



# Hurricane Helene impact on the Doe River: peak stage recurrence intervals and water quality findings

Ingrid Luffman, ETSU Department of Geosciences

Hurricane Helene made landfall in Florida on 9/26/2024 as a category 4 hurricane. It quickly traveled north into North Carolina (NC) and Tennessee (TN) and, as a tropical storm, produced high winds and torrential rains in western NC. Runoff caused flooding in western NC and east TN that scoured channels and floodplains, removed riparian forests, and destroyed homes and sanitary infrastructure. The National Water Center reported that the heaviest rainfall in the headwaters of the Nolichucky and French Broad Rivers and the high relief, which induced orographic precipitation, and floodplain development contributed to the scale of the damage. TDEC issued a temporary water contact advisory on 10/2/24 (TDEC, 2025), citing damage to wastewater treatment plants, sewer line crossings, and septic systems which could cause elevated levels of pathogens in downstream waters, a cautionary measure as there were no specific water quality data to inform the decision. In response to the flooding and water contact advisory, a team of researchers at ETSU developed recurrence interval models to assess the magnitude of the flooding, and began collecting water samples to assess the presence of pathogens along the Doe and Nolichucky Rivers. In this article, I'll share our results for the Doe River.

## Flood Recurrence Intervals

The US Geological Survey maintains stream gauges on rivers to track water level (called stage) and, from that, calculate discharge. Near-record stage was recorded at USGS stream gauges on the Doe River, only slightly below the peak stage recorded during the 1998 flood (Figure 1).

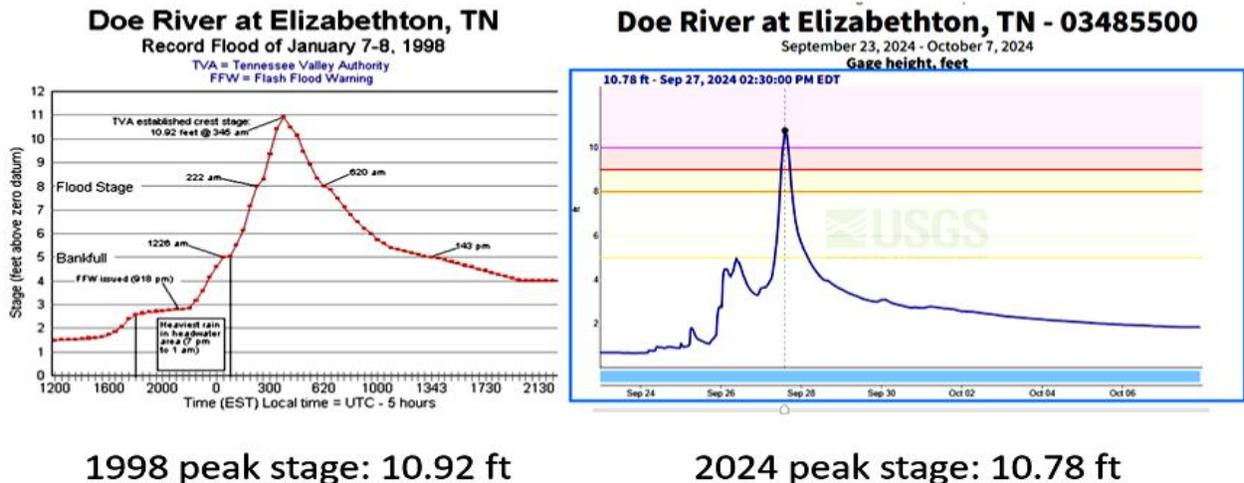


Figure 1. Comparison of stream hydrographs for 1998 and 2024 Doe River floods (Source: NWS, USGS).

We used existing USGS datasets of annual peak stage (the highest water level recorded each year) and after ranking the data, we calculated the recurrence interval ( $R$ ) using  $R = (\text{years of record} + 1) / \text{rank}$  and fit logarithmic and power law models to a graph of stage vs.  $R$  (Figure 2). Recurrence interval estimates in years for both models for the Doe River are 36 years for the Power Law model and 67 years for the Log model.  $R^2$  values indicate goodness of fit of each model (values closer to 1 are better), indicating the best fit model estimates that the flooding from Hurricane Helene had a recurrence interval of 67 years.

