* — The trail may need to be graded in spring or fall and should be done when the surface is wet. This maintenance can help direct the flow of water to avoid erosion and repair normal wear of the surface. After grading, the trail should be recompacted to reduce the migration of material. If the surface becomes loose and aggregate material is starting to migrate due to use or erosion, reshaping and compacting the trail to maintain its integrity would be necessary. Staff should take care to avoid "trail creep" that results from aggregate being fanned out during any regrading. Staff may need to add material to fill holes and shape properly. Applying water to the trail before compacting would enhance the rate of compaction on cohesive soils like clay and help protect against the intrusion of water in the future. For non-cohesive materials such as sand or gravel, apply mechanical force rather than applying water to support compaction.

    - *Natural surface maintenance* —Maintaining at least a 2% cross-slope to keep water from resting on the trail is important. Regrading and shaping this slope may be occasionally necessary along portions of the trail.

- **Trail structure maintenance**. Repair broken planks, protruding screws or nails, railings, surface, and check for structural damage. Bridges should be checked during regular maintenance and repaired promptly if issues arise.

- **Trail drainage maintenance – culverts.** Clean debris from culverts and swales on both ends of the culvert at least once per year or as needed.

- **Trail signage maintenance.** Repair broken planks, protruding screws or nails, railings, and surfaces, and check for structural damage. Replace, as necessary.

- **Maintenance for accessibility.** Addressing routine maintenance on tread surfacing and vegetation trimming ensures that trails do not create additional hazards and obstacles for accessibility.

Trail Monitoring

Monitoring trail conditions and their response to changes in natural conditions, visitor use, or operational issues is an important management tool for maintaining the park's trail system. Monitoring methods have been identified in Appendix A: Indicators, Thresholds, and Objectives, and two indicator topics are especially applicable to the physical aspects of trails: trail cross-sectional area and trail maintenance costs.

Trail conditions. The continued assessment of trail conditions is a critical activity to meet the sustainability goals of trails set by the general guiding principles of these guidelines and the goals and objectives of the trail management plan.

Please refer to appendix A for additional clarification, rationale, and monitoring and management strategies related to trail monitoring.

