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Implementing Climate-Smart Conservation

Law and Institutions

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Key Takeaways

California has demonstrated a commitment to protecting its endangered freshwater species for decades. Yet despite this, most protected species have not recovered, and now a new threat multiplier is pushing many populations to the brink: climate change. The usual conservation tools cannot keep up with the pace of change; instead, as described in our first report, *Climate-Smart Tools to Protect California's Freshwater Biodiversity*, the state needs to adopt a broad portfolio of climate-smart tools to conserve at-risk species. But is such change feasible? In this report, we show that laws such as the Endangered Species Act are not, for the most part, impediments to using the tools identified in our previous report. Rather, the problem lies with how society is applying them. To make real progress, the state must address the key issues that are hampering conservation work: permitting complexity, competition for funding, inadequate staffing, and a culture of risk aversion within agencies, water users, and environmental organizations. Although the federal government will continue to be a partner, the state should lead these efforts.

- **Address the key issues that are hampering adaptation efforts.** Agencies, water users, and the environmental community should work to promote innovation, experimentation, and flexibility at the pace and scale needed.
- **Strengthen the legal framework.** Most existing laws are already sufficiently flexible to allow for the incorporation of climate-smart conservation policies into species and ecosystem management. We outline regulatory and legislative changes that may make this approach more effective and expeditious.
- **Support watershed planning and implement urgent actions.** Beyond salmon, the state still lacks conservation plans for freshwater species and their ecosystems. California should integrate climate-smart conservation into all facets of ecosystem and biodiversity planning.
- **Build institutional capacity.** A combination of factors makes people reluctant to take risks and to act in innovative ways to adapt. Cultivating leadership that is committed to expanding permitting for climate resilience, embracing legal flexibility, developing training programs, and creating a reward structure that promotes innovation and adaptation will help.

Introduction

California is struggling to protect its freshwater biodiversity. Water diversions, land development, pollution, invasive species, and other factors have decimated native fish populations and precipitated a crisis in one of the world's most biodiverse places. Climate change is a threat multiplier for the state's freshwater ecosystems. Warming temperatures, more volatile precipitation, and sea level rise risk further harm to native species and threaten the extinction of some species within coming decades.

Although California has been a leader in climate change mitigation and adaptation, the state needs to engage in planning and take action to build resilience in rivers, lakes, and estuaries so that they can support

and recover native biodiversity as the climate changes.[1] Swift, bold, and innovative action will be necessary given the rapid changes underway.

In our first report, *Climate-Smart Tools to Protect California's Freshwater Biodiversity* (Sommer et al. 2024), we reviewed a broad suite of tools available to address the urgent problem of safeguarding California's freshwater biodiversity in the changing climate. This toolbox includes some familiar approaches—such as various ways to improve freshwater habitat—as well as approaches that may be less familiar, more experimental, and more controversial. We also recommended the adoption of a climate-smart conservation planning process, involving a broad range of stakeholders, to prioritize the selection of tools within watersheds and to adaptively implement those tools.

In this follow-up report, we explore the feasibility of implementing these tools and climate-smart planning in light of legal, policy, and institutional factors.[2] Our analysis draws on an extensive review of the legal literature on ecosystem and protected species management, as well as interviews and small workshops with a wide-ranging set of 45 experts from all over the state. These experts are working on the frontlines of ecosystem policy and management; they include state and federal regulators, members of the environmental conservation community, legal professionals, and representatives of many entities involved in water and land management.

We begin with a brief recap of the main findings of our *Climate-Smart Tools* report. We then explore some key legal questions related to climate-smart conservation. First, we explain that—contrary to common misperceptions—climate-smart conservation is mostly consistent with the two foundational statutes that guide species protection in California, the federal and California Endangered Species Acts (ESA and CESA, respectively). Second, we conclude that, while some legal modifications would be helpful, these laws generally do not impede adapting to climate change or using some of the newer, more controversial tools in our climate-smart toolbox.

This brings us to the central question of implementation: if not the law, then what *is* standing in the way of putting into practice a more forward-looking, climate-smart approach to conserving freshwater biodiversity? We review a range of factors that impede responses to climate change—including complex permitting processes, resource constraints, litigation risk, and a culture of risk aversion within agencies, environmental advocacy organizations, and water user and other stakeholder groups—all of which affect the extent of support among decision makers for a new approach to managing freshwater ecosystems. We conclude with a suite of recommendations that can facilitate shifting gears and adopting a climate-smart approach while there is still time.

1. In this report, we use "resilience" to describe the ability of ecosystems to recover desired functions—including support of native biodiversity—during and after climate-related disturbances, such as drought, flood, or warming water temperatures. We use the term "adaptation" to describe actions that lead to greater ecological resilience in the face of changing environmental conditions. The California Climate Adaptation Strategy (draft) is a useful step toward such planning for adaptation and resilience, but more detailed focus on freshwater ecosystems is also needed (CNRA 2024b).
2. This report is solely focused on assessing the tools recommended in the first report. We do not attempt to address all legal and policy actions that might be recommended to best address climate change in freshwater ecosystems.

Two accompanying appendices provide further details on our analyses of legal issues and implementation challenges, as well as additional recommendations.[3]

Setting the Stage: A Recap of *Climate-Smart Tools* and Conservation Planning

Our previous report—*Climate-Smart Tools*—recommends several key actions: the adoption of a climate-smart conservation planning process, the selection of portfolios of conservation tools for each watershed, and the immediate launch of initial lower-risk, exploratory climate-smart efforts while more deliberative planning is underway. *Climate-Smart Tools* reached the following conclusions:

Climate-smart conservation planning should occur at both the statewide and watershed levels. Under this approach, statewide planning can identify and prioritize bold climate adaptation actions to protect native freshwater biodiversity. This planning can guide the development of collaborative, watershed-scale plans for freshwater species conservation that consider future conditions, identify and screen potential management priorities, and assign responsibilities and benchmarks for implementation. Robust monitoring and assessment programs are critical, allowing for strategic pivots in approach when conditions change. Climate-smart planning need not start from scratch—where plans and programs already exist, they can be retrofitted to take climate change into account.

Portfolios of priority conservation tools for each watershed should be selected from the toolbox in our first report. Table 1 of this report provides a high-level summary of these 22 tools sorted into several broad management strategies. *Habitat support* includes actions to improve the abundance and quality of habitat for native species. *Species support* includes actions that seek to directly increase the abundance, genetic diversity, and resilience of vulnerable species. *Contingency actions* are included as a parallel strategy, in recognition that climate change, coupled with other stressors, may result in the extinction of some freshwater species.

