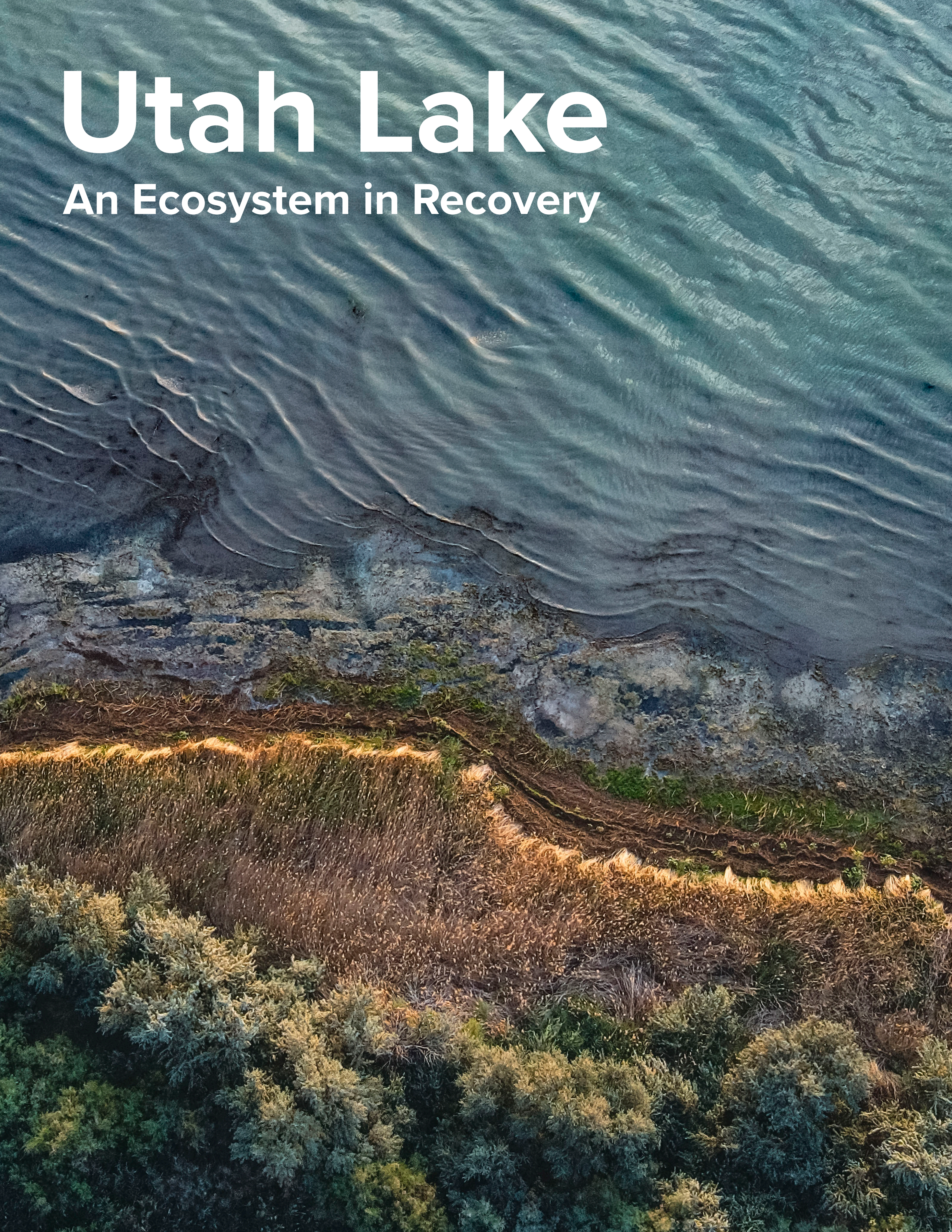
Utah Lake

An Ecosystem in Recovery



Thank you for taking the time to learn about Utah Lake, the unique waterbody at the heart of Utah Valley. Though it is the largest freshwater lake in Utah and a keystone ecosystem in North America, many in our community know little about its history, ecology, and importance to our future.

This desert lake is an island of water in the vast sea of land that is the Great Basin—a home to tens of millions of birds, fish, and other biodiversity. The lake sustained the Timpanogos Nation and their predecessors for thousands of years. When the Mormon Pioneers arrived in the valley, fish from Utah Lake saved them from starvation when their crops failed in the 1850s. Many of us literally would not be here if it weren't for the bounty and generosity of Utah Lake.

After major management mistakes in the 19th and early 20th centuries, we know a lot more about how to care for and rejuvenate Utah Lake. Four decades of collaborative research and restoration efforts are now bearing fruit. Algal blooms are declining, native species are recovering, and people across our valley are rediscovering the beauty, power, and wonder of this remarkable ecosystem.

In this delicate time of recovery and healing, we need your visionary leadership and vigilant participation. Unfortunately, some have tried to politicize and monetize Utah Lake, with one group even claiming without evidence that Utah Lake is broken and rapidly declining. Dangerous proposals being seriously considered could destroy the natural characteristics of the lake with artificial islands and highways.

As researchers and residents of Utah Valley, we have put together this magazine about the science, history, and beauty of Utah Lake. We draw on more than 70 scientific studies and showcase artwork by residents of Utah Valley. To dive deeper, visit utahlake.byu.edu and explore the references at the bottom of the document.

No amount of ecological work can replace the need to rehabilitate our community's relationship with Utah Lake. We call on all people of conscience and principle to help us magnify our sacred stewardship of Utah Lake. We must commit to science-based and culturally-sound restoration and conservation so all future generations can learn and benefit from Utah Lake.

With gratitude and hope,

Benjamin W. Abbott, Isabella Errigo, Andrew Follett, Gabriella Lawson, Mary Murdock Meyer, Haley Moon, Kevin Shurtleff, Joshua J. LeMonte, Mary Proteau, Kristina Davis, Kaye Nelson, Sam Rushforth, Scott Abbott, Weihong Wang, James Westwater, and Kathrine Edgar.

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Why Save Utah Lake?

A VIBRANT OASIS AT THE HEART OF UTAH VALLEY

Utah Lake is a keystone ecosystem and the centerpiece of our community. This spectacular lake provides critical habitat, abundant recreational opportunities, and invaluable ecosystem services such as removing pollution and creating local precipitation. For example, 10 million migratory birds fuel up or nest in and around the lake every year, and our world-class snow depends in part on the evaporation from the lake. Protecting this unique ecosystem is our duty and opportunity to ensure a flourishing Utah Valley for our descendants.

CENTURIES OF SUSTENANCE AND COMMUNITY

People have inhabited the shores of this dynamic lake for more than 20,000 years. Before European contact, there were 13 native fish species, a different plant community, and dozens of native mollusks that created a truly unique and resilient food web. Utah Lake sustained Native Americans such as the Timpanogos Nation and later the Mormon settlers, who would not have survived their first winters without the abundant fish and wildlife. Despite changes to the lake's hydrology and biology, Utah Lake remained the cultural center of Utah Valley with resorts, dance boats, and air tours through the 1900s.

FALSE NARRATIVES ABOUT UTAH LAKE'S PAST AND FUTURE

Utah Lake is one of the most misunderstood ecosystems in our state. Contrary to false claims of pending destruction, Utah Lake is on the road to recovery in many ways. The native June Sucker are rebounding, water flow has been increased by cooperative agreements, and wastewater treatment is reducing nutrient loading. Harmful algal blooms are declining for most of the lake, and ongoing, community-led restoration is enhancing the ecosystem and public access.

CLEAR AND PRESENT DANGER

Some of the misinformation about Utah Lake has been spread intentionally by developers who want to permanently change the lake. Drastic proposals to build islands or causeways would irreversibly damage Utah Lake, costing taxpayers millions and depriving future generations of the lake's beauty and ecosystem services. In this time of dramatic change, we need evidence-based management and legislation to protect and restore this unique, beautiful, and dynamic lake.

PROGRESS AND PRIORITIES

Over the past 40 years, hundreds of projects have contributed to the conservation and restoration of Utah Lake. Wildlife protections, delta restorations, wastewater treatment, and invasive species removal are making measurable progress. Greater support for conservation and research will have big dividends for all the inhabitants (human, fish, and otherwise) of Utah Valley.

Specifically, we recommend:

- Fostering community connection and understanding through education and recreation
- Restoring the lake's natural hydrology by returning more water to its tributaries
- Reducing pollutants by upgrading wastewater treatment and improving nutrient management in the watershed
- Removing invasive species in ecologically sound ways
- Ensuring that development around the lake follows best practices considering long-term quality of life and conservation of natural environments
- Protecting the lake from irresponsible and dangerous proposals that threaten its health and our future

Quick Facts About Utah Lake

Dimensions

Surface area: ~145 square miles (3rd largest freshwater lake in the western U.S.)

