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Metric	Study ID	Location	Reference	Study area	Location relative to cloud zone	Treatment	Objective	Approach/Method	Findings
Cloud-water interception	1	Lānaʻihale, Lānaʻi	Ekern (1964)	Site occupied by one non-native *Araucaria columnaris* (Cook pine).	Within	None	Quantify contribution of CWI to total precipitation input.	Measured RF and TF beneath one tree from 1955 to 1958.	CWI beneath *A. columnaris* constitutes 38% of total precipitation (CWI+RF).
	2	Lānaʻihale, Lānaʻi	Juvik and others (2011)	Three (3) sites selected along ridgeline for monitoring CWI of non-native *A. columnaris*.	Within	None	Quantify the contribution of CWI at different locations.	Measured RF, TF, and SF concurrently using tipping bucket rain gages and trough gages from December 2006 to August 2008.	CWI constitutes 59%, 64%, and 82% of total precipitation at the three sites. CWI rates exceed the rate in earlier study by Ekern (1964) due to better estimate of non-vertical RF contribution, increased height of *A. columnaris,* and more favorable atmospheric conditions along ridgeline.
	3	Auwahi & Waikamoi, Maui	Scholl and others (2007)	Waikamoi site dominated by native *Metrosideros polymorpha* (ʻōhiʻa) and *Acacia koa* (koa). Auwahi site comprised of remnants dominated by *Nestegis sandwicensis* (olopua) and *Dodonaea viscosa* (ʻaʻaliʻi), and grassland area dominated by non-native *Pennisetum clandestinum* (kikuyu grass).	Within	None	Quantify and compare sources of precipitation using stable isotopes.	Collected samples of RF and CWI and analyzed for stable isotopes. Used mixing model analysis to estimate contribution of CWI to total precipitation.	CWI constitutes 46% and 37% of total precipitation at Auwahi and Waikamoi forest sites, respectively. Estimate differs, in part, from follow-up study by Giambelluca and others (2011) because stable isotopes are a marker for precipitation and not droplet size, and rain and cloud water in locally generated clouds have similar isotopic composition.
	4	Auwahi & Waikamoi, Maui	Giambelluca and others (2011)	As above	Within	None	Quantify and compare CWI using canopy water balance and mechanical collectors.	Measured meteorologic parameters, TF using trough-type gages, and CWI using planar fog screens. Applied canopy water balance method to estimate CWI.	CWI constitutes 15% and 32% of total precipitation at Auwahi and Waikamoi forest sites, respectively. Planar fog screens were not useful for estimating CWI.
	5	Kona, Hawaiʻi	Brauman and others (2010)	Two (2) pairs of forest-pasture sites in similar climate zone. Pasture sites dominated by non-native *P. clandestinum*. Forest sites dominated by native ʻōhiʻa and understory tree fern *Cibotium glaucum* (hāpuʻu).	Within	None	Investigate effects of forest structure differences on net precipitation and CWI.	Measured RF and TF concurrently using tipping bucket rain gages and trough gages, and SF (qualitatively) with spiral-type collectors over 20-month period. Estimated net precipitation rates.	CWI constitutes 12% of total precipitation beneath the sparsely forested site and 27% beneath the densely forested site. Denser, taller forests increase canopy surface area and enhance rates of CWI. The denser forest structure is attributed to cattle exclusion and limited grazing.
	6	Hawaiʻi Volcanoes National Park, Hawaiʻi	Takahashi and others (2011)	Two study sites: one dominated by ʻōhiʻa and the other by non-native *Psidium cattleianum* (strawberry guava).	Within	None	Quantify and compare interception processes.	Measured RF, TF, SF, and meteorologic parameters concurrently using rain gages, and stationary troughs and tree collars for diverting TF and SF to collectors over 17-month period from June 2007 to October 2008. Applied canopy water-balance method to estimate CWI.	CWI constitutes 16% of total precipitation beneath *P. cattleianum* and 27% beneath ʻōhiʻa. Native ʻōhiʻa morphological characteristics may facilitate more effective harvesting of cloud-water droplets, enhancing CWI rates.
Net precipitation	2	Lānaʻihale, Lānaʻi	Juvik and others (2011)	Three (3) sites selected along ridgeline for monitoring CWI of non-native *A. columnaris*.	Within	None	Quantify net precipitation at different locations.	Measured RF, TF, and SF concurrently using tipping bucket and trough rain gages from December 2006 to August 2008.	SF rate was <1% of RF at all sites and not analyzed further. TF rate was 181-462% of RF among three sites.
	4	Auwahi & Waikamoi, Maui	Giambelluca and others (2011)	Waikamoi site dominated by native ʻōhiʻa and koa. Auwahi site comprised of remnants dominated by olopua and ʻaʻaliʻi, and grassland area dominated by non-native *P. clandestinum* .	Within	None	Quantify and compare net precipitation rates.	Measured meteorologic parameters, TF using trough-type gages.	TF rate was 87% of RF at Auwahi and 122% at Waikamoi site. 74% of CWI becomes TF at Auwahi and 83% of CWI becomes TF at Waikamoi.

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Net Precipitation	5	Kona, Hawai'i	Brauman and others (2010)	Two (2) pairs of forest-pasture sites in similar climate zone. Pasture sites dominated by non-native *P. clandestinum*. Forest sites dominated by native 'ōhi'a and understory tree fern hāpu'u.	Within	None	Investigate effects of forest structure differences on net precipitation.	Measured RF and TF concurrently using tipping bucket rain gages and trough gages, and SF (qualitatively) with spiral-type collectors over 20-month period. Estimated net precipitation rates.	TF was 113% of RF at densely-forested site and 64% at sparsely-forested site. Contributing factors to higher TF rate include differences in forest structure that enhance CWI. Thinning of understory at sparsely-forested site due to cattle grazing.
