Hawai`i as a Model System for Understanding Life, Land, and Culture – and what they mean for Sustainability

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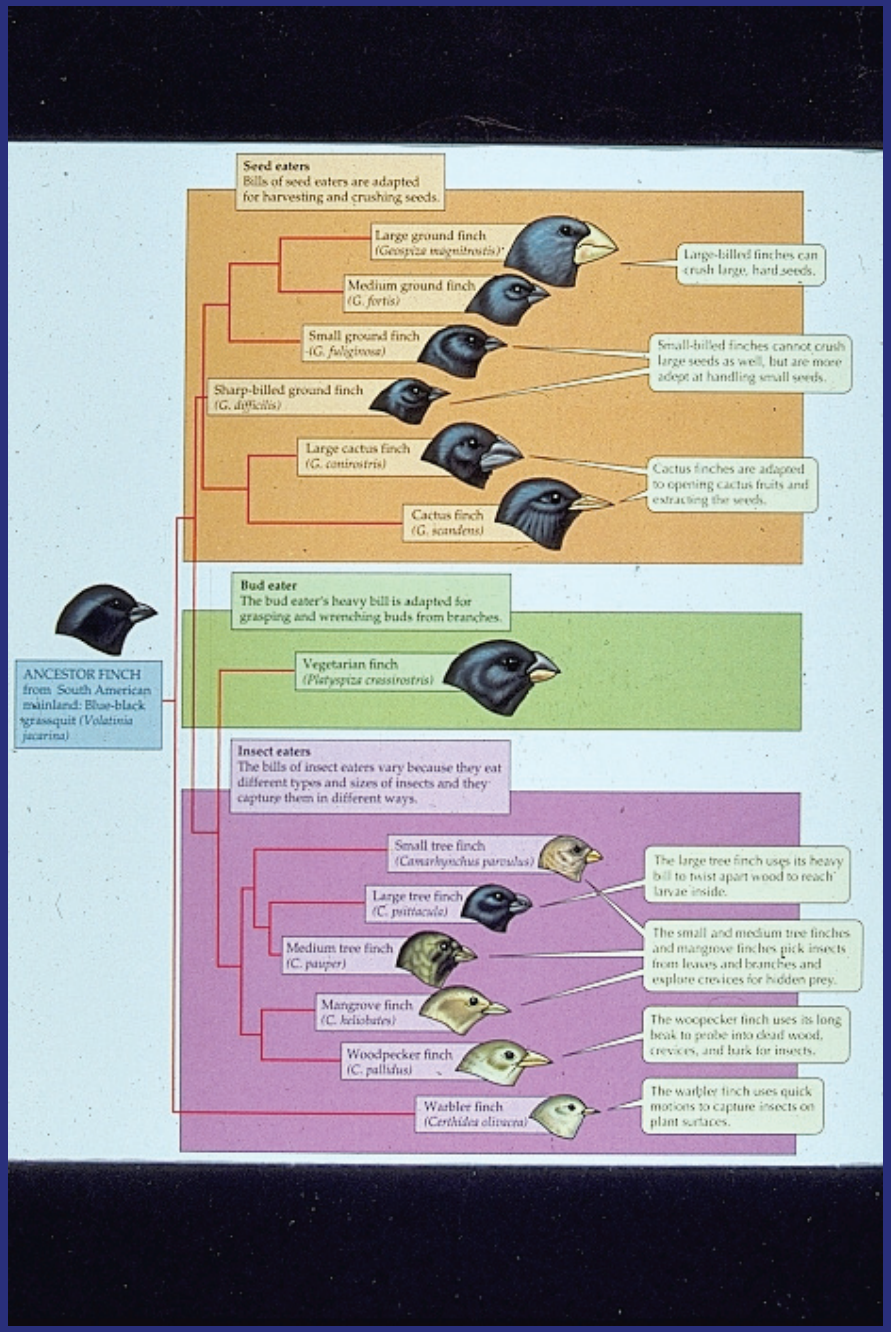
Model Systems – Molecular Biology

