

TAHOE CLIMATE ADAPTATION ACTION PORTFOLIO

2021

ACKNOWLEDGEMENTS

Thank you to all those who dedicate time and resources to safeguarding Lake Tahoe's communities and landscapes from the impacts of climate change.

SCIENCE AND ENGINEERING TEAM

Cody Andresen, Studio Percolate

Matt Antes, MS, Energetics

Emily Barnard, MS, Energetics

Brent Boehlert, PhD,
Industrial Economics Incorporated

Whitney Brennan, PhD,
California Tahoe Conservancy

Sudeep Chandra, PhD,
University of Nevada, Reno

Michael Dettinger, PhD,
U.S. Geological Survey (retired)

Sam Evans, PhD,
University of California at Berkeley

Dorian Fougères, PhD,
California Tahoe Conservancy

Chris Gillespie, MS, Energetics

Laura Haertling, Studio Percolate

Alan Heyvaert, PhD,
Desert Research Institute

Tim Holland, PhD,
University of California, Berkeley

Danielle Hughes,
Tahoe Transportation District

Ziga Ivanic, PMP, PE, Energetics

Gordon Keller, PE, GE,
USDA Forest Service,
Pacific Southwest Research Station

Christine Lee, MS,
Industrial Economics Incorporated

Jonathan Long, PhD,
USDA Forest Service,
Pacific Northwest Research Station

Patricia Maloney, PhD,
University of California, Davis

Patricia Manley, PhD,
USDA Forest Service,
Pacific Southwest Research Station

David Olson, MS,
USDA Forest Service,
Pacific Southwest Research Station

Ben Pogue, PMP, AICP,
Catalyst Environmental Solutions,
Project Manager

Greg Pohll, PhD,
Desert Research Institute

Karen Pope, PhD,
USDA Forest Service,
Pacific Southwest Research Station

Matthew Potts, PhD,
University of California, Berkeley

Seshadri Rajagopal, PhD,
Desert Research Institute

Jóse Sánchez, PhD,
USDA Forest Service,
Pacific Southwest Research Station

Geoffrey Schladow, PhD,
University of California, Davis

Peter Stine, PhD,
USDA Forest Service,
Pacific Southwest Research Station

Kenneth Strzepek, PhD,
Industrial Economics Incorporated

Katie Tartaglia, MS, Energetics

Dan Tormey, PhD, PG,
Catalyst Environmental Solutions,
Lead Researcher

Jacqueline Willwerth, MS,
Industrial Economics Incorporated

Patricia Winter, PhD,
USDA Forest Service,
Pacific Southwest Research Station

STAKEHOLDER ADVISORY GROUP

Whitney Albright,
California Department of Fish and Wildlife

Gary Arnold,
California Department of Transportation

Ivo Bergsohn,
South Tahoe Public Utility District

Kim Boyd,
Tahoe City Public Utility District

Zack Bradford,
League to Save Lake Tahoe

Nikki Caravelli,
Sierra Business Council

Nicole Cartwright,
Tahoe Resource Conservation District

Mark Enders,
Nevada Department of Wildlife

Brendan Ferry,
El Dorado County

Mary Fiore-Wagner,
Lahontan Regional Water
Quality Control Board

Meredith Gosejohan,
Nevada Division of State Lands

Shana Gross,
USDA Forest Service, Lake Tahoe
Basin Management Unit

Jenny Hatch,
Sierra Nevada Alliance

Eric Horntvedt,
North Tahoe Fire Protection District

Jay Howard,
Nevada Division of State Parks

Danielle Hughes,
Tahoe Transportation District

Susan Jamerson,
Washoe Tribe of Nevada and California

Chris Katopothis,
Nevada Department of Transportation

Jason Kuchnicki,
Nevada Division of Environmental Protection

Jack Landy,
U.S. Environmental Protection Agency

Mark McDaniel,
Nevada Division of Environmental Protection

Devin Middlebrook,
Tahoe Regional Planning Agency

Daniel Segan,
Tahoe Regional Planning Agency

April Shackelford,
North Lake Tahoe Fire Protection District
and Tahoe Fire and Fuels Team

Ryan Shane,
Nevada Division of Forestry

Daniel Shaw,
California Department of Parks and
Recreation, Sierra District

Roland Shaw,
Nevada Division of Forestry

Ellery Stahler,
Nevada Division of State Lands

Nikki Streegan,
Placer County

Kim Tenggardjaja,
California Department of Fish and Wildlife

Roger Trott,
Nevada Department of Transportation

Jason Vasques,
California Tahoe Conservancy

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INTRODUCTION

The Lake Tahoe Basin (Basin) combines nationally treasured natural resources with approximately 55,000 residents (2010 census) and an average annual visitation of 15 million (Tahoe Prosperity Center). The region's 501 square miles span spectacular waters, mountains, and forests, along with 20 communities, one city, and parts of five counties. Climate change threatens Tahoe with warmer temperatures and longer droughts, less snowpack, earlier runoff, more severe floods, increased erosion and shifts in lake level, and more severe wildfires, smoke, and heat. Adapting to climate change protects people and nature, makes infrastructure more resilient, and saves money. The Basin's concentrated mix of people and nature make it a challenging yet promising landscape for adapting to climate change.

The California Tahoe Conservancy (Conservancy) and Tahoe Transportation District (TTD) partnered with Basin agencies and stakeholders, and a team of technical experts to conduct a **scientific assessment** of the vulnerability of the Lake, forests, and communities to climate change impacts (tahoe.ca.gov/climate-change); develop a **Primer** of major climate impacts and existing adaptation partnerships (tahoe.ca.gov/climate-change); and produce this Climate Adaptation Action Portfolio (**Portfolio**) that identifies adaptation actions that are already being undertaken. These three documents serve as a foundation for adapting to climate change at Lake Tahoe. This Portfolio can also help inform adaptation planning in other mountain communities throughout California and Nevada.

A series of mandates and plans guide the adaptation work of public agencies and stakeholders in Tahoe. The states of California and Nevada have several laws, executive orders, and policies that require state agencies to integrate climate change

adaptation into planning and investment, and to create corresponding programs and regulations. Additionally, the Basin has concurrent regional and federal mandates that guide climate planning and work. Public agencies have responded with corresponding programs and ordinances. While many existing plans, such as the Lake Tahoe Regional Transportation Plan (RTP), focus on mitigation, the Portfolio purposefully focuses on adaptation. More detailed information on specific state and regional mandates guiding climate adaptation work in the Basin can be found in the Primer.

Public agencies, businesses, and non-profit organizations in the Basin have been implementing adaptation projects for many years and are committed to helping the Basin's population and environment adapt to future climate conditions. Basin partners coordinate much of this work through the Lake Tahoe Environmental Improvement Program (EIP). The EIP is an unparalleled partnership working to achieve the environmental goals of the Region. Local, state, and federal government agencies, private entities, scientists, and the Washoe Tribe of Nevada and California have collaborated for nearly 25 years to restore the environmental health of Lake Tahoe. This landscape-scale collaboration is a partnership between nearly 80 public and private organizations. This Portfolio summarizes what many public agencies are already doing, or will soon start to do, to accelerate adaptation in Tahoe, but is not an exhaustive list of climate actions taking place in the Tahoe Basin. The intent is to showcase the ongoing work agencies are undertaking to address the impacts of climate change, and to safeguard the quality of life, land, and waters in Tahoe. The Portfolio increases the awareness of planners, scientists, engineers, and other experts about the leading edge of adaptation work in the Basin, and helps them identify potential areas for collaboration and multiple benefits.

DEVELOPING THE PORTFOLIO

The Conservancy commissioned a vulnerability assessment for the Basin in which a Science and Engineering Team used downscaled climate data to better identify how resources and communities will be impacted by climate change. The resulting Integrated Vulnerability Assessment of Climate Change in the Lake Tahoe Basin (IVA) provides state-of-the-art information on how temperature and precipitation patterns will change, and how these changes affect the vulnerability of the resources that people care about. The IVA provides the foundation for this Portfolio. The resources assessed in the IVA include aquatic resources, wildlife, groundwater, and vegetation; transportation, power, water, and communication infrastructure; and cultural landscapes, public health and safety, and recreation. The IVA also analyzes the economic costs of climate change impacts. The full IVA is available on the Conservancy website at <https://tahoe.ca.gov/programs/climate-change/>. The impacts described in this Portfolio are drawn directly from the IVA unless otherwise noted.

The Portfolio development process was iterative and some stakeholders including agencies, jurisdictions, and organizations were not included in the original stakeholder meetings. Through a series of workshops, stakeholders, with support from the Science and Engineering Team, explored the implications of climate change impacts for the three sub-systems (i.e., Lake, Uplands, Communities). Stakeholders representing their own agencies or organizations were asked to identify the most significant actions

their agencies or organizations are taking to address the implications identified in the IVA (See Acknowledgements for the complete list of stakeholders). The Portfolio actions are self-reported and some agencies reported more robustly than others. Actions were constrained to those that are ongoing or have sufficient support (e.g., funding, staffing, board direction) to begin soon. For each action, they specified why it is adaptive—in other words, how the action changes management in response to the anticipated impact for a resource. They also identified the specific management practice, program, plan, or policy where the action occurs. This Portfolio does not include climate change mitigation.

The Science and Engineering Team identified critical science, engineering, and economic research priorities for each sub-system that will help improve adaptation actions (See “Improving Our Knowledge” sections for each sub-system). These align with the science priorities in the Tahoe Science Advisory Council (TSAC) Science to Action Plans for Lake Clarity and Uplands. Community research needs focused on transportation infrastructure based on the expertise of Energetics, a transportation and infrastructure consultant. Economic analyses of the benefits and costs of adapting to flooding and wildfire were conducted by Industrial Economics, Incorporated (IEC), unless otherwise noted.

The Portfolio is a major step towards meeting California and Nevada mandates to adapt to climate change and provides a steppingstone towards future efforts. It highlights how Basin partners have started adapting to climate change through numerous efforts. Through continued partnership, the Basin can get ahead of the climate change curve and ensure that everyone can enjoy its natural beauty and welcoming mountain



culture far into the future. Successful adaptation integrates climate science and economics in building community resilience, resource management, infrastructure engineering, and business operations. Some climate change impacts may be so significant that they transform the ecology and culture of Tahoe. Adaptation will be necessary for the foreseeable future and will necessarily involve many partners. The two states, the Tahoe Regional Planning Agency (TRPA), the Washoe Tribe of Nevada and California (Washoe Tribe), and numerous federal and local agencies have already started leading the way. For details on what planning initiatives are already in motion and on the horizon for these agencies please see the Primer.

PORTFOLIO STRUCTURE

People and nature cannot be easily separated at Lake Tahoe. The Basin's geography, geology, and ecology affect where people build roads and houses, the water they drink and air they breathe, and the open spaces where they recreate. Lake Tahoe is, in other words, a social-ecological system, and effective adaptation must involve each part of its landscape. This Portfolio is divided into three constituent components that incorporate a socio-ecological perspective for adapting to climate change.

The Portfolio first summarizes the future climate conditions for Lake Tahoe from the IVA. The rest of the Portfolio, which includes impacts, partnerships, and initiatives is organized around three sub-systems that make up the Basin – the Lake, its uplands, and its communities. Implementing adaptation measures using this systems approach accounts for the connections between ecosystems and people; helps coordinate investments; creates synergies and efficiencies; and should result in healthier and more resilient landscapes. The three sub-systems cover the following topics:

- **THE LAKE SUB-SYSTEM** addresses lake dynamics and clarity, aquatic resources, watershed hydrology and streamflow, and lake-connected ground water supply. The Lake Sub-system includes a costs and benefits analysis for protecting lake clarity through adaptation actions (See "The Benefits of Adaptation vs. the Costs of Inaction: Lake Clarity").
- THE UPLANDS SUB-SYSTEM** addresses biological diversity of the forest, forest ecosystem dynamics, and riparian, aspen, and meadow ecosystems. The Uplands Sub-system includes an analysis of the economic benefits and costs of adapting to wildfire (See "The Benefits of Adaptation vs. the Costs of Inaction: Wildfire").
- **THE COMMUNITIES SUB-SYSTEM** addresses transportation, water, power, and communications infrastructure; cultural resources; recreation; and public health and safety. The Communities Sub-system also includes an analysis of the economic benefits and costs of adapting to flooding and landslides (See "The Benefits of Adaptation vs. the Costs of Inaction: Landslides and Flooding").

Partnerships and initiatives are identified as examples of collaborative efforts to address specific impacts and manage the affected resources.

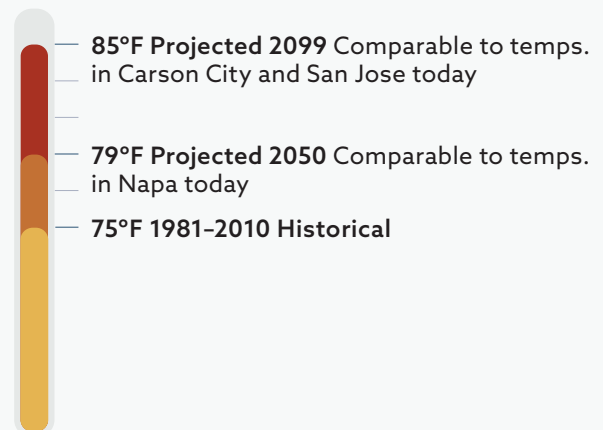
FUTURE CLIMATE CONDITIONS

The IVA provides detailed projections for temperature, precipitation, snowpack, drought stress, runoff, wildfire, and Lake level for future climate conditions, summarized here. The information and figures presented in this document come from the IVA and represent projections under the RCP 8.5 scenario unless otherwise noted.

TEMPERATURE

The average ambient temperature in the Basin has been rising over the past decade, and this trend is expected to intensify in the future. Climate modeling predicts that by 2100 average annual temperatures will increase by 3.6 to 9 degrees Fahrenheit. In other words, summertime temperatures in South Lake Tahoe will be equal to those currently experienced in Napa and San Jose (see Figure 1).

■ **Figure 1.** Average maximum temperature in South Lake Tahoe for the month of August (historical and projected).