As we describe in *Climate-Smart Tools* and its technical appendix, most of these tools can serve multiple objectives. For instance, freshwater flows could be improved by augmenting flows or by shifting the timing of flows so they more closely follow natural patterns. *Climate-Smart Tools* details the various tools already in use in California, such as actions to restore or improve habitat diversity. Other tools, such as species support through assisted migration or genetic engineering, are still rare—particularly in the freshwater context—because they entail more experimental and controversial approaches. Ecological risks and uncertainties tend to be higher for some of the most intrusive species support tools, such as gene editing and population supplementation.

In this follow-up report, we assess the legal issues around adopting climate-smart tools. First, we consider whether taking the recommended climate-smart approach to developing a portfolio of actions is consistent with the federal and state Endangered Species Acts. For this discussion, we generally refer to the broad suite of habitat and species support tools shown in the first three rows of Table 1. Second, we examine

3. Because the readership of this report is likely to include many non-lawyers, we omit legal citations from this report and refer those who are interested in more details and documentation to the appendices.

specific issues related to some of the emerging, novel, and sometimes controversial tools in the box—i.e., assisted migration, genetic support, hatchery reform, and contingency planning. (These emerging tools appear in orange in Table 1.) For detailed analysis and citations, please see the appendices to this report.[4] For more information about the nature and scope of these tools, see our first report, *Climate-Smart Tools*.

Table 1

Climate-smart conservation management toolbox

Strategy	Tool		
Habitat Support	1. Improved freshwater flow	2. Substrate restoration	3. Increased food for species
	4. Restoration of habitat diversity and processes	5. Temperature and water quality	6. Invasive species control
		7. Focused management zones	
Species Support: Distribution	8. Planning for range shifts	9. Helping species access historical habitat	10. Assisting migration to new geographic ranges
		11. Refuges	
Species Support: Population	12. Reduce sources of mortality	13. Remediate diseases	14. Population supplementation
Species Support: Genetics	15. Diversity protection	16. Assisted evolution	17. Hybridization
Contingency Actions	18. Historical conservation	19. Tissue archives	20. Genetic libraries
	21. Seed banks	22. Planning for species loss and novel ecosystems	

SOURCE: Sommer et al. (2024).
NOTE: Tools colored in blue are considered "emerging" for the purposes of the legal discussion in this report.

Climate-Smart Conservation Is Consistent with the Federal and State Endangered Species Acts

As highlighted in *Climate-Smart Tools*, California is at a crossroads for managing its freshwater ecosystems. The state's commitment to maintaining and restoring high-quality freshwater habitat and native biodiversity is laudable—and we expect it will guide conservation policy for the indefinite future. Yet, while the current management approach has successfully limited the number of extinctions, no protected freshwater species have been recovered in California, and many continue to decline (Mount et al. 2019). And current approaches are not well suited to rapidly changing conditions.

It has become common for observers to lay the blame for the lack of species recovery—and the sparse use of ecosystem-based, forward-looking management—on the federal and state Endangered Species Acts (ESA and CESA, respectively). Both laws were enacted roughly 50 years ago, well before awareness of climate change. In this line of thinking, these laws focus too narrowly and inflexibly on preventing harm to individual animals, focusing protections on individual species rather than encouraging approaches that consider ecosystems, biodiversity, and resilience in a changing world. But this perspective, while not

4. Technical Appendix A provides more detail on the legal issues and recommendations; Technical Appendix B assesses pathways for addressing the issue of mindset in the agencies and water and environmental community.

completely unfounded, is not the full picture. The ESA and CESA do require single-species harm prevention, but they also allow single-species actions to be undertaken with an ecosystem perspective and with a focus on future conditions.

If the ESA and CESA were designed from scratch today—incorporating a modern understanding of ecosystems, biodiversity, and climate change—these laws would likely look very different. And if the laws can be improved without undermining them, such changes should be considered. But we conclude that even as currently written, the laws are capable of supporting a more ecosystem-focused, climate-aware approach to species protection, one which better supports the ultimate goal of species recovery. The key lies in how the laws are implemented—specifically, in the manner that regulatory attention and funding are allocated and in the mindset that agencies and the water and environmental community—which in this report broadly includes federal, state, and local agencies; environmental advocates; and water users—brings to species protection.[5]

Improving Implementation of the Endangered Species Acts

The Endangered Species Acts require the protection of individual animals and species,[6] and they call on federal and state regulators to prevent harm to imperiled fish and wildlife in a variety of ways.[7] The statutes require species to be "listed" as threatened or endangered (and in case of CESA, as species of concern), and they prohibit any person or agency from "taking"—broadly, killing, harming, or harassing—individual members of listed species.[8]

Two federal agencies, the US Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS), have authority over the ESA; a state agency, the California Department of Fish and Wildlife (CDFW), implements CESA. To protect individual animals and species, the USFWS, NMFS, and CDFW review requests for permission to take fish and wildlife. Such permission may be required when land and water development negatively impacts listed species, although the degree of impact required to trigger the permitting requirement will vary.[9] Separately, a special kind of take permission is required for scientific,

5. This report suggests that tribes, which are sovereign entities, should be invited to be part of any federal or state decision process that would affect freshwater ecosystems, based on their sovereign status and their rights to water and fish. This report does not otherwise purport to offer a tribal perspective or otherwise address the unique considerations that apply when specific tribes are involved in or affected by decisions about freshwater ecosystems.
6. References to "species" in this report include specific populations listed as protected under the Endangered Species Acts.
7. This section describes the framework for fish and wildlife protection in general terms; protections for listed plants are described in Technical Appendix A.
8. Under the ESA, take occurs when any person or organization harasses, harms, pursues, hunts, shoots, wounds, kills, traps, captures, or collects an individual endangered animal or plant, and may also occur if a species' habitat is significantly modified or degraded. ESA threatened species are protected from take only if established by NMFS or USFWS rule; ESA candidate species do not receive protection from take. Under CESA, endangered, threatened, and candidate species are protected from take, which includes hunting, pursuing, catching, capturing, or killing an individual protected species, or attempting to do so. Take under CESA does not include habitat modification, and species of special concern are not protected from take.
9. Under the ESA, take permits for otherwise lawful activities are issued to individuals as well as to local and state governments through preparation of habitat conservation plans. If a federal agency is involved, take permission may be obtained when that agency consults with NMFS or USFWS to ensure that its actions do not jeopardize federally listed species or adversely affect critical habitat. In California, consultation is the more common pathway for take due to the substantial role of federal agencies in water management. Under CESA, take permits may be required for individuals as well as local and statement governments; full mitigation is required. The applicability of CESA's take requirement to certain federal activities has been the subject of disagreement (Lee 2020; Cal. AG 2020). In some instances, take permission for state-listed species can be provided through a determination that federal take authorization is consistent with state requirements.

educational, and recovery actions, including ecological restoration activities (although exemptions for restoration are increasingly available, as detailed in Technical Appendix A).[10] If a federal agency is taking the action, or issuing a permit or funding, then that agency has special obligations to "consult" with NMFS or USFWS (or in some cases, both) to avoid certain kinds of harm to federally listed species. In contrast, although state law requires public agencies to avoid contributing to the extinction of species, there is no parallel obligation to consult with CDFW under CESA. Whether under the ESA or CESA, obtaining a permit to take species can result in limitations on project actions and obligations to mitigate harm through investments in species and habitat support. The permitting process can provide important protection to species, but it can also be onerous and time-consuming for all parties, including the regulatory agencies (Biber 2021; CDFW 2021; Grenier et al. 2021; USFWS 2024).

