APPENDIX 1.

Survey content by site. The text version contains background and detailed strategy narratives for added context with each of the images, while the non-text version contains only the strategy title with each of the images. Scenarios are listed here in the order of passive/unmanaged, traditional restorative/utilitarian, and climatically adaptive strategies but appear randomized for participants in the actual survey.

Fig. A1.1 - Site 1: San Joaquin River at Temperance Flat

Background: The San Joaquin River Gorge Recreation Area, one of the last free flowing portions of the San Joaquin River that is not dammed, provides multiple recreational opportunities, including hiking and access to the Millerton Caves. T wo proposals have been made concerning this portion of the San Joaquin River, one is to build a new dam, and another is to designate eight miles as a Wild and Scenic River.

Strategy 1: Unmanaged trail access	Strategy 2: Dam and reservoir	Strategy 3: Wild and Scenic River
		
Strategy 1: Vulnerability to tree mortality and high severity fire are increased through years of drought and variable precipitation, and the ability of the ecosystem to retain and provision ground water and carbon is diminished. The social conditions are diminished when the scenery of an overly dense and dry woodland is coupled with the impacts of visitor overuse resulting from unmanaged recreational access. Rate the three images as "1" being most preferred and "3" being your least preferred.	Strategy 2: The site is developed as part of the proposed Temperance Flat reservoir. The reservoir displaces the existing woodland ecosystem of the watershed and creates a new shoreline with variable height. Recreational access for the reservoir is managed with limits, but not much infrastructure is built for the high levels of vehicle use, which makes it difficult for new species to establish and newly adapted ecotones to form.	Strategy 3: Woodlands within the watershed are managed as green infrastructure by sequestering carbon and regulating hydrological processes, provisioning groundwater, and buffering downstream communities from extreme flood events. Recreational access is managed under Wild and Scenic River guidelines with only the necessary minimal infrastructure designed to adequately accommodate and reduce the impacts of non-motorized access for hiking, caving, and river recreation.

Fig. A1.2 - Site 2: Upper Kern River

Background: The Kern River is a water source for urban and agricultural use, stored in Lake Isabella, but it is also a source of tourism, linked to the local economy of the town of Kernville, in the way of camping, rafting and fishing. Climate change is predicted to cause irregularities and intensities between annual precipitation levels and snowmelt timing, thus affecting the river tourism industry that Kernville depends on.

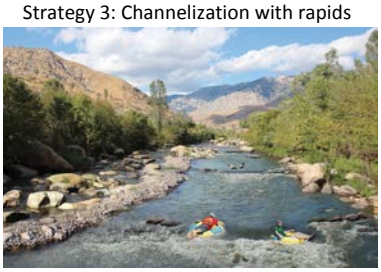
Strategy 1: Unmanaged river access	Strategy 2: Restored river habitat	Strategy 3: Channelization with rapids
		
Strategy 1: A combination of low and variable precipitation years results in reduced river flow. Unmanaged impacts from high visitor use levels contribute to degraded near river habitat. The coupled impacts from continued low water levels and visitor overuse lead to a more vulnerable river ecosystem.	Strategy 2: The nearshore habitat of the river is restored from visitor overuse and the river is channelized to ensure a minimum water depth exists for instream species. In this case visitors are restricted from accessing the river in order to maintain restored conditions that help to buffer for climatic variability.	Strategy 3: This stretch of the river is managed for both habitat restoration and visitor use in variable precipitation years. River access is limited to permitted outfitters with select entry and exit points to help mitigate visitor impacts to nearshore habitat, and in river features such as rocks are engineered to create rapids for recreational use as well as instream habitat with low waterflow in mind.

Fig. A1.3 - Site 3: Lower Owens River

Background: The Owens River runs along the east side of the Sierra Nevada and historically had extremely low flows due to over extraction of water by the LADWP but has since been restored to a more natural river flow. In one portion of the river, a large Tule and cattail wetland is obstructing the flow of water, causing diminished water quality to downstream users, fish die offs, habitat loss for threatened species and a lower quality grazing habitat for cattle.