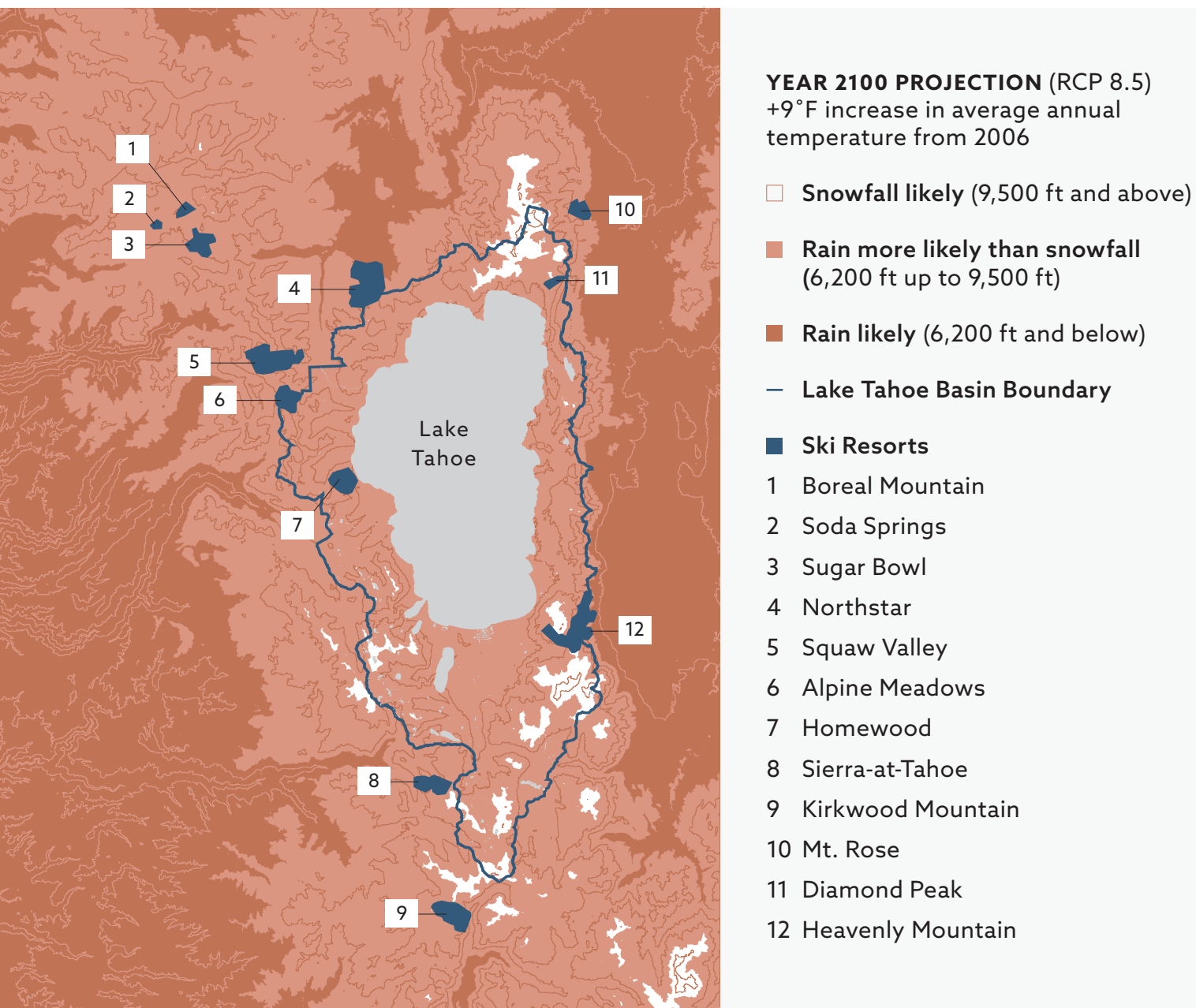
PRECIPITATION

As average annual temperatures rise, evaporation rates are expected to increase, resulting in increased atmospheric water vapor and precipitation potential. However, total precipitation in the Basin is not expected to change significantly through 2100. Instead, greater variability in year-to-year precipitation is expected, including more extreme droughts and storms. The amount of rainfall from the largest storms will increase by up to 30 percent.

SNOWPACK

Increased annual temperatures in the Sierra Nevada will cause the winter season to shorten. The elevation at which snow accumulates ("snow level") will eventually rise above the Basin's rim as less precipitation will fall as snow, and more will fall as rain (see Figure 2). Snow will melt earlier in the spring and summer, and overall snowpack will decline. At the same time, extreme snowstorms may become more common with longer periods of drought in between.

■ **Figure 2.** Areas projected to retain snowfall in 2100, including location of current ski resorts.

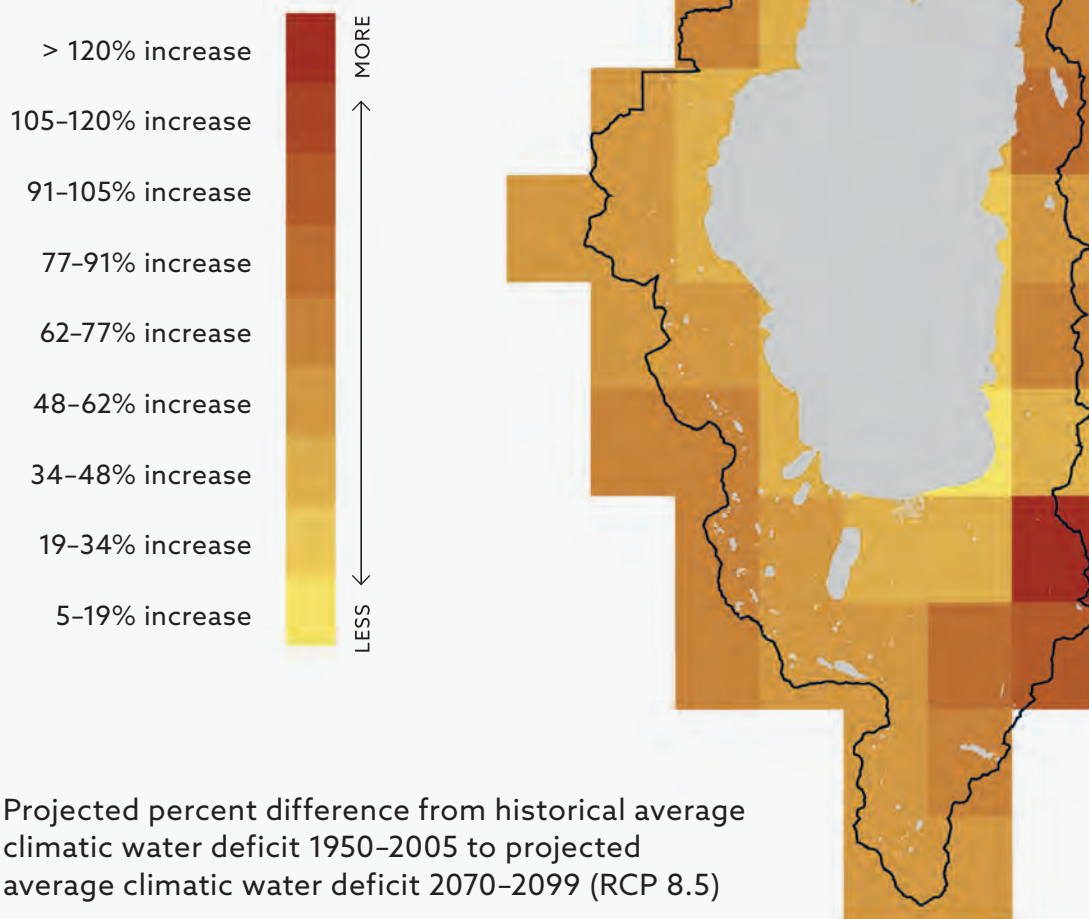


DROUGHT STRESS

Climatic water deficit (CWD), the potential stress of drought on plants, is projected to increase by more than 120 percent in some parts of the Basin by the end of the century. The northern and eastern sides are expected to experience the most severe increase in drought stress (see Figure 3).

■ **Figure 3.** Climate change increases drought stress on soils and plants

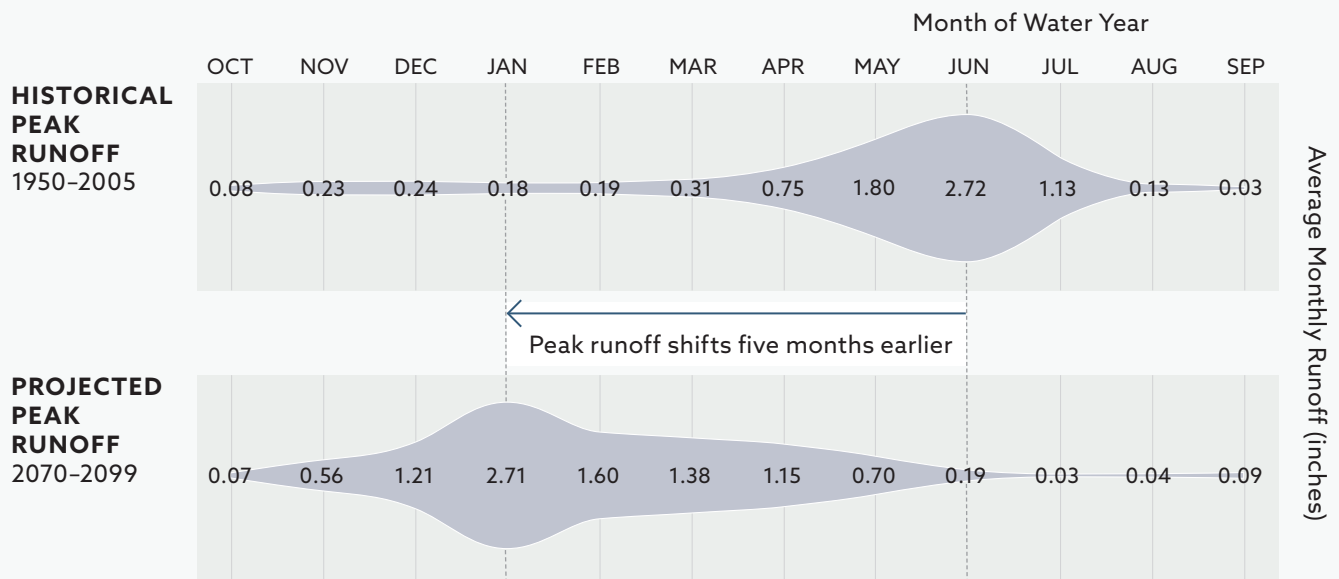
2070-2099 MODELED CLIMATIC WATER DEFICIT: An Estimate of Drought Stress on Soils and Plants



RUNOFF

Runoff, water draining from land, is projected to increase modestly in the Basin, with large variability between years. However, peak runoff (when stream flow is the highest) is projected to shift from the summer (June) to the winter (January), a difference of five months (see Figure 4). Much more water will run off the land during wintertime than historically because precipitation will fall more often as rain than snow.

■ **Figure 4.** Timing of annual peak runoff shifts from June to January.



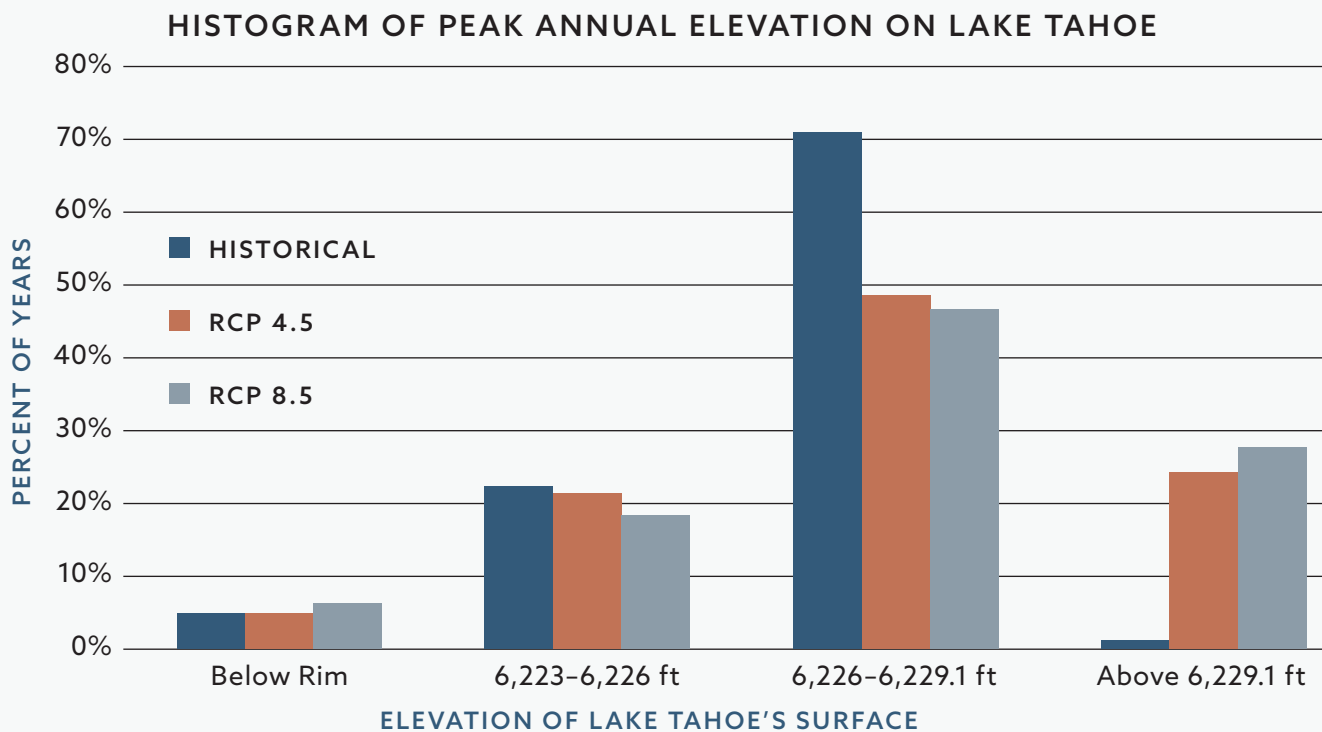
WILDFIRE

By 2100 the total area burned each decade is projected to be 61 percent larger than in 2000, totaling approximately 33,000 acres per decade. By comparison, during the 2001-2010 decade approximately 3,187 acres burned (including the 2007 Angora Fire). Low and mid-severity fire benefits conifer forests in Tahoe. However, high-severity wildfire, which kills large numbers of trees and significantly reduces the tree canopy, will become 89 percent more common than it is today by the end of the century.

LAKE LEVEL

Lake Tahoe's surface elevation ("lake level") typically peaks in the summer months, after the snowmelt has subsided and surface evaporation has overtaken inflows from tributaries. The Lake serves as an important water supply reservoir, with a dam at Tahoe City regulating lake level and downstream flows. The lake level is projected to frequently be outside the operable range of the dam. The Truckee River Operating Agreement (TROA) establishes the maximum operable limit of the dam to preserve the lakeshore environment, lakeshore structures, and to limit erosion. Modeling shows that sometimes the lake level will be below the dam's gated spillway, but most often the lake level will be above the maximum operational limit for the dam (6,229 feet in elevation, see Figure 5). This is because of the expected increase in the frequency and magnitude of extreme storms. If the lake level is above the operable limit, the dam is physically unable to release water downstream at a fast enough rate to avoid impacts to the lakeshore environment. The last time the lake was more than three-tenths of a foot over its legal limit was over a century ago.

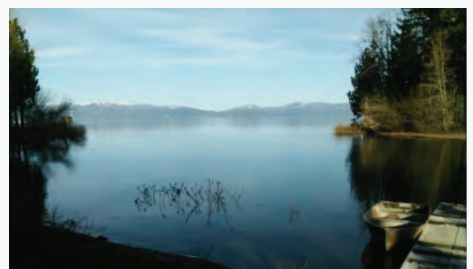
■ **Figure 5.** Histogram of annual peak lake surface elevations for the historical period, and the RCP 4.5 and RCP 8.5 ensembles. Photos taken from Lake Tahoe Dam in Tahoe City, looking toward Lake Tahoe.



6,222.83 ft



6,223.59 ft



6,227.97 ft

THE LAKE SUB-SYSTEM

The Lake is the ecological, social, and symbolic heart of Lake Tahoe. It is the defining feature of the region's ecology, the primary reason why people treasure the landscape, and the basis of the economy. Its 72 miles of shoreline captivate beachgoers, paddlers, hikers, homeowners, anglers, and tourists, offering quiet coves and majestic vistas around each curve.