	6	Hawai'i Volcanoes National Park, Hawai'i	Takahashi and others (2011)	Two study sites: one dominated by 'ōhi'a and the other by non-native *P. cattleianum*.	Within	None	Quantify and compare interception processes.	Measured RF, TF, SF, and meteorologic parameters concurrently using rain gages, and stationary troughs and tree collars for diverting SF to collectors over 17-month period from June 2007 to October 2008.	Net precipitation rate was 110% of RF at *P. cattleianum* site and 123% of RF at 'ōhi'a site. SF rate of 29% of RF reported at *P. cattleianum* site.
	7	Honouliuli, O'ahu	Gaskill (2004)	Four plot sites dominated by *Casuarina glauca* (longleaf ironwood), *Fraxinus uhdei* (tropical ash), *Eucalyptus robusta* (swamp mahogany), and *Grevillea robusta* (silk oak).	Below	None	Quantify and compare net precipitation rates among non-native forest stands.	Monitored RF, TF, and SF from October 1998 to April 2002.	Net precipitation rates during 1999 were 80-86% of RF for *E. robusta*, 82-85% for *C. glauca*, 79-95% for *F. uhdei*, and 71-88% for *G. robusta*. No significant differences reported among 4 species.
	8	Hawai'i Volcanoes National Park, Hawai'i	Mudd and Giambelluca (2006)	Two study sites comprising one native forest and one *P. cattleianum*-invaded forest.	Within	None	Quantify and compare water retention capacity of epiphytes among native and non-native forest stands.	Samples of epiphytic mosses, leafy liverworts, and filmy ferns analyzed in the laboratory for water-retention capacity.	Average epiphyte water-retention capacity at the native and *P. cattleianum*-invaded sites were 1.45 and 0.68 mm, respectively. The lower capacity in the *P. cattleianum*-invaded stand is attributed to the smooth stem surface of *P. cattleianum* being unable to support a significant epiphytic layer.
	9	Mākaha, O'ahu	Suzuki (2006)	Six plot sites dominated by native 'ōhi'a, koa, *Diospyros sandwicensis* (lama), and non-native *P. cattleianum*, *Schinus terebinthifolius* (Christmas berry), and *Coffea arabica* (Arabica coffee).	Below	None	Quantify and compare PAI, LAD, and NPVAD among dominant native and non-native species.	Measured PAI, LAD, and NPVAD using a plant canopy analyzer, and direct measurements of leaf and stem angles using an inclinometer.	Mean PAI for non-native tree species was 4.07-4.29, while mean PAI for native tree species was 3.15-3.53. Mean LAD in the non-native species (21–22°) was less than the native tree species (34–70°). Results for PAI and LAD imply greater interception loss rate potential (or lower net precipitation rate potential) for the three non-native species. The highest mean NPVAD was found in *P. cattleianum* (53°), which implies greater potential for increased partitioning of intercepted rainfall into stemflow.
	10	Mākaha, O'ahu	Mair and Fares (2010)	Three non-native forest stands dominated by *S. terebinthifolius*, *C. arabica*, and *P. cattleianum*.	Below	None	Quantify and compare TF rates among non-native forest stands.	Measured RF and TF using trough gages concurrently over 18-23 month period during September 2006 to August 2008.	Annual TF rates of 45%, 60%, and 62% of RF in stands dominated by *P. cattleianum*, *C. arabica*, and *S. terebinthifolius*, respectively. Significant differences in TF rate among 3 stands for medium and high-intensity RF events. TF rate implies low net precipitation rate for *P. cattleianum* among 3 non-native species; however, contribution of SF not considered. See follow-up study by Safeeq and Fares (2014).

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Net Precipitation	11	Mākaha, O‘ahu	Safeeq and Fares (2014)	As above	Below	None	Quantify and compare net precipitation rates among non-native forest stands.	Measured RF, TF, and SF concurrently using tipping bucket rain gages, stationary trough gages, and collars that divert SF to collectors over 10-month period during October 2009 to August 2010.	Net precipitation rates of 77%, 56%, and 60% of RF in stands dominated by *P. cattleianum*, *C. arabica*, and *S. terebinthifolius*, respectively. SF rate of 34% of RF at *P. cattleianum* site, which had highest net precipitation rate among 3 sites.
	12	Laupāhoehoe wet forest, Hawai‘i	Strauch and others (2016)	Three *P. cattleianum*-invaded forest sites and three native forest sites dominated by ‘ōhi‘a, koa, hāpu‘u, *Cheirodendron trigynum* (‘ōlapa), *Coprosma ochracea* (pilo), and *Ilex anomala* (kāwa‘u).	Within	Each site consisted of one fenced plot (pig exclosure) and one unfenced plot established in June 2012.	Quantify and compare TF rates among invaded and native forest sites, and fenced and unfenced plots.	Measured TF using standard all-weather rain gages, three gages per plot, during 16 events from November 2012 to April 2014. RF measured by Laupāhoehoe climate tower.	Mean TF rate was 102% of RF in *P. cattleianum*-invaded forest stands and 78% in the native forest stands.
Infiltration/Soil Properties	13	State of Hawai‘i	Yamamoto and Duffy (1963)	Total of 34 sites encompassing 25 different soil types and four types of land cover including forests, cultivated land, pastureland, and idle grassland.	Below	None	Quantify the water-storage capacities of surface soils under different land covers.	Measured water-storage capacity in surface soils at 34 sites.	Forest soils have the greatest total water storage capacity: 13% more than pasture soils, 12% more than cultivated soils, and 10% more than idle-grassland soils. Authors conclude greater water storage capacity implies higher rates of infiltration.