Strategy 1: Unrestricted grazing	Strategy 2: Fenced-off grazing	Strategy 3: Fishing & recreational access
		
Strategy 1: In low precipitation years the river continues to flow but at a level below what is needed to maintain viable fish populations. That, in combination with the unmitigated impacts to water quality and over browsing from passive grazing, results in a river ecosystem that is more vulnerable to drought and increased heat.	Strategy 2: Fencing off the river corridor from grazing and recreational access results in less impacts to the river ecosystem that would otherwise exist with unmanaged grazing and visitor overuse. This strategy would improve proximate fish habitat and water quality for downstream use.	Strategy 3: In this scenario water levels are controlled year-round through upriver releases to achieve a compromise between near-historic hydrological regimes and that year's available water supply. Instream species and near river vegetation would be managed as an indicator of ecosystem health. Minimal visitor infrastructure would be added to limit the impacts associated with access for permitted

Fig. A1.4 - Site 4: Templeton Meadows in the Gold Trout Wilderness

Background: Meadows in the Sierra ecosystems provide carbon storage, groundwater storage, water filtration, and unique habitat for native trout species, but cattle grazing of Sierra meadows has had detrimental effects on meadows, as cattle tend to aggregate around water sources, trampling vegetation, eroding stream banks and compacting soil. The degradation of meadow streams from grazing, along with climate induced warming of stream waters and the introduction of non-native trout are affecting the ability for native trout species to survive in these iconic recreational fishing sites.

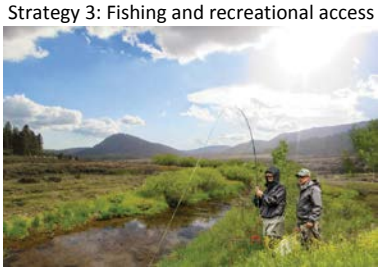
Strategy 1: Unrestricted grazing	Strategy 2: Fenced-off grazing	Strategy 3: Fishing and recreational access
		
Strategy 1: With passive grazing there are no controls for over browsing and erosion. Although grazing leases are permitted in many wilderness areas, the use of an already vulnerable meadow system for seasonal fodder significantly deteriorates the physical character and cultural expectations associated with wild places.	Strategy 2: Grazing is still permitted but restricted by fencing to the non-riparian areas of the meadow. This reduces erosion, which facilitates plant recovery and improves water quality in the stream corridor, which allows the meadow to partially recover. However, browsing is restricted to the outer portions of the meadow, which may increase the likelihood of forest succession, albeit gradually. In addition, the fence poses an aesthetic impact to wilderness character where signs of intervention are otherwise limited.	Strategy 3: Grazing is restricted from the meadow and surrounding forest. Water quality and near stream vegetation significantly increases. The stream becomes more channelized due to less erosion and the greater water content retained in the meadow allows the system to resist succession to forest. The trout population returns to a meadow with naturalized conditions, and with sufficient numbers recreational fishing is again seasonally permitted.

Fig. A1.5 - Site 5: Big Meadows in Sequoia National Forest

Background: A large portion of Sierra meadows have been degraded by overgrazing, drying, and lodgepole pine encroachment and thus have lost their ability to regulate seasonal water flow and filter out unwanted constituents. Many meadows are being restored to improve their hydrological function.