APPENDIX D: SITE PLANS

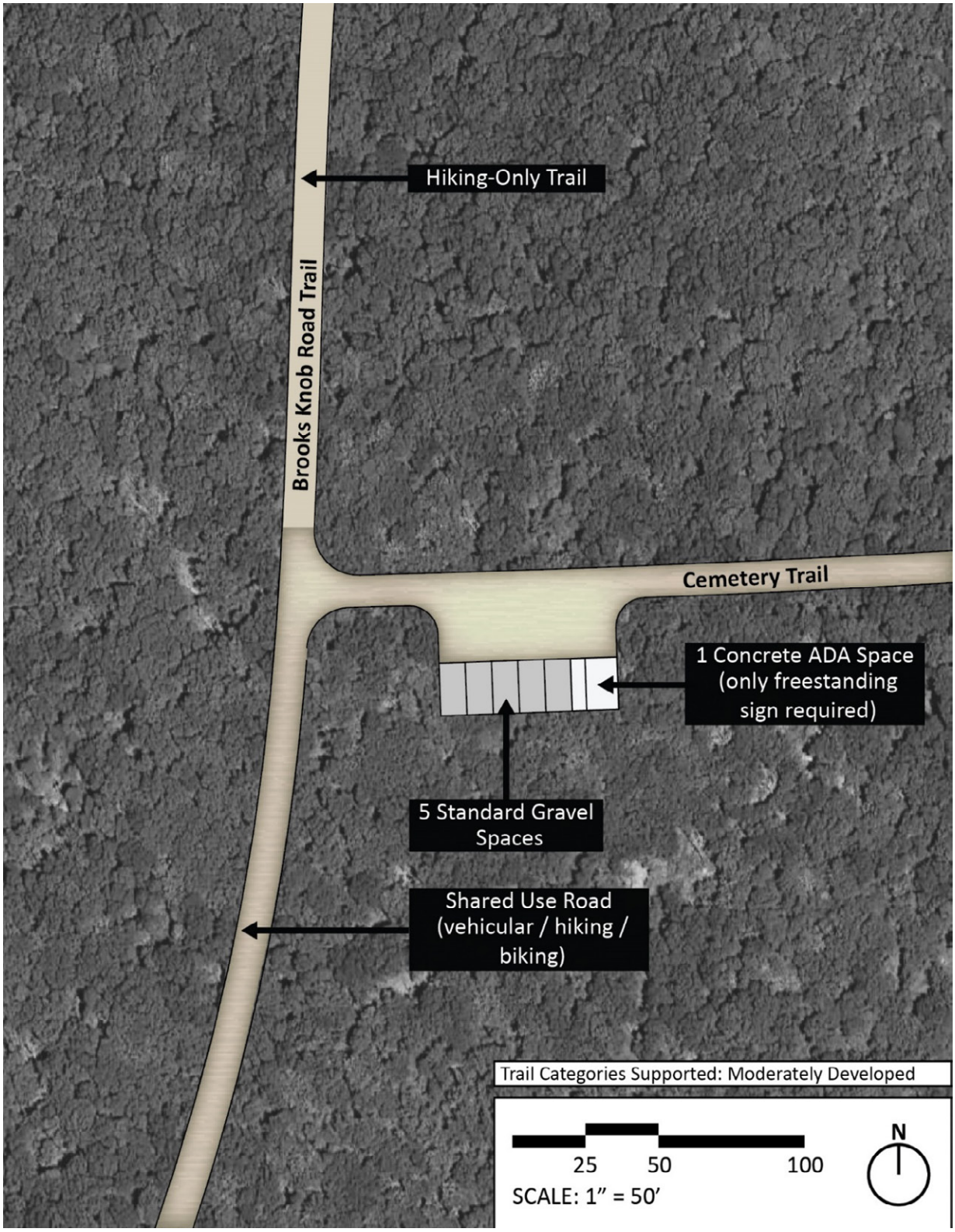

FIGURE D-1. BROOKS KNOB ROAD

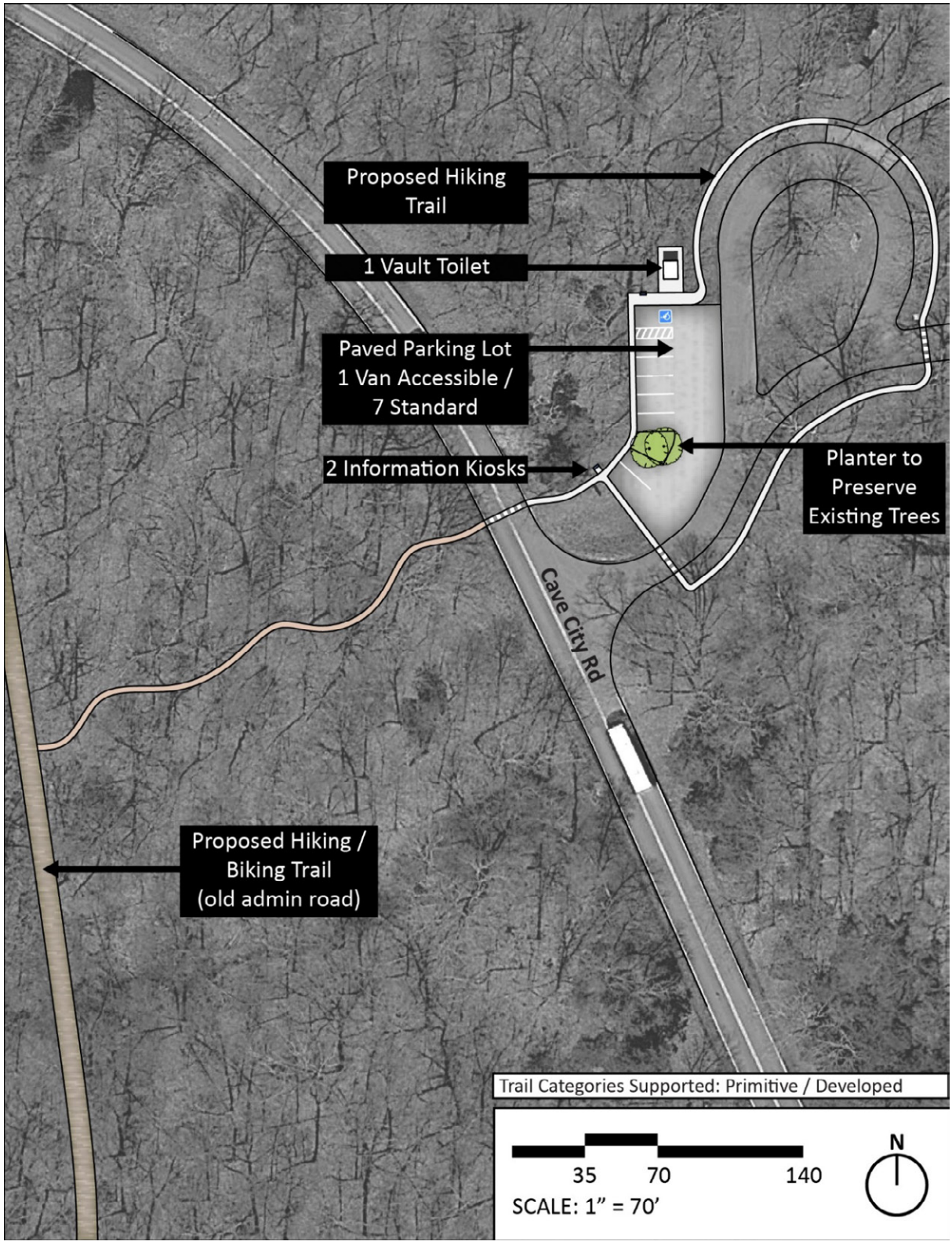

FIGURE D-2. HUNTS SINK

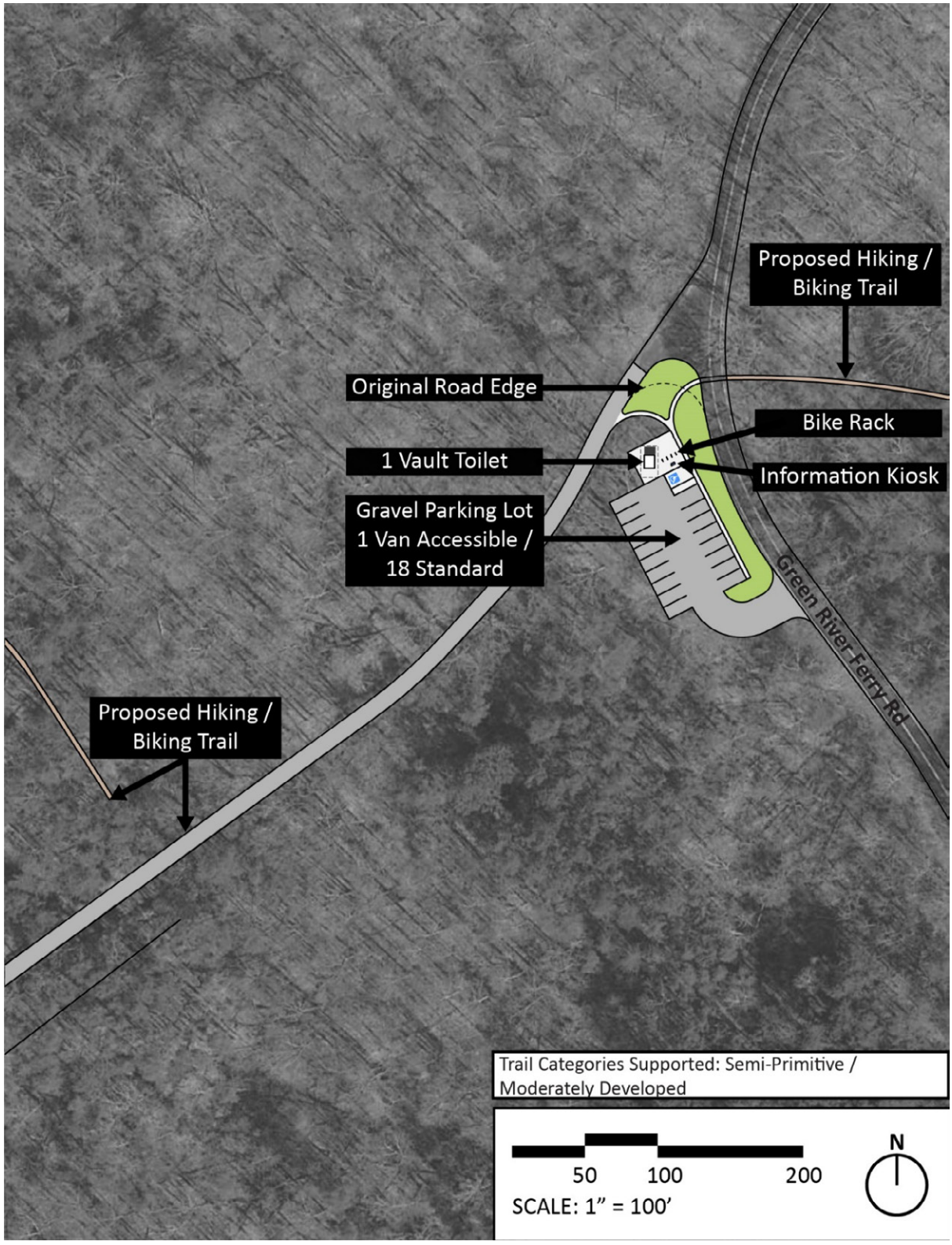

FIGURE D-3. SUGAR SINK – OPTION A

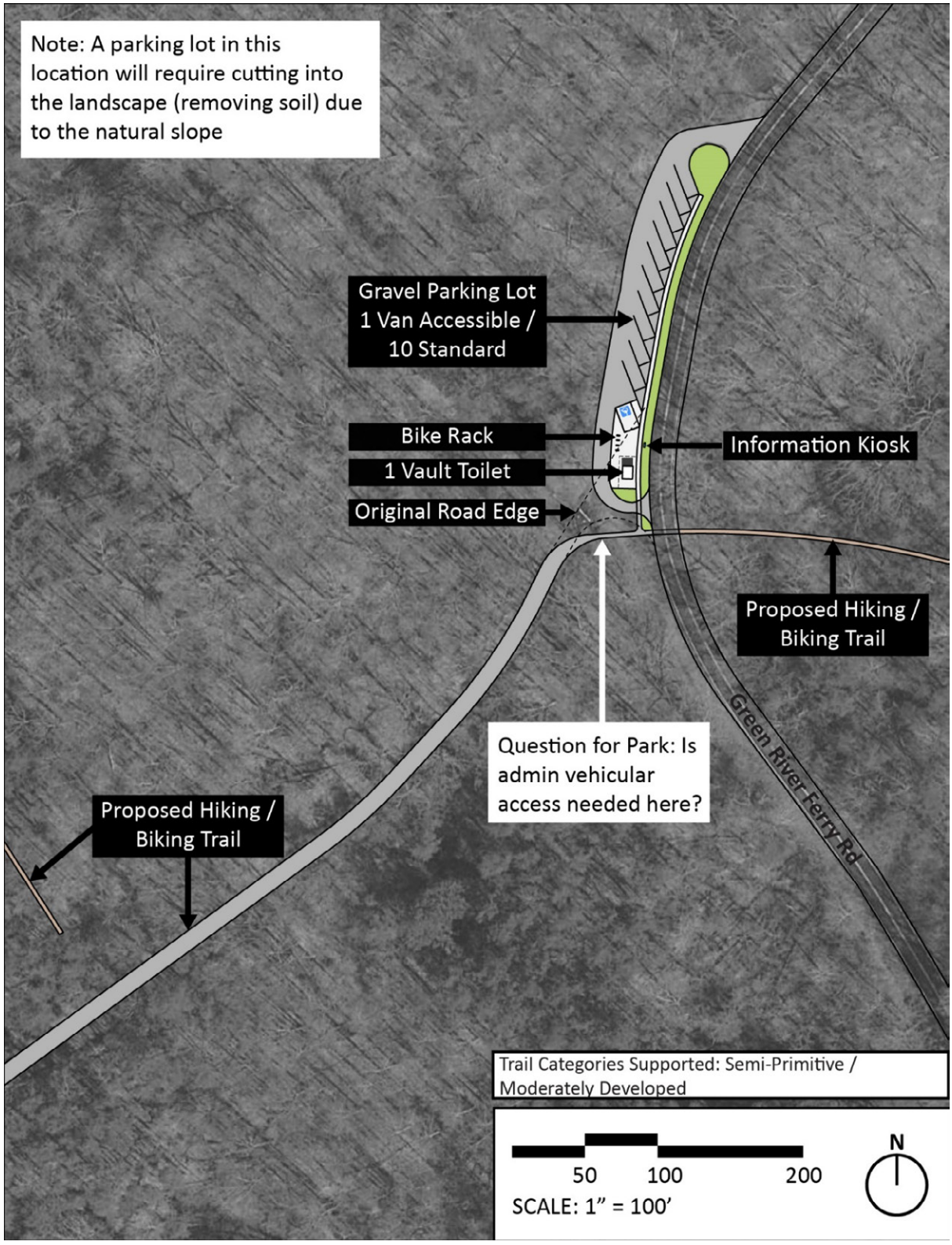

FIGURE D-4. SUGAR SINK – OPTION B

APPENDIX E: RELATED PLANNING EFFORTS

The following select planning efforts are related to this plan and helped inform its development.

DENNISON FERRY DESIGN CONCEPT PLAN / ENVIRONMENTAL ASSESSMENT, IN PROGRESS

The "Dennison Ferry Design Concept Plan" (in pre-NEPA stage and not yet implemented) addresses a new ramp, parking lot improvements, road improvements, and safety at the park's most popular boat ramp. The planning process is anticipated to be completed in 2025. While the plan addresses parking, safety and infrastructure, this trails plan specifies parking, includes trail connectivity to the Dennison Ferry site, and establishes visitor capacities at the Dennison Ferry and other river access locations. The proposed action described in this trails plan accounts for the Dennison Ferry site development project.