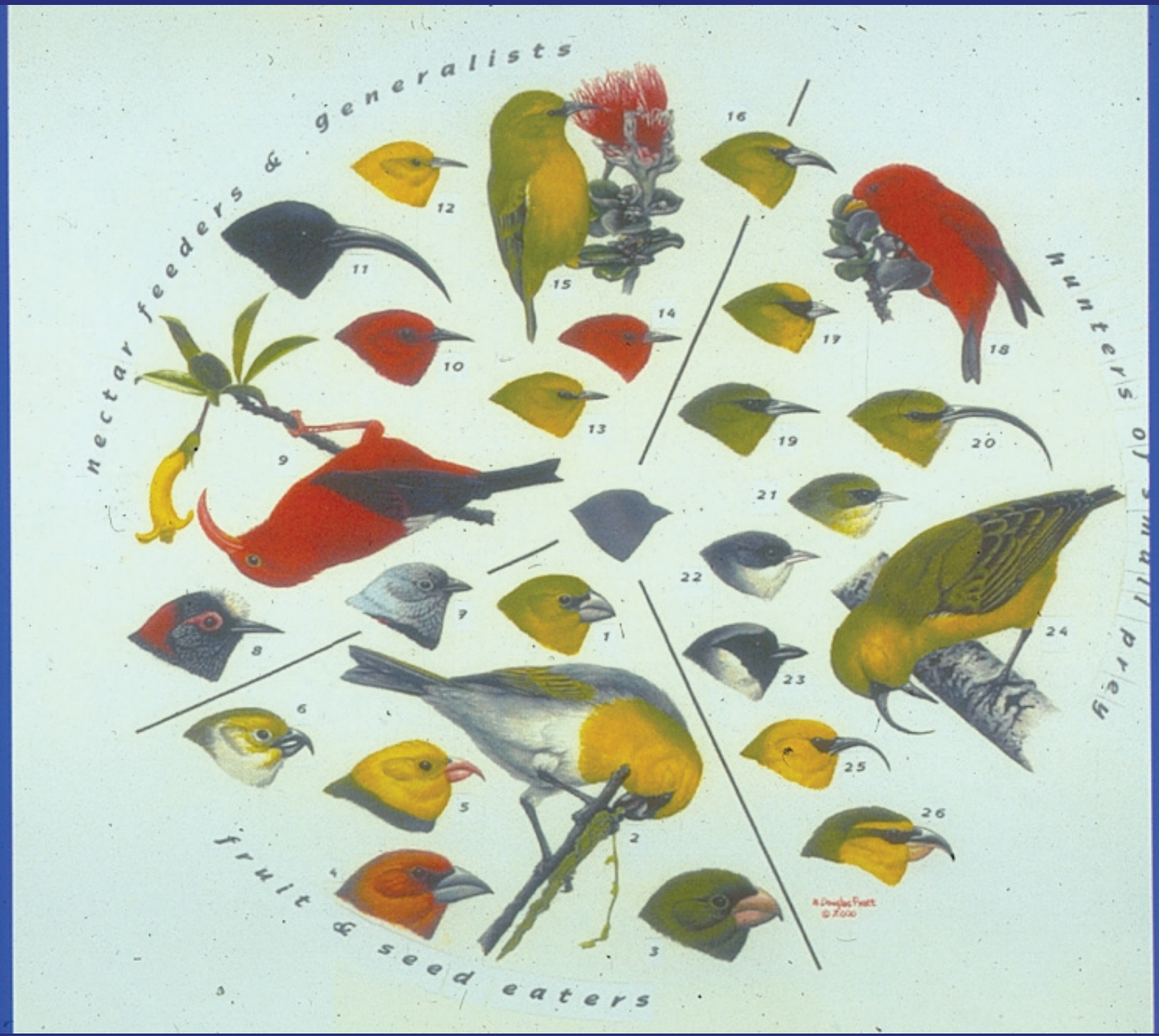
The nematode *C. elegans* exhibits all of the properties of multicellular organisms – yet it is only 1 mm long, can be grown as a microorganism, and all 959 of its cells are readily visible. It thus provides the researcher with an ideal compromise between complexity and tractability.

C. elegans web site

Hawai`i as a Model System

- Evolution and the origin of species
- Structure and functioning of ecosystems
- The development and sustainability of human societies


Seed eaters
Bills of seed eaters are adapted for harvesting and crushing seeds.
Large ground finch (Geospiza magnirostris)
Medium ground finch (G. fortis)
Small ground finch (G. fuliginosa)
Sharp-billed ground finch (G. difficilis)
Large cactus finch (G. conirostris)
Cactus finch (G. scandens)
Large-billed finches can crush large, hard seeds.
Small-billed finches cannot crush large seeds as well, but are more adept at handling small seeds.
Cactus finches are adapted to opening cactus fruits and extracting the seeds.
Bud eater
The bud eater's heavy bill is adapted for grasping and wrenching buds from branches.
Vegetarian finch (Platyspiza crassirostris)
ANCESTOR FINCH from South American mainland: Blue-black grassquit (Volatinia jacarina)
Insect eaters
The bills of insect eaters vary because they eat different types and sizes of insects and they capture them in different ways.
Small tree finch (Camarhynchus parvulus)
Large tree finch (C. psittacula)
Medium tree finch (C. pauper)
Mangrove finch (C. heliobates)
Woodpecker finch (C. pallidus)
Warbler finch (Certhidea olivacea)
The large tree finch uses its heavy bill to twist apart wood to reach larvae inside.
The small and medium tree finches and mangrove finches pick insects from leaves and branches and explore crevices for hidden prey.
The woodpecker finch uses its long beak to probe into dead wood, crevices, and bark for insects.
The warbler finch uses quick motions to capture insects on plant surfaces.


