Climate Variable	Trend	Relative Change by 2100	Observed Change	Projected Change	Confidence & Uncertainty (trend direction, magnitude)
Air temperature[1-6]	↑	High	**All Islands** *Air temperature* > From 1975-2006, the rate of temperature increases accelerated to 0.29°F/decade (compared to 0.79°F/decade from 1919-2006), with largest increases in winter low temperatures > Since 1975, higher elevation sites (>800 m) warmed faster (0.49°F/decade) than low elevation sites (0.16°F/decade) **Maui** *Air temperature* > The number of annual freezing days on Haleakala declined from 1958-2009 *Evapotranspiration* > From 1988-2013, potential evapotranspiration increased by 3%-7% per decade	**All Islands** *Mean annual temperature* > By 2021-2050: increase of +1-2°F, > By 2041-2070: increase of +1-3°F > By 2070-2100: increase of +2-5°F (up to +6.1-6.3°F in higher elevations, +3.6-4.5°F in lower elevations *Heat waves* > Extreme heat days are expected to become more frequent and more intense	**High** > High certainty that temperatures will increase > The amount of increase is somewhat uncertain because global climate models have a wide range of possibilities for this region, and they amount of increase expected changes depending on which emissions scenario is used
Precipitation (amount and timing)[3,5-6,7-9]	↑↓	Low to High	**All Islands** > Since 1970, downward trend in winter precipitation since 1970 > From 1913-2008, downward trend in dry season (July-Sept) precipitation at high rainfall (>3000 mm) and moderate rainfall (800-3000 mm) > La Niña events historically correlated with higher precipitation while El Niño events have been correlated with lower precipitation, and correlations have been magnified by changes in PDO phase; in the last decade there has been a decoupling of these modes and precipitation patterns	**Maui** Multiple possibilities for precipitation differ in direction and magnitude of change: > Little to no change in precipitation by 2071-2099 (Keener et al. 2013) > Increased rainfall on windward slopes and decreased rainfall on leeward slopes of Maui and Lānaʻi by 2099, and increased rainfall on Kahoʻolawe (Hamilton 2013) > Moderate to large decrease in precipitation (Timm et al. 2015): > > By 2041-2071: -16 to -18% (wet season), -24% to -32% (dry season) > > By 2071-2099: -17% to -25% (wet season), -29% to -46% (dry season)	**Low** > Precipitation is highly variable depending on location > Studies have made very different predictions, disagreeing on both the direction and magnitude of change (e.g., whether precipitation will increase or decrease, and by how much) > Factors such as the emissions scenario and climate models chosen, study methodology, geographic region included, and data resolution all contribute to differences in precipitation projections > > Not all models consider large-scale climate variability (e.g., El Niño) and possible changes in

Climate Variable	Trend	Relative Change by 2100	Observed Change	Projected Change	Confidence & Uncertainty (trend direction, magnitude)
			Maui > From 1998-2013, dry season (May-Oct) precipitation has declined by 3-8% above 1000 m elevation, which the greatest reductions on windward slopes		the trade winds > > Models with low resolution may not account for steep island topography
Precipitation (extreme events)[5,10-16]	↑↓	Low to Medium	**All Islands** *Extreme precipitation events* > Decreased frequency of moderate- and high-intensity extreme events and increased frequency of low-intensity events in 1980-2011 (compared to 1950-1979) > Trends are likely caused by natural variability associated with El Niño/La Niña events *Tropical cyclones* > 1966-1981: Relatively low activity (mean of 1.88 cyclones/year) > 1982-1994: Increase of 3.45 cyclones/year compared to 1966-1981 (mean of 4.31 cyclones/year) > 1995-2000: Decrease of 2.22 cyclones/year compared to 1982-1994 **Maui** Extreme precipitation events > Since 1950, intensity and frequency of extreme events has decreased in recent years > Trend may be reversing direction with more frequency extreme precipitation events occurring in recent years, except for Lānaʻi where extreme events have continued to decrease slightly > From 1960-2009, annual maximum 1-day precipitation volume decreased	**All Islands** *Extreme precipitation events* At least two possibilities differ in direction and magnitude of change > Reduced frequency of extreme precipitation events by 2100, with greater reductions in dry areas *(Timm et al. 2011)* > Little change in the frequency of extreme precipitation events *(Takahashi et al. 2011)* *El Niño events* (by 2090) > Slight decrease in the number of El Niño events (compared to 1891-1990) > Extreme El Niño events twice as likely to occur (from one event every 20 years to one event every 10 years) > No change in spatial pattern of El Niño events *Tropical cyclones* > Increased frequency and strength of tropical cyclone activity around the Hawaiian Islands	**Low** > Climate models disagree about whether extreme events will become more or less frequent/severe, but most models predict a decrease in frequency and an increase in intensity > Changes may vary by location and the type of event (e.g., tropical cyclone, El Niño event, etc.) > Changes in the frequency/severity of extreme events are heavily impacted by topography, and will likely be impacted by changes in the trade winds > The frequency and severity of extreme precipitation events and tropical cyclones are highly variable, and are influenced strongly by natural climate variability (e.g., cycles of ENSO and PDO)

