

ARTICLE

What We're Learning and Why it Matters: Long-Term Monitoring on the Northern Colorado Plateau

Arches National Park, Black Canyon Of The Gunnison National Park, Bryce Canyon National Park, Canyonlands National Park, Capitol Reef National Park [more »](#)



After more than ten years of monitoring, we've learned a lot about park ecosystems, how they're changing, and what they may look like in the future.

The National Park Service preserves America's most special and treasured places. Knowing which key natural resources are found in the parks, and whether they are stable or changing, can help park managers make sound, science-based decisions about the future.

The **Northern Colorado Plateau Network** (NCPN) is one of 32 **inventory and monitoring** networks building that knowledge. In 16 National Park Service **units**, our scientists and partners collect long-term data on key **natural resources**—like plant communities, soils, and the quality and quantity of water that we call "**vital signs**," because

their condition can indicate the overall health of park resources. We analyze the results, track the changes, and provide information to decisionmakers.

There's still plenty we don't know, but there's a lot we do know. Here are some common questions and answers.

What have you learned? What kinds of changes are you seeing?

The first several years of any monitoring program are devoted to figuring out what's "normal" for a given system. We collect data to establish a baseline, then determine the range in which measurements might be expected to fall under typical conditions. With more than ten years of data for some resources, we've learned numerous key things about the systems we study.

Water Quality

- The **water quality** in most NCPN parks is good. The most common issue of management concern seen in our data is waste contamination. Livestock, wildlife, and visitors can all be sources of waste contamination, including ***E. coli*** and **emerging contaminants**. Visitors can help keep park waters clean by using restrooms when available and eliminating waste more than 200 feet from water in the backcountry. Always filter water before drinking.
- NCPN data have helped clarify the role of livestock in waste contamination at **Zion** and **Capitol Reef** national parks. The parks are working with the State of Utah to develop plans to reduce livestock waste in the affected streams and rivers. When we have good data on problems, park managers can work on making positive changes.
- Water temperature is another common issue. Fish, insects, and other aquatic species all have a preferred temperature range. As temperatures get too far above or below that range, aquatic organisms are unable to survive. In **2016–2018**, at least one site in half the parks monitored had elevated temperature levels during the monitoring period. Water temperatures are expected to increase as climate change increases air temperatures and decreases surface-water flows in the U.S. Southwest.
- At Timpanogos Cave National Monument, long-term monitoring has revealed the **influence of human activities on cave waters**. At Hidden Lake, a decrease in dissolved CO₂ corresponded to implementation of a new cave management plan, leading to conditions that favored the formation of speleothems (cave decorations)—an important management goal in an active cave system. At Hansen Lake, trends in water chemistry mimicked trends that can be caused by air pollution. The only trend common to both pools was an increase in water temperature.



Green River, Dinosaur National Monument. NPS/Amy Washuta

Big Rivers

- **Variability is key** to river health and diversity. There is no one “perfect” flow that is good for rivers. They need dry years with low flows, wet years with high flows, and everything in between. Stability is generally bad for rivers, because a steady flow allows more vegetation to **become established** than a natural ebb-and-flow would. Once this happens, it is a lot harder for the river to do its job of reworking the river bank. On the other hand, when vegetation is occasionally scoured away, a diversity of physical and biological habitats are created.
- Natural flows, and variable flows that follow natural flow patterns (e.g., on regulated rivers), result in lower levels of invasive plants. Stable flows from dams generally **favor invasive plants** over native plants.

Invasive Exotic Plants

- Exotic-plant control works. Several parks have eliminated invasive exotic species from known locations, or made areas largely weed-free. NCPN monitoring results have reflected successful control efforts in several parks, including **Colorado** and **Fossil Butte** national monuments, and **Zion** and **Capitol Reef** national parks. These control efforts are most effective when the infestations are small. However, this work is never “done;” it’s an ongoing challenge. The NCPN monitors and regularly **reports** on invasive exotic plants at eight parks.



Bald eagle. (USFWS/Karen Laubenstein)

Landbirds

- NCPN landbird populations are experiencing more declines than increases. Over 15 years of data collection, 173 individual species have been detected in 11 NCPN parks. In 2020, a total of 121 **population-density trends** were estimated across three habitats: low-elevation riparian, pinyon-juniper, and sage shrubland. Eleven of those trends were significant (p -value < 0.05), including 9 declining trends and 2 increasing trends.

Wadeable Streams

- Wadeable streams in NCPN parks are prone to flash floods.
- At Zion National Park, **changes** in these systems tend to be sudden and unpredictable, and longer-term trends can be hard to detect.
- At Natural Bridges National Monument, vegetation along wadeable streams tends to be **well-adapted** to disturbances.
- At Arches National Park, increased drought stress has already been noted during dry years. If its current protections are maintained, the primary stressors on the **Courthouse Wash system** are likely to be climate change and exotic-plant invasions.