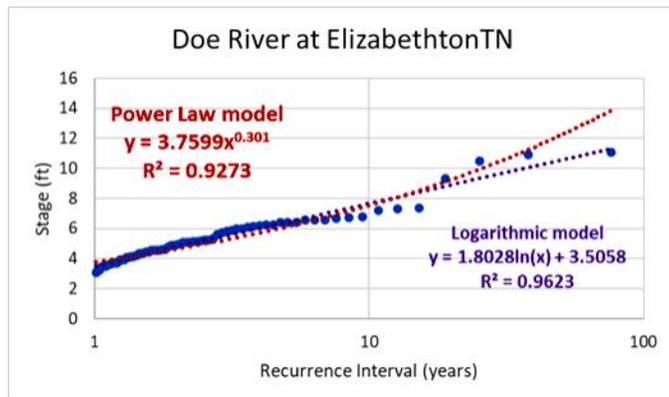


Figure 2. Recurrence interval estimates for Hurricane Helene-associated peak flows on the Doe River at Elizabethton, TN.

To validate our results, we compared them to National Water Center (NWC, 2024) 3-day rainfall data for the event. NWC reported rainfall recurrence intervals in the 50 to 100-year range for the headwaters of the Doe River (Figure 3). Our peak flow recurrence interval of 67 years is in line with the precipitation estimates.

## Water Quality Assessment

Following TDEC’s temporary water contact advisory and the damage to sanitary infrastructure, we identified 8 sites along the Doe River and sampled them for *E. coli* and total coliforms (indicators of fecal contamination) during October and November 2024. Sites were selected using the criteria of upstream damage, site accessibility, and existence of preexisting data, and included control sites with no or limited upstream storm impacts. We used industry standard method 9223 (APHA/AWWA/WEF, 2018) and processed all samples in our labs at ETSU.

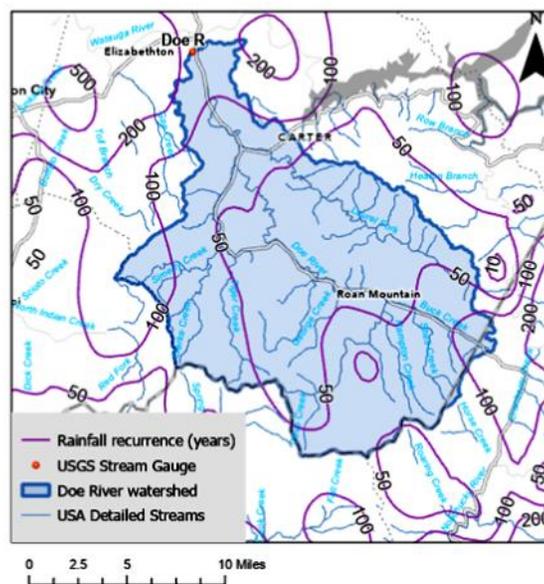
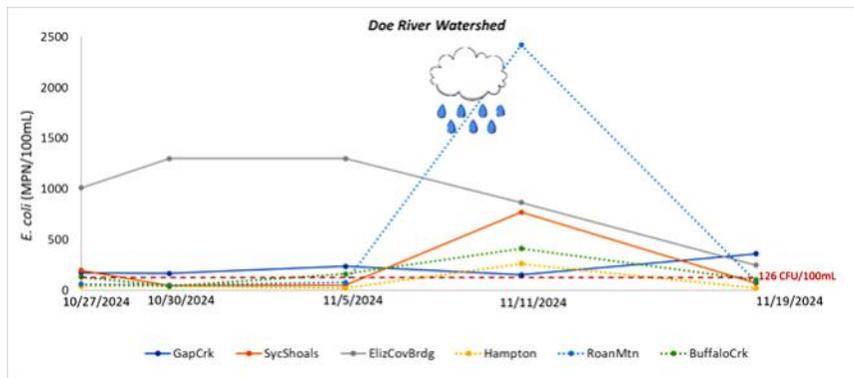


Figure 3. Hurricane Helene 3-Day rainfall recurrence isohyets for the Doe River watershed.