	14	O‘ahu	Wood (1971)	Six paired sites overlain with six different soils. Each pair comprised of an ungrazed forest site with one dominant tree species, and an adjacent pineapple, sugarcane, or pasture site. Dominant forest species include *G. robusta*, *E. robusta*, *Acacia confusa* (Formosan koa), and *Casuarina equisetifolia* (common ironwood).	Below	None	Quantify the effect of different land uses on the hydrologic characteristics of some O‘ahu soils.	Measured field infiltration rate at each land use pair (ungrazed forest vs. pasture/pineapple/sugarcane) and determined laboratory K_{fs} from undisturbed soil cores collected from four depths.	Infiltration rates were much larger for forested land covers than pasture/pineapple/sugarcane land covers at 5 of 6 sites. Mean K_{fs} in forested land covers were higher than in pasture/pineapple/sugarcane land covers. Livestock grazing is detrimental to maximizing infiltration rates.
	15	Kahana Valley, O‘ahu	Wirawan (1978)	Four study sites with five paired plots comprised of non-native grass *Andropogon virginicus* (broomsedge), and non-native trees *Schefflera actinophylla* (octopus tree), and *Syzygium cumini* (Java plum). Dominant native forest species include *Dicranopteris linearis* (uluhe), *Pandanus tectorius* (hala), and koa.	Below	None	Quantify and compare infiltration rates for different forest species.	Measured infiltration rates using a double-ring infiltrometer. A total of four to eight replicate tests were conducted at each plot site.	Infiltration rates were higher for plots of non-native *S. actinophylla* and *S. Cumini* than non-native *A. virginicus*. Infiltration rates in two paired plots (each pair consisting of an uluhe plot and a koa/hala mixed forest plot) were higher for uluhe in one pair and higher for koa/hala in the other. The lowest and highest mean infiltration rates were reported for *A. virginicus* (0.31 mm/min) and uluhe (40.64 mm/min), respectively.
	16 & 17	Kaho‘olawe	Giambelluca and Loague (1992); Loague and others (1996)	Island of Kaho‘olawe	Below	None	Quantify the spatial variability in near-surface soil hydraulic properties.	Measured K_{fs} and sorptivity at 110 sites distributed among 3 land-cover classes including exposed soil, shrubs and trees, and grass.	Mean K_{fs} in exposed soil was slightly higher than that of vegetated surfaces. Harmonic and geometric mean K_{fs}, and median K_{fs} were slightly higher for vegetated surfaces. The range in K_{fs} was much greater for exposed soil than for the vegetated land covers. Mean sorptivity among 3 land-cover classes was very similar.

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Infiltration/Soil Properties	18	Kaho‘olawe	Ziegler and Giambelluca (1998)	Multiple study sites representing three land-cover conditions: (1) bare soil, (2) bare soil that had been tilled or fitted with an erosion-control system, and (3) revegetated areas.	Below	Native and non-native plants planted in 3 restoration areas during 1985-1991. A fourth restoration area planted with mostly Tamarisk (*Tamarix aphylla*).	Quantify the effects of restoration on soil hydrological and physical properties.	Estimated K_{fs} and sorptivity using disk permeameter infiltration measurements collected during May-September 1996 in areas representing three land-cover conditions: (1) bare soil, (2) bare soil that had been tilled or fitted with an erosion-control system, and (3) revegetated areas.	Mean K_{fs} in revegetated areas was 3-5 times higher than that of bare soil and bare soil that had been tilled or fitted with an erosion-control system. Mean sorptivity in revegetated areas was slightly higher than that of bare soil and treated bare soil.
	19	Mākaha, O‘ahu	Verger (2008)	Portion of upper Mākaha valley watershed dominated by *S. terebinthifolius*, *C. arabica*, *S. cumini*, and *P. cattleianum*.	Below	None	Quantify the spatial variability of near-surface soil hydraulic properties.	Measured K_{fs} and determined soil physical properties at 54 sites from November 2007 to January 2008.	Differences in mean K_{fs} were not quantified by land cover. However, statistically significant differences in mean K_{fs} and mean porosity were reported based on topography. The highest mean K_{fs} and mean porosity were reported in gulch areas and the lowest in areas adjacent to the stream.
	20	Auwahi, Maui	Perkins and others (2012)	Restored dryland forest dominated by *Nestegis sandwicensis* (olopua) and *Dodonaea viscosa* (‘a‘ali‘i), and adjacent grassland area dominated by non-native *P. clandestinum*.	Within	Exclosure fencing built in 1997 around 10-acre tract. *P. clandestinum* eliminated with herbicides and replanted with native trees, shrubs, vines, and grasses.	Quantify and compare near-surface soil hydraulic properties.	Measured K_{fs}, hydrophobicity, and flow preferentiality in restored forest and adjacent grassland.	Mean K_{fs} in restored forest was double that of adjacent rangeland; hydrophobicity and preferential flow patterns were higher in restored forest sites. These changes act to distribute infiltrated water faster and deeper.
	21	Auwahi, Maui	Perkins and others (2014)	As above.	Within	As above.	Compare rates of infiltration with depth.	Experimentally irrigated 8 plots and measured soil moisture and temperature responses up to depth of 1 m at 8 plots in the restored forest and adjacent grassland areas.	Infiltrated water in reforested sites moved to depth faster with larger magnitude changes in soil water content. Median first arrival velocity of water was greater by factor of 13 in reforested sites.
	44	Hilo, Hawai‘i	Michaud and others (2015)	Four pairs of 10 m × 10 m plots dominated by native ‘ōhi‘a and *Diospyros sandwicensis* (lama), and non-native *Cecropia obtusifolia* (trumpet-tree), *Macaranga mappa* (bingabing), *Melastoma septemnervium* (melastoma), and *P. cattleianum*.	Below	All non-native species were removed mechanically from the removal plots during April-June 2004 leaving only native species.	Quantify effects of removal of invasive tree species on soil water potential, vapor pressure deficit, and interception loss during mild drought.	Measured air temperature, humidity, soil water potential, and throughfall in each plot from July 2004 to August 2005.	Soil water potential measurements indicate partial soil drying in control plots, but not removal plots, during droughts with recurrence intervals of 2 to 3 years. Authors concluded that transpiration and rainfall interception in the dense canopy of non-native species were most likely responsible for drier conditions in control plots.
