Southern California River and Stream Habitats

Climate Change Adaptation Synthesis

Introduction

The following section presents climate change adaptation planning results for rivers and streams. The results summarize discussions and activities completed by participants during a two-day adaptation workshop as well as peer-review comments and revisions and relevant examples from the literature or other similar efforts.[1] We first present current management **goals** identified by participants. The purpose of identifying management goals is to provide a foundation for evaluating whether and how climate change might affect the ability to achieve a given goal, and to develop options for reducing vulnerabilities through revised management activities. For each management goal, participants identified potential climate change vulnerabilities. This activity was followed by the evaluation of current management actions, including whether, in their current form, they can help to reduce identified vulnerabilities and/or how they can be modified to better address climate challenges. Following the evaluation of potential vulnerabilities of current management goals and actions, participants explored potential future management goals and adaptation **strategies** and identified more specific adaptation **actions** designed to reduce vulnerabilities or increase resilience of rivers and streams. For each adaptation action, participants then evaluated where, when, and how to implement those actions as well as collaboration and capacity needs. Lastly, we present a table summarizing all adaptation actions developed by participants as well as additional actions for consideration from the literature and from other similar efforts. Adaptation actions are grouped according to whether they (1) enhance resistance, (2) promote resilience, (3) facilitate transition, (4) increase knowledge, or (5) engage coordination in terms of responding to climate change.

Defining Terms

Goal: A desired result for a given resource.

Adaptation strategy: General statements of how to reduce vulnerabilities or increase resilience of current management goals.

Adaptation actions: Specific activities that facilitate progress towards achieving an adaptation strategy.

Current Management Goals and Potential Vulnerabilities

Workshop participants identified three key current management goals for rivers and streams:

(1) Inventory stream/creek characteristics to determine how they may be impacted by climate change,

[1] Workshop participants included: Edward Belden, National Forest Foundation; Jesse Bennett, USFWS; Lauma Jurkevics, CDWR; Kristie Klose, USFS; Arlee Montalvo, Riverside-Corona RCD; Christopher Taylor, CH2M; and Robert Taylor, USFS

(2) Protect streams down-gradient of state water project (SWP) lakes/dams, and
(3) Reconnect streams by removing ford stream crossings and replacing with bottomless arch stream culverts and bridges.

As part of the workshop activities, participants identified potential climate and non-climate vulnerabilities to current management goals and actions for rivers and streams. Potential vulnerabilities identified included:

- Increased water evaporation from lakes due to warming temperatures
- Decreased water availability for southern California reservoirs and lakes due to decreased snowpack in the Sierra Nevada, earlier snowmelt, and a greater proportion of precipitation falling as rain rather than snow
- Reduced amount of water in rivers and streams because of changing precipitation patterns
- Sensitivity of aquatic organisms to changes in air and water temperature, stream flow, sedimentation, and dissolved oxygen

In response to these vulnerabilities, participants then evaluated whether or not existing management actions may be effective in reducing vulnerability; identified what, if any, climate and non-climate vulnerabilities the action helps reduce; and evaluated the feasibility of action implementation. Given action effectiveness and feasibility, participants then evaluated whether or not to continue implementation of the action. For those actions recommended for continued implementation, participants then identified both how and where to implement.

Terminology

Action effectiveness: Identify the effectiveness of the action in reducing vulnerability.
High: action is very likely to reduce vulnerability and may benefit additional goals or habitats; *Moderate*: action has moderate potential to reduce vulnerability, with some limits to effectiveness; or *Low*: action is unlikely to reduce vulnerability.

Action feasibility: Identify feasibility of implementing the action.
High: there are no obvious barriers and it has a high likelihood of being implemented; *Moderate*: it may be possible to implement the action, although there may be challenges or barriers; or *Low*: there are obvious and/or significant barriers to implementation that may be difficult to overcome.

How to implement: Identify how to apply this action given vulnerabilities.
For example, consider planting native species that can cope with a range of future conditions or those best adapted to projected future conditions.

Where to implement: Identify the management, ecological, or site conditions where the action could be most appropriately implemented.
For example, is it best to implement in areas with high soil moisture holding capacity, areas projected to lose the most water supply, post-fire areas, highly roaded areas, etc.?