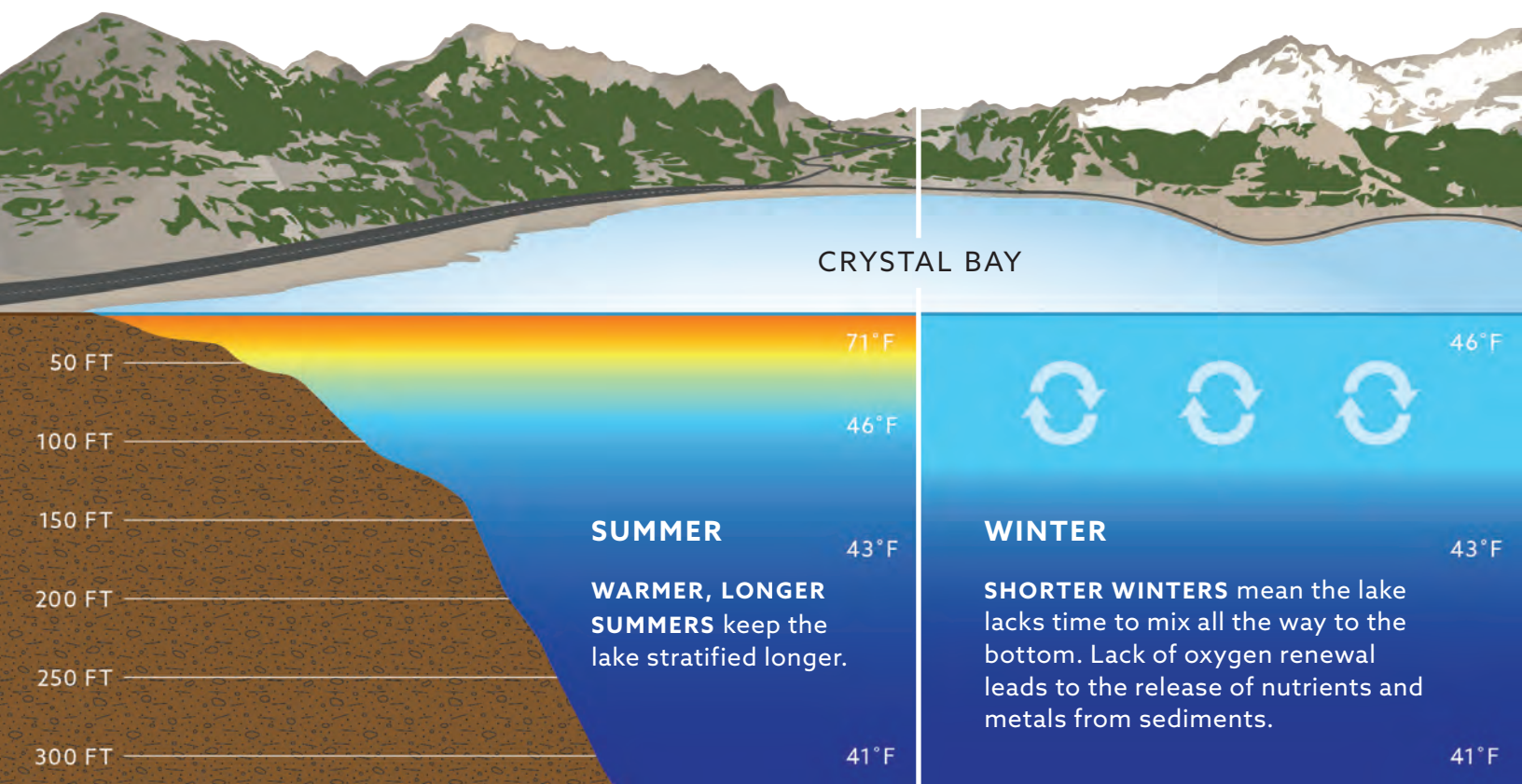
1. LAKE CLARITY

1A. CLIMATE IMPACTS

Lake Tahoe is known worldwide for its exceptional clarity and brilliant blue color. The mixing of the Lake's warm and cold waters is a critical ecological process that governs its chemistry, biology, and ecology—its health—and its famed clarity. Climate change, however, has begun to disrupt deep water mixing during the winter-time (see Figure 6). In the future mixing will be less pronounced, which may create compound impacts, including "dead zones"—areas of the Lake that lack dissolved oxygen—and harmful algal blooms that further reduce Lake clarity and pose a human health risk.

Disruption to lake mixing is likely to lead to stream and storm water becoming trapped closer to the surface of the Lake, simultaneously trapping sediment and nutrients near the shore instead of mixing them throughout the Lake. This may increase algal growth near the beaches where people recreate. More frequent and

■ Figure 6. Diminished mixing threatens Lake Tahoe's clarity



severe wildfires, as well as larger and more frequent flooding, could also increase the amount of sediment that flows into the Lake. Irregular mixing will likely lead to an increase in dead zones and in turn release large amounts of nutrients like orthophosphate and ammonium that further fuel algal blooms. Additionally, algal blooms that make people and animals sick may increase in extent, frequency, and duration.

1B. PARTNERSHIPS AND INITIATIVES

Lake Tahoe has one of the United States' premier Total Maximum Daily Load (TMDL) plans, which provides a science-based approach to restoring and protecting the lake's historical clarity. It establishes targets for implementing agencies to reduce storm water pollution from developed lands. The interagency Storm Water Quality Improvement Committee (SWQIC) consists of implementing agencies, regulators, funding agencies, and other partners. SWQIC facilitates the design, delivery, and effectiveness of storm-water quality improvement efforts to achieve Lake Tahoe clarity goals. The Lahontan Regional Water Quality Control Board (Lahontan Water Board) and Nevada Division of Environmental Protection (NDEP) oversee the program. Partners use the reporting tools on the Lake Tahoe Info (<https://laketahoeinfo.org>) website to track progress.

Tahoe Water Suppliers Association (TWSA) is a Lake Tahoe-based partnership consisting of municipal water agencies dedicated to providing and protecting clean drinking water for residents and visitors of the Basin. The mission of TWSA is to develop, implement, and maintain an effective watershed control program; advocate for the protection of Lake Tahoe as a viable source of drinking water; and satisfy additional state and federal requirements. The actions of this partnership serve to minimize declines in Lake Tahoe water quality and subsequent increases in water supply treatment costs, effects that result from increased thermal stratification in the Lake due to climate change.

The Nearshore Agency Working Group (NAWG) coordinates nearshore monitoring efforts and program activities and includes representatives from the U.S. Environmental Protection Agency (EPA), NDEP, Tahoe RCD, Lahontan Water Board, and TRPA.

1C. THE BENEFITS OF ADAPTATION VS. THE COSTS OF INACTION: LAKE CLARITY

Decreased lake clarity has economic as well as social and ecological impacts. Water quality impacts property prices, although with Lake Tahoe's historic high lake clarity this impact may not be observed for a long time. Reduced water quality (from the aforementioned thermal stratification) can increase the costs of treating domestic water supplies, increase the risk of waterborne illness, and decrease the enjoyment people derive from water-based recreation.

Numerous actions can reduce the negative effects of flooding on lake clarity. Such actions would provide environmental and economic co-benefits by safeguarding lake clarity while better protecting communities. The goals would be to increase the infiltration of rainfall into groundwater, and to reduce the velocity of storm water runoff during peak flooding. Investments could include increasing vegetation cover, constructing retention ponds to settle sediment, terracing slopes to slow flows, constructing floodways to divert sediment, and stabilizing highly erosive slopes.

Other actions can further enhance storm water management efforts as a co-benefit. The Lake Tahoe West Restoration Partnership (LTW), for example, is working collaboratively across all jurisdictions to restore the resilience of the 59,000 acres of forest that cover Lake Tahoe's west shore. Modeling from this initiative showed that sediment runoff increases following wildfire, hence reducing the occurrence or severity of wildfire would help protect lake clarity. Estimating the economic benefits of adapting to wildfire could examine how many tons of sediment are expected with and without wildfire, how each ton impacts clarity, and how much people would pay for improved clarity. The Lake Tahoe TMDL program's data on load reductions provides a ready source of information for such analysis.

1D. ADAPTATION ACTIONS

ASSESSMENT AND ADAPTIVE MANAGEMENT

- A.** At the request of Nevada Department of Conservation & Natural Resources (DCNR) and California Natural Resources Agency (CNRA), the TSAC is leading implementation of the Lake Tahoe Science to Action Plan. The initiative seeks to understand why the Lake's clarity is worsening in summer despite improving in winter, and to identify what actions public agencies can take to stem this. TSAC is working with the Lahontan Water Board, NDEP, and TRPA to review findings, expand the transfer of knowledge, and integrate recommendations in regional implementation and monitoring. TSAC will then update and improve the Lake Tahoe Clarity Model.
- B.** TRPA is leading the update of the Basin's environmental threshold carrying capacities established to safeguard the environment and limit development impacts to the Lake.
- C.** Lahontan Water Board, NDEP, U.S. EPA, and TRPA will continue to work with the science community to review protocols for nearshore monitoring of climate change-driven alterations in algal growth.
- D.** TSAC will work with Basin partners to develop priority models for Lake Tahoe that advance knowledge and accelerate climate change adaptation.
- E.** TSAC will initiate annual briefings to engage in the TMDL adaptive management process to help ensure that new scientific findings inform resource management and related Lake Tahoe Environmental Improvement Program (EIP) investments. The process will prepare integrated analyses of Lake, watershed, and climate conditions.

STORM WATER INFRASTRUCTURE

- A.** Lahontan Water Board, NDEP, and TRPA will work with urban-TMDL-implementing partners to assess how significantly performance of existing treatment best management practices (BMPs) may be anticipated to change under more contemporary and future climate regimes and inform stormwater managers if and how the current design standard has or will change in time. The agencies will also work to investigate potential new and enhanced treatment BMPs and practices that have not previously been implemented in the Basin for suitability of application.

- B.** Nevada Tahoe Conservation District (NTCD) partners with Nevada Department of Transportation (NDOT) and Douglas County to continuously assess BMP performance, perform adaptive management, and analyze sites for retrofit.

ENVIRONMENTAL AND PUBLIC HEALTH

- A.** Lahontan Water Board will continue to collaborate with county environmental health departments, homeowner associations, utility districts, USDA Forest Service, Lake Tahoe Basin Management Unit (LTBMU), and other partners to build programs to monitor and investigate harmful algal blooms. The goal is to better protect human and animal health when harmful levels of cyanotoxins are present in surface waters used for recreation and domestic water supply.
- B.** NTCD partners with U.S. Geological Survey (USGS) and Tahoe Resource Conservation District (Tahoe RCD) to monitor Lake Tahoe for nearshore human health concerns.

OUTREACH AND ADVOCACY

- A.** El Dorado County will conduct public outreach based on its National Pollutant Discharge Elimination System (NPDES) program and provide information to homeowners and business about how they can readily implement storm water BMPs.

2. WATERSHED HYDROLOGY AND STREAMFLOW

2A. CLIMATE IMPACTS

The naturally high variability in the amount of snow that accumulates and runoff that occurs in the Basin between the winter and summer seasons, and across years, will increase even further with climate change. Larger storms will become more frequent, leading to higher peak flows of runoff, and corresponding increases in erosion, transport of pollutants, and infrastructure damage.

A smaller snowpack will also hold less water. Rather than the snowpack melting steadily into the summer, the Basin's hydrology could shift dramatically, with peak streamflow occurring months earlier. Ecological changes would be correspondingly severe, particularly for riparian ecosystems.

2B. PARTNERSHIPS AND INITIATIVES

The interagency Upper Truckee River Watershed Advisory Group (UTRWAG) coordinates and shares information about landscape restoration all along the Upper Truckee River. The river is the most significant source of sediment to Lake Tahoe (with corresponding impacts to lake clarity), and the most extensive and biologically diverse wetland and marsh complex in the Basin. California Department of Parks and Recreation (DPR), LTBMU, Tahoe RCD, the City of South Lake Tahoe, and the Conservancy have invested over \$70 million in restoration through five major projects. The goal is to restore all nine miles of the river and over 1,000 acres of floodplain, which increase the sediment filtering capacity.

The LTW is working collaboratively across all jurisdictions to restore the resilience of the 60,000 acres of forests, watersheds, and communities that cover Lake Tahoe's west shore. Disturbances addressed by LTW include flooding, drought, insects and disease, and wildfire, all of which climate change is amplifying. The LTW initiative is restoring the resilience of west shore forests, watersheds, and communities to flooding, drought, insects and disease, and wildfire as amplified by climate change. Cardinal goals related to hydrology are to restore creeks and floodplains that provide clean water, habitat, and buffering from floods as well as droughts; and to restore aquatic ecosystems, that support viable populations of native species.

2C. ADAPTATION ACTIONS

RIVER AND STREAM RESTORATION

- A.** Tahoe RCD, DPR, Conservancy, LTBMU, El Dorado County, and the City of South Lake Tahoe will each continue restoring the Upper Truckee River (UTR) on their lands, including Johnson Meadow, the Lake Tahoe Golf Course, and the Upper Truckee River Marsh (UTM). Partners will also continue monitoring and adaptively managing already completed stretches of UTR restoration. The U.S. Army Corps of Engineers (USACE) will continue funding numerous watershed restoration projects, including the UTM and Johnson Meadows.
- B.** DPR, Tahoe RCD, Nevada Tahoe Resource Team (NTRT), NTCD, LTBMU, and the Conservancy will each plan, fund, and implement wetland and stream restoration projects on their lands that can accommodate increased flooding, withstand prolonged drought, and serve as climate refuges for native species. High-priority projects include Antone Meadows, Tahoe State Recreation Area, Burke Creek/Rabe Meadow, Marlette Creek, and Polaris Creek.
- C.** The Conservancy will complete a document about the Greater Upper Truckee Watershed Restoration that communicates the range of restoration and recreational achievements and future improvements that partners are leading. The document will also identify opportunities for integrated landscape resilience, mitigation, and adaptation.
- D.** Incline Village General Improvement District (IVGID) facilitates creek restorations for Third, Rosewood, and Incline Stream Environment Zones (SEZs). Creek restorations focus on enhancing channel flows, reducing sedimentation and providing a healthy aquatic ecosystem for natural species to thrive.

LANDSCAPE-SCALE HYDROLOGY

- A.** TSAC will assess mitigation measures designed to offset potential impacts from landscape-scale forest management practices like vegetation thinning and prescribed burning. The work will advance hydrologic modeling conducted for the LTW initiative and inform enhancements of the Lake Tahoe Clarity Model.

