Focal Resource: WILLOW FLYCATCHER

Taxonomy and Related Information

Subspecies *Empidonax traillii* brewsteri *and E. t.* adastus*, and E. t.* extimus; occurs across Sierra Nevada. One of the rarest birds in the Sierra Nevada, with fewer than 400 breeding individuals range-wide (Mathewson et al. 2013). Willow flycatchers have been extirpated from the southern Sierra Nevada and the majority of the population occurs in the extreme northern Sierra Nevada and southern Cascade mountains (Bombay et al. 2003; Green et al. 2003; King and King 2003; Mathewson et al. 2013).

General Overview of Process

EcoAdapt, in collaboration with the U.S. Forest Service and California Landscape Conservation Cooperative (CA LCC), convened a 2.5-day workshop entitled *A Vulnerability Assessment Workshop for Focal Resources of the Sierra Nevada* on March 5-7, 2013 in Sacramento, California. Over 30 participants representing federal and state agencies, non-governmental organizations, universities, and others participated in the workshop[1]. The following document represents the vulnerability assessment results for the **WILLOW FLYCATCHER**, which is comprised of evaluations and comments from a participant breakout group during this workshop, peer-review comments following the workshop from at least one additional expert in the subject area, and relevant references from the literature. The aim of this synthesis is to expand understanding of resource vulnerability to changing climate conditions, and to provide a basis for developing appropriate adaptation responses. The resulting document is an initial evaluation of vulnerability based on existing information and expert input. Users are encouraged to refer to the Template for Assessing Climate Change Impacts and Management Options (TACCIMO, http://www.taccimo.sgcp.ncsu.edu/) website for the most current peer-reviewed literature on a particular resource. This synthesis is a living document that can be revised and expanded upon as new information becomes available.

Geographic Scope

The project centers on the Sierra Nevada region of California, from foothills to crests, encompassing ten national forests and two national parks. Three geographic sub-regions were identified: north, central, and south. The north sub-region includes Modoc, Lassen, and Plumas National Forests; the central sub-region includes Tahoe, Eldorado, and Stanislaus National Forests, the Lake Tahoe Basin Management Unit, and Yosemite National Park; and the south sub-region includes Humboldt-Toiyabe, Sierra, Sequoia, and Inyo National Forests, and Kings Canyon/Sequoia National Park.

Key Definitions

Vulnerability: Susceptibility of a resource to the adverse effects of climate change; a function of its sensitivity to climate and non-climate stressors, its exposure to those stressors, and its ability to cope with impacts with minimal disruption[2].

[1] For a list of participant agencies, organizations, and universities please refer to the final report *A Climate Change Vulnerability Assessment for Focal Resources of the Sierra Nevada* available online at: http://ecoadapt.org/programs/adaptation-consultations/calcc.

[2] Glick, P., B.A. Stein, and N.A. Edelson, editors. 2011. Scanning the Conservation Horizon: A Guide to Climate Change Vulnerability Assessment. National Wildlife Federation, Washington, D.C.

Sensitivity: A measure of whether and how a species or system is likely to be affected by a given change in climate or factors driven by climate.

Adaptive Capacity: The degree to which a species or system can change or respond to address climate impacts.

Exposure: The magnitude of the change in climate or climate driven factors that the species or system will likely experience.

Methodology

The vulnerability assessment comprises three vulnerability components (i.e., sensitivity, adaptive capacity, and exposure), averaged rankings for those components, and confidence scores for those rankings (see tables below). The sensitivity, adaptive capacity, and exposure components each include multiple finer resolution elements that were addressed individually. For example, sensitivity elements include: whether the species is a generalist or specialist; physiological sensitivity to temperature, precipitation, and other factors (e.g., pH, salinity); dependence on sensitive habitats; species' life history; sensitivity of species' ecological relationships (e.g., predator/prey, competition, forage); sensitivity to disturbance regimes (e.g., wind, drought, flooding); and sensitivity to non-climate stressors (e.g., grazing, recreation, infrastructure). Adaptive capacity elements include: dispersal ability and barriers to dispersal, phenotypic plasticity (e.g., can the species express different behaviors in response to environmental variation), species' potential to adapt evolutionarily to climate change, species' intraspecific/life history diversity (e.g., variations in age at maturity, reproductive or nursery habitat use, etc.), and species' value and management potential. To assess exposure, participants were asked to identify the climate and climate-driven changes most relevant to consider for the species and to evaluate exposure to those changes for each of the three Sierra Nevada geographic sub-regions. Climate change projections were provided to participants to facilitate this evaluation[3]. For more information on each of these elements of sensitivity, adaptive capacity, and exposure, including how and why they were selected, please refer to the final methodology report *A Climate Change Vulnerability Assessment for Focal Resources of the Sierra Nevada*[4].

