Watershed Management Across the Hawaiian Islands

Problem Statement

Population growth and development, land use and degradation, invasive species, climate change and resource over-exploitation are growing threats that impact water resources vital to humans, plants, and wildlife in Hawaii. Demand on these water resources will increase as population pressures rise, native ecosystems are replaced by fast growing and water demanding plants (Fig. 1), and air temperatures warm.

Management efforts such as fencing, eradication of certain exotic plants and animals, and reforestation with native plants are expected to offset the impacts of these threats and so sustain water supply to Hawaiian streams, groundwater and nearshore areas, but projected impacts are uncertain. The effectiveness of these efforts can be greatly enhanced with a tool that can: 1) forecast the effects of threats; 2) prioritize watershed restoration based upon size, condition, impact on society; and 3) determine what management activity best meets that restoration need.

Fig 1. Shifts from a native ohia forest (top) to invasive strawberry guava (bottom) alter watershed hydrology and resilience to climate change.

Project Partners

- USDA Forest Service
- HI Division of Aquatic Resources
- University of Hawaii
- US Geological Survey
- Watershed Professionals Network
- Carnegie Institute of Science
- Kamehameha Schools
- Michigan State University
- PICCC

Developing a Tropical Decision Support Tool

Data collected from a unique model system along the Hilo-Hamakua regions of Hawaii Island are being used to build a TDST that can forecast how climate change and invasive plants alter water inputs to forests, streams, and nearshore areas. Rainfall ranges from 3000-6000 mm per year along this coast, while other variables such as temperature, soils, and vegetation are relatively constant (Fig. 2). Study plots established in streams and forests along this rainfall gradient monitor how stream flow, stream animals, and forest vegetation respond to changes in rainfall and thus climate change. Comparisons between native ohia (*Metrosideros polymorpha*) and forests invaded by strawberry guava (*Psidium cattleianum*) provide data on how invasion of native forests alters water budgets.

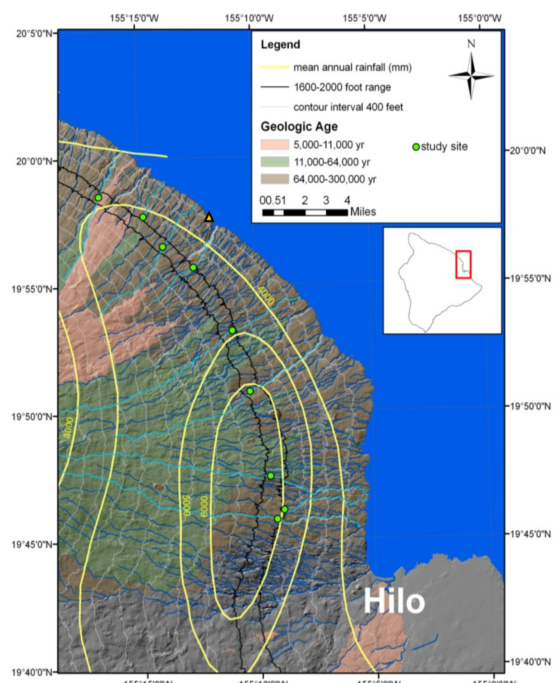

Fig 2. Hilo-Hamakua Coast with mean annual rainfall (yellow isohyets) and long-term monitoring sites (green dots).

Pacific Southwest Research Station

Modeling Changes in Stream Flow

Using a Distributed Hydrology, Soils and Vegetation Model (DHSVM), data collected from the Hilo-Hamakua coast study plots and from project partners (i.e., vegetation, soils, meteorological), were assembled into a framework to model stream flow from 86 catchments located along a mean annual precipitation gradient of 3000 mm under current climate, vegetation and soils profiles.

Following validation of the model, we examined how three vegetation change scenarios: 1) 600 m expansion of strawberry guava into native forest, 2) full invasion by strawberry guava, and 3) restoration to native forest would change water yield in streams in a warmer (+ 2°C air temperature) and drier climate (20% less rainfall) compared to current vegetation (mixed native and exotic stands) (Fig. 3).