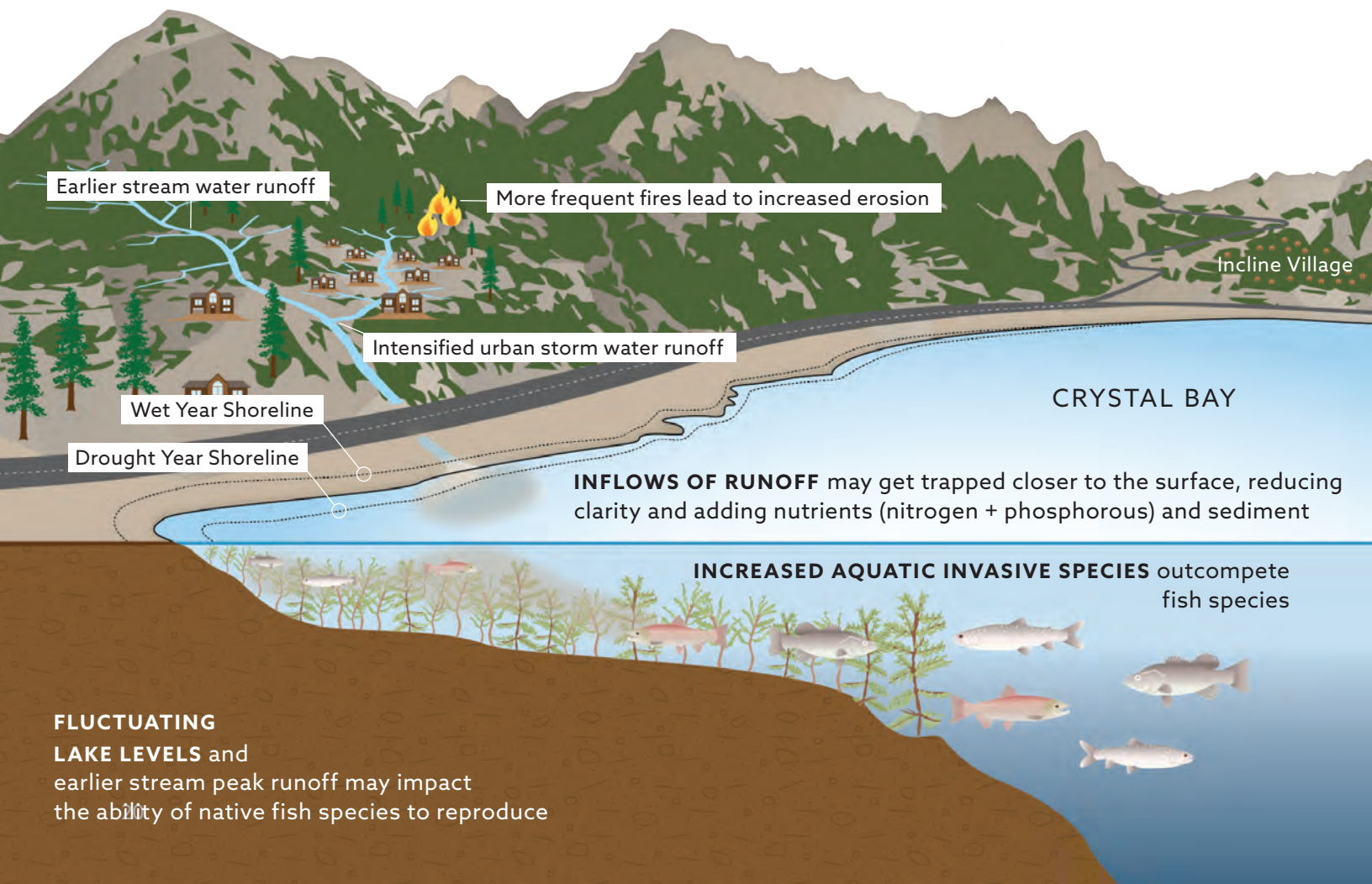
3. AQUATIC BIOLOGICAL DIVERSITY

3A. CLIMATE IMPACTS

Climate change will negatively influence a range of species that inhabit Lake Tahoe's waters, from the main body of water to its tributaries to the small lakes throughout the region. Spawning and rearing habitat for native fish will be impacted as cool water is less likely to be available in streams in the late spring and early summer, due to the peak runoff shifting earlier in the year (see Figure 7). Fish species and aquatic organisms that are less tolerant of warmer water will be particularly vulnerable.

Aquatic invasive species (AIS) are generalists that adapt well to altered environments and thus are likely to outcompete native species. Longer summers and warmer surface water temperatures will mean that AIS populations will likely proliferate, and may expand to more parts of the Lake, streams that drain into it, and nearshore environments including marinas. Native biological diversity has evolved with Tahoe's geological and chemical processes and plays a key role in cycling nutrients and particles that drain from the watershed into the Lake. Expansion of AIS populations and the disruption they cause to ecological processes may also reduce lake clarity.

■ **Figure 7.** Multiple climate impacts degrade native fish habitats.



3B. PARTNERSHIPS AND INITIATIVES

The Lake Tahoe AIS Coordinating Committee (LTAISCC) is a multi-agency team that prevents new AIS from establishing themselves in Lake Tahoe, controls the existing populations in the Lake, and conducts lakewide monitoring. LTAISCC standardizes data collection and treatment methods, shares information and resources, coordinates education and outreach, secures grant funding, prioritizes projects, and implements prevention and control projects. Primary field activities include rapidly detecting and removing any new AIS arrivals and inspecting any watercraft entering the Basin.

LTAISCC developed an AIS Action Agenda to provide resource managers with a comprehensive control strategy. The AIS Action Agenda addresses current and emerging threats and defines outcome-based performance metrics. It stresses the need to increase management capacity and thereby increase the pace of AIS control efforts, including comprehensive control targeting invasive fish, invertebrates, and amphibians in addition to invasive plants.

Lake Tahoe's Watercraft Inspection Program inspects every motorized watercraft to ensure it is clean, drained, and dry and not carrying AIS into Lake Tahoe.

The Nearshore Aquatic Weed Working Group (NAAWG) coordinates the various efforts underway to control and, where possible, eradicate populations of aquatic invasive plants in the nearshore of Lake Tahoe.

3C. ADAPTATION ACTIONS

AIS PREVENTION AND MONITORING

- A.** Tahoe RCD and TRPA will establish permanent watercraft inspection stations to increase capacity to process watercraft entering Lake Tahoe's waters. The stations are the critical first line of defense in preventing AIS from being introduced.
- B.** The LTAISCC will increase and improve multijurisdictional monitoring to rapidly detect and eradicate new and expanding AIS populations.
- C.** The USACE will continue supporting partners via funding from the Tahoe 108 Program for invasive species management to control aquatic invasive species in Lake Tahoe and prevent new exotic species from being introduced, including monitoring, prevention, public outreach, and boat inspections.
- D.** California Department of Fish and Wildlife (CDFW) will continue to quarantine vessels that test positive for invasive mussel species and release those vessels following decontamination.

AIS CONTROL

- A.** The LTAISCC will use the AIS Action Agenda to guide strategies that increase the pace and scale of control projects.
- B.** Tahoe RCD, TRPA, NTRT, NDSL, and DPR will each use new technologies and climate scenarios to increase the speed, efficiency, and effectiveness of projects

that control current infestations and restore the nearshore. Attention will first focus on (but extend beyond) iconic areas like Emerald Bay and Lake Tahoe Nevada State Park.

- C. NTRT and NDSL will continue to provide financial support to partners and research institutions for AIS prevention, control and monitoring projects identified in the AIS Action Agenda.
- D. DPR will partner with University of California Davis to expand the control of mysis shrimp, hypothesized to contribute to diminished lake clarity, and associated research in Emerald Bay. This work will inform large-scale actions to reduce shrimp populations throughout Lake Tahoe.
- E. Tahoe RCD will investigate the feasibility of updating marina and mooring infrastructure designs to accommodate larger fluctuations in lake elevation, reduce the spread of AIS, and improve navigation and water flow in areas constrained by AIS.

NATIVE FISH SPECIES

- A. Nevada Department of Wildlife (NDOW) and CDFW will further assess Lahontan cutthroat trout recovery opportunities and increase hatchery capacity. CDFW will expand existing tools for native fish conservation. NDOW will continue Lahontan cutthroat trout reintroduction work on Third Creek.
- B. During stream restoration, NTCD, IVGID, and NDSL are removing barriers for aquatic organisms to promote fish passage in historical creek reaches.
- C. The LTBMU is monitoring stream temperature in various tributaries to guide management efforts needed for the conservation, enhancement, and/or restoration of habitat for growth, reproduction, and survivorship of native aquatic species.

4. GROUNDWATER CONNECTED TO THE LAKE

4A. CLIMATE IMPACTS

Groundwater sustains the creeks, meadows, and wetlands that are home to diverse fish, animals, plants, and cultural resources. Historically, groundwater has kept these areas flourishing long into the summer. On the south shore, deep groundwater tables provide the primary source of drinking water. The groundwater basins that are connected to the Lake (so-called “low elevation groundwater”), maintain their levels despite decreased infiltration, and this also minimizes the impacts of pumping for domestic water supplies. These groundwater basins are therefore expected to be resilient to climate change unless the Lake’s level drops precipitously.

4B. PARTNERSHIPS AND INITIATIVES

Public utility districts play the primary role in managing the Basin’s groundwater. In particular, the South Tahoe Public Utility District (STPUD) manages groundwater for domestic water supplies on the south shore. The Tahoe-Sierra Integrated Regional Water Management Group, which involves numerous Basin partners, pursues state and federal funding to address long-term and emerging water resource challenges.

STPUD developed the Tahoe Valley South Basin 2014 Groundwater Management Plan (GWMP) with partners to manage groundwater supplies and protect groundwater quality. Following the requirements established by the Sustainable Groundwater Management Act, this plan fulfills STPUD's responsibility to develop and implement a groundwater sustainability plan that meets the long-term goals of the groundwater basin and ensures that it is operated within its sustainable yield, without causing undesirable effects. In May 2020, STPUD adopted a resolution to update the 2014 GWMP, which will be completed by January 2022. This plan addresses local climate change impacts, including changes in precipitation, snowmelt, timing in peak streamflow, and frequency and intensity of droughts, which could warrant substantial changes in local groundwater management and planning (STPUD 2020).

The League to Save Lake Tahoe runs the Pipekeeper Program, a citizen science program to address stormwater runoff into Lake Tahoe, and Snapshot Day for Water Clarity, an annual citizen science water quality monitoring event.

4C. ADAPTATION ACTIONS

WATER AND WASTEWATER INFRASTRUCTURE

- A.** Lahontan Water Board will address infrastructure vulnerabilities of water and wastewater utilities through four actions:
 - i. Adopt new, re-issue, or amend permits that identify requirements to reduce vulnerability through site-specific or project-specific discharge plans.
 - ii. Develop guidance for permitting (e.g., administrative procedures manuals) to address vulnerability and climate change impacts on regulated facilities.
 - iii. Encourage (possibly through permit requirements and enforcement actions) utility districts to prepare and submit risk abatement plans for building resilient and safe infrastructure.
 - iv. Urge (possibly through permit requirements and enforcement actions) communities, utilities, and water agencies that have completed risk assessments to increase resilience by upgrading and improving infrastructure.
- B.** NDOT and Douglas County, with help from NTCD, are building a stormwater decant facility on Kingsbury Grade to localize maintenance and provide state of the art decant water treatment.
- C.** Tahoe City Public Utility District (TCPUD) will reduce reliance on groundwater for drinking water and fire suppression needs by constructing and maintaining the West Lake Tahoe Regional Water Treatment Plant, a facility designed to utilize and treat surface water from Lake Tahoe.

WATER CONSERVATION

- A.** Lahontan Water Board will promote drought resilience by supporting projects and practices that use water more wisely, eliminate water waste, and reuse water for multiple purposes where possible. Lahontan Water Board will coordinate with State Water Resources Control Board staff and relevant partner agencies to iden-

tify and recommend actions to effectively permit projects that develop new and underutilized water resources, expand surface water and groundwater storage where appropriate, and add operational flexibility to build and enhance resilience to climate change.

- B. TCPUD will continue to implement new technology through SMART meter installation designed to improve leak detection and usage reporting and promote water conservation measures for commercial and residential water use.

GROUNDWATER MONITORING

- A. All public utility districts in California will monitor groundwater elevations within aquifers used for drinking water. If they observe declining trends, they will adjust pumping schedules to maintain groundwater levels above minimum pumping thresholds. In low priority aquifers there is no regulated threshold. (General Improvement Districts (GIDs) on the Nevada side of Lake Tahoe get water from Lake Tahoe itself and therefore do not conduct groundwater monitoring).

5. IMPROVING OUR KNOWLEDGE OF THE LAKE

Critical topics for further investigation include:

- Assessment of the hydrodynamics of Lake Tahoe under various climate scenarios
- Modeling of the hydrology, relative vulnerability, and sediment delivery of the Basin's 63 individual drainages
- Improved forecasting of flooding
- Surface and groundwater dynamics, and hence understanding of water supply to downstream communities
- Better understanding of the relationship between mysis shrimp, native daphnia, other zooplankton, and their impact on lake clarity
- Expanded assessment of the effectiveness and economics of different restoration, AIS control, resilience-building, and adaptation actions
- Applying historical and current climate data to Basin projects that assess and model the Lake
- Conducting statistical analysis and monitoring key climate change metrics associated with meteorology, hydrology, pollutant loading, and storm water management
- Evaluating how nearshore aquatic resources respond to climate change, including a combination of historical and ongoing remote sensing data and geospatial analysis
- Assessing how climate change is impacting lake physiodynamics and clarity

UPLAND SUB-SYSTEM

Lake Tahoe's conifer forests, streams, and meadows are home to an array of birds, mammals, and fish. These upland ecosystems also provide the trails, resorts, and open spaces where people recreate, venture into the backcountry, and reconnect with nature. They are integral to the quality of environment and life in the Basin.

1. FOREST ECOSYSTEM DYNAMICS AND SOILS

1A. CLIMATE IMPACTS

As droughts become more severe, the loss of drought-sensitive vegetation and dependent wildlife, increase in insect and disease outbreaks, and increases in the frequency and extent of wildfire are expected to cause long-term changes in forest structure and composition. The death of large numbers of trees will increase the risk that wildfire will burn entire stands of trees and release all the carbon they contain into the atmosphere. Altogether, climate change will alter biological, geological, and chemical cycles, and undermine vital ecosystem processes and services.

1B. PARTNERSHIPS AND INITIATIVES

The LTW is working collaboratively across all jurisdictions to achieve multiple goals including helping forests recover from fire, drought, and insect outbreaks; and ensuring that fires burn primarily at low to moderate severity and provide ecological benefits. Key strategies are to increase the pace and scale of forest thinning and increase the use of prescribed fire as a landscape restoration tool. Through LTW, the Conservancy, LTBMU, and DPR will adaptively manage and monitor effectiveness. DPR will continue their 30+ year prescribed fire and forest management program in coordination with other LTW prescribed fire plans to continue and expand upon forest restoration. Lahontan Water Board will partner, collaborate, and provide technical support for LTW and similar efforts.

The Tahoe-Central Sierra Initiative (TCSI) aims to protect communities and restore forest and watershed health to 2.4 million acres of the Sierra Nevada, including the Basin. The Conservancy, Sierra Nevada Conservancy, LTBMU and Tahoe and Eldorado National Forests, University of California, The Nature Conservancy, National Forest Foundation, and California Forestry Association jointly lead the initiative. TCSI links eight landscape-level collaboratives to establish a regional model for resilience and forest restoration. Partners have secured over \$32 million in California Climate Investments grant funds to implement high-priority forest health projects that sequester carbon and reduce the risk of wildfires. Projects are currently thinning 20,000 acres, removing 164,000 tons of biomass, and implementing 8,000 acres of prescribed fire across ownerships and jurisdictions.

The Tahoe Fund has identified forest health as its number one priority and has launched the Smartest Forest Fund, a sub-fund of its Environmental Venture Trust, to use philanthropy to drive innovative forest health initiatives. The fund's goals are to expedite planning and implementation of forest restoration projects; use

technology to enhance wildlife studies and harvesting plans; find new outlets for excess vegetative fuel; and prepare the community for wildfire evacuation (Tahoe Fund 2020a). The Smartest Forest Fund addresses climate change impacts such as increased wildfire risk, degraded forest health due to drought, disease, and bark beetle outbreaks.

1C. THE BENEFITS OF ADAPTATION VS. THE COSTS OF INACTION: WILDFIRE

The economic analysis conducted for this Portfolio demonstrates that adapting to wildfire provides significantly greater benefits than costs. By reducing the severity of future wildfires, each \$1 million invested in forest management actions would reduce property damages by \$10 million.

The study found that the net value of benefits would be ten times greater than prevention treatment costs, primarily because of avoided property losses, followed by avoided smoke impacts. Thinning produced benefits across all categories, property, carbon, and smoke. Prescribed burning produced larger property benefits with significantly smaller smoke benefits and does not provide a carbon sequestration benefit compared to thinning. The study noted that it likely underestimated benefits because it lacked data for the benefits that accrue to other resources from less severe fire.

1D. ADAPTATION ACTIONS

FOREST HEALTH

- A.** Placer County, DPR, NTRT, Nevada Division of Forestry (NDF), LTBMU, the Conservancy, and other Tahoe Fire and Fuels Team (TFFT) members, will continue to increase the pace and scale of forest health projects while enhancing landscape resilience and improving wildlife habitat. Projects will include the strategic use of prescribed fire, consistent with the most recent scientific research, to cost-effectively treat larger landscapes for wildland fuel accumulation while providing ecological benefits that increase climate resilience.
- B.** NTCD, NTRT and NDF will continue to work with local fire districts to prioritize forest health projects in areas where riparian restoration can also be accomplished to provide the greatest ecosystem benefits.

