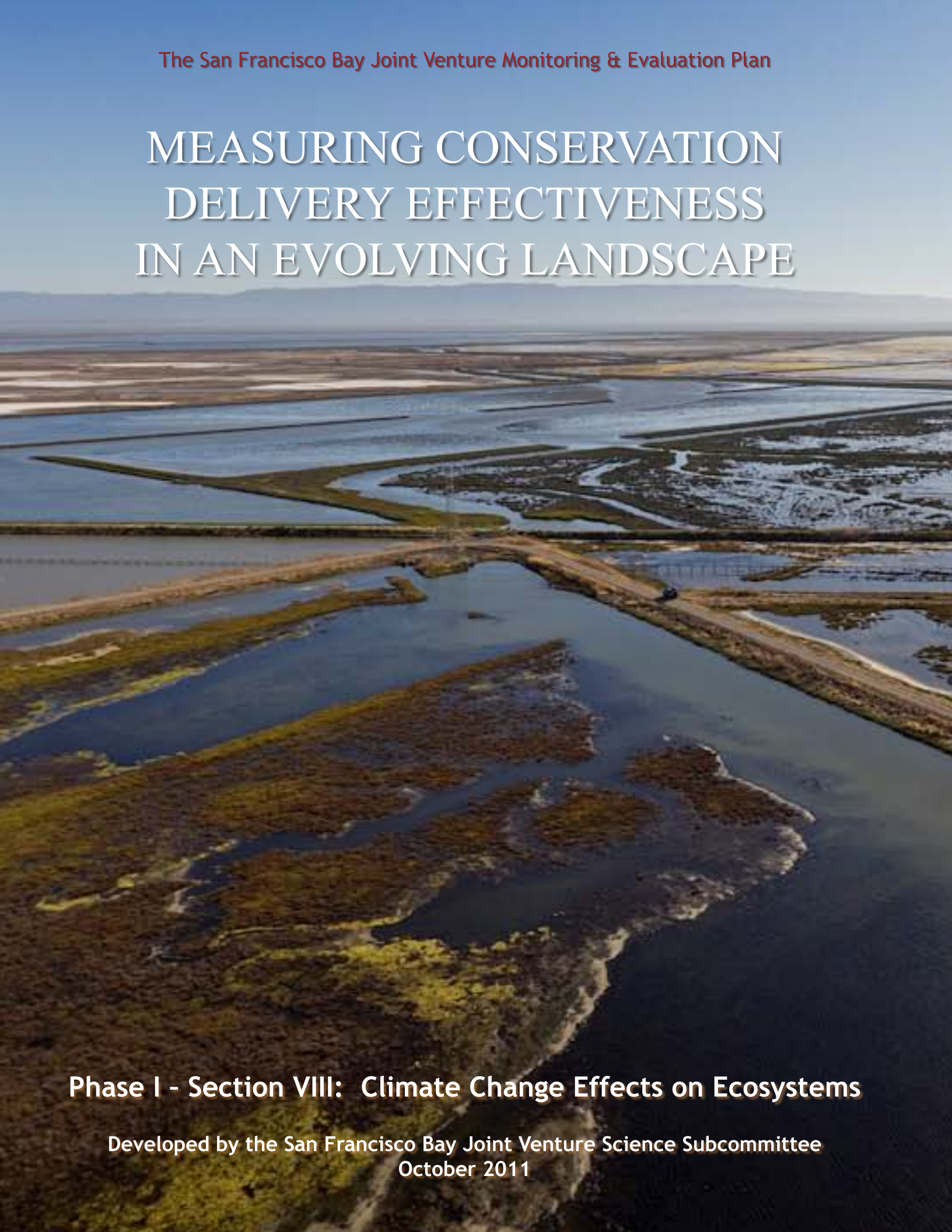
The San Francisco Bay Joint Venture Monitoring & Evaluation Plan

MEASURING CONSERVATION DELIVERY EFFECTIVENESS IN AN EVOLVING LANDSCAPE



Phase I - Section VIII: Climate Change Effects on Ecosystems

Developed by the San Francisco Bay Joint Venture Science Subcommittee

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The SFBJV Science Coordinator designed and compiled the information presented in this document section. She accepts the responsibility of accurately reflecting the information provided by all participants.

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VIII. Climate Change Effects on Wetland Ecosystems

Climate change is the overarching conservation issue of our time, and stands as one of the greatest challenges facing the region. Already, climate change effects on natural systems are becoming increasingly apparent (Tompkins and Adger 2004; Welch 2005; Parmesan 2006; Parry et al. 2007). Integrating climate change into conservation strategies is vital if biodiversity is to be protected in the long term (Hannah et al. 2002; Welch 2005; Araujo and Rahbek 2006; Heller and Zavaletta 2009). Climate-driven changes will therefore profoundly affect San Francisco Bay Joint Venture (SFBJV) partners' ability to protect, enhance and restore regional ecosystems. As existing stresses on natural systems combine with, and exacerbate, the projected ecological impacts associated with climate change, designing effective natural resource conservation, restoration and management measures will require an understanding of those interactions. Therefore, in an era of climate change, implementing conservation and restoration actions will necessitate not only addressing current or past environmental problems, but also anticipating and preparing for those of an uncertain future (Poinani et al. 2011).

Climate change adaptation is emerging as the main framework for conservation and resource management (Lawler 2009, Lawler et al. 2009, Heller and Zavaletta 2009 Glick et al. 2011a). Various approaches for climate change adaption are being developed, some specific to given focal ecosystems, others more generally applicable. For each ecosystem appropriate adaptation actions need to be chosen, implemented, and examined for success. Monitoring efforts, therefore need to support these steps by addressing the following outcomes via both surveillance and targeted monitoring efforts (Nichols and Williams 2006):

- Understand the rates and types of climate-related impacts by documenting empirical changes in abiotic and biotic indicators through time via surveillance monitoring, and determine the vulnerability of given ecosystem(s) or target organism(s) to *documented* changes;
- Improve predictive capability by tying empirically derived monitoring data into model development and/or refinement, and assess vulnerability of given ecosystem(s) or target organism(s) to *projected* changes;
- Investigate and evaluate the effectiveness of implemented adaptation management or restoration actions to ameliorate the projected climate change impacts on ecosystems through targeted monitoring, and apply in an adaptive management framework.

Well-designed regionally standardized monitoring programs at both project- and landscape-levels are needed to inform climate-smart adaptation, management and restoration. These programs need to include focus on habitat specificity, focusing monitoring on target habitat types, to either reveal that we know little about one specific habitat type, or that threats are graver for one type than another, at a given time. Effective monitoring designs focused at projected changes in target indicators in space and time are also essential, and need to include specific thresholds for monitoring results to trigger actions in time to maximize adaptive effectiveness.