The Endangered Species Acts Support Forward-Looking Approaches to Resilience

The regulatory focus on preventing take of listed species without a permit has fostered the view that the Endangered Species Acts are inflexible, backward-looking, and unable to accommodate broader ecosystem-based approaches to enhance resilience. However, the Endangered Species Acts also support forward-looking approaches to advance species resilience. In fact, as described in detail in Technical Appendix A, the laws provide many opportunities for adaptive species protection—and some of this work is already being undertaken.

Importantly, the federal ESA's central directive is to manage ecosystems to facilitate species recovery, so that species are no longer in danger of extinction and can be removed from the protected lists. This recovery goal must be applied in a manner that is consistent with the ESA's guiding principle: using the best available science to conserve species. These standards mean that agencies can—and arguably must—integrate information on changing conditions into decisions about conservation and recovery. Indeed, many of the ESA's core provisions—including listing, habitat conservation, and recovery plans—allow for the consideration of future conditions. And the ESA regulatory framework provides useful tools for responding to ongoing change, such as the promulgation of protective regulations, the designation of experimental populations, the issuance of research and recovery permits, and programs to provide landowner incentives for voluntary and advance conservation, such as assurances and conservation benefit agreements.

Similarly, California law requires CDFW to prioritize recovery, apply adaptive ecosystem-based management, and employ the best available science. Like the federal ESA, key provisions of CESA related to listing, conservation measures, and recovery plans also allow for consideration of future conditions. And CESA and related provisions of the Fish and Game Code provide multiple opportunities to integrate ongoing ecological change into decision making through safe harbor agreements, natural community conservation plans, and regional conservation investment strategies. More detail on these provisions is provided in Technical Appendix A.

10. Technical Appendix A describes the take permission process required for scientific research or recovery actions, and it also explores the ways in which restoration permitting is undergoing significant improvement thanks to leadership by organizations such as Sustainable Conservation in collaboration with the state of California and local agencies, an effort supported by PPIC (Sustainable Conservation n.da, Sustainable Conservation n.db; Grenier et al. 2021).

In short, both federal and state governments have considered climate change when making decisions about wildlife populations. They also sometimes use the regulatory opportunities identified above to creatively pursue affirmative species conservation. But these efforts have not incorporated a sufficiently robust portfolio of tools to cope with climate change, and they are not proceeding at a pace and scale sufficient to make a difference for California's freshwater ecosystems.

Our analysis suggests that the key problem lies not with the endangered species laws, but with the way society is applying them. In our recommendations, outlined later in this report, we note some ways in which updating the species protection laws would facilitate the use of the options identified in *Climate-Smart Tools* by providing clarity or by allowing more flexible, forward-looking actions to recover species. But our fundamental conclusion is that the endangered species laws themselves are not the key obstacle to implementing the tools. Instead, the challenge lies in shifting how regulators, influenced by agencies and the water and environmental community, apply the laws—how they determine which species receive regulatory attention and whether ecosystems and biodiversity are factored into choices about protection and resource allocation. There is a need to cultivate willingness to embrace innovation, take risks, and discuss tradeoffs. At present, the implementation of the endangered species laws in freshwater ecosystems is significantly focused on protecting individual species; much less attention is given to ecosystem-level management or biodiversity.

Likewise, although climate change is often discussed in ESA planning, such discussions do not result in the adoption of bold actions designed to achieve recovery in light of future conditions at the needed pace and scale. For the tools identified in the *Climate-Smart Tools* report to be effective in protecting freshwater ecosystems, agencies and the water and environmental community will need to shift focus—continuing, of course, to protect individual species, but reallocating staff and funding to a significant degree in order to give more resources and policy support to bolder, more expansive actions. As described in the appendices, some important work is already happening along these lines, such as multi-species conservation plans, some ecosystem-based recovery plans, recovery plans that incorporate climate change, and the designation of experimental populations. And in many ways, perspectives and practices are already starting to shift. To meet the challenge of the rapidly changing climate's effects on California's freshwater ecosystems, however, these perspectives and practices will need to change faster and at a larger scale.

As we discuss further below and in the two appendices, there are multiple reasons why change is not happening at the requisite pace and scale.[11] These include perceived and real limits on authority, mismatches between federal and state law, risk of litigation, resource constraints (funding, staffing), and a culture of risk aversion. Ultimately, effectively applying the recommendations in *Climate-Smart Tools* to respond to climate change will require tradeoffs in resource allocation. And making these tradeoffs at a large scale will require building institutional, cultural, and governance capacity for climate-smart management within agencies and the water and environmental community.

11. Technical Appendix A describes the legal issues and opportunities outlined above in more detail. Technical Appendix B provides an overview of key elements of building institutional, cultural, and governance capacity for climate-smart management of freshwater ecosystems.

Most Emerging Tools Are Also Legal Under Current Federal and State Statutes

Beyond the general question of whether a climate-smart conservation approach is consistent with the federal and state Endangered Species Acts, we explored the legal issues surrounding the use of some tools and approaches that are still relatively experimental in California's freshwater ecosystems. These tools include genetics and diversity support (genetic modification, epigenetics, and hybridization), assisted migration, hatchery reform, and contingency actions, including planning for new (or "novel") ecosystems in the event of species loss. Some of these "emerging tools" (see Table 1) may be controversial. For example, critics of assisted migration and genetic support have argued that the tools themselves can pose risks to species or to ecosystems more broadly. And our interviews revealed that some in agencies and the water and environmental community are wary of undertaking contingency actions for fear they will be perceived as essentially "giving up" on species at the brink of extinction.[12]

We begin with the emerging tools and some of the additional legal questions they raise. We then look at contingency actions.

Emerging Tools

On balance, federal law tends to provide more guidance on emerging tools than state law, especially for assisted migration. However, both federal and state law would benefit from improved clarity and flexibility. There is a particular need for new thinking in the category of genetic support for adaptation. Most or all of these improvements could be accomplished through new internal guidance, formal policies, or new regulations specifically tailored to species protection and recovery under climate change. Even absent such changes, however, there is already a clear permitting structure for approving projects that use these emerging tools—permits that are available for scientific research, education, management, and recovery actions. We refer to these as "research and recovery permits."