Although portions of the Doe River are classified by TDEC as impaired for *E. coli* (downstream from Railroad Grade Road), we were pleased to find that sites in the upper watershed generally met or approached recreational water quality standards for *E. coli*, which is 126 CFU/100mL as a geometric mean of the five samples. Downstream sites generally did not meet standards. All sampling sites except the Elizabethton Covered Bridge site experienced notable increases in *E. coli* following precipitation, though it’s important to note that *E. coli* at the Covered Bridge was consistently high throughout the sampling period, and the rainfall may have improved water quality at that site due to a flushing effect (Figure 4).

Figure 4. *E. coli* concentration in water samples from the Doe River watershed following Hurricane Helene. Dotted series are located in headwaters. Red dashed line is the water quality standard for recreational water (geometric mean of 126 CFU/100mL). Rain occurred prior to the 11/11/2024 sampling event.



Impacts of extreme weather events such as Hurricane Helene on water quality emphasize the critical importance of obtaining baseline data to more accurately understand these impacts. Although significant water contamination often occurs immediately after extreme weather events, particularly when there is damage to sanitary infrastructure, sustained long-term monitoring is essential to fully understand the persistence of these impacts and the patterns of recovery in affected water bodies.

*Acknowledgements: Sincere thanks to the ETSU team of researchers that included Drs. Md Rasheduzzaman, Phil Scheuerman, and Beth O'Connell, and multiple student volunteers. Dr. Rasheduzzaman was coauthor on the conference paper on which this article is based.*

#### References

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Ingrid Luffman, PhD, is a hydrologist with the ETSU Department of Geosciences and a founding member of the Boone Watershed Partnership. Ingrid will present the evening program, *ETSU Geoscientists Respond to Hurricane Helene*, on Friday, April 24 at 7:30 pm at the Roan Mountain State Park Conference Center.



## Blue Ridge Discovery Center: Connecting Community to the Natural History of the Blue Ridge

— Lisa Benish

For nearly two decades, the Blue Ridge Discovery Center (BRDC) has worked to connect people of all ages to the natural history, ecology, and wonders of the Blue Ridge Mountains. Rooted in the belief that curiosity leads to stewardship, BRDC has grown from a small grassroots vision into a regional hub for hands-on environmental education, serving youth, families, schools, and lifelong learners throughout Northeast Tennessee, Southwest Virginia and Northwestern North Carolina.



BRDC was established in 2008 with a simple but powerful mission: *to inspire curiosity, discovery, and stewardship through the wonders of the Blue Ridge*. From the beginning, the organization recognized that the mountains themselves are the best classroom. Rather than relying solely on traditional lecture-style programming, BRDC embraced experiential, field-based learning placing binoculars in students' hands, turning over rocks in mountain streams, hiking balds, and helping participants identify organisms of all kinds.

The organization's early years were marked by partnership-building and community trust. Collaborations with local schools, naturalists,

land managers, and conservation organizations allowed BRDC to expand its reach while remaining deeply grounded in place-based education. Programs were designed not only to teach facts about local ecosystems, but to foster a lasting relationship between participants and the landscape that surrounds them.

Over time, BRDC's offerings grew to include school field trips, homeschool programs, naturalist rallies, summer day camps, and overnight specialty camps. Among its most distinctive programs is the Ornithology Camp, an immersive experience for youth ages 11–17 who have a developing interest in birds and wildlife. Participants learn field identification skills, conduct bird surveys, explore diverse habitats, and gain hands-on experience with scientific observation techniques.

