Development of modeling-based decision support tools for managing impacts of climate change and invasive species on tropical forest watersheds

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Abstract: Rising air temperatures, changes in rainfall, and expanding invasive plant cover will all influence water cycling and availability in the tropics, but independent and interactive effects are poorly understood, let alone quantified. Further, structured decision support is largely absent from tropical watershed management, greatly limiting capacity to make decisions that are strategic and efficient at landscape scales. To address these concerns, we examined stream flow across a series of watersheds spanning a highly constrained 4000 mm gradient in mean annual precipitation (MAP ranging from 2500 to 6500mm) on the Island of Hawaii. Specifically, we used published data sources to parameterize the Distributed Hydrology Vegetation Soils Model (DHSVM), modeled flow in 87 watersheds in windward Hawaii Island, and validated modeled output for stream flow against six years (2006-2011) of real stream flow and paired climate data. We then ran the fully parameterized DHSVM under various scenarios of climate change (reduced/increased precipitation; warming) and expanding invasive species cover. Modeling results point to a very strong influence of MAP on water flow, and a negative influence on variation in water flow. Modeling also revealed reductions in flow with invasion with larger reductions when invasion was accompanied by warming. Critically, climate change, particularly changes in temperature, and invasive species cover appear to have manageable impacts on watershed function in our tropical forest watersheds – with modeled invasive plant removal treatment restoring flow. We then used DHSVM-based analyses to develop a structured decision support tool designed to increase the adaptive capacity of human infrastructure and of targeted ecosystems to absorb climate change through enhanced management. We conclude that reducing impacts of both climate change and invasive species can be efficiently achieved through a DST process that identifies portions of the landscape that are most reasonable to manage, based on ownership, ecological condition, accessibility, cost and water yield benefits of the management action.