During the workshop, participants assigned one of three rankings (High (>70%), Moderate, or Low (<30%)) to each finer resolution element and provided a corresponding confidence score (e.g., High, Moderate, or Low) to the ranking. These individual rankings and confidence scores were then averaged (mean) to generate rankings and confidence scores for each vulnerability component (i.e., sensitivity, adaptive capacity, exposure score) (see table below). Results presented in a range (e.g. from moderate to high) reflect variability assessed by participants. Additional information on ranking and overall scoring can be found in the final methodology report *A Climate Change Vulnerability Assessment for Focal Resources of the Sierra Nevada*[4].

[3] Geos Institute. 2013. *Future Climate, Wildfire, Hydrology, and Vegetation Projections for the Sierra Nevada, California: A climate change synthesis report in support of the Vulnerability Assessment/Adaptation Strategy process.* Ashland, OR. http://ecoadapt.org/programs/adaptation-consultations/calcc.

[4] Kershner, J.M., editor. 2014. *A Climate Change Vulnerability Assessment for Focal Resources of the Sierra Nevada.* Version 1.0. EcoAdapt, Bainbridge Island, WA. http://ecoadapt.org/programs/adaptation-consultations/calcc.

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This document is available online at EcoAdapt (http://ecoadapt.org/programs/adaptation-consultations/calcc).

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Overview of Vulnerability Component Evaluations

SENSITIVITY

Sensitivity Factor	Sensitivity Evaluation	Confidence
Generalist/Specialist	**3 Specialist**	**3 High**
Physiology	**1 Low**	**2 Moderate**
Habitat	**3 High**	**3 High**
Life History	**2 Moderate**	**3 High**
Ecological Relationships	**3 High**	**2 Moderate**
Disturbance Regimes	**3 High**	**3 High**
Non-Climatic Stressors – Current Impact	**3 High**	**3 High**
Non-Climatic Stressors – Influence Overall Sensitivity to Climate	**3 High**	**2 Moderate**
Other Sensitivities	**2 Moderate**	**2 Moderate**

Overall Averaged Confidence (Sensitivity)[5]: Moderate-High

Overall Averaged Ranking (Sensitivity)[6]: Moderate–High

ADAPTIVE CAPACITY

Adaptive Capacity Factor	Adaptive Capacity Evaluation	Confidence
Dispersal Ability	**2 Moderate**	**3 High**
Barriers Affect Dispersal Ability	**1 Low**	**3 High**
Plasticity	**2 Moderate**	**2 Moderate**
Evolutionary Potential	**2 Moderate**	**2 Moderate**
Intraspecific Diversity/Life History	**1 Low**	**2 Moderate**
Species Value	**1 Low**	**2 Moderate**
Specificity of Management Rules	**3 High**	**3 High**
Other Adaptive Capacities	**None**	**2 Moderate**

Overall Averaged Confidence (Adaptive Capacity)[5]: Moderate-High

Overall Averaged Ranking (Adaptive Capacity)[6]: Moderate

EXPOSURE

Relevant Exposure Factor	Confidence
Climatic water deficit	**2 Moderate**
Snowpack	**2 Moderate**
Shifts in vegetation type	**2 Moderate**
High flows	**2 Moderate**

[5] 'Overall averaged confidence' is the mean of the entries provided in the confidence column for sensitivity, adaptive capacity, and exposure, respectively.
[6] 'Overall averaged ranking' is the mean of the perceived rank entries provided in the respective evaluation column.