BRDC's historic facility in Konnarock, Virginia, has also become an important part of its story. The beautifully restored building serves as both an educational space and a gathering place for the community. From workshops and lectures to teacher training and small events, the building reflects BRDC's commitment to preserving local history while supporting future generations of naturalists.

Central to BRDC's success has been its emphasis on accessibility. The organization works intentionally to ensure that financial barriers do not prevent young people from participating in programs. Scholarships and partnerships with local schools help bring students outdoors who might not otherwise have the opportunity.

BRDC's work aligns closely with the conservation legacy of Roan Mountain and the broader Blue Ridge region. The high-elevation balds, spruce-fir forests, and biodiverse habitats of this area are globally significant, yet they require informed and engaged communities to protect them. Through its programs, BRDC seeks to cultivate not just knowledge, but stewardship—encouraging participants to see themselves as caretakers of these remarkable landscapes.

As environmental challenges grow more complex, the need for place-based education has never been greater. BRDC remains committed to adapting and evolving while staying rooted in its founding principles. Whether introducing a child to their first magnified view of a salamander, helping a teen identify warblers during spring migration, or engaging adults in thoughtful natural history discussions, the organization continues to build connections between people and place.

The upcoming Spring Naturalist Rally provides a wonderful opportunity to reflect on this history and to look toward the future. BRDC's story is ultimately one of community—of educators, volunteers, donors, board members, and participants who share a belief in the transformative power of outdoor learning. It is also a story that continues to unfold.

As BRDC looks ahead, its goals remain grounded in the same vision that launched the organization in 2008: fostering curiosity, encouraging exploration, and nurturing stewardship in the heart of the Blue Ridge. The mountains have always been our greatest teachers. BRDC simply helps create the opportunities for people to listen, observe, and discover.

Lisa Benish is an environmental educator and the Executive Director of the Blue Ridge Discovery Center in southwest Virginia. She works closely with community partners to develop immersive programs that highlight the ecological richness of the Blue Ridge region. Lisa will present *Discovering the Blue Ridge: Place-Based Nature Education at Blue Ridge Discovery Center*, on Saturday, April 25 at 7:30 pm in the Roan Mountain State Park Conference Center.



## GIFTS AND MEMORIALS

*Friends of Roan Mountain gratefully acknowledges these charitable gifts*

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# ROAN MOUNTAIN REUNIONS

—Tracy Campbell

The Friends of Roan Mountain Winter Naturalists Rally is like a reunion that kicks off a new year of rallies. While winter is still with us, right about the time most nature-lovers begin longing for the new sprouts of spring, the Conference Center at Roan Mountain State Park becomes a gathering place for folks of all ages. At the one-day winter rally, local experts share their knowledge and skills to preserve and pass on wisdom that connects all of us who care about Roan Mountain. On this day in February, a fire burns in the big stone fireplace at the back of the room. Friends who may only get to see one another at the rallies meet again and catch up. Finding out how friends are doing and what's been going on in each other's lives can make it seem like some kind of family reunion. There is excitement in the mountain air as we look forward not only to learning together, but also to the fellowship and having lunch together. These rallies have been taking place for multiple decades, and while we're together, we also recall fond memories of the folks who used to be there but are no longer with us.



During every season, all Friends of Roan Mountain rallies are like reunions. The spring and fall rallies last for entire weekends with multiple opportunities to share meals. These weekends not only feel like reunions but create an atmosphere of multi-generational mini-nature camps with experts and seasoned naturalists who sometimes travel some distance to share with the Friends of Roan Mountain. Young families are often introduced to the naturalist rally experience at the X-treme Roan Adventures Kids' rally that takes place each summer right before school starts. When kids grow up attending the rallies, they gain priceless knowledge about the world around them and experiences that will inspire them to continue attending throughout their adult lives with other lifelong learners.

In our current digital age, many people of all ages are spending a great deal of time on screens and are often isolated from one another instead of participating in real face-to-face interactions in real settings. Roan Mountain is one of the very best places for people to discover and explore what is real. Listening to great speakers, going on field trips, and participating in hands-on activities allow for even more memory-making time together. The rallies give people opportunities to learn together and build deeper connections to the place we all love. Shared experiences like this foster a sense of wonder and appreciation. The hands-on nature journaling activity that took place during the winter rally will continue at other rallies this year, and participants will periodically gather again with their journals in other natural areas around the region.



