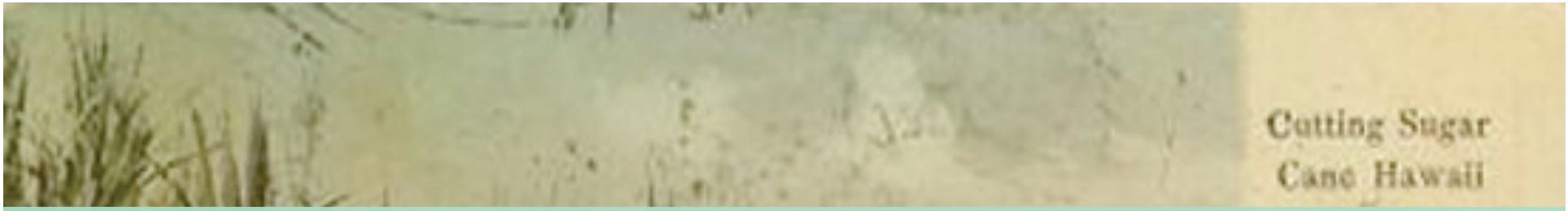


The Value of the Long View: A Long-Term Industrial Ecosystem Model of Hawai'i Island

Professor Marian Chertow

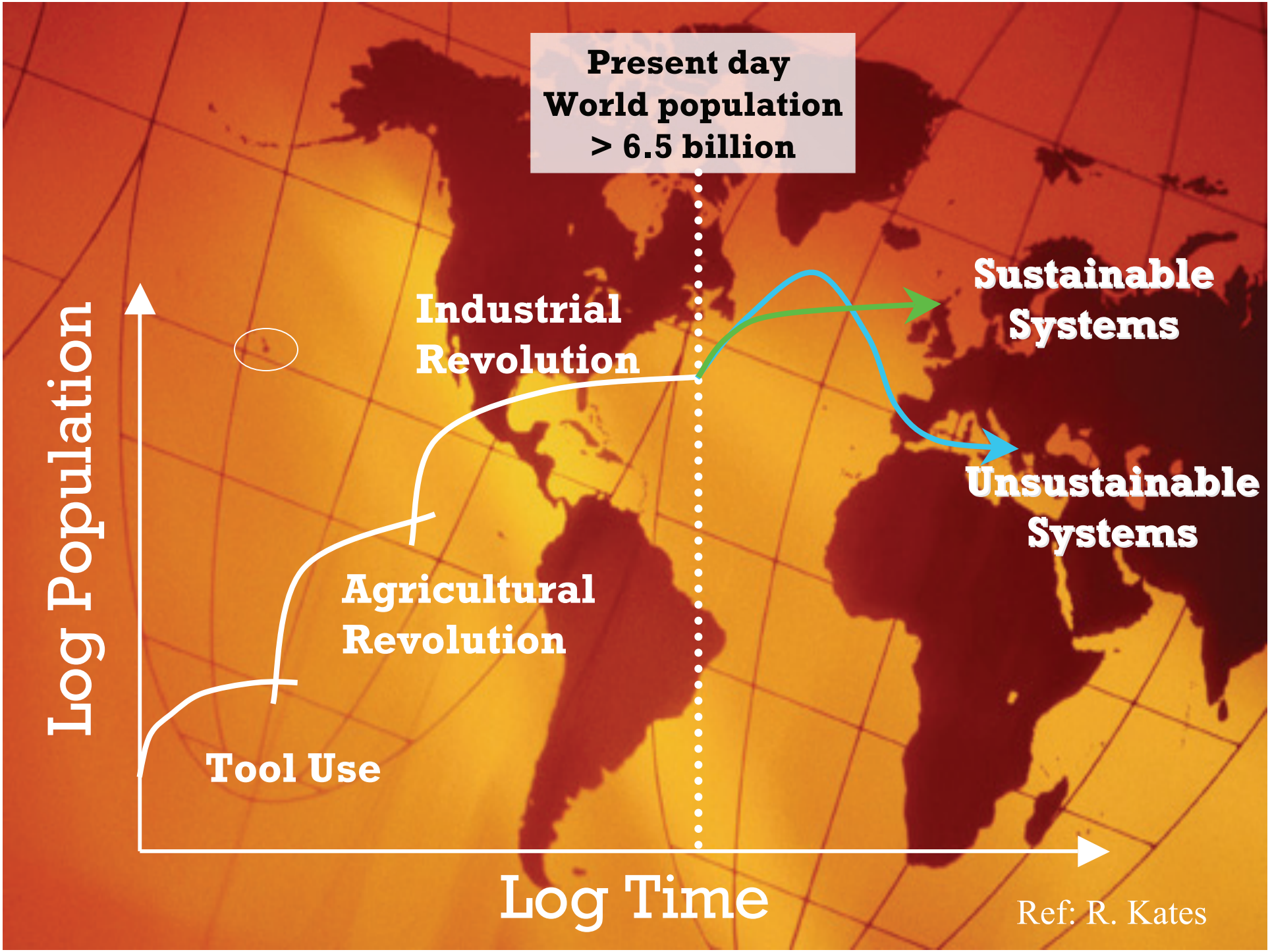
Yale School of Forestry and Environmental Studies

May 21, 2009

Outline of Tonight's Remarks

1. Looking back and looking forward: why a long-term study?
2. Human systems transforming Hawai'i Island
    1. Agriculture
    2. Urbanization
    3. Transportation infrastructure
    4. Tourism

3. Long-term impacts – the case of biodiesel
4. Study challenges and caveats
5. Program plans and concluding thoughts


Present day
World population
> 6.5 billion
Sustainable
Systems
Industrial
Revolution
Unsustainable
Systems
Agricultural
Revolution
Tool Use
Log Population
Log Time
Ref: R. Kates

Reflecting on the past - four historic transitions and four historic icons

Ahupua'a to 1840s traditional land ownership

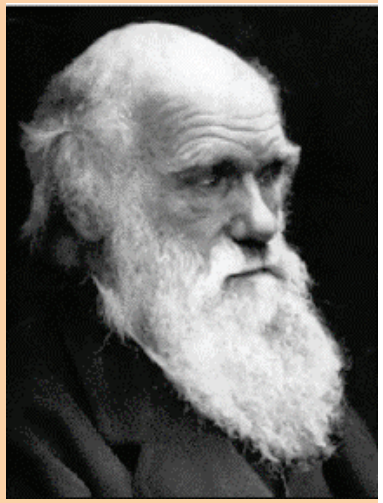
Māhele to 1898, privatization of land

U.S. ceded territory 1898-1959 land divided between federal and private landowners

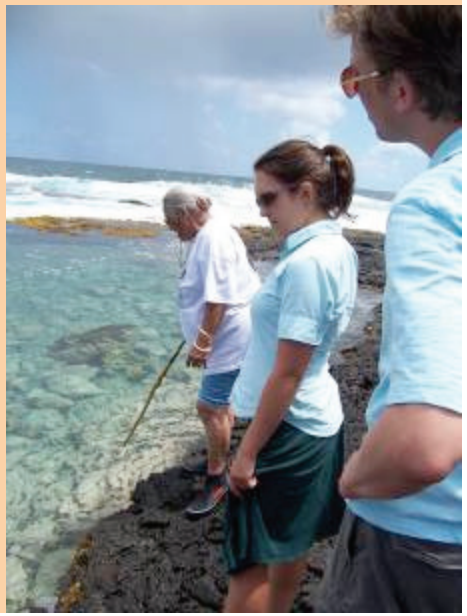
Hawai'i joined the union in 1959

The modern island context

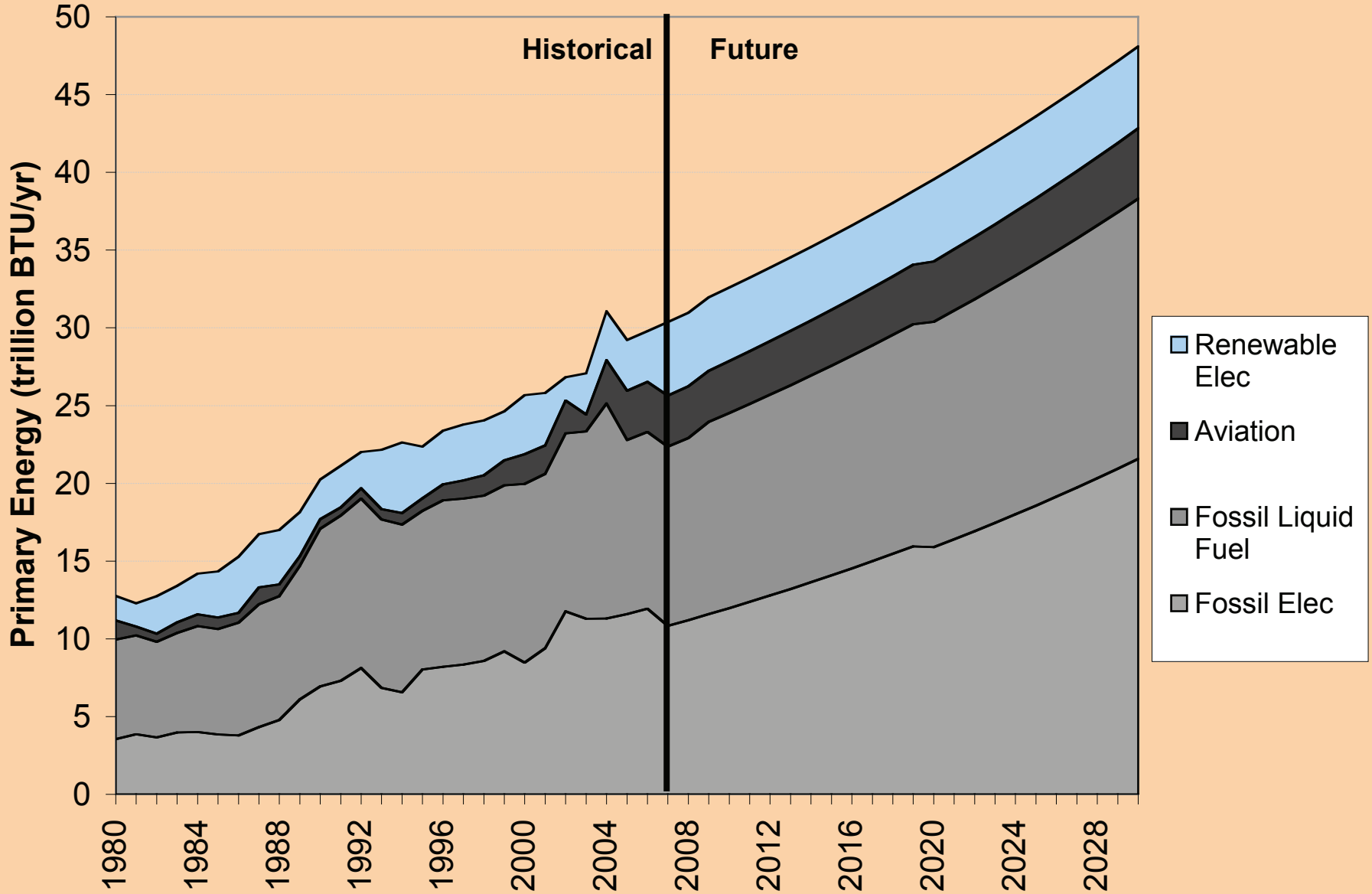
- Modern transportation and open migration have made geographical boundaries more permeable and increased the connectivity of islands to the rest of the world.
- Still, islands face limits especially:
  - Resource availability & security
  - The assimilative capacity of the environment to absorb harmful impacts.