Elevation: 4489' above sea level (this "Compromise level" was set by law in 1885 and updated in 1986)

Depth: 9' (average), 18' (maximum)

Watershed size: 2950 square miles

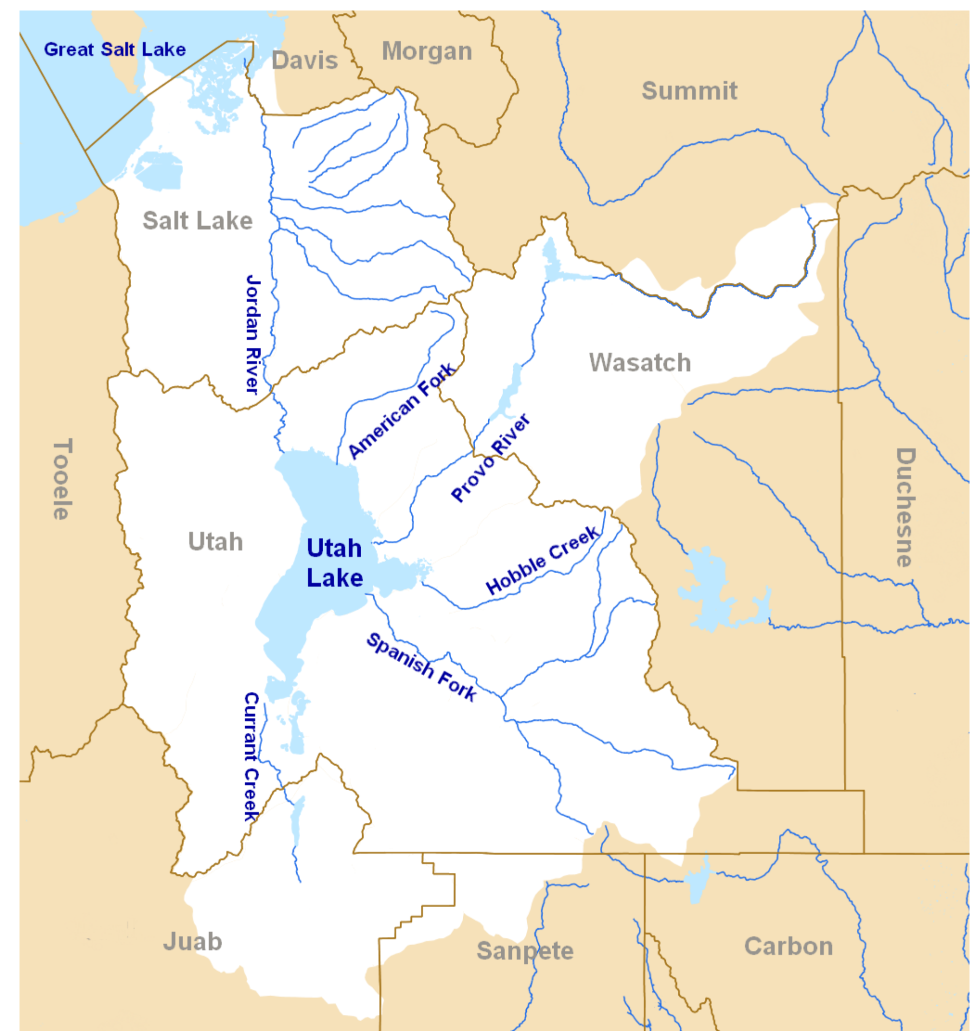
People

First settlement: Unknown, but likely more than 20,000 years ago

Indigenous peoples: The Timpanogos Nation of the Shoshone Tribe, Paiute, Goshute, and Ute

Current population: ~600,000 in the watershed

Projected population in 2050: 1,300,000



Biodiversity

Species:

- 226 birds
- 49 mammals
- 18 fish
- 16 amphibians & reptiles
- over 500 invertebrates
- over 150 algae and cyanobacteria
- over 400 diatoms

Habitat:

- around 30,000 acres of wetlands
- about 10 million fish
- 10 million migratory birds in the corridor

Hydrology

Water volume: 902,000 acre-feet

Water inflow: 930,000 acre-feet/year

- Rivers: 45%
- Groundwater: 41%
- Direct precipitation: 14%

Water outflow: 930,000 acre-feet/year

- Jordan River: 46%
- Evaporation: 38%
- Groundwater: 16%

Water residence time: 6 months

Why Should We Care About Utah Lake?

Utah Lake is more than just a scenic backdrop for selfies, though it does support a growing number of nature and event photographers. This lake is of enormous importance to Utah Valley culturally, ecologically, and economically.

In the vast, arid expanse of the Great Basin (200,000 square miles of landlocked mountains and valleys), Utah Lake is a vibrant oasis of water and wetland. The lake provides habitat for hundreds of invertebrates, 226 species of birds, 49 mammals, 18 fish, and 16 amphibians and reptiles. Its wetlands and shorelines are a major migration corridor for 35 million birds, including cranes, eagles, pelicans, and shorebirds that come from as far as Alaska and Patagonia to nest or feed. The deltas and lakebed are as productive as tropical rainforests per square foot, supporting a dense food web of plants, invertebrates (mollusks, insects, arachnids, etc.), and consumers (fish, birds, mammals, and people).

The lake freely provides ecosystem services that most of us never think about. Utah Lake supports everything from skiing at Sundance, to growing our famous Utah cherries, to enjoying our clean mountain environment. For example, Utah Lake removes hundreds of tons of excess nutrients such as nitrogen and phosphorus from our wastewater, and it processes or stores other pollutants including arsenic, mercury, and sulfur from coal-fired powerplants. Utah Lake regulates our local climate, with its evaporation decreasing summer temperatures and providing a source of moisture for rain and snow in the Wasatch and Uinta Mountains. Additionally, the water in and from Utah Lake protects our air quality by preventing the lakebed from becoming a major source of dangerous dust. This may not sound like a big deal, but areas that have neglected their terminal lakes (lakes without an outlet) such as Owen's Lake in California have ended up spending tens of millions each year to keep down the dust.

Utah Lake provides world class recreational opportunities (check out the Utah Lake Commission's list of 29 things to do at Utah Lake). The number of motor and sailboats on the lake is increasing, and improved access now allows the launching of canoes, kayaks, and rafts along most of the east shore.

Marinas around the lake provide access for boaters who sail, water ski, kayak, windsurf, fish, and hunt. Most fish and birds in Utah Lake are safe to eat, and you can check current consumption advisories. The growing trail system is providing easier access to shorelines and wetlands for all members of our community to spot wildlife, catch fish, paddleboard, or just enjoy the beautiful environment. A large group of professional and amateur photographers work on Utah Lake. Nature, family, and event shoots are extremely popular, with the Utah Lake Photography clubs on Facebook and Instagram claiming nearly 2,000 members.

Many in our valley also recognize the spiritual importance of Utah Lake. These lands and waters were sacred to the Timpanogos Nation and other indigenous peoples as well as the Mormon Pioneers who would not have survived their first winters without the bounty of the lake. Whatever our personal history and beliefs, conserving the unique beauty and functions of Utah Lake reverences these lands and brings our community together.

What is the History of Utah Lake?

THE DEEP PAST

Utah Lake has a long and fascinating geological and human history. For example, if you were standing on the shore of Utah Lake 20,000 years ago, you would be covered by 500 feet of water. At that time, an inland sea named Lake Bonneville covered much of Utah. Tributaries to Lake Bonneville deposited sediment that created a flat valley floor and benches where many of our towns and cities are now built. Like the Utah Lake system today, Lake Bonneville didn't have an outlet to the ocean. Around 15,000 years ago, water levels got so high that the lake spilled into the Snake River Valley in Idaho. In just a few days, much of the lake drained to the Pacific in the second largest known flood in geologic history.

The drier climate after this Bonneville Flood resulted in the lake eventually shrinking until only the Great Salt Lake, Utah Lake, and Sevier Lake remained. From about 5,000 years ago until the 1800s, Utah Lake has fluctuated around its current elevation of 4,500' above sea level.

