Central Valley Landscape Conservation Project: Vulnerability Assessment Process and Methods

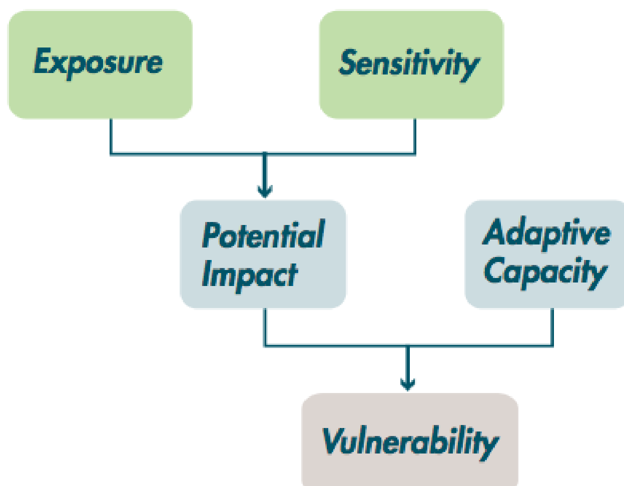
Definitions of Terms

Exposure: A measure of how much of a change in climate or climate-driven factors a resource is likely to experience (Glick et al. 2011).

Sensitivity: A measure of whether and how a resource is likely to be affected by a given change in climate or factors driven by climate (Glick et al. 2011).

Adaptive Capacity: The ability of a resource to accommodate or cope with climate change impacts with minimal disruption (Glick et al. 2011).

Vulnerability: A function of the sensitivity of a particular resource to climate changes, its exposure to those changes, and its capacity to accommodate or cope with those changes (adapted from IPCC 2007).



Above: Key components of a vulnerability assessment. From Glick et al. 2011.

Vulnerability Assessment Process

The California Landscape Conservation Cooperative, in collaboration with EcoAdapt and the Center for Collaborative Policy, convened a 2-day workshop on October 8-9, 2015 at the Harper Alumni Center at California State University, Sacramento. The primary goal of the workshop was to assess the vulnerability of a suite of stakeholder-identified priority natural resources (i.e., habitats, species, species groups). Thirty scientists and resource managers participated in this workshop, representing 16 different agencies, organizations, and universities. Information from the workshop such as the agenda, presentations, handouts, readings, and other resources can be found on the workshop support page.[1]

Participants were provided with a foundation of information from which they could assess the vulnerabilities of the selected priority natural resources. Scientific literature, maps, and existing related vulnerability assessments and biogeographic models were assembled and provided for their review prior to the workshop on the workshop support page. At the workshop, participants were introduced to general vulnerability assessment theory, approaches, and case studies; given an overview of projected climate trends in the Central Valley, instructed in the process and worksheets; and organized into several different small working group arrangements assigned by expertise to discuss and assess the vulnerability of habitats, species, and species groups and record their answers on the worksheets. Reference material was provided in the workshop: habitat maps on each table and a poster summarizing projected climate and non-climate-related changes in the Central Valley.

Workshop participants applied the vulnerability assessment method described below to 35 priority natural resources. As this was an expert elicitation process, participants were encouraged to make decisions based on their knowledge and expertise, and the workshop process and vulnerability assessment model were designed to be flexible to support collaborative modification and improvement. Almost all of the 35 resources were assessed during the workshop; rice croplands was not assessed at the workshop, but identified as an important habitat and assessed by regional experts outside of the workshop.

Participant rankings, scores, and comments were compiled into vulnerability assessment summaries, which were supplemented with information from the scientific literature. Each habitat, species group, and species vulnerability assessment summary was reviewed by workshop participants and, in some cases, additional subject-matter experts. Comments, additional content recommendations, and revisions from these reviewers were incorporated into the summaries. Only changes in the explanatory text were incorporated; vulnerability rankings and scores provided by workshop participants were not altered unless participants had left them blank during the workshop. Final vulnerability assessment summaries can be found on the Central Valley Landscape Conservation Project page.[2]

Vulnerability Assessment Method

The vulnerability assessment model applied in this process was developed by EcoAdapt[3] (Hutto et al. 2015, EcoAdapt 2014a, EcoAdapt 2014b, Kershner 2014), and includes evaluations of vulnerability by regional stakeholders who have detailed knowledge about and/or expertise in the ecology, management, and threats to focal habitats, species groups, and species.