Vegetation and Soils

- At Capitol Reef National Park, the NCPN is helping park managers learn how park grasslands have changed since grazing ended. In 2020, the network published a **trend analysis** of data collected at active and retired grazing allotments in the park's northern section. In allotments retired since the 1990s, vegetation and soils were in relatively good condition, and trends were stable or improving. In the grazed allotment, condition was declining for 9 of 22 monitored parameters. NCPN uplands monitoring data are often used in resource management and planning at Capitol Reef National Park. Continued monitoring will help managers to know where restoration projects are most needed—and most likely to succeed. This helps ensure tax dollars are wisely spent.
- Seasonal precipitation was found to be an important influence on vegetation cover at Capitol Reef National Park. Looking at vegetation data in the context of **climate data** shows us how plant communities have responded to past patterns of temperature and precipitation. This helps us predict how current communities **may respond** to expected patterns of increased temperatures and decreased water availability. The record we're putting together now can help park managers know what to expect in the future.



Grassland, Capitol Reef National Park.

What are the current and expected effects of climate change in network parks?

Long-term monitoring does more than tell us what's happened in the past. It shows us how a system works under a range of different conditions. Once we have a long-term data record that reveals baseline data and past and current trends, we can determine how sensitive different vital signs are to climate—and where, when, and how much they are likely to respond as the climate changes. What follows is a list of changes we are already seeing reflected in our data, and expected effects based on our own record and the best available climate models.

Climate

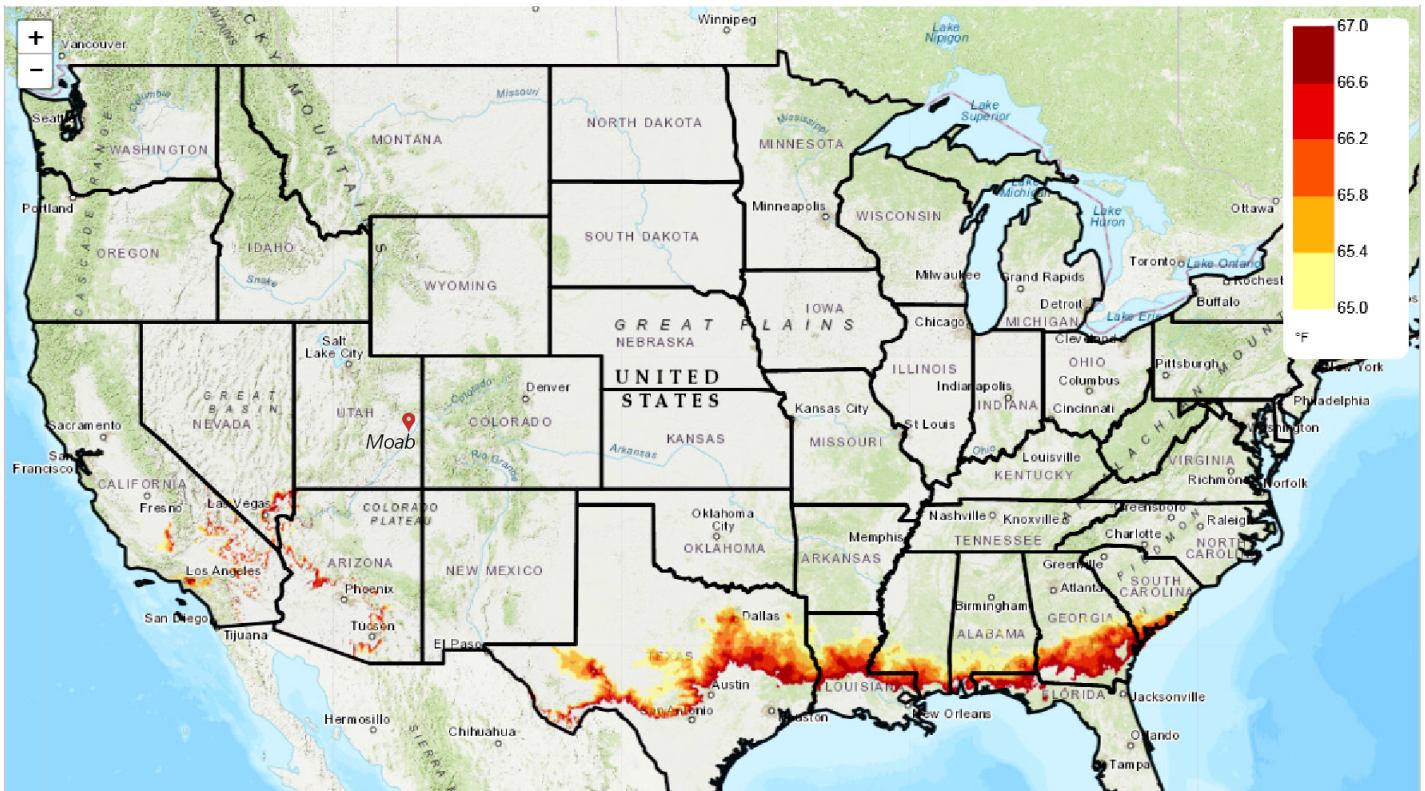
- **Spring is coming earlier** in parks across the US. One possible result is that changes in phenology (the timing of seasonal activities, such as leaf unfolding, flowering, and wildlife migration) may make some resources unavailable when they're needed by their consumers. Parks may also experience longer fire seasons.
- Habitat for key species is changing in and around Zion National Park. Species distribution models, in combination with historical temperature data and future temperature projections, show that **suitable habitat** may become more abundant for Shivwits milk-vetch. Habitat may also increase for the desert tortoise, but decline for American pika. Information like this can help park managers assess the potential effects of management actions.