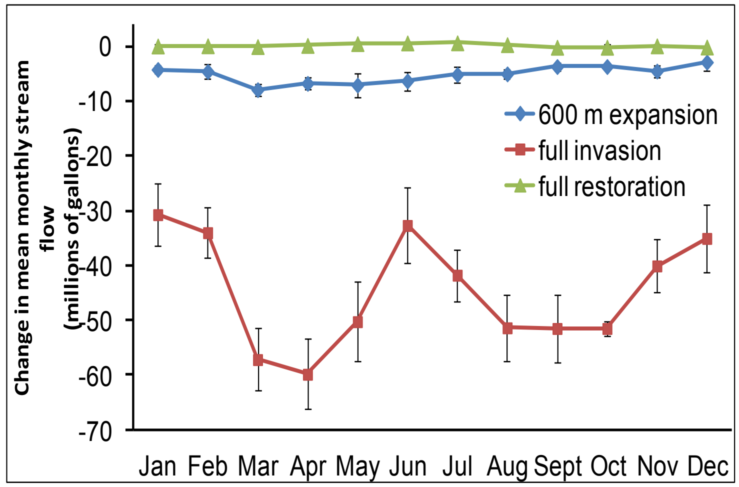

Fig 3. Predicted change in mean monthly stream flow for the Kolekole River in a warmer (+ 2°C air temperature) and drier climate (20% less rainfall). Full invasion of strawberry guava reduced annual stream flow by 540 million gallons (red), 600 m expansion of strawberry guava reduced stream flow by 62 million gallons (blue), restoration to native forest increased annual stream flow by 2 million gallons (green).

Improved Management of Hawaiian Watersheds

Output from the DHSVM as well as data from field observations are being used to build a Tropical Decision Support Tool for watershed management in Hawaii. DSTs create virtual watersheds (Fig. 4) that enable land owners, resource managers, and conservation organizations to examine how various climate change and invasive species scenarios described above can alter decision making. This process can help managers to prioritize watersheds needing restoration and identify best management practices by quantifying how various management decisions (or lack thereof) may influence watersheds function and water yields to streams, groundwater and nearshore.

For example, a TDST would be able to predict threats to water yield in each of the sub-catchment units in Fig. 4. Red colored units represent areas that provide abundant sources of water and that do not require any management action. Blue colored units represent areas where water yield is most at risk from a combination of physical (e.g., slope, roughness) and biological factors (e.g., strawberry guava, feral ungulates). End users can then run various management scenarios (i.e., fencing, reforestation) to indentify where and what type of restoration will be most effective at maintaining water yield.

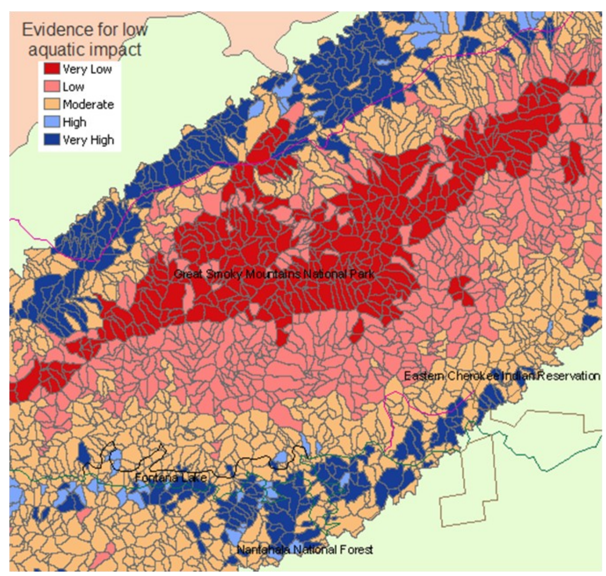

Fig. 4. Example of a virtual watershed from a decision support tool. Blue areas represent areas of high aquatic impact and that require some management action (e.g., fencing, reforestation with native species).

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