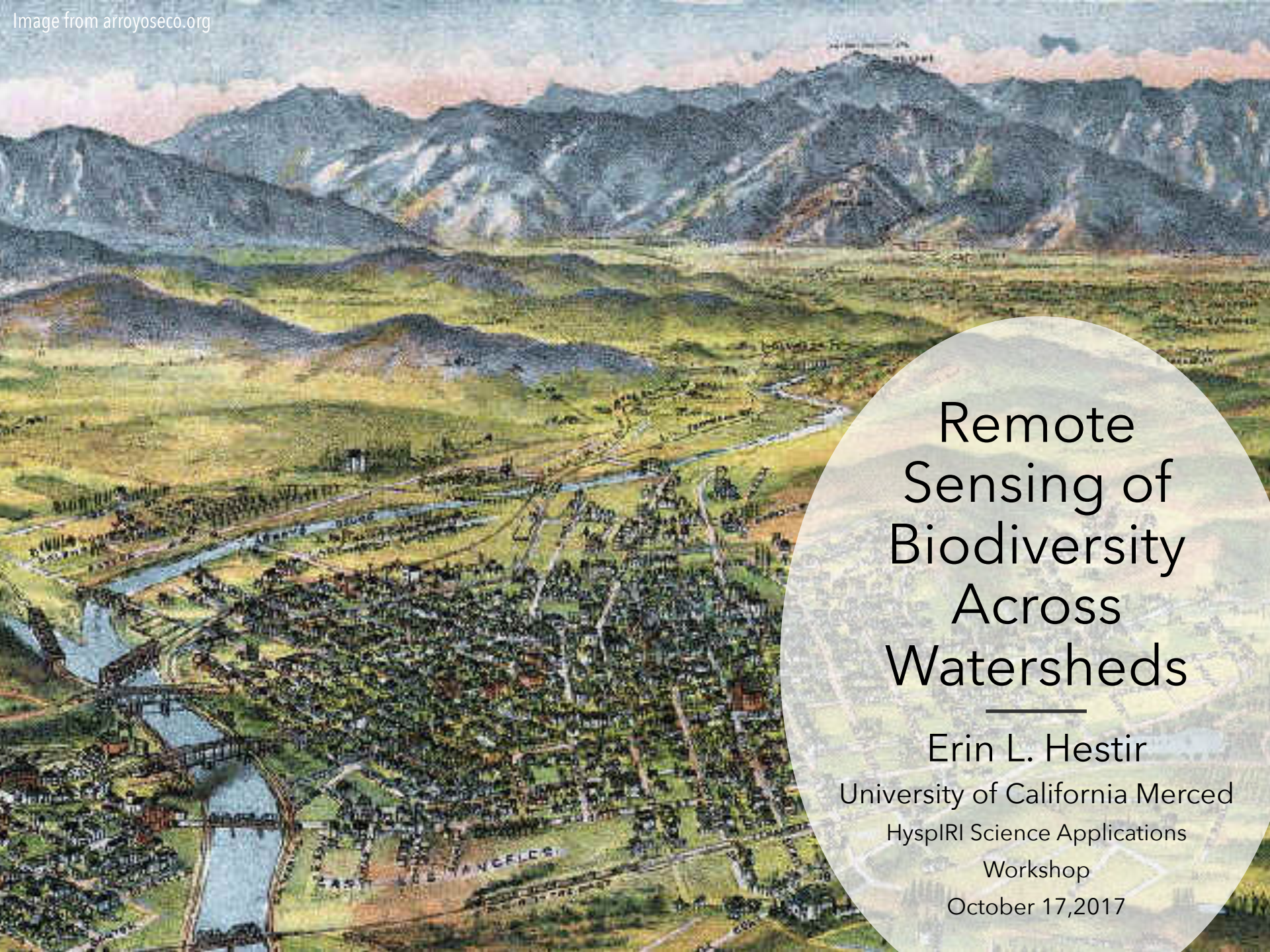