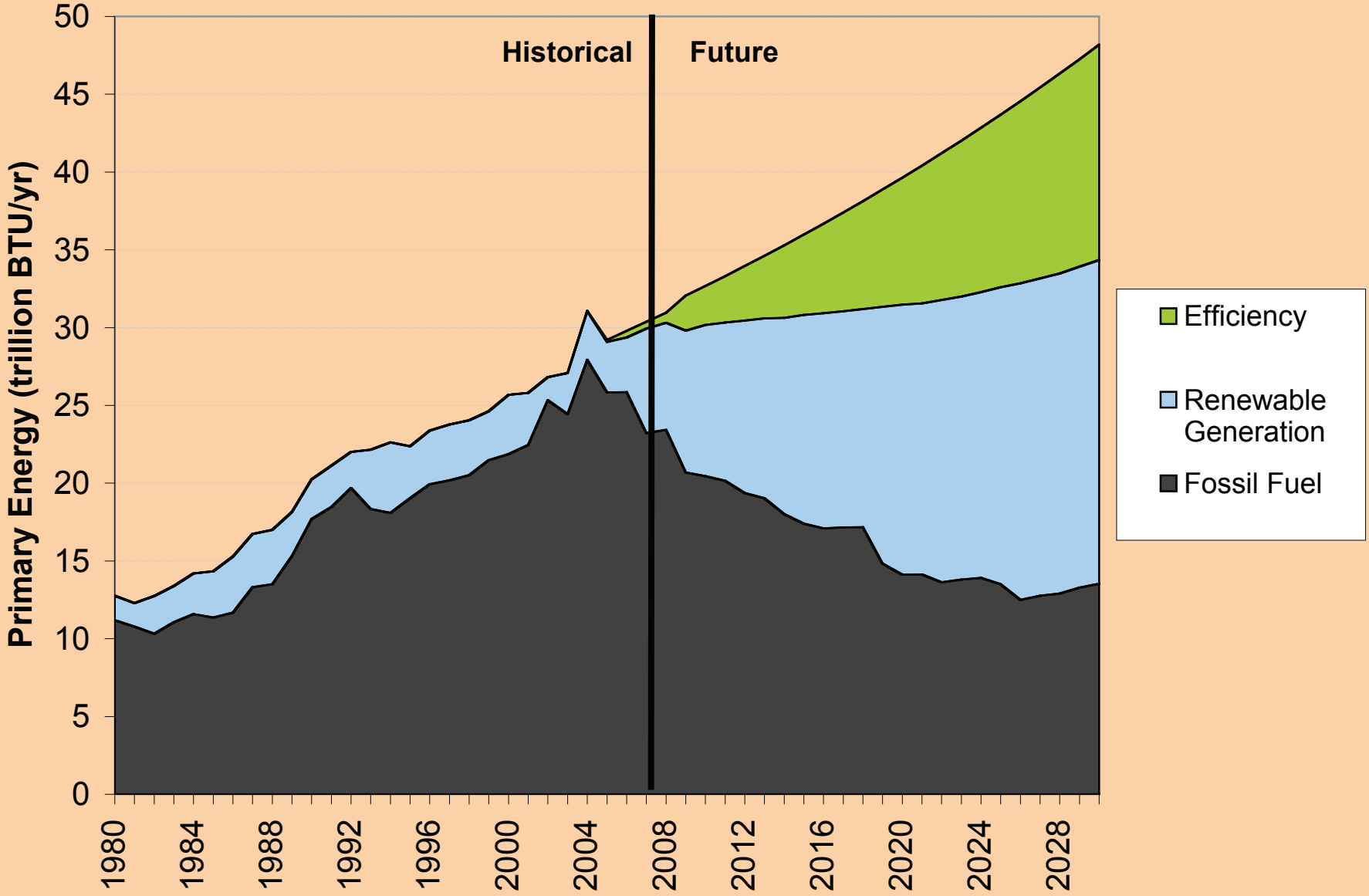
So: bounded systems in many respects (but not all!), islands present a dynamic, manageable unit of study, but with significant sustainability challenges.



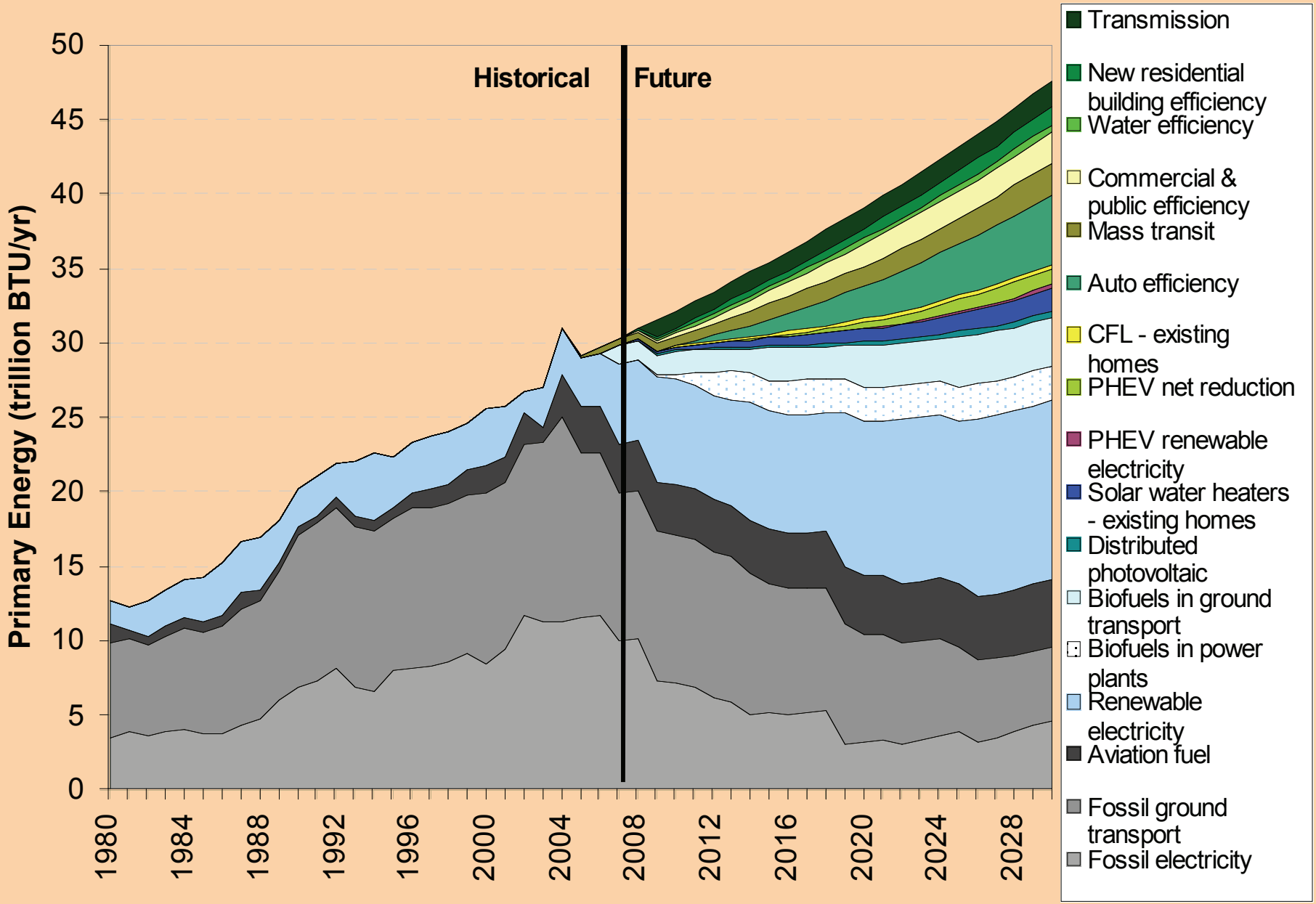
Envisioning the future on Hawai'i Island Energy Use: Status Quo