Exposure Region	Exposure Evaluation (2010-2080)	Confidence
Northern Sierra Nevada	**2.5 Moderate–High**	**No answer provided by participants**
Central Sierra Nevada	**2.5 Moderate–High**	**No answer provided by participants**
Southern Sierra Nevada	**3 High**	**No answer provided by participants**

Overall Averaged Confidence (Exposure)[5]: Moderate

Overall Averaged Ranking (Exposure)[6]: Moderate–High

Sensitivity

1. **Generalist/Specialist.**
   a. Where does species fall on spectrum of generalist to specialist: Specialist
      i. Participant confidence: High
   b. Factors that make the species more of a specialist: Predator/prey relationship, foraging dependency

Additional comments: Willow flycatcher is a habitat specialist; it needs willow and alder multi-structure, large open meadows with large shrub and tall herbaceous cover, and with soil saturation and moderate elevation, which determine snowpack and subsequent timing of the emergence of prey. The willow flycatcher also requires flying insects as prey.

References: The willow flycatcher is dependent on insects as prey (Durst et al. 2008), and earlier snowmelt, warmer stream water, and intermittent flows may reduce the abundance of aquatic insects (Perry et al. 2012). Events that influence the overall abundance of arthropods, such as regional droughts, may be critical drivers of productivity for generalists such as willow flycatchers (Durst et al. 2008).

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2. **Physiology.**
   a. Species physiologically sensitive to one or more factors including: Precipitation
   b. Sensitivity of species' physiology to one or more factors: Low
      i. Participant confidence: Moderate

Additional comments: Sensitive to climate-created habitat (i.e., wet meadows).

References: *See "Question 3. Sensitive habitats" below.*

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3. **Sensitive habitats.**
   a. Species dependent on sensitive habitats including: Wetlands, seeps/springs, ecotones, other – shrub cover to open meadow
   b. Species dependence on one or more sensitive habitat types: High
      i. Participant confidence: High

Additional comments: The willow flycatcher needs meadows and surface water through July. It relies upon rare, water-dependent habitat experiencing extensive degradation due to alterations to hydrological cycles.

References: The willow flycatcher only occurs at elevations above the snowpack line, and requires wet meadows with willow stands (Harris et al. 1987 cited in Sanders and Flett 1989). Meadow desiccation appears to be the most important proximate factor in willow flycatcher decline in the Sierra Nevada (Green et al. 2003). Desiccation can result from reduced snowpack, as well as flashy runoff events that can increase incision and erosion in meadows (Viers et al. 2013). Drier meadows tend to be dominated by grasses rather than sedges, rushes and willow (Viers et al. 2013), and do not provide adequate habitat for willow flycatcher. Siegel et al. (2008) postulate that the extirpation of the willow flycatcher from meadows in Yosemite National Park may be in response to climate cycles leading to meadows drying out.

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4. **Life history.**
   a. Species reproductive strategy: In between r- and k-selection
      i. Participant confidence: High
   b. Species polycyclic, iteroparous, or semelparous: Iteroparous

Additional comments: The willow flycatcher has relatively low reproductive output due to its dependence on mid-elevation habitat, which limits the length of the nesting season and thus its nesting attempts during a season.

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5. Ecological relationships.

a. Sensitivity of species' ecological relationships to climate change including: Forage, habitat, hydrology, other – extreme events
b. Types of climate and climate-driven changes that affect these ecological relationships including: Temperature, precipitation
c. Sensitivity of species to other effects of climate change on its ecology: High
    i. Participant confidence: Moderate

Additional comments: 'Extreme events' include snowfall in summer and high winter and spring flows that result in stream channel incision and meadow desiccation.

References: The willow flycatcher is sensitive to extreme weather events, such as summer snowfall, as well as both droughts, and high winter and spring flows that can result in channel incision and meadow desiccation (Viers et al. 2013), which render the habitat unsuitable. As mentioned above, willow flycatchers are also sensitive to meadow desiccation, which results in a reduction of willow cover and standing water, leading to encroachment by conifers. Presence of conifers and lack of standing water may allow predators easier access to nests, leading to a principle cause in willow flycatcher population decline in the Sierra Nevada (Green et al. 2003).

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6. Disturbance regimes.

a. Disturbance regimes to which the species is sensitive include: Drought, flooding
b. Sensitivity of species to one or more disturbance regimes: High
    i. Participant confidence: High

Additional comments: Willow flycatcher requires saturated soils and, as stated above, any disturbance that results in stream isolation from floodplain (e.g., extreme flows) may render habitat unsuitable for this species. Drought that results in reduced soil moisture may kill water willows upon which flycatcher depend.