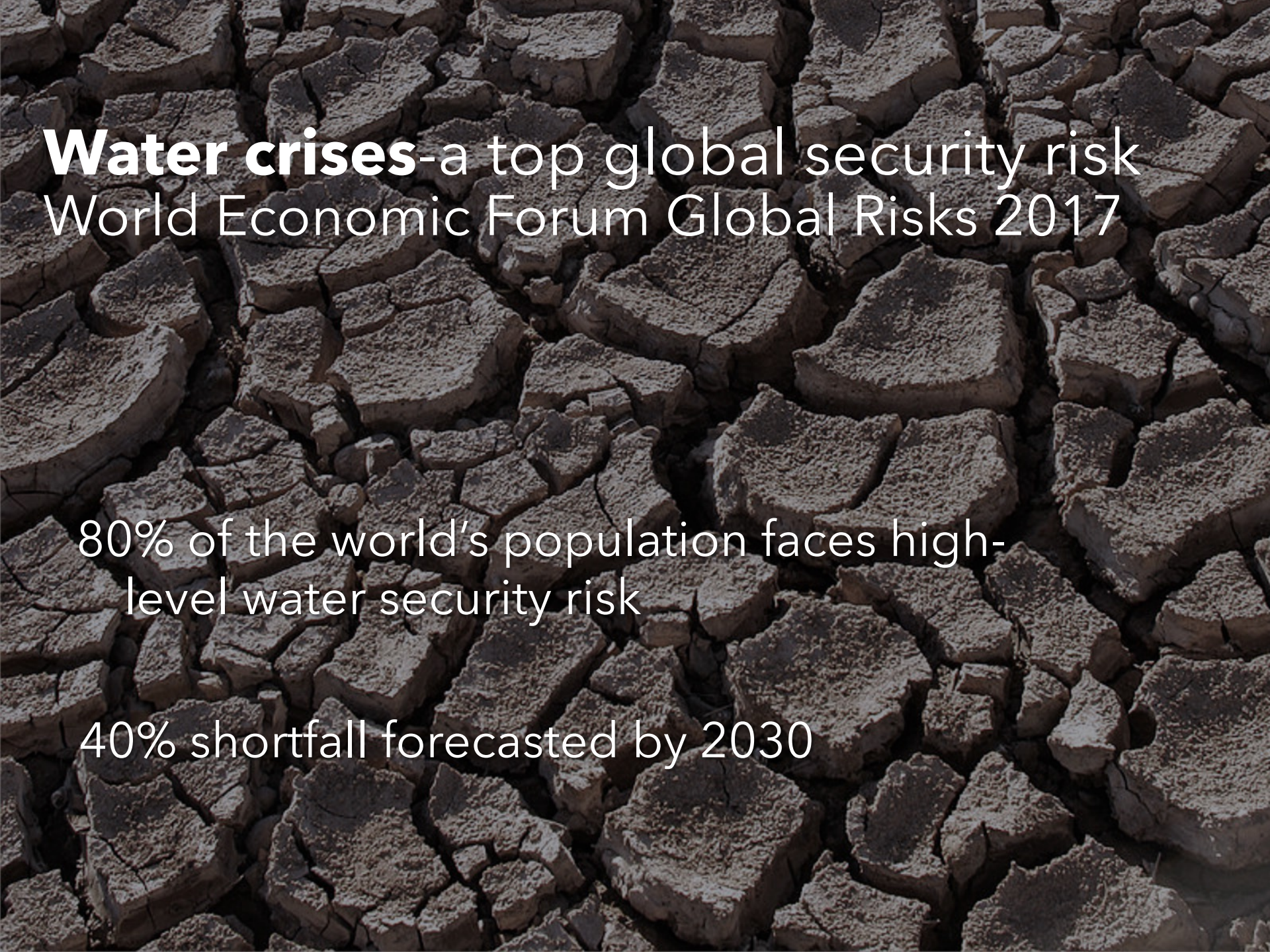