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[1] http://climate.calcommons.org/cvlcp/vulnerability-assessment-workshop

[2] http://climate.calcommons.org/cvlcp

[3] Sensitivity and adaptive capacity elements were informed by Glick et al. 2011, Manomet Center for Conservation Sciences 2012, and Lawler 2010.

Stakeholders evaluated vulnerability for each resource by discussing and answering a series of questions for sensitivity, adaptive capacity, and exposure using worksheets designed for the purpose. Each vulnerability component (i.e., sensitivity, adaptive capacity, and exposure) was divided into specific elements. For example, habitats included three elements for assessing sensitivity and five elements for adaptive capacity while species included five elements each for assessing sensitivity and adaptive capacity. Elements for each vulnerability component are described in more detail below.

Stakeholders assigned one of five rankings (High, Moderate-high, Moderate, Low-moderate, or Low) for each component of vulnerability. Stakeholder-assigned rankings for each component were then converted into scores (High-5, Moderate-high-4, Moderate-3, Low-moderate-2, or Low-1) and the scores averaged (mean) to generate an overall score. For example, scores for each element of habitat sensitivity were averaged to generate an overall habitat sensitivity score. Scores for exposure were weighted less than scores for sensitivity and adaptive capacity; this was due to greater uncertainty about the magnitude and rate of future change. Sensitivity, adaptive capacity, and exposure scores were combined into an overall vulnerability score calculated as:

Vulnerability = Climate Exposure x Sensitivity - Adaptive Capacity

Elements for each component of vulnerability were also assigned one of three confidence rankings (High, Moderate, or Low). Confidence rankings were converted into scores (High-3, Moderate-2, or Low-1) and the scores averaged (mean) to generate an overall confidence score.

Vulnerability and confidence rankings and scores for a given element were supplemented with information from the scientific literature. The final vulnerability assessment summaries for a given resource include stakeholder-assigned rankings, confidence evaluations, and narratives summarizing expert opinions and information from the scientific literature. Due to stakeholder differences in interpretation, we recommend referring to the narratives for each habitat in addition to rankings and scores.

Vulnerability Assessment Model Elements

Sensitivity & Exposure

1. Climate and Climate-Driven Factors (Habitats, Species, Species Groups).

Habitats. Habitat sensitivity to climate and climate-driven factors was evaluated by considering whether the habitat occurs in a relatively narrow climatic zone, and/or whether it experiences large changes in structure or composition in response to relatively small changes in climatic factors. More sensitive habitats are likely to be those that occur within a narrow climatic zone and/or experience large changes in composition or structure in response to small changes in climatic factors (Lawler 2010).

Species and Species Groups. Species sensitivity to climate and climate-driven factors was evaluated by considering both direct (e.g., physiological, phenological) and indirect (e.g., ecological relationships) sensitivity. Physiological sensitivity refers to a species' physiological ability to tolerate changes that are higher or lower than the range that they currently experience. Species that are able to tolerate a wide range of climatic factors may be considered less sensitive (Glick et al. 2011). Phenological sensitivity refers to a species' ability to phenologically track climate (e.g., temperature). Species that cannot phenologically track environmental changes may be considered more sensitive. The sensitivity of a species also depends on the sensitivity of its ecological relationships (e.g., habitat needs, diseases, predator-prey dynamics, foraging, pollination, competition). Ecological relationships significantly affected by small changes in climatic factors likely have higher sensitivity.

Climate and climate-driven factors considered included air temperature, precipitation, snowpack amount, timing of snowmelt and runoff, soil moisture, altered stream flows, and others. Benefits to the resource from climate and climate-driven factors were also considered.

2. Disturbance Regimes (Habitats, Species, Species Groups). Habitats, species, or species groups may be sensitive to natural disturbance regimes that shape an ecosystem or feature over a long time scale such as wildfire, flooding, drought, insect and disease outbreaks, or wind, among others. Habitat, species, or species group sensitivity was evaluated by considering whether the resource shows larger changes in response to relatively small climate-driven changes in disturbance regimes (more sensitive) or conversely, whether it would take much larger climate-driven changes in disturbance regimes to elicit a substantial change in the resource (less sensitive) (Lawler 2010).

3. Future Climate Exposure (Habitats, Species, Species Groups). Habitat, species, and species group exposure evaluations included consideration of projected future climate changes (e.g., temperature and precipitation) as well as climate-driven changes (e.g., altered fire regimes, altered flow regimes, shifts in vegetation types). In particular, to what degree is the resource likely to be exposed to and affected by a given change? Stakeholders were provided with a summary of historical, current, and projected future climate changes for the Central Valley to aid in the exposure assessment (Appendix C: "Overview of Projected Future Changes in the California Central Valley".