Glick at al. (2011b) provide a step-by-step framework for climate-smart restoration programs for the Great Lakes region that can help guide needed approaches for West Coast wetlands (Figure 8.1 & 8.2): First, within a strategic decision-making and adaptive management cycle, specific climate adaptation approaches are developed for a given suite of initially identified restoration goals and targets/indicators. Vulnerabilities (Figure 8.3) of the suggested approaches and targets to climate change are then assessed and summarized, before climate-smart management strategies are identified and prioritized for implementation. After a monitoring program has been implemented to evaluate these efforts, resulting data are reviewed and approaches are reassessed and previous steps are revised, closing the adaptive management loop (Figure 8.2).

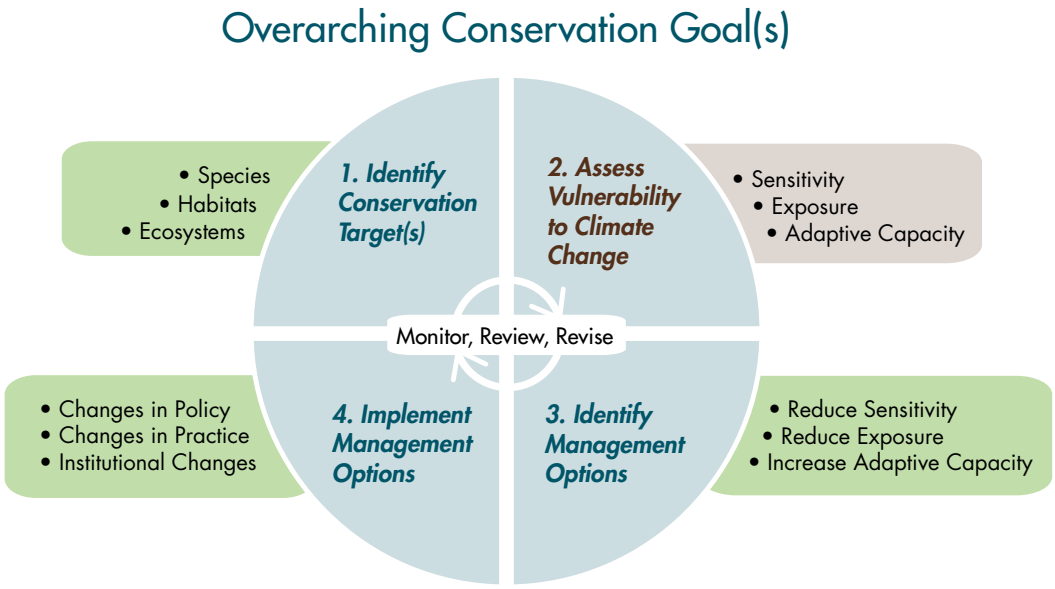

Figure 8.1: Framework for developing Climate Change Adaptation Strategies (*Source: Glick et al. 2011a).*

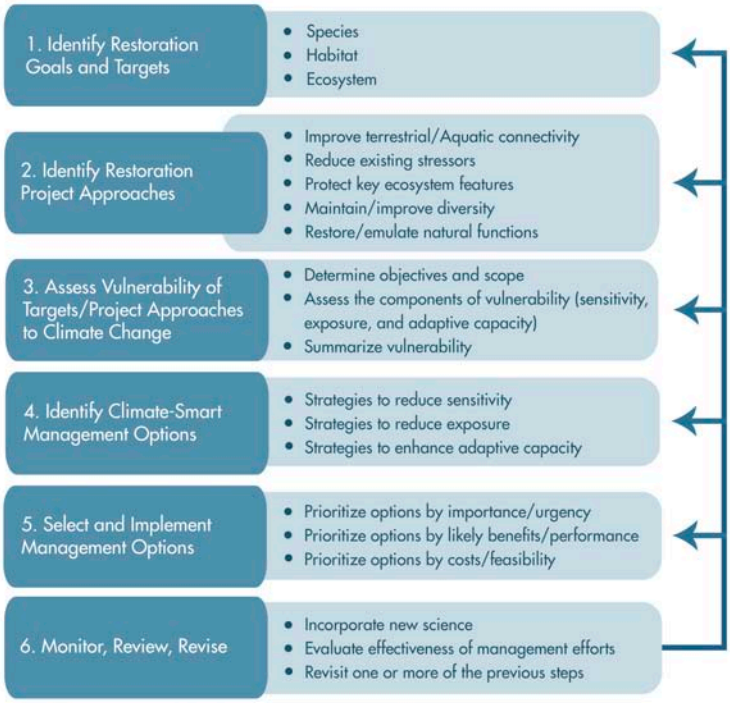

Figure 8.2: Framework for developing climate-smart restoration programs (*source: Glick et al. 2011b*)

Since scientists are already documenting climate change impacts on SFB area ecosystems (Kimmerer and Weaver 2010, Knowles 2010, Ackerly et al. 2011, Micheli et al. in press), inter-disciplinary programs have to be set up to develop a clear understanding of the long-term changes and vulnerabilities the SFBJV region will face over the coming decades, and the rate at which they will likely occur. As outlined in Figure 8.1 above, managers need vulnerability assessments that address both biological and human welfare concerns as a first step toward developing adaptation strategies. Ecosystem vulnerability assessments must integrate the human context, especially in determining the effectiveness of wetland restoration and its value to "ecosystem services" that benefit humanity. Ecosystem services will help buffer human communities, yet, unless an integrative approach is taken, human land and water use decisions may constrain opportunities for ecosystem restoration and management. This inter-relatedness needs to be integrated into our approach, especially in planning for uncertainty and increasing our understanding of vulnerabilities.

Increased air and water temperatures, greater variation in precipitation and timing of runoff, heightened storm frequency and intensity, amplified drought stress on upland soils and vegetation, sea level rise, and ocean acidification are projected to be major climate change-related impacts on SFBJV region ecosystems (Kimmerer and Weaver 2010, Knowles 2010, Ackerly et al. 2011, Micheli et al. in press). Local and regional patterns of primary and secondary effects of climate change will influence the outcomes of restoration and management actions. For example, the most prominent and least predictable of these may be freshwater flow dynamics into the estuary

impacting salinity (Kimmerer & Weaver 2010).
Moreover, sea level rise (SLR), poses one of the biggest challenges to SFBJV region habitat restoration success, within the San Francisco Bay (SFB) and coastal wetlands, estuaries and shorelines, and drives a great need for empirically based projections of SLR timing and extent, as well as species response and movement in conjunction with other climate impacts. This information is needed to inform land protection and restoration decisions, and to design adaptation response options. Therefore, long-term trend assessments of physical and biological systems are required to accurately estimate potential future rates of change for both physical and biotic parameters.