Remote Sensing of Biodiversity Across Watersheds

Erin L. Hestir
University of California Merced

HyspIRI Science Applications Workshop

October 17,2017

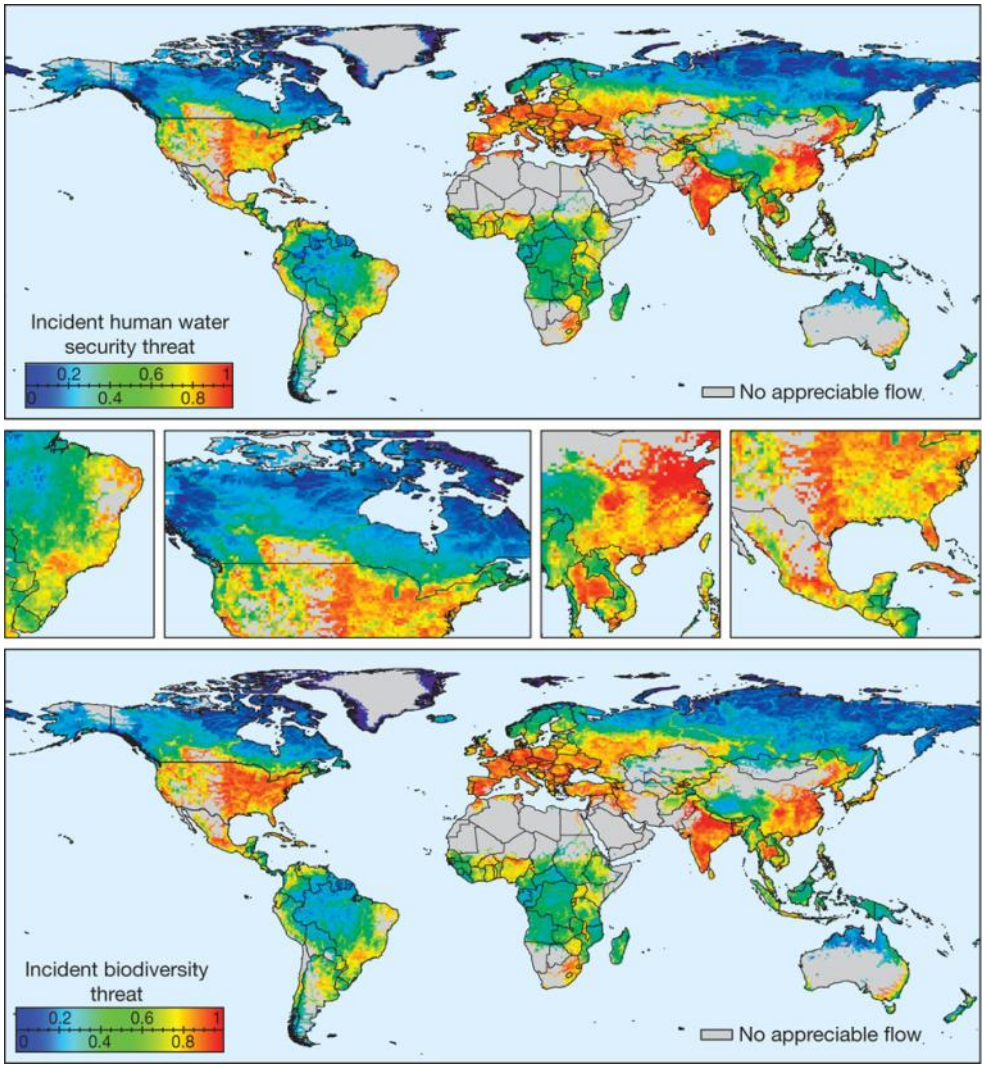


Water crises-a top global security risk
World Economic Forum Global Risks 2017

80% of the world's population faces high-level water security risk

40% shortfall forecasted by 2030

Water security and biodiversity



"A strikingly small fraction of the world's rivers remain unaffected by humans" Vorosmarty et al. 2010

ARTICLE

nature
doi:10.1038/nature094

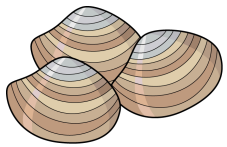
Global threats to human water security and river biodiversity

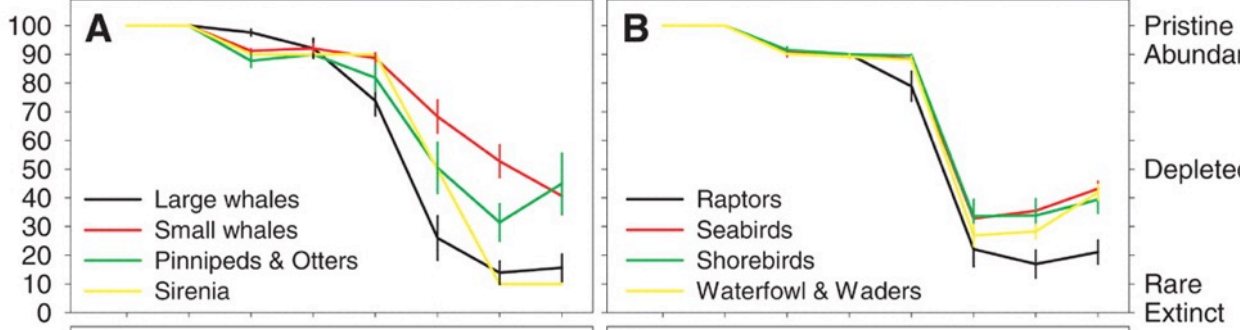
C. J. Vörösmarty[1]*, P. B. McIntyre[2]*†, M. O. Gessner[3], D. Dudgeon[4], A. Prusevich[5], P. Green[1], S. Glidden[5], S. E. Bunn[6], C. A. Sullivan[7], C. Reidy Liermann[8] & P. M. Davies[9]

