Sierra Nevada Individual Species Vulnerability Assessment Briefing: Willow Flycatcher

Subspecies *Empidonax traillii* brewsteri *and E. t.* adastus*, and E. t.* extimus

Background and Key Terminology

This document summarizes the primary factors that influence the vulnerability of a focal resource to climate change over the next century. In this context, vulnerability is a function of the sensitivity of the resource to climate change, its anticipated exposure to those changes, and its capacity to adapt to changes. Specifically, sensitivity is defined as a measure of whether and how a resource is likely to be affected by a given change in climate, or factors driven by climate; exposure is defined as the degree of change in climate or climate-driven factors a resource is likely to experience; and adaptive capacity is defined as the ability of a resource to accommodate or cope with climate change impacts with minimal disruption (Glick et al. 2011). The purpose of this assessment is to inform forest planning by government, non-profit, and private sector partners in the Sierra Nevada region as they work to integrate climate change into their planning documents.

Executive Summary

The overall vulnerability of the willow flycatcher species is ranked as moderate-high, based on rankings of moderate-high sensitivity to climate and non-climate stressors, moderate adaptive capacity, and moderate-high exposure.

The willow flycatcher species is indirectly sensitive to climate-driven changes such as:

- reduced snowpack,
- decreased groundwater, and
- increased frequency of high flows.

Models predict shifts from snow to rain over the next century and a reduction in snowpack at elevations where the majority of willow flycatchers occur. The northern Sierra Nevada is expected to experience the greatest reduction in mean annual flow, likely contributing to meadow desiccation.

Willow flycatchers are also sensitive to non-climate stressors including:

- grazing, and
- cowbird parasitism.

These non-climate stressors lead to direct mortality, habitat reduction, and can amplify the effects of climate-driven changes. For example, grazing may compact soils and accelerate streambank erosion and incision, which may compound the desiccation effects anticipated in Sierra Nevada meadows as a result of climate change. The capacity of the willow flycatcher to adapt to changes in climate is limited by its small and isolated population, low dispersal ability, and low plasticity.

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Sensitivity & Exposure

Sensitivity to climate and climate-driven changes

Sensitivity of the willow flycatcher to climate and climate-driven changes will likely be driven by its reliance on large, open mid- and high-elevation wet meadows with large area-to-edge ratios. 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) that are multi-structural and provide tall herbaceous cover for nesting and foraging. 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. 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). High-elevation wet meadows are already rare, and desiccation and conversion of mid-elevation wet meadows would further decrease available habitat for willow flycatcher.

Future climate exposure

The climate and climate-driven changes most relevant to willow flycatcher are those that impact the distribution, structure and function of wet montane meadows. Although responses to climate will vary depending on meadow size, as well as geologic, edaphic and biological characteristics of the meadow (Viers et al. 2013), meadow are will likely be exposed to reductions in snowpack and groundwater, as well as increased high flows events.

Snow volume and timing: Despite modest projected changes in overall precipitation, models of the Sierra Nevada region largely project decreasing snowpack and earlier timing of runoff (Miller et al. 2003; Dettinger et al. 2004b; Hayhoe et al. 2004; 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, 2004 b; Young et al. 2009; Null et al. 2010). Annual snowpack in the Sierra Nevada is projected to decrease between 64-87% by late century (Thorne et al. 2012; Flint et al. 2013), with declines of 10-25% above 3750 m (12303 ft), and 70-90% below 2000 m (6562 ft) (Young et al. 2009). The greatest declines in snowpack are anticipated for the northern Sierra Nevada (Safford et al. 2012), with current pattern of snowpack retention in the higher-elevation southern Sierra

Nevada basins expected to continue through the end of the century (Maurer 2007). The greatest losses in snowmelt volume are projected 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), the elevation range within which with the majority of montane meadows (Viers et al. 2013) and willow flycatchers (Mathewson 2010) occur. Areas with willow flycatcher populations in the northern Sierra Nevada are predicted to be below snowpack in 70 years.

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). Mean annual flow is projected to decrease most substantially in the northern bioregion (Null et al. 2010).

Runoff: Frequency of extreme precipitation is expected to increase in the Sierra Nevada between 11-49% by 2049 and 18-55% by 2099 (Das et al. 2011). A shift from snowfall to rainfall is also expected to result in flashier runoff with higher flow magnitudes, which may lead to erosion of topsoil (Weixelman et al. 2011; Viers et al. 2013), channel incision, drying of meadows (Viers et al. 2013), and less water stored within watersheds. Decreased mean annual flow will result in part because a shift from snowfall to rainfall is expected to result in flashier runoff with higher flow magnitudes, resulting in less water stored within watersheds (Null et al. 2010). Mean annual flow is projected to decrease most substantially in the northern bioregion (Null et al. 2010; Viers et al. 2013), which will likely contribute to desiccation of meadows.

Climatic water deficit: 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. 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). 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 modeling using the Basin Characterization Model predicts increased water deficits (i.e., decreased soil moisture) by up to 44%, with the greatest increases in the northern Sierra Nevada (Thorne et al. 2012; Flint et al. 2013; 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 system 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).

Sensitivity to non-climate stressors

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).

Adaptive Capacity

The willow flycatcher may be limited in its capacity to adapt to future climate changes due to its limited extent and isolation, population status, low dispersal ability, and lack of plasticity. Flycatchers are found in meadows 1454 m to 2410 m (4770 ft to 7907 ft) in the Sierra Nevada (Mathewson 2010). They have been extirpated from the southern Sierra Nevada, and currently 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; Siegel et al. 2008; Mathewson et al. 2013). 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). Willow flycatchers exhibit high site fidelity, returning to natal or nearby meadows (Mathewson et al. 2013), and dispersal is low. Although the willow flycatcher can initiate early breeding in response to brief climatic variations, and may modify its behavior to regulate nest temperature, overall it lacks the plasticity to nest in other habitat types (Green et al. 2003). It also 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 (Mathewson 2010).

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