Research and recovery permits can provide significant flexibility for innovation

One general challenge with many emerging tools involves the risk of harm to listed species or their habitat. Fortunately, both the ESA and CESA have special provisions that authorize take of listed species for scientific activities or innovative efforts to support recovery under research and recovery permits.[13] Any individual, organization, or agency that conducts an action qualifying as research or recovery that may take ESA-listed species is eligible to receive a federal research and recovery permit. If an action only takes state-listed species, CDFW can issue a permit to individuals or organizations listed as eligible. These permits differ depending on the relevant law or regulation, but they are typically limited to academics, research institutions, and similar organizations. Although CDFW can authorize third parties to undertake innovative

12. In interviews conducted for *Climate-Smart Tools*, some staff in environmental advocacy organizations and public agencies expressed concern that pursuing contingency actions would send the signal that there was no longer interest in saving species at risk of extinction or that determining that species could not be saved would be an excuse to remove ecosystem protections.
13. The ESA authorizes take permits for scientific activities and to enhance propagation and survival. CESA authorizes take permits for science, education, and management activities. This report refers to both collectively as "research and recovery permits."

projects using emerging tools, the department has generally shied away from doing so, especially for projects related to genetic support. Alternatively, CDFW can conduct the research and recovery work itself.

Both federal and state law authorize assisted migration, but current state policy discourages its use

Many freshwater species need to move as part of their natural life cycles. Mobility enables them to seek out the right habitat conditions, locate better food sources, find the best spawning grounds, and reproduce. But many barriers now prevent individuals from dispersing and migrating within their customary ranges, and climate change, water management, and other environmental modifications may make some habitat inhospitable. *Climate-Smart Tools* lays out several ways to help wildlife overcome barriers to movement, which could in turn help them maintain populations and genetic diversity under changing conditions. Law and policy often distinguish between approaches that improve access to *historical* habitat versus approaches that help species move to areas *outside* their historical range. The latter is called "assisted migration" in *Climate-Smart Tools* and below.

Assisting migration to areas that are outside of a species' historical range poses distinct challenges. Property owners in the relocation area may resist, fearing that the presence of listed species will restrict their activities or create the potential for them to be charged with take of those species. To address this, on the federal side, the ESA allows USFWS and NMFS to identify relocated populations of species as "experimental" and "non-essential"—designations that can provide more flexibility in managing the relocated populations. In addition to giving conservation projects more leeway, these designations can help secure the cooperation of property owners in areas of expansion. USFWS has already designated more than 60 non-essential experimental populations, mostly for terrestrial species (e.g., the gray wolf, grizzly bear, black-footed ferret, California condor), and NMFS has provided this designation for six anadromous fish populations, including four in California.[14] And a 2023 regulation allows USFWS to be more proactive with assisted migration by allowing the agency to determine where existing habitat may become incapable of supporting a species and to move that species to more suitable locations when appropriate (USFWS 2023).

On the state side, CDFW is also authorized to undertake or approve assisted migration to conserve and recover species, and it has broad authority to take state-listed species if it carries out the project. Although the law allows the agency to support moving species outside of their historical range, a 2017 policy discourages this option, citing the potential for unexpected outcomes (CDFW 2017a). State law is also less flexible than federal law in providing assurances regarding take liability to landowners in areas where relocations would occur. Under state law, assurances cannot be provided for take of state-listed species (unless special circumstances allow for a safe harbor agreement or the state concurs with federal assurances; see Technical Appendix A). The state can agree to support a federal experimental population, but there is no general state law for designating experimental populations.

14. The four experimental populations of anadromous fish in California are: Central Valley spring-run Chinook salmon below Friant Dam on the San Joaquin River (NOAA 2013), Central Valley spring-run Chinook salmon in the Upper Yuba River Upstream of Englebright Dam (NOAA 2022), and winter-run Chinook salmon and Central Valley spring-run Chinook salmon in the McCloud and upper Sacramento Rivers above Shasta Dam (NOAA 2023).

Rules governing hatcheries may harm efforts to support the genetic diversity of native fishes

Hatcheries have been present in California since the late 19th century, and today state, federal, and private fish hatcheries produce millions of pounds of fish each year. In many respects, hatcheries are a success story. Salmon, steelhead, and trout hatcheries raise fish to mitigate for the impacts of dam construction, reservoir operations, and lost habitat. By supplementing fish populations, hatcheries support longstanding tribal, recreational, and commercial fishing activities. Hatchery fish have successfully repopulated some rivers, such as Putah Creek in Northern California, where fish from regional hatcheries have colonized the stream. And some conservation-focused hatcheries are now sustaining listed species whose wild populations have crashed—including Delta smelt, spring-run Chinook salmon, and winter-run Chinook salmon.

Hatcheries also pose challenges, however, because they tend to lower genetic diversity in wild stocks of salmonids and other native species and can select for undesirable traits (e.g., domestication). Genetic diversity is essential for adapting to changing climatic conditions and for maintaining resilience in the face of major events like heatwaves, wildfires, and flow changes. To support the genetic diversity of California's native fishes, *Climate-Smart Tools* recommends considering the following hatchery management practices. This report evaluates those recommendations and concludes that—assuming adequate funding—some of these practices can be accomplished under existing law, while others would require legal changes:[15]

- **Using breeding programs to improve genetic diversity for climate resilience.** As explained in *Climate-Smart Tools*, for species currently produced in hatcheries (e.g., salmon and steelhead), breeding programs can improve genetic diversity in hatchery stocks to help build climate resilience. At present, selective breeding is already commonly used to build desired traits. From a law and permitting perspective, the introduction of new breeding programs focused on climate resilience would raise scientific questions and would require agency approvals (e.g., take permits, recovery plans, and revision of hatchery genetic management plans). These permitting paths are readily available under the ESA and CESA and relevant regulations and policies, however, so changes in law are not needed.
- **Suspending hatchery stocking or relocating hatcheries to seaward locations.** *Climate-Smart Tools* explains that fish biologists have recommended considering these more controversial steps when there is evidence that hatchery practices have adverse effects on wild fish populations (e.g., competition, loss of diversity, and inbreeding). These recommendations suggest that an important way to protect the diversity of wild river populations would be to limit breeding between wild and hatchery stock. Permanent or long-term suspension of hatchery fish stocking would likely provoke resistance from those who depend on these stocks for fishing, although relocating hatcheries could allay some of these concerns.
  From a legal perspective, there could be some challenges to overcome. Fish stocking is mentioned in many different provisions of state law as well as state policies. Also, some hatcheries may be required as mitigation for dam operations or otherwise made a condition of environmental approvals. In addition, hatchery populations of many salmon and steelhead runs have some ESA protections, which means that one or more of the state and federal fisheries agencies, depending on the species, have authority over how the runs are managed. Separately, at least one California court has held that state law limits CDFW's discretion to end hatchery operations—although no court has considered this question for a specific

15. *Climate-Smart Tools* describes these potential reforms; Technical Appendix A to this report provides more detail about the legal analysis.

hatchery in the context of climate change. And some state and federal hatcheries may have obligations to tribes regarding the production of hatchery fish.