Marine mammals

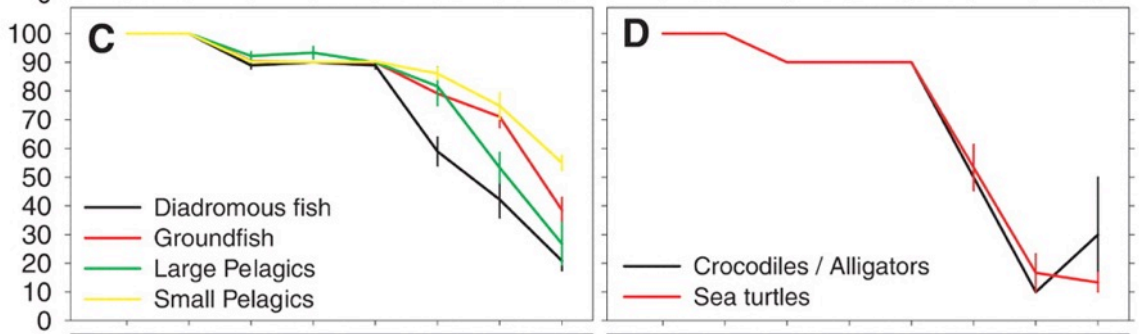
Fish

Invertebrates

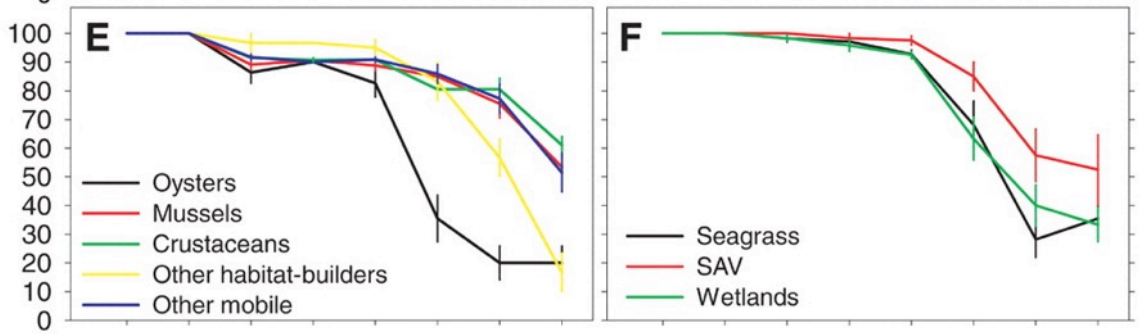