American pika habitat is projected to shrink in Zion National Park. USFWS/Chris Kennedy

- Overall average temperatures are rising, and they are **rising faster** in the Southwestern US than in some other parts of the country. At the same time, the Southwest is **getting drier**. Current projections indicate it will continue to get hotter. Based on that, and how vegetation has responded to previous droughts, we expect longer—and hotter—droughts that will have bigger impact on vegetation than in the past.

- It's currently **projected** that by 2100, the average temperature for Moab, Utah, will be 10°F higher than it is today (66°F instead of the current 56°F). That adds up to a tremendous amount of extra heat every year. Places with an average temperature of 66°F currently include areas of the southeastern US, along with areas of southern Nevada and south-central Arizona (see figure below)—places much warmer than today's Moab.



Areas of the US where the average temperature is currently 66 degrees Fahrenheit.

Source: <https://climatetoolbox.org/>

- Precipitation patterns are harder to predict, but we do know that as it gets hotter, **evaporation increases**, meaning much more precipitation is needed to maintain the same amount of water in the system. If precipitation doesn't come, droughts get stronger.
- Because precipitation is unlikely to increase proportionally with temperature, and because different plant communities persist under **different conditions**, park visitors in future decades will likely see a very different vegetative landscape. Changes to plant communities affect the animals that depend on those plants, so there may be changes across plant and animal communities.
- Even the desert can experience drought. Though they develop many **adaptations** to help them survive in arid environments, desert plants need certain amounts of water, and they need it at certain times.

Vegetation

- In 2017–2018, there were 16 consecutive months of **below-average precipitation** at the Natural Bridges National Monument climate station. This drought—the worst seen in 30 years—was more stressful for junipers in southeast Utah (e.g., Hovenweep and Natural Bridges national monuments) than previous local droughts have been. We and others are trying to figure out **why**. We will be investigating how many trees perished in the drought, and if vegetation recovers as it did from past drought (e.g., 1999–2003).
- The most recent drought has highlighted the way different plant types and species have different strategies to **survive drought**, and taught us a lot about what to expect as climate change progresses. For example, junipers kill off their own branches and may ultimately survive by paring down their canopies to a branch or two. Grasses die back during drought. Their new growth depends not only on precipitation from the current year, but also from **previous years**, so grasses may not be able to take advantage of a wet spring in one year if precipitation was below average the previous year.



Patch of dying junipers with the Abajo Mountains in the background, Cedar Mesa, Utah. NPS/Dana Witwicki

Water

- A lot of NCPN surface water is vulnerable to hot, dry conditions. **Measured springflow** at Arches National Park is closely related to air temperature, because higher air temperatures mean more water is used by plants and lost to evaporation. That leaves less surface water for animals. The same process affects many smaller streams that rely on groundwater for much of the year. Extreme drought in 2018 caused one of our long-term water-quality monitoring sites to go dry and caused very low flows in others.
- We've recorded **increasing water temperatures** (related to increasing air temperatures) in places as diverse as cave pools, large reservoirs, and mountain streams. This can stress aquatic life—both directly and indirectly through effects on things like dissolved oxygen. It also increases the likelihood of harmful **algal blooms**, like the ones that recently occurred at Curecanti National Recreation Area (2018) and **Zion National Park** (2020). Harmful algal blooms kill fish. They can also kill pets and cause severe illness in people. They are a significant public health risk and are likely to increase with rising temperatures.



Algal bloom at Blue Mesa Reservoir, Curecanti National Recreation Area, 2018. NPS photo.

