INDIVIDUAL SPECIES VULNERABILITY ASSESSMENT WORKSHEETS

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Prioritize the gray boxes in each section. If there is not enough time to complete the white boxes, the project team may populate these after the workshop and ask participants to review answers later.

Species: _____

1. Sensitivities to Climate and Climate-Driven Factors

Sensitivity involves factors that currently shape the species; exposure involves future climate changes that could affect the species, and is covered in another section below.

Species sensitivity to climate and climate-driven factors may be direct (e.g., physiological, phenological) or indirect (e.g., ecological relationships).

(1) 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.

(2) 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.

(3) Species' ecological relationships may also be affected by climate or climate-driven factors. Ecological relationships could include: predator/prey, foraging, competition, habitat, pollination, dispersal, symbiont/mutualist/parasite, and others. For example, climate-driven changes in Clark's nutcracker distribution or behavior could have a significant impact on whitebark pine regeneration, as this species is dependent on the Clark's nutcracker for seed dispersal. Ecological relationships significantly affected by small changes in climate and climate-driven factors likely have higher sensitivity.

Instructions

Step 1: Using the list provided below, identify the factors that the species is sensitive to. Consider physiological, phenological, and ecological relationship sensitivity to climate and climate-driven factors.

Step 2: For those factors that the species is sensitive to, estimate the degree of sensitivity, and your level of confidence in your estimate of sensitivity.

Step 3: If you have time, indicate any references that you feel are particularly relevant to your answers.

Air temperature	Timing of snowmelt & runoff	Water temperature
Precipitation (amount)	Soil moisture	Extreme events: heat waves
Precipitation (timing)	Altered stream flow regimes	Extreme events: drought
Snowpack amount	Extreme events: storms	Other (please specify)

FACTOR	DEGREE OF SENSITIVITY 1 (low) – 5 (high)	CONFIDENCE 1 (low) – 3 (high)	RELEVANT REFERENCES

FACTOR	DEGREE OF SENSITIVITY 1 (low) – 5 (high)	CONFIDENCE 1 (low) – 3 (high)	RELEVANT REFERENCES

Do any of the climate or climate-driven factors listed above BENEFIT the species? If so, list the factor and describe how the species benefits. *Include any relevant citations.*

Comments: *Provide any comments to support or clarify your conclusions above.*

2. Sensitivities to Disturbance Regimes

Natural disturbance regime is a concept that describes the pattern of disturbances that shape an ecosystem over a long time scale; it is distinguished from a single disturbance event because it describes a spatial disturbance pattern, a frequency and intensity of disturbances, and a resulting ecological pattern over space and time.

Species may be at greater risk of decline or elimination even in response to small changes in disturbance regimes. For example, altered fire regimes in grassland habitats may increase invasion rates and abundance of non-native annual grasses and weed species that outcompete native species. Changes in disturbance regimes may be either good or bad for the species.

Circle all disturbance regimes to which the species is sensitive (consider both magnitude and frequency): *If none apply, do not circle any.*

Wildfire	Flooding	Insects	Other (please describe)
Disease	Wind	Grazing	

Overall, how sensitive is the species to the circled disturbance regimes? *1 – 5 (1=low sensitivity; 5=high sensitivity)*	**Confidence in the sensitivity to disturbance regimes:** *1 – 3 (1=low confidence; 3=high confidence)*
_____	_____

Comments and Citations: *Briefly describe your selection of disturbance regimes above, detailing how the specified disturbance regime affects the species.*

3. Future Climate Exposure

Climate exposure involves projected future climate changes that could affect the species and the likely degree of exposure to those changes.

Instructions

Step 1: Using the list provided below, identify the future climate and climate-driven changes most relevant to consider for this species.

Step 2: For those climate and climate-driven changes that the species is likely to be affected by, estimate the degree of exposure and your level of confidence in your estimate of exposure. Use the information provided on projected future climate changes for the Central Valley to inform your estimate of degree of exposure.

Step 3: If you have time, indicate any potential areas of refugia from each climate or climate-driven change.

Increased air temperature	Earlier snowmelt & runoff	Increased wildfire
Changes in precipitation (amount)	Increased water temperatures	Extreme events: more heat waves
Changes in precipitation (timing)	Lower stream flows	Extreme events: more drought
Decreased snowpack	Increased flooding	Other (please specify)

CLIMATE OR CLIMATE-DRIVEN CHANGE	DEGREE OF EXPOSURE 1 (low) – 5 (high)	CONFIDENCE 1 (low) – 3 (high)	Potential Areas of Refugia from Change?