THE PEOPLES OF UTAH LAKE

The Utah Lake area has been a crossroads of humanity for at least 12,000 years. That's when the Clovis people populated parts of the Great Basin. Later, the Fremont and Numic peoples (ancestors of the Shoshone and Paiute) were joined in about 1400 AD by the Athapascans (ancestors to the Navajo and Apache tribes). Until the end of the 1800s, the Utah Lake area was primarily inhabited by the Shoshone, Paiute, and Goshute peoples.

The first contact with Europeans is believed to have occurred in 1776, when Father Silvestre Velez de Escalante passed through

Painting of Chief Walkara by Solomon Carvalho (1854)

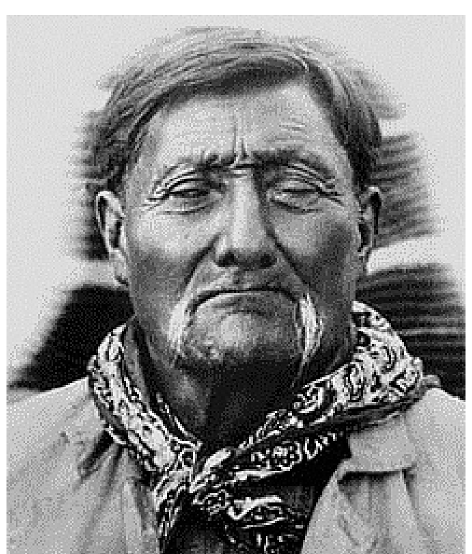
Utah Valley. The Snake-Shoshone Timpanogostzis Nation (hereafter Timpanogos Nation) inhabited a large portion of central and eastern Utah at that time, led by Chief Turunianchi. The Timpanogos and associated bands likely numbered 70,000 or more and often congregated around Lake Timpanogos, now known as Utah Lake. Lake Timpanogos was described as an oasis because of the abundant freshwater fish, water birds, and other wildlife that occupied its shallow waters, wetlands, and river deltas. The abundant reeds around and within the lake were known as Eu-tah, potentially the origin of the name Utah. Young reeds were used for weaving, and mature reeds were used to make arrows. Though the Timpanogos are often mistakenly referred to as Ute, they are a part of the Shoshone Tribe.

In 1847, Brigham Young arrived with the Mormon Pioneers in the Salt Lake Valley. The seven grandsons of Chief Turiunachi led the Timpanogos at that time, including Chiefs Sowiette, Walkara, Tabby, and Sanpitch.

In 1849, Young sent settlers south to establish Fort Utah on the banks of the Timpanogos River—now known as the Provo River. After only a few months of cooperation, relations between the Mormons and the Timpanogos soured. In January of 1850, three Mormon settlers murdered a Timpanogos man known as "Old Bishop" after accusing him of stealing a shirt. Fearing the response of the Timpanogos and Brigham Young, who had warned the settlers not to engage in violence, the men dumped Old Bishop's body in the Provo River. When he was found, the Timpanogos retaliated by stealing and killing some of the settlers' livestock.

After repeated letters and visits to Salt Lake, the settlers at Fort Utah eventually convinced Brigham Young to send the militia to exterminate any hostile Timpanogos men, though they did not disclose their murder of Old Bishop, which had instigated the conflict. The years of violence that followed are called Walkara's War. The Timpanogos Chiefs and many others negotiated and fought to protect their homeland and people, eventually resulting in a temporary peace agreement with Young.

A period of relative peace ensued between the Timpanogos and Mormon settlers. During crop failures in 1855-1856, fish from Utah Lake saved many settlers from starvation in both the Utah Valley and Salt Lake Valley.



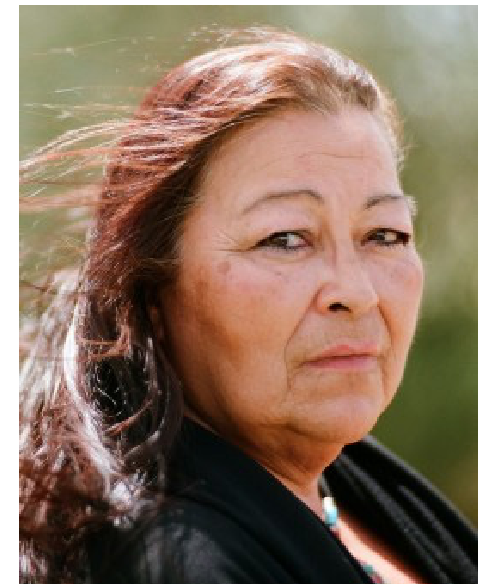
Photograph of Chief Tabby, who negotiated peace in 1867 (late 1800s).

In 1865, tensions escalated again in what is called the Black Hawk War, which resulted in the death of hundreds of Native Timpanogos. There were brutal encounters throughout Utah Valley and the surrounding area. Chief Tabby eventually negotiated a peace treaty with Joseph Stacey Murdock, the local leader of the Mormon settlers who took and later married Secunup, the daughter of Chief Aeropean. Chief Tabby led the Timpanogos to join the Northern Shoshone in the Uinta Valley Reservation, which had been created by President Abraham Lincoln in 1861.

In the decades that followed, the Timpanogos were largely forgotten. In the 1880s, four Ute Bands were relocated to the Uinta Reservation, where they were recognized as the Ute Indian Tribe. Because the Timpanogos had been referred to as Utah Indians, many mistakenly assumed they were a part of the same group. The Timpanogos Nation lives to this day on the Uinta Valley Reservation and throughout Utah. They are led by Chief Executive Mary Murdock Meyer, who is a contributor to this article and the great great great granddaughter of Chief Walkara on her mother's side and Chief Aeropean on her father's side.

GROWING POPULATION AND GROWING PRESSURE

In the following century, Utah Valley saw rapid growth and change. Widespread agriculture and a growing population led to ditches, canals, and eventually the rerouting of the entire Provo River from Provo Bay to the northwest, where it currently enters Utah Lake. There were diversions in all the major tributaries to Utah Lake (Provo, Spanish Fork, American Fork, Hobble Creek, Benjamin Slough, and Currant Creek). Some tributaries became seasonally dry (Provo River) or permanently disconnected from the lake (Hobble Creek). As the water flow to Utah Lake decreased, the pollution delivery skyrocketed. Sewage, industrial, and agricultural runoff from the surrounding cities and farms added



Chief Executive Mary Murdock Meyer, leader of the Timpanogos Nation

nutrients, pesticides, metals, and other pollutants. These contaminants were dumped directly in the lake or were transported there by rivers and groundwater.

In addition to the loss of water and increase in pollution, overfishing was causing large declines in the native fish populations. Up to that point, Utah Lake had been an incredibly productive fishery. After the completion of the Transcontinental Railroad—which enabled rapid transport of live fish—the settlers started introducing new species in an attempt to rejuvenate the commercial and subsistence fishery of Utah Lake. Black bullhead catfish were introduced in 1872. In 1883, there was an initial release of 200 baby common carp. Largemouth bass followed in 1890. Some of these fish did reproduce rapidly, but they put pressure on the native species, permanently changing the lake's food webs. The intentional or accidental introduction of plants such as phragmites and salt cedar further changed the ecosystem.

Through all this change, Utah Lake remained important culturally, economically, and ecologically. Native and introduced fish species were a major food source and the lake was the center of community activities. Resorts sprung up around the lake, including pavilions, a dance boat, horse tracks, and performance halls (for details about this period, check out the Utah Lake Legacy film produced by the June Sucker Recovery Implementation Program). In the 1900s, recreationalists took to the lake in sailboats, motorboats, and even airplanes.

ROCK BOTTOM

The darkest period ecologically for Utah Lake arguably occurred during the Dust Bowl of the 1930s. The lake level dropped 12 feet because of persistent drought conditions and new water diversions (including the world's largest pumping station at the time). Except for a few pools, Utah Lake was reduced to a dry lakebed. With no water in the lake, the Jordan River (Utah Lake's sole outlet) stopped flowing, cutting off irrigation for much of Salt Lake County. The Utah governor drove a pickup truck across the lakebed to inspect the situation, declaring a state of emergency. The temporary loss of the lake modified local climate and devastated agriculture and property values in both Utah and Salt Lake counties.

Together, the loss of water, increase in pollution, and introduction of invasive species caused permanent damage to the lake's biodiversity. The Utah sculpin went extinct and 10 other native fish were extirpated (eliminated locally). Native mollusks and plants were also extirpated or pushed to extinction, triggering major changes in the aquatic and terrestrial environment that make up the Utah Lake ecosystem.