PARK ENTRANCE SIGNS, IN PROGRESS

Park staff are currently working on installing welcome/entrance signs, with parking at three different locations, to match the style and experience at the parkway entrance from exit 48 on Interstate 65, where visitors may stop and take photos. This work would occur at Green River Ferry Road north entrance, the Chaumont entrance, and the Cedar Sink entrance to Mammoth Cave National Park.

HOUCHIN FERRY SITE DEVELOPMENT CONCEPT PLAN / ENVIRONMENTAL ASSESSMENT, 2020

The Houchin Ferry site development concept plan addresses the Houchin Ferry site's deficient facilities and reestablishes safe river access through parking improvements and a newly designed ramp extension, includes an emergency boat launch, and adds a new overlook with an approach trail through its 2020 finding of no significant impact decision document for the environmental assessment. The plan also includes a pedestrian suspension bridge over the Green River to connect recreational facilities and trails on the south and north sides of the river. Funding for the project improvements has been requested but not approved to date; however, the ramp extension is planned for implementation by 2025. The proposed action described in this trails plan accounts for the direction outlined in the Houchin Ferry site development project selected alternative. This plan is available at https://parkplanning.nps.gov/documentsList.cfm?projectID=70636.

CAVE AND KARST MANAGEMENT PLAN / ENVIRONMENTAL ASSESSMENT, 2019

The cave and karst management plan provides a consistent framework for managing the world-class cave and karst resources in the park through its 2019 finding of no significant impact decision document for the environmental assessment. The plan provides direction to protect and conserve all 450 caves in the park and its entire karst groundwater system through the use of science to promote stewardship and understanding. The cave and karst management plan is

complementary to this trail management plan, as it focuses on the subterranean resources of the park, while the trail management plan is focused on aboveground resources and facilities.

MAMMOTH CAVE NATIONAL PARK FOUNDATION DOCUMENT, 2014

The foundation document provides basic guidance for planning and management decisions—a foundation for planning and management. The core components of a foundation document include a brief description of the park and the park's purpose, significance, fundamental resources and values, and interpretive themes. The foundation document also includes special mandates and administrative commitments, an assessment of planning and data needs that identifies planning issues, planning products to be developed, and the associated studies and data required for park planning. Along with the core components, the assessment provides a focus for park planning activities and establishes a baseline from which planning documents are developed. The foundation document is available at https://www.nps.gov/maca/learn/management/upload/MACA_FD_2014_508.pdf.

GREEN RIVER FERRY IMPROVEMENT PROJECT ENVIRONMENTAL ASSESSMENT, 2011

The Green River Ferry improvement project addresses ferry rehabilitation with the addition of an upstream canoe ramp, parking lot improvements, and Echo River Spring trail improvements. The actions of this plan were implemented and serve as an example for the other ferry sites for providing safe and enjoyable river access to visitors. The proposed action described in this trails plan accounts for the Green River Ferry site development project.

REHABILITATE CAVE TOUR TRAILS PLAN / ENVIRONMENTAL ASSESSMENT, 2010

This project proposed the reconstruction of existing cave trails to improve safety, durability and the protection of natural and cultural resources through its 2010 finding of no significant impact decision document for the environmental assessment. Similar to the cave and karst management plan, it is a complement to this trail management plan, as it focuses on subterranean resources. This plan is available at https://parkplanning.nps.gov/documentsList.cfm?projectID=17838.

COMPREHENSIVE TRAIL MANAGEMENT PLAN / ENVIRONMENTAL ASSESSMENT, 2008

The comprehensive trail management plan sets the direction for a new loop trail for biking and hiking through its 2008 finding of no significant impact decision document for the environmental assessment. This popular biking and hiking trail is now known as the 9.1-mile Big Hollow Trail, which was maintained in partnership with the Kentucky Mountain Bike Association. This plan is available at https://parkplanning.nps.gov/documentsList.cfm?projectID=17179.

GENERAL MANAGEMENT PLAN / ENVIRONMENTAL IMPACT STATEMENT, 1983

The general management plan provides long-term direction for park resource preservation and visitor use through its 1983 record of decision document for the environmental impact statement. Management zones and their desired conditions provide guidance on ensuring that resources are passed on unimpaired to future generations and visitor experiences remain high quality. This trails plan project area primarily occurs in the natural zone. For zone descriptions, see the 1983 general management plan at https://www.nps.gov/maca/learn/management/upload/MACA-General-Management-Plan-WebVersion.pdf.

APPENDIX F: IMPACT TOPICS DISMISSED FROM FURTHER ANALYSIS

The following impact topics are not analyzed because they do not exist in the project area; would not be affected by the proposal or the likelihood of impacts are not reasonably expected; through the application of mitigation measures, there would be no potential for significant effects; and/or comments from the public or agencies did not warrant retaining these topics for analysis.

DARK NIGHT SKY

National Park Service *Management Policies 2006* codifies that "the Service will preserve, to the greatest extent possible, the natural lightscapes of parks, which are natural resources and values that exist in the absence of human-caused light" (NPS 2006a). Most of Mammoth Cave National Park has a class 4 rating on the Bortle Scale, as well as consistent Unihedron Sky Quality Meter readings over 21.0, which qualifies it for Silver Tier Status from the DarkSky International for "exemplary nighttime landscapes" (Groves et al. 2021). The park was certified as an International Dark Sky Park by DarkSky International in 2021 and has worked collaboratively with local campgrounds and the nearby Town of Park City, Kentucky, just south of the park, which is preparing its own application to become a Dark Sky City (Groves et al. 2021). The park's dark sky quality is in good condition and the National Park Service does not anticipate any actions proposed in this plan to impact the park's exceptional dark night sky given mitigations through dark sky-friendly design, such as limiting the use of artificial lighting to areas where needed, using minimal-impact lighting techniques, and shielding the use of artificial light. Therefore, dark night sky was dismissed as an impact topic.

PALEONTOLOGY

National Park Service *Management Policies 2006* codifies that "paleontological resources, including both organic and mineralized remains in body or trace form, will be protected, preserved, and managed for public education, interpretation, and scientific research" (NPS 2006a). Paleontological resources identified in the park include marine invertebrate fossils, shark and plant remains, and guano and bones associated with prehistoric and historic bat roosts (NPS 2011b). The majority of all paleontological resources in the park are below the surface. Fossils may also exist within the surface layers, such as the Mississippian shales of the Illinois Basin and other Mississippian units, which contain faunal species, including crinoids, foraminifera, and ostracods, as well as Lepidodendron tree trunks (NPS 2011). No known paleontological sites exist near any proposed trail alignments. If paleontological resources are identified in the final trail alignment, the resources would be collected and documented and/or trails would be rerouted to protect associated resources. Therefore, paleontological resources was dismissed as an impact topic.

SOUNDSCAPES

National Park Service *Management Policies 2006* codifies that "the Service will restore to the natural condition wherever possible those park soundscapes that have become degraded by

unnatural sounds (noise) and will protect natural soundscapes from unacceptable impacts" (NPS 2006a). The prominence of natural sounds at Mammoth Cave is high. The impact of human-caused sound sources across Mammoth Cave National Park in relation to the natural acoustic conditions is approximately 1 decibel above the natural ambient sounds level—a low number compared to parks throughout the national park system (NPS 2015a). New trail construction would likely have temporary impacts on the soundscape while construction activities occur, such as human-caused sounds from equipment, vehicular traffic, and trail crews. Any construction associated with implementing the action alternatives, such as hauling materials or operating equipment, could result in dissonant sounds, but such sounds would be localized and of short duration, typically less than a couple of weeks in any given spot. After the completion of construction, visitor trail use would begin. The presence of visitors on trails would have a negligible impact on natural soundscapes, as the sound of voices rarely carries for any significant distance, and no motorized use would be allowed on trails. Therefore, acoustic environment and soundscapes were dismissed as an impact topic.

ETHNOGRAPHIC RESOURCES

Ethnographic resources are traditional park sites, structures, objects, landscapes, and natural resource features that have significance due to their importance to the present way of life of members of a sociocultural group associated with the park. The ethnographic resources at Mammoth Cave National Park offer insights into the rich and varied legacy of human habitation in the area. Seven Tribal Nations are traditionally associated with Mammoth Cave National Park lands. The park is also home to several natural history societies that meet NPS criteria for designation as traditionally associated groups.

Ongoing consultation between Mammoth Cave National Park staff and Tribes would continue to take place to ensure that ethnographic resources or resources of significance would not be impacted by the preferred alternative. The proposed new trails or reroutes under the preferred alternative would not impact known ethnographic resources or impede the ability of Tribes or traditionally associated groups to use park lands for traditional purposes. Analyzing ethnographic resources cannot provide a meaningful difference between the alternatives; therefore, ethnographic resources was dismissed from further analysis.