Strategy 1: Unrestricted social trails	Strategy 2: Restricted access & restoration	Strategy 3: Prevent tree encroachment
		
Strategy 1: Unmanaged recreational access to meadows can result in social trails that degrade and fragment the hydro-ecological interface. The erosion caused by these emergent trails may also reduce water storage capacity of the system, making it more vulnerable to forest succession. The physical marks of unchecked recreational use may also impact the scenic conditions that visitors expect and rely upon.	Strategy 2: Limiting visitor use to a narrow trail corridor along the edge of the meadow and forest reduces the number of trails in the meadow to help restore the soil and vegetation of this ecosystem. However, this strategy focuses on restoration back to a known, historic baseline rather than anticipation of future climate change, such as increased heat and drought conditions that may lead to forest succession.	Strategy 3: While drought and heat will be common determinants of future forest and meadow conditions, there are strategies to adaptively resist successionary change. The 'plug and pond' retention method is one approach that increases meadow water storage and thereby staves off tree encroachment due to the difficulty lodgepole pines have in tolerating high soil moisture levels.

Fig. A1.6 - Site 6: Generals Highway Forest

Background: Fire is one of the driving disturbances in forests that maintains ecological balance but because of past fire suppression, many Sierra forests have grown overcrowded and are at a higher risk for severe wildfires. Sequoia National Park was one of the first parks to employ prescribed burning as a management strategy to restore forest health and minimize the risk of severe wildfires.

Strategy 1: Fire suppressed dense forest

Strategy 1: Overly dense tree stands, and canopy cover impact the forest ecosystem by limiting available ground cover and light for flora, and access to habitat for many fauna. These conditions make the forest vulnerable to high severity fire and difficult to access for recreational use.

Strategy 2: Mechanically thinned forest

Strategy 2: Forest thinning can open canopies to provide more available light, which along with clearing of detritus on the ground can encourage more native plant growth in the understory. This improves habitat conditions for many species and reduces susceptibility to high severity fire events.

Strategy 3: Prescribed burning

Strategy 3: Low level prescribed fire is an adaptive management method that increases forest resilience amid changing climatic conditions. Prescribed burning can maintain thinned forests, native groundcover, and increase groundwater retention. Forests managed with fire are typically more resistant to collapse like with forests that are unmanaged, overly dense, and contain less drought-tolerant endemic species.

Fig. A1.7 - Site 7: Railroad Fire near Sugar Pine

Background: The Railroad Fire of 2017 burned 12,000 acres of forest land near Sugar Pine. The fire burned intensely in areas that had already experienced high levels of tree mortality as well as in areas that had previously been treated by prescribed burning and mechanical thinning. Post-fire forests are managed for multiple outcomes including, prevention of erosion and its effects on watersheds, harvesting viable timber products, minimizing the risk of future insect outbreaks, minimizing the severity of subsequent fires, and promoting ecosystem regeneration.

Strategy 1: Passive forest regrowth

Strategy 1: Post-fire ecosystems and the soil that underlies them are sensitive environments. The state of the forest that succeeds these scarred landscapes is in large part determined by the conditions of the system at this point. If nothing is done to course correct, then the forest is likely to again fill in with many young trees not necessarily adapted to future extremes resulting in overly dense stands highly vulnerable to further high severity fires. Importantly however, if soils are left intact without soil compaction then the understory vegetation and conifer growth can recover.

Strategy 2: Post-fire salvage logging

Strategy 2: Post-fire salvage logging in places damaged by wildfire and other natural disturbance allows remaining timber to be utilized, however the use of heavy machinery, as is common with this practice, results in serious impact to soil compaction which can result in delayed understory and conifer growth. While this strategy may be beneficial for the local economy in the short term, delayed succession may ultimately lead to a more vulnerable forest system, subject to greater erosion and without the necessary biomass and tree age class diversity needed to regenerate the ecosystem.

Strategy 3: Climate-adapted regrowth

Strategy 3: Facilitated regeneration is practiced as a low-impact method to manually plant conifer seedlings that originated from a population more genetically adapted to the future temperature and precipitation conditions at this site. By avoiding compaction caused by heavy machinery and plating seedlings, the soil can retain more precipitation as groundwater, and there is less potential for post-fire run-off. This method, at once assisted migration and adaptive forest succession management, may help to reduce vulnerability to high severity fires so long as occasional low-level prescribed burns are utilized to maintain conditions going forward.