Climate Variable	Trend	Relative Change by 2100	Observed Change	Projected Change	Confidence & Uncertainty (trend direction, magnitude)
Drought[5,12,17]	↑	Medium	**All Islands** > Increased drought length in 1980-2011 (compared to 1950-1979) > Drought conditions are usually less prevalent during La Niña years, and more prevalent during El Niño years	**Maui** By 2080-2100: > Increased risk in low- and mid-elevation leeward areas > Decreased risk on the mid-elevation windward slopes of Haleakalā and the summit of Mauna Kahalawai > No change in risk in other areas **Lānaʻi and Kahoʻolawe** > Increased risk throughout both islands, with the exception of the summit of Lānaʻi (no change)	**Low** > Drought predictions are closely related to those for precipitation, which are very uncertain (see row above) > Few studies have projected drought risk, and background information is unavailable on the methodology for Keener et al. 2012 and Takahashi et al. 2011
Streamflow[7,18-19]	↓	Low to High	**All Islands** From 1943-2008 (compared to 1913-1943): > 22% decline in streamflow (19% wet season, 27% dry season) > 23% decline in baseflow (22% wet season, 27% dry season) > Increased high-flow variability (especially Jan-March) > Shift towards more days with low-flow conditions and fewer days with high-flow conditions > Jan-March streamflow is typically low following El Niño events, and high following La Niña events; this pattern is enhanced during positive PDO phases	**All Islands** No streamflow projections are available for the coming century. If mean annual rainfall decreases within a given watershed, it is likely that: > Low flows would become lower, and streamflow/baseflow would continue to decline > Flows would become more variable and more unstable ('flashy'), especially in wet years	**Low** > Streamflow is closely related to changes in both precipitation and temperature, but is also impacted by land cover and vegetation composition, substrate, groundwater withdrawals, and management practices > Increases in CO_2 could alter vegetation processes, all of which could also alter streamflow; these include evapotranspiration rates, leaf area, and stomatal conductance

Climate Variable	Trend	Relative Change by 2100	Observed Change	Projected Change	Confidence & Uncertainty (trend direction, magnitude)
Stream temperature[20-22]	↑	Unknown	**All Islands** > No information is available about stream temperature trends > Stream temperatures are lower in forested areas compared to urban areas > Stream temperatures are lower in the wet season than during the dry season	**All Islands** > No stream temperature projections for this region are available. **United States (mainland only)** > In the contiguous U.S., stream temperatures may increase by an average of 2°–5°C	**Low** > No regional studies have been published on the impacts of climate change on stream temperatures, but researchers generally agree that stream temperatures will increase as air temperature increases > Several studies have compared forested vs. urban sites and dry vs. wet seasons > Studies of temperate streams may not be generalizable to tropical streams
Sea level rise[23-30]	↑	High	**All Islands** *Extreme sea level events* > Extreme sea level events result from a combination of factors including long-term sea level rise, tides, and storms > Since 1920, extreme SLR events have increased from a frequency of every 20 years to every 5 years **Maui** *Sea level rise* > Kahului station from 1947-2015: Average increase of 2.04 mm/year (+/- 0.42) *Shoreline change* > Average long-term change was erosion at -0.17 m/year (+/-0.01), with 85% tending towards erosion and 14% towards accretion > Average short-term change was erosion at -0.15 m/year (+/-0.01), with 76% tending towards erosion and 18% towards accretion > 11% of beach length (7 km) was lost to erosion	**Global** Multiple sea level rise possibilities vary in magnitude, depending on which factors they take into account: > By 2100, sea level rise will likely rise between 0.75 and 1.9 m *(Vermeer and Rahmstorf 2009)* > Likely global sea level (90% probability, compared to 2000; *Kopp et al. 2014*) > > By 2030: 0.10-0.18 m (95% probability is 0.08-0.21 m) > > By 2050: 0.18-0.38 m (95% probability is 0.14-0.49 m) > > By 2100: 0.29-1.21 m (95% probability is 0.19-1.76 m) > A survey of global modeling studies (including the two studies above) estimates a range between 0.2 and 2.0 m *(Marra et al. 2012)* **Maui** *Shoreline change* By 2050 and 2100 (compared to 2005): > Baldwin: -11.2 ± 1.9 by 2050, -31.6 ± 3.2 by 2100 > Kaanapali: -10.2 ± 2.3 by 2050, -29.2 ± 3.6 by 2100 > North Kihei: -11.0 ± 3.2 by 2050, -29.0 ± 5.6 by 2100	**Moderate-High** > Although there is widespread agreement that sea level will rise, projections vary widely depending on whether or not they include large-scale climate variability (ENSO, PDO) and the contribution of ice-sheet collapse > It is difficult to predict how ice sheets will respond to increasing temperatures; models are unable to estimate large non-linear changes in ice sheets > The emissions scenario and climate models chosen also contribute to large differences among the available projections > Sea level rise measurements use various baselines, including Mean High Water, Mean Higher High Water, Mean Sea Level, and others > Tidal datums vary from island to island and there is no set standard for which to use and which time period to set as a reference > The Vermeer and Rahmstorf (2009) estimate given here (0.75-1.9 m) incorporates ice-sheet collapse and has been used in studies modeling coastal flooding in Maui