Table 1 below explores current management goals and actions, potential vulnerabilities, and ways to revise current actions to reduce vulnerabilities for rivers and streams. The table is structured to provide:

1. A current management goal;
2. Potential climate and non-climate vulnerabilities that affect the success of achieving the management goal;
3. Multiple current management actions;
4. An evaluation of action effectiveness, feasibility, and potential vulnerabilities that the may be reduced by action implementation; and
5. A description of where and how to implement the action given climate vulnerabilities and whether or not implementation of the action may have indirect effects on other resources, either positive or negative.

Revised Management Actions

The following list describes trends and commonalities amongst the climate-informed current management actions discussed by participants in Table 1.

- Several themes emerged within the management actions identified by workshop participants including:
    - A need for inventory and monitoring of rivers and streams in the region, which included an inventory of all riffles, pools, creeks, and streams, the location of invasive plants, and water supply monitoring, population and species use monitoring;
    - Identifying ways to keep water in the system, maintain flows, and ensure that aquatic systems are able to maintain functionality; and
    - Managing for fish and other aquatic organisms by monitoring populations and enhancing stream connectivity.
- The majority of management actions identified by workshop participants focused on *increasing knowledge* through the use of inventories, monitoring programs, and research. A limited number of actions addressed *enhancing resistance* (e.g., removing invasive species, maintaining creek flow, identifying improvements to sustain species) and *promoting resilience* (e.g. improving aquatic organism passage).
- Workshop participants noted that wildlife will benefit from many of these actions, and specific actions may also decrease stream temperatures and improve safety for pedestrians and traffic (e.g., by replacing perched fords). Conflicts could arise with urban communities concerned about their water supply and recreational opportunities, and some species could be negatively impacted by foliar herbicides and aquatic organism passages.
- Workshop participants recommended a number of locations for implementation of these management actions; these included areas with suitable habitat for fish and amphibians, Core 1 watersheds, State Water Project reservoirs/lakes, and areas that will receive the most positive impacts per dollar.

Table 1. Current management goals, potential vulnerabilities, and current management actions for rivers and streams. For each current management action participants evaluated its effectiveness (likely to reduce climate vulnerability) and feasibility (likelihood of implementation), and identified climatic and non-climatic stressors the action could help to ameliorate the effects of. Given action effectiveness and feasibility, participants then evaluated whether or not the action should continue to be implemented. If the action was recommended for continued implementation, participants detailed any changes regarding where and how to implement given climate vulnerabilities. Lastly, participants evaluated whether there were potential conflicts with or benefits to other resources from action implementation.

Current Management Goal: Inventory stream/creek characteristics to determine how they may be impacted by climate change

Potential vulnerabilities:

- Reduced amount of water in rivers and streams because of changing precipitation patterns

Current Management Action[2]	Current Effectiveness	Current Feasibility	Does Action Ameliorate Effects of Any Vulnerabilities?	Continue to Implement Action Given Climate Vulnerabilities?	Where/How to Implement Given Climate Vulnerabilities	Other Resource Considerations
Inventory pools, runs, riffles, creeks, and streams	Moderate – will serve as baseline for other actions	High	Yes – may help managers develop strategies to maintain water into and through summer	Yes	**Where**: Throughout entire watershed, keying in on areas with suitable habitat for fish/amphibians **How**: Inventory should include non-native plant locations, species use, and species composition. May need to update as climate conditions change.	**Other resources action benefits**: Water for species use in drought conditions **Other resources with potential conflicts**: None
Identify places where improvements could be made to sustain species success	Moderate – will help direct habitat improvement actions	High	Yes – may help prioritize actions given climate vulnerabilities	Yes	**Where**: Concentrate on areas that will retain water for species survival during drought. May need to update as climate conditions change. **How**: Prioritize locations by the largest positive change for the cost.	**Other resources action benefits**: N/A **Other resources with potential conflicts**: N/A

[2] Determining the cost involved in retaining water within the system for longer periods of time was also identified as a current management action for this goal, but was not evaluated, so it is not listed in this table.