The goal for this M&E Plan section is to establish an initial framework for the regionally coordinated assessment of projected climate change impacts on wetland ecosystems, and associated upland and subtidal transition zones and habitats in the context of current and future SFBJV conservation, enhancement, and restoration implementation actions. The section offers a general appraisal of the potential impacts of climate change on SFBJV conservation target species addressed in other sections of this plan.

At this time, this Plan section is not designed to present a detailed monitoring program with schedules and protocols, data

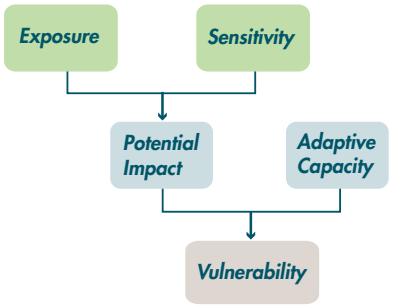

Figure 8.3: Key components of vulnerability, illustrating the relationship among exposure, sensitivity, and adaptive capacity (*from: Glick et al. 2011a*)

management specifics, and other concrete details. Instead it is to establish an overall framework that will provide general guidance to SFBJV partners in the assessment of vulnerability to climate-related changes to habitat extent, status and trends of target species and indicators of habitat condition, and the effects of SFBJV conservation, enhancement, or restoration implementation actions. It also aims to develop a process to accomplish the integration with existing and emerging regional climate change adaptation initiatives and networks such the Bay Area Climate Change Consortium (BAECCC) and the North Bay Climate Adaptation Initiative (NBCAI). More details will be developed throughout phase II of the M&E planning process.

The Climate Change Section Will Provide:

- A framework to assess the long-term effectiveness of SFBJV conservation delivery projects focused on wetland ecosystems in the context of projected climate change impacts at the project and SFB area regional scales;
- An outline of monitoring and evaluation objectives to support the assessment of real-time climate change related wetland ecosystem changes in order to refine the predictive and vulnerability modeling that informs adaptive management at the project and regional scales within the SFBJV region;
- Recommendations for further research, monitoring and evaluation metrics, data collection protocols, and data repositories, including existing monitoring and evaluation programs to leverage and integrate with, as relevant to various target species and wetland ecosystems throughout the region.

Focus Team Process & Participants

In a series of in-person meetings and phone conferences, the climate change focus team established lists of potential climate change impacts, focus-specific M&E and research objectives, relevant metrics, protocols, and data repositories, key partners, and existing programs for potential integration. All focus teams convened on May 26, 2011 for a daylong professionally facilitated workshop to vet and identify the top priorities of the identified monitoring, evaluation and research objectives.

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Albertson, Joy	US Fish & Wildlife Service - San Francisco Bay NWR Complex
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Ballard, Grant	PRBO Conservation Science
Block, Giselle	US Fish & Wildlife Service - Refuges Inventory and Monitoring Program
Ferner, Matt	SF Bay National Estuarine Research Reserve
Gardali, Tom	PRBO Conservation Science
George, Doug*	ESA Philip Williams and Associates
Gerhart, Matt*	State Coastal Conservancy
Higgason, Kelley*	Gulf of the Farralones National Marine Sanctuary
Kamman, Rachel	Kamman Hydrology
Kerkering, Heather	Central and North Coast Ocean Observing System
Micheli, Lisa*	Pepperwood & BAECCC Terrestrial Biodiversity ("Ackerly") Group
Nur, Nadav	PRBO Conservation Science
Sloop, Christina	*Team Coordinator*, San Francisco Bay Joint Venture
Valoppi, Laura	South Bay Salt Pond Restoration Project
Wainer, Laura*	Save the Bay
Wood, Julian	PRBO Conservation Science

*Particiated in prioritization of objectives at May 2011 workshop.

Focal Habitats and Species

All wetland habitat types and focal species of the SFBJV region outlined throughout the M&E Plan should be addressed by the actions proposed in this section. Focal organisms include waterfowl, shorebirds, and other waterbirds, riparian landbirds, special status species, and invasive species.

Focal wetland habitat types are defined in the introduction section of this Plan, as well as in the SFBJV Implementation Plan (2001). As outlined in the priority research objective section below, climate sensitive species need to be identified as indicators of change in each habitat type.

Projected Climate Change Impacts

Some of the potential ecosystem climate change drivers and their related impacts include ["➔" indicates possible outcome of primary and secondary climate-induced drivers; see also Figure 8.4]:

- Air temperature changes ➔ Water temperature and upland soil moisture changes ➔Increased water diversions for human use ➔ Impacts on target species and food resource phenology
- Water temperature changes ➔ Impact on ocean system ➔ Change in fog dynamics ➔ changed air temperature and evapotranspiration rates ➔ Changed soil moisture
- Earlier Sierra snowmelt ➔ Earlier peak runoff of Central Valley rivers ➔ Greater flooding earlier in season, less freshwater later in season ➔ Changes in salinity magnitude, timing, and variability
- Changes in tidal cycle and salinity magnitude, timing, and variability ➔ Shifts in subtidal sediment movement ➔ Changes in invertebrate (e.g., bivalves, oysters), phytoplankton, and eelgrass persistence & species' distributions ➔ Tidal marsh plant distribution shifts ➔ Tidal marsh species persistence & distribution changes
- Increased precipitation variability and potential for extreme events (drought and storm intensity and/or frequency) across region➔ Impact on sensitive species in tidal marshes, salinity variations, erosion/deposition of sediment ➔ Potential for more frequent flooding with associated damage to infrastructure ➔ Loss/decline of target species, impacts to shoal habitats ➔ Increased likelihood for more anthropogenic 'hard structures' for shoreline protection
- Increased stress on native fauna and flora ➔ Changes in persistence of native species ➔ Facilitated establishment of invasive species (plants, invertebrates, etc.) ➔ Impact on community structure and sensitive species
- Sea Level Rise ➔ Loss of shoreline habitat (inundation depth and duration of salt marshes and tidal flats) ➔ Localized increased salinity in formerly freshwater and brackish zones ➔ Landward migration of tidal marsh habitat ➔Loss of higher marsh zones and ecotones
- Ocean acidification ➔ Potential for decreased viability of subtidal and inter-tidal fauna and flora, especially in coastal ocean ➔ Potentially decreased species persistence & and/or changes in species distributions

Monitoring and Evaluation Objectives

Priority M&E Objectives and Associated Strategies, Metrics & Methods

Summarized below are the highest priority M&E objectives the climate change focus group identified based on their potential to meet multiple criteria:

1) ease of implementation
2) long-term importance;
3) being a natural "early" step;
4) usefulness for managing or modeling;
5) ability to help evaluate SFBJV "effectiveness"; and
6) cost-effectiveness.

These criteria were assigned scores from 1-5 (lowest to highest value) by each participant. Final scores were averaged across participants and the top three priority objectives are listed below.