Fig. A1.8 - Site 8: Case Mountain Giant Sequoia Complex

Background: Climate change prediction models show that temperatures in the Southern Sierra will increase and that precipitation patterns will change inevitably affecting the narrow climatic envelope of the giant sequoia range. The groves of the Case Mountain Complex are the only giant sequoias managed by the BLM. Currently, these groves are full of dense mixed conifer growth, ladder fuel, and a heavy forest floor fuel load, all conditions that could contribute to the spread of a severe fire in the future.

Strategy 1: Fire suppressed

Strategy 1: Giant sequoias rely on heat from fire to open seeds in their cones. Despite this, many sequoia groves lie within forests that are otherwise managed for fire suppression. This not only limits species reproduction but also leads to overcrowding of understory vegetation and competing conifers that in turn make the groves more vulnerable to high severity fire beyond what the species has adapted to. The dense tree stands in this scenario provide limited opportunities for visitor use access, which stands in contrast to low level of groundcover of naturalized groves.

Strategy 2: Mechanically thinned

Strategy 2: One method to restore sequoia groves back to a more naturalized composition is to remove competing conifers and masticate the remaining ground cover. This mechanical thinning is a temporary solution that doesn't consider future climatic variability or maintain low level prescribed burns. Furthermore, soil compaction from mechanical thinning can poses a risk to the shallow root structure of the sequoias and this method may impact scenic expectations of visitors.

Strategy 3: Prescribed burning

Strategy 3: The use of low-level prescribed burns in giant sequoia groves is an adaptive management strategy that allows for soil regeneration, maintenance of low groundcover, and sequoia seedlings to activate under heat. Although due to historic suppression some thinning may be necessary before low level burns can be employed, further semi-annual prescriptions can keep the groves in a functionally resilient state that's more accessible for limited visitor use.

Fig. A1.9 - Site 9: Dinkey Collaborative Forest Program

Background: The Dinkey Landscape Restoration Collaborative is a forest restoration program in the community near Dinkey Creek and was formed in 2010 to be an ecological restoration management group based on science with the main goals of improving the health of the forest, minimizing chances of severe wildfire and benefiting the local economy. The area that the Dinkey Collaborative oversees, has experienced high tree mortality, and they have begun working to thin and remove the dead trees.

Strategy 1: Fire suppressed forest

Strategy 1: The continued paradigm of fire suppression results in denser tree stands, which contain many smaller trees as opposed to a thinner stand of larger trees. In some cases, the biomass of these dense stands is as much as ten times that of pre-suppression forest structure. These forests are more vulnerable to high severity fires, which pose hazards to structures and diminish air quality in nearby communities.

Strategy 2: Mechanically thinned

Strategy 2: Mechanical thinning, also known as selective logging, can be used to space out the forest to a near pre-suppression density. Mastication techniques that clear the forest floor of biomass can be applied in parallel. These methods increase the resilience of the forest, however further thinning efforts will need to be undertaken with continued tree mortality and understory growth. Thinning can provide a small economic return to the community but may not be politically feasible at the scale needed to address the issue.

Strategy 3: Climate-adapted regrowth

Strategy 3: Assisted migration of mixed conifer and oak forests into a new climatic envelope can help to buffer the system from further collapse associated with largescale tree mortality of pines. Tree mortality from native pine bark beetle is exacerbated by the stress of hotter and drier climate coupled along with dense tree stands. Forest floors can be manually thinned and species more adapted to future conditions can be planted amid natural canopy openings, which can reduce the vulnerability of the forest to high severity fire and limit scenic impacts of pervasive die-off.

Fig. A1.10 - Site 10: Table Mountain Preserve

Background: The Sierra foothills are a biologically diverse region of mixed oak woodlands where ranching is a historically important land use. Large ranches are significantly more beneficial to ecosystems, relative to the exurban development seen throughout the wildland-urban interface. While grazing is a culturally valued land use for some, so too are both access to recreational amenities and the ecological preservation of endemic species for others.