Current Management Goal: Protect streams down-gradient of state water project (SWP) lakes/dams

Potential vulnerabilities:

- Increased water evaporation from lakes due to warming temperatures
- Decreased water availability for southern California reservoirs and lakes due to decreased snowpack in the Sierra Nevada, earlier snowmelt, and a greater proportion of precipitation falling as rain rather than snow

Current Management Action	Current Effectiveness	Current Feasibility	Does Action Ameliorate Effects of Any Vulnerabilities?	Continue to Implement Action Given Climate Vulnerabilities?	Where/How to Implement Given Climate Vulnerabilities	Other Resource Considerations
Maintain creek flows downstream of SWP lakes/dams (per FERC license requirements)	High	High – but requires regulatory approval	Yes – reservoirs are required to release water at sufficient volumes to support biota downstream of the dam, regardless of drought conditions	Yes – depending on length of drought	**Where**: At existing SWP reservoirs/lakes **How**: Continue with dam releases	**Other resources action benefits**: Decreases stream temperatures because of cold water coming from the deeper portions of reservoirs **Other resources with potential conflicts**: Urban water supply, opportunities for water recreation, possibility of high nutrient loads and low dissolved oxygen in water releases (depending on their frequency and from what depth released)
Monitor water supply of SWP lakes	Moderate	High – regulatory requirement	Yes – addresses vulnerabilities indirectly by providing data for management decisions	Yes	**Where**: At existing SWP reservoirs/lakes **How**: No answer provided by participants	**Other resources action benefits**: No answer provided by participants **Other resources with potential conflicts**: No answer provided by participants

Provide sufficient SWP water to protect water quality, provide downstream flow, and maintain ecosystem services	Moderate – High	Moderate – High	Moderate – High	Yes – depending on length of drought	**Where**: No answer provided by participants **How**: Re-examine recreational uses and identify alternatives; engage the public through education and outreach about water conservation issues	**Other resources action benefits**: Multi-benefit use for southern California **Other resources with potential conflicts**: Conflicts may occur as stressors increase
Current Management Goal: Reconnect streams by removing ford stream crossings and replacing with bottomless arch stream culverts and bridges						
Potential vulnerabilities: • Sensitivity of aquatic organisms to changes in air and water temperature, stream flow, sedimentation, and dissolved oxygen						
Current Management Action[3]	**Current Effectiveness**	**Current Feasibility**	**Does Action Ameliorate Effects of Any Vulnerabilities?**	**Continue to Implement Action Given Climate Vulnerabilities?**	**Where/How to Implement Given Climate Vulnerabilities**	**Other Resource Considerations**
Install aquatic organism passages (AOP) and implement before-after-control-impact (BACI) studies	High	Moderate – expensive	Yes – having access to an entire stream network decreases vulnerability to extirpation by providing greater environmental heterogeneity	Yes	**Where**: In Core 1 watersheds (these have the highest intrinsic value to maintain as strongholds for fish) **How**: Completely remove or replace perched fords in Core 1 watersheds with bottomless arch culverts or bridges	**Other resources action benefits**: Improves habitat for all aquatic biota, especially fish and amphibians who would have access to spawning grounds; links isolated populations for improved genetic diversity; safer for pedestrians, equestrians, and vehicular traffic **Other resources with potential conflicts**: Arroyo toad, red-legged frog, southwest willow flycatcher

[3] Additional current management actions identified for this goal were: 1) Plant riparian areas after disturbances such as AOP installation or fire post-AOP, 2) Minimize water withdrawals, 3) Engage in education and outreach with UCSB's Bren School of Environmental Management to determine discharge volumes through time. These were not evaluated, so they are not listed in this table.

Removal of invasive arundo and tamarisk	High	Moderate – limited by logistics, cost, and rate of spread	Yes and no – removing arundo and tamarisk is good for native species, riparian habitats, and water levels overall (e.g., arundo is a fire hazard, competes with natives, unable to provide habitat for native species); however, some birds (flycatcher) use tamarisk for nesting habitat	Yes	**Where**: Core 1 watersheds (have high intrinsic value for fish and wildlife) **How**: Continue to remove invasive riparian plants that outcompete natives for water, focusing on arundo and tamarisk	**Other resources action benefits**: In general, water levels should rise as competition for water decreases, which would improve habitat for aquatic and riparian communities; there is some evidence that arundo contains toxins within plant tissues **Other resources with potential conflicts**: Southwest willow flycatcher (uses tamarisk for nesting); foliar herbicide sprays may have negative consequences
Steelhead population density monitoring	Moderate	Moderate – limited by cost	No – monitoring only provides information on species response to climate change, and fish population densities and ontogenies in Mediterranean climates are naturally dynamic	Yes	**Where**: Core 1 watersheds (have high intrinsic value for fish and wildlife) **How**: Monitor trout populations, augmenting the dataset with those data collected by the CDFW and the National Marine Fisheries Service	**Other resources action benefits**: Could gain insight into most vulnerable populations **Other resources with potential conflicts**: None

Future Management Goals and Adaptation Actions

Workshop participants identified the following possible future management goals and adaptation actions for rivers and streams:

Management Goal/Adaptation Strategy: Increase partnerships to facilitate stream connectivity.