Alternative Future With Concerted Action

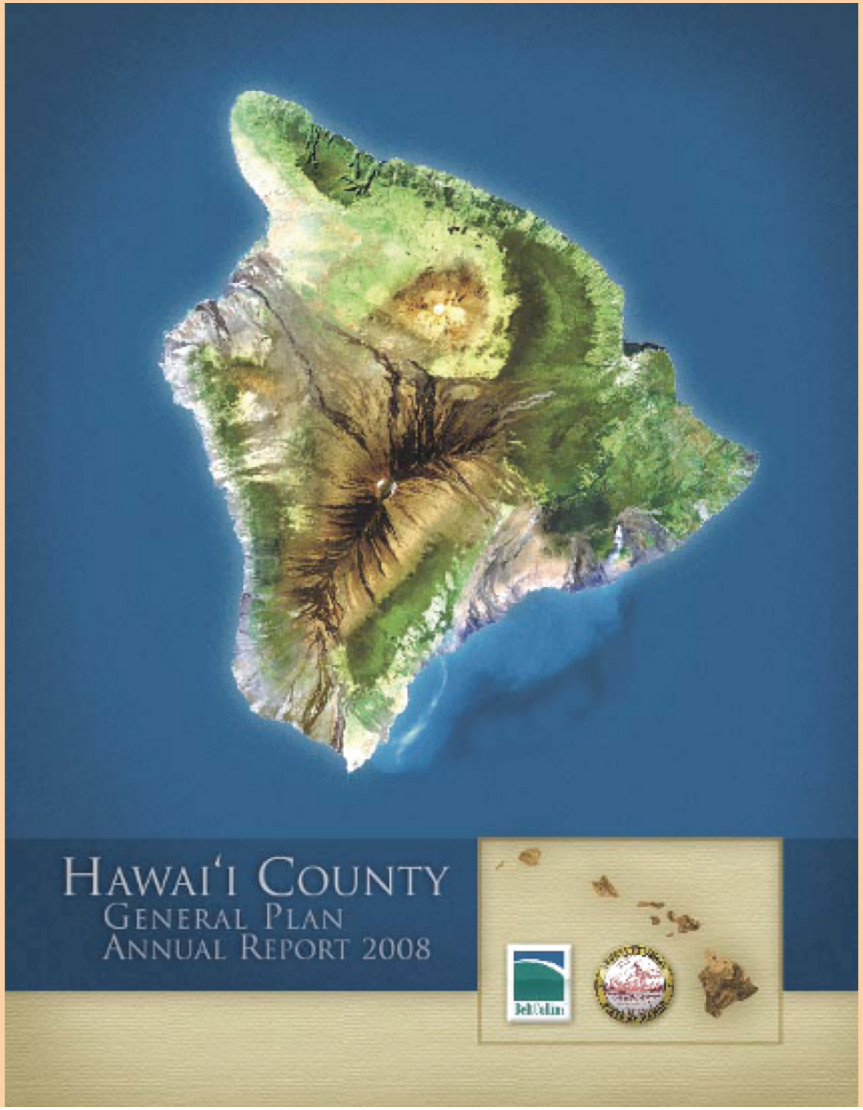


Summary of Wedges



County has already adopted an orientation to long-term goals and objectives

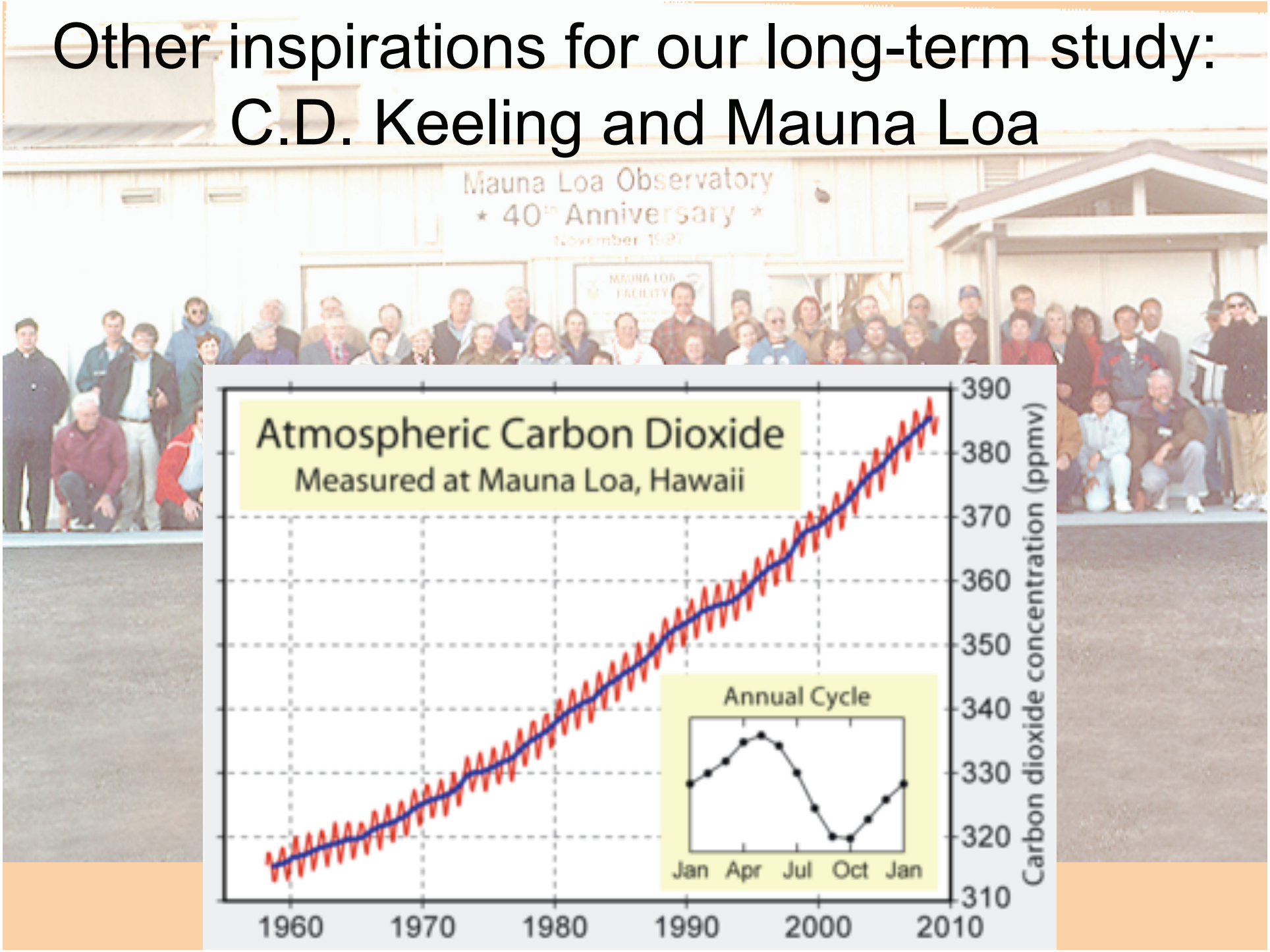
77 indicators defined and being tested



3 broad areas

- Environment
- Economy
- Community

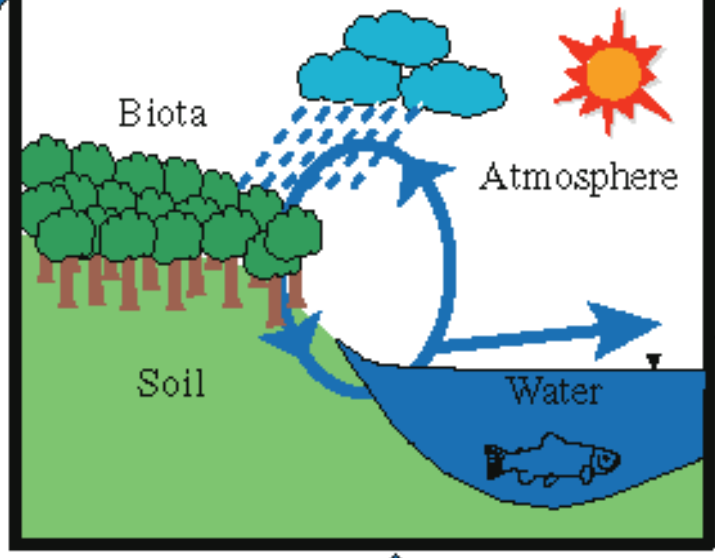
Other inspirations for our long-term study: C.D. Keeling and Mauna Loa