That said, although there are questions that would need to be answered (on a species- and hatchery-specific basis), the state and federal governments do have significant authority to manage fish and to reshape outdated hatchery practices. These authorities are discussed further in Technical Appendix A.

Both federal and state laws restrict using genetic modification to assist evolution

Even with large, diverse populations, natural selection may be insufficient to cope with future extreme conditions. Assisted evolution represents an intensive intervention to help select for individuals that can better survive warmer and drier conditions under climate change. Selective breeding in hatcheries may be appropriate for this purpose. Other, less familiar strategies include gene editing (which may include introducing new genes), or epigenetics (i.e., influencing how genes are expressed).[16] As described in *Climate-Smart Tools*, both of these approaches are experimental and pose unanswered scientific questions; the legal issues are complex and somewhat different between them, particularly under state law.

Gene editing. This form of genetic modification—sometimes known as "transgenics"—has widespread commercial applications in agriculture (e.g., herbicide-resistant strains of corn), but its use in conservation applications is still limited. Indeed, many of the commercial applications (e.g., fatter farmed salmon in the US) have been controversial, reflecting public concerns over the potential harmful effects of transgenic organisms. This concern would likely be stronger in the conservation context, where transgenic species would be released into the wild and could interbreed with the unmodified species and compete for food and habitat.

The law governing federal oversight of gene editing is currently unclear. If a species is listed, ESA permissions (likely under research and recovery permits) must be obtained for any take or other impacts to the species, but there is nothing specific to gene editing in the statute or ESA regulations. Under the multi-agency Coordinated Framework for the Regulation of Biotechnology, several agencies claim some oversight over transgenic species, including the Environmental Protection Agency, the Food & Drug Administration, and the Animal Plant Health Inspection Service within the US Department of Agriculture (APHIS) (The White House 2017). Thus far, the principal focus of these agencies has been commercial applications in areas such as pesticides, agriculture, and food production (USDA et al. 2023). The EPA has approved an experimental permit for genetically engineered mosquitos, which was categorized as a pesticide project (Erwin 2023). The transgenic American Chestnut was designed for conservation purposes, to improve the tree's resistance to disease. The project, currently on hold, faced a complex and uncertain pathway to approval before ultimately being submitted to APHIS (Erwin 2023). No federal agency has provided guidance specific to assisted evolution in fish and wildlife conservation, and permitting responsibilities remain unclear.

California law is more explicitly restrictive. The state has specific provisions addressing transgenic aquatic animals. For example, state law permits certain kinds of transgenic research but requires that the organisms be held in closed water systems. It also bans the introduction of transgenic species to the waters of the

16. Epigenetic processes occur when environmental factors such as diet, stress, and toxic substances affect gene expression in animals without altering the DNA sequence. For example, high temperature exposure during the larval stage may cause certain genes to be expressed as the individuals get older.

state and prohibits the spawning, incubation, or cultivation of any transgenic species of salmonids anywhere in California, including in hatcheries.

Epigenetics. Unlike genetic modification, epigenetic changes do not introduce new genetic material into an organism or remove specific DNA sequences. Rather, epigenetics works within an organism's existing potential range of gene expression, allowing it to adapt to changing conditions. For example, laboratory acclimation and breeding have been tested to select seaweed strains that can better withstand climate stress (Pazzaglia et al. 2021). In some cases, these new traits become heritable. However, because no new genetic material is introduced or DNA sequences removed, epigenetic changes do not qualify as "transgenic" under current state definitions. At the same time, although there are no legal standards specific to use of epigenetic techniques, CDFW does have broad permitting authority generally over the possession or release of any organism that might affect native populations. And the usual CESA take provisions would also apply.

Federal law is also less than clear on epigenetics, and it is uncertain whether the tool would be covered by the Coordinated Framework for the Regulation of Biotechnology. In 2024, APHIS proposed amending its policy to cover intentional genomic alterations, which would appear to include epigenetic changes; however, these proposed standards still do not directly address conservation. Of course, any epigenetic changes that alter a species listed under the federal ESA—or that have the potential to otherwise take a listed species—would require ESA take approvals, likely under research and recovery permitting.

Federal law is somewhat flexible regarding hybridization of species; California law is unclear

Another relatively controversial tool is deliberate hybridization—the crossbreeding of individuals from different or closely related species. Plant hybridization is commonly used to generate specific desirable traits such as fast growth, appearance, and disease resistance. More recently, hybridization has been used in commercial aquaculture for fish and invertebrates, and in fish stocking.[17] *Climate-Smart Tools* suggests that a similar strategy might be employed in situations where individual species are unable to adapt quickly to climate change. The report suggests that these opportunities would require careful evaluation. Sometimes hybridization—whether natural or otherwise—can result in the loss of biodiversity, such as when the genes of a common species dilute the genes of a rare species. But in other settings, hybridization supports adaptability and resilience, helping to strengthen a species and therefore protect biodiversity.

For decades, hybrids were not protected under the ESA. Even natural hybrids could not be listed as threatened or endangered for fear they would negatively affect native species or other ecosystem elements. Federal attitudes have changed, however, and today natural hybrids may be protected under the ESA on a case-by-case basis (DOI 2000). USFWS also acknowledges that human-initiated hybridization can potentially provide genetic resources that can save species from extinction. Current ESA propagation policies theoretically authorize the use of hybridization in captive breeding programs, at least where other measures have failed or are unlikely to achieve recovery.

17. Aquaculture examples include hybrid striped bass and oysters (Rahman et al. 2018). Fish stocking examples include hybrid striped bass (wipers) and tiger trout, species that are not listed for protection (On the Water 2018).

While federal policy on hybridization has evolved, California's policies remain unclear. On the one hand, current CDFW regulations provide a pathway for permitting hybridization in the context of commercial aquaculture and fish programs. State regulations also provide that CDFW may authorize co-mingling of hybrid and non-hybrid species, and CDFW policy allows for conservation propagation under some circumstances (CDFW 2017b.) On the other hand, at least with respect to fish, state law discourages releasing hybrids into the wild if they would impact native populations. Interviews conducted for this report also suggest that there would be resistance to the release of hybrid species because of a general reluctance to interfere with natural processes and perceptions of risk. These factors suggest that legal and policy clarity would be useful (see Technical Appendix A). Moreover, regulators, environmental stakeholders, and potentially affected property owners and resources managers will need to build organizational and cultural capacity to address these issues (see Technical Appendix B).