Photo by Marty Silver

All the rallies, during every season, spark discovery not only about nature and the Roan Mountain region, but also about each other. These events offer a time to grow stronger as a group. Bringing the Friends of Roan Mountain together because we all care about learning, the mountain, and our community, honors the traditions and the spirit of these rallies as we guide their evolution and preserve these experiences for future generations. New friends of all ages are always welcome!

# FloraQuest Apps

just jamey

After years of carrying hard copies of plant manuals and floras while doing rare plant surveys, I relish new technology that helps plant lovers ditch unnecessary weight and streamline field studies. Smart phone and tablet cameras can substitute for magnifying lenses and new apps enable plant identification. A waterproof (and washable!) tablet with a stand-alone GPS chip would allow drafting survey reports in the field without having to transcript field books. My first experience with a flora app was the Flora of Virginia Mobile App that has been available for at least a few years and it works well for much of northeast Tennessee, however there are several plants here not found in Virginia.

Thanks to FloraQuest developed by the Southeastern Flora Team at the UNC-Chaple Hill Herbarium, we now have new apps available that cover the Southeast United States' rich plant life. There are currently four apps available with a fifth expected this year. The most recent one covers Tennessee:



FloraQuest: Northern Tier: Delaware, Kentucky, Maryland, New Jersey, Pennsylvania, Virginia, West Virginia, Washington, D.C., plus southern Illinois, Indiana, New York, and Ohio

FloraQuest: Carolinas & Georgia: North Carolina, South Carolina, and Georgia

FloraQuest: Florida: Florida

FloraQuest: South-Central (new in 2025!): **Tennessee**, Mississippi, and Alabama  
*Coming in 2026:* FloraQuest: Western Tier: *Louisiana, Arkansas, and portions of Missouri, Texas, Oklahoma, and Kansas*

Each is bargain priced with a one-time fee of \$19.99 for both iOS and Android, meaning free updates might be available in the future. Each app includes thousands of plants, diagnostic keys, range maps, color photos, habitat descriptions, conservation status, and more, and they work offline.

You can read more about the features at <https://ncbg.unc.edu/research/unc-herbarium/flora-apps/>



## The Xtreme Roan Adventures 2026, July 24-25!

Your family should join us for Xtreme Roan Adventures. Sometimes we get in the river. Sometimes we get on top of the mountain. Sometimes we hug a salamander.

The whole family will choose from over twenty Adventures. Most are within a short walk from the Roan Mountain State Park amphitheater. These Adventures are scaled for short legs and short attention spans. All ages of kids can find something new and interesting.

Try out the Free Friday Night Adventures, July 24. Enjoy the magic of nature study at night. It's really cool. Saturday, July 25, is a full day of Adventures. Enjoy as many Adventures and activities as you can. Bring a picnic or get the catered lunch.

Our Adventure Leaders are the best. Nature study is their profession or their passion. All are impressive. Join them on an Adventure. Everyone will learn something new. Get in the river. Get on top of the mountain. Hug a salamander. And more.

Updates on: [Xtreme Roan Advnitures.org](http://XtremeRoanAdventures.org)  
Or contact: Ken Turner, [ken@XtremeRoanAdventures.org](mailto:ken@XtremeRoanAdventures.org)  
423-366-9326