Adaptation action: Increase coordination among all partners for aquatic organism passage projects (AOP).

After identifying possible future management goals and actions for rivers and streams, participants were asked to evaluate action effectiveness and feasibility; identify the timeframe for action implementation; describe where and how to implement the action; and identify collaboration and capacity needs. Timeframe, collaboration and capacity needs are defined below.

- **Implementation timeframe:** Identify when the action could feasibly be implemented.
  - *Near*: <5 years; *Mid*: 5-15 years; or *Long*: >15 years.
- **Collaboration:** Identify any other agencies, organizations, or people – both internal and external – needed to collaborate with in order to implement this tactic.
- **Capacity needed**: Identify capacity needed for implementation such as data, staff time and resources, funding, or policy changes, among others.

Table 2 below explores the future management goals/adaptation strategies, actions, and implementation recommendations developed by workshop participants for rivers and streams. The table is structured to provide:

1. A future management goal/adaptation strategy;
2. Adaptation actions for each goal/strategy;
3. An evaluation of action effectiveness, feasibility, and implementation timeframe; and
4. A description of where and how to implement and collaboration and capacity needed to move forward with implementation.

This workshop activity was intended to generate a range of recommended adaptation actions that could be implemented both now and in the future. The resulting actions are not comprehensive, and users of this report are encouraged to explore additional adaptation actions that may help reduce vulnerabilities, increase resilience, or capitalize on opportunities presented by climate change for rivers and streams.

Future Management Actions

The following list describes trends and commonalities amongst the future management actions discussed by participants in Table 2.

- Workshop participants identified one future management action, which was to increase coordination among partners for aquatic organism passage projects. They noted that this action could be accomplished, in part, by organizing a meeting of all stakeholders, including a number of agencies and organizations that operate in the region.

- Workshop participants recommended prioritizing aquatic organism passage projects based on the need of trout and other aquatic species, as well as on the action's level of positive impact.

Table 2. Potential future management goals, adaptation actions, and action implementation details including where and how to implement and collaboration and capacity needs for rivers and streams. Action effectiveness (likelihood of reducing vulnerability), feasibility (likelihood of implementation), and timeframe (near: <5 years; mid: 5-15 years; long: >15 years) were also evaluated for each adaptation action.

Management Goal: Increase partnerships to facilitate stream connectivity					
Adaptation action	**Effectiveness**	**Feasibility**	**Timeframe**	**Implementation (where/how)**	**Collaboration & Capacity**
Increase coordination among all partners for aquatic organism passage projects (AOP)	High	High	Mid	**Where**: Prioritize projects based on greatest need and greatest impact for metapopulations of trout and other aquatic organisms **How**: Organize meeting of all stakeholders to discuss strategies, leverage funding/capacity, and obtain local knowledge about topics such as ephemeral streams	**External collaboration**: National Marine Fisheries Service, CDFW, CA Coastal Conservancy, National Forest Foundation, National Fish and Wildlife Foundation **Internal collaboration**: No answer provided by participants **Capacity needed**: No answer provided by participants

Additional Adaptation Actions for Consideration

Table 3 summarizes all of the adaptation actions generated by workshop participants for rivers and streams and includes additional actions for consideration; additional actions comprise those from the literature as well as those identified by land and resource managers during other workshops. These strategies and actions are grouped according to one of five categories:

1. **Enhance Resistance**. Implementation of these strategies can help to prevent the effects of climate change from reaching or affecting a resource. One common type of resistance actions are those designed to reduce non-climate stressors.
2. **Promote Resilience**. These strategies can help a resource weather the impacts of climate change by avoiding the effects of or recovering from changes.
3. **Facilitate Transition (or Response)**. Transition or response strategies intentionally accommodate change and enable resources to adaptively respond to changing and new conditions.
4. **Increase Knowledge**. These strategies are aimed at gathering more information about climate changes, impacts, and/or the effectiveness of management actions in addressing the challenges of climate change.
5. **Engage Coordination**. Coordination strategies may help align budgets and priorities for program of work across lands or establish or expand collaborative monitoring efforts or projects, among others.