Climate Variable	Trend	Relative Change by 2100	Observed Change	Projected Change	Confidence & Uncertainty (trend direction, magnitude)
Coastal flooding & saltwater intrusion[5,29-37]	↑	High	**All Islands** *Coastal inundation* > Sea level rise has contributed to both marine inundation (flooding in areas with a direct hydrological connection to the ocean) and groundwater inundation (flooding in areas with an indirect hydrological connected due to elevated water tables) **Maui** *Saltwater intrusion* Waiehu Deep Monitor Well (north Maui) > From 1985-1999, the midpoint of the transition zone between freshwater and sea water rose 2.2 m/year (i.e., freshwater lens became shallower) Mähinahina Deep Monitor Well (west Maui) > No change in the midpoint of the transition zone over time	**All Islands** *Saltwater intrusion* There are no projections available for saltwater intrusion (see below for groundwater inundation) > Sea level rise will likely contribute to increased water salinity and higher water tables, especially during storms > Drought conditions also increase groundwater salinity > Increased human populations and associated water withdrawals will contribute to saltwater intrusion into groundwater sources **Maui** *Coastal inundation* Kahului: > At 0.75 m SLR, 0.55 sq. km inundated (land and building value of $18.7 m); saltwater intrusion would significantly impact the freshwater Kanaha Pond Wildlife Sanctuary > At 1.90 m SLR, 2.13 sq. km inundated (value of $296 m) Lahaina: > At 0.75 m SLR, 0.04 sq. km inundated (land and building value of $57.5 m) > At 1.90 m SLR, 0.37 sq. km inundated (value of $394 m) Kanaha Pond State Wildlife Sanctuary (Kahului in north Maui): > At 0.3 m (est. by 2057), 24.9% of total area inundated > At 0.74 m (est. by 2100), 25.3% of total area inundated (0.3% by marine inundation, 25% of area flooded by groundwater inundation) Keālia Pond National Wildlife Refuge (south Maui): > At 0.3 m (est. by 2057), 21.9% of total area inundated > At 0.74 m (est. by 2100), 28.2% of total area inundated (0.6% of total area flooded by marine inundation, 27.6% of area flooded by groundwater inundation)	**Moderate** > Because there are no downscaled sea level rise projections for this region, models of flooding/inundation use set amounts of sea level rise to determine the area flooded (rather than reporting the amount of change by 2050/2100 like many other studies do) > Cooper et al. (2012) based their coastal inundation models on SLR estimates by Vermeer and Rahmstorf (2009) > Kane et al. (2015) based their models on global SLR projections by Church et al. (2013), which do not take melting ice sheets into account > Saltwater intrusion is also impacted by recharge rates and groundwater pumping/withdrawals (withdrawals likely play a larger role in saltwater intrusion than does sea level rise)