	45	Ko‘olau Mountains, Island of O‘ahu	Enoki and Drake (2017)	Six study sites of paired native/non-native plots with overstory dominated by non-native *P. cattleianum* (non-native plots) and ‘ōhi‘a, koa, *Leptecophylla tameiameiae* (pūkiawe) and ‘a‘ali‘i (native plots). Understory in native plots dominated by uluhe, *Cinnamomum burmannii*, *Clidemia hirta*, or *Hibiscus arnottianus*.	Below	None	Evaluate the effects of non-native *P. cattleianum* on soil properties.	Measured litter mass, soil pH, soil water content, and litter decomposition rates in each plot. Litter decomposition rates were measured using a Tea Bag Index (TBI) approach.	Accumulated litter mass and soil pH decreased with rainfall in native plots, whereas invasion by *P. cattleianum* increased the amount of litter and reduced differences in soil water content and soil pH. *P. cattleianum* increased (1) initial litter decomposition rate, and (2) long-term litter stabilization factor of the TBI at wetter sites. Conclusions suggest the accumulation of litter was likely caused by indirect effects of *P. cattleianum* through the alteration of soil-moisture properties.

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Infiltration/Soil Properties	46	State of Hawai‘i	Perkins and others (2018)	Multiple study sites on five islands representing three broad land-cover conditions: (1) grasses, (2) trees and shrubs, and (3) bare soil.	Below and within	None	Compare near-surface soil hydraulic properties.	Compiled K_{fs} measurements from study sites on five islands and collected from 1979 to 2018.	Geometric mean values of K_{fs} are 203 mm/hr for soils hosting trees and shrubs, 50 mm/hr for grasses, and 13 mm/hr for bare soil. Differences in mean K_{fs} are statistically significant at the 95% confidence level.
	49	Islands of Kaua‘i and Hawai‘i	Fortini and others (2020)	Total of 39 study sites on the islands of Kaua‘i and Hawai‘i with paired plots for comparing two types of forest management treatments: (1) native versus non-native forests, and (2) fenced versus unfenced forests.	Within	None	Explore how vegetation and soil characteristics affect infiltration capacity across mesic and wet forest communities and along a 4 million years substrate age gradient.	Measured K_{fs} and additional measurements related to soil, vegetation, and weather conditions collected in each plot for use in determining potential explanatory variables related to K_{fs}. Conducted statistical regression analyses to identify significant explanatory variables.	Ungulate damage is negatively associated with K_{fs} across moisture and substrate age gradients. The following selected features were positively associated with K_{fs}: (1) increased forest canopy, understory and floor vegetative cover, (2) greater presence of large roots, and (3) lower grass and bare soil covers. Authors note that percent cover of ‘ōhi‘a and *H. gardnerianum* was positively correlated with K_{fs}.
Direct runoff & streamflow	12	Laupāhoehoe wet forest, Hawai‘i	Strauch and others (2016)	Three *P. cattleianum*-invaded forest sites and three native forest sites dominated by ‘ōhi‘a, koa, hāpu‘u, ‘ōlapa, pilo, and kāwa‘u.	Within	Each site consisted of one fenced plot (pig exclosure) and one unfenced plot established in June 2012.	Quantify and compare runoff volumes and rates among invaded and native forest sites, and fenced and unfenced plots.	Runoff plots were established within each fenced and unfenced plot. Runoff from each plot was funneled into buckets for measuring runoff volumes during 16 events from November 2012 to April 2014.	Runoff volumes in native forest plots were significantly higher than *P-cattleianum*-invaded plots. Runoff rates as a percentage of TF were not significantly different among invaded and native forest sites, and fenced and unfenced plots.
	18	Kaho‘olawe	Ziegler and Giambelluca (1998)	Multiple study sites representing three land-cover conditions: (1) bare soil, (2) bare soil that had been tilled or fitted with an erosion-control system, and (3) revegetated areas.	Below	Native and non-native plants planted in 3 restoration project areas during 1985-1991. A fourth restoration area planted with mostly *T. aphylla*.	Quantify the effects of restoration on Hortonian overland flow development. Hortonian overland flow occurs when the rainfall intensity exceeds the infiltration capacity of a soil.	Estimated the steady-state infiltration capacity for three land-cover conditions: (1) bare soil, (2) bare soil that had been tilled or fitted with an erosion-control system, and (3) revegetated areas. Measured one-minute rainfall intensity from March 1994 to May 1995, and during March-October 1996. Compared measured rainfall intensities with estimated infiltration capacity for each land-cover condition.	The estimated steady-state infiltration capacities of bare soil and treated bare soil were exceeded by 14% and 5% of the non-zero one-minute rainfall values, respectively. The estimated infiltration capacity of revegetated areas was never exceeded by the one-minute rainfall values. Results imply that the measured rainfall intensities have greater potential to induce Hortonian overland flow in bare soil and treated bare soil, than in revegetated areas.
	22	Kaukonahua, O‘ahu	Anderson and others (1966)	Paired watershed study: one dominated by native uluhe and the other by non-native *Syncarpia glomulifera* (turpentine tree), several species of Eucalyptus (species not specified), and rubber trees.	Below	Uluhe watershed was burned during August-September 1953 and replanted with *Lophostemon confertus* (Brushbox) and *Eucalyptus pilularis* (Blackbutt eucalyptus) by March 1954.	Quantify and compare streamflow discharge in response to vegetation change.	Monitored streamflow and RF at both sites for 4 years from January 1951 to June 1955. In the analysis, a total of 36 storms were selected for the non-native tree watershed and 39 storms for the uluhe watershed during the pre-fire period. For the post-fire period, a total of 43 storms were selected for each watershed.	Runoff rate as a percentage of RF in the watershed dominated by native uluhe decreased from 28% to 25% following burn treatment. Runoff rate in the watershed dominated by non-native trees increased from 10% in the pre-fire period to 13% in the post-fire period.