Table 3. Summary of adaptation goals and actions for rivers and streams, grouped by category (enhance resistance, promote resilience, facilitate transition, increase knowledge, and engage coordination). Adaptation goals and actions include those generated by workshop participants for rivers and streams, as well as additional actions identified from the literature and by land and resource managers during other workshops.

RIVERS AND STREAMS		
Category	**Adaptation Goal**	**Adaptation Action**
Enhance resistance	Protect streams down-gradient of State Water Project (SWP) lakes/dams	• Continue with dam releases to maintain flows downstream of SWP lakes/dams • Monitor water supply in SWP lakes and reservoirs
	Manage invasive species	• Remove arundo and tamarisk to reduce competition with native species for water
	Restore native species to disturbed areas	• Plant native species in riparian areas after disturbances, such as wildfire or infrastructure improvements[4]
	Increase the resistance of roads and other infrastructure to high peak flows and flooding at stream crossings	• Identify roads within high-priority ecological areas that are most at-risk for future flooding and determine whether those roads can be improved or decommissioned[5] • Plant vegetation near infrastructure to stabilize banks[6]
	Protect rivers and streams from heavy public use	• Examine current recreational use and identify water-based alternatives • Educate recreational users about water conservation and river/stream protection
	Improve water quality by reducing sedimentation	• Optimize grazing management practices to reduce sediment production[4] • Manage vegetation (e.g., mechanical treatments) to reduce fire severity and subsequent erosion and sedimentation[4]
Promote resilience	Reconnect streams to allow the movement of sediment and aquatic organisms	• Remove perched ford stream crossings or replace with bottomless arch culverts or bridges in Core 1 watersheds
	Increase resilience of trail system to higher peak flows by addressing areas with high demands for access	• Upgrade trail bridges with stronger rot-resistance materials[4] • Reroute trails above waterways with high flood risk[4] • Convert road/trail use to other transportation modes (e.g., from vehicle to bicycle or foot)[4]

[4] Actions were sourced from the Climate Adaptation Project for the Sierra Nevada and/or the Northern Rockies Adaptation Partnership.

[5] Luce, C. H., Rieman, B. E., Dunham, J. B., Clayton, J. L., King, J. G., & Black, T. A. (2001). Incorporating aquatic ecology into decisions on prioritization of road decommissioning. *Water Resources Impact*, *3*(3), 8–14.

[6] Griggs, F. T. (2009). *California riparian habitat restoration handbook, second edition*. Chico, CA: River Partners.

Facilitate transition	Identify and protect refugia	• Designate conservation easements to extend riparian buffers along rivers and streams[4]
Increase knowledge	Monitor species at risk of decline under future climate conditions	• Monitor steelhead populations, augmenting the dataset with data collected by the CA Dept. of Fish & Wildlife and the National Marine Fisheries Service
	Build an information base for timely response to future disturbance events (e.g. flooding, pollution, fire)	• Continue installing and monitoring river/stream gages and snotel sites and consider additional needs for monitoring data (e.g., precipitation)[4] • Develop a database of baseline information on stream and riparian conditions, including location of high-quality habitat most in need of protection[4] • Prioritize data collection based on forecasted drought[4] • Incorporate water flow information into integrated watershed management plans[4]
	Inventory stream characteristics to determine potential climate change impacts	• Inventory and map pools, runs, riffles, creeks, and streams, including non-native plant locations, species use, and species composition
	Increase knowledge of groundwater resources	• Enhance streamflow and groundwater monitoring to obtain real-time data and improve understanding of surface water-groundwater interactions[4]
	Increase knowledge of existing built resources	• Create geospatial database of culverts and bridges[4]
Engage coordination	Increase partnerships to facilitate the protection of aquatic ecosystems	• Increase coordination among partners for aquatic organism passage projects to improve cooperation and leverage funding and local knowledge • Integrate planning efforts among multiple agencies, including fire prevention and management, road management, aquatic restoration, and fisheries and wildlife management
	Minimize risks to human safety	• Communicate risk of high peak flows and flooding to public and private stakeholders[4] • Evaluate and monitor patterns of visitor use relative to hydrological dynamics[4] • Limit visitor access to sites when safety is a concern[4]