BIOMASS UTILIZATION

- A.** NTRT and NDF will explore opportunities to remove biomass using energy-efficient methods, and to utilize associated forest restoration byproducts.
- B.** Placer County will continue to implement its strategic Wildfire Protection and Biomass Utilization Program to minimize the risk of wildfire and use biomass to produce heat and electrical power.
- C.** TFFT will increase the use of restoration byproducts to offset fuel treatment costs and simultaneously accelerate climate adaptation.

- D. Sierra Business Council (SBC) will continue to educate and advocate for biomass utilization and bioenergy facilities to restore forest health, offset public safety power shutoff impacts, and furnish well-paying, year-round employment. This includes policy changes, collaboration with land managers, market-based approaches like California's Bioenergy Marketing Adjusting Tariff, and piloting technologies with the Sierra Institute's Build Community Program and the Rural Economic Development Wood Utilization Innovations Team.

CARBON SEQUESTRATION

- A. DPR will model 25 years of change in forest structure and how it will influence fire behavior. They will also analyze the stability of live tree carbon, and the retention of aboveground carbon stocks in the event of a wildfire.
- B. The Conservancy will use California Climate Investments funding combined with analytical tools developed in TCSI to maximize the carbon benefits of forest treatments, and streamline efficiency within the Basin such as on its Dollar Creek and biomass transportation projects.
- C. California Department of Forestry and Fire Protection (CAL FIRE) currently releases an annual Forest Ecosystem and Harvested Wood Product Carbon inventory. They will work with partners to model different forest management and utilization scenarios and associated impacts on carbon sequestration rates and stocks.

NEW MANAGEMENT AGREEMENTS AND REGULATIONS

- A. LTBMU and Conservancy will use an existing Good Neighbor Authority agreement to work collaboratively to accelerate fuel reduction treatments in the wildland-urban interface (WUI), including on urban lots. LTBMU and the Conservancy will use a forthcoming federal-state shared stewardship agreement to accelerate forest restoration programs in the Basin, including securing private investment.
- B. The Conservancy will update their forest management guidelines to anticipate future climate conditions and fire behavior, and augment training for field staff and expand inspections to identify insect and disease infestations.
- C. Per California Senate Bill 901 (2018), Lahontan Water Board will develop permits and conduct outreach, inspections, and reviews for managing vegetation and wildfire in utility corridors. Lahontan Water Board will revise or develop new regional permits to facilitate timber harvesting under Forest Practice Rule exemptions while mitigating water quality impacts, and with CAL FIRE will inspect and report on the use and efficacy of these exemptions. Finally, Lahontan Water Board will develop policies and permits that support the reintroduction of fire, thinning practices, and infrastructure (e.g., lumber mills and biofuel-generation plants) to protect the integrity and resilience of forested landscapes and minimize wildfire.
- D. TRPA will invite Basin partners that regulate and implement forest health treatments to work towards a regional approach to forest restoration and will continue to collaboratively lead the review of regulations to remove impediments to adaptation.

2. THE BIOLOGICAL DIVERSITY OF FORESTS

2A. CLIMATE IMPACTS

Climate change will alter the structure and composition of forested landscapes, and likely decrease the availability of habitat for native species. Prolonged warmer temperatures and temperature spikes may push lower-elevation species, including invasive species, to higher elevations and displace existing native species. Climate change is likely to decrease and fragment already scarce alpine habitats. Altogether the distribution, abundance, and genetic diversity of native species that are highly specialized or that live only at high elevations is likely to decrease. Some may go extinct within the Basin.

2B. PARTNERSHIPS AND INITIATIVES

Biological diversity goals of LTW include restoring terrestrial ecosystems, including meadows, that support viable populations of native species and proactively managing habitat to protect sensitive and threatened forest species, such as California spotted owl and northern goshawk. Key strategies include restoring meadows, managing invasive species, increasing habitat connectivity, and supporting native plants and wildlife. Land managers in the Basin are focused on protecting sensitive species and habitat while maintaining biodiversity on the landscape.

2C. ADAPTATION ACTIONS

PROTECTING NATIVE AND SENSITIVE SPECIES

- A. NTRT and NDOW will monitor sensitive wildlife species to ascertain changes in their populations or distribution. This includes surveying for pikas, California spotted owls, mountain beaver, shrews, northern goshawks, and Pacific marten.
- B. NTRT, NDOW, and DPR will each monitor wildlife diversity. Specifically, NTRT will continue to survey bird diversity and nesting success in aspen stands to identify habitat and climate-related changes in bird communities. DPR will resurvey and analyze a baseline wildlife inventory to assess changes in wildlife community and habitat use, the influence of management on species composition, and the arrival and departure dates of migratory species.
- C. Placer County will continue to manage and control exotic forest species.
- D. The Conservancy will explore opportunities to prepare a private lands conservation and connectivity assessment that identifies priority needs and opportunities for linking private and public lands to promote biodiversity, wildlife migration routes, and highway crossings.
- E. CDFW will continue a program to tag black bears in the Basin to better understand seasonal use and movements of black bears in the Basin.

REVEGETATION AND REFORESTATION PRACTICES

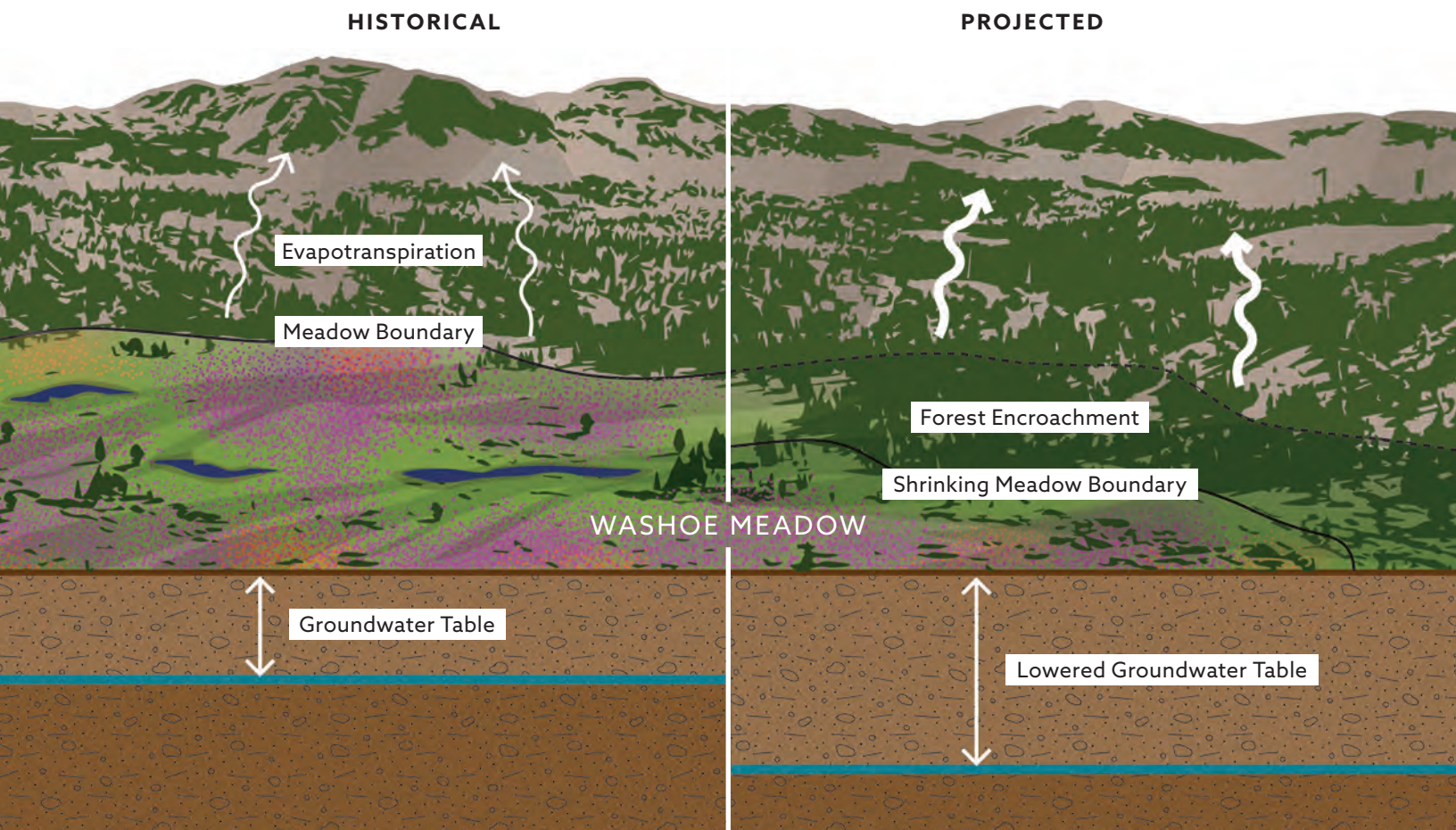
- A. El Dorado County and NTRT will adjust the mix of plant and tree seeds that it uses in revegetation and restoration projects to accommodate expected shifts in suitable elevation.
- B. Tahoe Environmental Research Center (TERC), part of the University of California at Davis, is investigating which sugar pine trees are most genetically suited to adapt to expected climate changes.
- C. The Sugar Pine Foundation will grow diverse resistant species, plant sugar pine trees, and monitor reforestation efforts.

3. WETLANDS, RIPARIAN AREAS, AND AQUATIC WILDLIFE

3A. CLIMATE IMPACTS

Snowpack plays a critical role in upland groundwater tables, riparian and aspen and meadow ecosystems, and associated aquatic wildlife. With climate change, more precipitation will arrive as rain than snow causing declines in annual snowpack, drops in groundwater levels, and changes in associated vegetation and wildlife. Greater evapotranspiration from increased temperatures, increased wildfire, and more severe drought stress will compound these impacts.

■ **Figure 8.** Forests encroach on wetlands and habitat is lost.



Wetland and riparian ecosystems with the small and often isolated aquifers characteristic of the Sierra Nevada mountains, are particularly vulnerable. Conifers and shrubs will encroach into meadows, outcompeting aspen, as their water tables drop during prolonged drought periods. Meadows without consistently high groundwater are likely to disappear entirely, eliminating critical refugia for the birds, fish, and amphibians that depend on the habitat (see Figure 8).

Variations in streamflow will disrupt aquatic ecosystems. Wintertime flash flooding will degrade stream channels. Summertime streamflows will have less volume and warmer temperatures. Connections between streams, lakes, aspen stands, fens, and meadows are likely to decrease as water ponds for shorter periods and soil moisture declines faster.

3B. PARTNERSHIPS AND INITIATIVES

The UTRWAG coordinates wetland and riparian restoration efforts along nine miles of the UTR and 1,000 acres of floodplain. Restoration efforts will enhance wetland and riparian ecosystems along the river and within the UTM which will provide critical refuge for wildlife and increase resilience to climate change. Most recently, the Greater Upper Truckee River Watershed Partnership, including the UTR and Trout Creek watersheds and adjacent watersheds, has begun a document that communicates the range of restoration and recreational achievements and future improvements that partners are leading; and identifies opportunities for integrated landscape resilience, mitigation, and adaptation.

3C. ADAPTATION ACTIONS

ACQUISITION OF SENSITIVE LANDS

- A.** NTRT and the Conservancy will each acquire environmentally sensitive lands to enhance ecosystem services, wildlife habitat, and landscape resilience throughout the Basin.

PLANNING, DESIGN, AND PERMITTING

- A.** Lahontan Water Board will support aquatic ecosystem restoration through funding, permits, monitoring, and technical assistance. Lahontan Water Board will also implement priority projects identified in the 2018 Triennial Review List (Resolution No. R6T-2018-0050) to protect and enhance the function of wetlands and floodplains, and the sustainability and resilience of groundwater supplies and forested landscapes. These include exploring Source Water Protection, Riparian Protection Policy, and Instream Flow Criteria.
- B.** The League and NTRT will continue to advocate for and work closely with partner agencies to advance restoration projects that help stream and meadows adapt to climate change.

- C. The EPA will continue to participate in the TRPA-led development of a Lake Tahoe Basin Wetland Monitoring and Restoration Plan. The EPA will continue to advocate for climate-related SEZ monitoring metrics, such as vegetation vigor in meadows, which could capture three decades of historical climate change and allow ongoing assessment into the future. The EPA will also recommend that the final SEZ restoration prioritization framework includes an evaluation of climate change-related benefits.
- D. The Conservancy and NTTRT will each incorporate vegetation and channel treatments in riparian and aspen restoration projects to provide greater resilience to extreme precipitation events and flooding.
- E. NTCD will continue to seek funding to restore impaired streams and historic meadows to provide both climate and landscape resilience. The focus of these projects is to expand the persistent riparian footprint.

RESTORING LANDSCAPE RESILIENCE

- A. NTTRT will restore and enhance steep, rocky, and sensitive state land to increase landscape resilience, protect stream environments, and reduce nutrient and sediment loading to Lake Tahoe.
- B. The Washoe Tribe will remove conifers in Máyala Wáta (Meeks Meadow) to reduce encroachment and restore natural meadow functions.
- C. The League will host hands-on volunteer restoration-adaptation events for streams and meadows throughout the Basin.
- D. The EPA will implement the Wetland Plan through monitoring, funding, and decision-making.
- E. Lahontan Water Board will help implement California's 2017 Climate Change Scoping Plan by supporting and collaborating on the protection and restoration of forested headwaters and mountain meadows, thereby maintaining water quality, increasing water storage and availability, and sequestering carbon.
- F. Tahoe RCD will restore Johnson Meadow along the UTR, which includes over 200 acres of meadow and riparian habitat. The project will remove conifers that are encroaching on meadows and aspen stands. The restoration will increase soil moisture retention, sequester carbon, and protect habitat that provides refuge for diverse species under climate change, and include a long-term monitoring plan. Tahoe RCD is exploring the possibility of including a bikeway and bridge through the meadow, which would provide recreational benefits as well as emergency access and egress to neighboring communities.
- G. NTCD will pair forest health projects with riparian restoration projects by thinning conifers that have encroached into riparian areas and integrating the cut material into stream channels as woody debris.

4. IMPROVING OUR KNOWLEDGE OF UPLANDS

Critical topics for further investigation include:

- A catalog of highly vulnerable plants and animals, including habitat requirements, migration pathways, and monitoring needs
- Assessment of areas that are critical to maintaining habitat connectivity
- Monitoring of mid and low- elevation groundwater-dependent ecosystems to provide early warning of climate change impacts
- Evaluation of existing water content and potential storage in aquifer zones where recharge and discharge occur
- Assessment of impacts of mechanical and prescribed fire fuel reduction treatments on surface water and groundwater
- Development of technologies or management practices to increase groundwater infiltration from brief, infrequent summer showers to help maintain soil moisture
- Preparation of geospatial analysis of upland vegetation conditions and groundwater-dependent ecosystems, to inform Basinwide prioritization of areas for restoration or management.

COMMUNITIES SUB-SYSTEM

Tahoe's unique mountain culture and community stems from its immediate connections to the lake, the forests, and the peaks. The extraordinary geography shapes each day – homelife, routines, ways of thinking, and wellness. It also exerts profound influence on the infrastructure and services that underwrite commerce, recreation and tourism, and public health and safety. With tourism comprising 40 percent of the Basin's \$5 billion annual economy, Tahoe depends on reliable transportation, water supply, energy, and communications systems. Climate change is expected to increase disruptions, shorten the lifecycle of investments, and increase annual repair and rehabilitation costs (some costs will be offset from less extreme and less frequent freeze-thaw cycles).