4. Non-Climate Factors (Habitats, Species, Species Groups). Other non-climate stressors have the potential to exacerbate the effects of climate change on resources, or vice versa, although they may also have independent or antagonistic effects. Habitats, species, or species groups that have to endure multiple non-climate stressors may be more sensitive to climate changes. To understand the impact of a given non-climate stressor on a resource, stakeholders evaluated two factors: (1) the degree to which the stressor affects the sensitivity of the resource to climate change, and (2) the degree of current exposure to the stressor. Non-climate factors considered included: urban/suburban development; agriculture and rangeland practices; impervious surfaces; roads, highways, trails; land use change; dams, levees, water diversions; invasive and other problematic species; and groundwater overdraft, among others.

5. Life History (Species, Species Groups). Species life history sensitivity was evaluated by considering its reproductive strategy; for example, species with longer generation times and fewer offspring may be at increased extinction risk under long-term climate change. Species with a short generation time that produce many offspring may be better able to take advantage of climate changes (Glick et al. 2011).

6. Dependencies (Species, Species Groups). Stakeholders evaluated the sensitivity of species and species group dependencies by considering: (1) dependence on sensitive habitat types; (2) dependence on specific prey or forage species; and (3) where the species falls on the spectrum of generalist to specialist. Species and species group sensitivity is likely to be influenced by the sensitivity of its dependencies (e.g., specialized habitat needs or prey) to climate change. Species that use multiple habitats or utilize multiple prey or forage species are likely less sensitive to climate change. Conversely, species with very narrow habitat needs or habitat specialization, single prey or forage species, or dependence on another sensitive species may have a higher likelihood of decline if climate change significantly affects the habitat or species they are dependent upon. For example, species that depend on ephemeral wetlands or deep snowpack are likely to be susceptible to climate impacts such as increased temperatures or changes in precipitation regimes.

Adaptive Capacity

1. Extent, Integrity, and Connectivity (Habitats, Species, Species Groups).

Habitats. Habitats that are currently widespread in their geographic extent, with high structural and functional integrity and connectivity may be better able to withstand impacts and persist into the future despite climatic and non-climate stressors (higher adaptive capacity). Habitats exhibiting degraded structural or functional integrity, isolation or fragmentation, or small or declining extent due to climatic and non-climate stressors likely have lower adaptive capacity (Manomet Center for Conservation Sciences 2012). Stakeholders evaluated the geographic extent, structural and functional integrity, and continuity of each habitat.

Species and Species Groups. Species and species groups that are currently widespread in their geographic extent, with a robust population status and connectivity between populations likely have higher adaptive capacity. These species and species groups may be more likely to withstand and persist into the future despite climatic and non-climatic stressors. Species and species groups that are endemic, threatened or endangered, and/or occur as isolated or fragmented populations likely have lower adaptive capacity. Stakeholders evaluated the geographic extent, overall health or population status, and degree of connectivity between populations of each species or species group.

2. Dispersal Ability and Barriers (Habitats, Species, Species Groups).

Habitats. More permeable landscapes with fewer barriers to dispersal and/or migration will likely result in greater adaptive capacity for habitats because they can shift as conditions change. Stakeholders identified barriers and evaluated the degree to which each barrier affects dispersal/habitat continuity.

Species and Species Groups. Species and species groups that are poorer dispersers, in general, are more susceptible to climate change, leading to less adaptive capacity (Glick et al. 2011). However, multiple or significant barriers to dispersal can also decrease the adaptive capacity of species or species groups with high innate dispersal ability. Stakeholders assessed the ability of the species or species group to disperse, identified barriers, and evaluated the degree to which each barrier affects dispersal ability.

Barriers to dispersal considered included: urban/suburban development, agricultural and rangeland practices, energy production and mining, roads/highways/trails, dams and water diversions, invasive/non-native species, land use change, riprap, and geologic features, among others.