These objectives are also consistent with recommendations adopted by the SFBJV Management Board (SFBJV 2008), including: *"*Identify bird species of greatest conservation need and areas most at risk because of global climate change;" and *"*Develop indicators and thresholds to gauge progress of climate change and assess the actual vs. projected impacts."

Priority M&E Objective 1:

Identify Climate-Sensitive Indicators and Define and Standardize Key Monitoring Metrics; Regional Scale.

Develop wetland type specific conceptual models that articulate the key processes climate change will affect and help define hypotheses to monitor and evaluate impacts. Utilize existing indicator suites, or identify novel climate-sensitive indicators and define relevant key abiotic and biotic metrics to assess climate-related changes affecting regional ecosystems. Define and standardize related key metrics to measure long-term condition trends and impacts in real-time, and to utilize as empirical inputs to obtain well calibrated model outputs.

Strategies:

- Explore existing climate-focused metrics (e.g., Changes in hydrograph/precipitation, soil moisture changes, vegetative change, etc.) in use by key partner organization programs (e.g., Nur 2008, San Francisco Estuary Team 2011),
- Apply information in current scientific literature,
- Use collaborative approach (e.g.,hold workshops) including scientists, resource managers, and regulatory agency staff.

Priority M&E Objective 2:

Collect Empirical Data for Wetland Ecosystem Vulnerability Analyses; Project & Regional Scale

Monitor environmental drivers and their impact on climate-sensitive indicator species and SFBJV target organisms for use in vulnerability analyses. Evaluate vulnerability via exposure and sensitivity assessments and consider adaptive capacity of indicators. Every five years, monitor and evaluate projected changes in habitat suitability due to climate change impacts for indicator species and/or SFBJV target organisms.

Strategies:

- Explore existing climate-focused metrics in use by key partner organization's programs (e.g., Nur 2008, San Francisco Estuary Team 2011)
- Utilize available downscaled watershed-scale climate projections (e.g., Micheli et al. *in press*).
- Utilize standardized key monitoring metrics for climate-sensitive indicators and target organisms.
- Contribute climate-sensitive indicator monitoring data to regionally shared online repositories, which may be linked with other programs to enable larger-scale assessment of local changes across a broader climatic gradient.
- Utilize existing target species abundance assessment protocols as outlined in their specific sections.

Priority M&E Objective 3a:

Monitor Sea Level Rise, Salinity, and Sediment Dynamics, Project and Regional Scale.

Monitor sea level rise and related salinity change magnitude, timing and variability, and sediment dynamics at key areas throughout SFB, and in SFBJV region coastal estuaries. This should include estimation of suspended sediment concentrations and bedload transport rates at mouths of tributaries, and accretion or erosion rates of geomorphic surfaces, and determination of the rate of organic and sediment accretion in natural and restored marshes compared to the rate of sea level rise.

Strategies:

- Utilize and expand as necessary existing network of spatially-distributed field sensors,
- Set a long-term context for accretion rates utilizing sediment core data,
- Utilize well-calibrated process-based sediment models,
- Provide cost savings through remote sensing with adequate quality control (e.g., ground-truth),
- Incorporate SLR measurements and models into projections of habitat change (e.g., Knowles 2010),
- Integrate with Regional Sediment Management protocols and process,
- Expand existing monitoring infrastructure, if needed (or refine, if possible).

Priority M&E Objective 3b: *Evaluate Climate-induced Change in Habitat Spatial Extent; Regional Scale*

Every five years, in conjunction with net landscape change (NLC) analysis (see M&E plan NLC section), evaluate the net change (gains & losses) in spatial extent of SFBJV region wetland types, with a goal to track long-term changes due to climate change induced drivers. Use data to model future geomorphological changes that may be a result of climate change drivers.

Strategies

- Utilize area, extent, and contiguity of habitats (drawn from NLC section) to evaluate net habitat conversion due to sea level rise (see objective 3a), and upland vegetation conversion due to changes in soil moisture and potentially fire regime, subtracted from area conversion due to land use change.
- Utilize Bay Area Aquatic Resource Inventory (BAARI) and other tools outlined in the NLC section.

In models:

- Include data layers (as available or needed tools) on patterns of change in land use, coverage of change in impervious surfaces[1]
- Include layers on urban land use expansion changes

[1] Contact Jim Thorne at UC Davis Information Center for the Environment for data.

Additional M&E Objectives

Below is a non-ranked listing of additional objectives for monitoring and evaluation for climate change, addressing remaining key needs in support of priorities outlined above. These objectives address the long-term assessment of vulnerability of targets. They are offered here for further consideration and evaluation in the next M&E planning phase. Moreover, appropriate time scales for climate change related monitoring need to be worked out. A workshop to develop appropriate monitoring timeframes for different climate-related variables will serve this purpose.

TARGET SPECIES STATUS AND TRENDS & VULNERABILITY

- Demography of Target Bird Species; Project & Regional Scale – Assess nest survival, nest attempts, and over-winter survival of target bird species. This information is needed to determine impacts of climate change on long-term viability of populations and serves to inform viability analyses.
- Food Availability; Project & Regional Scale - Implement intensive surveys of major food resources (e.g., aquatic invertebrates) during key periods (e.g., winter for waterfowl and shorebirds; breeding season for some waterbirds) to provide data on target species food availability, to inform climate change vulnerability analyses.
- Phenology Changes; Project & Regional-Scale - Provide data on migratory bird phenology by implementing intensive (daily or weekly) bird surveys during the migratory periods (i.e., fall arrivals and spring departures). This will help inform climate change vulnerability analyses.

HABITAT FUNCTION & VULNERABILITY

- Reference Sites; Regional Scale - Determine a set of criteria to be used for selecting reference sites where coordinated long-term monitoring of biological and physical metrics could be implemented and used to gauge regional effects of climate change. Consider National Estuarine Research Reserves and other reserve sites as promising candidates for regional reference areas.

PHYSIAL DRIVERS

Precipitation & Storm Frequency

- *Impacts on Target Species; Project & Regional Scale - Monitor loss of target species during extreme storm events.*
- *Impacts on Salinity; Regional Scale - Monitor changes in salinity levels at key habitats throughout the SFB estuary and coastal wetlands.*
- *Impacts on Tidal Marshes; Project & Regional Scale - Assess impacts of the combination of SLR & storm events on tidal marsh bird and mammal species.*

Ocean-Estuary Linkages

- *Upwelling & Acidification; Regional Scale - Monitor the influx of up-welled and acidified water into the SFB estuary.*
- *Larval Exchange; Regional Scale - Monitor larval exchange between the SFB estuary and coastal ocean (i.e., population connectivity)*

BIOTIC DRIVERS

- Vegetative change Project & Regional Scale – Monitor change in vegetation communities in reference sites.
- Predation risk (abundance of predators, access of predators, and refugia from predators) Project & Regional Scale – Asses predation risk in habitats affected by SLR and other areas impacted by climate change
- Contaminants; Project & Regional Scale - Monitor and evaluate combined effects of contaminants and climate change stressors.
- Invasive Species Response; Project & Regional Scale - Monitor response of key invasive species to climate-related habitat changes.
- Human Disturbance Contribution; Project & Regional Scale - Assess the combined contribution of human disturbance and climate-related impacts on target organism stress.