Round Bald Blueberry Adventure

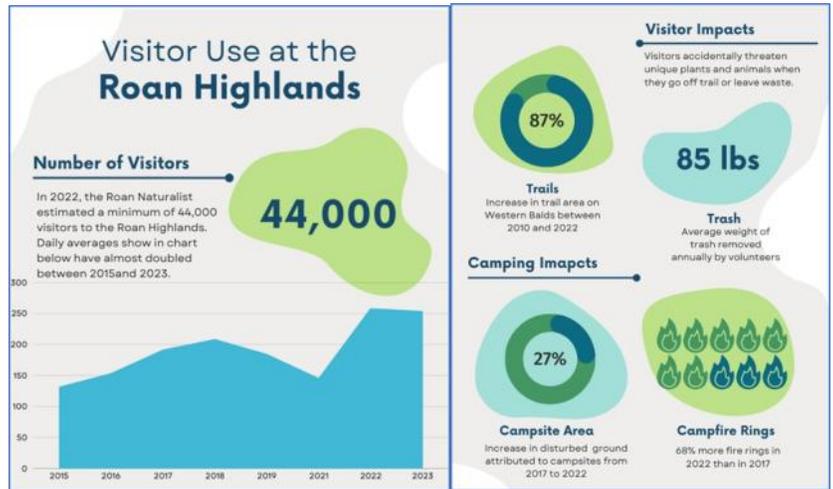
# Visitor Use Management of the Roan Highlands

Joe DeLoach and Christina Soto, with contributions by the Roan VUM Committee

The Roan Highlands are a rich and diverse cluster of high elevation mountains stretching along the North Carolina and Tennessee border. Popular with visitors for decades, use and impacts have increased dramatically over the past 25 years. Impacts are especially noticeable across the balds which are traversed by the Appalachian Trail (A. T., or Trail) near Carvers Gap – Round Bald, Jane Bald, and Grassy Ridge. Impacts include unintentional Trail widening and erosion, proliferation and expansion of campsites, trash, and parking congestion. With increased visitation comes environmental degradation and a less desirable experience for the visitor.

These infographics illustrate the increase in visitor use and impacts over recent years.

*Roan Highlands Visitor Use Infographic by Monica Mogilewsky, Appalachian Trail Conservancy (ATC) Data collected by Southern Appalachian Highlands Conservancy (SAHC) Roan Naturalists, ATC Staff, and Volunteers*



When the Appalachian Trail relocation across Round Bald from Carvers Gap was constructed to replace the steep, numerous log steps, it was recognized that heavy use and soft soil necessitated a wider and more hardened path than typical for the A. T. Though state of the art at the time, 2000-2001, such high increase in visitation was not anticipated. The ease of traverse, publicity in print sources and social media, and possibly implementation of a parking fee at the Roan Mountain Day Use Area, have shifted use and impact from the top of the mountain to Carvers Gap. With several trails--some concrete and paved--larger parking lots, and overall higher levels of amenities, the Roan Mountain Day Use Area is better able to accommodate visitation than Carvers Gap and the balds.



These photos show the effects of increased use on the A. T. The photo, at left, was taken soon after the Trail relocation was completed, in the early 2000s. Though the Trail at the time was in very good condition, the photo shows a visitor getting off the Trail to go around other visitors and their dogs. Below, this photo taken from near the same location, shows the cumulative effect of this practice over 25 years.