Overall confidence in your assessment of exposure: *1 – 3 (1=low confidence; 3=high confidence)* _____

4. Life History

Species reproductive strategy may influence its sensitivity to climate change; 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.

Species reproductive strategy	**Confidence in your assessment of the species' reproductive strategy:** *1 – 3 (1=low confidence; 3=high confidence)*
• *Produces many offspring and has a short generation time (e.g., fruit fly) = R-selection* • *Produces few offspring and has high parental investment (e.g., elephant) = K-selection* • *A mid-range example would be a species that produces 3-5 young/year* Select a value that corresponds to the reproductive strategy above. 1 – 5 (1=r-selection; 5=k-selection) _____	_____

Average length of time to reproductive maturity (in days): _____

5. Dependencies

Species that use multiple habitats or utilize multiple prey or forage species are likely less sensitive to climate change (e.g., generalists). 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 (e.g., specialists). 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.

Overall, how much does the species depend on one or more sensitive habitat types? (e.g. vernal pools) *1 – 5 (1=low dependency; 5=high dependency)* _____	**Confidence in habitat dependency:** *1 – 3 (1=low confidence; 3=high confidence)* _____
List any sensitive habitats upon which this species depends. *Sensitive habitats could include wetlands/vernal pools, grasslands, seeps/springs, deep, cool ponds, and balds, among others)*	
How much does the species depend on a specific prey or forage species? *1 – 5 (1=low dependency; 5=high dependency)* _____	**Confidence in prey/forage dependency:** *1 – 3 (1=low confidence; 3=high confidence)* _____
Are there other critical dependencies that have not been addressed that influence the species' sensitivity to climate change (e.g., reproductive dependency)? If so, list below and rank degree of dependency. *1 – 5 (1=low dependency; 5=high dependency)* _____	**Confidence in other dependency:** *1 – 3 (1=low confidence; 3=high confidence)* _____
List any other dependencies. If none, write *N/A*. *Other critical dependencies could include host plant species, pollinators, seed dispersal, specific disturbance regimes, etc.*	
Broadly, where does this species fall on the spectrum of generalist to specialist? *1 – 5 (1=generalist; 5=specialist)* _____	**Confidence in generalist/specialist:** *1 – 3 (1=low confidence; 3=high confidence)* _____

6. Sensitivity and Current Exposure to Non-Climate Stressors

Sensitivity of the species to climate change impacts may be highly influenced by the existence, extent of, and current exposure to non-climate stressors. Although a species may be sensitive to a non-climate stressor, if it is not currently exposed to it/affected by it, the overall sensitivity of the species will be lower.

Instructions

Step 1: Using the list provided below, identify the non-climate stressors most likely to increase sensitivity of the species.

Step 2: For those non-climate stressors that the species is likely to be affected by, estimate the degree of current exposure, and your level of confidence in your estimate of current exposure.

Step 3: Indicate whether current exposure to a non-climate stressor occurs across the study area or is highly localized. If the current exposure occurs in a very particular location, indicate that specific location.

Urban/Suburban development	Groundwater overdraft	Roads, highways, trails	Pollution & poisons
Impervious surfaces	Invasive & other problematic species	Land use change	Nutrient loading
Dams, levees, & water diversions	Agriculture & rangeland practices	Other (please specify)	

NON-CLIMATE STRESSOR (add specific details about stressor – e.g., what kind of agricultural practices or land use change?)	**DEGREE STRESSOR AFFECTS SENSITIVITY 1 (low) – 5 (high)**	**CONFIDENCE 1 (low) – 3 (high)**	**IS EXPOSURE CONSISTENT ACROSS STUDY AREA OR HIGHLY LOCALIZED?** (if localized, identify locations)	**CONFIDENCE 1 (low) – 3 (high)**

Individual Species Sensitivity & Exposure Assessment

NON-CLIMATE STRESSOR (add specific details about stressor – e.g., what kind of agriculture or land use change?)	**DEGREE STRESSOR AFFECTS SENSITIVITY 1 (low) – 5 (high)**	**CONFIDENCE 1 (low) – 3 (high)**	**IS EXPOSURE CONSISTENT ACROSS STUDY AREA OR HIGHLY LOCALIZED?** (if localized, identify locations)	**CONFIDENCE 1 (low) – 3 (high)**