nectar feeders & generalists
hunters of small prey
fruit & seed eaters
1
2
3
5
6
8
9
10
11
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25
26

Islands as Model Systems

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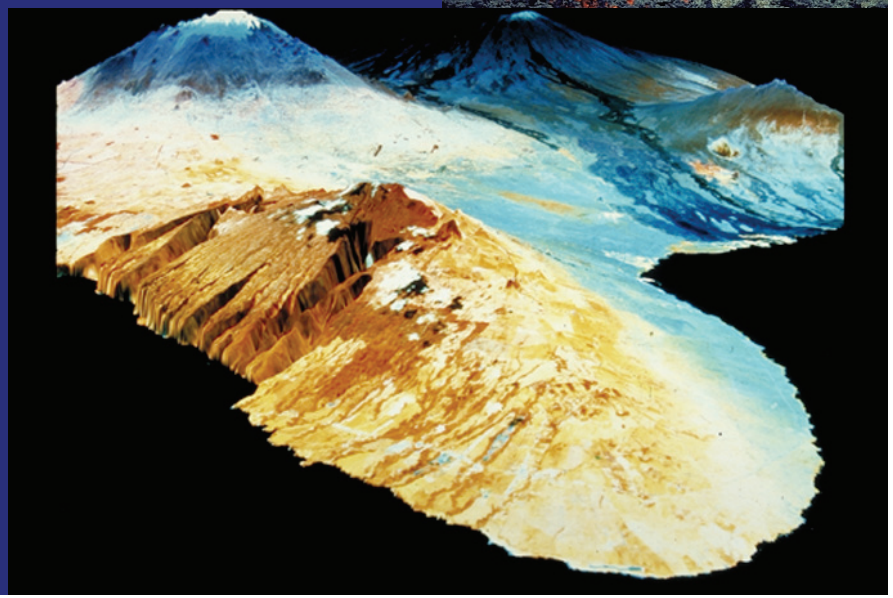
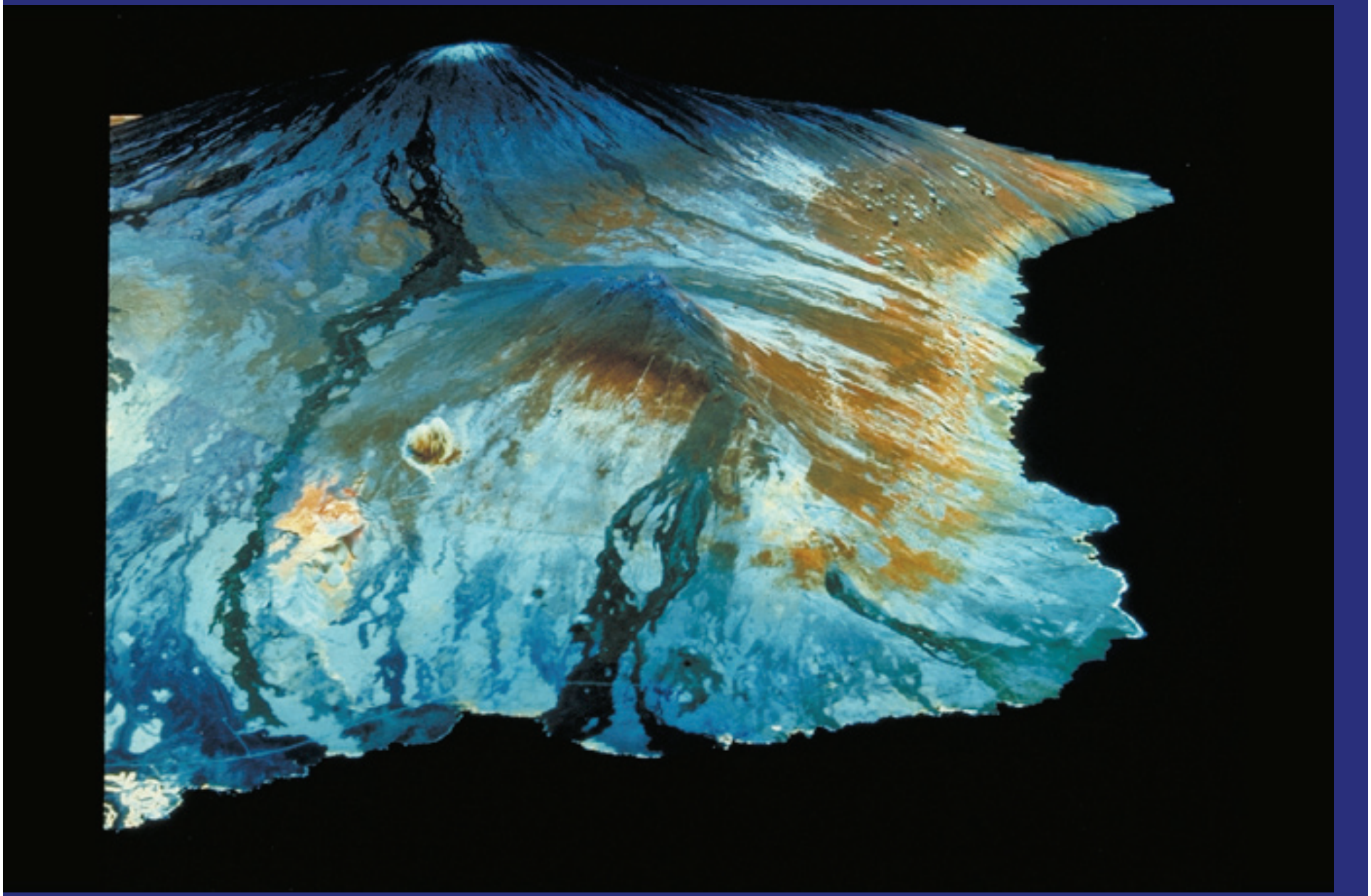
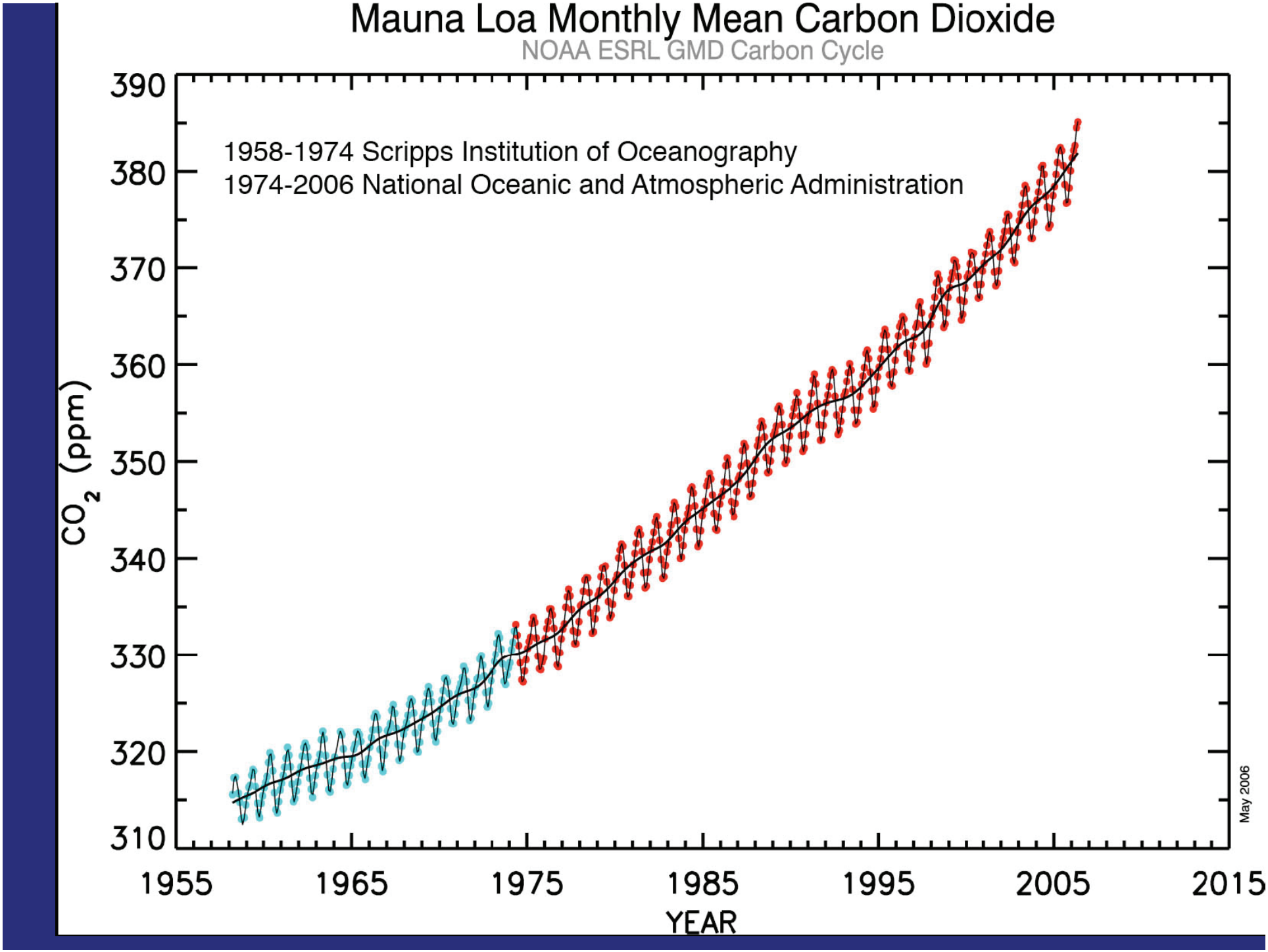
Why Ecosystems?