WETLANDS

To comply with Executive Order 11990, "Protection of Wetlands," any facilities or construction would be designed to avoid adverse impacts associated with the destruction or modification of wetlands and to avoid direct or indirect support of new construction in wetlands wherever there is a practicable alternative. While wetlands are somewhat rare in the park, the park contains 17 high-quality wetlands, most of which are rare in the state (Groves et al. 2021). Thorough on-the-ground trail scoping has identified proposed trail alignments that would avoid traveling through wetlands. Impacts on wetlands would likely be fewer than 0.1 acres, given the limited area and the desire to avoid wetlands for long-term trail sustainability and financial and operational viability. If it were determined that impacts on wetlands would exceed 0.1 acres, then the National Park Service would conduct wetlands compensation and a wetlands statement of findings in accordance with Executive Order 11990 (NPS 2016). Some trails would require

minimal stream crossings, and the compliance for these crossings would be tiered and would occur in the future. Stream crossings would be designed in a manner to reduce any impacts on hydrology. Short-term temporary impacts on wetlands due to trail construction would be mitigated by adhering to the best management practices outlined in *NPS Procedural Manual #77-1: Wetland Protection*, such as properly maintaining appropriate erosion and siltation controls during ground disturbing activities. Therefore, wetlands was dismissed as an impact topic.

FLOODPLAINS

To comply with Executive Order 11988, "Floodplain Management," any facilities or construction would be designed to avoid adverse impacts associated with the occupancy and modification of floodplains and to avoid direct or indirect support of floodplain development wherever there is a practicable alternative. Floodplain forest makes up about 5% of the park, which provides habitat for a diversity of riparian species (Groves et al. 2021). The proposed riverbank camping would not involve building any infrastructure and would only designate certain areas as safe for primitive camping. For any trails along the riverbank, alignment would be selected to avoid impacts on the riverbank and ensure the long-term viability of the trail. Infrastructure at the river would be limited to signage for the new trail. The proposed actions are exempt as minor facilities in non-high hazard areas; therefore, the proposed action would not necessitate the need for a floodplains statement of findings per NPS policy. Short-term temporary impacts on floodplains due to construction would be mitigated by adhering to the best management practices, such as implementing seasonal closure, structural flood protection measures, and specific actions to minimize impacts on floodplain natural resource values, effective flood warning, and flood evacuation, as appropriate. Therefore, floodplains was dismissed as an impact topic.

THREATENED AND ENDANGERED SPECIES

The National Park Service accessed the most recent US Fish and Wildlife Service list of species that are listed and protected under the federal Endangered Species Act that may occur in the park (USFWS 2024) and the Mammoth Cave NPS species list (NPS 2023). The species considered but dismissed in this document are provided in table F-1.

Table F-1. Dismissed Federally Endangered, Threatened, and Candidate Species That May Occur in Mammoth Cave National Park (as of March 2024)

Common Name	Scientific Name	Federal Status	Potential for Species or Habitat in Planning Area	Proposed or Designated Critical Habitat Present in Planning Area
Bats				
Gray Bat	*Myotis grisescens*	E	Yes	No
Birds				
Whooping Crane	*Grus americana*	EXPN	No	No

Common Name	Scientific Name	Federal Status	Potential for Species or Habitat in Planning Area	Proposed or Designated Critical Habitat Present in Planning Area
Insects				
Monarch Butterfly	*Danaus plexippus*	C	Yes	No
Crustacean				
Kentucky Cave Shrimp	*Palaemonias ganteri*	E	Yes	CH
Fish				
Diamond Darter	*Crystallaria cincotta*	E	Yes	CH (unoccupied)

C = candidate; CH = critical habitat; E = endangered; EXPN = experimental population, nonessential

The Indiana bat, northern long-eared bat, and tricolored bat have been carried forward for analysis as an impact topic. In addition, all special status mussel species have been carried forward for analysis as an impact topic. The remaining species have been dismissed from detailed analysis for the following reasons.

Gray bats (E). The gray bat occupies a limited geographic limestone karst area of the southeastern United States and can be found in the project area at two cave locations. With rare exceptions, gray bats live in caves year-round and migrate seasonally between hibernating and maternity caves. During the winter, gray bats hibernate in deep, vertical caves. In the summer, they roost in caves located along rivers. Changes to vegetation aboveground are not anticipated to impact this species in a measurable way. Mitigation measures would be implemented to reduce impacts on bats overall, such as not disturbing bats found nesting, hibernating, estivating, or otherwise living in or immediately near the worksites, and resource management would be notified/consulted when wildlife must be disturbed or handled. Because the proposed action does not include any changes to its primary habitat of caves, the project is not likely to adversely affect the gray bat.

Whooping crane (EXPN). The proposed action is anticipated to have no impact on the species because it does not impact wetlands or larger streams that would be suitable habitat for whooping cranes. Whooping cranes have not been observed in the park. Because the proposed action does not include any changes to its primary habitat, the project is not likely to adversely impact whooping cranes.

Monarch butterfly (C). Monarch butterflies are known to occur in the project area. The park contains a diversity of milkweed, which serves as habitat for the species (Groves et al. 2021). Because milkweed is such a common species found in the park, the proposed action is not anticipated to have an impact on the monarch butterfly at the population level. Park staff would conduct site surveys before ground disturbance and confirm the location of milkweed or other habitat for this species. If any species of milkweed are identified in the survey, park staff would implement the mitigation measures, including minor reroutes to avoid any critical habitat. Therefore, the project is anticipated to have no effect on the monarch butterfly.

Kentucky cave shrimp (E). The entire known population of the Kentucky cave shrimp occurs only in streams in base-level passages in the cave system in the park. The Kentucky cave shrimp is currently known to inhabit two caves located north of the Green River. These tiny crustaceans feed on bacteria, protozoa, and other minute organisms that live on organic matter that wash into cave streams. The Kentucky cave shrimp, like other aquatic cave life, is vulnerable to the degradation of water quality in its habitat. Contamination of groundwater by siltation and chemicals from agricultural land, inadequate sewage treatment, excessive amounts of deposited manure, oil and gas development, and toxic spills could extinguish the species. The species' final critical habitat consists of a stream in a base-level cave passage characterized by abundant quantities of organic matter and sediments of coarse silt and very coarse-to-very fine sand (*Federal Register* 1983). Drainage from the area of the proposed new trail development can be presumed to reach some portion of the cave that may contain cave shrimp. The potential effects are primarily from runoff from sites during construction. Adequate controls would to be taken to prevent erosion and sedimentation. Any anticipated impacts on water quality are analyzed under that impact topic, and associated mitigation measures would be implemented to ensure water quality is not significantly impacted by the proposed action. For example, standard erosion control methods would be installed early in the construction period, which would reduce the chances of sediments or hazardous materials entering the groundwater from the sites. Therefore, the project is not likely to adversely affect the Kentucky cave shrimp.

Diamond darter (E) critical habitat. Unoccupied final critical habitat for the diamond darter is located in the project area. This project does not involve any changes to the bed of the river nor its flow. Further, this critical habitat is unoccupied, and the diamond darter is not known to occur in the project area. For these reasons, the project is anticipated to have no effect on the diamond darter nor its habitat.

VIEWSHED

At Mammoth Cave National Park, the topography and dense tree cover limits the vistas in the park. Several viewpoints along trails and roadway allow visitors to take in the vistas of the river valleys and hillsides. Under the preferred alternative, no new trails and facilities would be built in the vicinity of these existing overlooks. Visitors could continue to enjoy the views from these locations. In addition, several of the new trails established under the preferred alternative would provide access to new vistas that would expand on the existing opportunities to enjoy overlooks throughout the park. Additionally, trail construction related activities would be temporary and are not expected to have viewshed impacts. Since there are no adverse effects on the viewshed under the preferred alternative and impacts on viewsheds would likely be beneficial, this topic was dismissed from further analysis.

SOCIOECONOMICS

Since Mammoth Cave National Park was established in 1941, the tourism industry in the area has expanded to meet visitor demands. Much of this tourism industry is clustered around the Interstate 65 interchanges at the gateway communities of Horse Cave, Cave City, Park City, Brownsville, and Bowling Green. Within the broader visitor service area are three principal cities—Elizabethtown, Glasgow, and Bowling Green. The visitor service area includes more than

2,000 motel rooms, more than 7,500 campsites, and numerous tourist attractions, dining options, and retail centers.

Visitation and tourism to Mammoth Cave's gateway communities would not be substantively changed from current conditions, given the management strategies outlined in the plan. Some of the management strategies in the plan could affect when and where visitors recreate in the park (addressed in the visitor use and experience analysis) but would be unlikely to change how many people visit the area or their spending and travel habits. Accordingly, no meaningful change to the area's socioeconomic conditions, including the business opportunities, population, and demographics of the area, could be attributed to the strategies in the plan. If any impact were to occur, it would likely be beneficial due to potential employment opportunities associated with trail construction and maintenance and growth and improvement in hiking, biking, and equestrian opportunities that could attract more tourism to the area and associated economic activity. Any benefit would likely be small and difficult to measure in the context of the gateway communities and visitor service area. As there would be no noticeable difference in socioeconomic effects between alternatives 1 and 2, any further analysis of this topic would not influence the selection of an alternative. Based on a preliminary evaluation of impacts on this socioeconomic environment, it was determined that this impact topic could be dismissed from further analysis.