Additional Metrics for Use in Hypothesis Testing & as Model Input

Additional monitoring metrics are listed here for future consideration to:

1) Be utilized in the testing of specific hypotheses evaluating potential management options to mitigate the effects of climate change,
2) Contribute to continued predictive model calibration and refinement to help improve future projections.

In general, metrics used should be aligned with those from existing protocols used by land management agencies as much as possible. Integration with the California Landscape Conservation Cooperative's Environmental Change Network focused on State-scale climate change impacts should also be considered.

Metrics for consideration include:

- Spatial variability in temperature and rainfall amount,
- Target invasive species abundance and distribution changes,
- Primary productivity (as it is relevant to target organisms),
- Vegetation transects to assess vegetation responses,
- Sinuosity & other spatial attributes of related tidal channels,
- Abundance and distribution changes of key food resources for target species (e.g., invertebrate data),
- Target species nest monitoring for tidal marsh and tidal flat birds, survival during extreme events, predation [important cause of nest failure] etc.,
- Heron and egret brood size (see San Francisco Estuary Team 2011),
- Chlorophyll a or biomass to assess waterborne life that impacts trophic dynamics or nutrient cycling in marshes (phytoplankton, zooplankton),
- Nutrients concentrations in water and sediment,
- Dissolved oxygen dynamics (i.e., Hypoxic events frequency or spatial extent in deep marsh),
- Groundwater elevation,
- Carbon sequestration potential of marshes,[2,3]

[2] This might be an important way to evaluate restoration success of tidal marshes (long-term monitoring would not have to be done frequently – Carbon is being sequestered at various rates within marsh types – It would be valuable to assess restored marshes by this parameter).

[3] This was also identified in the SFBJV white paper, Wetland Restoration and Impacts from Climate Change (SFBJV 2008) as a means to provide potential sources of funding for restoration and climate change research.

- Waterborne life that impacts trophic dynamics or nutrient cycling in marshes (phytoplankton, zooplankton, fish)
- Plant, invertebrate and bird phenology
- Population genetic diversity as a measure of target species adaptive capacity

Research & Information Needs

Priority Research & Information Needs

The Climate Change Focus Team voted on main research needs by each choosing three top research priorities, one vote/objective. Below are the top votes:

Priority Research Need 1a[4]: *Impacts of Climate Drivers on the Evolution of Restored Wetland Habitats; Project & Regional Scale.* Assess the potential impacts of various projected climate change scenarios on restoration-related habitat evolution, (e.g., in the context of long-term trajectories of restored tidal marsh and riparian habitats, and the consequences of expected vegetation change for wildlife; or projected vegetation migration patterns in habitat transition zones, and within-zone shifts in plant communities due to salinity changes.

Priority Research Need 1b: *Sediment Models for Marsh Accretion & Erosion; Project & Regional Scale.* Determine how accurately regional sediment (inorganic component) and marsh accretion (organic component) models predict net accretion & erosion rates in individual marshes in the SFBJV region. As needed, design improvements in sediment data collection and/or analysis. Determine the sediment budget for different sections of SFB and relevant coastal estuaries. Conduct long-term status and trend monitoring of sediment dynamics.

Priority Research Need 2: *Vulnerability Assessments[5] of Target Organisms and Indicators; Regional Scale[6]* - Perform vulnerability assessments to assess impacts of climate drivers on population processes, sustainability, and connectivity of target or indicator species: determine which species are most vulnerable to the effects of climate change (e.g., SLR) and ensure that those species are sufficiently monitored. Incorporate demographic impacts (e.g., reproductive or nest success, overwinter survival). Do this for all target groups in the SFBJV region (waterfowl, shorebirds & waterbirds, riparian land birds, special status species[7], other key indicator species).

[4] Priority research needs 1a & 1b were tied in the number of votes.

[5] Glick et al. 2011.

[6] This objective links directly with research objectives outlined in the riparian land bird section module.

[7] This objective links directly with a prioritized research objective outlined in the special status species section module.

Priority Research Need 3: *Importance of Ocean-Estuary Linkages to Tidal Wetland Resilience; Regional Scale.* Assess the dependence of tidal wetland resiliency on estuary-ocean linkages beyond SLR effects on marsh flooding and sediment dynamics:

- *Larval Exchange; Regional Scale*. Determine how important larval exchange is between the estuary and coastal ocean (i.e., population connectivity)
- *Freshwater Runoff & Tidal Range; Regional Scale*. Investigate how this process will change with altered freshwater runoff or increased tidal range;
- *Influx of Upwelled & Acidified Water Impact; Regional Scale.* Evaluate how important the influx of upwelled and acidified water is into the estuary.

Additional Research and Information Needs

Here we list additional important research and information needs for assessing climate change impacts to inform adaptation, and support vulnerability and predictive modeling:

TARGET SPECIES STATUS AND TRENDS & VULNERABILITY

Habitat Suitability Assessments:

- Conservation and Restoration Planning; Regional Scale - Model projected changes in habitat suitability for target species (e.g., tidal marsh species) and pinpoint areas of highest expected change, given climate impacts. Seek to restore areas that will likely become important habitat areas in the future, and provide space, if possible, for the migration of habitats (e.g., from adjacent uplands to wetlands). This proactive approach will help prevent or counteract future losses.
- Special Status Species; Regional Scale[8] - Determine how much special status-species specific suitable habitat (by habitat type) will likely be available at 5, 10, 20, 50 years into the future considering various projected SLR, sediment supply, restoration, implementation and development scenarios.
- Waterfowl[9] - Evaluate and model the impacts to respective diving and dabbling duck abundance and health from climate change as it relates to projected impacts of SLR, salinity and phenology changes (migration timing), and invertebrate prey abundance and quality on survival and foraging energy expenditure.

HABITAT FUNCTION

ADAPTIVE MANAGEMENT CONSIDERATIONS

- Utilizing Citizen Science Monitoring; Regional Scale - Evaluate the feasibility of utilizing citizen science monitoring to collect meaningful data addressing climate change impacts on wetlands (e.g., range expansions or demographic shifts in shorebirds, fouling invertebrates, invasive species, etc.).

[8] This objective links directly with research objectives outlined in the special status species section module.
[9] This objective links directly with research objectives outlined in the waterfowl section module.