1. TRANSPORTATION INFRASTRUCTURE

1A. CLIMATE IMPACTS

Landslides and flooding threaten a significant portion of the Basin's highway system. Today the costs of climatic events that exceed highway design standards amounts to \$7 million annually; by 2100 climate change is expected to increase these costs to between \$11 and \$75 million annually—as high as \$8,400 per mile (IEc 2019). The costs of winter road maintenance and damage from freeze-thaw cycles, landslides, and avalanche hazards are already high in the Basin (Tahoe Regional Transportation Plan). Additional costs are expected with increased hazard risks from warming and extreme events. Landslides and flooding also threaten the Basin's \$26.9 billion in total property value.

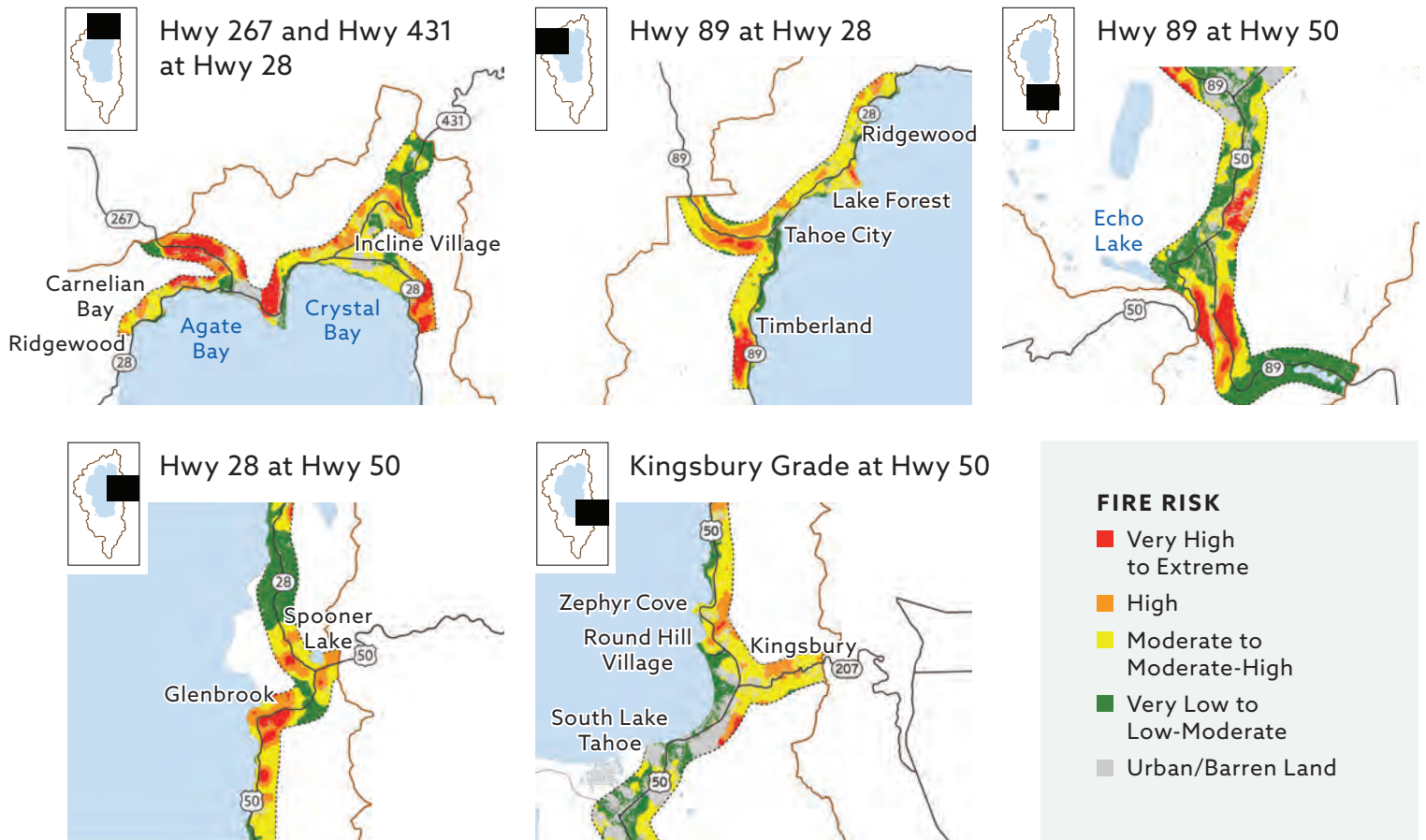
The Basin has over 3,000 miles of roads that traverse canyons, steep slopes, and high mountain passes. Each highway segment carries over 10,000 vehicles per day. Few segments have alternative routes, making the transportation system particularly vulnerable to landslides, wildfire, flooding, and avalanches.

Landslides cause road damage, lengthy transportation disruptions because of the time required to move tons of rock, soil, and debris, lost business activity from canceled trips, and water quality impacts. They can also destroy power and communication lines, water storage tanks, and pipelines. More frequent and severe storms and snowmelt events are likely to increase the frequency of landslides, particularly in areas already prone to this hazard (see Figure 10 and Table 1).

Nearly every highway segment runs through areas of high fire risk (see Figure 9 and Table 1). In addition to damaging highways, multi-use paths, and bridges, wildfires can disrupt access to roads and fuel delivery services and contaminate water supply.

Extreme storms and flooding, and debris flow after fires, will damage roads and drainage structures and increase maintenance costs. Flooding can disrupt and wash out highways, bike paths, and recreational facilities. Many Basin bike paths run parallel to creeks, rivers, and the lakeshore, and hence are located in flood zones.

■ **Figure 9.** Current wildfire risk surrounding key highway intersections

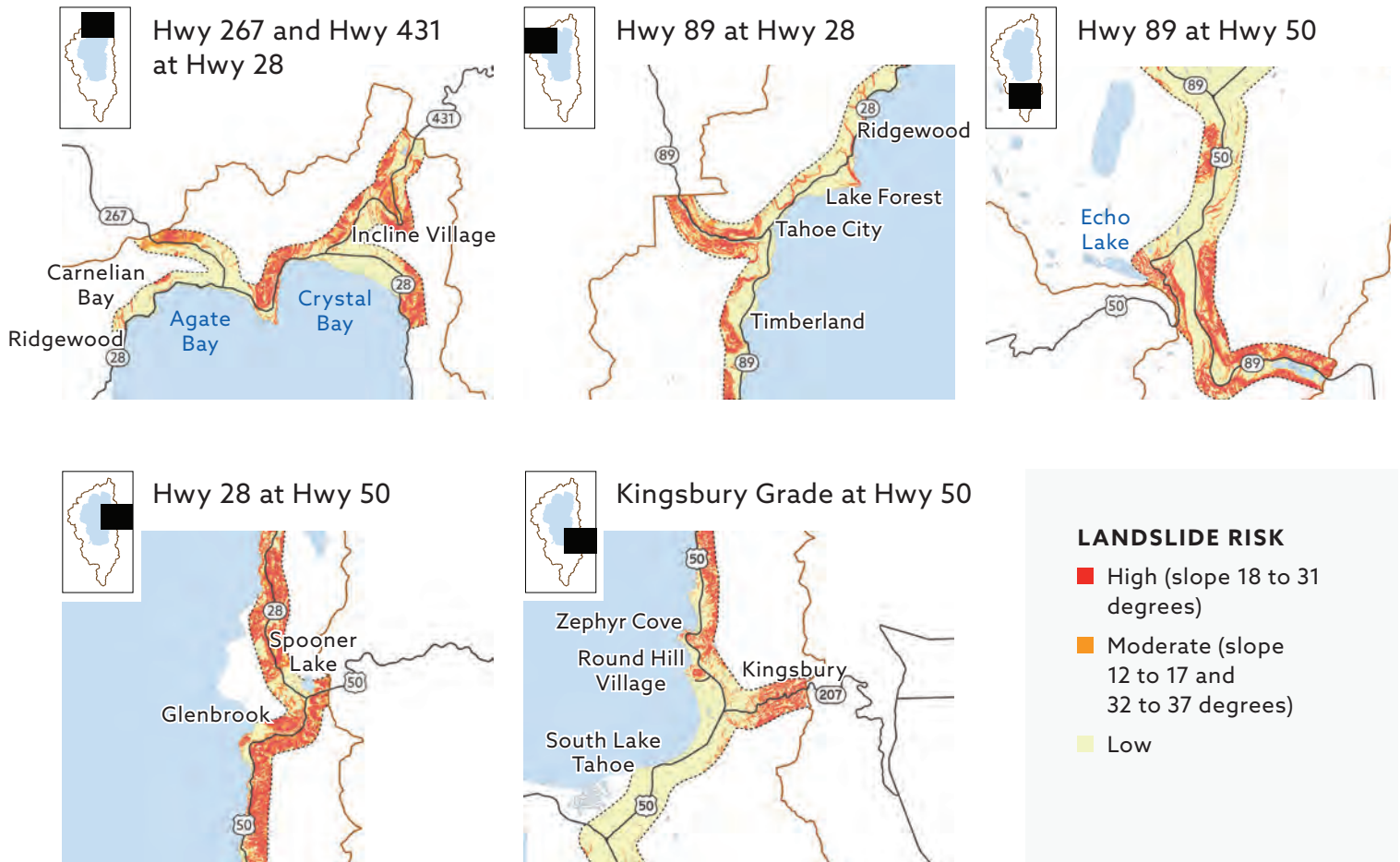


Fires grow faster on steep slopes. Climate change is expected to amplify the risk of wildfires to highways, leading to implications for mobility and evacuation routes.

■ **Table 1.** Average hazard scores for transportation infrastructure [The darker the shading, the higher the risk of that climate hazard on that infrastructure system. Low risk = pale yellow, medium risk = orange, high risk = red. IEc 2019]

TRANSPORTATION ASSETS	Flooding Hazard	Temperature Hazard	Wildfire Hazard	Landslide Hazard	Avalanche Hazard
Major roads/evacuation routes (highways) and bridges	Orange	Yellow	Red	Red	Yellow
Minor/residential roads and bridges	Orange	Yellow	Yellow	Yellow	Yellow
Public transit systems and stations	Orange	Pale Yellow	Orange	Orange	Yellow
Airport grounds and facilities	Orange	Yellow	Yellow	Yellow	Yellow
Bike paths and bridges	Red	Pale Yellow	Yellow	Yellow	Yellow

■ **Figure 10.** Current landslide risk surrounding key highway intersections



Landslides occur more frequently on moderately steep slopes. Climate change is expected to amplify the risk of landslides to highways, leading to implications for mobility and evacuation routes.

Flooding can also damage water pumps, communication devices, and electrical substations. Subsequent erosion can scour bridges and undermine roadbeds, power poles, and pipelines. Peak streamflow and runoff for six Basin watersheds analyzed in the IVA is projected to increase on average by 16 percent by 2050.

1B. PARTNERSHIPS AND INITIATIVES

The states of California and Nevada are continuing a Bi-State Consultation on Transportation that began in 2017 to accelerate improvements in transportation infrastructure. The consultation process identified a ten-year list of priority projects, and an approach to providing services that is consistent with the RTP, as a way to focus political support and action for funding among the federal, state, regional, local, and private sectors. The stakeholders hope to fill the funding gap with sustainable funding mechanisms to fulfill the ten-year priorities.

The goal of the RTP is to provide a world-class transportation system to, from, and around the Lake that shifts the primary mode of travel from the private vehicle to other modes of transportation, including transit. The RTP assumes successful implementation of corridor management strategies and traffic operations, using a systematic approach to solving transportation challenges of the Tahoe Basin. It identifies safety improvements including removing shoulder parking in high use recreation areas to avoid conflict with first responders, undergrounding powerlines along evacuation routes, addressing landslide and avalanche potential, and reducing flooding impacts throughout the region.

1C. THE BENEFITS OF ADAPTATION VS. THE COSTS OF INACTION: LANDSLIDES AND FLOODING

The economic analysis conducted for this Portfolio demonstrates that adapting management to increased landslides and flooding provides significantly greater benefits than costs and would help maximize the societal benefits of limited financial resources.

For landslides, the analysis considered building resilience through slope stabilization measures designed to last for 20 years. As reference, the study used the 1983 landslide that closed U.S. Route 50 for two-and-a-half months and cost \$10.4 million in repairs and \$180 million in economic disruption. Based on risk assessment findings and engineering studies, the analysis found that the benefits of adaptation over the 40-year period from 2021 to 2060 would be nearly seven times greater than the costs.

For flooding, the analysis considered building resilience to the 100-year flood in the UTR Basin, based on damages observed during the historic 1997 flood. That flood caused \$132 million (2019 dollars) of damage in El Dorado County, with two-thirds of this focused on the Federal Highway System. With climate change, the magnitude of the 100-year flood event could increase by 250 percent by 2050. Such an event could also increase in frequency occurring on average every 21 years. The study looked at upstream catchment approaches (e.g., vegetation cover, check dams, retention ponds) to reduce flood peaks; channel approaches in urban areas (e.g., channel straightening, decreasing channel roughness, building dikes); and adapting critical assets (e.g., reinforcing bridges, storage tanks). The study found that the benefits of adaptation would be over three times greater than the costs.

1D. ADAPTATION ACTIONS

ASSESSMENT AND PLANNING

- A.** TTD will prepare a multi-jurisdictional hazard mitigation plan that builds on the IVA and assesses natural, technological, and human-caused risks to regional infrastructure and operations. The plan will include risk mitigation strategies that create safer, more resilient communities.
- B.** TRPA will work with partners to develop scenarios that integrate climate change impacts in regional development and serve as a planning reference.

- C. NTCD has been working with Douglas County, NDOT, and local government to assess areas for conversion into a “complete street” that addresses transportation needs of all users, aesthetics, stormwater, and other conservation issues.
- D. California Department of Transportation (Caltrans) will begin undertaking detailed adaptation assessments for assets identified in the Caltrans Climate Adaptation Priorities Report for District 3, starting with the highest priority. These assessments will take a closer look at the exposure to each asset using more localized climate projections and more detailed engineering analyses. Then Caltrans will develop and evaluate adaptation options for the priority assets to ensure that they are able to withstand future climate change.

ENGINEERING AND CONSTRUCTION

- A. Placer County will use retaining walls and slope stabilization techniques to make single-access roads and key trails less vulnerable to landslides and mudflow. Work will focus on areas below steep slopes with a history of damage or blockage.
- B. Placer County will retrofit at-risk bridges to protect against flooding, landslides, and debris flows. The County will prioritize bridges with lower stability ratings and higher traffic counts, such as Edgewood Road over Wise Canal, and Dry Creek Road over Rock Creek.
- C. El Dorado County will purchase new, more efficient and environmentally friendly equipment to better manage roadways under climate change. This includes blowers, sanders, and brining equipment. The County will also apply new technologies, like beet juice and other recycled byproducts, and adjust operations to reduce roadway ice, minimize snowplow damage, and eliminate fine sediment. Finally, the County will retrofit existing infrastructure to increase resilience to extreme flooding.
- D. The Fanny Bridge Community Revitalization Project, led by TTD, is replacing a seismically deficient bridge below the Lake Tahoe dam, and building a new Truckee River Bridge that provides critical public safety by ensuring two ingresses and egresses from the west shore. The bridge and roundabouts are complete, with remaining improvements scheduled for completion in 2021, including other benefits such as improvements to walking, biking, and transit that can reduce greenhouse gas (GHG) emissions.
- E. NDOT will complete resurfacing, restoration, and rehabilitation projects on SR 431, SR 28, and US 50 that integrate stormwater and erosion control solutions as well as provide space for future bicycle and pedestrian improvements. NDOT and NTCD are assessing stormwater outfalls annually and retrofitting with treatment if space allows.