THE RIVER TO RECOVERY

After the trauma of the lake drying out, management and governance of the Utah Lake watershed changed course. Limits on diversions were implemented and projects to measure and manage river flow were put in place. Coordination among communities increased with the creation of major water projects, including some that piped in water from the Colorado River basin, which is just to the southeast of the Utah Lake watershed. As the population grew, both state and federal regulation of water quality led lakeside communities to start treating their wastewater in the 1950s, reducing nutrient pollution to the lake.

These conservation and restoration efforts got a huge boost in the 1980s when the June Sucker—one of the last surviving native fish—was recognized as an endangered species. Listed in 1987, there were only a few hundred June Sucker remaining in the lake. The endangered status led to greater funding and the creation of a comprehensive restoration plan that involved regulators, water users, developers, wastewater facilities, and fisheries across the state.

In 1999, nine local, state, and federal organizations agreed to a comprehensive program to restore habitat and protect the June Sucker. Working collaboratively, water flow was restored to the Provo River, Hobble Creek was reconnected to the lake, nutrient standards were tightened for wastewater, and ongoing habitat restoration improved the quality and amount of healthy lakeshore and lakebed. Because of this progress, the June Sucker was downlisted from endangered to threatened in 2021.

Harvest of June Sucker and other native fish from the shore of Utah Lake in 1855.
Courtesy of the June Sucker Recovery history.

Who Owns Utah Lake?

The State of Utah is legally responsible to manage Utah Lake. The Utah Division of Forestry, Fire, & State Lands (FFSL) is the agency tasked with overseeing the lakebed. Lands, lakebeds, and riverbeds protected by the state in this way are referred to as sovereign lands. The state holds and manages sovereign lands according to the public trust doctrine, a legal principle that has been established by multiple sources, including the Utah Constitution, state legislation, state common law, and possibly federal constitutional law. The public trust doctrine requires Utah to act as a trustee to hold the lake for the benefit of all Utahns—present and future. However, the state's authority and responsibility to protect Utah Lake in this way have been challenged multiple times in recent history.

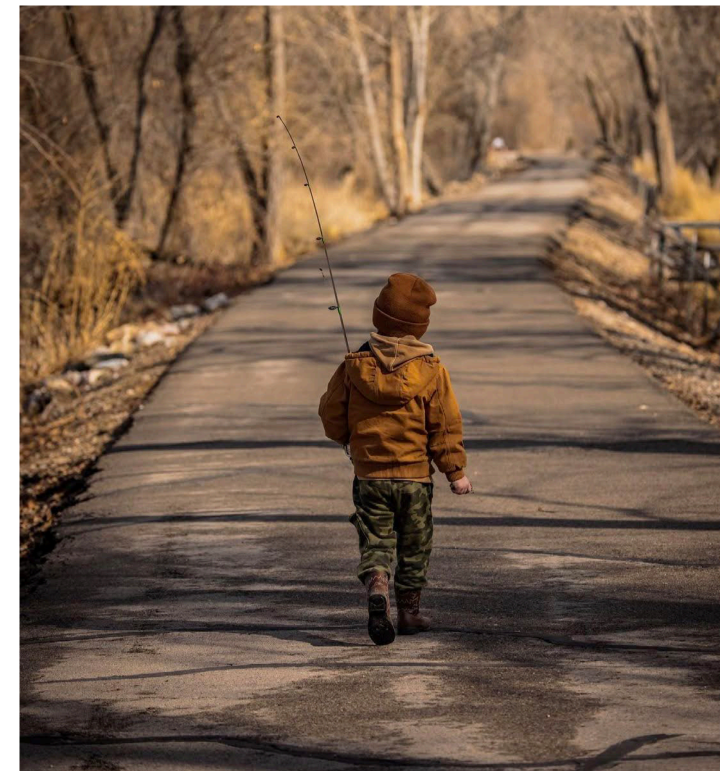
During the 1970s oil crisis, the U.S. federal government issued oil and gas leases for drilling underneath Utah Lake. Local citizens and lawmakers were alarmed that this could cause pollution and permanent damage to the lake. The Utah government filed a lawsuit that was finally decided in the U.S. Supreme Court in 1987. The Supreme Court upheld Utah's responsibility and right to the bed of Utah Lake, reaffirming that Utah acquired the lakebed and other sovereign lands at statehood under the equal footing doctrine.

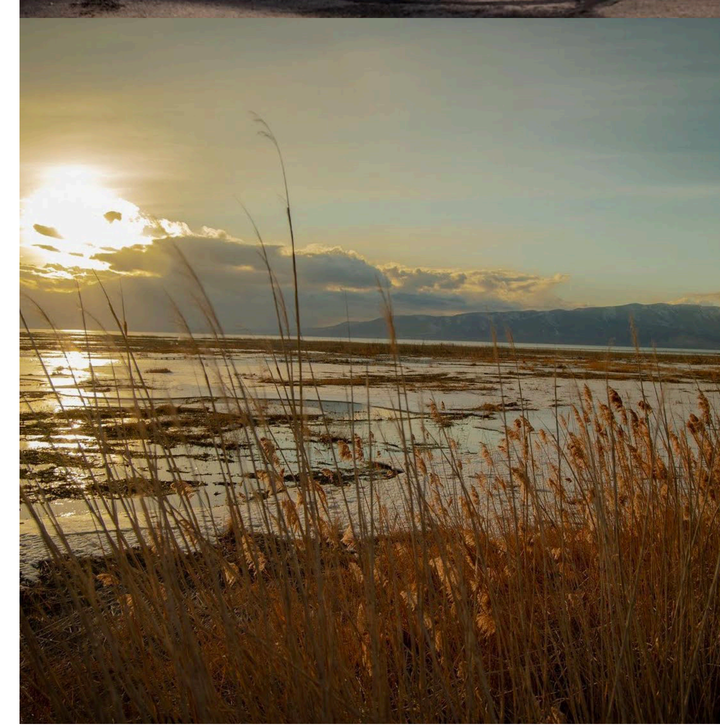
Disputes over Utah Lake and other nearby waterbodies have further clarified legal responsibility. In 1990 the Utah Supreme Court ruled that the "essence of [the public trust] doctrine is that navigable waters should not be given without restriction to private parties and should be preserved for the general public for uses such as commerce, navigation, and fishing." The court specified that even leasing of these lands can be invalidated. A 2019 ruling by the Utah Supreme Court specified that "the abdication of the general control of the state over lands under the navigable waters of an entire harbor or bay, or of a sea or lake. . . is viewed as a gross infringement of the public trust doctrine."

The most overt and effective challenge to the public trust doctrine started in 2017. A limited liability company wanted to build 20,000 acres of artificial islands within Utah Lake. The company—misleadingly named Lake Restoration Solutions—proposed to destroy the lake's natural characteristics by creating deeper channels, disturbing healthy sediment, altering water circulation, and killing all the fish in the lake. They claimed that this "restoration" was necessary because of nutrient-laden sediment, despite multiple lake coring studies that have shown Utah Lake's sediment has natural levels of nutrients (see the section on dredging). They proposed to pay for the radical reengineering of the lake by selling real-estate on their artificial islands, where they planned to house up to 500,000 people.

In 2017, the company pitched the islands plan to state legislators and lobbied them to pass a law allowing the transfer of the lakebed to a private corporation. In January of 2018, Representative Mike McKell of Spanish Fork introduced the Utah Lake Restoration Act (H.B. 272), which would allow the state to dispose of sovereign lands in exchange for "comprehensive restoration" of the lake system. Despite the law's clear constitutional problems and the infeasibility of the island proposal, H.B. 272 passed with overwhelming support in both the house and senate. This law—now codified as U.C.A. § 65A-15—hasn't yet been tested in court, but if the legislature attempts to transfer large portions of the lakebed to private parties, they would almost certainly run into legal barriers. For example, the transfer must not interfere with the existing public trust doctrine, and it would be reviewable by the state courts, who have previously policed the doctrine quite strictly. Though the financing, legality, and ecology of the island proposal are dubious at best, the proposal remains at large (see section on threats to Utah Lake).

In addition to the public trust doctrine in state law, several federal environmental statutes regulate changes to lake management. The National Environmental Policy Act (NEPA) requires thorough environmental assessments before large engineering projects could move forward. NEPA specifically mandates an environmental impact statement (EIS), which takes an average of 4.5 years to complete. Given its unprecedented scope, a massive ecosystem engineering proposal like the islands project should be expected to be among the longest ever NEPA processes, potentially lasting more than a decade or two. Additionally, dredging or filling Utah Lake or adjacent wetlands would require deniable permits and significant study under U.S. law (33 U.S.C.A. § 1344). Any action that may affect endangered or threatened species, such as the June Sucker, would require consultation and input from still more federal agencies, and actions seen as too risky may be precluded by certain Endangered Species Act provisions (16 U.S.C.A. § 1536(a)(2)).