State Factors

Time
Topography
Parent material
Climate
Biota

Ecosystem Pattern and Processes



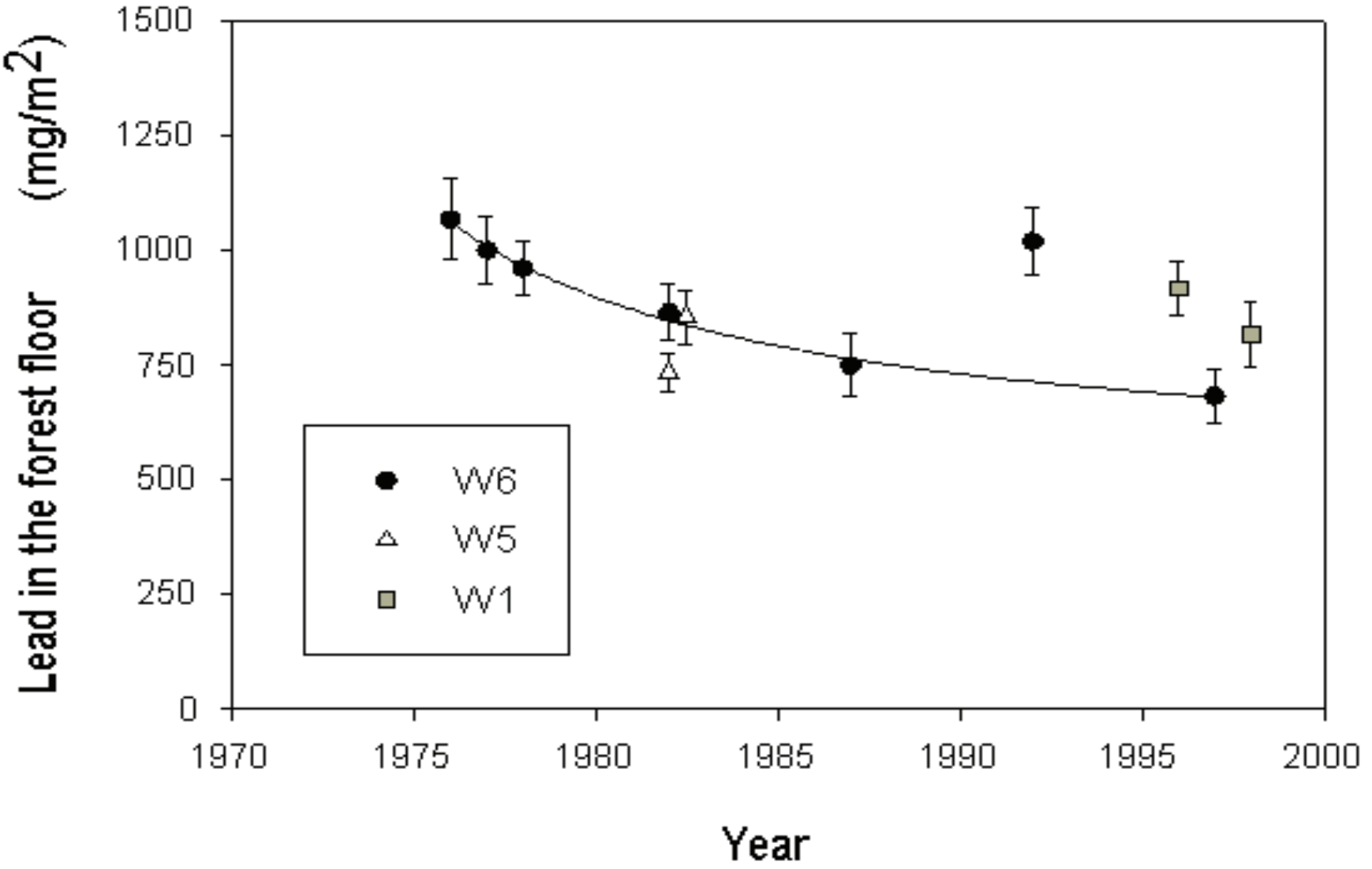
Ecosystem Functions & Services

Forest production
Water quality
Water quantity
Trace gas fluxes
Soil C storage
Biodiversity maintenance
Landscape diversity

NATURAL
- Extreme climate events
- Irruptions of native biota
  (e.g. pathogens, insect outbreaks, big herbivores)
- Geologic events
- Lightning fires

ANTHROPOGENIC
- Human-accelerated climate change
- Introduction of exotic species
- Land use disturbance (e.g. clear-cutting, agriculture)
- Air pollution/atmospheric deposition

Conceptual diagram of the Hubbard Brook Ecosystem Study



Trends in concentrations of Pb in precipitation and forest floor at the **Hubbard Brook Environmental Forest**. The decline in concentrations of Pb since the mid-1970s is consistent with lower Pb emissions due to changes from leaded to unleaded gasoline

The Program

To build on our strong relationships and engage Hawai'i Island:

- as a long-term research site (at least two decades);
- to study how human actions influence resource stocks, flows, use, and loss;
- historically, currently, and prospectively, as the…

Long-term Industrial Ecosystem Model – Hawai'i Island (LIEM – Hawai'i)

Recasting several successful elements from Mauna Loa and Hubbard Brook

- a system followed in detail over an extended period of time, adding socioeconomic parameters to biophysical ones
- the idea of a system sufficiently contained so that inputs and outputs could be quantitatively determined, although this is more challenging in a human/industrial setting.
- rather than conduct experiments, emphasize the observation of approaches being implemented on the island to determine best practices e.g. in construction or biofuel development or tourism.

How will this study differ from others?

Industrial Ecology …looks at human/industrial systems in the context of their natural surroundings

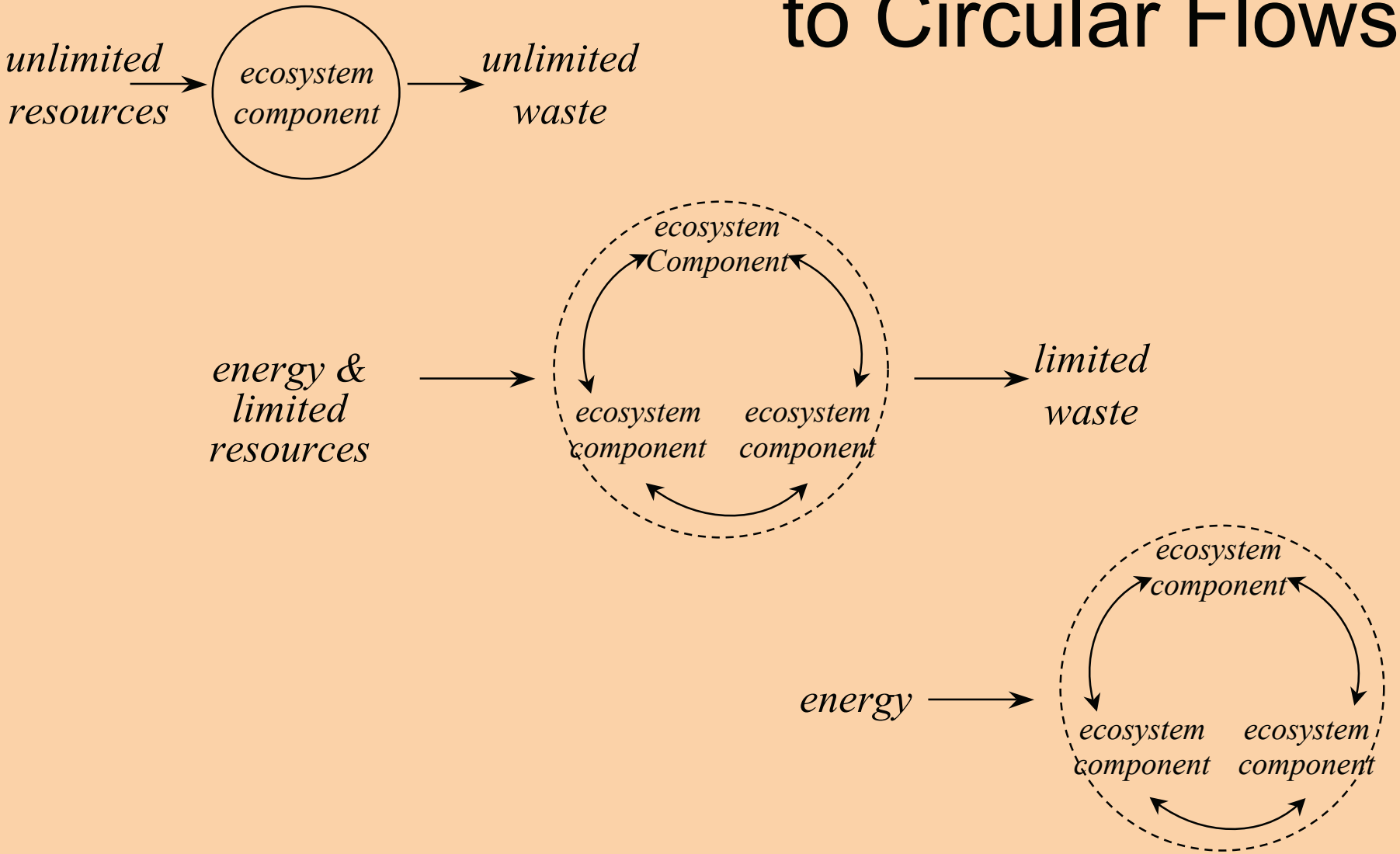
Industrial ecology provides ideas, methods, and tools that provide a strong foundation for this work…

Industrial ecology is the study of the flows of materials and energy in industrial and consumer activities, of the effects of these flows on the environment, and of the influences of economic, political, regulatory, and social factors on the flow, use, and transformation of resources.

Robert White

The Greening of Industrial Ecosystems 1994

Moving from Linear to Circular Flows

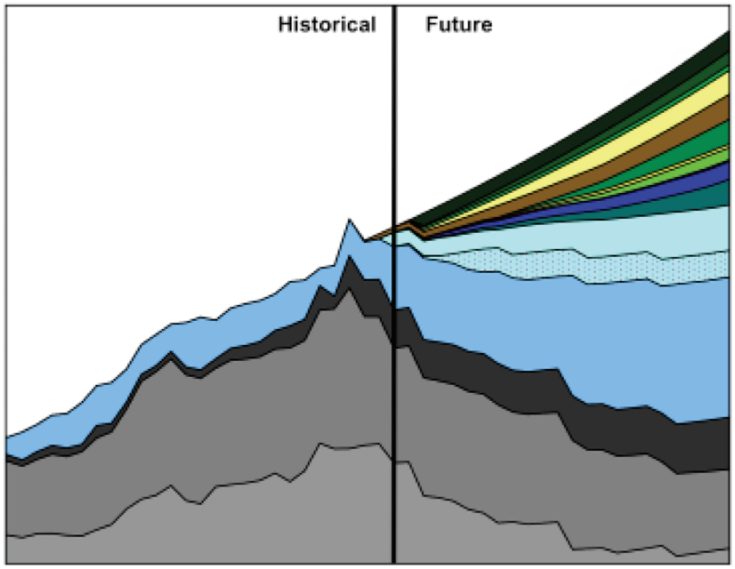


Source: T. Graedel

How we got here: Partnering with the Kohala Center and the County on Industrial Ecology