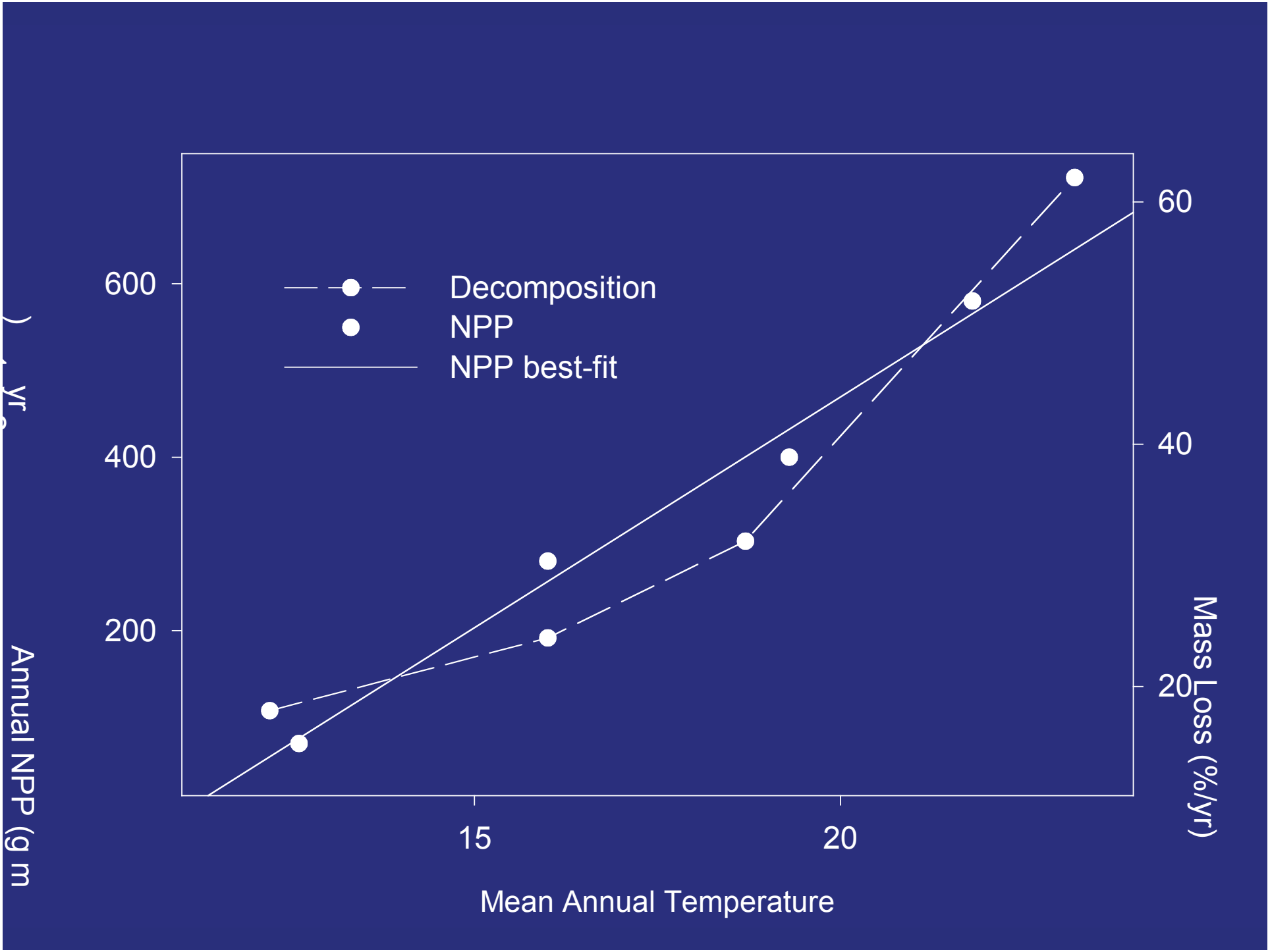
Relative simplicity. All basalt, low diversity, volcanic topography.