Contingency Actions and the Law

Even with best efforts to protect native species, some extinctions are likely in the coming decades. *Climate-Smart Tools* urges two types of immediate statewide contingency actions: collecting more information about and samples from vulnerable species, and planning for the management of novel ecosystems. These contingency actions offer significant conservation benefits with little risk, but they nonetheless can be controversial. Some in agencies and the water and environmental community resist acknowledging that some species may not persist within their historic range. Moreover, some in this community view activities such as seed banks as a first step toward reduced species protection—regardless of the absence of evidence for such cause and effect. To implement contingency actions, these biases must be overcome. If contingency actions are not employed in the near term, valuable opportunities to obtain knowledge about some species will be lost forever.

Fortunately, as described below, there are no meaningful legal impediments to contingency actions.

Information and sample gathering for vulnerable species can rely on research and recovery permits

As described by *Climate-Smart Tools*, information and sample-gathering efforts would include both historical conservation work (gathering information about species characteristics, behaviors, and habitat), along with the gathering of physical specimens and records (e.g., tissue archives, genetic libraries, and seed banks). Securing specimens, taking samples, and studying organisms raises the potential for harm to some individuals. Based on interviews for this report, researchers often view the take prohibitions under ESA and CESA as impediments to the study of listed species; they find the regulatory processes burdensome and time-consuming to navigate. This challenge could be addressed through more efficient permitting for research and recovery actions (Grenier et al. 2021).[18] Agencies can prioritize such actions by reallocating funding and staffing to support contingency efforts related to climate response and by supporting the use of innovative approaches such as programmatic permits, which allow multiple permittees to join a pre-existing approval over time.

18. In some instances, certain research or recovery activities might be covered under restoration permitting, discussed in Technical Appendix A.

The state can plan for changing ecosystems and species loss

Climate change and human actions have altered, and continue to alter, land and waterscapes, creating novel ecosystems comprising a mix of native and non-native species. The changed conditions in these novel ecosystems increase the risk that some native species will become extinct. *Climate-Smart Tools* recommends planning for these changes to reduce ad hoc, crisis-based decision making and ultimately to improve outcomes.

There is no legal impediment to advance planning for novel ecosystems, and policymakers can plan for any eventuality—as long as stakeholders are not forced to fund analysis of scenarios that are entirely speculative. From a political and policy perspective, such planning is likely to be controversial. As noted above, some in agencies and the water and environmental community believe that planning for change implies giving up on restoring historical conditions or protecting the status quo. This is not the case. An aircraft may have life rafts and life preservers on board, but this does not mean that the pilot has given up flying the plane to its intended destination. Planning for novel ecosystems creates a framework in which people can develop a collective understanding of potential futures and explore the risks and choices presented by different scenarios. Of course, there would be debates about which conditions are foreseeable and which are speculative, but this is often true in environmental analysis.

Planning for novel ecosystems can help support investments in developing models and testing hypotheses to understand how species and ecosystems respond to change (Power et al. 2024). The process can also help build cultural, institutional, or governance capacity to confront and manage ongoing change (Technical Appendix B). Developing social capacity for discussing tradeoffs and making choices in light of available resources are critical elements of preparing for change in advance, as opposed to simply reacting to it after the fact.

Implementing Climate-Smart Conservation Strategies Faces Challenges

There is broad consensus in the scientific community that climate change is an existential threat to native biodiversity. In recent years, this consensus has resulted in an increasing focus on habitat and species support tools like restoration, flow augmentation, and dam removal. It has also spurred increasing conversation around more controversial emerging tools, such as hatchery reform and assisted migration. It is clear, however, that in California's freshwater ecosystems, the pace and scale of actions are not keeping up with the pace and scale of change or species decline. And the further agencies and the water and environmental community falls behind in addressing this problem, the more difficult it will be to solve.

As described above, contrary to perceptions, the law itself is generally not an obstacle to taking a broad-based approach to climate-smart conservation. This raises the question of why such action is proving so difficult. Our discussions with numerous individuals involved in climate-related conservation work—either as regulators, implementors, or permittees—revealed that multiple factors are slowing the response. Here we briefly review four of these factors; Technical Appendices A and B provide additional details.

- **Complex and lengthy permitting processes.** Acquiring ESA, CESA, and other approvals to implement the recommendations in *Climate-Smart Tools* requires considerable time and financial investment, which can slow forward-looking conservation work. For example, a tidal marsh restoration project in the Bay Area will typically involve permits from six different state and federal agencies (Grenier et al. 2021). Through the efforts of Sustainable Conservation, permitting agencies, and others, there has been progress in expediting and simplifying the permitting process for restoration. Examples include the Cutting Green Tape initiative (CNRA n.d.), led by the California Natural Resources Agency; collaborative efforts between state and federal wildlife agencies to coordinate permitting; and the increasing use of programmatic permits that allow for regional efforts (Sustainable Conservation n.d.). Restoration practitioners we interviewed noted that while these are all important advances, delays remain a source of frustration. Also, the climate-smart tools will not always qualify for simplified restoration approvals, leading to increased permitting complexity, greater cost, and longer timelines. To implement the tools, continued improvements in permitting—and reliable funding—will be needed to keep pace with changing conditions and to encourage innovation.
- **Competition for limited resources.** Complex permitting processes add to the cost of conservation projects, requiring a large portion of project budget for permit management. For example, in the restoration context, a recent review of federal funding found that approximately one-third of restoration budgets go to managing the permitting process (Madsen 2024). Regulatory agencies face significant constraints in staff resources for processing permits. Staff responsible for ESA and CESA compliance have limited time and budgets, which makes it difficult to balance permitting review of individual projects with undertaking the forward-looking conservation work necessary to manage ecosystems in a changing context. As discussed above, the administration of ESA and CESA requires both, but the resources needed for projects that build resilience in freshwater ecosystems have been lacking.
- **Risk of litigation.** Decisions related to species protection are often challenged in court (Doyle and King 2023). There is disagreement in agencies and the water and environmental community about the burden of such challenges relative to wildlife protection decisions generally, and about litigation's positive or negative influences on species protection. In either case, it is clear that the potential for litigation influences behavior in regulatory processes and decision making on some of the most high-profile issues. And when a suit is filed, litigation requires the investment of agency resources, which further heightens competition for those resources. Litigation can also take a personal and professional toll on those involved, particularly in high-profile cases. The "combat science" over the future of the Sacramento–San Joaquin Delta provides a cautionary case study (Mount 2011). These factors, combined with signals from leadership, create strong incentives for agencies and their staff to take conservative approaches.
- **A culture of risk aversion.** All of these factors—permitting complexity, limited resources, and a desire to avoid litigation—contribute to a culture of risk aversion in agencies, a culture that is sometimes exacerbated by a similar risk aversion in agencies and the water and environmental community. Assessing risk is an important element of species protection, and avoiding risk is sometimes the best choice. But interviews conducted for this report reveal a pervasive view that the culture of risk aversion—both within and outside of agencies—acts as a significant obstacle to climate-smart conservation management, even more so than the law itself. At its most basic level, the desire for defensible certainty drives agencies and the water and environmental community to be overly conservative in listed species permitting and management, often relying on methods and policies used in the past to rationalize actions in the present.