COMMERCIAL SERVICES

Existing commercial services opportunities associated with the park's trail system are CUA permits for canoe livery services, bike livery services, and guided horseback riding. Commercial use authorization permit holders base their business operations outside of the park and are authorized to conduct operations in the park. Canoe livery service providers rent canoes, kayaks, and related equipment to park visitors and shuttle their clients and gear between boat launches and takeouts in the park. Currently, there are three authorized commercial liveries. Similarly, bike livery services rent bikes and e-bikes to visitors and transport the bikes to locations in the park, primarily along the hike-and-bike trail. One concessioner, which bases their business operation inside the park, is authorized but not required to rent bikes.

For the canoe livery services, the plan's thresholds and visitor capacities allow for substantial growth in river use, including livery supported use, from current conditions. Therefore, there are no anticipated impacts on canoe livery services in the near future. However, if the boats per view threshold is approached in the future due to increasing use, the National Park Service may begin to "actively manage the amount, timing, and distribution of CUA livery-supported boats at all boat launches within the park boundary" (see appendix A). The initial impact of this action would likely be to cause the CUA permit holders to alter their operations to change the locations and timing of their dropoffs, which could impact the business opportunity. If the threshold continues to be exceeded, this action could affect the total volume of clients the CUA permit holders could serve. However, these changes in management would occur only after significant growth in business opportunity and with ample notice to the operators (by way of this planning document) that future change was possible. Furthermore, park staff would work with commercial operators and explore opportunities to update stipulations for CUA permit holders

to manage to desired conditions before taking action that may have further impacts. Therefore, the plan does not alter business prospects for the canoe livery services.

There are no immediate actions in the plan that would measurably impact the operations or business opportunity for bike livery services or guided horseback riding services. If anything, increased mileage of trails for equestrian and bike use and improved trailhead amenities would better support these operations. Due to the lack of impact on commercial services based on preliminary analysis, this impact was dismissed from further analysis.

ENVIRONMENTAL JUSTICE

Environmental justice was considered and dismissed from further analysis for the following reasons:

- While local residents include minority and low-income populations, these populations would not be disproportionately affected by activities associated with the construction or implementation of the alternatives.
- Implementing the alternatives would not result in any identifiable adverse human health effects. Therefore, there would be no direct or indirect adverse effects on any minority or low-income population.
- Implementing the alternatives would not result in any identified effects that would be specific to any minority or low-income community.

APPENDIX G: ACTIONS CONSIDERED BUT DISMISSED

While developing alternatives, it became clear that some proposed alternatives and actions did not need to be further analyzed. Certain alternatives can sometimes be considered but eliminated from further study for a variety of reasons listed in the NPS Director's Order 12 Handbook. The following actions were considered but dismissed from further consideration:

- **Addition of a parking lot near Big Hollow South Trail Loop.** While there is a need for parking to allow visitors to access the Big Hollow Trail loops (north and south), the topography near the Big Hollow South Trail Loop wouldn't allow enough room to adequately build a long-term parking lot at this location and was therefore dismissed. Instead, this plan proposes to build a trailhead with parking at the Big Hollow North Trail Loop, in alignment with the past trails plan (NPS 2008).

- **Expansion of the Big Hollow Trail to the east.** While there is a need to extend opportunities on the Big Hollow Trail network, building additional trails to the east of Big Hollow is not feasible due to sensitive resource concerns and was therefore dismissed. Instead, this plan proposes to build an additional trail loop north of the Big Hollow network named Sugar Sink loop.

- **Widening of the bike-and hike-trail connections**. Some members of the public advocated for 4-foot-wide trail connectors coming off the bike-and-hike trail to connect to other trails. However, the planning team identified this area as a prime location to expand the park's primitive trail network—expanding opportunities for an experience that is currently rare in the park. Several 4-foot-wide moderately developed trail opportunities are identified in other areas of the park.

- **Addition of a perimeter trail.** Several trail options were considered to provide longer distance opportunities for recreation. Building a trail along the entire perimeter of the park (following the park boundary) was determined to be infeasible. A perimeter trail would be infeasible due to its complexities associated with building and maintaining the trail, including the infrastructure needs and resource impacts associated with crossing the river and was therefore dismissed.

- **Addition of a trail from Houchin Ferry heading east.** One of the many trails considered by the planning team, this trail was dismissed because there are topographical restrictions, the area floods often and would pose maintenance challenges, and it would negatively impact the wetlands in that area.

- **Addition of a trail from Houchin Ferry heading west.** This trail was dismissed because it would lead to sensitive resources of concern.

- **Horse access south of the river.** Park staff are committed to improving the existing horse trails north of the river to ensure they are sustainable into the future and provide enjoyable riding experiences for visitors. Concentrating horse use to the trails north of the river is necessary to protect the park's fragile cave resources and water quality. Opening up trails south of the river to horse use was therefore dismissed.

- **Addition of regional connector trails.** A number of trails connecting local communities to one another were considered as part of this plan. While the National Park Service supports connections in the greater region, the bureau does not have jurisdiction on land anywhere outside of the park's boundary. Park managers are open to continuing working with the neighboring communities to explore feasible trail routes into the park to align with the trails in the park.
- **Trail connection from First Creek to McCoy Hollow.** This trail was dismissed because it is not viable for resource protection. Instead, a connection from Wet Prong Trail to McCoy Hollow Trail is included in this plan.
- **Addition of a trail parallel to Houchin Ferry Road.** This trail was dismissed because it would be unsustainable to create a trail parallel to the existing road. Instead, horse access would be permitted on Houchin Ferry Road once the special regulation is approved.

APPENDIX H: ACCESSIBILITY

LEGAL REQUIREMENTS

Accessibility is both a civil right, enshrined in federal laws, regulations, and standards, and a health and safety concern for people with disabilities. Inaccessible facilities, programs, services, and activities put people with disabilities at risk and expose the National Park Service to complaints and lawsuits. The National Park Service must ensure that it is providing access to park programs, including hiking and paddling access on land and water trails in an equitable manner.

The Architectural Barriers Act (ABA) became law in 1968. The act requires all buildings or facilities designed, built, or altered with federal funds, or leased by federal agencies, be accessible to people with disabilities. The Rehabilitation Act became law in 1973, and section 504 of this act applies to programs and activities that are conducted by federal agencies and by entities that receive funding from, or operate under a permit from federal agencies. Section 504 requires that these programs and activities provide an equal opportunity for individuals with disabilities to participate in an integrated setting as independently as possible.

The Americans with Disabilities Act became law in 1990. Except for title V, section 508(c), this act does not apply to federal agencies' facilities and programs. Federal agencies were already required to be accessible under the act and section 504 of the Rehabilitation Act before it became law. The Americans with Disabilities Act applies to state and local government services, to public accommodations such as motels and hotels, and to organizations that are open to the public. Title V, section 508(c) of the Americans with Disabilities Act applies to federal wilderness areas. It reaffirms the 1964 Wilderness Act and clarifies that agencies aren't required to change the character of wilderness areas to provide accessibility. Section 508(c) also defines a wheelchair and states that wheelchairs meeting that definition may be used in federal wilderness areas.

ACCESSIBILITY CODES, STANDARDS, AND GUIDELINES

To ensure that facilities and services are being provided in an accessible manner, entities follow sets of codes, standards, and guidelines that define the minimum legal requirements. As of May 2023, the National Park Service has adopted the International Code Council (ICC) family of codes to provide standards and guidance for the compliance of buildings and sites. Prior to the adoption of ICC standards, the National Park Service used the Architectural Barriers Act Accessibility Standards (ABAAS) to inform minimum requirements for accessible design. Although the International Code Council will take precedent over ABAAS in most instances, ABAAS still serves as the primary source of guidance for outdoor developed areas which includes outdoor facilities, including trails, campgrounds, picnic areas, and outdoor recreation access routes, among others. The International Code Council and ABAAS should be referenced in the design and construction of all new and modified facilities.

UNIVERSAL DESIGN

As explained above, accessibility codes and standards provide the National Park Service with minimum requirements. The ideal way to integrate accessibility is to use the principles of universal design. Universal design is the design of programs and facilities that are usable by all people, to the greatest extent possible without separate or segregated access for people with disabilities. A facility built on universal design principles makes it possible for a whole group to enjoy the same experience. Directors Order 42: *Accessibility for Visitors with Disabilities* includes universal design principles as an accessibility requirement, in that all new and reconstructed facilities, programs, and associated elements are to be accessible to the greatest extent possible. This commitment often exceeds the minimum requirements of accessibility codes and standards. The result of universal design is independence, integration, and dignity for everyone.