Comments and Citations: *Briefly describe how each of the stressors selected above are likely to make the species more sensitive to climate change.*

7. Other Sensitivities

Are there other critical factors that have not been addressed that influence the sensitivity of the species? *List below any other factor that you may consider critical to understanding the potential response of this species to climate change that was not represented with the previous questions. If no other factors apply, write N/A and specify your confidence associated with this question.*	**Collectively, to what degree do these factors influence species' sensitivity?** *1 – 5 (1=low degree; 5=high degree)* _____
Confidence in the degree to which these factors influence species sensitivity: *1 – 3 (1=low confidence; 3=high confidence)* _____	
Comments and Citations: *Describe any "other sensitivities" and how they affect the species.*	

Prioritize the gray boxes in each section. If there is not enough time to complete the white boxes, the project team may populate these after the workshop and ask participants to review answers later.

Species: _____

1. Extent, Status, and Dispersal Ability

Species that are currently widespread in their geographic extent, with a robust population status, connectivity, and a high ability to disperse likely have higher adaptive capacity. These species may be more likely to withstand and persist into the future despite climatic and non-climatic stressors.

Species that are endemic, threatened or endangered, occur as isolated or fragmented populations, and/or exhibit limited ability to disperse likely have lower adaptive capacity.

What is the geographic extent of the species? *1 – 5 (1=endemic to my particular area; 5=transboundary)* _____	**Confidence in extent:** *1 – 3 (1=low confidence; 3=high confidence)* _____
What is the population status of the species? *1 – 5 (1=endangered; 5=robust)* _____	**Confidence in status:** *1 – 3 (1=low confidence; 3=high confidence)* _____
What is the population connectivity for the species? *1 – 5 (1=isolated/quite fragmented; 5=continuous)* _____	**Confidence in connectivity:** *1 – 3 (1=low confidence; 3=high confidence)* _____
What is the ability of the species to disperse? *1 – 5 (1=low ability; 5=high ability)* _____	**Confidence in dispersal ability:** *1 – 3 (1=low confidence; 3=high confidence)* _____
Maximum annual dispersal distance: *The maximum average distance a species will likely move to establish a new population in a more suitable habitat. We are interested in how quickly a species could spread across the coast or ocean in response to climate change. This should reflect a distance that is feasible.* **Circle one.** >100 km; 75-100 km; 50-75 km; 25-50km; 5-25 km; 1-5 km; <1 km	**Confidence in maximum annual dispersal distance:** *1 – 5 (1=low confidence; 5=high confidence)* _____

Comments and Citations: *Provide any comments or citations to support or clarify your conclusions above.*

2. Barriers to Dispersal

Species that are poorer dispersers, in general, are more susceptible to climate change, leading to less adaptive capacity. However, multiple or significant barriers to dispersal can also increase the vulnerability of species with high innate dispersal ability.

Instructions

Step 1: Using the list provided below, identify the most relevant barriers to dispersal for this species.

Step 2: For each barrier to dispersal, specify the type of barrier, estimate the degree of to which the barrier affects species dispersal, and estimate your level of confidence in your assessment of the impact of the barrier.

Step 3: If you have time, indicate any references that you feel are particularly relevant to your answers.

Urban/Suburban development	Agricultural & rangeland practices	Land use change
Energy production & mining	Invasive/Non-native species	Riprap
Roads, highways, trails	Dams, water diversions, & levees	Geologic features
Other (please specify)		

BARRIER TO DISPERSAL (specify type of barrier – e.g., conversion to vineyard)	**DEGREE BARRIER AFFECTS SPECIES DISPERSAL 1 (low) – 5 (high)**	**CONFIDENCE 1 (low) – 3 (high)**	**RELEVANT REFERENCES AND COMMENTS**

Comments and Citations: *Provide any comments or citations to support or clarify your conclusions above.*

3. Intraspecific/Life History Diversity

Life history diversity: Species with a diversity of life history strategies (e.g., variations in age at maturity, reproductive or nursery habitat use, or resource use) may be more resilient to climate change.

Genetic diversity: 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 exhibit higher adaptive capacity.

Phenotypic and behavioral plasticity: Species with the capacity to express different traits (e.g., phenology, behavior, physiology) in response to environmental variation likely have higher adaptive capacity. For example, many species exhibit phenotype plasticity in response to inter-annual variation in temperature and precipitation.

Instructions

Step 1: For each characteristic listed below estimate the degree of diversity or plasticity and your level of confidence in your estimate.

