

# Where Have We Been?

An overview of current knowledge about the relationship between vegetation and hydrology in Hawaii

Travis Idol

Department of Natural Resources & Environmental  
Management

University of Hawaii-Manoa



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# Status and Trends in Hawaiian Forest Management

1. Conservation lands on most islands have been reforested with non-native species; a few have proven invasive
2. Mauka pastures are being converted back to forests, often for timber production
3. With or without grazing, dry forests are being invaded by exotic grasses, shrubs and trees



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# Status and Trends in Hawaiian Forests and Watersheds

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# Major Hydrology Issues

1. Do native vs exotic or invasive species differ in watershed function?
2. Are forests better than pastures for watershed function?
3. Are invasive species in dry forests a concern hydrologically?



1. Do native vs exotic or invasive species differ in watershed function?

## Conventional Wisdom

### Exotic and invasive species

1. use more water
2. reduce water infiltration
3. potentially increase runoff and erosion



# 1. Do native vs exotic or invasive species differ in watershed function?

## Research

### Water use

- There is a strong relationship of tree diameter to sapwood area, leaf area, and thus water demands and use (Meinzer et al. 2001)
- Understory invasives are more productive in disturbed wet or mesic forests (Pattison et al. 1998, Baruch et al. 2000) and thus more demanding of water



# 1. Do native vs exotic or invasive species differ in watershed function?

## Research

### Soil Properties/Water Infiltration:

- The size of soil aggregates is a good measure of stability and infiltration rate
- Yamamoto and Anderson (1971) found no patterns related to native or invasive status



# 1. Do native vs exotic or invasive species differ in watershed function?

## Research

Invasives may increase runoff and erosion

- Soil cover is the most important factor for reducing raindrop impact and slowing runoff and erosion
- revegetation of Kahoolawe shows dramatic improvements over bare surface (Ziegler et al. 2000)
- In intact forests, species that reduce understory cover and forest floor litter will likely increase runoff and erosion
- Silk-oak (*Grevillea robusta*) leaf litter seems to repel water, which would encourage runoff, reducing infiltration and recharge



## 2. Are forests better than pasture for watershed function?

### Conventional Wisdom

1. Forest cover improves porosity and water infiltration
2. Forest cover improves groundwater recharge and maintains more constant stream flows
3. Forests increase fog drip and effective precipitation



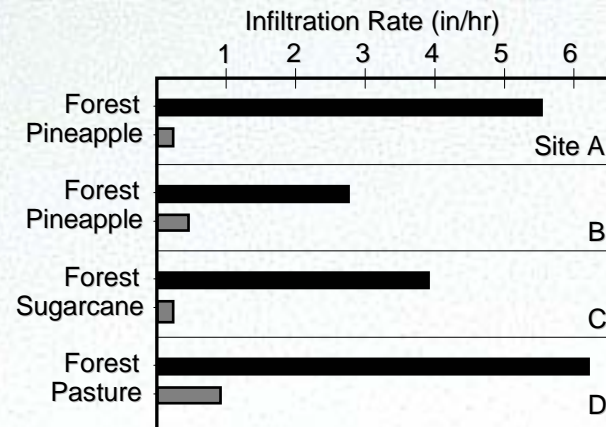
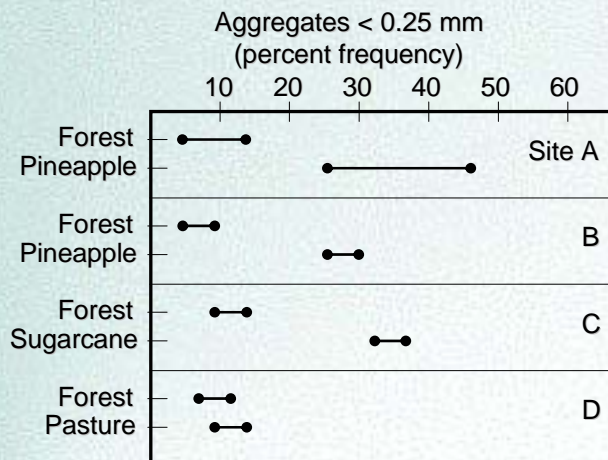
## 2. Are forests better than pasture for watershed function?

### Research

Forests cover improves porosity and infiltration

-The little research done suggests this may be true in some locations (Wood 1971)

-aggregate size was the same, but infiltration rate was much higher



## 2. Are forests better than pasture for watershed function?

### Research

Forests cover increases recharge and stream flow

- Most research contradicts this claim
- Trees use more water than pasture because of greater leaf area
- Stream flows generally increase after forest harvesting

*Annual stream flow increase after harvesting (mm)*

<u>% Cover</u>	<u>Forest Type</u>		
<u>Reduction</u>	<u>Conifer</u>	<u>Deciduous</u>	<u>Scrub</u>
20	80	80	40
40	150	120	50
60	220	150	70
80	300	200	90
100	390	250	100

Hamilton and King (1983)



## 2. Are forests better than pasture for watershed function?

### Research

Forests cover increase recharge and stream flow

- Trees may reduce fluctuations in stream flows
  - Reduce runoff, which maintains more constant flow
  - Improve deep percolation in fine-textured soils with low hydraulic conductivity



## 2. Are forests better than pasture for watershed function?

### Research

Forests increase fog drip and effective precipitation

- Auracaria* plantings on Lanai Hale are effective at increasing capture of fog drip
- In other tropical montane forests, increase is ~20%
- It is difficult to quantify fog drip because of high spatial variability
- Fog drip increase has to be balanced against increased ET from forests



### 3. Are dry forest invasive species a concern hydrologically?

#### Conventional Wisdom

1. Invasive species are less efficient in water use and so dry out the soils
2. Invasive species are more productive and thus more water-demanding than native species



### 3. Are dry forest invasive species a concern hydrologically?

#### Research

Invasive species are less efficient in water use

- little work has been published on the water use efficiency of invasive dry forest species
- native tree water use efficiency is related to
  1. leaf hydraulic conductivity
  2. wood density, which affects stem water storage(Stratton et al. 2000)



### 3. Are dry forest invasive species a concern hydrologically?

#### Research

Invasive species use more water than native species

- As a general rule, water use is related to growth rate and leaf area
- Christmas berry (*Schinus terebinthifolia*) successfully invades due to more effective use of water during the wet season (Stratton and Goldstein 2001)
- it goes dormant during the dry season, unlike most native trees
- most native trees rely on water in the surface soil and continue to grow year-round
- thus, wet season recharge may be greater in native dry forest



# Summary and Indicators of Hydrologic Impact

## Invasive Species in Conservation Reserve Forests

1. Water use is strongly related to productivity and leaf area
2. Invasives that reduce understory and soil cover will likely increase runoff and erosion
3. Some species may have repellent leaf litter that reduces infiltration



# Summary and Indicators of Hydrologic Impact

## Watershed Value of Forest vs Pasture

1. Trees generally use more water than pasture grasses
2. Infiltration rates may be higher under forest cover; soil cover is the key for good infiltration rates
3. Stream flow is generally lower under forest cover but seasonal fluctuations may be reduced
4. Fog drip can increase effective precipitation in montane forests; does it overcome increased ET?



# Summary and Indicators of Hydrologic Impact

## Invasive Species in Dry Forests

1. Little work done on hydrologic impacts of invasive species in dry forests
2. For some species, more rapid growth during the wet season means more water use and perhaps less recharge
3. Most dry forest trees use water in shallow soil layers all year long



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