PROGRAM ACCESSIBILITY

For the purposes of evaluating accessibility, a "program" is an activity in which people may participate. Essentially, the program is the reason a person visits an area and may include opportunities such as hiking on a trail, camping in a campground, viewing the scenery at an overlook, paddling on a river, enjoying solitude in the wilderness, or gathering information at a visitor center. All facilities need to be constructed according to the applicable accessibility standards. Even historic structures are required to be as accessible, as can be accomplished without destroying the historic significance of the structure. If a facility is not accessible and cannot reasonably be made accessible, the program should be relocated or provided in another manner by use of an accessible programmatic alternative.

ACCESSIBLE PROGRAMMATIC ALTERNATIVES

If physical access to programs is not possible, programmatic alternatives can be provided. An alternative program must allow everyone to participate together. Separate segregated programs just for people with disabilities aren't permitted. For example, if an evening program at a campground previously has been held in an amphitheater that isn't accessible, the program should be moved to an accessible location until the amphitheater is accessible. Under section 504 of the Rehabilitation Act, access to programs that don't depend on constructed facilities are also required to provide equal opportunity to all. People with disabilities may not be denied the opportunity to participate in a program if they meet the criteria to participate and their participation doesn't fundamentally alter the program. While all people are to have an equal opportunity to participate in programs and to strive to gain the same benefits offered by those programs, no guarantee of success is required.

ACCESSIBILITY OF SUPPORTING FACILITIES

All modified and newly constructed facilities, including parking areas, restrooms, routes, campgrounds, and river launches, and takeouts, will need to meet accessibility standards as outlined in ABAAS and ICC Standards. Park managers should strive to make these supporting facilities accessible, regardless of the accessibility of the trails they are serving.

Technical analysis completed on previous efforts determined that the high fluctuation of water levels on the Green River and Nolin River would not allow for the constructability of accessible river launches and take outs. There are multiple models of commercially available accessible paddling launches on the market today, and it is recommended that park managers continue to explore ways of providing accessible and safe means of physical access to the river and explore accessible programmatic alternatives using virtual or multimedia river tours.

TRAIL INFORMATION: TRAILHEAD SIGNAGE AND WEB CONTENT

All trail users need trail information to make informed decisions. For example, hikers want to know which trail is most appropriate for the amount of time they have available, the people in their group, and the type of hike that best suits their needs or desires. Information about the accessibility of a trail enables people with disabilities to decide whether the characteristics of the trail are suited to their abilities. When this information is available on websites and in printed materials, it allows all trail users, including people with disabilities, to understand the possible challenges of the trail before arriving at the trailhead.

The new trail information signs must include the following information:

- length of the trail or trail segment
- type of trail surface
- typical and minimum trail tread width
- typical and maximum trail grade
- typical and maximum trail cross slope

Signs can provide additional information to help people with disabilities decide whether or not to attempt a trail. For example, information about the height of any major obstacles, such as boulders in the trail tread, can help people determine if they can overcome these barriers. Having a caution notice indicating that the International Symbol of Accessibility is helpful. The International Symbol of Accessibility is not required or encouraged on trail information signs. Posted information reflects the condition of the trail when it was constructed or assessed and on what date the information was current. Because conditions in the outdoors are subject to change, knowing when an assessment was made is also helpful.

RELEVANT TECHNICAL REQUIREMENTS FOR TRAIL DESIGN

The following section briefly describes the primary technical requirements most relevant to trail planning, as found in ABAAS and supplemental guidance. Additional requirements and guidance can be found in ABAAS 1017 related to passing spaces, resting intervals, protracting objects, openings, and other provisions that will be more relevant to design considerations.

Clear Tread Width

The clear tread width of trails must be a minimum of 36 inches. The 36-inch-minimum clear tread width must be maintained for the entire distance of the trail and may not be reduced by gates, barriers, or other obstacles unless a condition for exception does not permit full compliance with the provision.

Running Slope

Running slope, also referred to as grade, is the lengthwise slope of a trail, parallel to the direction of travel. Trails or trail segments of any length may be constructed with running slopes up to 1:20 (5%). To accommodate steep terrain, trails may be designed with shorter segments that have a running slope and length, as shown in table H-1, with resting intervals at the top and bottom of each segment.

Table H-1. Maximum Running Slope and Segment Length

Running Slope Steeper Than	But Not Steeper Than	Maximum Length of Segment
1:20 (5%)	1:12 (8.33%)	200 feet
1:12 (8.33%)	1:10 (10%)	30 feet
1:10 (10%)	1:8 (12%)	10 feet

Cross Slope

Cross slope is the side-to-side slope of the surface of a trail. Some cross slope is necessary to provide drainage and to keep water from ponding and damaging the trail surface, especially on unpaved or natural surfaces. When the trail surface is constructed of concrete, asphalt, or boards, the cross slope must be no steeper than 1:48 (2%). When the trail surface is constructed of materials other than concrete, asphalt, or boards, cross slopes no steeper than 1:20 (5%) are allowed when necessary for drainage.

Surface

The surfaces of trails, passing spaces, and resting intervals must be firm and stable. A firm trail surface resists deformation by indentations. A stable trail surface is not permanently affected by expected weather conditions and can sustain normal wear and tear from the expected uses between planned maintenances. Paving with concrete or asphalt may be appropriate for highly developed areas. For less-developed areas, crushed stone, fine crusher rejects, packed soil, soil stabilizers, and other natural materials may provide a firm and stable surface. Natural materials also can be combined with synthetic bonding materials to provide greater stability and firmness. These materials may not be suitable for every trail.

CONDITIONS FOR EXCEPTIONS

The Architectural Barriers Act Accessibility Standards recognize the existence of constraints and limitations in the outdoor environment and allow for exceptions from specific provisions in the technical requirements where certain circumstances, referred to as “conditions for exceptions,” apply. When an entity determines that any of the conditions for exceptions do not permit full compliance with a specific provision in the technical requirements, compliance with that provision is required to the extent practicable. The phrase “to the extent practicable” means reasonably doable under the circumstances. The conditions for exceptions should be used only after all other design options are thoroughly explored. Where a condition for exception applies to only part of a trail, the rest of the trail must comply with all the technical requirements. The

following section describes the four conditions for exceptions and provide examples of situations where they might apply.

1. **Compliance is not practicable due to terrain.**

   The phrase "not practicable" means not reasonably doable. For example, where a trail is constructed in a steeply sloped area, compliance with the running slope provision may not be practicable on parts of the trail where it would require extensive cuts or fills that are difficult to construct and maintain, cause drainage and erosion problems, significantly lengthen the trail, and create other adverse environmental impacts.

2. **Compliance cannot be accomplished with the prevailing construction practices.**

   This condition does not require the use of construction equipment or methods other than those typically used in a particular type of setting. For example, where hand tools would normally be used to construct a trail to minimize the impact on a sensitive adjacent stream and the prevailing construction practices for this type of setting do not include blasting, blasting does not have to be used to remove a rock outcrop to comply with the clear tread width provision. Compliance with the clear tread width provision is required to the extent that it can be accomplished using hand tools. Prevailing construction practices are those used by most contractors or designers faced with the same or similar projects in the area. Preferences or practices used by a single contractor or designer are not necessarily prevailing construction practices.

3. **Compliance would fundamentally alter the function or purpose of the facility or the setting.**

   This condition recognizes that public lands provide a wide variety of recreational experiences, from highly developed areas to wilderness areas that appear unchanged from primeval times and provide opportunities for people to experience primitive and challenging conditions. The condition applies where compliance with specific provisions in the technical requirements would fundamentally alter the function or purpose of the facility or the setting. For example, people using primitive trails experience the outdoor environment in a nearly natural state, with limited or no development. The use of manufactured building materials or engineered construction techniques to comply with specific provisions in the technical requirements for trails could fundamentally alter the natural or undeveloped nature of the setting and change the recreational experience. Trails that are intended to provide a rugged experience, such as a cross-country training trail with a steep grade, a fitness challenge course with abrupt and severe changes in elevation, and a trail that traverses boulders and rock outcroppings to provide users with the opportunity to climb the rocks, are other examples. To remove the obstacles on these trails or to reroute the trails around the obstacles would fundamentally alter the function or purpose of the trails.

4. **Compliance is limited or precluded by any of the following laws or by decisions or opinions issued or agreements executed pursuant to any of the following laws: Endangered Species Act; National Environmental Policy Act; National Historic Preservation Act; Wilderness Act; or other federal, state, or local law, the purpose**

of which is to preserve threatened or endangered species; the environment; or archeological, cultural, historical, or other significant natural features.

The laws specified in this condition prescribe certain activities or require certain analyses to be prepared or procedures to be followed when planning projects that may impact features protected under the laws. The condition does not require full compliance with a specific provision in the technical requirements where compliance is limited or precluded by the laws or by decisions or opinions issued or agreements executed pursuant to the law

APPLYING AND DOCUMENTING EXCEPTIONS

When a condition for exceptions does not permit full compliance with a specific provision in the technical requirements on a portion of a trail, that portion of the trail must comply with the specific provision to the extent practicable. When extreme or numerous conditions for exceptions make it impracticable to construct a trail that complies with the technical requirements, the entire trail can be exempted from complying with the technical requirements. An entire trail can be exempted from the technical requirements only after applying the conditions for exceptions to portions of the trail. When determining whether to exempt an entire trail from the technical requirements, consider the portions of the trail that can and cannot comply with the specific provisions in the technical requirements and the extent of compliance where full compliance cannot be achieved.