Analysis and Recommendations for the Hawai'i County Energy Sustainability Plan

October 3, 2007



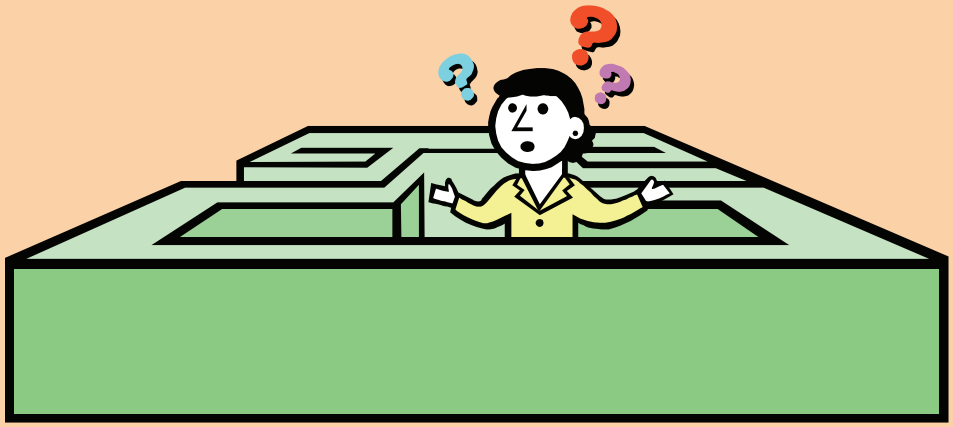
By Michael Davies, Claire Gagne, Zeke Hausfather, & Dawn Lippert
Project Manager: Jeremiah Johnson, Ph.D.
Faculty Advisor: Marian Chertow, Ph.D.

Yale School of Forestry and Environmental Studies

Research conducted for The Kohala Center, Kamuela, Hawai'i and the Hawai'i County Department of Research and Development
Prepared for and Funded by the Hawai'i County Council

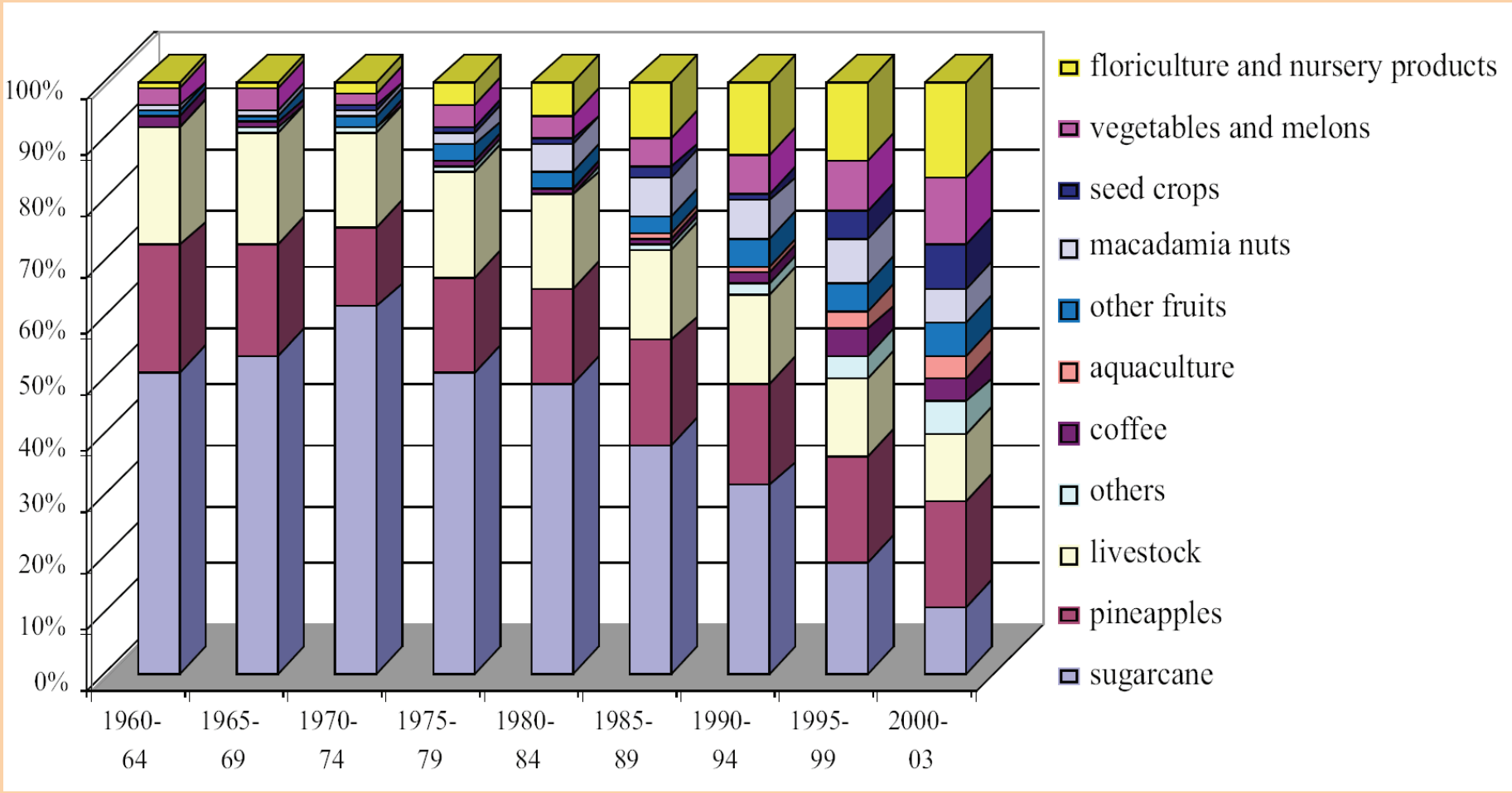
Human systems transforming Hawai'i Island

1. Agriculture
2. Urbanization
3. Transportation infrastructure
4. Tourism



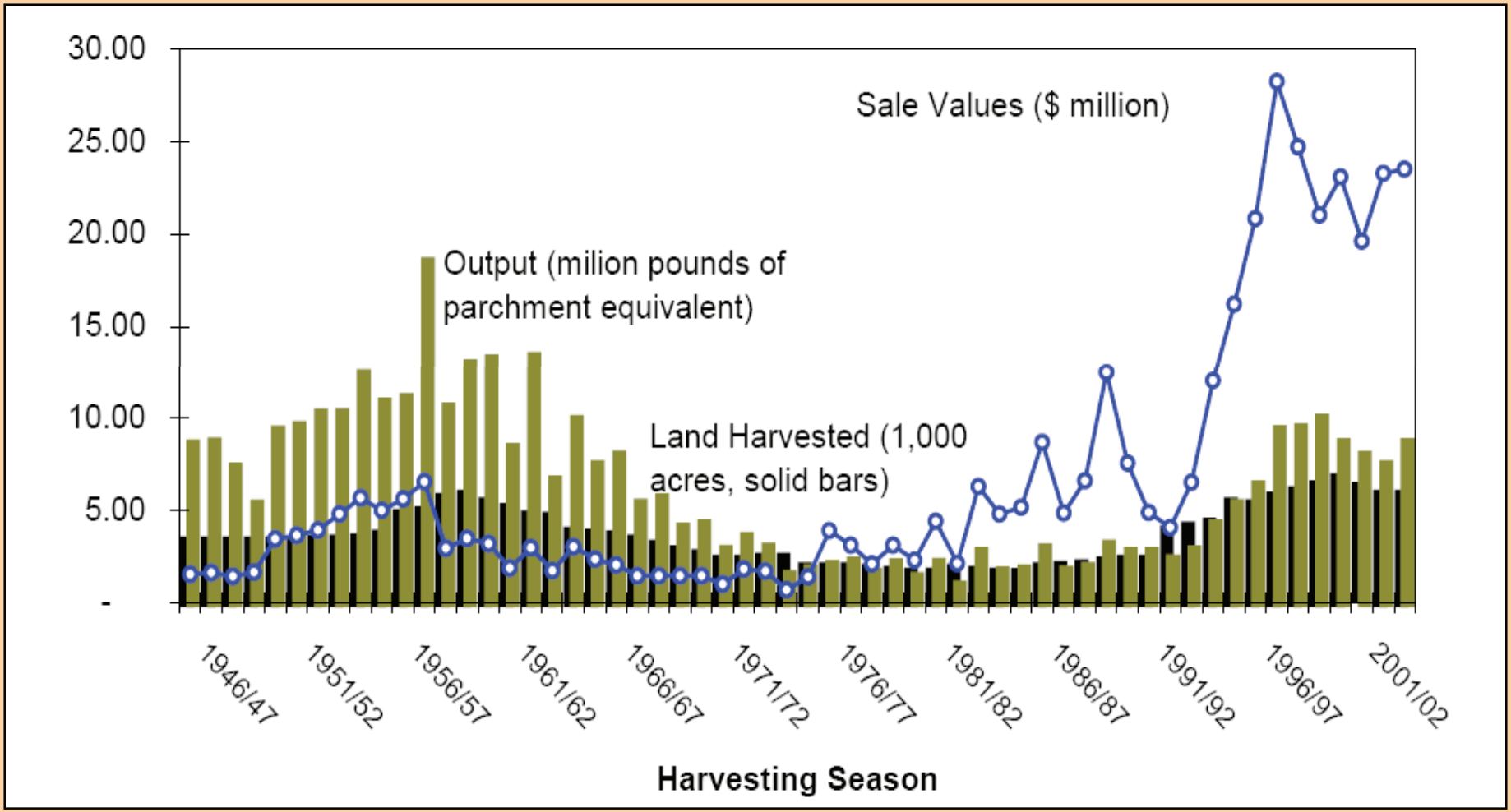
Statewide shifts in agricultural land use