Strategy 1: Passive grazing	Strategy 2: Restoration of woodlands	Strategy 3: Assisted migration
		
Strategy 1: Foothill ecosystems are subject to the vulnerabilities of a shifting climatic envelope and historic land uses, a double exposure that's magnified with increasingly common lower precipitation and higher temperatures years. Passive grazing is impactful if not managed, but this physical and scenic degradation is magnified when already stressed ecosystem conditions exist from drought and heat.	Strategy 2: Grazing can be curtailed or restricted during years of variable climatic conditions. The absence of grazing may allow vegetation to remain intact and standing, however a changing climate means that the range has shifted for plants that once flourished in this narrow temperature and precipitation band along the Sierra. Despite these changing conditions, foothill open spaces will remain open for recreational use given their proximity to the Valley.	Strategy 3: An adaptive strategy for managing ecosystems with shifting climatic envelopes is to assist in the migration of species, which are themselves being pushed out of a narrow temperature and precipitation band, to a climatic-ecological niche that these species are now best suited to occupy. In this scenario continued recreational access and additional community support for assisted migration projects leads to sustained visitor use.

Fig. A1.11 - Site 11: Highway 190 near Camp Nelson

Background: Sierra roadways will be impacted by more variable and extreme weather, and the resulting impacts of wildfire, erosion, flooding, landslides, and pavement deterioration. When wildfires burn understory vegetation, erosion control is lost, and methods need to be used in order to manage for potential mudslides, rockslides and flooding.

Strategy 1: Post-fire/flood landslide	Strategy 2: Post-fire/flood landslide barriers	Strategy 3: Post-fire/flood reseeding
		
Strategy 1: High severity fires can burn both the groundcover and overstory vegetation. In so doing the surface water absorption and stabilizing characteristics of soil and roots are compromised. Landscapes with steep slopes are made more vulnerable when fire disturbance is followed by a high-volume precipitation event, which can lead to rock, mud, and landslides that can impact roads.	Strategy 2: A double exposure happens when fires and floods impact nearby infrastructure such as roads that people rely upon for commerce, tourism, and life. Traditionally these hazards to roadways are limited by barriers erected to restrain otherwise natural processes from impacts to roadways. However, larger magnitude events associated with climate change mean that this command and control solution has its limits.	Strategy 3: One strategy that can help to prevent or mitigate the impacts of slides is the reseeding of hillsides after high severity fire events. The use of native plants with drought resistant root structures in combination with erosion control methods like the use of straw socks can help to lessen the impacts of post-fire landslides and increase the likelihood that roadways won't be damaged.

Fig. A1.12 - Site 12: Mammoth Mountain Ski Area

Background: With the onset of warmer winters and increased drought conditions in California and the Sierra, snowpack will become more variable and as some result recreational skiing opportunities will be less certain. Ski resorts either must adapt by adjusting their recreational activities or by making snow with machines.

Strategy 1: Low snowpack closure

Strategy 1: Low or variable snowpack will result in ski area closures. These years of drought and increased temperatures may result in expanded tree mortality to higher elevations, which in conjunction with unmanaged recreational access would contribute to ecologically vulnerable conditions.

Strategy 2: Snowmaking to maintain skiing

Strategy 2: Snowmaking can be employed to restore more certain conditions for expected winter recreation. This interventionist approach would rely on greater water and power generating ability from nearby source watersheds that are already in drought, thus leading to greater reliance on already vulnerable supplies.

Strategy 3: Adaptive recreational re-use

Strategy 3: Shifting recreational use to incorporate typically non-winter sports, such as biking, as a year-round option is a resilient alternative that doesn't rely on limited water and energy sources associated with drought. Managed trail access can limit ecological impacts for already vulnerable species to a narrow trail corridor.