- Best Management Practices; Regional Scale - Develop best management practice recommendations for climate adaptation (general/specific, short-term/long-term) for land managers and restoration practitioners. For example, highlight a focus on improving the condition of existing wetland habitats to provide a climate change buffer for target species.
- Assessing Vulnerability of Natural & Human Systems; Regional Scale - Develop a strategy to gain the support of the general public for rigorous assessments of habitat (and community) vulnerability to climate change.

RATES OF CHANGE

- Rate of Climate Change Impacts on Wetlands; Project & Regional Scale - Determine the accelerating rates (speed) of change and frequency of extreme events at the local and microclimate scale, pertinent to target wetland habitats in the SFBJV region to inform vulnerability and predictive modeling.
- Forecast Change on Riparian System[10] – Evaluate climate change scenarios of expected flood management, and future riparian area loss or conversion due to SLR, development, restoration and other likely land use changes. Focus analysis of rapid changes.
- Forecast change to tidal marsh habitat and tidal flats. Including effects of storms and high tides.
- Impacts on Hypoxia Rate in Tidal Marshes; Project Scale – Assess dissolved oxygen dynamics in tidal marshes to determine how important hypoxic event frequency or spatial extent are to marsh function in deep marsh habitats to inform vulnerability models on relevant targets.

SEDIMENT

- Impacts from Delta Infrastructure Changes; Regional Scale - Evaluate the potential impacts on estuary & coastal systems from watershed (Delta) infrastructure (management decisions) changes and modifications to inform sediment models.

PRECIPITATION & STORM FREQUENCY

- Rainfall & Snowmelt Variability Impacts; Regional Scale - Model projected impacts of rainfall variability and snowmelt on SFBJV area wetlands.
- Riparian Soil Moisture Conditions; Regional Scale - Determine future impacts to soil moisture conditions in SFBJV area Riparian systems to inform vulnerability and predictive models.
- Storm Severity & Frequency Impacts; Regional Scale - Project storm severity & frequency and related impacts on the system (e.g., long-term geomorphic response), including tidal marsh and tidal flats to inform vulnerability and predictive models.

SEA LEVEL RISE

- Distribution of High Tide Refugia; Project & Regional Scale - Determine spatial extent and distribution of current high tide refugia to help prioritize projects where high tide refugia are part of current restoration designs. Evaluate management options to provide additional high tide refugia.

[10] This objective links directly with research objectives outlined in the riparian land bird section module.

Data Management

Collective standardized data collection and sharing protocols should be developed for the SFBJV region and linked to existing relevant national databases. A useful way of collective data storing is to create a common metadata website that provides relevant information on the data, shows the spatial extent of the data on a map, data format and ease of transfer, and includes disclaimers about data availability and allowed uses. This approach lets data owners decide whether to post entire datasets, or to just provide their metadata information and allow others to request a full dataset directly from the source, specifying intended use. An existing portal for this proposed online forum is in development via the San Francisco Bay Conservation Commons. This metadata approach allows for datasets to reside in different databases, and after standard data conventions are developed and followed, will enable easy transfer. Development of clear protocols on the rights and responsibilities of data sharing will only help this process of collaboration.

Target species population and habitat status monitoring data should be contributed or linked via metadata portals to online repositories, such as Migratory Bird Data Center, California Avian Data Center and Avian Knowledge Network, DFG's Biogeographic Information and Observation System (BIOS), eBird, Calflora for plants, and others. These may be linked further with other programs to enable larger-scale assessment of local changes across a broader climatic gradient.

In addition to providing cross-linked databases, user-friendly visualization tools for trend analysis and interpretation are needed, as well as easy to construct reports for download. Training sessions for resource manager users need to be designed and implemented to assure that these tools will be utilized by the constituencies they are meant to inform.

Existing Programs and Tools

Relevant climate change assessment programs and tools in existence or in development are alphabetically listed below. The climate change focus team will determine in the next M&E plan planning phase how these programs and tools can best be utilized, expanded upon, and integrated with the outlined monitoring and evaluation objectives and research needs.

Existing Programs

- *Applied California Current Ecosystem Studies (ACCESS)* - ACCESS focuses on the oceanic habitats in Federal and State waters of northern and central California. ACCESS partners have been investigating the spatial and temporal relationships between oceanographic processes, zooplankton, and marine birds and mammals in the region surrounding Cordell Bank and the Gulf of the Farallones. Ongoing surveys started in May 2004. Four to five cruises are conducted annually between April and October.
- *Bay Conservation and Development Commission (BCDC)* - *Innovative Wetland Adaptation Strategies Study in Lower Corte Madera Creek Watershed.* This project is evaluating the benefits of tidal wetlands to flooding protection and wave attenuation, the sensitivity of these ecosystem services to sea level rise, and the types of management measures that could be employed to enhance or protect the tidal wetland system and its benefits to inland communities in the future.
- *Central & North Coast Ocean Observing System (CeNCOOS)* - CeNCOOS is focused on provision of physical parameter datasets for coast and San Francisco water quality information, salinity temperatures, surface currents, working with National Weather Service on atmospheric elements.
- *Gulf of the Farallones National Marine Sanctuary (GFNMS) - Beach Watch Program* – The program can provide long-term data on changes in beach profile, bird and mammal assemblages, etc. for outer coastal areas.
- *National Park Service - Vital Sign Monitoring Framework* – not specifically targeted at climate change adaptation, but there may be useful indicators to work with.
- *National Estuarine Research Reserves (NERR)* - track effects of climate change on tidal marshes. Their goal is to utilize the 28 NERRs into a network of "sentinel sites" for climate change impacts. NERR long-term system-wide monitoring program is in place focused on water quality & biological monitoring of two SFB NERR sites. *SFB NERR* is implementing a project quantifying suspended sediment concentrations in China Camp marsh channels – this should be expanded to other areas throughout SFB.
- *Regional Water Quality Control Board – SFB Nutrient Numeric Endpoint Project* - To address nutrient over-enrichment (eutrophication) in State waters, SFB Water Board is working with the State Water Board, the Southern California Coastal Water Research Program (SCCWRP) and the San Francisco Estuary Institute (SFEI) to develop nutrient numeric endpoints (NNE) for the SFB Estuary.
- *Pacific Flyway Shorebird Survey* (PFSS) – PFSS data are used in models to project impacts of habitat change on shorebird populations throughout the SFB region and entire Pacific Flyway (PRBO Conservation Science project lead: M. Reiter).
- *San Francisco State University and University of San Francisco* – T. Parker, J. Callaway and others are conducting studies on the re-vegetation dynamics of restored tidal marshes, and are developing efficient assessment and monitoring methods (see Parker et al. 2011).
- *USGS, UC Davis– Bodega Marine Lab* - Jim Cloern (USGS) has been collecting phytoplankton and chlorophyll data for SFB to assess levels of and changes in primary productivity over time. John Largier's (UCD BML) research group has collected phytoplankton, zooplankton data in Tomales Bay.
- *USGS Western Geographic Science Center and University of San Francisco* – With their respective research programs in tidal marshes, Drs. John Callaway (USF) & Kristin Byrd (USGS) work to assess carbon sequestration values and re-vegetation rates in marshes.