Industry Composition in Hawaii's Agriculture Sector: 1960-2003



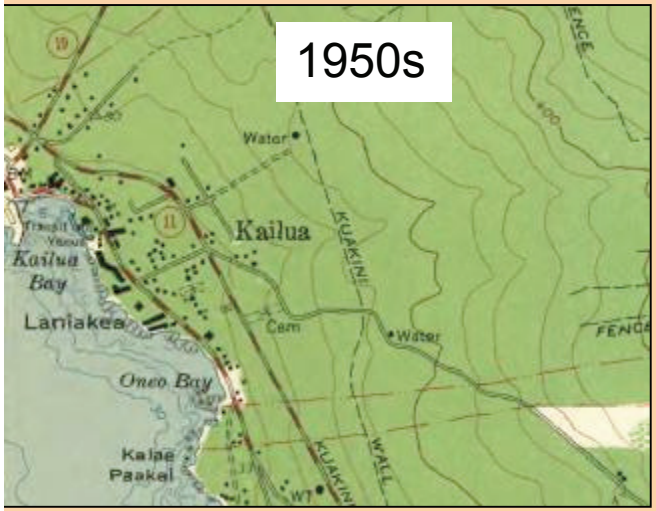
Source: Junning, Cai and Leung, PingSung. Growth and Stability of Agricultural Production in Hawaii: A Portfolio Analysis. April 2006. University of Hawaii at Manoa: College of Tropical Agriculture and Human Resources Cooperative Extension Service. Available from: http://www.ctahr.hawaii.edu/oc/freepubs/pdf/EI-9.pdf.

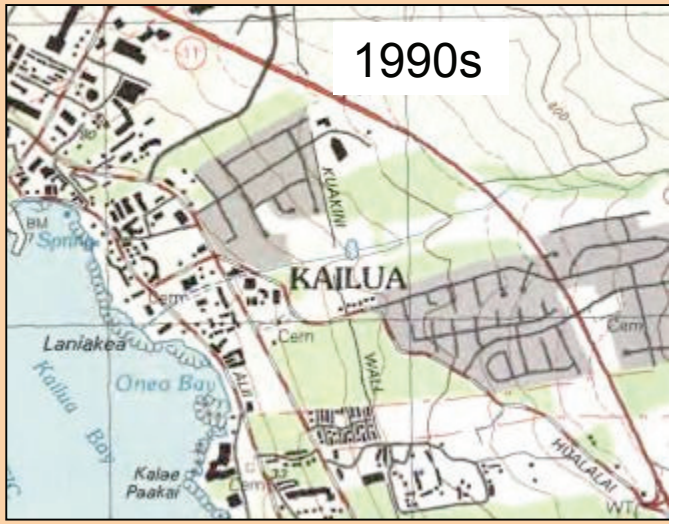
Kona Coffee Farm Production 1946-2003 tracing through the result of land use decisions

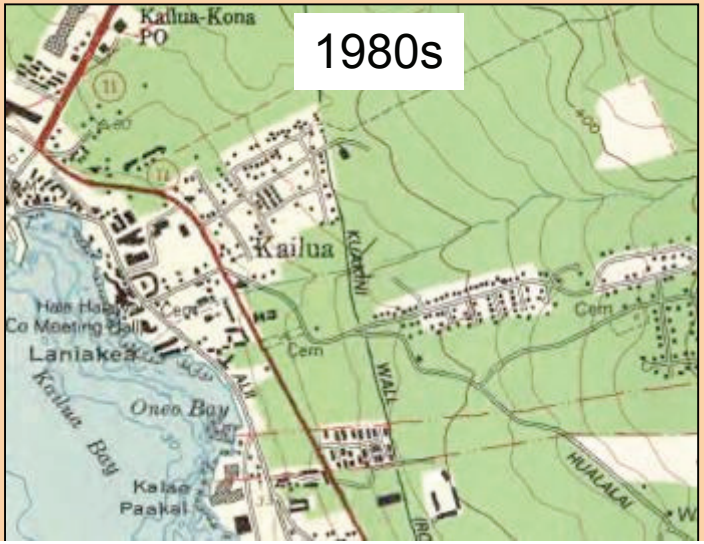


Source: Southichack, 2004

Urbanization:
The Growth of Kailua/Kona

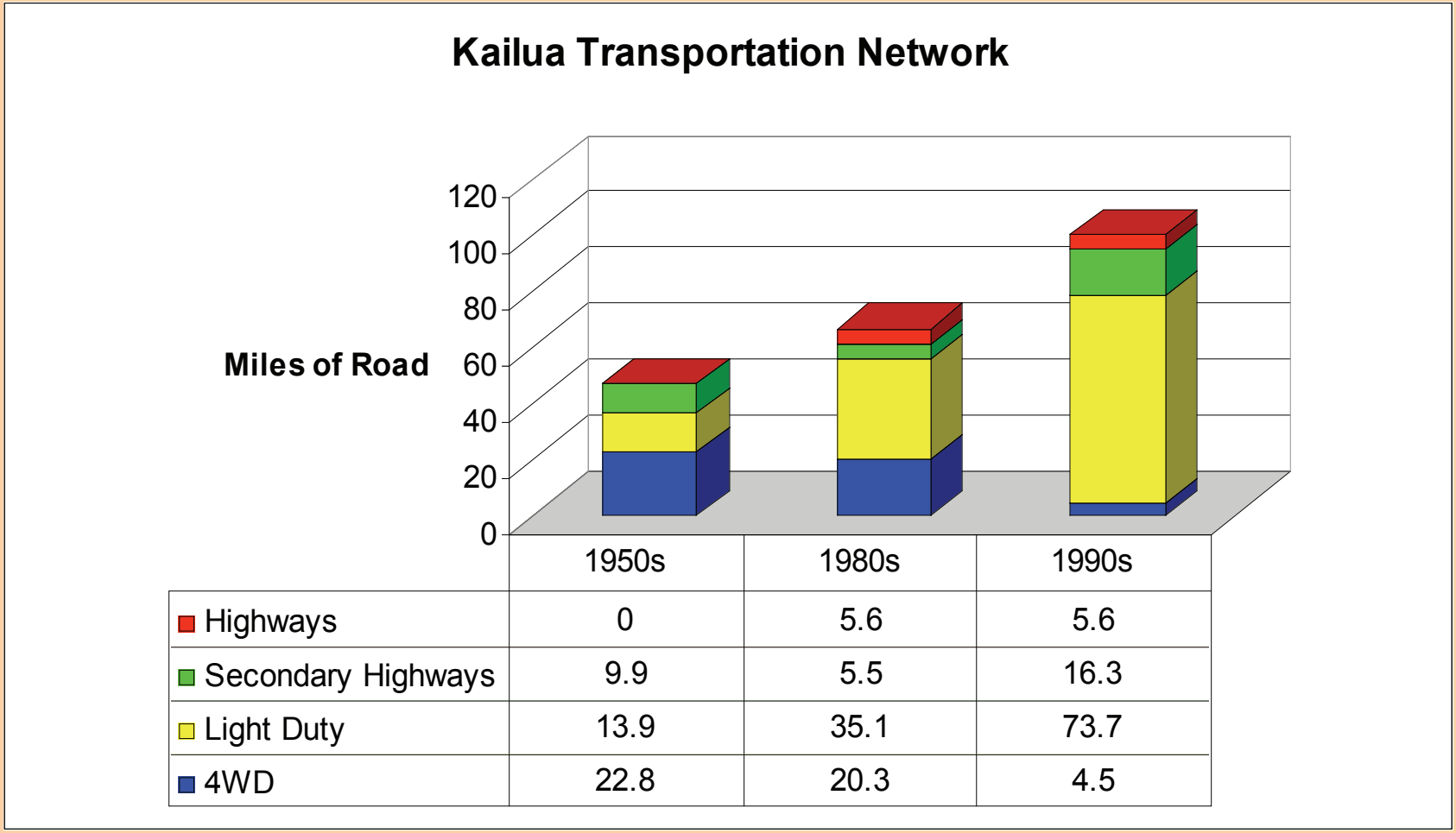






Source: USGS Topographic Maps for Kailua-Kona

Transportation



	1950s	1980s	1990s
Highways	0	5.6	5.6
Secondary Highways	9.9	5.5	16.3
Light Duty	13.9	35.1	73.7
4WD	22.8	20.3	4.5

Hawai'i Department of Business, Economic Development, & Tourism
Data Book Time Series

Metabolism of the tourist industry:
Daily Resource Requirements/ Guest

Table 1: Summary of Infrastructure Demand, Residents and Visitors

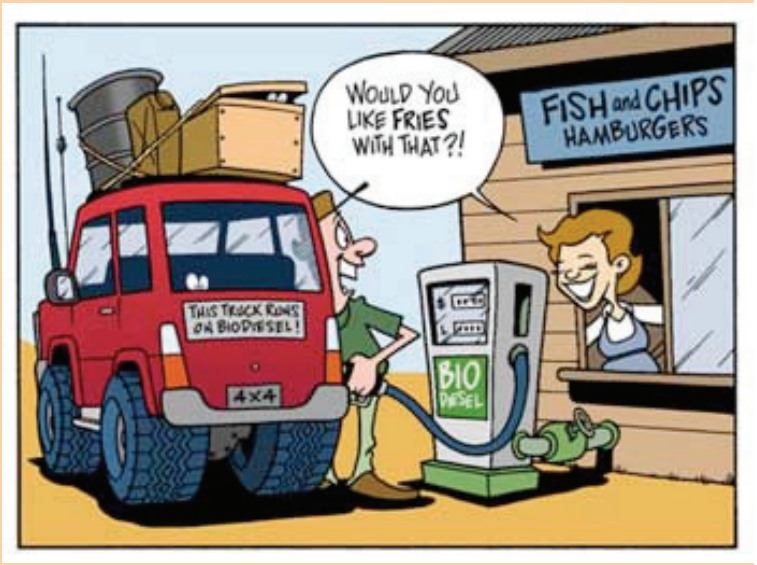
	Water	Sewer	Electric	Utility Gas	Solid Waste	Hwy Gas & Diesel
Total Demand	(m gal)	(m gal)	(GWh)	(mmBtu)	(m lbs)	(m gal)
Residents	61,429	33,587	5,253	1,287,940	2,423.2	353.7
Visitors	11,856	8,022	1,944	1,521,257	421.3	52.1
Daily Per Capita Demand	(gal)	(gal)	(KWh)	mmBtu	(Lbs)	(gal)
Residents	138.9	75.9	11.9	0.003	5.5	0.8
Visitors	206.7	139.8	33.9	0.027	7.3	0.91