Permitting complexity, competition for resources, litigation risk, and risk-averse culture all combine to make it difficult to manage for rapid or ongoing changes in ecosystems. As a result, agencies and the water and environmental community focuses on the familiar—attempting to maintain the status quo or restore historical conditions—rather than promoting innovation, experimentation, and flexibility at the pace and

scale needed to manage for species recovery and adapt to change. These factors also make it easier to defer or delay controversial or risky actions that are, nonetheless, necessary for effective adaptation. As noted in *Climate-Smart Tools*, risk-taking, a broad portfolio of actions, and institutional flexibility are essential to respond to changing conditions. Bringing these elements together successfully will require leadership and committed support from the political branches of government.

The Way Forward: Adopting a Climate-Smart Approach to Protect Freshwater Biodiversity

In *Climate-Smart Tools* we outlined the urgent need for new approaches to managing freshwater species and their ecosystems. Simply put, the current approaches are not working fast enough, and the window of opportunity to change course is rapidly closing. To successfully prepare for and adapt to changing conditions, climate-smart conservation needs to be integrated into all planning and regulatory actions. And a portfolio approach to conservation is needed, rather than overreliance on a few tools. This will require a willingness to consider emerging and controversial conservation tools—and to take risks.

In this report we have examined some of the legal and institutional issues that are likely to face efforts to implement climate-smart conservation actions. Based on this review, we offer the following conclusions and recommendations.

Strengthen the Legal Framework

Our analyses here and in Technical Appendix A conclude that most existing laws are already sufficiently flexible to allow for the incorporation of climate-smart conservation policies into species and ecosystem management. However, some regulatory and legislative changes may make this approach more effective and expeditious. Specifically:

- **Develop species and habitat protection policies that respond to climate change.** In recent years, in some contexts, federal agencies began to account for future climate conditions, going beyond assessment of climate impacts to authorize a broader portfolio of actual response tools. For example, a 2023 USFWS rule supports assisted migration of species. Innovative, climate-focused policies such as these should be expanded, coordinating between agencies with authority over terrestrial and land use issues, and those responsible for freshwater ecosystems. As a priority action, the state should develop its own innovative, climate-focused policies that create opportunities for bold action and allow the state to take the reins in managing its freshwater ecosystems. If possible, alignment between state and federal agencies on such policies would also be helpful.
- **Increase resources dedicated to climate adaptation.** For most agencies, substantial funds, personnel, and time are invested in managing project-specific permits and approvals. To respond to climate change in freshwater ecosystems, resources need to be invested in watershed-scale thinking that anticipates future conditions and promotes biodiversity protection and recovery, in addition to single-species protections. More funds would be ideal. Given the reality of limited resources, however, a reprioritization of staff and funding—and a willingness to make sometimes difficult tradeoffs—will be required.
- **Assess and regulate emerging conservation tools.** The state and federal governments also should develop clear policies and guidance for staff on the use of emerging conservation tools, including some of

the more controversial tools such as genetic modification and hybridization. Effective use of these tools will require building greater institutional, cultural, and governance capacity for learning, adaptive action, risk assessment, and tradeoffs. See Technical Appendix B.

- **Revisit hatchery policy.** Reforming hatchery policies will be an important part of an adaptation strategy for several high-profile species. The California Salmon Strategy calls for a comprehensive review of hatchery practices, including addressing whether hatcheries should be closed or moved to protect wild salmon (CNRA 2024a). Done well, this review would provide an opportunity to revise and update laws governing hatcheries in light of climate change, and for the state to take the lead role in protecting biodiversity in its freshwater ecosystems.

Support Watershed Planning and Implement Urgent Actions

Successful adaptation to climate change requires robust planning for how to prepare for and respond to change. This is particularly important in conservation, where outcomes are often unexpected. California has a Climate Adaptation Plan (CNRA 2024b) that it updates regularly, including an element that focuses on building resilience in natural systems. But beyond salmon, the state still lacks conservation plans for freshwater species and the ecosystems on which they depend. California should integrate climate-smart conservation into all facets of ecosystem and biodiversity planning. These improvements should include:

- **Engage in statewide climate-smart conservation planning for native species.** CDFW, in cooperation with the Department of Water Resources (DWR) and the State Water Resources Control Board (SWRCB), should develop climate-smart conservation policies for native freshwater species. This state-level planning would enable the state to make decisions about goals and priority watersheds and otherwise establish boundaries within which local planning can take place (see below). Ideally, federal agencies would be engaged in the planning process, but the state should take the lead.
- **Conduct climate-smart conservation planning at the watershed scale.** In previous PPIC reports, we have promoted the development of ecosystem management plans at the watershed scale as the best approach to protect at-risk native species while also conserving native biodiversity (Mount et al. 2019; Grenier et al. 2021). Climate-smart conservation planning in individual watersheds should be an integral part of this effort. Interested and affected stakeholders should develop these watershed plans, guided by statewide planning and supported by technical assistance from CDFW, DWR, and the SWRCB. Technical Appendix A describes potential legal frameworks for such planning.
- **Incentivize the development of climate-smart conservation plans.** The legislature should examine ways to promote climate-smart conservation planning for priority watersheds. With the 2014 Sustainable Groundwater Management Act (SGMA), the state has used a two-pronged approach: the state compels groundwater basins to develop groundwater sustainability plans that are approved by DWR, and the legislature has directed funds to support local planning and implementation The legislature should consider a similar approach for climate-smart planning that incentivizes local engagement. To support compliance, these plans could be integrated into regulatory programs such as Water Quality Control Plans, Habitat Conservation Plans, and Natural Community Conservation Plans (Gray et al. 2021; Mount et al. 2019; Technical Appendix A).
- **Act now.** One of the problems with plans is that they often take years to prepare, delaying urgent actions. As emphasized in *Climate-Smart Tools,* California does not have the luxury of waiting until planning efforts are complete. Rather, contingency actions (described above) and habitat and species support actions should begin immediately—including pilot and experimental programs. Planning should also occur but should not be used as an excuse to put off difficult actions (e.g., hatchery reform).