3. Resistance and Recovery (Habitats, Species, Species Groups). Some habitats, species, or species groups may be more resistant to changes, stressors, or maladaptive human responses, or are able to recover more quickly from stressors once they do occur, resulting in greater adaptive capacity. In particular, *resistance* refers to the stasis of a resource in the face of change. For example, some resources may have higher tolerance thresholds than others in response to climate perturbations, leading to higher adaptive capacity. Alternatively, maladaptive human interventions can reduce the resistance of a resource by accelerating rates or severity of change, leading to lower adaptive capacity. *Recovery* refers to the ability to "bounce back" more quickly from stressors once they do occur. For example, some habitats may have more rapid regeneration times and/or are dominated by species with short generation times. Habitats, species, or species groups with a shorter recovery period from the impacts of stressors (<20 years) may have greater intrinsic adaptive capacities than slower developing/recovering resources (>20 years), as slower recovering resources may be more intrinsically vulnerable to the potential intervening effects of climate change (Manomet Center for Conservation Sciences 2012). Stakeholders evaluated the degree to which the habitat, species, or species group is resistant to the impacts of stressors and/or maladaptive human responses, and the degree to which the habitat or species group is able to recover from the impacts of stressors.

4. Diversity.

Habitats. Habitat diversity was evaluated by considering each habitat's physical and topographical diversity, component species and functional group diversity, and dependency upon a single keystone or foundational species. Habitats with diverse physical and topographical characteristics (e.g., variety in aspects, elevation, sediment types) may be better able to persist under changing climate conditions than less varied habitats because they exist across widely differing conditions (Manomet Center for Conservation Sciences 2012). The level of diversity of component species and functional groups in the habitat may also affect its adaptive capacity (or sensitivity) to climate change impacts. For example, habitats with multiple species per functional group are likely to have greater adaptive capacity because response to changes in climate varies among the species (Glick et al. 2011). Dependency on a single keystone or foundation species can also affect the habitat's adaptive capacity, contingent upon the species' vulnerability to climate change.

Species and Species Groups. Species and species group diversity was evaluated by considering life history and genetic diversity as well as behavioral and phenotypic plasticity. Species and species groups that demonstrate a diversity of life history strategies (e.g., variations in age at maturity, reproductive or nursery habitat use, or resource use) are likely to have greater adaptive capacity as they can cope with a range of conditions. Similarly, species or species groups able to express different and varying traits (e.g., in phenology, behavior, or physiology) in response to environmental variation have greater adaptive capacity than those that cannot modify their physiology or vary behavior to better cope with climate changes and its associated effects. Many species can exhibit phenotypic plasticity in response to inter-annual variation in temperature and precipitation. However, only some species and/or populations will be better able to adapt evolutionarily to climate change. For example, species with characteristics such as faster generation times, genetic diversity, heritability of traits, larger population size, or multiple populations with connectivity among them to allow for gene flow likely have greater adaptive capacity and may be less vulnerable to future climate changes.

Management Potential (Habitats, Species, Species Groups)

Management potential reflects the ability of resource managers to alter the adaptive capacity and resilience of a habitat, species, or species group to climatic and non-climate stressors, as managers may have the potential to intervene in ways that reduce the impacts of stressors. Management potential can be evaluated in two ways: (1) Societal value - Is the habitat highly valued? Habitats with high societal value (e.g., rivers or streams) likely have higher adaptive capacity as people may have a greater interest in protecting and/or maintaining them and the ecosystem services they provide; and (2) Managing or alleviating climate impacts - Can impacts, climate or non-climate, on the habitat be managed or alleviated? If human intervention or management has a high likelihood of alleviating impacts, the adaptive capacity of the habitat is also likely higher. The costs and benefits of management actions will vary depending on habitat type. Management actions will likely be most feasible when habitats are culturally and economically valued and the costs of implementing new management actions are low. Stakeholders evaluated societal value and societal support for managing or conserving a given resource; the likelihood of managing or alleviating climate impacts; and the degree to which extreme events (e.g., flooding, extended drought) would influence societal support for taking action. Additionally, stakeholders considered the likelihood or support for maintaining or enhancing a given resource on working landscapes and the degree to which agriculture and rangelands benefit/support/increase resilience of a resource; these last two considerations are specific to the conditions and situations of the Central Valley.

Confidence Evaluation

Each of the sensitivity, adaptive capacity, and exposure elements described above for habitats, species, and species groups were assigned a confidence rank: High, Moderate, or Low. These approximate confidence levels were based on the Manomet Center for Conservation Sciences (2012) 3-category scale, which collapsed the 5-category scale developed by Moss and Schneider (2000) for the IPCC Third Assessment Report. The vulnerability assessment model applied here assesses both the confidence associated with individual element rankings, and also uses these rankings to estimate the overall level of confidence for each component of vulnerability as well as overall vulnerability.

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