Photos by Steve Perri and Tim Stewart

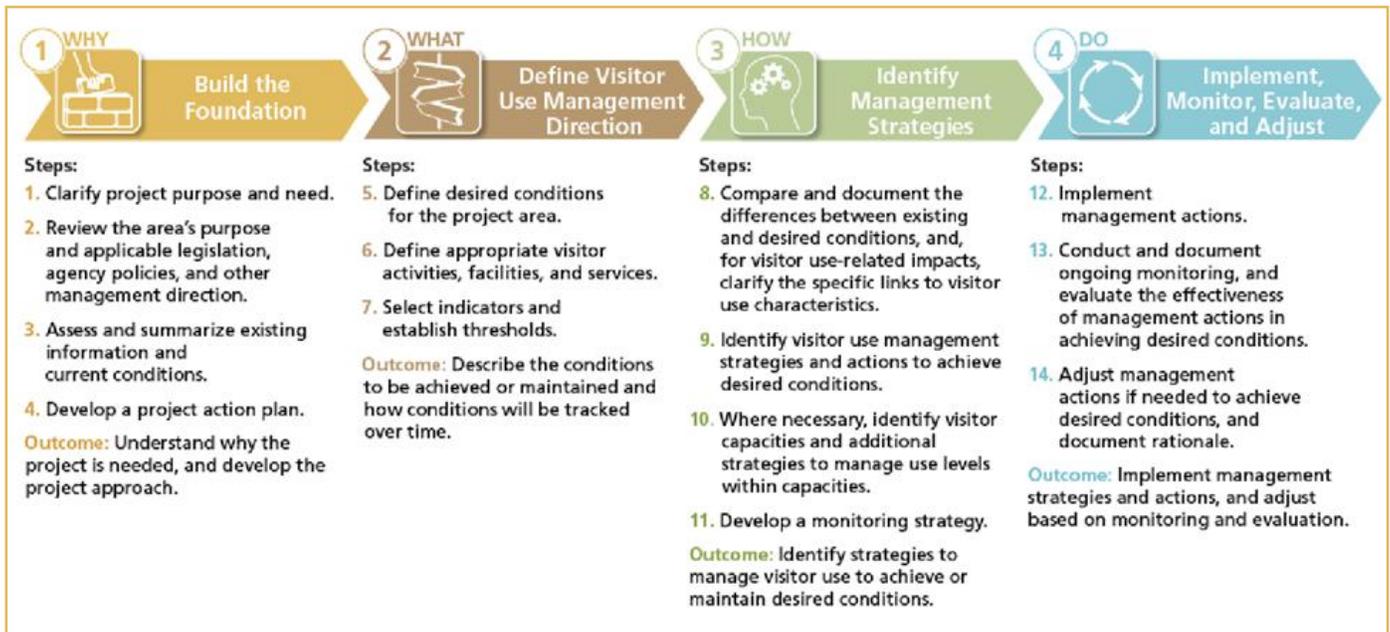
The increased use has led to parking congestion at Carvers Gap, and not just on summer weekends. Parked cars have blocked the road to the Roan Mountain Day Use Area for emergency personnel and visitors. The following photo was taken along NC Highway 261.



## Visitor Use Management

Government agencies have adopted a uniform Visitor Use Management (VUM) process as guidance for federally managed lands and waters to sustain resources and quality visitor experiences. VUM is defined as “the proactive and adaptive process for managing characteristics of visitor use and the natural and managerial setting using a variety of strategies and tools to achieve and maintain desired resource conditions and visitor experiences.” More information on VUM may be found at <https://visitorusemanagement.nps.gov/>.

The VUM process follows a collaborative, 14-step Interagency Visitor Use Management Council (IVUMC) framework. IVUMC’s framework is a rigorous approach to develop, implement, and monitor strategies and actions to provide sustainable access to lands and waters. The process is summarized below.



Along the Appalachian Trail, VUM has been utilized at several heavily impacted areas. These include [Max Patch](#) in North Carolina, [McAfee Knob](#) in Virginia, the A. T. in Georgia, and Franconia Ridge in New Hampshire. A VUM process has begun in the Grayson Highlands Crest Zone in Virginia.

In the Roan Highlands, the VUM process was established in 2022. The purpose is to bring together key management partners and stakeholders to collaborate and develop a plan to protect the ecological integrity and character of the Roan Highlands, particularly Round Bald, Jane Bald, and Grassy Ridge. These partners and stakeholders, which comprise the Roan Highlands VUM Committee, include the Appalachian Trail Conservancy; Bakersville, North Carolina; Friends of Roan Mountain; Roan Mountain A.T. Community; Roan

Mountain State Park; the Southern Appalachian Highlands Conservancy; the Tennessee Eastman Hiking & Canoeing Club (TEHCC); the Cherokee National Forest, and the Pisgah National Forest (together, USFS). The Committee has hosted two open houses in the communities of Roan Mountain, TN, and Bakersville, NC, with training workshops to review the framework steps.