Planning for Sustainable Tourism, DBEDT 2005, Modeling Report Summary

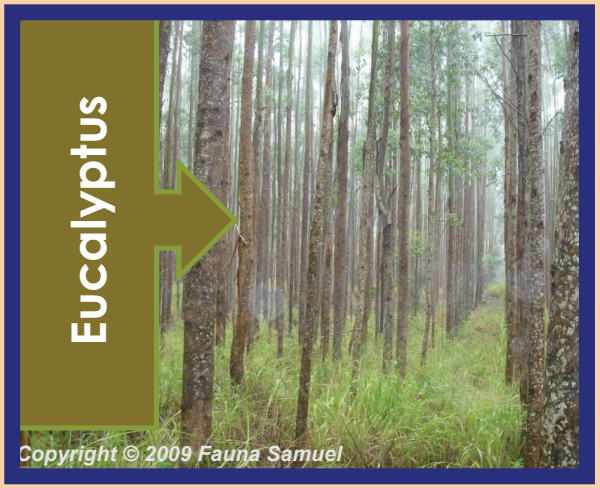
Biodiesel Case Study

Key issues when assessing impacts and viability of biofuel/biodiesel production on Hawai'i Island

- Water use
- Land use
- Energy inputs
- Lag time to production
- Uncertainty of crop yields
- Genetically modified organisms
- Inter-island competition



Feedcrop selection – From many to few



Preliminary findings

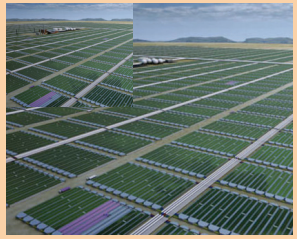
Highest conversion rate

Lowest conversion rate

Scenario #1

372,540 – 606,000 acres

Scenario #2



8,090 – 67,420 acres

Scenario #3

190,315 – 336,710 acres

Source: Yale F&ES – M. Fischer, F. Samuel, H. Sugano , S. Yong, 2009

Challenges I – Complex adaptive systems

- *Dynamic network of multiple agents interacting (acting and reacting) with decentralized control*
- *System adapts to both external forces (climate change, rising oil prices) and internal forces (abundance of prey, legislation banning plastic bags)*
- Examples – Ant colony, transportation network, governments, food production/distribution system
- The case of the food system (http://www.trojanmice.com/index.htm)

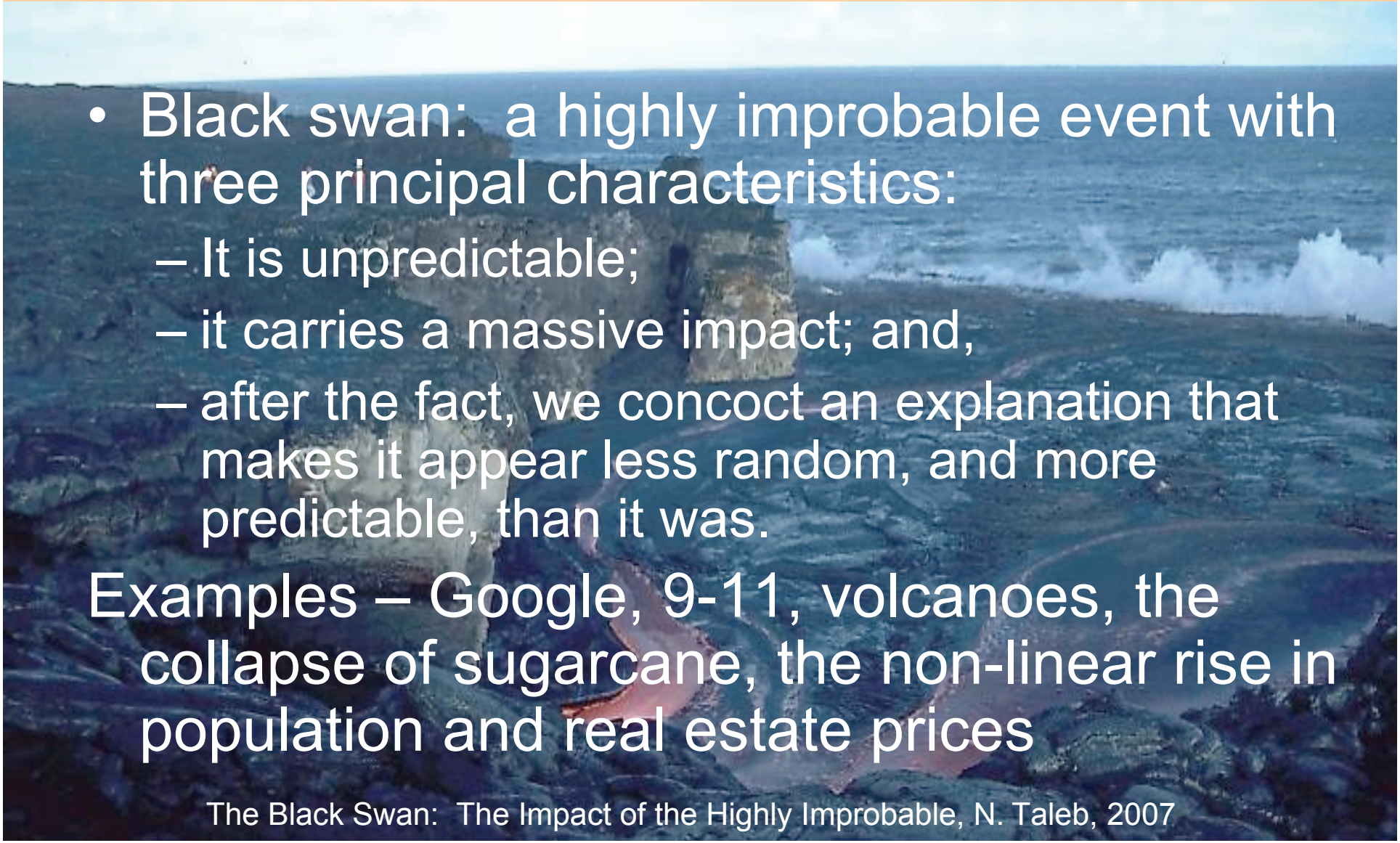
  - 10 day food supply for Hawai'i Island

  - But: no food plan, food manager or other controlling process.

  - Self organizing system of many components constantly adapting to the overall environment

  -Even an individual food shop is itself a system with many parts

Challenges II: Black Swans



- Black swan: a highly improbable event with three principal characteristics:
  - It is unpredictable;
  - it carries a massive impact; and,
  - after the fact, we concoct an explanation that makes it appear less random, and more predictable, than it was.

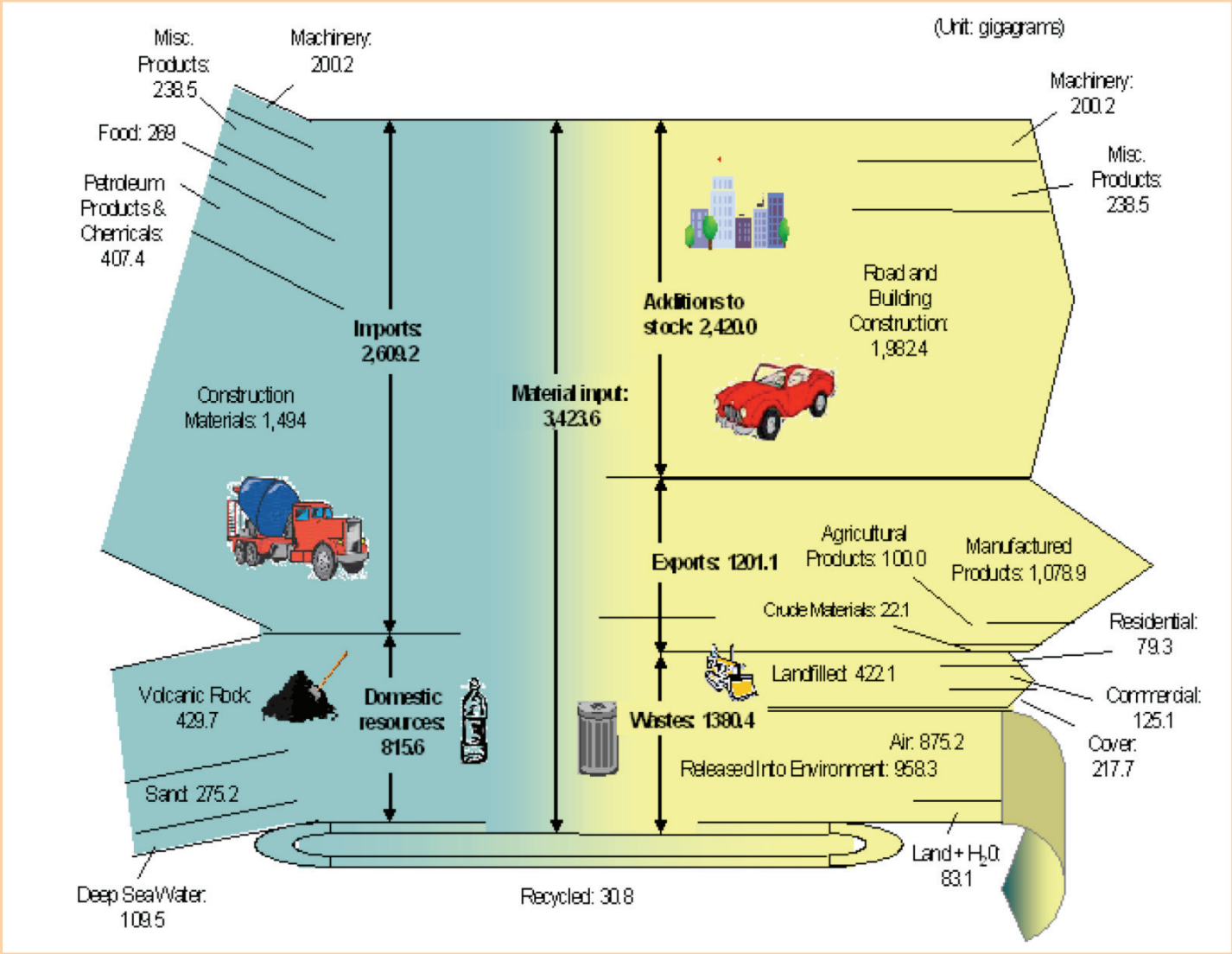
Examples – Google, 9-11, volcanoes, the collapse of sugarcane, the non-linear rise in population and real estate prices