	23	Mānoa, O‘ahu	Dunkell and others (2011)	Seven pairs of 10 m × 5 m forested fenced and unfenced plots dominated by multiple non-native species.	Below	Pig exclosure fencing built during June-July 2007.	Determine whether feral pig exclusion influences runoff volume and total suspended solids (TSS).	Monitored runoff volume and TSS from runoff plots (1.2 m x 4.2 m) installed in each fenced and unfenced plot during 11 storm events during June 2008 to April 2009.	Mean runoff volumes indicated (1) lower runoff volumes in the fenced plots of 3 pairs, (2) similar runoff volumes in the fenced plots of 3 pairs, and (3) higher runoff volume in the fenced plot of the remaining pair.

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Direct runoff & streamflow	24 & 25	Hilo and Volcano, Hawai‘i	Giambelluca and others (2009); Nanko and others (2015)	Seven sites dominated by ‘ōhi‘a, *Miconia calvescens* (miconia), *Morella faya* (faya), and mixtures of other species for measuring light transmission ratio. Three sites dominated by ‘ōhi‘a and miconia for measuring ambient rainfall, throughfall, and raindrop kinetic energy.	Below (rainfall, throughfall); Below and within (light transmission)	None	Verify relation between miconia invasion and accelerated erosion in Hawai‘i.	Measured canopy light transmission and throughfall drop characteristics for comparing stands of miconia and ‘ōhi‘a, and open areas. Light transmission was measured using a ceptometer. Rainfall drop-size diameter and velocity were measured using laser disdrometers during December 18-22, 2007.	Throughfall kinetic energy beneath miconia was significantly higher than ambient rainfall and throughfall energy beneath ‘ōhi‘a. Median throughfall drop size for miconia was twice that of ambient rainfall. Highly erosive throughfall beneath a stand of single-story miconia resulted from large drops forming on miconia leaves with relatively high fall velocities. The results imply that erosive throughfall beneath stands of miconia increases soil erosion and decreases infiltration capacity, which may in turn enhance runoff.
Evapo-transpiration	7	Honouliuli, O‘ahu	Gaskill (2004)	Four plot sites dominated by *C. glauca*, *F. uhdei*, *E. robusta*, and *G. robusta*.	Below	None	Quantify and compare ET rates among four non-native species.	Measured tree sapwood area and monitored sap flux, soil moisture, and leaf area index in three species (*C. glauca*, *F. uhdei*, *E. robusta*) from June 2000 to March 2002.	ET rates were 90, 94, and 65% of RF for *F. uhdei*, *E. robusta*, and *C. glauca*, respectively.
	15	Kahana Valley, O‘ahu	Wirawan (1978)	One study site comprised of three plots dominated by non-native grass *A. virginicus*, and native uluhe, hala, and koa.	Below	None	Quantify and compare actual ET rates from three different plant types (grass, fern, and tree).	Measured pan evaporation from August to October 1974. Measured soil-water content from samples collected every two weeks. Estimated actual ET rates using a water-balance approach.	Estimated actual ET rates were 81%, 93%, and 96% of potential ET in plots dominated by uluhe, koa/hala, and *A. virginicus*, respectively.
	26	Waikāne, O‘ahu	Mueller-Dombois (1972)	Two sites with one comprised of non-native grass *A. virginicus* and the other of non-native evergreen *S. cumini* and *Mangifera indica* (mango).	Below	None	Quantify and compare the water-loss rates in leaves from one grass and two tree species.	Hourly rates of water loss were measured in green tree leaves and grass blades after cutting using short-period weighing method in October 1970 and October 1971. Daily water-loss rates were measured in leaves from *S. cumini* and blades from *A. virginicus* in February 1972.	Hourly leaf water-loss rates in *M. indica* were 3-18 times higher than *A. virginicus*. Measured daily and estimated monthly leaf water-loss rates in *S. cumini* were 7.8-9.6 times higher than *A. virginicus*. Author notes that results imply *S. cumini* and *M. indica* utilize most of the available soil water in root zone and that more direct runoff is expected in areas covered with *A. virginicus*.
	27	Waikamoi, Maui	Santiago and others (2000)	Six 10 × 10 m plots divided into three pairs according to slope angles: (1) level, poorly drained sites dominated by ‘ōhi‘a with understory dominated by *Carex alligata* (Hawai‘i sedge), and (2) moderately sloped sites dominated by ‘ōhi‘a and an open sub-canopy shrub and tree fern layer.	Within	None	Quantify and compare the effects of waterlogged soils on whole-tree and stand-level transpiration rates of ‘ōhi‘a.	Measured tree sapwood area and monitored sap flux using heat-dissipation probes from September 1996 to February 1997, and estimated whole-tree and stand-level transpiration rates.	Whole-tree water use in ‘ōhi‘a was lower at level, poorly drained sites and strongly correlated with leaf area. Stand-level water use was 79-89% of potential ET for sloped sites and 28-51% of potential ET for level, poorly drained sites.
	28	Hawai‘i Volcanoes National Park, Hawai‘i	Giambelluca and others (2007)	Two study sites dominated by ‘ōhi‘a and *P. cattleianum*.	Within	None	Quantify and compare stand-level ET rates	Measured sapflow, energy balance, TF, SF, and soil moisture.	ET as a function of available energy was 27% higher at the invaded site than the native site. During dry canopy periods, ET at the invaded site was 53% higher than that of the native site.
	29	Hawai‘i Volcanoes National Park, Hawai‘i	Giambelluca and others (2008)	As above	Within	None	Explore mechanisms of observed higher ET rate at invaded site	Measured tree basal area, cross-sectional xylem and heartwood areas, and stem diameter.	Non-native *P. cattleianum* has much lower stem diameters, on average, with little or no heartwood. However, cross-sectional xylem area is much greater facilitating higher transpiration rates.