Documentation of the basis for exceptions is required when a condition for an exception prohibits full compliance with technical requirements on a portion of a trail. Recording and retaining documentation of determinations of the basis for exceptions for any outdoor recreation feature is a good practice. These records may become valuable accounts of decisions and rationale when future changes are required or the public inquiries about conditions. When work necessary to meet the technical requirements would directly or indirectly substantially harm the protected aspect, document the reason for the determination and then apply the exception. The documentation also may need to be included in the analysis or procedure records if required by specific laws. An explanation of the condition that resulted in the determination that full compliance could not be achieved, the date the decision was made, and the name of the individuals who made the decision must be recorded, and the documentation must be retained with the records for the construction or alteration project.

Documentation is especially important for exceptions taken due to condition 4. Federal laws and applicable state or local laws specified in condition 4 prescribe certain activities or require certain analyses or procedures be followed when planning to construct or alter facilities that may affect the cultural, historic, or natural features or species protected by that law.

APPENDIX I: MITIGATION MEASURES APPLIED TO ALTERNATIVE 2 (NPS PREFERRED ALTERNATIVE)

Congress has charged the National Park Service with managing the lands under its stewardship "in such manner and by such means as will leave them unimpaired for the enjoyment of future generations" (NPS Organic Act, 16 USC 1). As a result, the National Park Service routinely evaluates and implements mitigation measures whenever conditions occur that could adversely affect the sustainability of national park system resources.

To ensure that implementation of the plan protects natural and cultural resources unimpaired for future generations and provides for a high-quality visitor experience, a consistent set of mitigation measures and best management practices that align with federal regulations and NPS *Management Polices 2006* would be applied to the preferred alternative as follows.

GENERAL

- According to NPS *Management Policies 2006*, for all trail construction activities, park staff would strive to apply sustainable practices to minimize potential environmental impacts. New or rerouted trails would not compete with or dominate park features or interfere with natural processes, such as the seasonal migration of wildlife, forest regeneration, hydrologic activity, and geological processes. All trail work would emphasize environmentally sensitive construction, use of nontoxic materials, resource conservation, and recycling.

- In areas where additional improvements to infrastructure are necessary, existing trailheads and previously disturbed areas would be used where practicable to avoid or minimize new impacts on natural and cultural resources in the park.

- Resource management staff would provide all contractor employees and volunteer trail crews with information that would appraise them of and sensitize them to relevant natural resource issues and the importance of minimizing impacts. This information could be shared in person, via contract language, or as part of an informational package. Trail crews would be educated about the importance of avoiding impacts on sensitive resources that have been flagged for avoidance, which may include natural and cultural resources. Resource Management division staff would be notified and consulted when wildlife must be disturbed or handled.

- Construction zones for rerouted and new trails, as well as staging areas and work zones, would be identified and demarcated with construction tape or some similar barrier before any construction activities begin. The tape would define the zones and confine the activity to the minimum area needed for the trail work. No disturbance would occur beyond these limits other than protection measures for erosion/sediment control.

- All tools, equipment, surplus materials, and rubbish would be removed from the project area upon project completion. Construction debris would be hauled from the park to an appropriate disposal location.

- Signs or other means would be used to protect sensitive resources on or adjacent to trails and destinations.
- Visitors would be informed of the importance of protecting the park's natural resources and leaving these undisturbed for the enjoyment of future generations. Leave No Trace and Tread Lightly! materials would be posted at the visitor centers and online and distributed as appropriate. Leave No Trace educational materials would be developed to remind visitors to the Green and Nolin Rivers not to disturb the mussels, dispose of waste properly, and give the mussels space while recreating.
- Impervious surfaces would not be used on trails except where necessary to ensure the long-term durability of the trail.
- Park staff would install gates at caves and around springs as conditions warrant it to be necessary to preserve natural resources and visitor safety.

VISITOR SAFETY

- Construction activities would be scheduled to minimize construction-related impacts on visitors. Areas not under construction would remain accessible to visitors as much as is safely possible.
- The National Park Service would implement measures to reduce the adverse effects of construction on visitor safety. Measures may include, but are not limited to, noise abatement, visual screening, and directional signs that aid visitors in avoiding construction activities.
- Per NPS standards, NPS trail crews would coordinate and supervise any trail construction or maintenance. Specifically, the National Park Service would monitor and/or direct placing the water bar; placing drainage; brushing and clearing; revegetating; identifying where to obtain fill and other materials for trails; and determining how to apply fill materials such as soil, gravel, and rocks. The park's sustainable trail guidelines (see appendix C) will guide trail construction and maintenance.
- To minimize the amount of ground disturbance, to the extent possible, staging areas would be in previously disturbed areas, away from visitor use areas. All staging and stockpiling areas would use existing disturbed lands to the extent possible and be rehabilitated to natural conditions following trail construction work.
- Park staff would implement timely and accurate communication with visitors, such as changes to programs, services, sites, or permitted activities via news releases, visitor contacts, the park website, park mobile application, social media, and signage.

NATURAL RESOURCES

- Removing or impacting native vegetation adjacent to trails would be minimized as much as possible to protect native plants and prevent the spread of nonnative species. The spread of invasive vegetation that results from the removal of and impacts on native vegetation would be monitored and treated.
- Erosion mitigation measures would be used during and after construction until disturbed areas are stabilized by new vegetative growth. Mitigation measures would include silt fences and other runoff control measures. Erosion-control matting must conform to park-provided specifications to avoid wildlife entrainment. All seed and plant mixes for revegetation must be reviewed and approved by park management.
- Construction equipment would be inspected and properly cleaned to remove dirt and debris that may harbor nonnative species before being delivered to the park.
- If paleontological resources are identified in final trail alignment when breaking rock, the resources would be collected and documented and trails would be rerouted to protect associated resources.
- New and existing trails would avoid rare plant species or large tracts of forest areas with high diversity and quality. Two actions would occur to verify the presence of rare plants in proposed trail areas. First, a review of historical plant data and a site survey should be conducted by park natural resource staff. Secondly, a site survey, upon initial flagging of a proposed trail alignment, would be conducted to identify rare plants or sensitive vegetative communities where initial review may identify the presence of sensitive species. The survey would be conducted by qualified park or contract professionals to identify conditions in a trails planning area with a 100% visual survey of the proposed alignment.
- The establishment of buffers based upon vegetation sensitivity would be conducted for each trail project, as conditions deem necessary, by the trail lead in coordination with the park natural resource staff.
- Areas under ecological restoration should be identified during initial trails planning to minimize disturbance to the restoration process.
- Revegetation efforts would strive to reconstruct the natural spacing, abundance, and diversity of native plant species in the trail corridor. No foreign materials with the potential to introduce invasive plant species would be brought into the area. The spread of invasive species would be reduced by using local ecotypes for native plantings and seeding when possible. At new and improved river access sites, interpretive signage would be installed to help prevent the spread of aquatic invasive species (i.e., boat cleaning before river entry).
- Qualified biologists would conduct studies to determine if rare, threatened, or endangered state or federally listed species were present before ground disturbance to avoid disturbance and ensure appropriate locations and facility design.

- All crew members and volunteers assisting in the trail work efforts would be educated about the importance of avoiding impacts on sensitive resources that have been flagged for avoidance.

- New and existing trails would avoid sensitive areas where a rare and/or endangered plant or animal species or its known habitat exist. Care would be taken not to disturb any other sensitive wildlife species (reptiles, migratory birds, raptors, and bats) found nesting, hibernating, estivating, or otherwise living in or immediately near the worksites. Resource management personnel would be notified/consulted when wildlife must be disturbed or handled.

- Vegetation and tree removal work would be sensitive to seasonality to avoid impacts on roosting, breeding, and nesting species to the maximum extent practicable. All tree removal would only occur from October 1 to March 31 when tree roosting bats are not expected to be on the landscape. Additionally, no removal of potential Indiana bat primary maternity roost trees would occur at any time of year. Indiana bat primary roost trees consist of live trees and/or snags ≥9 inches diameter breast height that have exfoliating bark, cracks, crevices, and/or hollows. Trails should also avoid seasonal nesting areas or park staff would adhere to seasonal park policy, such as temporary closures, for trail use or tree clearing in specified areas. A review of site conditions where sensitive habitats may exist in the trails planning area would be conducted with the park biologist and if necessary, with the US Fish and Wildlife Service. If conditions exist, buffers would be established, based on habitat sensitivity, where (1) trails would be excluded, (2) temporary seasonal closures would be required, or (3) limitations on seasonal construction would be established. When resource conditions are in areas with multiple jurisdictions or require additional expertise, the park biologist may request additional reviews of conditions with biologists from other agencies or the scholarly community. The viewing of distinct park features and the feasibility for visitor access should also be identified during site assessment. Informal consultation with the US Fish and Wildlife Service would be conducted for each trail project site during implementation to evaluate impacts on any special status species and their habitat when work would extend beyond the activities authorized under the park's USFWS-approved section 7 programmatic agreement (USFWS 2012).