What Are the Biggest Threats to Utah Lake?

Though many aspects of the Utah Lake system are improving, there are real threats ahead. The most immediate are proposals to create artificial islands and to form a Utah Lake Authority patterned after the Inland Port Authority.

The proposal to create giant islands across a fifth of the lake surface alleges to be an all-in-one solution for all of Utah Lake's problems. The developers claim they would remove all invasive species, create a deep and clear lake, and increase available water for the valley. In reality, this proposal would change the nature of Utah Lake so drastically our ancestors wouldn't even recognize it. The problems with this project have been enumerated in detail elsewhere, including these two op-eds from when the proposal first came to light in 2018: The present, future and past of Utah Lake and Keep Utah Lake shallow and wet. Briefly, this project depends on a false pretense that the lake is dying, it ignores virtually everything we know about the lake's ecology, and it would blast a cultural crater so deep in the heart of our community that our ancestors and children would never let us rest. Ecologically, this proposal would remove all three of the natural protections that make Utah Lake resilient to nutrient loading (cloudy water, evaporative precipitation of nutrients, and a shallow and wide bathymetry—see the section on algal blooms).

More generally, these kinds of "moonshot" mega projects with outside investors have been proposed before. Right here in Utah Valley, we flirted with the idea of a ski resort behind Y Mountain for more than 30 years. The investors never showed up and the proposal ended with nothing but bankruptcy and a heap of wasted taxpayer dollars to show for it. These large miracle solutions are always just what they seem: too good to be true. True ecological restoration takes scientific evidence, community engagement, and persistent collaboration.

The Utah Lake Authority proposal is more complex. The stated goals of increasing resources available for restoration are justified. However, the draft legislation which failed this year did not involve local cities and water users in its design and approach. With revision, there could be improvements to the governance of Utah Lake. However, if the proposal is just a smokescreen for the islands project or destruction of wetlands around the lake, it should be opposed.

There are other threats to Utah Lake beyond islands and legislation. Population growth and development around the lake could threaten habitat and increase nutrient loading. Unless development is done wisely and strategically, things could get worse for Utah Lake in a big way. Protecting the lake from major modifications such as causeways and islands is the most conservative and safe pathway forward. For example, the causeways built across the Great Salt Lake triggered unexpected changes in the lake's hydrology and biogeochemistry, leading to economic damages and the most toxic concentrations of methylmercury ever observed. On the other hand, smart development coupled with conservation of sensitive areas could be a boon for the lake. If water is returned to the lake's tributaries and nutrients are removed from wastewater via enhanced treatment, growth is not incompatible with a vibrant and recovering Utah Lake.

Another serious threat for Utah Lake is climate change. We are currently in the most extreme megadrought (>10-year dry period) in the last 400 years and likely in the past 2,000 years. This megadrought is attributable to human disruption of the climate. Looking into the future, climate models project that the Utah Lake watershed will continue to receive approximately the same amount of precipitation as in the past. However, this precipitation will be less consistent, and there will be a shift from snow to rain. At the same time, increased evaporation and demand for irrigation water in the warmer temperatures will result in less water available to sustain Utah Lake and the downstream Great Salt Lake. We need to be looking ahead and working on climate solutions now to ensure that our lake can continue to thrive in the future.

The final threat to the lake is societal apathy and disconnection. There are rampant misconceptions about Utah Lake, including beliefs that the lake is toxic, poisoned, or drying out. These beliefs have stopped many in Utah Valley from visiting and caring about Utah Lake. We can each do our part by visiting the lake and sharing our love of it with our neighbors and leaders.

Is Utah Lake Getting Better or Worse?

This is one of the most important and complex management questions. Unsurprisingly, the answer is it depends on what you are talking about.

Let's start with the harmful algal blooms (see the section on blooms for more detail). You may have recently heard about the blooms that affect parts of Utah Lake most years. Increased public awareness of blooms is a good thing, but it's important to remember that this does not mean blooms are a new or worsening problem. Over the past 35 years, the overall amount and duration of blooms have decreased, likely due to restoration of water flow to the lake and improved wastewater treatment. However, blooms in Provo Bay and on the east shore are persistent hot spots with blooms occurring in 30 of the last 34 years. Because the trails and marinas along the east shore are where most people interact with the lake, there is a widespread belief that things are getting worse. This is reinforced by the fact that when a bloom appears, it gets a lot of media attention, but when a bloom disappears (usually just a week or two later), most people never hear about it. Continued reduction in wastewater, urban, and agricultural nutrient sources combined with increased water flow will accelerate the decrease in blooms.

While we cannot bring the many extinct Utah Lake species back from the dead, we can establish more natural water quantity and quality to restore some of the extirpated (locally eliminated) species and work to manage the invasive species such as carp and phragmites. The invasive species removal programs have made real progress—removing millions of tons of fish and cutting down hundreds of acres of phragmites. However, invasive removal is an uphill battle. There are virtually no examples of the complete elimination of invasive species from an area as large as the Utah Lake watershed. We can reduce numbers, but it is likely impossible to completely remove the carp and phragmites that now inhabit our lake.

This is not completely a bad thing, because both of these species provide ecosystem services, including collecting and removing nutrients and other pollutants, and serving as habitat and food for other species.

Talking about habitat and wildlife, the story is more straightforward. The restoration efforts surrounding the June Sucker and other species have been extremely successful. Minimum fish flows have been established for Provo River and Hobble Creek, creating access to habitat even during the worst drought years. Likewise, large areas of wetland and delta habitat have been created or protected, and this is only increasing with current conservation projects. Fish, birds, and the people who love them are very happy with the notable improvements in the Utah Lake ecosystem over the past few decades.

There is another dimension of Utah Lake that is perhaps as or more important than the ecology and hydrology: our community's relationship with the lake.

Thirty years ago, it was very common to spend time on and around Utah Lake. Many of us grew up swimming, fishing, waterskiing, and camping around Utah Lake. Even though the ecological status of the lake is better today than it was then, many people have negative attitudes towards the lake and visitation has dropped substantially. This has led to calls to dredge the entire lake, make radical changes to governance, or even cover it with artificial islands. These extreme proposals are a symptom of our loss of connection and understanding with this beautiful waterbody. One of the most important things we can do for Utah Lake is to talk about it, share our photos, and invite our friends to discover this unique ecosystem.

Does Utah Lake Need to be Dredged?

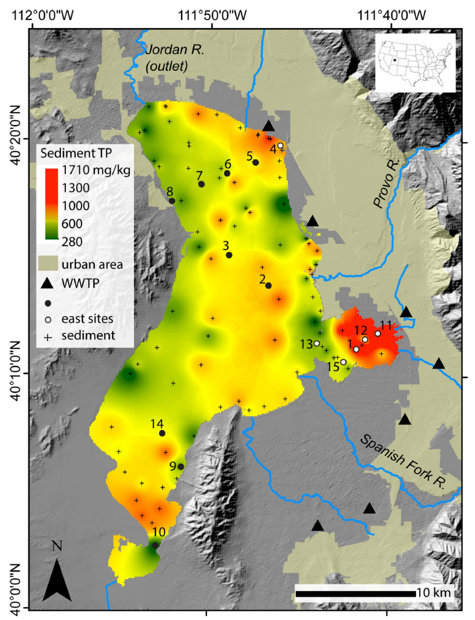
If you've ever talked about Utah Lake on social media, chances are someone proposed to dredge the lake and "start over." There is something intuitive and attractive about this argument, but as usual, the reality is much more complex. Before getting into the nitty gritty details of dredging, let's look at the unique geology and sediment of Utah Lake.

The silt, clay, gravel, and cobbles below Utah Lake go very deep. There is potentially up to 10,000 ft of unconsolidated sediment underneath the lake. This material and the bedrock under it are dissected by multiple seismically active faults. This is one reason Utah Lake has so many springs.

People often assume that the lakebed is polluted with nutrients and that the lake is filling up with sediment. Both these beliefs are incorrect, or at least incomplete. Like most waterbodies, Utah Lake does contain both natural and human-derived compounds that can be dangerous. However, multiple studies have shown that the lakebed has natural levels of phosphorus and very low levels of other pollutants in the sediment.

Concerning the claim that Utah Lake is filling up with sediment, this is technically correct, but the question is, how quickly? Rates of sedimentation (accumulation of material on the lakebed) are extremely slow, ranging from 1 to 2 mm a year. This means that it takes around 25 years for the lakebed to rise an inch, which is very similar to the deposition rate of the past 10,000 years based on lake core studies.