- Wildfire often causes catastrophic changes in water quality and flood magnitude. A 2006 wildfire in Zion National Park's North Creek drainage caused **debris flows** that were toxic to fish, overtopped culverts, and damaged homes downstream of the park. Algal blooms continued for years after the fire, which made the stream uninhabitable for fish. Wildfire frequency and intensity are expected to increase.
- Even if annual rainfall stayed about the same, a hotter future is effectively a drier future for NCPN parks because of **increased water demand** and losses to evaporation.

Big Rivers

- Recent years have been dry. The **first-ever** "call" on the Yampa River occurred in August 2018. (The Colorado Division of Water Resources places a call on a stream when water rights owners do not receive the amount of water they have a legal right to. When a call is in place, some water users are forced to reduce or stop their use in order to send enough water downstream to fulfill the older water right.) Average flows on the Yampa River in September 2018 were 56.9 cubic feet per second (cfs), the **second-lowest** ever (the previous being 46 cfs in 2002). At Curecanti National Recreation Area, Blue Mesa Reservoir dropped to an elevation of 7,437.18 feet in fall 2018. This was the **lowest** it had been since 1984, when it reached its record low of 7,427.71 feet.

Wadeable Streams

- As the climate becomes hotter and drier, we expect base streamflows to decrease in our wadeable streams.



Landbirds

- Some NCPN landbird species will be more vulnerable to future warming and drying than others. When network staff and partners examined 12 years of landbird-monitoring data with long-term climate records, they found that some species decreased in density as drought stress increased. But other species showed a positive response to an increase in water deficit. The direction and magnitude of a given species's response was dependent on habitat type and species traits. Birds that breed in multiple habitats may find it easier to adapt to future conditions. **These results** will help land managers to **focus conservation efforts** on places where certain species are most vulnerable to projected climate changes.

Invasive Exotic Plants

- Once established, invasive exotic plant populations generally increase when left alone. They capitalize on habitat disturbances (such as wildfires, flooding, extreme droughts, construction activities, and other land-use practices), and then become established. Future climate patterns are expected to result in increasing numbers of environmental disturbances. This will increase opportunities for invasives.



How is the Northern Colorado Plateau Network helping park managers plan for future conditions?

In addition to improving our understanding of what's happening and what's likely to happen in the future, NCPN ecologists work with many partners to apply that knowledge to management scenarios. Here are some ways NCPN data can make a difference in park management.

- NCPN water and vegetation monitoring are helping to determine the **sensitivity** of park **vital signs** to a changing climate. Climate projections tell us how much change to expect. Sensitivity tells us how the things we care about are likely to respond. Combined, this tells us which, when, and where vital resources are vulnerable. Knowing this, **managers can be proactive** and mitigate what could happen if we did nothing but watch.
- Inventory and monitoring data are informing **Climate Smart Conservation** efforts at many national parks. Together, scientists and managers think through potential climate impacts to park resources, use scientific data to analyze different situations, and then identify and evaluate management options most likely to be feasible, achievable, and effective. After participating in workshops hosted by the Northern Colorado Plateau Network, parks in the NPS Southeast Utah Group are working with U.S. Geological Survey scientists to restore and conserve grasslands and pinyon-juniper forests.
- Our work is helping managers know which types of plants may be more **resilient** to projected climate changes. This will help them decide which plant communities to prioritize for restoration, so parks don't waste time and money planting species that are unlikely to survive. We expect some species to be affected by drying conditions **sooner than others** depending on their inherent sensitivity to drought and their distribution on the landscape. Some live on dry sites, others on less dry sites. Understanding these distributions will help us determine where to expect change sooner. This also helps us understand our options as the climate gets drier—where and what to plant or promote, and where and what to let go.



Knowing which plants will likely be best-suited to which places can help maximize the success of restoration projects. NPS/Joshua Doucette

- The more prepared we are for transitions to new vegetation assemblages, the better. If we can proactively promote desirable species, we close gaps that would otherwise be filled by opportunistic invasive (i.e., undesirable) species. Thus, we're starting to think about ecological function of different species. Which species are **suited** to the new climate on different soil types in the parks? What benefits do they offer to other species (either animal or human), and how can we maintain biodiversity? Studying how plants respond to climate across a wide area on many different soil types may provide the clues to determining which species might survive in new places in the future.
- Using case studies at Zion and Bryce Canyon national parks, ecologists modeled how different **fuel-reduction treatments** affect post-fire hydrology. The model can help park managers estimate the effect of such efforts on wildfire severity and post-wildfire runoff or erosion. By predicting the likely results of different treatments, the model can help managers identify the most effective, cost-efficient options available to them.
- All this knowledge is made possible by the sometimes grueling task of routine **long-term monitoring**, which provides the essential information needed to manage parks under changing conditions.

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