Invasive Species and Restoration

Restoration Ecology & Invasive Species

- What is an invasive species?
  - *Invasive species (USDA – NISIS)*:
    - (1) nonnative to the ecosystem under consideration, **and** (2) whose presence causes or is likely to cause economic or environmental harm, or harm to human health
  - *Alien, nonnative, exotic, naturalized, weed*




Restoration Ecology & Invasive Species

- Costs of Invasive Species
  - Economic
    - >$120 billion annually in the U.S. (Pimentel et al. 2005)
  - Health
    - Introduced pathogens and diseases (e.g., West Nile virus; Am. chestnut blight; Dutch elm disease; ohia rust; etc.)




Restoration Ecology & Invasive Species

- Costs of Invasive Species
  - Biodiversity
    - 2nd most important cause of loss of biodiversity
    - In the U.S., >1/2 of the species listed as threatened or endangered are at risk due to competition with or predation by nonnative species

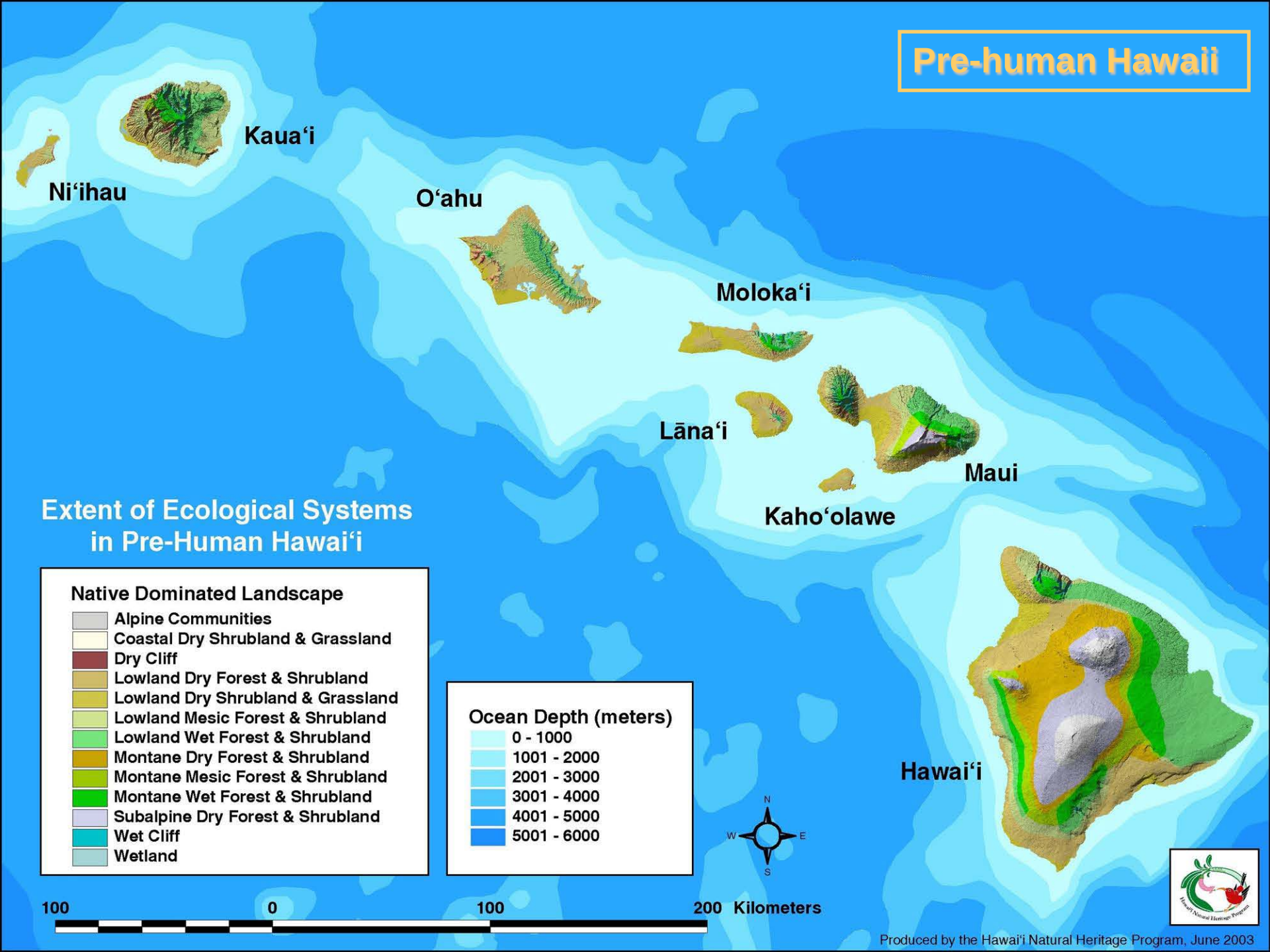



Restoration Ecology & Invasive Species

- Costs of Invasive Species
  - Ecological systems, processes, goods and services
    - Changes in disturbance regimes
    - Nutrient cycling
    - Hydrology
    - Carbon cycling