Another common misconception is that the Geneva Steel mill and wastewater outflows have permanently polluted the lake. The mill operated from 1944 to 2001 and did produce air, soil, and water pollution, mainly from the coal used in the steelmaking. Ongoing restoration efforts in Vineyard and the surrounding area are cleaning up contaminated soil and groundwater.



Randall et al., 2019

Thankfully, heavy metal concentrations in lake water and sediment are generally low. For example, lead concentration in three sediment cores ranged from <10 mg/kg below 30 cm and ~40 mg/kg near the surface. Likewise, copper and zinc concentrations ranged from 10 mg/kg to 100 mg/kg (Williams, 2021). These levels are well below the EPA's limits of 420 mg/kg for lead, 4300 mg/kg for copper, and 7500 mg/kg for zinc. While there is still work to be done, Utah Lake's healthy sediments can be attributed to the lake's natural characteristics and improved management of pollutant sources in its large watershed.

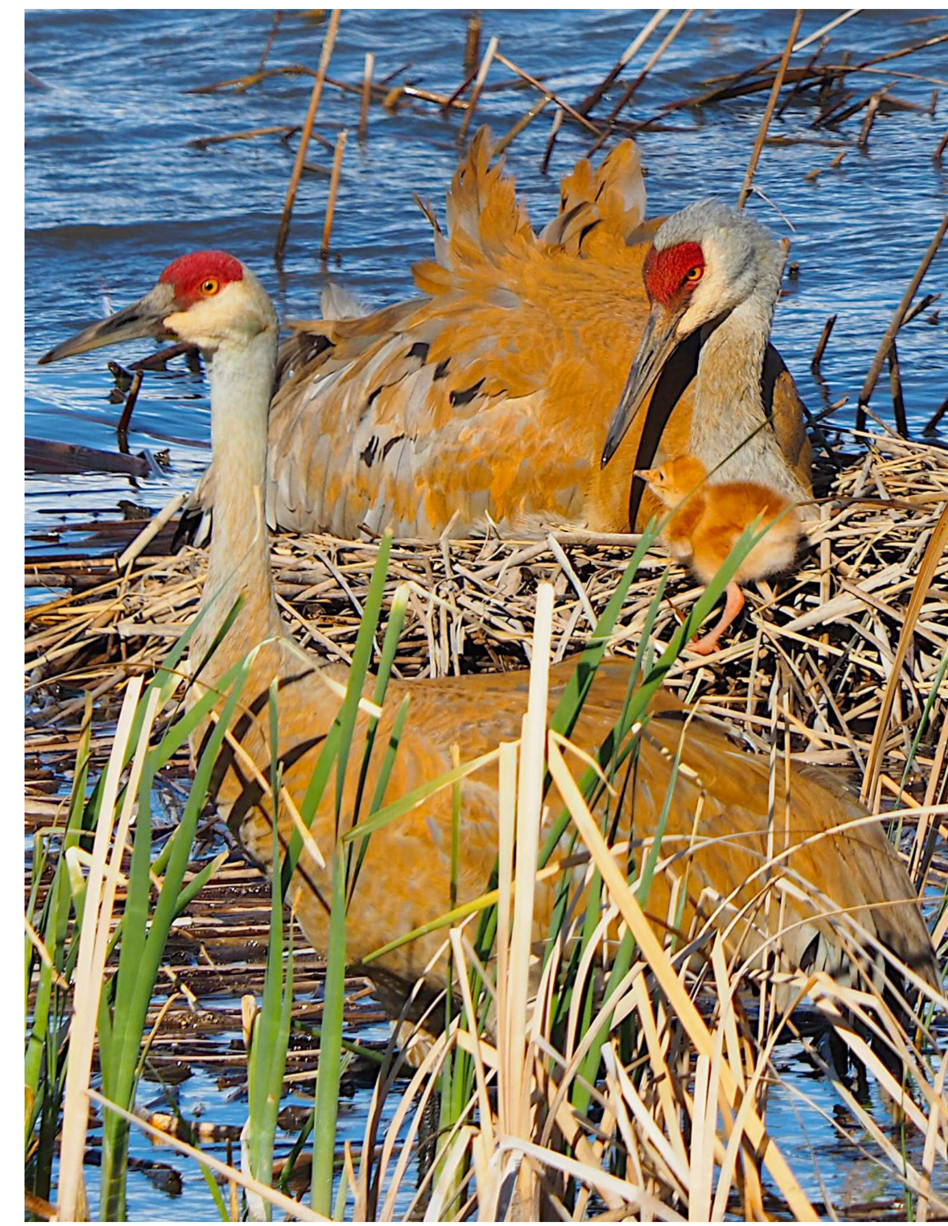
Now that we have some background, let's talk about the proposals to dredge Utah Lake. Dredging is the excavation of material from an underwater environment. It is most often used in marine environments such as ocean ports to keep channels open for large ships. Environmental dredging is the targeted removal of material contaminated with persistent pollutants that pose a risk to human health or the environment. While lakebed sediments are extremely effective at removing or immobilizing most pollutants, there are some "forever chemicals" that can require mechanical cleanup.

Whether for navigation or environmental cleanup, dredging has serious downsides. First, it damages the community of organisms in and on the lakebed. Benthic (bottom-dwelling) microorganisms have amazing abilities to remove or immobilize pollution, including excess nutrients, organic pollutants, and some harmful metals. The benthic community plays such an important role in purifying the lake water that it is often described as the lake's liver. This is an important reason why Utah Lake's sediments are in such good shape despite decades of nutrient loading from wastewater. Dredging can damage the microbial community and alter the water flow through the sediment, decreasing nutrient removal by the lakebed and therefore increasing nutrient levels in the water column. Consequently, the use of dredging to remove excess nutrients is rare and controversial.

Another problem with dredging is that it can unearth natural and artificial pollutants that were safely stored in the sediment. Lakes receive large amounts of dissolved and particulate material from rivers, groundwater, and atmospheric deposition. Most of this material is harmless or even beneficial, such as the sediment and natural nutrients that support the lake's habitat and food webs. However, potentially toxic chemicals also make their way into lakes including mercury and other heavy metals from coal burning and gold mining, arsenic and selenium from groundwater, and a host of human-made compounds such as persistent organic pollutants and petroleum products. Biological and chemical processes in the lake water and sediment can deactivate, break down, or bury most of these pollutants. However, many pollutants are sensitive to changes in oxygen, and dredging can trigger large releases that can last for years or decades. Except for rare cases of extreme pollution, the best practice is to allow sediments to naturally stabilize pollutants in the lake while working to eliminate external sources. In time, contaminated material is further protected as it is covered by clean sediment, a process called natural capping.

While most discussion of dredging revolves around removing pollutants, there are proposals to dredge Utah Lake for recreational and development purposes. This is problematic because deepening the lake would destroy the distinct hydrology and biogeochemistry that make it resilient. A deeper lake, divided into multiple basins, would quickly stratify (separate into layers due to temperature and salinity), potentially creating an anoxic dead layer that kills animal life in the water column and lakebed. These changes in oxygen could trigger the release of nutrients and toxins from the sediment, with reactive phosphorus and methylated mercury being of particular concern. We should be extremely cautious before changing the fundamental characteristics of this unique water body. In other wide and shallow lakes, including the Great Salt Lake, the construction of channels, causeways, or islands has created a suite of expensive and damaging unintended outcomes.

There are also legal, financial, and technical barriers to dredging Utah Lake. Because it is expensive and environmentally damaging, dredging is carefully regulated by multiple state and federal laws (see section on who owns Utah Lake). The environmental impact statement for a project as large as dredging Utah Lake would likely take decades. It would also be the largest and most expensive freshwater dredging project in the history of the world. The Hudson River Cleanup is the largest freshwater dredging project in the U.S., with 2.7 million cubic yards of sediment removed over 10 years. According to the proponents of the artificial island project, dredging Utah Lake would require approximately 1 billion cubic yards of sediment to be removed. That would make the project 370-times larger than the already enormous Hudson River project. This could easily cost $10 billion while providing no ecological benefit to the lake system.



Rather than dredging, we should prioritize reducing pollutant delivery to Utah Lake, preserving a healthy microbial and invertebrate community in the lakebed and lakeshore, and protecting the natural sediment structure.

What Was Utah Lake like Ecologically Before European Settlement?

We are still learning a lot about the ecological history of Utah Lake, but what we do know provides important context for current conservation and restoration efforts.