CORRIDOR-SCALE IMPROVEMENTS AND MANAGEMENT

- A. TRPA is implementing the State Route 89 Corridor Management Plan (adopted September 2020) in coordination with TTD, LTBMU, El Dorado County, DPR, Caltrans, CAL FIRE, the Washoe Tribe, and nine other partners. Goals include protecting the environment, improving safety (including landslide and avalanche issues that cause significant road closures), expanding travel choices, enhancing

visitor experiences, leveraging technology, and promoting economic vitality. The Washoe Tribe has been working on installing cultural signage along the new bike trail on the west shore of the Lake and is proposing a cultural center at the snow park along SR 89.

- B. TRPA will incorporate IVA findings in the RTP and corridor plans, including policy and project recommendations for resilience and adaptation.
- C. TTD, TRPA, NTRT, Nevada Division of State Parks (NDSP), LTBMU, NDOT, Nevada Highway Patrol, Federal Highway Administration, Washoe County, Carson City, Douglas County, NDSL, IVGID, NV Energy, and the Washoe Tribe are implementing the Nevada State Route 28 Corridor Management Plan and Nevada State Route 28 Corridor Safety Improvements, Shared Use Path & Environmental Improvements Program of Projects. This initiative, involving eleven miles of undeveloped shoreline parallel Nevada SR 28 on the east side of Lake Tahoe in Nevada, will reduce GHG emissions and increase resilience by relocating highway parking to designated mobility hubs; helping people navigate with wayfinding technologies; undergrounding powerlines; laying fiber optic data and telecommunications; adding fire hydrants; relocating a failing sewer line out of the highway under the path to protect water quality during extreme events and minimize road closures; and improving safety, trails, and transit.

ALTERNATIVE MODES OF TRANSPORTATION

- A. TTD will lead the analysis and design of a high-speed cross-lake passenger ferry system. The project will provide multiple benefits including reduced GHG emissions and increased resilience in the transportation system. Specifically, it will develop clean energy transportation alternatives, enhance Basinwide emergency response coordination, and provide alternative means for evacuation during a catastrophic wildfire or road closure in the event of a landslide or avalanche.
- B. NTCD will seek out funding to implement the “Expanded Kahle Vision” which seeks to build over 5 miles of multi-use path and over 10 miles of bike lanes.

2. WATER, POWER, & COMMUNICATION INFRASTRUCTURE

2A. CLIMATE IMPACTS

In addition to the general risks that landslides, wildfire, flooding, and avalanches pose for infrastructure and property, several additional vulnerabilities apply to water, power, and communication systems (see Table 2).

Flooding poses significant risk to the Basin’s wastewater treatment and storm water systems. Inundation of sewer facilities or lift stations could cause wastewater to flow into the Lake. Similar flooding could inundate storm water detention basins, releasing large volumes of sediment and other pollutants. Such events would significantly impact water quality and ecology. Meanwhile, flooding could expose, erode, and damage the underground pipes that convey wastewater outside the Basin.

■ **Table 2.** Average hazard risk for water, power, and communication infrastructure [The darker the shading, the greater the risk. Low risk = pale yellow, medium risk = orange, high risk = red].

INFRASTRUCTURE ASSETS	Flooding Hazard	Temperature Hazard	Wildfire Hazard	Landslide Hazard	Avalanche Hazard
Water and wastewater	Orange	Pale Yellow	Yellow	Yellow	Yellow
Electricity: high-voltage lines, plants, substations	Orange	Orange	Red	Orange	Yellow
Fuels: natural gas lines, gasoline refueling stations	Pale Yellow	Pale Yellow	Yellow	Orange	Pale Yellow
Broadcast and telecom transmission towers	Pale Yellow	Pale Yellow	Orange	Orange	Yellow
Housing and buildings	Yellow	Orange	Red	Yellow	Pale Yellow

More frequent extreme storms are projected to fill Lake Tahoe faster than the dam at Tahoe City can release water. The water surface level will frequently exceed its legal operable limit by up to five feet, creating widespread erosion, flooding, and damage to lakeshore habitat, property, marinas, and infrastructure. Conversely, drought-induced drops in lake level will strand piers, boats, and marinas, and expose sensitive habitat.

The Basin's electricity comes from power plants often located hundreds of miles away. Projected increases in the intensity and duration of heat waves can strain the regional power grid, reduce the capacity of transmission lines precisely during periods of peak demand, and increase the chance of outages.

Furthermore, the Basin's high-voltage power transmission lines and four substations traverse or are in high fire risk areas. Hotter temperatures cause powerlines to sag more, increasing the risk that they may contact vegetation and ignite a wildfire. In addition, longer periods of drought combined with more extreme winter events impact tree roots, leading to unstable trees which may fall on powerlines. Loss of such infrastructure would leave thousands of people without power. Statewide analysis shows that an eight-hour power outage in the City of South Lake Tahoe would cost nearly \$400,000.

2B. PARTNERSHIPS AND INITIATIVES

Currently public utility districts, Liberty Utilities, and NV Energy play the primary role in managing the Basin's water and power systems, and private companies manage communications. NV Energy recently developed its Natural Disaster Protection Plan (per Senate Bill 329) that addresses how they will mitigate and respond to wildfires, severe storms, and other natural disaster risks. Eighteen partners including the U.S. Department of the Interior, States of California and Nevada, Truckee Meadows Water

Authority, and Pyramid Lake Paiute Tribe implement the TROA, which governs flows from the Lake into the Truckee River. The Tahoe-Sierra Integrated Regional Water Management Group, which involves numerous Basin partners, pursues state and federal funding to address long-term and emerging water resource challenges.

STPUD developed the Urban Water Management Plan (UWMP) to evaluate whether water suppliers can meet the water demands of customers in the long term and under a range of water supply scenarios. The UWMP addresses climate change impacts such as changes in precipitation regimes, snowmelt, streamflow timing, and frequency and intensity of droughts.

2C. ADAPTATION ACTIONS

ASSESSMENT, PLANNING, AND MONITORING

- A.** In 2019 STPUD adopted a Climate Change Adaptation Plan component of its Capital Improvement Program. Accordingly, STPUD will conduct a risk and resiliency assessment of the activities and procedures necessary to respond to a catastrophic storm. STPUD will also assess the vulnerability of its underground utility lines at surface water crossings to increase their resilience to flooding. Finally, STPUD will continue to assess and monitor sewer mains and storm flows to identify vulnerable sewer system reaches.
- B.** El Dorado County will develop updated design standards and guidelines to begin upsizing infrastructure so it can accommodate potentially higher flood flows.
- C.** The Conservancy and NTCD will each design restoration and erosion control projects with BMPs that incorporate climate change scenarios.
- D.** Lahontan Water Board will develop permit requirements, policies, and guidance, and expand its coordination with stakeholder groups, to emphasize storm water capture and use, low impact development, and local and regional water management. Lahontan Water Board may modify the statewide NPDES permit template to include example climate change adaptation language.
- E.** California Department of Water Resources (DWR) will coordinate with the Conservancy on climate adaptation studies, including possible use of decision-scaling methods to improve water resources planning and resilience.
- F.** TCPUD will complete a risk and resilience assessment for critical infrastructure to evaluate vulnerabilities, threats, and consequences from all hazards. A subsequent emergency response plan will be developed that will include strategies for improving resilience, plans and procedures for responding to hazards, and actions and equipment to minimize the impact of hazards to critical drinking water and sewer conveyance systems.
- G.** TCPUD will continue to assess and monitor sewer mains located in vulnerable areas.
- H.** IVGID participates in legislative advocacy efforts at the federal government to support appropriations for water and wastewater infrastructure improvements.

INFRASTRUCTURE IMPROVEMENTS

- A. TRPA will continue to regulate development of new shorezone structures under the new Shoreline Plan that supports boating, paddling, swimming, and other water-based recreation under increased potential for extended drought. The plan provides the basis for updating piers, moorings, public boat ramps, and marina facilities, while ensuring effective natural resource management and environmental threshold attainment.
- B. TRPA will update the Regional Plan and its Code of Ordinances to ensure that infrastructure projects consider climate adaptation.
- C. El Dorado County will increase the miles of power lines that it moves underground to reduce wildfire risk.
- D. STPUD and the Tahoe Basin Water for Fire Suppression Partnership, an association of public and private water purveyors, are assessing the vulnerability of water infrastructure to wildfire, and planning corresponding infrastructure hardening projects. The assessment synthesizes lessons learned from recent wildfires in California, including loss of power and pressure during an event, and water line contamination after an event.
- E. DPR will improve the water line, powerline, and related infrastructure at D.L. Bliss State Park in response to projected drought and wildfire. The project includes installing fire prevention water hydrants, which are currently lacking along this stretch of shoreline that has the highest visitation in the Basin. DPR will partner with Liberty Utilities to move the powerline off trees and provide for continuous maintenance. The project will improve water supply reliability, the recreation experience, sanitation, fire preparedness, community safety, and emergency response.
- F. DPR will improve the water intake at Eagle Point Campground in Emerald Bay. The water line is currently damaged and is vulnerable to exposure and could create a boating hazard during prolonged drought. Its loss would substantially impact recreation.
- G. The USACE and IVGID will plan and implement the IVGID Phase II Sewer Effluent Pipeline Project and the IVGID Sewer Pond Treatment Project using 595 Program funding.
- H. TCPUD will prioritize capital improvements identified in the Tahoe Cedars and Madden Creek Water System Master Plans necessary to improve the protection and delivery of drinking water and enhance firefighting capabilities.
- I. TCPUD plans to design and construct two regional water storage tanks on Tahoe's west shore to improve availability of secure drinking water and water supply needed for fire suppression.
- J. IVGID has been in the process of assessing, repairing and replacing water and effluent pipelines and associated infrastructure as capital assets age overtime.

POWER SYSTEM RESILIENCE

- A. Liberty Utilities, LTBMU, and the Conservancy are improving forest health and resilience along powerline corridors that minimize ignition and public safety power shutoff risks, while simultaneously thinning the surrounding forest in ways that increase its ability to withstand drought and wildfire. The project creates planning, operational, and financial efficiencies by working across jurisdictions at a landscape scale. In addition, NV Energy is working with NDF to improve forest health and resilience along powerline corridors in Lake Tahoe Nevada State Park.
- B. NV Energy will underground electric lines on HWY 28 and replace/harden lines to Glenbrook and up Spooner.
- C. Placer County will improve the energy independence of new subdivisions and significant developments through on-site renewable energy generation and storage systems, including microgrids. The County will also increase access to local, decentralized, reliable energy supplies such as solar, wind, and hydroelectric, with priority for sheriff and fire stations, community shelters, medical centers, and public works yards.
- D. TCPUD will install and maintain backup power generators at critical infrastructure facilities such as sewer pump stations and water booster stations, storage tanks, and well pump houses.

3. TRIBAL LANDSCAPES

3A. CLIMATE IMPACTS

Lake Tahoe is the center of the aboriginal territory of the Washoe Tribe. Increased temperatures, reduced snowpack, longer growing seasons, wildfire, and drought may degrade and decrease the abundance of cultural resources. These span wildlife, water, foods, medicines, archaeological artifacts, sacred sites, knowledge, and sense of place and well-being.

3B. PARTNERSHIPS AND INITIATIVES

The Washoe Tribe has longstanding relationships with numerous federal and state public agencies. The Tribe is a member of the TFFT and participates in the EIP as well as numerous initiatives like the SR 28 Corridor Management Plan and LTW.

The Máyala Wáta Restoration Project at Meeks Meadow is a project by the Washoe Tribe in partnership with the LTBMU and with additional funding from the Conservancy. The Washoe Tribe will remove conifers from throughout Máyala Wáta (Meeks Meadow) to reverse encroachment and restore groundwater tables and ecological processes. The Tribe will monitor ground water at Máyala Wáta for 5 years to determine effects of conifer removal on ground water levels in a montane meadow. The Tribe will monitor native plant population post conifer removal and harvest culturally significant plants used for medicine, basket weaving, food, and ceremonial use.

The Tribe will routinely culturally burn the meadow to reduce conifers and promote regeneration of culturally significant plants. The Conservancy will continue to support tribally led restoration efforts.

The California Landscape Conservation Partnership Tribal Team (Tribal Team) was formed to incorporate tribal perspectives and interests in California Landscape Conservation Partnership activities. The Tribal Team works to create opportunities for partnerships between and among Tribes and other land managers in order to foster a holistic view of land management that includes tribal cultural heritage and traditional ecological knowledge (Landscape Conservation Cooperative Network 2020).

3C. ADAPTATION ACTIONS

PUBLIC EDUCATION

- A.** The Washoe Tribe will use signage, outreach events, and service projects to increase public education and awareness about its diverse historical and current connections to Lake Tahoe, including potential impacts of climate change.

PLANNING

- A.** The Washoe Tribe will develop a larger cultural plan of the Meeks area to include the stewardship of Máyala Wáta, the Meeks Bay resort, and other partnerships in the area.
- B.** The Conservancy will explore opportunities to partner with the Washoe Tribe to plan and cultivate tribal resilience gardens on state lands, leveraging the Newsom Administration's Policy on Native American Ancestral Lands, an existing memorandum of understanding (MOU) between the Washoe Tribe and the Conservancy.

4. RECREATION

4A. CLIMATE IMPACTS

Millions of visitors recreate on Tahoe's public lands each year. Sixteen-thousand visitors enjoy Emerald Bay, a popular site on Lake Tahoe, on an average summer day, many of whom use its beaches and campgrounds. Longer warm seasons are likely to increase visitation and recreation in the Basin, thus increasing the wear and tear on facilities and increasing environmental impacts.

Despite rising demand, more frequent and severe wildfire and smoke may limit access to public lands. After a fire, land managers may have to close an area for an extended period to allow ecosystems to recover. Wildfires may also damage trails, bridges, buildings, and facilities. Smoke may make it hazardous to recreate outside and may cause visitors to cancel their plans altogether.

Precipitation patterns also have numerous impacts. Extreme storms and flooding, and debris flows after fires, will damage roads and drainage structures, and increase maintenance costs. Less snowpack may also decrease opportunities for downhill skiing and other snow sports, though snowmaking technologies may preserve high-elevation opportunities. Overall, the length of the Basin's winter recreation season is projected to decrease 52 percent by 2100, with resorts projected to lose \$270 million in annual revenues by 2090. It is likely that some resorts will close completely.

Fluctuations in lake level will also impact recreation. High lake levels reduce the size of beaches and decrease how many people can put down a towel. Conversely, low water levels make it harder to reach the water from piers, developed areas, and marinas, and decrease the Lake's aesthetic appeal. This may discourage recreation, boating, and angling. Drought is also expected to degrade historical artifacts. As evaporation increases and inflows decrease, the Lake may drop for extended periods, exposing sunken objects to the weather and possible vandalism.

Increasing visitor numbers may challenge land management agencies. More patrols, lifeguarding, equipment, signage, waste removal, and other services will be needed to maintain safe, high-quality, wildlife-friendly visitor experiences. The longer warm season will increase these needs even further and may require the development of new seasonal regulations and permits.

4B. PARTNERSHIPS AND INITIATIVES

Formed in 2017, the Tahoe-Truckee Sustainable Recreation and Tourism Council (formerly the Sustainable Recreation Working Group) aims to provide high-quality outdoor recreation experiences, while preserving and restoring the Basin's outstanding natural and cultural resources. The group includes private, public, and nonprofit recreation and conservation stakeholders. The group works to increase coordination, engage communities, integrate recreation in corridor planning, develop a Basinwide strategic plan, establish corresponding performance measures and monitoring, and address hot-spot challenges. The working group's values include shared leadership, equitable and inclusive access, quality experiences, respect for communities, and health and well-being.