Pre-human Hawaii



Extent of Ecological Systems in Pre-Human Hawai‘i

Native Dominated Landscape

- Alpine Communities
- Coastal Dry Shrubland & Grassland
- Dry Cliff
- Lowland Dry Forest & Shrubland
- Lowland Dry Shrubland & Grassland
- Lowland Mesic Forest & Shrubland
- Lowland Wet Forest & Shrubland
- Montane Dry Forest & Shrubland
- Montane Mesic Forest & Shrubland
- Montane Wet Forest & Shrubland
- Subalpine Dry Forest & Shrubland
- Wet Cliff
- Wetland

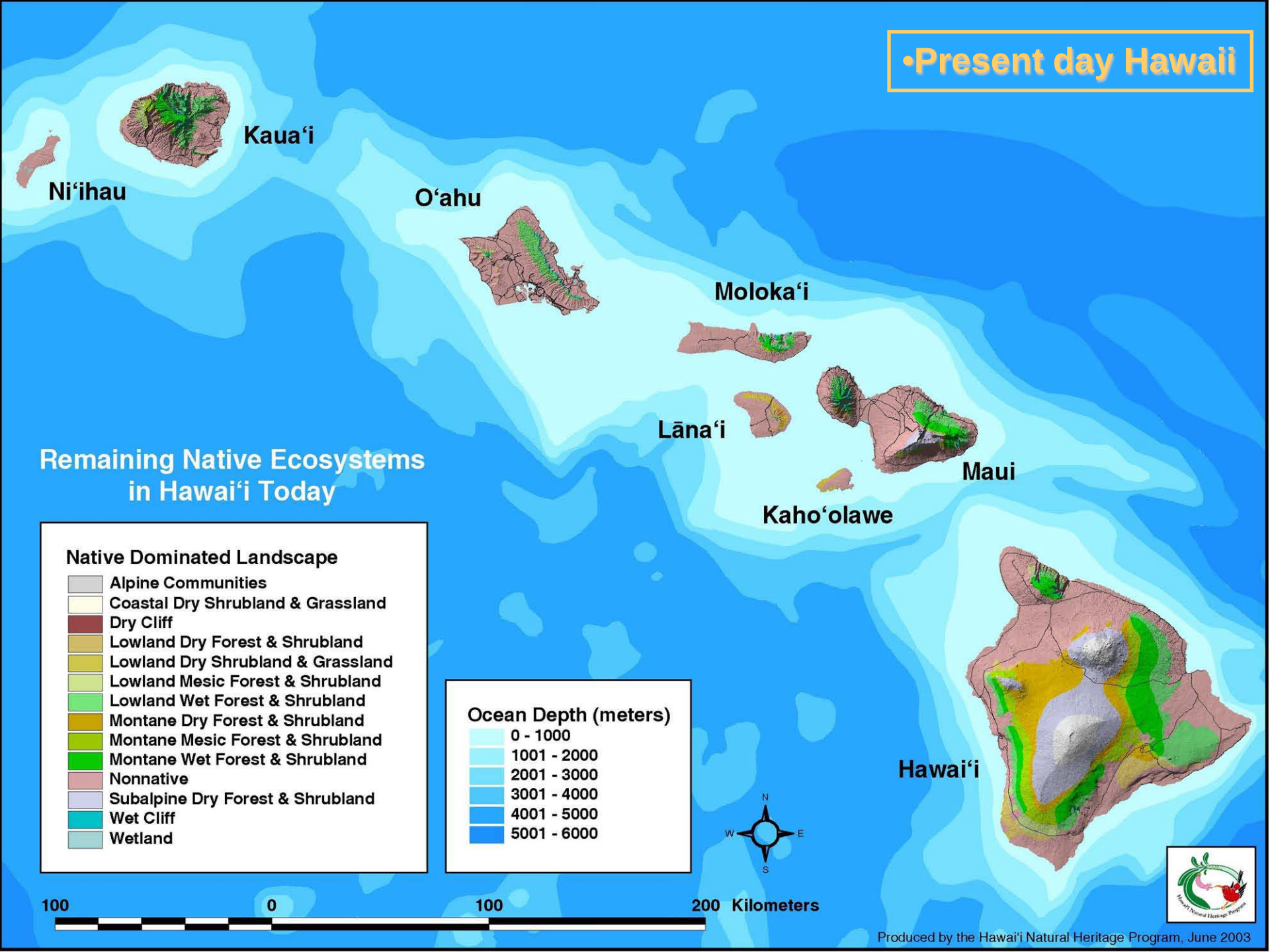
Ocean Depth (meters)