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Metric	Study ID	Location	Reference	Study area	Location relative to cloud zone	Treatment	Objective	Approach/Method	Findings
Evapo-transpiration	30	Kahauloa & Hōnaunau, Hawai‘i	Kagawa and others (2009)	Three study sites 5 km apart each dominated by native ‘ōhi‘a and hāpu‘u, *Eucalyptus saligna* (Sydney bluegum), and *F. uhdei*.	Within	None	Quantify and compare the whole-tree and stand-level transpiration rates for the selected tree species.	Measured tree sapwood area and monitored sap flux using heat-dissipation probes during August-September 2006, and estimated whole-tree and stand-level transpiration rates.	Whole-tree water use in *E. saligna* and *F. uhdei* was more than three times higher than ‘ōhi‘a. Stand-level water use in ‘ōhi‘a was the lowest among the three species. Stand-level water use in *F. uhdei* was more than twice as much as *E. saligna* and ‘ōhi‘a. Native understory tree fern hāpu‘u accounted for 70% of water use in the ‘ōhi‘a forest.
	31	Kona, Hawai‘i	Brauman and others (2012b)	Two (2) pasture and 2 forest sites in similar climate zone. Pasture sites dominated by non-native *P. clandestinum*. Forest sites dominated by native ‘ōhi‘a and hāpu‘u.	Within	None	Investigate effects of vegetation differences on potential ET.	Collected concurrent meteorological and vegetation measurements over 18-month period. Estimated potential ET at each site.	Overall potential ET at forest sites was less than pasture sites because of interaction of aerodynamic and stomatal control on potential ET, in conjunction with low wind speeds and low vapor-pressure deficits.
	32	Hilo, Hawai‘i	Cavaleri and others (2014)	Four pairs of 10 m × 10 m plots dominated by native ‘ōhi‘a and *Diospyros sandwicensis* (lama), and non-native *Cecropia obtusifolia* (trumpet-tree), *Macaranga mappa* (bingabing), *Melastoma septemnervium* (melastoma), and *P. cattleianum*.	Below	All non-native species were removed mechanically from the removal plots during April-June 2004 leaving only native species.	Quantify effects of removal of invasive tree species on remaining whole-tree and stand-level transpiration rates.	Measured tree sapwood area and monitored sap flux of one native (‘ōhi‘a) and three non-native species (*C. obtusifolia*, *M. mappa*, *M. septemnervium*) using heat-dissipation probes for 10 months during February-November 2008. Estimated whole-tree and stand-level transpiration rates.	Native ‘ōhi‘a had the lowest sap-flow rates per unit sapwood, and stand-level water use in removal plots was half that of the invaded plots.
	33	Kīlauea, Hawai‘i	DeLay (2015)	Two study sites at Nāhuku and Ola‘a: one dominated by ‘ōhi‘a and the other by *P. cattleianum*. Six additional plot sites at Keauohana and Nānāwale Forest Reserves.	Below and within	None	Assess the effect of *P. cattleianum* invasion on stand-level transpiration rates. Quantify transpiration rates of native fern hapu‘u.	Monitored sap flux using heat-dissipation probes from June 2006 to January 2009, and estimated whole-tree and stand-level transpiration rates. Estimated tree transpiration at plots with varying *P. cattleianum* density.	Native hapu‘u was 8% and 25% of stand transpiration at the Nāhuku (native) and Ola‘a (invaded) sites, respectively. Stand-level transpiration as a fraction of potential ET was significantly higher at the invaded site relative to the native site. Modeled tree transpiration increased by 20% when ‘ōhi‘a forest was converted to *P. cattleianum* with same basal area.
	50	Kīholo, Hawai‘i	Dudley and others (2020)	Multiple transects and plots dominated by the non-native *Prosopis pallida* and located along the coastline within Kīholo State Park.	Below	None	Understand the spatial patterns of transpiration rates in phreatophytic plant communities.	First, used airborne high-resolution LiDAR (Light Detection and Ranging) to generate spatially explicit and contiguous information. Next, developed regression relations between LiDAR metrics (i.e., ground elevation and tree canopy height) and plot-scale stable isotope measurements of vegetation stem water to assess groundwater use and transpiration rates. Finally, used electrical resistivity imaging to assess subsurface geology and hydrology and their relations to *P. pallida* stand structure.	*P. pallida* cannot access groundwater above a threshold ground elevation of about 15 m above sea level without declines in tree biomass and height. Transpiration modelled across the study area was 0.034 ± 0.017 mm/day, but over 98% of transpiration came from areas where groundwater depths were less than 15 m.

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Water budget & watershed models: net precipitation, groundwater recharge, ET, direct runoff, streamflow.	7	Honouliuli, O‘ahu	Gaskill (2004)	Four plot sites dominated by *C. glauca*, *F. uhdei*, *E. robusta*, and *G. robusta*.	Below	None	Quantify and compare recharge rates among four non-native species.	Estimated recharge from May 2001 to April 2002 using water balance model.	No observed recharge during period of study. Selected species not ideal for restoring and protecting groundwater resources.
	17	Kaho‘olawe	Loague and others (1996)	Island of Kaho‘olawe.	Below	None	Simulate overland flow variability among 70 catchments to identify areas vulnerable to erosion.	Used rainfall-runoff model to estimate direct runoff for 10 rainfall events between February 1966 and September 1972 in each of the 70 catchments.	Total estimated direct runoff volume was greatest in catchments dominated by exposed soil and least in catchments dominated by shrubs and trees.
	19 & 34	Mākaha, O‘ahu	Verger (2008); Verger and others (2008)	Study area comprised of 5.5 km^2 upper Mākaha valley. Land cover represented by broad categories of bare land, evergreen forest, grassland, palustrine wetland, and scrub/shrubland.	Below and within	Simulated hydrologic response to conversion of scrub/shrubland to evergreen forest.	Quantify and compare the effects of changing vegetation (also effects of rainfall variability and groundwater pumping).	Calibrated watershed model using data from November 2005 to May 2006, then altered land cover and reran model.	For land cover change scenario, direct runoff decreases, ET increases, but little change in total streamflow. Changes to groundwater recharge not reported.