Step 2: If you have time, indicate any references that you feel are particularly relevant to your answers.

CHARACTERISTIC	DEGREE OF DIVERSITY OR PLASTICITY 1 (low) – 5 (high)	CONFIDENCE 1 (low) – 3 (high)	COMMENTS AND RELEVANT REFERENCES
Life history diversity			
Genetic diversity			
Behavioral plasticity			
Phenotypic plasticity			

Comments and Citations: *Provide any comments or citations to describe or clarify the diversity of life history strategies for the species, characteristics that may allow the species to adapt evolutionarily, or how the species is able to modify its physiology or behavior.*

4. Resistance

Some species may be more resistant to changes, stressors, or maladaptive human responses; these species likely exhibit higher adaptive capacity.

Resistance refers to the stasis of a species in the face of change. Some species may have higher tolerance thresholds than others in response to climate perturbations, leading to higher adaptive capacity. For example, species exhibiting drought adaptations (e.g., dormancy) may be better able to survive and/or withstand significant changes in the face of altered water availability. Alternatively, maladaptive human interventions can reduce the resistance of a species by accelerating rates or severity of change, leading to lower adaptive capacity.

To what degree is the species resistant to the impacts of stressors/maladaptive human responses? *1 – 5 (1=low degree; 5=high degree)* _____	**Confidence in resistance:** *1 – 3 (1=low confidence; 3=high confidence)* _____

Comments and Citations: *Provide any comments or citations to support or clarify your conclusions above.*

5. Management Potential

Management potential reflects our ability to impact the adaptive capacity and resilience of a species to climatic changes.

Management potential can be evaluated in two ways:
(1) Societal value: Is the species highly valued? Species with a high societal value likely have higher adaptive capacity, as people may have a greater interest in protecting and/or maintaining them and the ecosystem services they provide.
(2) Managing or alleviating climate impacts: Can climate impacts on the species be managed or alleviated? If human intervention or management has a high likelihood of alleviating climate impacts, the adaptive capacity of a species is likely higher. The costs and benefits of management actions will vary depending on the species; actions will be most feasible when the species and/or its services are culturally and economically valued and the costs of implementing actions are low.

How much do people value this species? *1 – 5 (1=low value; 5=high value)* _____	**Confidence in species value:** *1 – 3 (1=low confidence; 3=high confidence)* _____
Describe species value.	
How much societal support (e.g., financial, regulatory, legislative) is there for managing or conserving this species? *1 – 5 (1=low support; 5=high support)* _____	**Confidence in societal support:** *1 – 3 (1=low confidence; 3=high confidence)* _____
Describe societal support.	
To what degree can agriculture and rangelands benefit/support/increase resilience of this species? *1 – 5 (1=low degree; 5=high degree)* _____	**Confidence in degree:** *1 – 3 (1=low confidence; 3=high confidence)* _____
Describe how agriculture and rangelands benefit/support/increase resilience of this species.	

To what degree would extreme events (e.g., flooding, extended drought) influence societal support for taking action? *1 – 5 (1=low degree; 5=high degree)* _____	**Confidence in degree:** *1 – 3 (1=low confidence; 3=high confidence)* _____
Describe the type of event that may influence societal support.	
What is the likelihood of or support for retired agriculture land being converted to maintain or enhance this species? *1 – 5 (1=low likelihood; 5=high likelihood)* _____	**Confidence in likelihood:** *1 – 3 (1=low confidence; 3=high confidence)* _____
Describe likelihood of or support for retired agriculture land being converted to maintain or enhance this species.	
What is the likelihood of managing or alleviating climate impacts for this species? *1 – 5 (1=low likelihood; 5=high likelihood)* _____	**Confidence in likelihood:** *1 – 3 (1=low confidence; 3=high confidence)* _____
Describe likelihood of managing or alleviating climate impacts.	

6. Other Adaptive Capacity Factors

Are there other critical factors that have not been addressed that may affect the species' adaptive capacity? *List below any other factor that you may consider critical to understand the potential adaptive response of the species to climate change that has not been addressed yet. If no other factors apply, write N/A and specify your confidence associated with this question.*	**Collectively, to what degree do these factors affect the adaptive capacity of the species?** *1 – 5 (1=low degree; 5=high degree)* _____
Confidence in the degree to which these factors affect the species' adaptive capacity: *1 – 3 (1=low confidence; 3=high confidence)* _____	
Comments and Citations: *Describe any other adaptive capacity factors for the species.*	