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7. Interacting non-climatic stressors.

a. Other stressors that make the species more sensitive include: Agriculture and aquaculture, human intrusions and disturbance, natural system modifications, invasive and other problematic species
b. Current degree to which stressors affect the species: High
    i. Participant confidence: High
c. Degree to which non-climate stressors make species more sensitive: High
    i. Participant confidence: Moderate

Additional comments: Non-climatic stressors include grazing, cowbird parasitism and predation, elevated predation risk (e.g., from small mammals) resulting from meadow desiccation and conifer encroachment, and direct human disturbances such as pack stations and development. This species appears extremely sensitive to even light grazing pressure, with ~90% of the Sierra population occurring in ungrazed meadows.

References: The willow flycatcher's sensitivity to non-climatic stressors may exacerbate its sensitivity to climate change (Mathewson et al. 2013). Flycatchers are sensitive to disturbances such as grazing during the breeding season from late June until mid-August (Taylor and Littlefield 1986; Sanders and Flett 1989). Cattle can upset nests in willow thickets directly, and adversely affect regeneration of woody vegetation (Crumpacker 1984 cited in Sanders and Flett 1989), compact soils, and accelerate streambank erosion and incision (Thomas et al. 1979, Platts 1984, and Ratliff 1984, cited in Sanders and Flett 1989), resulting in lowered water tables (Van Haveren and Jackson 1986 cited in Sanders and Flett 1989). Grazing may compound the incision and desiccation effects anticipated in Sierra Nevada meadows as a result of climate change, leading to habitat conversion to meadows dominated by grasses (Viers et al. 2013). Conversion may in turn facilitate predation (Cain et al. 2003; Green et al. 2003; Mathewson et al. 2013), and cowbird parasitism (Sanders and Flett 1989).

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8. **Other sensitivities.**
    a. Other critical sensitivities not addressed: Wintering habitat; disturbance to corridors
        i. Participant confidence: Moderate
    b. Collective degree these factors increase species' sensitivity to climate change: Moderate

Additional comments: It is not known to what extent loss or degradation of migration stopover or wintering habitat in Central America may affect this species.

References: Degradation and loss of wintering habitat in Central America may also play a role in species decline (Finch and Stoleson 2000).

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9. **Overall user ranking.**
    a. Overall sensitivity of this species to climate change: High
        i. Participant confidence: High

Adaptive Capacity

1. **Dispersal ability.**
   a. Maximum annual dispersal distance: 5-25 km (3.1-15.5 mi)
      i. Participant confidence: High
   b. Ability of species to disperse: Moderate
      i. Participant confidence: High
   c. General types of barriers to dispersal include: Other – distance from natal grounds
   d. Degree barriers affect dispersal for the species: Low
      i. Participant confidence: High
   e. Possibility for individuals to seek out refugia: Willow flycatcher exhibit high site fidelity, and most return to their natal meadows or nearby. However, compared to other species (e.g., amphibians) their ability to disperse is high as they have re-colonized restored meadows within 30 km (18.6 mi) of source populations in the Lassen region.

References identified by participants: Mathewson et al. 2013

References: Dispersal is fairly low given the willow flycatcher's high site fidelity, returning to natal or nearby meadows (Mathewson et al. 2013). However, willow flycatchers have been recorded in restored meadows within 30 km (18.6 mi) of natal populations in the Lassen region (Mathewson et al. 2013).

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2. **Plasticity.**
   a. Ability of species to modify physiology or behavior: Moderate
      i. Participant confidence: Moderate
   b. Description of species' ability to modify physiology or behavior: Willow flycatchers may regulate temperature in the nest by either shading young, or sitting on the nest to incubate once young are hatched. Other ways the species is able to modify its physiology or behavior includes reducing heat stress feathers and early initiation breeding, among others.

References: Willow flycatchers may modify behavior to regulate nest temperature, and can initiate breeding early in response to brief climatic variation, but overall they lack the plasticity to nest in other habitat types (Green et al. 2003).