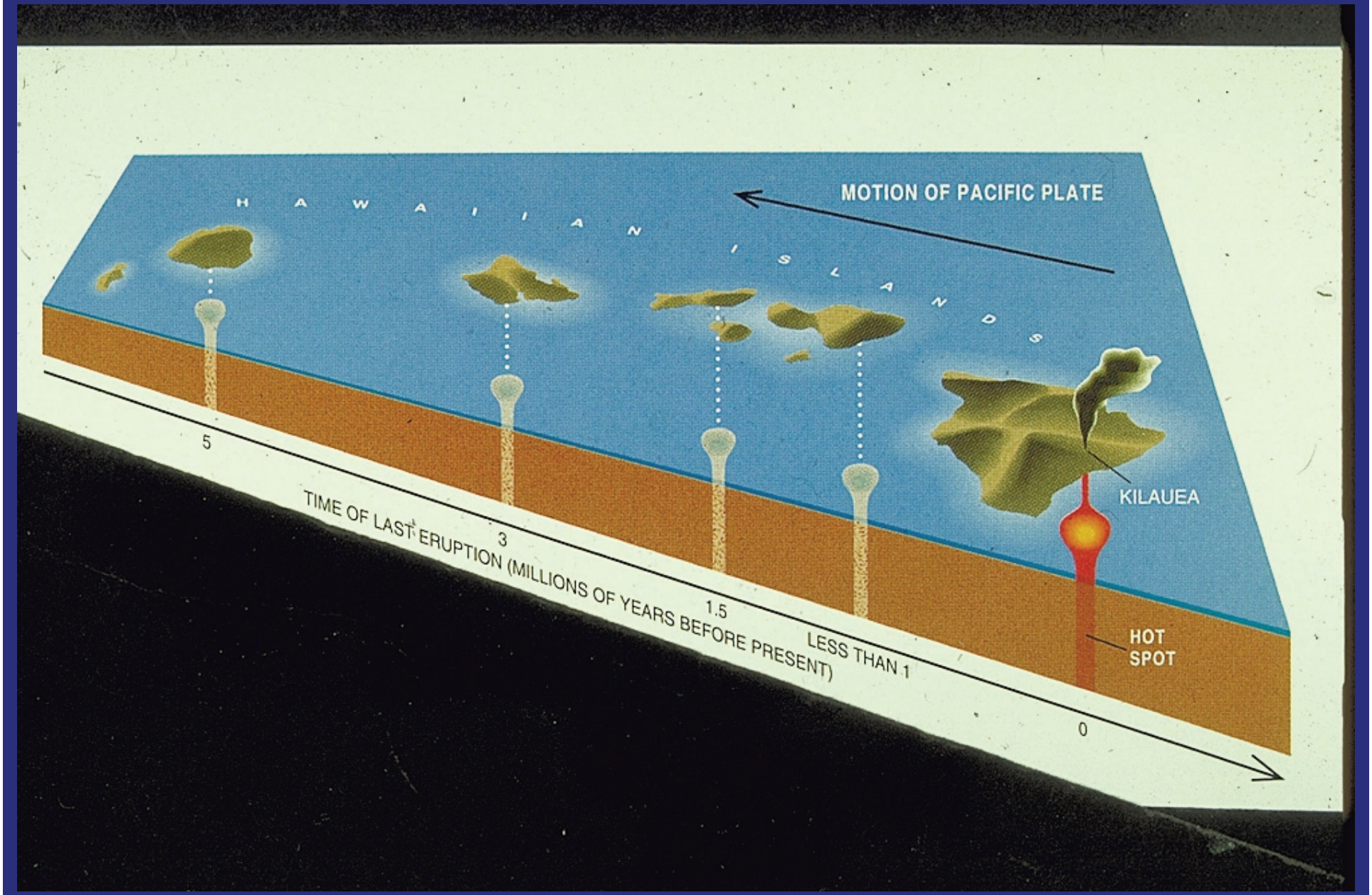
Continuous gradients. Well-defined substrate ages, spectacular rainfall gradients.