- 0 - 1000
- 1001 - 2000
- 2001 - 3000
- 3001 - 4000
- 4001 - 5000
- 5001 - 6000

N W E S

100 0 100 200 Kilometers

Produced by the Hawai‘i Natural Heritage Program, June 2003


•Present day Hawaii
Kaua'i
Ni'ihau
O'ahu
Moloka'i
Lāna'i
Maui
Kaho'olawe
Hawai'i
Remaining Native Ecosystems in Hawai'i Today
Native Dominated Landscape
Alpine Communities
Coastal Dry Shrubland & Grassland
Dry Cliff
Lowland Dry Forest & Shrubland
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200 Kilometers
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Restoration Ecology & Invasive Species

- Invasive species need to, by definition, overcome multiple barriers (Richardson et al. 2000):
  - 1) *Introduction*: arrive at a site outside of their previous geographical range
  - 2) *Colonization*: reproduce and increase in number to form a colony that is self-perpetuating
  - 3) *Naturalization*: establish new self-perpetuating populations, undergo widespread dispersal, and become incorporated within the resident flora
- Lots of species get past #1, but a very small fraction can overcome #s 2 and/or 3

Restoration Ecology & Invasive Species

- What determines invasive species success?
  - Very few introductions lead to invasions
    - Nonnatives have not evolved in the system
      - Lack of pollinators, seed dispersers, mutualists, etc.
      - Invaders not resistant/resilient to natural disturbance regimes, herbivores and predators, etc.




Restoration Ecology & Invasive Species

- What determines invasive species success?
  - Successful invaders
    - Rapid, genetic adaptation on short time scales
    - EICA (Evolution of increased competitive ability)
      - w/o predation, reallocate resources from defense mechanisms into growth and development
    - Enemy release hypothesis – the success of invaders is due to release from co-evolved natural enemies
    - Novel weapons hypothesis - chemicals exuded in the native range are benign to surrounding (co-evolved) plants. In new areas these compounds are often toxic.




Restoration Ecology & Invasive Species

- Why worry about invasive species?
  - Present in almost all ecological systems
    - Island ecosystems particularly vulnerable to invasion
  - Lots of past focus on biodiversity, more focus now on ecosystem processes
    - Still have poor understanding of ecological impacts of invasion
  - Elimination of invaders and restoration of pristine species assemblages likely impossible in many cases
    - Need better understanding of ecological impacts of invasion
    - Need better understanding of how to deal with invasion in a restoration context