- Implement dog leash rules, and use signage to keep users and dogs on trails to avoid disturbance to wildlife.

- Following the completion of construction activities, all areas of disturbed soils and vegetation would be regraded and revegetated as soon as possible. Natural topographic features would be restored to the extent possible using local excavated soils or from other park projects, and native species would be used in all revegetation efforts. Restoration efforts would be maximized by using salvaged topsoil (or clean fill) and native vegetation and by monitoring revegetation success for several growing seasons as appropriate. Undesirable species would be monitored and control strategies initiated if needed.

- Consider soil conditions when determining the final layout of a trail, including its soil type, susceptibility to erosion, drainage and permeability characteristics, and compatibility for recreational use. The US Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) soil survey information would be used as the primary reference. Additional site evaluation, as deemed necessary by the trail lead, would be conducted if survey information is not available or identified conditions are adverse to a sustainable trail. When adverse trail conditions are identified in the soil survey information, park staff would identify alternative options for trail design and its implementation, including (1) aborting the trail (new or existing), (2) designing the trail with modifications that address adverse soil conditions, or (3) designing the trail as planned.

- Measures to control dust and erosion during construction could include the following: watering dry soils; using silt fences and sedimentation controls; stabilizing soils during and after construction with specially designed fabrics, certified straw, or other materials; covering haul trucks; and revegetating disturbed areas with native species as soon as possible after construction, with measures taken to avoid introduction of invasive species.

- Where trails are proposed in disturbed or previously developed areas of the park, considerations and verification of the following items should be included: the presence of utilities, established right of ways, remaining structures, cultural landscape features or archeological significance, and the presence of hazardous materials or contaminated conditions. If any of these conditions exist on the proposed site, a determination of impact and trail alignment options would need to be developed to address the conditions present.

- The riparian buffer zones or setbacks of trails adjacent to or crossing rivers and streams would be considered during site planning. The trail location outside of the established riparian function buffer zone would be established whenever feasible.

- Trails should have minimal river/stream crossings along a segment, which should be avoided where possible to minimize impacts on the stream. Where a crossing is necessary, an evaluation of the stream quality and resource sensitivity should inform the design and location of the crossing. Stream crossings should be located at riffle areas instead of at pools or meanders, as riffles are relatively stable, have the coarsest substrate, and can best accommodate a crossing (IMBA 2004). All stream crossings will be evaluated in compliance with Director's Order 77: *NPS Benefits Sharing*.

- Healthy trees of any size should not be removed except where they interfere with trail traffic and/or the trail cannot be relocated to eliminate the interference. Healthy trees over 12 inches diameter breast height should remain, and the trail should be routed to avoid being placed in the area directly under the outer circumference of the tree branches (i.e., the dripline). When branches extend over the trail, the corridor would follow the vertical trail clearance standards.

- National Park Service soundscape preservation and noise management requirements would be followed (i.e., Director's Order 47: *Soundscape Preservation and Noise Management* and NPS *Management Policies 2006*).
- Standard noise abatement measures during construction would be implemented.
- Vehicles and equipment idling times would be limited when parked to reduce emissions.
- The contractor would not leave vehicles idling for more than five minutes.
- Storm drain protection devices (e.g., hay bales, "pigs," socks, or drain covers) would be installed around or over storm drain inlets when doing any construction or maintenance work within 25 feet of the inlet(s).
- A washout area would be designated on the job site in a grassy or graveled area where pooled water could soak into the ground. Wash outs would never be done on a street or paved area or near a storm drain.
- If no washout area were available, wash outs would be done into a container (5-gallon bucket or wheelbarrow) and disposed of material properly.
- Low-impact development and/or infiltration techniques would be incorporated into new construction or reconstruction of existing, impervious areas, such as rain gardens, constructed wetlands, infiltration swales or basins; grass (or vegetated) filter strips or swales; tree islands or planters; permeable pavement; and surface sand filters.
- To preserve dark night skies, park staff would do the following:
    - restrict the use of artificial lighting in parks to those areas where security, basic human safety, and specific cultural resource guidelines could be met
    - use minimal-impact lighting techniques
    - shield the use of artificial lighting where necessary to prevent the disruption of the night sky, natural light conditions, physiological processes of living organisms, and similar natural processes

WETLANDS

- Mitigation measures would be applied to protect wetland resources. Once a management strategy has been selected, a survey would be performed to certify wetlands in the project area and to identify locations of wetlands and open water habitat more accurately. Wetlands would be delineated by qualified NPS staff or certified wetland specialists and marked before any construction starts. All pathway construction facilities would be sited to avoid wetlands, or if that were not feasible, to otherwise comply with Executive Order 11990, "Protection of Wetlands," the Clean Water Act, and Director's Order 77-1: *Wetland Protection*. Additional mitigation measures would include the following, as appropriate:

- Employ standard avoidance, minimization, and mitigation strategies.
- Avoid wetlands during construction, using bridge crossings or retaining walls wherever possible. Increased caution would be exercised to protect these resources from damage caused by construction equipment, erosion, siltation, and other activities with the potential to affect wetlands. Measures would be taken to keep construction materials from escaping work areas, especially near streams or natural drainages.
- Use elevated boardwalks over wetland sections where it is not feasible to avoid the wetland or apply feasible mitigation measures. Boardwalks along shorelines would be placed on helical piers or other elevated structures that can be periodically shifted toward the water to maintain the shoreline experience as isostatic rebound occurs.
- Design footbridges in such a way as to completely span the channel and associated wetland habitat (i.e., no pilings, fill, or other support structures in the wetland/stream habitat). If footbridges could not be designed in such a way as to avoid wetlands, then additional compliance (e.g., a wetland statement of findings) would be done to assess impacts on wetlands and ensure no net loss of wetland area.
- The design process would evaluate opportunities to improve wetland conditions and quality when trail elements were located adjacent to or within a suspected wetland.
- Boardwalks, fences, signs, and similar measures would be used to route people away from sensitive resources, such as wetlands or riparian habitats or historic structures, while still permitting access to important viewpoints.
- Upon final design and if warranted, a formal delineation and any applicable Clean Water Act permitting would occur before groundbreaking.

CULTURAL RESOURCES

- Park staff are developing a programmatic agreement in coordination with consulting parties, including the Kentucky Heritage Council State Historic Preservation Office (SHPO) and Tribes traditionally associated with park lands, which would describe historic property identification actions and minimization and avoidance practices should it be determined that a proposed action may impact a historic property. The phased programmatic agreement would particularly focus on mitigating adverse effects on archeological resources but would also cover cultural landscapes and features like historic roads. Consulting with the Tribes and the state historic preservation office would be finalized and included as part of the decision document for the trails plan.
- Before new trail construction begins, park staff would conduct an archeological survey along the potential route of any new trails to identify currently unknown and significant archeological resources so that they may be avoided. If the effects on resources could not

be avoided or minimized in the new trail corridors developed for this plan, further consultation with the state historic preservation office, associated Tribal historic preservation officers, and the Advisory Council on Historic Preservation according to 36 CFR 800 would be conducted, as necessary, to resolve an appropriate alternative.

- Should construction unearth previously unidentified cultural resources, work would be stopped in the area of discovery, and park staff would consult with the state historic preservation office and associated Tribes, as necessary, according to 36 CFR 800.13 and in accordance with the programmatic agreement developed for this plan. In the unlikely event that human remains, funerary objects, sacred objects, or objects of cultural patrimony were discovered during construction, provisions outlined in the park Comprehensive Agreement for Inadvertent Discoveries (2023 – under review) would be followed.

- Park staff would consult with park and regional subject matter experts (cultural resource management team) about trails in close proximity to cultural resources and implement reasonable mitigations to protect these resources.

TRAIL DEVELOPMENT AND MANAGEMENT

- All new trails and existing trails would employ sustainable trail techniques and be constructed according to the design parameters outlined in the sustainable trail guidelines (see appendix C). Trail class designations are identified in appendix C and inform the above prioritization and all other trail work.

- In the event that resource thresholds were exceeded in a given area, park staff would implement corrective measures to minimize resource impacts, which may include trail closures for periods of time, requiring trail permits or other management actions (see "Appendix A: Indicators, Thresholds, and Objectives").

- The National Park Service would review and update or supplement compliance, if necessary, should existing conditions or proposed work be inconsistent with or not adequately covered by this plan. Such actions would be conducted in a manner consistent with Director's Order 12: *Conservation Planning, Environmental Impact Analysis, and Decision-Making* and other laws.

APPENDIX J: REFERENCES

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As the nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historic places; and providing for the enjoyment of life through outdoor recreation. The department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The department also has a major responsibility for American Indian reservation communities and for people who live in island territories under US administration.

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Mammoth Cave National Park
Comprehensive Land And River Trails Plan And Environmental Assessment

October 2024