Mauna Loa Monthly Mean Carbon Dioxide
NOAA ESRL GMD Carbon Cycle
1958-1974 Scripps Institution of Oceanography
1974-2006 National Oceanic and Atmospheric Administration
CO2 (ppm)
390
380
370
360
350
340
330
320
310
1955
1965
1975
1985
1995
2005
2015
YEAR
May 2006


Decomposition
NPP
NPP best-fit
600
400
200
15
20
60
40
20
Mass Loss (%/yr)
Mean Annual Temperature

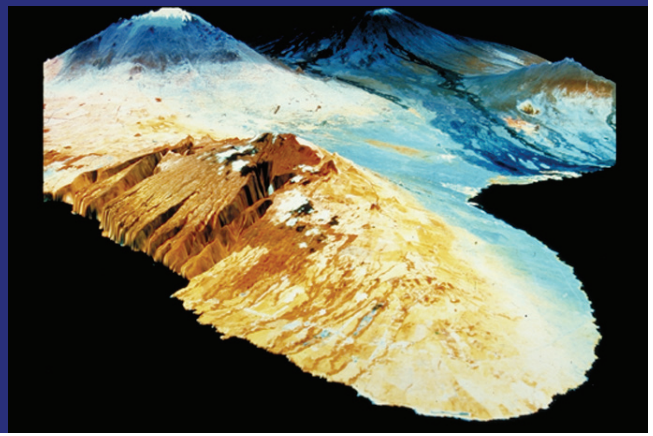

HAWAIIAN ISLANDS
MOTION OF PACIFIC PLATE
KILAUEA
HOT SPOT
5
3
1.5
LESS THAN 1
0
TIME OF LAST ERUPTION (MILLIONS OF YEARS BEFORE PRESENT)

Why Ecosystems?

Relative simplicity. All basalt, low diversity, volcanic topography.

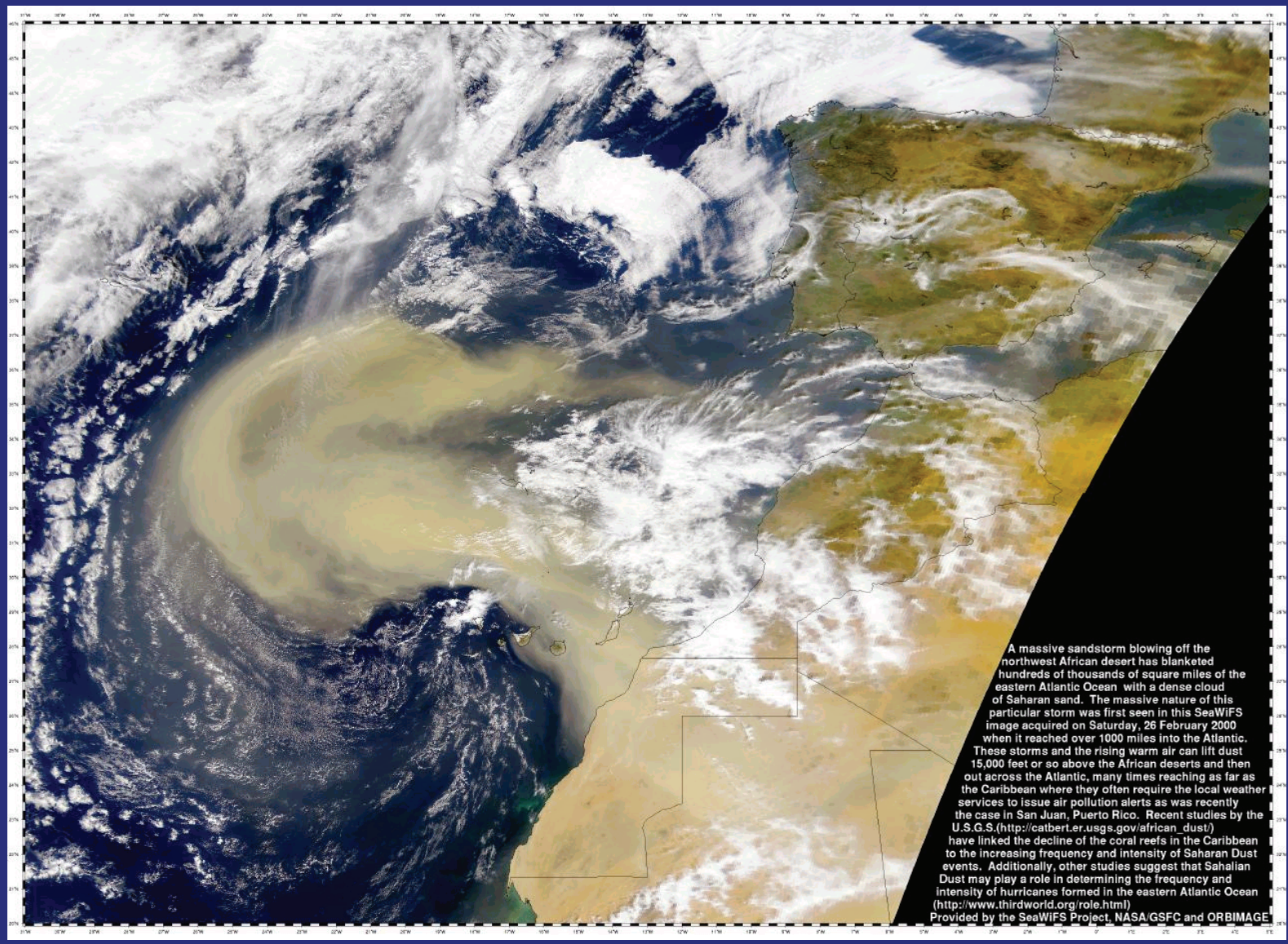
Continuous gradients. Well-defined substrate ages, spectacular rainfall gradients.