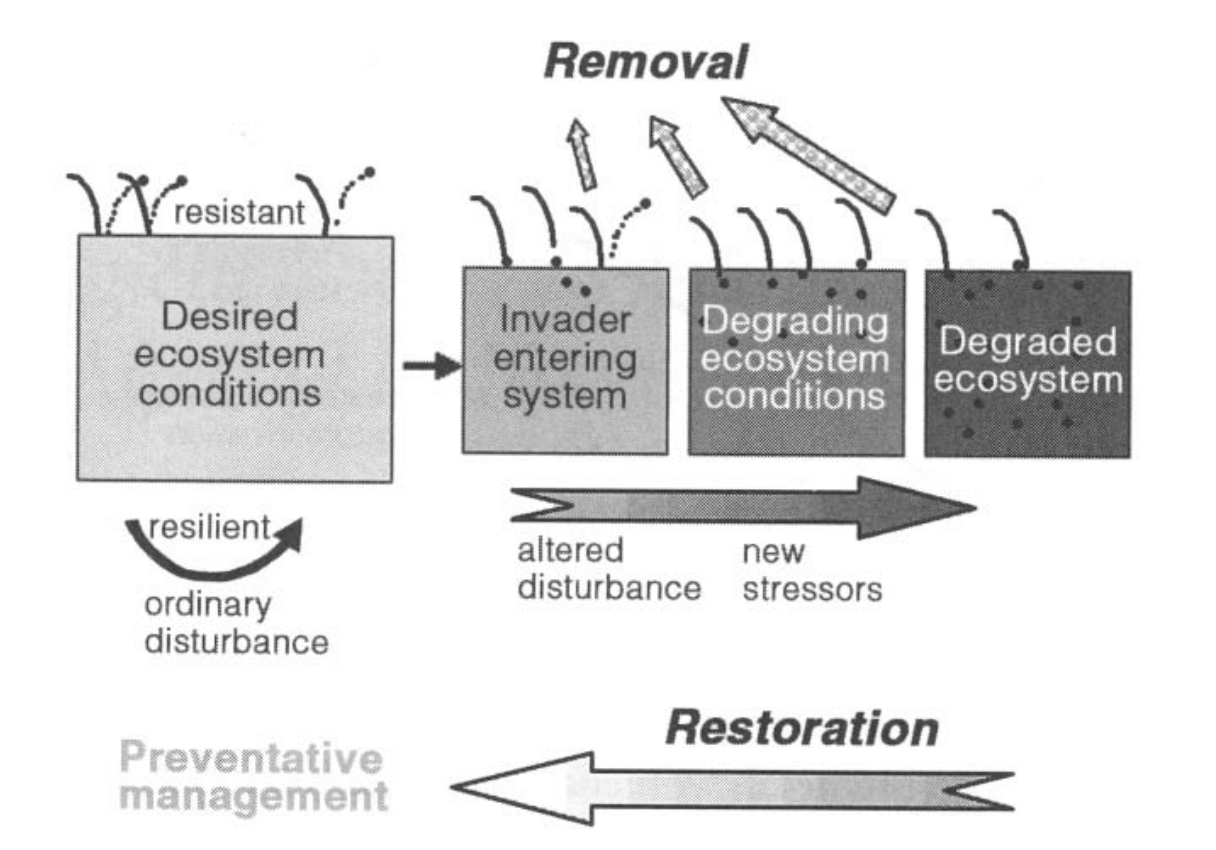
Restoration Ecology & Invasive Species

- **Goal of restoration = sustainable ecosystems**
  - Over a series of natural disturbance events
  - Retain abiotic and biotic processes
  - Resilient – return to pre-disturbance conditions following a disturbance (w/o human intervention)
  - Resistant to change following arrival of propagules of invasive species




Restoration Ecology & Invasive Species

- Management and preventive approaches
  - Prevention → relatively pristine state
  - Management (i.e., removal) → degraded state



(D'Antonio & Chambers 2006)

Restoration Ecology & Invasive Species

- Management and preventive approaches
  - Prevention management
    - Ecosystems currently providing valuable services or intact structure/processes
    - Maintain or increase ecosystem resistance prior to (or during early stages of) invasion
    - Maintain ecosystem resilience following a disturbance