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3. **Evolutionary potential.**
   a. Ability of species to adapt evolutionarily: Moderate
      i. Participant confidence: Moderate
   b. Description of characteristics that allow species to adapt evolutionarily: Multiple subspecies of willow flycatcher exist, however, the overall population is small and subspecies are isolated.

Additional comments: Willow flycatcher has relatively low reproductive output for a passerine bird due to dependence on higher elevations, which limit nesting attempts within a season. Also, existing stressors may reduce nesting success (e.g., higher predation resulting from sub-optimal habitat).

References: The willow flycatcher is thought to be one of the rarest birds in the Sierra Nevada, with surveys estimating fewer than 400 breeding individuals range-wide (Serena 1982, Harris et al. 1987, and Bombay 1999 cited in Mathewson et al. 2013), divided between isolated subspecies (Bombay et al. 2003; Mathewson et al. 2013).

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4. **Intraspecific diversity/life history.**
   a. Degree of diversity of species' life history strategies: Low

        i. Participant confidence: Moderate
  b. Description of diversity of life history strategies: None recorded

Additional comments: The willow flycatcher has limited habitat used for breeding.

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5. Management potential.

  a. Value level people ascribe to this species: Low
     i. Participant confidence: High
  b. Specificity of rules governing management of the species: High
     i. Participant confidence: High
  c. Description of use conflicts: Grazing reduces willow and herbaceous understory, both critical habitat components for this species. The species is also highly sensitive to meadow desiccation.
  d. Potential for managing or alleviating climate impacts: Restoration of meadow habitats is possible by improving floodplain function and thus increasing meadow wetness and density of willow and herbaceous cover. Alternative grazing management and cowbird management are also potential actions.

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6. Other adaptive capacity factors.

  a. Additional factors affecting adaptive capacity: None
     i. Participant confidence: Moderate
  b. Collective degree these factors affect the adaptive capacity of the species: Not applicable

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7. Overall user ranking.

  a. Overall adaptive capacity of the species: Low
     i. Participant confidence: Moderate

Additional comments: The ecological tolerance of willow flycatcher is low, as it is dependent on mid-elevation wet meadows with large area to edge ratios. These large meadows are rare at higher elevations and mid elevations may experience desiccation or convert to forb and grass dominated systems which are less suitable for this species.

Exposure

1. **Exposure factors[7].**
    a. Factors likely to be most relevant or important to consider for the species: Climatic water deficit, snowpack, shifts in vegetation type, high flows
        i. Participant confidence: Moderate (all)

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2. **Exposure region.**
    a. Exposure by region: North – Moderate-High; Central – Moderate-High; South – High
        i. Participant confidence: No answer provided by participants

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3. **Overall user ranking.**
    a. Overall exposure of the species to climate changes: High
        i. Participant confidence: Moderate

Additional comments: Willow flycatcher is one of the rarest birds in the Sierra Nevada with less than 400 breeding territories range-wide. They are also dependent on a rare habitat type that has been highly degraded. They are very sensitive to meadow desiccation and habitat suitability is incompatible with current livestock management practices employed in most meadows in the Sierra on public and private land. They have been extirpated from the southern Sierra and the majority of the population now occurs in the far northern Sierra and southern Cascades at elevations predicted to be below snowpack in 70 years. The most relevant elements of climate exposure to willow flycatcher are those that impact the distribution, structure, and function of wet meadows, including changes in dominant vegetation type, snowpack, climatic water deficit, and high flows.

References:
Snow volume and timing: Overall, April 1st snowpack in the Sierra Nevada, calculated as snow water equivalent (SWE), has seen a reduction of 11% in the last 30 years (Flint et al. 2013), as a consequence of earlier snowmelt (Cayan et al. 2001; Stewart et al. 2005; Hamlet et al. 2007), increased frequency of melt events (Mote et al. 2005), and increased rain:snow ratio (Knowles et al. 2006). However, trends in snowpack in the Sierra Nevada have displayed a high degree of interannual variability and spatial heterogeneity (Mote et al. 2005; Safford et al. 2012). SWE in the southern Sierra Nevada has actually increased during the last half-century, due to increases in precipitation (Mote et al. 2005; Mote 2006; Moser et al. 2009; Flint et al. 2013).