	35 & 36	Southern O‘ahu	Giambelluca (1986; 1996)	Pearl Harbor and Honolulu basins representing areas of diverse land use and climate.	Below and within	Simulated conversion of developed land cover to natural land cover.	Quantify and compare differences in water-budget components for land-cover change scenarios.	Used water-budget model to estimate groundwater recharge for current and hypothetical land-cover scenarios.	Among 4 land-cover scenarios, pre-Polynesian land-cover scenario showed lowest mean recharge whereas plantation (sugarcane and pineapple) scenario showed highest mean recharge.
	37	Kawela, Moloka‘i	Rosa (2013)	Watershed comprised of >50% shrubland. Land cover represented by broad categories of forest, grassland, shrubland, and bare soil.	Below and within	Simulated hydrologic response for three land-cover change scenarios: (1) degraded, (2) restored, and (3) pre-human contact.	Quantify and compare water-budget components for each land-cover change scenario.	Calibrated watershed model using data during April 2008 to March 2010, then altered land cover and reran model.	For restored scenario, precipitation and ET increase and direct runoff and recharge decrease. For degraded scenario, precipitation, ET, direct runoff, and recharge all decrease.
	38	Central & west Maui	Engott and Vana (2007)	Central and western portion of the island of Maui	Below, within, and above	Simulated response of groundwater recharge to land-cover changes that largely reflect reductions in sugarcane and pineapple acreage and irrigation rates.	Quantify and compare water-budget components for the different scenarios.	Used water-budget model to estimate water-budget components for each historical and hypothetical land-cover scenario.	Land-cover changes between 1926 and 2004 decreased estimates of mean annual recharge by 34% as a result of reduced agricultural irrigation. Agricultural irrigation for 2004 land-cover condition is responsible for 18% of mean annual recharge.
	39	Island of Hawai‘i	Engott (2011)	Island of Hawai‘i	Below, within, and above	Simulated conversion of non-native forest to native forest, and expansion of urbanized areas.	Quantify and compare water-budget components for land-cover change scenario.	Used water-budget model to estimate water-budget components for current and hypothetical future land-cover scenarios.	Little effect of projected future urbanization on groundwater recharge; however, conversion of non-native forest to native forest increased estimates of mean annual recharge in selected aquifers by as much as 12%.
	40	Kona, Hawai‘i	Brauman and others (2012a)	Two (2) pasture and 2 forest sites in similar climate zone. Pasture sites dominated by non-native *P. clandestinum*. Forest sites dominated by native ‘ōhi‘a and hāpu‘u.	Within	None	Investigate effects of vegetation differences on groundwater recharge.	Monitored RF and meteorologic parameters concurrently to estimate potential ET over 18-month period. Estimated groundwater recharge as residual in water balance.	Greatest groundwater recharge rates as function of rainfall in dense forest (106%) and lowest in open forest (87%). Changes in vegetation that affect CWI play larger role than changes that affect ET.

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Water budget & watershed models: net precipitation, groundwater recharge, ET, direct runoff, streamflow.	41	Kona, Hawai‘i	Brauman and others (2014)	Conceptualized 1,000-hectare recharge area between 600 and 1,400 meters above sea level. Recharge area comprised of low-rainfall/low-elevation dense forest dominated by native ‘ōhi‘a and hāpu‘u, high-rainfall/mid-elevation sparse forest dominated by ‘ōhi‘a and hāpu‘u, and low-rainfall/ high-elevation pasture dominated by non-native *P. clandestinum*.	Within	Simulated hydrologic response to changes in land-cover over a 200-hectare segment within the 1,000-hectare recharge area: (1) dense forest converted to native koa silviculture, (2) sparse forest converted to dense forest, and (3) pasture converted to koa silviculture.	Evaluate potential impacts of land-cover conversions on groundwater recharge and groundwater levels and whether incentivizing land-cover change is rational.	Estimate groundwater recharge as residual in water balance. Estimate response in groundwater levels to changes in recharge by extrapolation from USGS groundwater model.	Recharge increased by 5% for the sparse-to-dense forest conversion scenario but decreased by 1-2.5% for other two land-cover conversion scenarios. Similarly, groundwater levels increased by ~2 m for the sparse-to-dense forest conversion scenario but decreased by ~0.5-1.2 m for the other scenarios.
	42	Islands of Kaua‘i, O‘ahu, Maui, and Hawai‘i	Izuka and others (2018)	Islands of Kaua‘i, O‘ahu, Maui, and Hawai‘i	Below, within, and above	Simulated hydrologic response to conversion of existing land-cover to predevelopment conditions in 1870	Quantify and compare water-budget components for predevelopment land-cover conditions	Used water-budget model to estimate water-budget components for current and predevelopment land-cover conditions in 1870	On O‘ahu, Kaua‘i, and Maui, the difference between estimated recharge for predevelopment and recent conditions is only a few percent. Estimated recharge for predevelopment on Hawai‘i Island is 20% lower than estimated recharge for recent conditions; much of this difference is attributable to canopy evaporation, which occurs in forested land covers. The area of forested land cover on Hawai‘i Island is 41% greater and canopy evaporation was 61% greater for predevelopment (1870) than for recent (2008) conditions.