The Roan Highlands VUM Committee is in the 3<sup>rd</sup> “How” phase in the graphic above. Some actions that have been taken include:

- Repairs to the A. T. near Carvers Gap by TEHCC after erosion from Hurricane Helene
- Installation of peak finders and boardwalks to concentrate use and impacts on Round Bald. Indiscriminate wandering and trampling have likely extirpated some rare northern disjunct plants near the summit.
- Installation of No Parking signs on the North Carolina side of Carvers Gap
- Installation of boot brushes near Carvers Gap to reduce transport of non-native and potentially invasive plants
- Conducting campsite inventories to understand overnight usage
- Conducting GIS studies utilizing aerial photography and remote sensing to document trail width changes over the past five years
- Doing research on visitor use and interpretive signage
- Launch of the Roan Highlands website, [www.roanhighlands.org](http://www.roanhighlands.org), to educate visitors about the Roan's special environment
- Publicity of the campfire ban between Hughes Gap and Doll Flats after Hurricane Helene
- Development of a brochure and poster

## What You Can Do

- Visit the Roan Highlands website at [www.roanhighlands.org](http://www.roanhighlands.org) to:
  - Plan your visit to the area and read about any current alerts
  - Download the first issue of the VUM newsletter
  - Read about other conservation projects in the area
  - Review other nearby locations to visit
- Practice and promote Leave No Trace Principles, including staying on the trails
- Try to avoid the high use periods at Carvers Gap. There is less visitation early and late in the day, and on weekdays. Carpool when possible.
- Visit other sites instead of Carvers Gap. These could include the Roan Mountain Day Use Area (\$3 isn't that much!), Roan Mt. State Park, Hampton Creek Cove State Natural Area, and other portions of the A. T., including balds such as Hump Mountain.
  - Not too far away are Unaka Mt., Grandfather Mt., Mt. Mitchell, and Elk Knob. Each have reopened since Helene and none are heavily impacted.

Though “there’s no place like Roan”, it is a unique and beautiful place that needs help to withstand overuse. Please join us in helping!



## GIFTS AND MEMORIALS

*Friends of Roan Mountain gratefully acknowledges these charitable gifts*

Caroline & Bob Doherty	Jerry Faulkner
Norma Morrison vis PayPal Giving	Susan Peters



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# Friendly Reminders



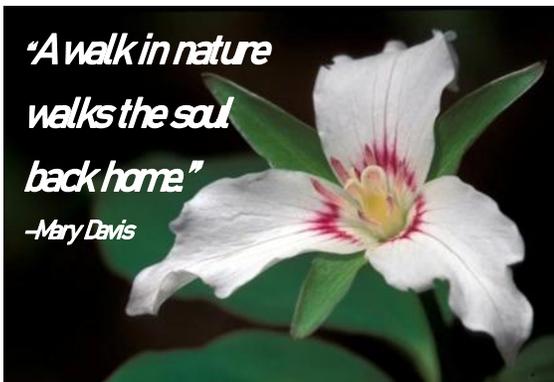
**MEAL Orders** – Payment for Spring Rally meals must be received by Tuesday, April 21st . The reservation form can be found in the brochure or on our website. Mail your check and reservation form to Nancy Barrigar–Treasurer, 708 Allen Avenue, Elizabethton, TN 37643.

**You can also register online. Find the [link](#) and rally brochure on our website's homepage.**



**Door Prizes** – We gladly accept items donated for door prizes. These will be given away on Friday and Saturday prior to the evening programs. Ideas: nature-related books and field guides, photos or art, outdoor gear, plants, homemade goodies . . .

If you prefer to read your FoRM newsletters online (color version) email [friendsofroan@gmail.com](mailto:friendsofroan@gmail.com) with your request.



## MARK YOUR CALENDAR

Spring Rally	Last Friday - Sunday in April	April 24 - 26, 2026
Youth - XRA	Last Friday & Saturday in July	July 24 - 25, 2026
Fall Rally	Friday - Sunday in September nearest 1st day of Fall	Sept 18 - 20, 2026
Winter Rally	Saturday in February near Valentine's Day	February 13, 2027