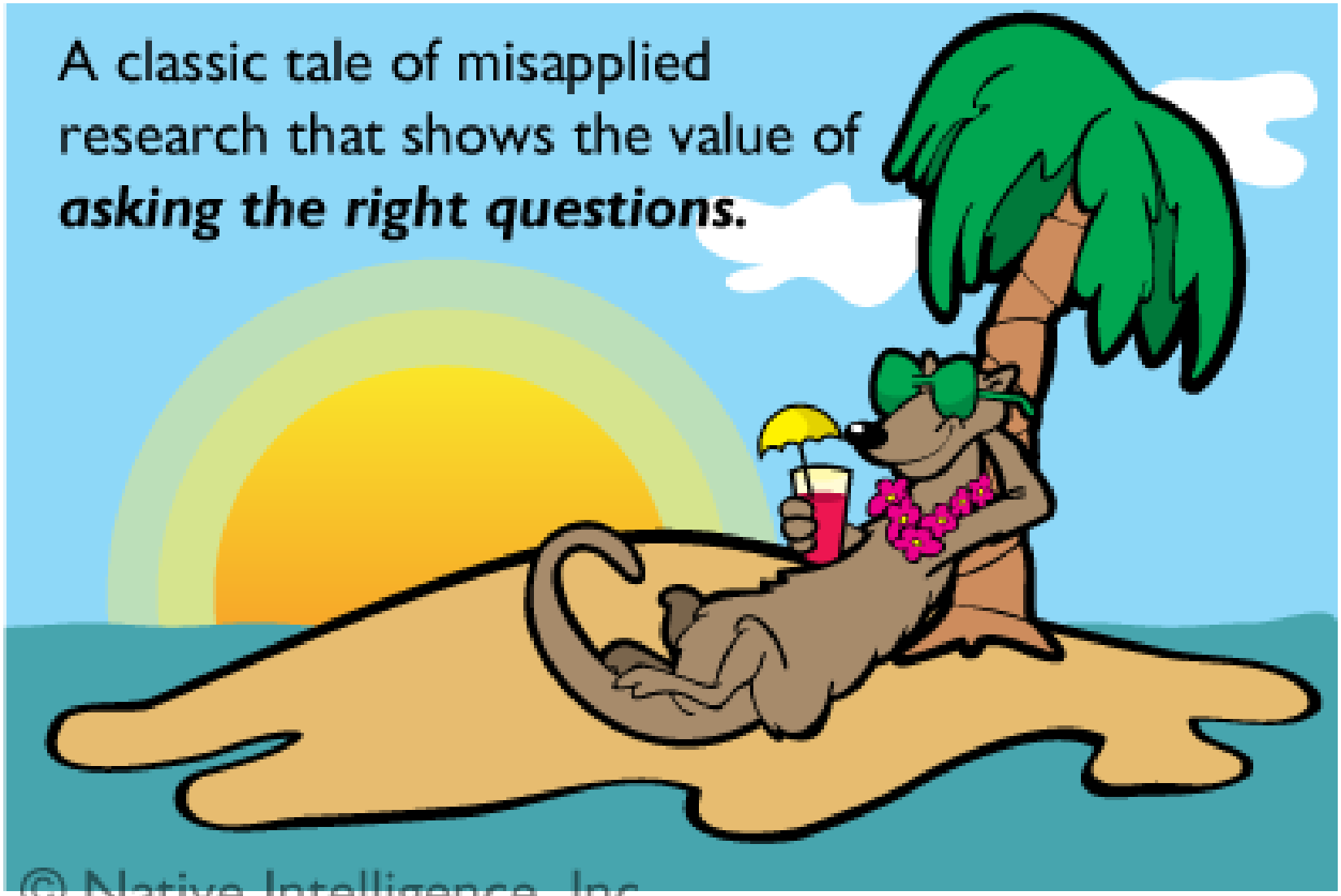

Restoration Ecology & Invasive Species

- Management and preventative approaches
  - Active management
    - Following establishment of invaders and changes in ecosystem properties and processes – altered or degraded ecosystem
    - *Top-down control*: removal/elimination of invader
      - Manual removal, herbicides, biological control
      - Control of pathways of propagule arrival
    - *Bottom-up control*: restoration of properties or processes that contribute to stability and sustainability
      - Manipulation of disturbance regimes
      - Manipulation of soil conditions to favor desirable species
      - Direct seeding of desirable species

Restoration Ecology & Invasive Species

- Are invasive species always bad for restoration?
  - Not all invaders are necessarily “bad”
    - Many “fade out” naturally over time
      - Management would be a poor expenditure of resources
    - Can be used to facilitate desirable species
      - “Benevolent” invaders
    - Should nonnative species potentially be used in restoration?
      - Provision of ecosystem goods and services
      - Highly degraded systems where desirable species not likely to establish





A classic tale of misapplied research that shows the value of *asking the right questions.*
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Ecological Attributes of Restored Ecosystems

- Restored Species Composition
  - Reflects the composition of the reference ecosystem
  - Full complement of species – or have the potential to attract any that are missing
  - Introduce only natives (usually!)
  - Maintain resistance to invasive species
  - Functional Diversity (pollinators, N fixers, etc.)



Ecological Attributes of Restored Ecosystems

- Physical environment – must be capable of supporting the biota
  - Hydrology
  - Soils

- Normal ecosystem function
  - Reproduction, biotic interactions, water and nutrient cycling



Ecological Attributes of Restored Ecosystems

- Landscape Context – Flow of energy and material into, through, and out of the restored ecosystem
  - Connectivity vs. fragmentation

- External Threats – influence of adjacent ecosystems



Ecological Attributes of Restored Ecosystems

- Resilience – can withstand normal stress events and recover from disturbance

- Self-Sustainability – no further need for restoration activities
  - Periodic management may be necessary in some cases