One of the biggest changes in the lake is the loss of native species and the introduction of invasive ones. Virtually every group of plants, animals, and microorganisms have been affected. Only two of the original 13 native fish species survive in Utah Lake, and the loss of native mollusks (snails, mussels, and clams) continues to this day. Combine this with changes in both water and land plants, and Utah Lake is a very different ecosystem than the Native Timpanogos would have experienced!

Fifteen non-native fish species, including carp, walleye, bass, catfish, and most recently pike have become established in the lake, where they now eat other fish or disturb the lakebed. Likewise, the non-native common reed phragmites was introduced as a decorative plant, but it now dominates many of the waterways and lakeshores around Utah Lake. These changes in ecological community have fundamentally changed how Utah Lake works. Despite what we see in movies, both extinction and the establishment of invasive species are effectively permanent.

The historical clarity of Utah Lake is a point of controversy and continued research. While lake cores do suggest that there was a shift in lake clarity in the 1960s or 1970s, two factors suggest that Utah Lake has always been relatively cloudy. First, the unique hydrology of the lake causes the constant formation of calcite in the water, which removes phosphorus and creates a unique milky color. These processes protect the lake from nutrient pollution and are caused by evaporation, which concentrates minerals in the lake water (think of hard water scale deposits on a boiling pan). Second, because Utah Lake is so large and shallow, wind action can easily stir up sediment from the lakebed. However, it is likely that Utah Lake was somewhat clearer in the past than it is today for several reasons:

1. There was greater water flow to the lake through rivers
2. There were no carp
3. There was more submerged vegetation that could prevent waves and sediment mixing along the lakeshore
4. There were native mollusks that filtered the water.

Even at that time, the lake was likely a beautiful milky or muddy color for much of the year, except for during snowmelt and periods of little wind when clams and other bivalves could filter the water.

The hydrology of Utah Lake was very different before the water projects of the 1900s. The lake level used to fluctuate more depending on the time of year and amount of snowmelt. Being a large shallow lake, small changes in water level translated into a dynamic shoreline and system of wetlands around much of the lake. Humans now control the amount of water getting to the lake—diverting much of the natural flow and importing water from outside of the basin with pipelines and tunnels. This has the advantage of providing water during drought years and protecting human buildings around the lake, but it comes at the cost of degrading habitat and harming species that depend on natural fluctuations in water flow.

One thing that hasn't changed substantially is the depth of the lake. Utah Lake has always been shallow. Its bathymetry (underwater topography) was determined by Lake Bonneville, which deposited thick sediments that now make up the living lakebed. Despite claims that Utah Lake used to be deeper, analysis of sediment cores show it has always been a huge and shallow waterbody (see section on dredging for more detail).

Why does Utah Lake Have Algal Blooms?

THE GLOBAL NUTRIENT OVERLOAD

Like many waterbodies in the U.S. and globally, Utah Lake has been overfertilized, creating a condition called eutrophication. Almost everything humans do—from growing food to using fossil fuels to flushing the toilet—adds nutrients to the environment. Because of this global nutrient overload, approximately 2 in 3 freshwater and estuarine ecosystems worldwide are experiencing various levels of eutrophication. When an ecosystem is overfertilized or eutrophic, there can be an overgrowth of algae and cyanobacteria (another family of photosynthesizers). Besides being unsightly, these blooms can be harmful in two ways. First, the cyanobacteria can produce powerful toxins that can sicken people and animals who are exposed to the water. Second, the overgrowth can create so much organic material that oxygen gets depleted in the water, creating a dead zone where no fish or other animals can survive.

Given the amount of nutrients in Utah Lake, it is classified as hypereutrophic—the highest award in a contest you don't want to win. However, Utah Lake only experiences occasional blooms usually only over a portion of the lake. In fact, Utah Lake was just ranked in the lowest category of algal bloom severity and persistence by a nationwide satellite study this year—cleaner than many lakes and reservoirs in Utah. If Utah Lake is hypereutrophic, why doesn't it have more frequent and severe blooms?

The answer is that the characteristics of Utah Lake make it extremely resilient to algal blooms. Three factors prevent the lake from looking like pea soup year-round. First, the cloudy water of the lake limits light availability, slowing growth of both algae and cyanobacteria below the lake surface. Second, the high rate of evaporation causes constant formation of calcite, which scrubs nutrients from the water or make them difficult for the algae to use. Third, the shallow and wide bathymetry of the lake means that even when blooms occur, they don't create a dead zone because the water is so well mixed. The shallow, well-mixed water also limits the release of phosphorus and other pollutants from the sediment, which become mobile when oxygen is depleted (see section on dredging).

Ultimately, the characteristics that people complain about the most are some of Utah Lake's most important assets!

SOURCES OF NUTRIENTS IN THE UTAH LAKE WATERSHED

So where are the nutrients coming from? Congratulations, you just asked the most controversial question about Utah Lake! It is true that we still have a lot to learn about nutrient cycling in Utah Lake, and we need continued research. However, there is an emerging picture of where nutrients come from and how they affect the lake system.

More than a decade ago, the Utah Division of Water Quality commissioned a comprehensive study of Utah Lake nutrients to answer this question. They found that 77% of the phosphorus came from wastewater treatment plants, with the remaining portion coming from agricultural and urban runoff and natural sources. Like any research project, this study had its limitations, for example, it didn't measure stormwater inputs into the lake. Predictably, some people and organizations challenged the finding that nutrients are mainly from wastewater, and the debate has been raging ever since. Some have claimed that dust deposition from the West Desert or nutrient release from the sediment are much more important than nutrients from human wastewater. The scientific process requires people to challenge each other, so

these alternative explanations are actually very useful. Let's test them against the available evidence.

First, it's important to know that not all nutrients are created equal. The total amount of phosphorus or nitrogen in the water can be much larger than the fraction that is available for algae and cyanobacteria. Additionally, many forms of nutrients are bound up in organic materials or protected by mineral compounds. It is only the free and reactive nutrients (such as phosphate, nitrate, and ammonium) that can easily be used by algae and cyanobacteria. It is true that dust and river water are often high in total nutrients because of the types of rocks in our mountains, but these natural sources are usually very low in reactive nutrients. This has been confirmed by several studies, including a large citizen science project that collected samples from nearly all the waterbodies in the watershed. On the other hand, wastewater outflows contain the yummiest imaginable nutrients in wonderfully clear water—a perfect recipe for a bloom.

More convincingly, there is a distinct human fingerprint where the blooms are occurring. While blooms are infrequent and have actually decreased for most of the lake over the past 35 years, there are persistent hot spots in Provo Bay and the east shoreline where wastewater treatment plants discharge into the lake. If dust or the natural sediment were causing the blooms, we would expect a consistent pattern across the whole lake, or even more powerful blooms on the west and south side of the lake where there is more evaporation and dust.

But are we sure that reducing wastewater nutrients would help? This is likely the second most controversial question about Utah Lake! Some people have claimed that because nutrient levels are so high in the lake, even if we reduced human inputs, it wouldn't make any difference. Like the dust and sediment arguments, this is a reasonable hypothesis, but it isn't supported by the evidence. A series of nutrient addition and removal experiments just finished last year have definitively shown that nutrients are the factor that limits blooms throughout the year in all portions of the lake. This likely comes back to the total versus reactive nutrient question. While Utah Lake is high in total nutrients (TP and TN), the available fraction of those nutrients is low enough to limit the initiation and spread of blooms for most of the year.

WHAT CAN WE DO TO REDUCE THE BLOOMS?

If nutrients are causing the blooms, what is the best way to reduce nutrient availability in the lake? You can now shout controversy BINGO because this question is just as contested as the last two! If you express nutrient concentration in Utah Lake as a mathematical formula, you'd get something like this:

$$\textit{Nutrient Concentration} = \frac{\text{(Nutrient input to the lake — nutrient removal in the lake)}}{\text{Water flow to the lake}}$$

Even if you don't love math, you can hopefully see that there are multiple ways of reducing nutrient availability. First, we could continue working with farmers and cities to reduce water use, allowing more natural flow to the lake. Second, we could lower nutrient inputs by improving wastewater treatment, reducing stormwater inputs, and improving agricultural practices. Third, we could enhance nutrient removal processes by restoring wetlands, protecting the lakebed, and dismissing any proposals that would reduce evaporation such as building islands. Fourth, we could continue researching nutrient cycles in the lake and testing targeted interventions in high-risk bays and marinas, such as localized dredging, chemical treatment, and algae harvesting. Fifth, we could do all the above. Pro-tip from a teacher: pick all the above.