- *USGS Western Geographic Science Center and Western Ecological Research Center* - J.Y. Takekawa and B. Jaffe are collaborating on shoal ecology and sediment flux assessments at the Dumbarton Bridge.
- *USGS Western Ecological Research Center (WERC) SFB Estuary Field Station*– J.Y. Takekawa and K. Thorne are modeling sea level rise and storms for SFB marshes for the conservation and management of endangered wildlife populations.
- *USGS WERC SFB Estuary Field Station* — J.Y. Takekawa and K. Thorne are monitoring high water events from tides and storms for assessment of predation risk for marsh species.
- *USGS California Water Science Center* - K. Swanson, J. Drexler, and D. Schoellhamer are modeling accretion processes for marshes in SFB under sea level rise scenarios.

Existing Tools

- *Biogeographic Information and Observation System (BIOS)* – BIOS is a system designed to enable the management, visualization, and analysis of biogeographic data collected by the Department of Fish and Game and its Partner Organizations. In addition, BIOS facilitates the sharing of those data within the BIOS community. BIOS integrates GIS, relational database management, and ESRI's ArcIMS and ArcGIS Server technologies to create a statewide, integrated information management tool.
- *Calflora* – The Calflora database aggregates and makes available data on native and non-native California wild plants, with approximately 2 million occurrence records, 20,000 checklists, and 20,000 monthly users monthly. The database includes all formats of plant occurrence data (lines, polygons, points, checklists). Calflora's increasingly comprehensive non-native and native plant data provide raw material for identifying unique microsites and assemblages, predicting distributions of weeds and natives, and tracking and monitoring distribution changes due either to natural change or from human translocation of species.
- *PRBO Conservation Science - SLR model* – impact of changes in sea level and salinity, acting in concert with future sedimentation to alter suitability of habitat for tidal marsh plants and birds (five species; Project lead: S. Veloz).
- *Western Hemisphere Shorebird Reserve Network (WHSRN)* – Climate Change Vulnerability Assessment for Shorebird Habitat (CC-VASH): climate change assessment tool - CC-VASH is an innovative, Excel-based assessment and decision-making tool developed by the Manomet Center for Conservation Sciences Shorebird Recovery Project and the USFWS Northeast Region Division of Refuges. Designed to be applicable to any coastal site containing shorebird habitat

Programs In Development

- *Climate change scenario planning with regard to waterfowl* in Central Valley of California (J. Fleskes, potential for extension to SFB area?)
- *North Bay Climate Adaptation Initiative (NBCAI)* - Sonoma County-wide pilot: Pilot biodiversity monitoring plan developed for North Bay to inform climate adaptation at watershed scales; Watershed health indicators & Salmonid monitoring plan developed for North Bay.
- *PRBO Conservation Science - California Environmental Change Network (ECN)* ECN is modeled after the European ECN to monitor environmental change at preserve sites throughout the region and California (Project leader: T. Gardali).
- *University of California –Davis - Bodega Marine Laboratory - Bodega Ocean Acidification Research (BOAR)* - The BOAR consortium is examining spatial and temporal changes in seawater chemistry and the impacts of this variability on the ecology, physiology, and biomechanics of critical nearshore marine invertebrates.
- *USFWS National Wildlife Refuge System* - Inventory & Monitoring Program
- *San Francisco Estuary Institute (SFEI), Save the Bay & partners* - A monitoring protocol for tidal marsh transition zones/ecotones is in development.

Tools In Development

- *NERR - SLAMM model* - Sea Level Rise Affecting Marshes Model is applied by Eric Van Dyke at Elkhorn Slough National Estuarine Research Reserve.
- *Our Coast–Our Future* – High resolution seamless digital elevation model, sea level rise and extreme storm scenarios, and decision support tool to plan for and respond to sea level rise and storms along the north-central California coast.
- *PRBO Conservation Science - Sea Level Rise Model, part II:* Information on habitat suitability is coupled with demographic models of bird response to extreme storms and sea level rise impacts, assessing long-term viability (Project leader: N. Nur).
- *PRBO Conservation Science - ZONATION modeling* – Model is utilized to predict areas with highest change.
- *San Francisco Data Commons* – A Sonoma Ecology Center/University of California Davis Information Center for the Environment/PRBO Conservation Science partnership for building a centralized SFB area data clearinghouse.
- *SUNTANS SF Bay Modeling* - Climate change scenarios are being applied to SFB through Stanford University. University of California, Berkeley will assess changes in sea level, salinity, wind and waves, and sediment distributions.
- *USGS- CASCaDE model* - Plans exist for expanding CASCaDE model for a focused approach via specific SLR and geographic scenario evaluations. The USGS CASCaDE model (hydrodynamic, sediment, etc.) has been used in the north part of SFB to evaluate SLR impacts (should be expanded to south SFB as well)
- *USGS – WARMER model* - Kathleen Swanson is refining WARMER model for marsh accretion.
- *USGS Coastal Storm Modeling System (CoSMoS)* – This modeling system is being applied to the NOAA "Our Coast–Our Future" project along the north-central coast from Half Moon Bay to Bodega Head (Project Lead: Patrick Barnard). There are plans to try to apply it in SFB also in the near future.

Key Partners

- Bay Area Ecosystem Climate Change Consortium (BAECCC)
- Bay Conservation and Development Commission (BCDC)
- Calflora
- Central and Northern California Ocean Observing System (CeNCOOS)
- California Coastal Conservancy
- County representatives
- Gulf of the Farallones, Cordell Bank, and Monterey Bay National Marine Sanctuaries
- Kamman Hydrology & Engineering
- National Geodetic Survey (NGS)
- NERRs (SFB, Elkhorn Slough)
- NOAA's Center for Operational Oceanographic Products and Services (CO-OPS)
- North Bay Climate Adaptation Initiative (NBCAI)
- Parks and Open Space Districts as monitoring sites
- Pepperwood Foundation
- Peter Baye
- Philip Williams and Associates (PWA) and the studies of Steve Crooks and Michelle Orr
- PRBO Conservation Science
- Richardson Bay Audubon and California Audubon
- San Francisco Estuary Institute
- San Francisco State University
- Save the Bay
- South Bay Salt Pond Restoration Project
- The Bay Institute (TBI)
- University of California - Berkeley
- University of California - Davis
- USGS –
- University of San Francisco
- USFWS – SFB National Wildlife Refuge complex
- USFWS – National Wildlife Refuge Inventory & Monitoring Program
- USFWS – National Park Service (West Coast region, includes the Golden Gate National Recreation Area and Point Reyes National Seashore)
- Wetlands and Water Resources, Inc.