Climate Variable	Trend	Relative Change by 2100	Observed Change	Projected Change	Confidence & Uncertainty (trend direction, magnitude)
Wildfire[38-39]	↑	Unknown	**All Islands** > Overall trend towards increases in area burned from 1904-2011, but with high interannual variability > Wildfire frequency in Hawaiian Islands is positively correlated with human activity and population growth (e.g., Lānaʻi has far few ignitions than Maui, due to low-density population)	**All Islands** > There are no wildfire projections available. > Wildfire will likely increase if drought events increase	**Low** > Wildfire is strongly correlated with dry conditions, and precipitation projections are highly uncertain > Increasing temperatures are likely to increase evapotranspiration, and may cause higher climatic water deficits even if precipitation increases slightly
Species distribution (forest birds - includes mosquito distributions related to avian malaria)[1,40-41]	↑↓	High	**All Islands** *Mosquito distribution* > Based on precipitation and temperature data from 1971-2000, mosquito habitat expands during increased rainfall years (e.g. La Niña years), with predominant expansions occurring in windward locations and small to moderate increases in habitat area in leeward locations > Mosquito habitat declines under drought conditions (e.g., El Niño years), with core habitat remaining in windward locations	**All Islands** Forest birds > By 2100, species richness is expected to decline, with 90% of modeled bird species likely losing >75% of their current range (due to increased temperatures and risk of avian malaria) > Small island endemic species are most vulnerable to climate-driven habitat loss **Maui** *Forest birds* > Over 90% range loss for the A'kohhekohe and Maui Parrotbill by 2100, and 75% range loss for the Maui `Alauahio Forest area at risk for avian malaria > By 2100, the area of forest at low-risk for malaria will decrease by 50% within the Hanawi Forest, due to range expansion of mosquitos > Lānaʻi and Kahoʻolawe do not receive enough precipitation to support mosquito habitat, and this is unlikely to change	**Moderate** > Mosquito expansion is heavily dependent on increasing temperatures (high certainty) and adequate precipitation (low certainty) > Modeled ranges vary depending on the emissions scenario chosen, and they may end up being smaller than presented in the Fortini et al. 2015 study > Forest bird distribution models did not incorporate potential habitat loss to urban or agricultural development > Additional factors that were not addressed in the models but may impact bird distributions include ecological interactions and non-climate stressors

Climate Variable	Trend	Relative Change by 2100	Observed Change	Projected Change	Confidence & Uncertainty (trend direction, magnitude)
Species distribution (native and invasive plants)[42-45]	↑↓	Medium to High	**Maui** *Native plant species* > The upper limit of cloud forests on Haleakala has shifted downslope during dry periods over the last 3000 years, in response to El Niño drought events and local moisture availability > Haleakala silversword population growth has decreased in response to drier conditions since 1990 (lower elevations) and 2000 (higher elevations) > Silversword mortality is highest and population declines started earliest at low-elevation areas within the plant's distribution	**Maui** *Native plant species* > Downslope contraction of cloud forest vegetation on Haleakala if rainfall decreases > Upslope movements may be possible if rainfall increases, but habitat gains would be modest compared to the losses associated with drought **All Islands** Native plant species (by 2100) > 39% average reduction in climatically suitable habitat for native plants > 15% of modeled species will likely have no overlap between current and future suitable habitat (i.e., will have to migrate to persist) > 5% of modeled species are projected to lose >99% of their current climate envelope (i.e., these species will "wink-out") > Most vulnerable species include: single island endemics, species with a conservation listing (e.g., endangered), coastal species, monocots, and dry forest-affiliates *Invasive plant species (by 2100)* > ~11% increase in land area suitable for invasion (12% increase in critical habitat areas) > Invadable habitat will increase greatly on the leeward slopes of Maui and Lānaʻi > All but 4 modeled species are projected to expand > Invasion risk increases at higher elevation locations	**Moderate** *Native plant species* > Modeled changes in plant distribution are dependent on the emissions scenario used, as well as additional factors that affect species distribution and survival, but which were not considered here (e.g., reductions in habitat quality/availability, adaptive capacity traits, disease risk, new invasions) > El Niño events can significantly affect vegetation distribution by altering patterns of precipitation and drought, but projected changes in these factors are poorly understood *Invasive plant species* > Models may under-represent invasive species distribution because the majority of the data was sourced from areas of conservation concern rather than from across the entire landscape > Climatic tolerances of individual species and how they may react to changes are not well-understood > On islands where invasive plants have only recently become established, populations have not reached an equilibrium with the environment and models may predict future distributions less accurately

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