LOOKING TO THE FUTURE

While nutrients are clearly a big part of the problem, remember that everything is connected in complex ecosystems. Water temperature and lake level are strongly correlated with the severity of blooms on Utah Lake, with worse blooms in warmer years when the water level is low. Two factors likely contribute to these correlations. First, algae and cyanobacteria can replicate faster in warmer water. Second, because wastewater nutrient inputs are constant (in flood and drought, we all use the toilet daily), the lake experiences higher nutrient concentrations in low water years. These interactions highlight both opportunities and threats. On the threat side, climate change and more demand for agricultural water are making it harder to prevent blooms on Utah Lake. On the opportunity side, we could get more bang for our buck if we both reduce nutrient inputs by upgrading treatment plants and increase natural water flow to the lake by cooperating with farmers and cities.

There is one point about Utah Lake nutrients that we hope is agreed upon: divisions and finger pointing are not helpful. Though wastewater plants are often viewed as villains, we are all part of the problem (everyone poops). We need to view the wastewater plants as indispensable allies, not enemies. They have already implemented many measures to reduce nutrient pollution, including tertiary treatment in some plants. We should thank them for their progress and provide the resources to further reduce nutrients. We also need to look upstream (figuratively) of the treatment plants. To get where we want to go, we need integrated approaches that manage nutrient sources at the watershed level, not only at the end of the line. This is a challenge but also a huge opportunity based on experience from other areas affected by blooms. Implementing nutrient reduction and recapture strategies could create local business opportunities, increase our water and nutrient security, reduce our water and fertilizer expenses, and result in a cleaner and healthier environment.

Cooperation on nutrient and water management will only become more important in the future. The population of the Utah Lake watershed is expected to double by 2050. We are not going to make progress unless we exercise great foresight and investment now.

If We Live in a Desert, Why Do We Have Such a Huge Lake?

First off, Utah Valley isn't technically a desert. With just over 17" of precipitation annually, central Utah is solidly in the semiarid zone (deserts have less than 10" of precipitation). But the question of why Utah Lake exists is still a great one. In the huge expanse of the dry Great Basin, Utah Lake is a rare gem of freshwater and vegetation. Like most things about it, the hydrology of Utah Lake is complicated and fascinating.

Because this area is relatively dry, one of the distinguishing characteristics of Utah Lake is its enormous watershed (area of land that contributes runoff and groundwater to the lake). Nearly 3,000 square miles of mountains and valleys are needed to provide enough water flow to keep Utah Lake wet. Compare that to Lake Tahoe, which has about the same area as Utah Lake but only a 500 square-mile watershed! Because it drains such a huge area, Utah Lake is very sensitive to changes in land use, water diversions, and climate.

There are three basic ways that water gets to Utah Lake: 1. Rivers and streams flow into the lake (45% of inflow), 2. Groundwater seeps into the lake through springs and sediments (41%), and 3. Rain and snow fall directly into the lake (14%). Now that we know how water gets into the lake, where does it go from there? Just like the inflows, there are three major options: 1. Lake water flows through the Jordan River toward the Great Salt Lake (46% of outflow), 2. Lake water evaporates back to atmosphere (38%), and 3. Lake water seeps back into the ground, mostly toward the north (16%). Though these inflows and outflows seem straightforward, they are very difficult to measure, and we are still learning a lot about the lake's hydrology. In fact, a study came out last year that more than tripled estimates of groundwater flow to Utah Lake!

Some people wrongly assume that evaporation and river flow to the Great Salt Lake are wastes of water. When you understand the hydrology of the lake, you see that these water flows are crucial to maintaining a thriving and healthy local environment. First, water that evaporates from Utah Lake provides an important source of downwind rainfall and snow. In fact, landlocked areas like ours receive more than two thirds of their precipitation from upwind evaporation and transpiration from land and lakes. In the water cycle, nothing is wasted! Second, this evaporation increases local humidity and decreases temperature (like a giant evaporative cooler). In a single year, evaporation from the lake sucks about a trillion megajoules of energy from the atmosphere—that's enough energy to power all of Utah's electricity for 6.5 years! Third, the water flowing through the Jordan River valley is the lifeblood of the Great Salt Lake. Like Utah Lake, the Great Salt Lake provides invaluable habitat and serves as a cornerstone of Utah's identity and economy. Fourth, evaporation from Utah Lake is an important release valve when water levels get too high. For example, in the spring of 1983, record snowpack led to catastrophic flooding along the Wasatch Front.

While terminal lakes are drying up around the world, mainly because of excessive diversions, we need to protect the Utah Lake and Great Salt Lake to avoid air pollution, loss of habitat, loss of tourism, and damage to local quality of life. Climate change has already made our droughts more intense and precipitation less reliable. Looking to the future, we will need to reduce water use and eliminate greenhouse gas emissions to preserve our beautiful and unique environment. Utahns currently use more water per capita than almost any state in the U.S., leaving us lots of room for improvement in agricultural, urban, and domestic water use.

Saving and Protecting Utah Lake

Around and within Utah Lake, dozens of restoration projects are ongoing. These diverse projects are being led by individual citizens, cities, the county, the state, and the federal government. The Utah Lake Commission has a list of many such projects here. Even more conservation and restoration projects are on the horizon, ranging from expansion of trails and access points to the creation of new water management laws that favor conservation.

Continuing and expanding existing conservation efforts could have large payoffs for the status and future of Utah Lake. Here are seven prioritized recommendations:

1. Rehabilitate our cultural connection with the lake through outreach and education
2. Reduce nutrients from wastewater plants and other sources by upgrading facilities and improving urban and agricultural practices
3. Increase river flow to the lake through cooperative agreements with farmers and cities
4. Continue habitat restoration efforts around the lake and its tributaries
5. Support research on the lake's ecology and sustainable practices for its watershed
6. Continue removing invasive species such as carp and phragmites in ecologically sensitive and sound ways
7. Integrate the health and conservation of Utah Lake into strategic planning of future development in the valley

How Can I Learn More?

1. The Utah Lake Symposium website (utahlake.byu.edu) has video presentations, references, and an online version of this document that you can easily share with family and friends.
2. The Utah Lake Commission maintains the official website for Utah Lake, which has great photos, blog posts, and even a podcast on science, restoration, and recreation: www.utahlake.org
2. The June Sucker Recovery Implementation Program has great articles, photos, and activities: June Sucker Recovery
3. The Utah Reclamation Mitigation and Conservation Commission has excellent information on Utah Lake and its connected rivers and wetlands: URMCC
4. The Central Utah Water Conservancy District has some great card games and activities that can help you learn about and protect Utah Lake and its watershed: CUWCD
5. The Provo River Delta project is seeking to restore habitat for the June Sucker and other species: Provo River Delta
6. The Valley Visioning project commissioned by the Utah County Council of Governments provides excellent resources on possible futures for Utah Valley, including development around Utah Lake: Envision Utah

Acknowledgements

This work was made possible by dozens of volunteers, photo contributors, and community partners. Thank you for your passion and generosity. We acknowledge and thank the Timpanogos Nation—the original caretakers of Utah Lake—for their participation, historical guidance, spiritual leadership, and gracious gestures toward reconciliation.

The layout and printing of this document were funded by Brigham Young University's Environmental Ethics Initiative, which is supported by the Nature Conservancy. The research for this document was funded by the U.S. National Science Foundation (grants EAR-2011439 and EAR-2012123), the Utah Department of Natural Resources' Watershed Restoration Initiative, the Simmons Research Endowment, and the Provo River Watershed Council. Funding and logistics for the Utah Lake Symposium—the basis for some of this work—were provided by Conserve Utah Valley, the Utah Valley Earth Forum, Utah Valley University, and the following corporate partners: Big Monocle, Sunrise Engineering, Clyde Snow Attorneys at Law, Nu Skin, the Utah Valley Chamber of Commerce, and Rio Tinto.

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page 12-13 imagery: Painting of Chief Walkara by Solomon Carvalho (1854), Photograph of Chief Tabby photographer unknown, photograph of Chief Executive Mary Murdock Meyer, Harvest of June Sucker and other native fish from the shore of Utah Lake in 1855 is courtesy of the June Sucker Recovery history.

page 15 imagery: A child headsto Utah Lake to fish by Travis McCabe, Travis McCabe, Travis McCabe, and Boaters enjoy the south end of Utah Lake by Jared Tamez

page 16 image: A view of the lake from Inlet Park, Saratoga Springs by Preston Holman

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