	43	North Hilo and Hāmākua districts, Hawai‘i	Strauch and others (2017)	Total of 88 watersheds spanning a 4,500 mm mean annual rainfall gradient.	Below and within	Simulated hydrologic response to changes in climate and land-cover. Land-cover change scenarios include: (1) native forest above 600 m modeled invasion by *P. cattleianum*, (2) forests below 1,828 m completely converted to *P. cattleianum*, and (3) current *P. cattleianum*-invaded forests restored to native forests.	Quantify and compare impacts of climate and land-cover conversion on streamflow.	Calibrated watershed model using streamflow data collected during water years 2005-2012 on Honoli‘i stream, then altered land cover and climate inputs and reran model.	Mean annual streamflow decreased by 0.92% for the modeled +600 m expansion of *P. cattleianum* scenario and 1.85% for the complete conversion to *P. cattleianum* scenario. Mean annual streamflow increased by 1.03% for the restoration of *P. cattleianum*-invaded forests to native forest scenario.

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	47	Waikamoi, Maui	Bremer and others (2019)	Nature preserve spanning 2,622 hectares on the slopes of Haleakalā.	Within	Quantified change in groundwater recharge over a 100-year period in response to two counterfactual non-native forest invasion scenarios: (1) a spread rate of 5% per year, and (2) a spread rate of 10% per year. Both scenarios assume no management to control the spread of non-native forest.	Evaluate the potential for forest conservation to be financed (fully or partially) based on savings to the water utility associated with avoided replacement costs.	First, applied a statistical regression to estimate actual ET over time for the two counterfactual scenarios (5% and 10% spread rates) from 2018 to 2117. Second, computed avoided loss of freshwater yield (groundwater recharge + surface runoff) over time as difference between modeled actual ET in the two counterfactual scenarios and the baseline actual ET. Next, used an estimated value of 0.51 for the ratio of groundwater recharge to freshwater yield (groundwater recharge + surface runoff) to compute the portion of avoided loss of actual ET, which could be considered groundwater recharge. Finally, quantified monetary benefits of avoided loss of groundwater recharge through conservation actions that avoid invasion scenarios.	Groundwater recharge benefits of planned conservation activities reached 40.9 to 146.3 million cubic meters over 100 years depending on invasion spread rate assumptions, which translates to cost savings of 2.7 to 137.6 million dollars to the water utility in present value terms.
Water budget & watershed models: net precipitation, groundwater recharge, ET, direct runoff, streamflow.	48	Island of Maui	Brewington and others (2019)	Island of Maui	Below, within, and above	Simulated groundwater recharge for current and four land-cover conditions, and two future climate conditions.	Understand how changing land management and climate could influence groundwater-recharge rates.	Used a water-budget model to estimate groundwater recharge and other water-budget components for current and four future land-cover conditions, and for two future climate scenarios. The four land-cover scenarios, Futures 1 to 4, were developed through stakeholder engagement. The two future climate scenarios include a “wet” and “dry” climate condition derived from high-resolution downscaled climate projections.	For the dry future climate, recharge for land cover Futures 1 to 4 increased by 12%, 0.7%, 0.01%, and 11% relative to 2017 land cover conditions, respectively. Corresponding increases under the wet future climate were 10%, 0.9%, 0.6%, and 9.3%. Conversion from fallow/grassland to diversified agriculture increased irrigation, and therefore recharge. Above the cloud zone (610 m), conversion from grassland to native or alien forest led to increased fog interception, which increased recharge. The greatest changes to recharge occurred in Futures 1 and 4 in areas where irrigation increased, and where forest expanded within the cloud zone.
	49	Hanalei, Kaua‘i	Fortini and others (2020)	Hanalei River watershed	Below and within	Simulate streamflow using input values of K_{fs} derived from field measurements.	Evaluate the sensitivity of runoff to the range of measured K_{fs} values.	Parameterized a watershed model for Hanalei River watershed using range of K_{fs} values measured by Fortini and others (2020).	Despite large variability in observed K_{fs} values used in model, the modeled downstream effects were comparatively small (~9% change in streamflow). Authors conclude the model insensitivity to K_{fs} likely was driven by the fact that the rainfall values used in the simulation were generally lower than the range of measured K_{fs} values.

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Decision-Support Tools	51	North Hilo and Hāmākua districts, Hawai‘i	Povak and others (2017)	Total of 88 watersheds spanning a 4,500 mm mean annual rainfall gradient.	Below and within	Simulate streamflow for current and two land-cover conditions, and six climate conditions. The two land-cover conditions include complete conversions to (1) *P. cattleianum* and (2) native forest species.	Develop a decision support tool aimed at prioritizing watersheds for invasive species removal and native forest protection from non-native species invasions.	Used a watershed model to estimate streamflow for current and two land-cover conditions, and for six climate scenarios to identify where invasive species removal and protection from invasion would have the greatest benefit to increasing or maintaining native biodiversity and hydrologic functioning.	For dry future climate (20% reduction in mean annual rainfall), streamflow decreased by 30% decline for current land-cover conditions and an additional 2% when catchments were fully invaded by *P. cattleianum*. About 6.3% of the study area was identified as high priority for invasive species removal, based on simulated streamflow response to *P. cattleianum* removal, high quality road or trail access, and high conservation value of native forests. High protection priority was indicated for high-elevation watersheds, near the upper range of *P. cattleianum* where simulated streamflow was most sensitive to invasion. Users can access the decision-support tool at: https://www.fs.fed.us/psw/tools/watershedexplorer/
	52	Island of O‘ahu	McLean and others (2019)	Island of O‘ahu	Below and within	Simulate groundwater recharge rates and other water-budget components for 29 land-cover conditions and two rainfall conditions.	Develop a decision-support tool to support researchers, stakeholders, and resource managers address questions of water-resource sustainability.	Used a water-budget model to simulate groundwater recharge for 29 land-cover conditions and two rainfall conditions. The output from the water-budget simulations is stored in a metadata database that can be accessed by the decision-support tool through user-defined spatial queries.	Users can apply the decision-support tool to interactively modify land-cover and/or rainfall conditions across a user-defined region of interest on the island of O‘ahu and retrieve estimates of simulated changes in groundwater-recharge rates. Users can access the decision-support tool at: https://recharge.ikewai.org/#/home

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