In 2018, USDA Forest Service (USDA FS) Region 5 developed the Sierra Nevada Recreation and Infrastructure Climate Change Vulnerability Assessment and Adaptation Strategy to assess climate change vulnerability and develop recreation and infrastructure adaptation strategies for National Forest lands in the Sierra Nevada. This initiative addresses the increased vulnerability of infrastructure and recreation resources such as roads, bike paths, and bridges to increased runoff during storm events and changes to snowmelt, stream hydrology, and peak streamflows as a result of climate change (Halofsky et al. [in press]).

The goal of the Tahoe Trails Endowment is to build an endowment that will generate enough funding to support the increasing need for trail maintenance around the Basin. Climate impacts such as a loss of winter recreation opportunities due to changes in temperature and snowpack, as well as increases in visitation and summer recreation due to longer warm seasons, will require more trail development and maintenance.

4C. ADAPTATION ACTIONS

PLANNING AND CONSTRUCTION

- A. DPR is developing a vision-setting Cornerstone Document for Emerald Bay and D.L. Bliss State Parks. The plan focuses on how to manage property in ways that uphold core values and promote long-term resilience and adaptive capacity. The plan considers climate change impacts, energy, water availability, and demography, with sustainability strategies emphasizing GHG emission reductions, water and energy efficiency, resource management investments, and facility development and renovation.
- B. TRPA will continue to work with members of the Tahoe-Truckee Sustainable Recreation and Tourism Council to integrate climate scenarios and adaptation in sustainable recreation plans and projects.
- C. DPR will continue implementing the Kings Beach General Plan and the Pier Installation Project. The new, longer pier will be able to reach the water during droughts. DPR is planning numerous facility and management improvements to accommodate recreation during all future lake level scenarios.
- D. TCPUD will complete a joint North Tahoe Active Recreation Facility Needs Assessment with North Tahoe Public Utility District (NTPUD) to evaluate a broad and comprehensive regional approach to planning for future construction of recreation facilities that considers the most efficient use of land and resources.
- E. TCPUD will work with the LTBMU to plan for construction of future visitor amenities at 64 Acres that facilitates management of increased visitation to the North Tahoe area.
- F. DPR aims to continue its maritime heritage program in Emerald Bay to preserve and protect the area's unique collection of sunken boats. Low water levels during droughts expose the historic barges to air, and future droughts may expose additional irreplaceable artifacts. The program uses underwater photographs to map, document, and monitor heritage artefacts.
- E. DPR aims to stabilize and repair the Vikingsholm mansion on the shore of Emerald Bay and increase its resilience to future flooding. Extended periods of high lake level elevated ground water and destabilized the building's foundation and features.

MANAGING INCREASED VISITATION

- A. DPR plans to augment its capacity to ensure public safety, maintain facilities, and provide interpretation for rapidly increasing numbers of visitors (personal communication with Sierra District Superintendent, 2019). DPR manages 70 percent of shoreline access on the California side of the Basin and has observed an increase in accidents and fatalities over the past decade.
- B. NTRT and NDSP will improve and increase visitation monitoring at Lake Tahoe Nevada State Park and use this data to inform the design of a new facility and procedures for limiting visitation during peak periods.

- C. Placer County will coordinate with LTBMU where ski resorts are operating on USDA FS land under a special use permit to support wintertime recreational activities that are less dependent on snowpack.
- D. The Conservancy will adjust its staffing and its management guidelines for public lands to accommodate longer summer and shorter winter seasons and more visitors, including opening and closing dates, maintenance schedules, and public education by stewards.

5. PUBLIC HEALTH AND SAFETY, INCLUDING WILDFIRE AND EMERGENCY RESPONSE

5A. CLIMATE IMPACTS

The greatest threats to public health and safety are wildfire, smoke exposure, and extreme heat. Increasingly frequent and severe wildfire will threaten lives, especially if a wildfire shuts down a primary ingress and egress route while people are trying to flee. Wildfire will also threaten property throughout the Basin. Some heavily populated areas already possess particularly valuable property while facing high to extreme wildfire risks. Placer and El Dorado Counties have \$911 million and \$1.2 billion of property, respectively, in areas with such risks (see Table 3).

Wildfire is expected to degrade air quality in the Basin and in downwind Washoe communities. This will negatively affect the health of local populations who are vulnerable due to a lack of air conditioning, pre-existing respiratory conditions, young or old age, and low income, which makes it harder to relocate temporarily to avoid smoke. The elderly, young children, those with preexisting conditions, and those who work outdoors face the greatest risk. Similarly, those who are physically or socially isolated may not be able to ensure their own safety, and those with low income may not be able to afford mitigation measures like taking time off work or temporarily relocating. The total annual health-related costs from the largest projected mid-century wildfire and smoke event are between \$7.4 and \$40.8 million.

5B. PARTNERSHIPS AND INITIATIVES

The bi-state TFFT consists of representatives of Basin fire agencies, the Washoe Tribe, CAL FIRE, NTRT members from NDF and NDSL, University of Nevada and California Cooperative Extensions, the TRPA, LTBMU, conservation districts from both states, the Conservancy, and Lahontan Water Board. TFFT protects lives, property and the environment from wildfire by implementing prioritized fuels reduction projects and engaging the public in becoming a fire adapted community. TFFT formed the Tahoe Network of Fire Adapted Communities (FAC) to engage communities and strengthen communication and support between them and public agencies. TFFT also includes the Fire Public Information Team (Fire PIT) that delivers coordinated messaging to residents and visitors. Fire PIT products include annual wildfire aware-

■ **Table 3.** Percentage of property at different wildfire risk levels, by county

County	Very Very Low Fire Threat Level	Very Low Fire Threat Level	Low Fire Threat Level	Low-Moderate Fire Threat Level	Moderate Fire Threat Level	Moderate-High Fire Threat Level	High Fire Threat Level	Very High Fire Threat Level	Extreme Fire Threat Level	Total Assessed Property Value in Basin (millions)
Douglas	0%	9%	6%	14%	19%	32%	19%	0%	0%	\$1,066
Carson	35%	56%	3%	3%	2%	1%	1%	0%	0%	\$71
Washoe	1%	4%	3%	18%	39%	20%	14%	1%	0%	\$1,579
Placer	4%	15%	5%	12%	23%	23%	11%	5%	2%	\$5,093
El Dorado	3%	21%	7%	13%	16%	13%	15%	9%	3%	\$4,835
TOTAL	\$401	\$2,006	\$706	\$1,663	\$2,777	\$2,469	\$1,701	\$682	\$238	\$12,644

ness events, coordinated media releases, and customized Living with Fire outreach campaigns conducted with the University of Nevada’s Cooperative Extension.

AlertTahoe is designed to protect communities in the Basin from catastrophic wildfires and other natural hazards through an innovative system of networked cameras and sensors. The system quickly detects local wildfires to accelerate response, limit wildfire damage, and improve public safety. This initiative reduces negative public health impacts from smoke exposure and increases regional resilience by giving residents more time to evacuate (Tahoe Prosperity Center 2020). This initiative addresses the increased frequency and severity of wildfire that is anticipated as a result of climate change.

The South Lake Tahoe Emergency Management Community Council (EMCC) is a multi-disciplinary group of emergency responders that was established in 2006 to address emergency preparedness in South Lake Tahoe. The council collaborates with several partner agencies to identify emergency management issues, develop plans based on the National Incident Management System, carry out emergency response planning exercises, and assist local agencies in developing a unified community approach to emergency management (Lake Valley Fire Protection District 2020). This partnership addresses the increased frequency and severity of wildfire and seeks to improve public health and safety.

5C. ADAPTATION ACTIONS

DISASTER PREPAREDNESS AND COMMUNITY RESILIENCE

- A. TTD will help lead the Department of Homeland Security's technical assessment and engineering study of the Regional 911 Dispatch and Traffic Management Center. This includes procedures, recommendations, and performance indicators for communication and information systems, personnel, training, equipment, logistics, and funding. When implemented, the project will have multiple benefits including GHG emission reductions and increased transportation system resilience through better traffic management and emergency response coordination.
- B. Lahontan Water Board will continue participating in the Office of Emergency Service's Emergency Response Technical Working Group, which aims to improve interagency coordination and communication in fire preparedness, response, and recovery.
- C. The Conservancy will explore opportunities to partner with sister state and local government agencies to establish north and south shore community resilience centers to serve both as community evacuation and emergency response centers and to build long-term resilience and recovery operations for local communities, including use of Conservancy lands.
- D. Placer County will continue to operate the Homeless Resource Helpline and Whole Person Care, and to coordinate with the Homeless Resource Council of the Sierras to provide shelter during extreme heat events, severe winter weather, and other hazardous conditions, such as Community House in Kings Beach. The County will also work with local medical providers and hospitals to ensure facilities can meet increased demand caused by extreme events. Finally, Placer County will provide animal services during such crises.
- E. SBC and the Sierra Small Business Development Center will continue to provide educational resources to help small businesses prepare for disaster, improve their resilience, and maintain business continuity as the climate changes (e.g., low snow years, major smoke events).
- F. SBC and Sierra Climate Adaptation and Mitigation Partnership (Sierra CAMP) will continue serving as a hub for regional capacity building. Action includes identifying funding, resource, networking, and educational opportunities, and facilitating collaboration and exchange.
- G. The Lake Tahoe South Shore Chamber of Commerce (Tahoe Chamber) will continue to provide educational workshops and information through our Chamber communication channels (website, social media, and print publications) to help Chamber members and other local businesses and community organizations to prepare for disaster situations, improve their resilience, and maintain sustainable operations as the climate in our region changes.

POLICY DEVELOPMENT AND ENFORCEMENT

- A.** Placer County will require any new large-scale developments in the WUI, avalanche-prone areas, and rural and isolated areas to develop emergency preparedness plans. The county will require all such developments in moderate through very high fire risk areas to have multiple points of ingress and egress to improve evacuation and emergency response access.
- B.** Placer County will continue to enforce requirements to provide defensible space around homes and other buildings in fire-prone areas and will strengthen standards as needed to provide adequate protection under future climate conditions.
- C.** El Dorado County will implement home hardening and green building standards on new construction sites to reduce fire risk and energy use.
- D.** El Dorado County will implement its new vegetation management ordinance to reduce wildfire risk on private property.
- E.** TFFT will support the adoption and implementation of local codes and ordinances that increase wildfire protection and climate adaptation activities, such as defensible space and home hardening requirements.

WILDFIRE EDUCATION

- A.** TFFT will provide guidance and assistance to residents through the FAC for defensible space, fire-safe landscaping, and lost-cost home retrofits that make it less likely for homes to catch fire from embers.
- B.** Tahoe RCD, a member of TFFT, is distributing materials and hosting community workshops that educate residents, landowners, and businesses about how to mitigate fire risks and respond to a wildfire. The Tahoe RCD is also developing a guide for retrofitting and hardening homes to mitigate fire risks and safeguard communities and hosting corresponding workshops. The work is geared toward residents, architects and engineers, and educators, and will be published in a peer-reviewed journal.

WILDFIRE PREVENTION AND MITIGATION

- A.** TFFT, including Tahoe RCD, will integrate resilience and recovery in the Lake Tahoe Basin Community Wildfire Protection Plan (CWPP) Update. The Update will reprioritize projects based on completed work and emerging opportunities. It will also include a social science-based outreach strategy and plan that better reaches targets, improves the efficacy of messaging, and changes behavior. The Update will also incorporate new information on water and power infrastructure, Basinwide Pre-Attack Plans, vulnerable and disadvantaged communities, and home retrofitting and hardening.

- B. TFFT's Pre-Attack Plan Working Group completed large-scale community plans that improve the efficiency and effectiveness of first responders. Planning analyzed completed fuel reduction treatments, vulnerable populations, critical infrastructure including water sources, evacuation routes, management objectives, and communications. It also identified emergency operation centers, incident command posts, staging areas, temporary refuge areas, and shelters.
- C. TFFT will complete and maintain WUI fuel reduction treatments within five years. This includes working with the California Conservation Corps (CCC) and Lake Tahoe Community College to expand the restoration workforce and better meet increased treatment needs.
- D. NDF will provide financial support to fire protection districts and other partners to conduct pre- and post-wildfire planning and mitigation through its Wildland Fire Protection Program, and to implement wildfire education, prevention, and mitigation projects.
- E. North Lake Tahoe Fire Protection District (NLTFPD) will increase and refine its monitoring and modeling of fuel loading throughout its jurisdiction, to better anticipate and respond to ignitions under changing climate conditions and fire behavior.
- F. Placer County's multidisciplinary task force will continue to identify, prioritize, and implement wildfire safety improvements, including coordinating grant proposals with fire protection districts and partner public agencies.
- G. CAL FIRE and the Conservancy will implement the Tahoe Program Timberland Environmental Impact Report (PTEIR) to streamline fuels treatment in the Basin.
- H. The Washoe Tribe is working on creating a cultural burn team, to assist with low intensity prescribed fire in Máyala Wáta and tribal parcels in Incline Village, Olympic Valley and possibly Skunk Harbor.
- I. IVGID participates in the Tahoe Water for Fire Suppression Partnership. This Partnership will be working with the Regional Fire Districts to submit water system projects for improving fire suppression in the Basin.
- J. In partnership with NLTFPD, IVGID will protect its lands and the Basin by performing defensible space best management practices.
- K. IVGID will enter into grant agreements with the STPUD as a member of the Lake Tahoe Community Fire Prevention Partnership. This partnership was formed out of the member agencies of the TWSA and its purpose is to obtain appropriations from the Federal Government through the USDA FS for planning, design, and construction of water system improvements that have a direct relationship to wildland fire suppression.
- L. The Conservancy will support the AlertTahoe partnership by expanding the Alert Wildfire Camera network and/or improving the existing network for increased resolution and auto-detection capabilities.

WILDFIRE RESPONSE

- A. CAL FIRE is working with partners to determine locations of new CAL FIRE stations on both the North and South side of the Lake. DPR and CAL FIRE are exploring the possibility of locating a new CAL FIRE station on DPR land to improve their ability to respond to wildfire, jointly implement prescribed burning, and serve the state parks. This will improve wildfire response by having stations in key response areas. These stations will better safeguard the people and protect property and resources.
- B. DPR seeks to partner with Desert Research Institute (DRI) to improve the long-term air quality sensor at D.L. Bliss State Park, one of the few in the Basin, and install a companion fire camera. These technologies would provide real-time fire weather monitoring, and are essential tools for improving evacuation planning, emergency response, and fire suppression under future climate conditions.
- C. TTD will acquire a cross-jurisdictional platform, Lake Tahoe Basin End Warning Systems, to improve coordination of traffic, emergency response, parking, and transit management, especially during extreme weather events and emergency roadway issues.
- D. CAL FIRE has a long-standing budget change proposal (BCP) to add two CCC Fire hand Crews to the Basin, located in Meyers. This includes added repeated radio frequencies to connect both sides of the Lake with Emergency Command Centers.

6. IMPROVING OUR KNOWLEDGE OF COMMUNITIES

Critical topics for further investigation on transportation infrastructure include:

- Integration of hydrological modeling of future flood scenarios into transportation capital improvement programs, and road, bridge, and infrastructure standards and designs
- Assessment and mapping of landslide hazards based on climate modeling, particularly changes in soil saturation
- Assessment of how to build the resilience of bike path segments exposed to increased flooding, including hardening, foundation support, and drainage improvements
- Incorporation of traffic modeling in emergency egress planning, including scenario modeling of how well real-time electronic traffic guidance systems would function during an emergency

**THE LAKE TAHOE BASIN'S CLIMATE
ADAPTATION ACTION PORTFOLIO**

2021



CALIFORNIA TAHOE CONSERVANCY

1061 Third Street, South Lake Tahoe, CA 96150 | (530) 542-5580 | tahoe.ca.gov