The Black Swan: The Impact of the Highly Improbable, N. Taleb, 2007

Some useful tools I:
Land use/satellite image analysis

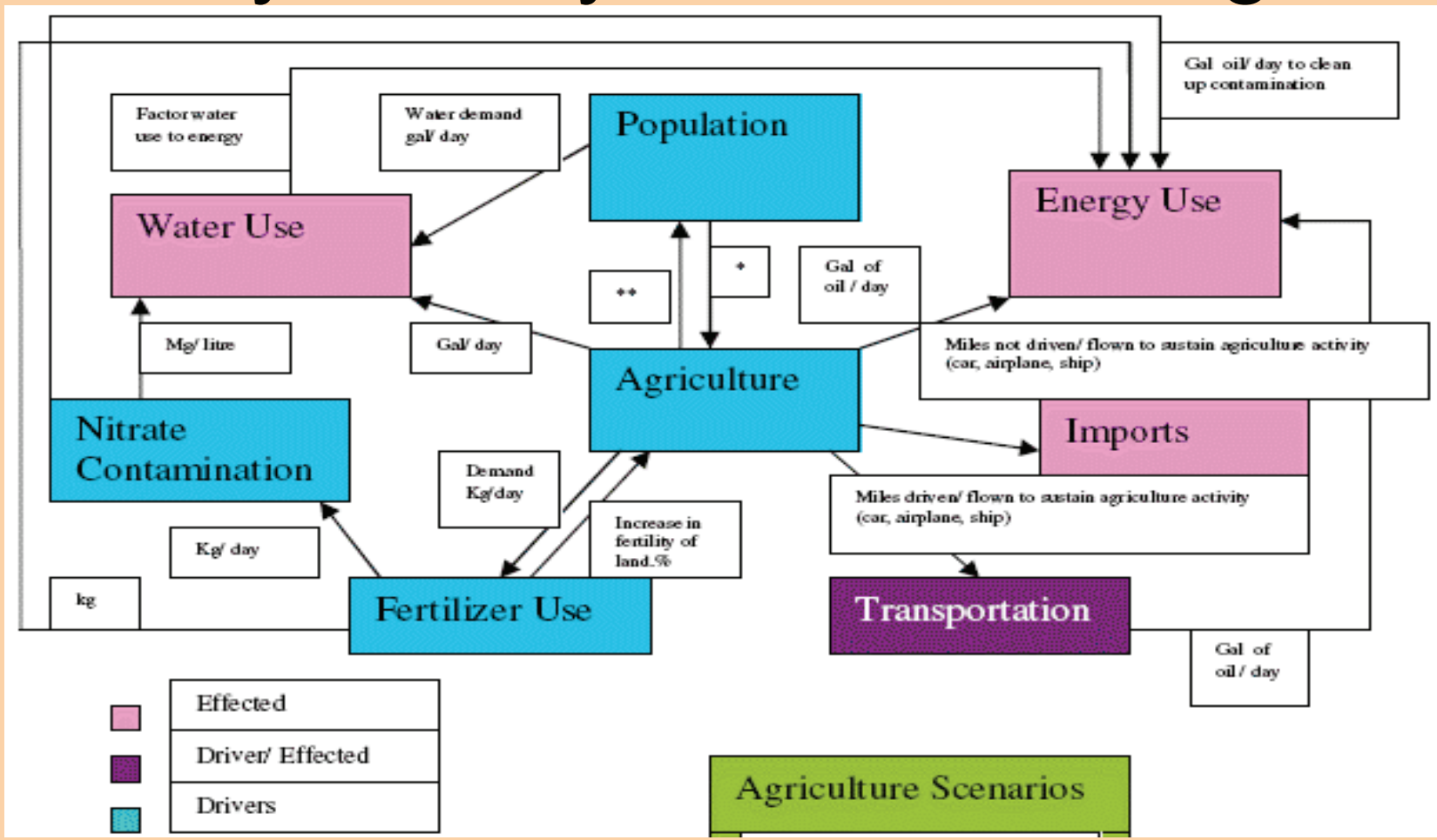
Can you analyze this appropriately “East-West” satellite image from earlier this year?

Some useful tools II: Material Flow Analysis



Source: Yale F&ES Houseknecht, Kim, and Whitman, 2006

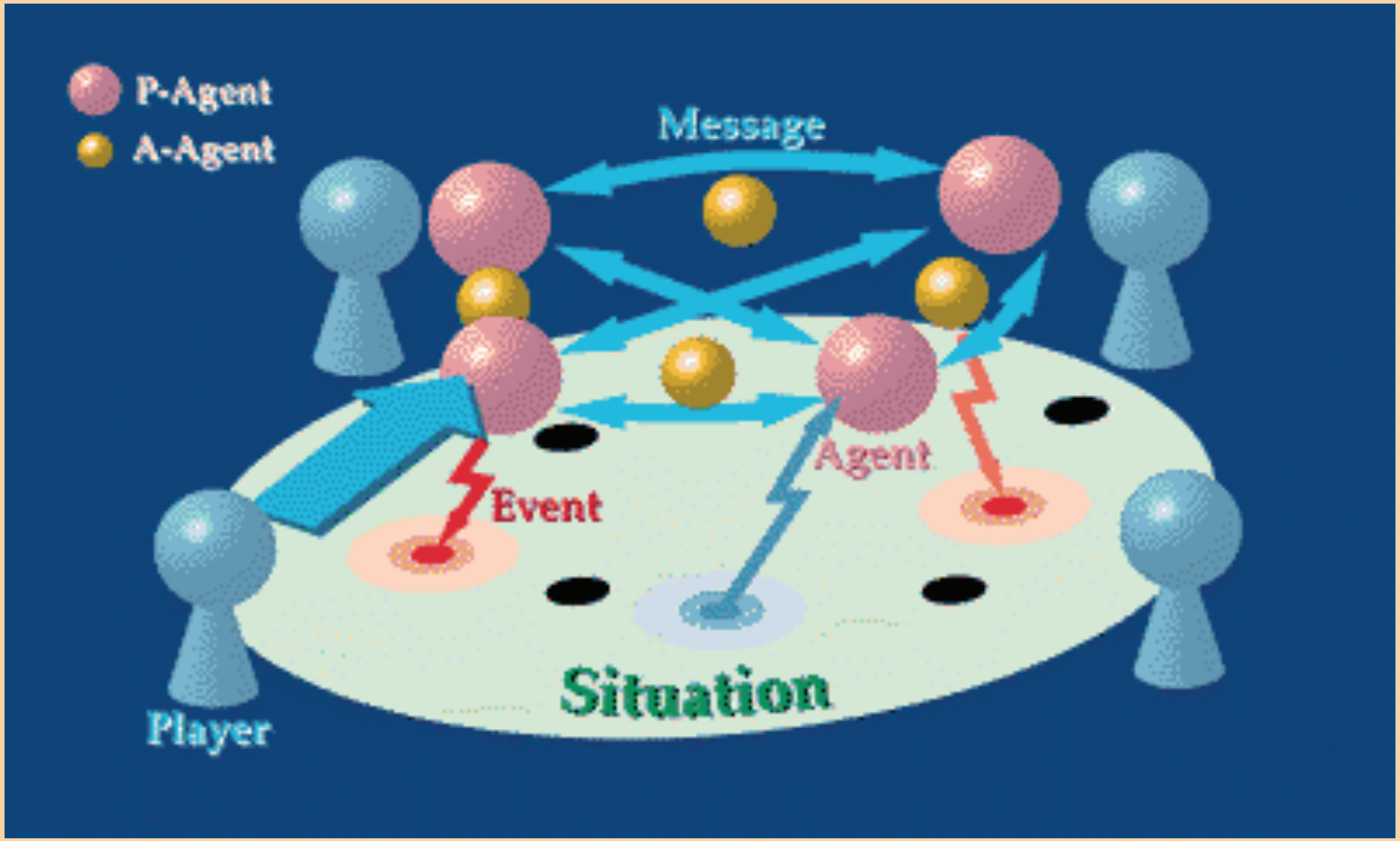
Some useful tools III: System dynamic modeling



Task: Develop a dynamic model to describe and predict water use of Hawaii

Source: Yale F&ES – Fugate, Gelmann, Hospodsky, Michelangelo, Tanuma

Some useful tools IV: Agent-based modeling



Steps for organizing the study

- Summer plans –
  - Social ecological issues
  - First look at protocols
  - Examine grant opportunities

- Scope organizational issues with the County and the Kohala Center

Mahalo and Discussion

marian.chertow@yale.edu