Distinctive rock chemistry. Mantle source, with isotopic signature from basalt weathering (determined using element/Nb ratios) different from the ocean (using $^{87}Sr/^{86}Sr$), continental crust (using $^{143}Nd/^{144}Nd$).



Rock, Rain, and Dust

- In young soils, most of the nutrients that forests need come from the breakdown of lava rock
- Where it's wet, rock is depleted of most of its nutrients by a few tens of thousands of years, and most nutrients (not phosphorus) come from rain and cloudwater
- Phosphorus from lava lasts longer - a good thing, because there is very little in rain. However, by 1.5 million yrs most of the phosphorus from rock is gone. Thereafter, the trickle of dust blown in from Asia (mostly during Ice Ages) is the most important source of phosphorus to Hawaiian forests



A massive sandstorm blowing off the northwest African desert has blanketed hundreds of thousands of square miles of the eastern Atlantic Ocean with a dense cloud of Saharan sand. The massive nature of this particular storm was first seen in this SeaWiFS image acquired on Saturday, 26 February 2000 when it reached over 1000 miles into the Atlantic. These storms and the rising warm air can lift dust 15,000 feet or so above the African deserts and then out across the Atlantic, many times reaching as far as the Caribbean where they often require the local weather services to issue air pollution alerts as was recently the case in San Juan, Puerto Rico. Recent studies by the U.S.G.S.(http://catbert.er.usgs.gov/african_dust/) have linked the decline of the coral reefs in the Caribbean to the increasing frequency and intensity of Saharan Dust events. Additionally, other studies suggest that Sahalian Dust may play a role in determining the frequency and intensity of hurricanes formed in the eastern Atlantic Ocean (http://www.thirdworld.org/role.html)

Provided by the SeaWiFS Project, NASA/GSFC and ORBIMAGE

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Model Systems - Culture

In the Pacific, history has given us an unparalleled opportunity to compare what literally hundreds of societies have wrought, at times in highly similar environments, at times in strikingly different ones. It is not only the range of environmental variation among isolated Pacific islands, but also the demonstrable fact that many societies had common origins, that renders them such marvelous microcosms – such wonderful natural and cultural experiments – of history.

Kirch 2000

Polynesian voyagers arrived in the Hawaiian Archipelago around A.D. 700-800

Hokule'a off the windward Moloka'i coast

Polynesian Agriculture

- Features of both the society and the land make human-land interactions more accessible to understanding in Polynesia than anywhere else

- Hawaiians in particular were great farmers, intensifying agriculture by very different pathways in the very different lands that they farmed

- The most significant contrast was irrigated wetland cultivation (lo`i kalo) versus rain-fed dryland agriculture (uala and other crops)

- The mode of agricultural production shaped (in part) the development of society – in Hawai'i as elsewhere