Build Institutional Capacity

As noted above, the law is not the major impediment to climate-smart conservation. Rather, a combination of factors makes people reluctant to take risks and to act in innovative ways to adapt. In this report we highlighted four areas—permitting complexity, competition for resources, litigation, and risk aversion—that inhibit forward-looking responses. Here are five recommendations for reforms that can help organizations build capacity for adapting to climate change:[19]

- **Continue to promote and expand permitting for climate resilience.** Permitting complexity and timelines make it difficult to undertake bold, forward-looking action to adapt to changing climate. The state should undertake an initiative—in collaboration with federal agencies—that prioritizes adaptation and climate resilience in permitting projects, whether restoration or otherwise. For restoration permitting, agencies should create well-staffed, place-based permitting teams that prioritize the restoration of ecological function through large-scale conservation projects (Grenier et al. 2021). Teams should be given guidance by agency leadership on prioritizing efficiency, flexibility, and innovation (Sustainable Conservation 2024). For research and recovery actions, clear guidance and innovations like programmatic permits—already being used in restoration permitting—can improve the pace and scale of progress (USFWS 2024). In all cases, permitting actions should be designed to accommodate changing conditions. These efforts will require increased staff and resources, which may require making tradeoffs with other priorities.
- **Allocate resources (funding, staffing, regulatory attention) with climate change in mind, making tradeoffs where necessary.** Increasingly, agencies are asked to do far more than can be completed with existing budgets and staffing, and they must make difficult choices about where to allocate resources (CDFW 2021).[20] Regulatory agencies responsible for conserving species listed under the ESA and CESA need the capacity and will to reevaluate existing resource allocations to prioritize actions that protect biodiversity in a changing climate. The law allows agencies some discretion to make choices about funding, staffing, and agenda, as long as choices are consistent with their core mission as established by statute. Guidance and support from leadership at the highest levels of government would be ideal. Also, the state legislature can provide incentives through its budget processes. Agencies and the water and environmental community can choose to bolster these efforts by signaling support and by being willing to embrace innovative action and greater risk-taking.
- **Design governance to allow nimble response to ongoing change.** All agencies and water and environmental organizations, both public and private, should increase their capacity to adapt to uncertainty and changing conditions. As described in Technical Appendix B, the allocation of resources to ongoing learning and the development of knowledge networks are key to this effort. Oftentimes, an "adaptive water governance" approach to problem-solving—described in detail by Cosens et al. (2018) and in Technical Appendix B—will promote robust public engagement, collective learning, flexibility, and innovation. Adaptive water governance emphasizes local collaboration under the umbrella of higher levels of government (such as the state) to develop solutions designed to respond to ongoing change. Local participation fosters acceptance and commitment over time, while retained state and federal authority protects the public interest.
- **Embrace legal flexibility.** The flexibility in existing laws is not fully utilized by regulatory agencies and stakeholders, who tend to prefer clearly defined, fixed standards (e.g., flow and water quality standards) that

19. A more complete discussion of these and other reforms is presented in Technical Appendices A and B.
20. CDFW has reported severe funding gaps. Among the service tasks performed by CDFW, its single most underfunded task is species and habitat conservation (74% underfunded). CDFW also concluded that, as of 2020, staffing resources were only sufficient to accomplish about 36 percent of the department's overall mission-level needs (CDFW 2021).

are easy to administer and defend in court. The legitimate concern is that interests will abuse flexibility to their advantage and make it harder to reach conservation goals. But the current approach is too rigid to adapt quickly. One alternative is "bounded legal flexibility"—incorporating the ability to pivot quickly into legal requirements, while also retaining protections. This can be accomplished in multiple ways such as, for example, adopting fixed standards that can be satisfied with a range of actions that are tested through improved adaptive management. In some cases, standards could be more open-ended or changeable but provide heightened notice, comment, and reporting requirements, along with a date on which the flexibility sunsets. More details and suggestions are provided in Technical Appendix B.

- **Consider institutional culture.** Using climate adaptation tools will require changes in the culture of all organizations within agencies and the water and environmental community. Institutions must take risks to successfully promote innovation that leads to critical learning about which adaptation strategies will succeed. All adaptation strategies, by their nature, require innovation in the face of uncertainty, with the risk that some efforts will not succeed. Both agency and advocacy cultures create strong disincentives for risk-taking. To build adaptive capacity, public and private institutions need to develop more nuanced approaches to risk. Leadership committed to supporting adaptation, training programs, and a reward structure that promotes innovation and adaptation will help. See Technical Appendix B. Political leadership from the senior executive branch and legislature could encourage and endorse innovation and problem-solving.

Conclusion

The changing climate is accelerating California's decades-long decline in native biodiversity. There is an urgent need to act now to change the trajectory of decline and to prepare for significant changes ahead. Our first report—*Climate-Smart Tools*—recommends a suite of actions that can be used to manage native freshwater species and their ecosystems in the face of rapid change. Some of these tools are widely used today and some are new, while others are controversial. *Climate-Smart Tools* recommends that each watershed in the state compile a portfolio of these tools to adapt to the changing climate and to stem losses of biodiversity and native species.

In this report we conclude that laws such as the ESA and CESA are not, for the most part, impediments to using the tools to protect species. Today's environmental laws contain considerable flexibility and can support climate-smart conservation. We described key challenges to adapting conservation to climate change, which include permitting complexity, competition for funding, inadequate staffing, threats of litigation, and a culture of risk aversion within agencies and the water and environmental community. We then offered a suite of solutions.

To promote clarity, support funding, and reduce the risk of litigation,[21] we recommend that the state take a leadership role, and strengthen the law and policy framework for adaptation in freshwater ecosystems. As described in this report and Technical Appendix A, helpful actions include promoting and incentivizing the development of climate-smart conservation plans at the statewide and watershed scale and developing policies for using emerging tools. Recommended actions also include improving permitting for actions that

21. Clarity in law and policy can reduce the risk of litigation by removing the need for agencies to rest their claim to authority on relatively general language. The more specific the authority, the less likely the agency action will be challenged.

are designed to accommodate ongoing change and increasing conservation funding and staffing, through augmentation and, as needed, reallocation of existing resources.

Successful implementation of the climate–smart tools will require agencies and the water and environmental community to improve capacity to address ongoing change in freshwater ecosystems. As described in this report and Technical Appendix B, local collaboration with state oversight can contribute to capacity, as can the development of human and institutional infrastructure for ongoing learning, environmental standards designed to accommodate change, and a focused effort to foster organizational cultures that encourage innovation and risk-taking.

There is a lot of disheartening news about the decline of California's native freshwater species. But restoration efforts have shown that many species, given half a chance, show remarkable resilience. The threats facing California's aquatic ecosystems call for bold and immediate action; the good news is that, with courage and ingenuity, there is a path forward.

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