Next Steps - A Phased Approach

In this first planning phase, each M&E Plan focus section features priority objectives and references supporting information determined by the SFBJV science sub-committee. This information will be utilized in planning phase II to secure implementation funding for the outlined priority objectives, and as a basis for further Plan development to continue to refine and integrate the overall Plan objectives as our knowledgebase evolves. Phase III will evaluate and incorporate additional conservation goals and target performance objectives into an upcoming revision of the SFBJV Implementation Plan (originally released in 2001). We therefore consider the M&E Plan a "living document" that will change over time with continually refined and focused content. For more details on the planning phases, please refer to the Introduction & Overview section of this plan under *Planning Phases – A "Living Document."*

Future Challenges For Climate Change Related Monitoring And Research Include:

- Linking effects of conservation delivery actions to target organism stability, and habitat resilience in the context of climate change impacts.
- Determining appropriate adaptation strategies and desired outcomes relevant to target habitats.
- Refining monitoring objectives with focus on measuring climate adaptation action impact or progress against specified outcomes.
- Developing suitable performance targets and management thresholds.
- Identifying and implementing appropriate metrics (e.g., vital rates) that are relevant to the SFBJV and larger landscape scales (e.g., flyways).
- Maximizing integration with other regional and national climate change assessment initiatives.

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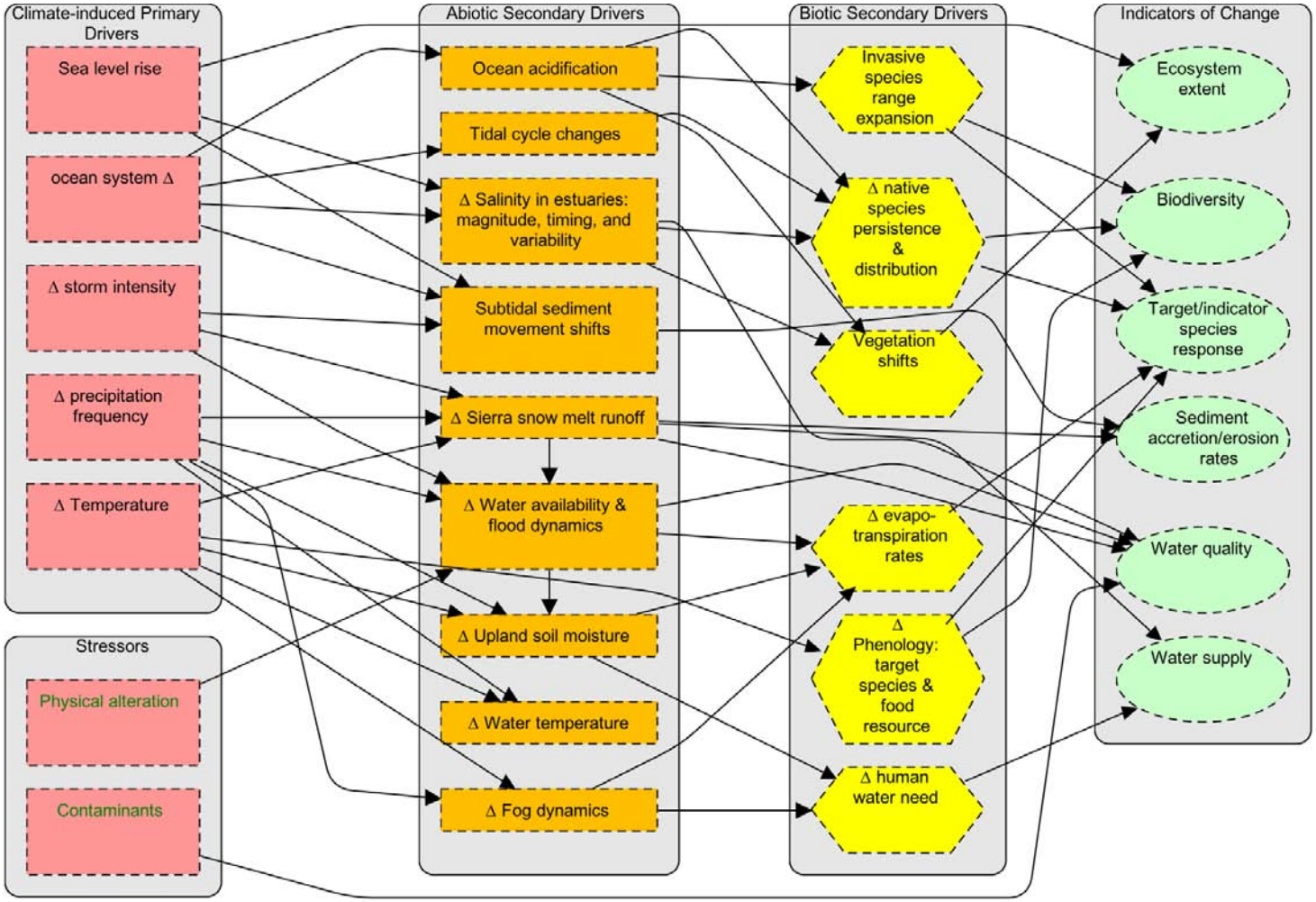

Figure 8.4: Draft Conceptual Model of the inter-relationships of climate induced primary drivers, stressors and secondary drivers, and indicators of change. The SFBJV science partner community will continue to refine this model in phase II of the planning process

The San Francisco Bay Joint Venture is a partnership of public agencies, environmental organizations, the business community, local governments, and landowners working cooperatively to protect, restore, increase, and enhance wetlands and riparian habitat in the San Francisco Bay Watersheds. We bring an ecosystem and collaborative approach to developing and promoting wetland and riparian habitat conservation throughout the Bay Area.

The Joint Venture Management Board

Nonprofit and Private Organizations

Bay Area Audubon Council
Bay Area Open Space Council
Bay Planning Coalition
Citizens Committee to Complete the Refuge
Ducks Unlimited
National Audubon Society
Pacific Gas & Electric Company
PRBO Conservation Science
Save the Bay
Sierra Club
The Bay Institute

Public Agencies

Bay Conservation and Development Commission
California State Coastal Conservancy
California Department of Fish and Game
California Resources Agency
Contra Costa Mosquito and Vector Control District
National Fish and Wildlife Foundation
NOAA National Marine Fisheries Service
Natural Resources Conservation Service
SF Bay Regional Water Quality Control Board
San Francisco Estuary Partnership
U.S. Army Corps of Engineers
U.S. Environmental Protection Agency
U.S. Fish and Wildlife Service
U.S. Geological Survey
Wildlife Conservation Board

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