Despite modest projected changes in overall precipitation, models of the Sierra Nevada region largely project decreasing snowpack (Miller et al. 2003; Dettinger et al. 2004b; Hayhoe et al. 2004; Knowles and Cayan 2004; Maurer 2007; Young et al. 2009) and earlier timing of runoff center of mass (Miller et al. 2003; Knowles and Cayan 2004; Maurer 2007; Maurer et al. 2007; Young et al. 2009), as a consequence of early snowmelt events and a greater percentage of precipitation falling as rain rather than snow (Dettinger et al. 2004a, 2004b; Young et al. 2009; Null et al. 2010).-An increase in flashy precipitation events may lead to erosion of moist peat and topsoil due to flooding (Weixelman et al. 2011, Viers et al. 2013), as well as drying of meadows caused by channel incision (Viers et al. 2013).

Annual snowpack in the Sierra Nevada is projected to decrease between 64-87% by late century (2060-2079) (Thorne et al. 2012; Flint et al. 2013; Geos Institute 2013). Under scenarios of 2-6˚C warming,

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[7] Participants were asked to identify exposure factors most relevant or important to the species but were not asked to evaluate the degree to which the factor affects the species.

snowpack is projected to decline 10-25% at elevations above 3750 m (12303 ft), and 70-90% below 2000 m (6562 ft) (Young et al. 2009). Several models project greatest losses in snowmelt volume between 1750 m to 2750 m (5741 ft to 9022 ft) (Miller et al. 2003; Knowles and Cayan 2004; Maurer 2007; Young et al. 2009), because snowfall is comparatively light below that elevation, and above that elevation, snowpack is projected to be largely retained. The greatest declines in snowpack are anticipated for the northern Sierra Nevada (Safford et al. 2012), with the current patterns of snowpack retention in higher-elevation southern Sierra Nevada basins expected to continue through the end of the century (Maurer 2007).

Average fractions of total precipitation falling as rain in the Sierra Nevada can be expected to increase by approximately 10% under a scenario of 2.5˚C warming (Dettinger et al. 2004b). Increased rain:snow ratio and advanced timing of snowmelt initiation are expected to advance the runoff center of mass by 1-7 weeks by 2100 (Maurer 2007), although advances will likely be non-uniformly distributed in the Sierra Nevada (Young et al. 2009). Snow provides an important contribution to spring and summer soil moisture in the western U.S. (Sheffield et al. 2004), and earlier snowmelt can lead to an earlier, longer dry season (Westerling et al. 2006). A shift from snowfall to rainfall is also expected to result in flashier runoff with higher flow magnitudes, and may result in less water stored within watersheds, decreasing meal annual flow (Null et al. 2010). Mean annual flow is projected to decrease most substantially in the northern bioregion (Null et al. 2010).

Climatic water deficit: Increases in potential evapotranspiration will likely be the dominant influence in future hydrologic cycles in the Sierra Nevada, decreasing runoff even under forecasts of increased precipitation, and driving increased climatic water deficits (Thorne et al. 2012). Climatic water deficit, which combines the effects of temperature and rainfall to estimate site-specific soil moisture, is a function of actual evapotranspiration and potential evapotranspiration. In the Sierra Nevada, climatic water deficit has increased slightly (~4%) in the past 30 years compared with the 1951-1980 baseline (Flint et al. 2013). Future downscaled water deficit projections using the Basin Characterization Model (Thorne et al. 2012; Flint et al. 2013) and IPCC A2 emissions scenario predict increased water deficits (i.e., decreased soil moisture) by up to 44% in the northern Sierra Nevada, 38% in the central Sierra Nevada, and 33% in the southern Sierra Nevada (Geos Institute 2013).

More information on downscaled projected climate changes for the Sierra Nevada region is available in a separate report entitled *Future Climate, Wildfire, Hydrology, and Vegetation Projections for the Sierra Nevada, California: A climate change synthesis in support of the Vulnerability Assessment/Adaptation Strategy process* (Geos Institute 2013). Additional material on climate trends for the species may be found through the TACCIMO website (http://www.sgcp.ncsu.edu:8090/). Downscaled climate projections available through the Data Basin website (http://databasin.org/galleries/602b58f9bbd44dffb487a04a1c5c0f52).

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