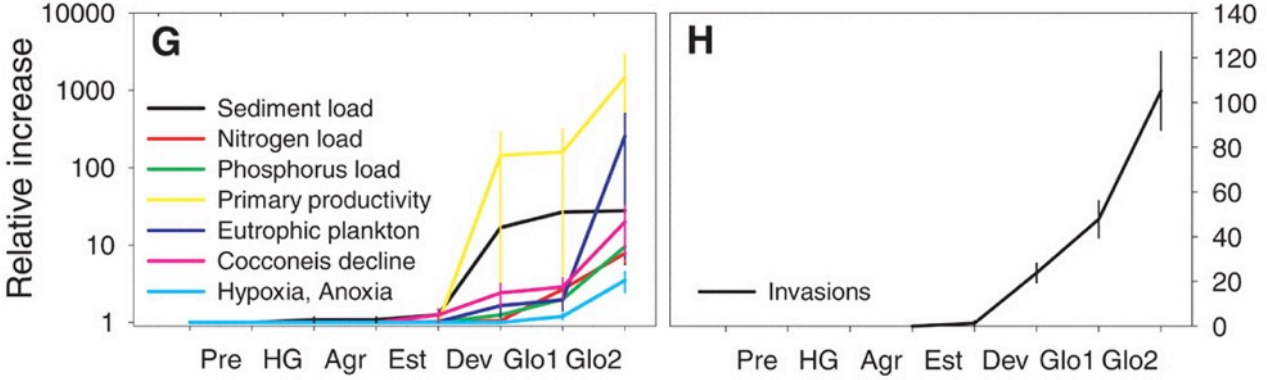
Coastal Birds



Reptiles

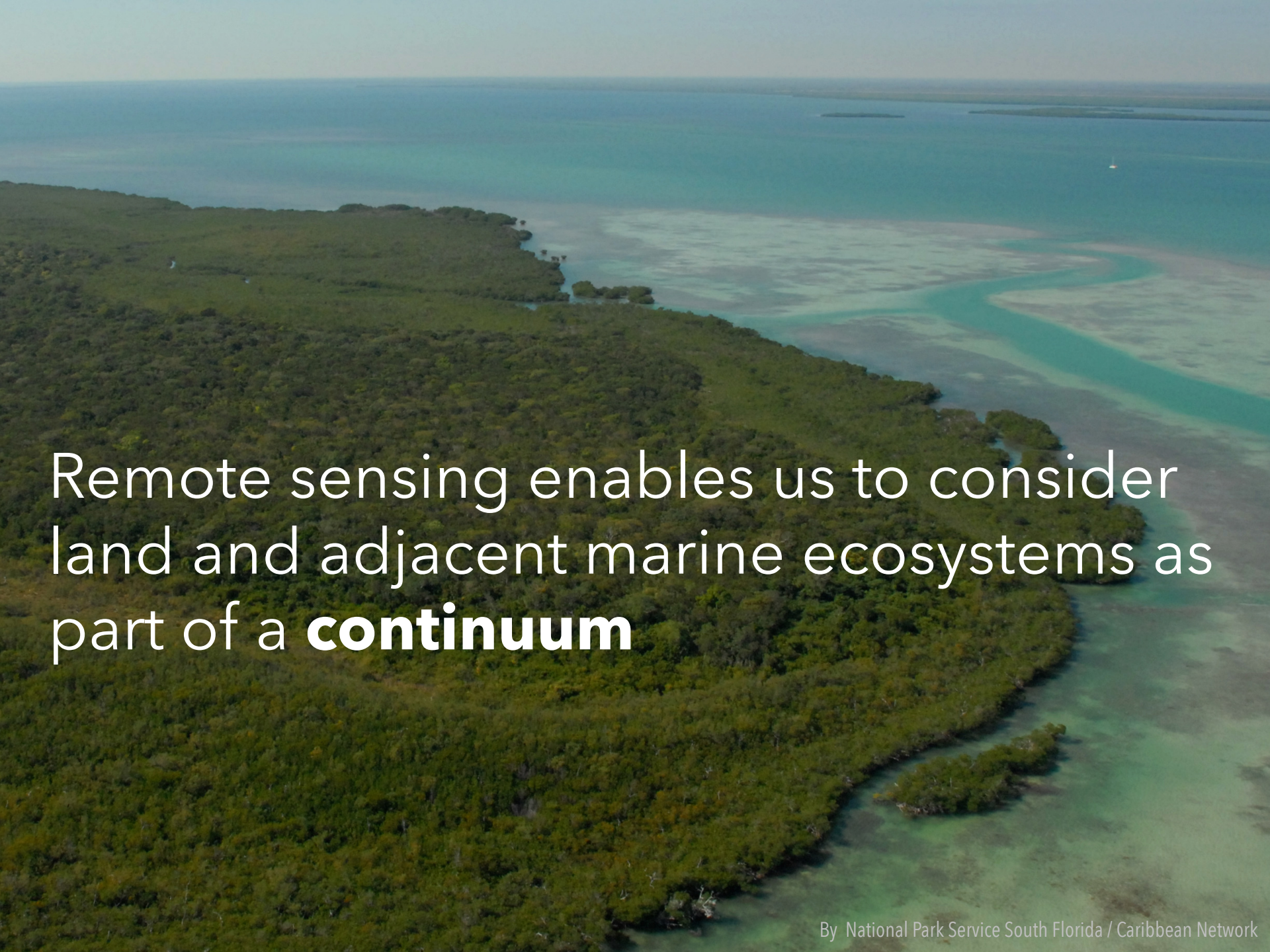


Vegetation

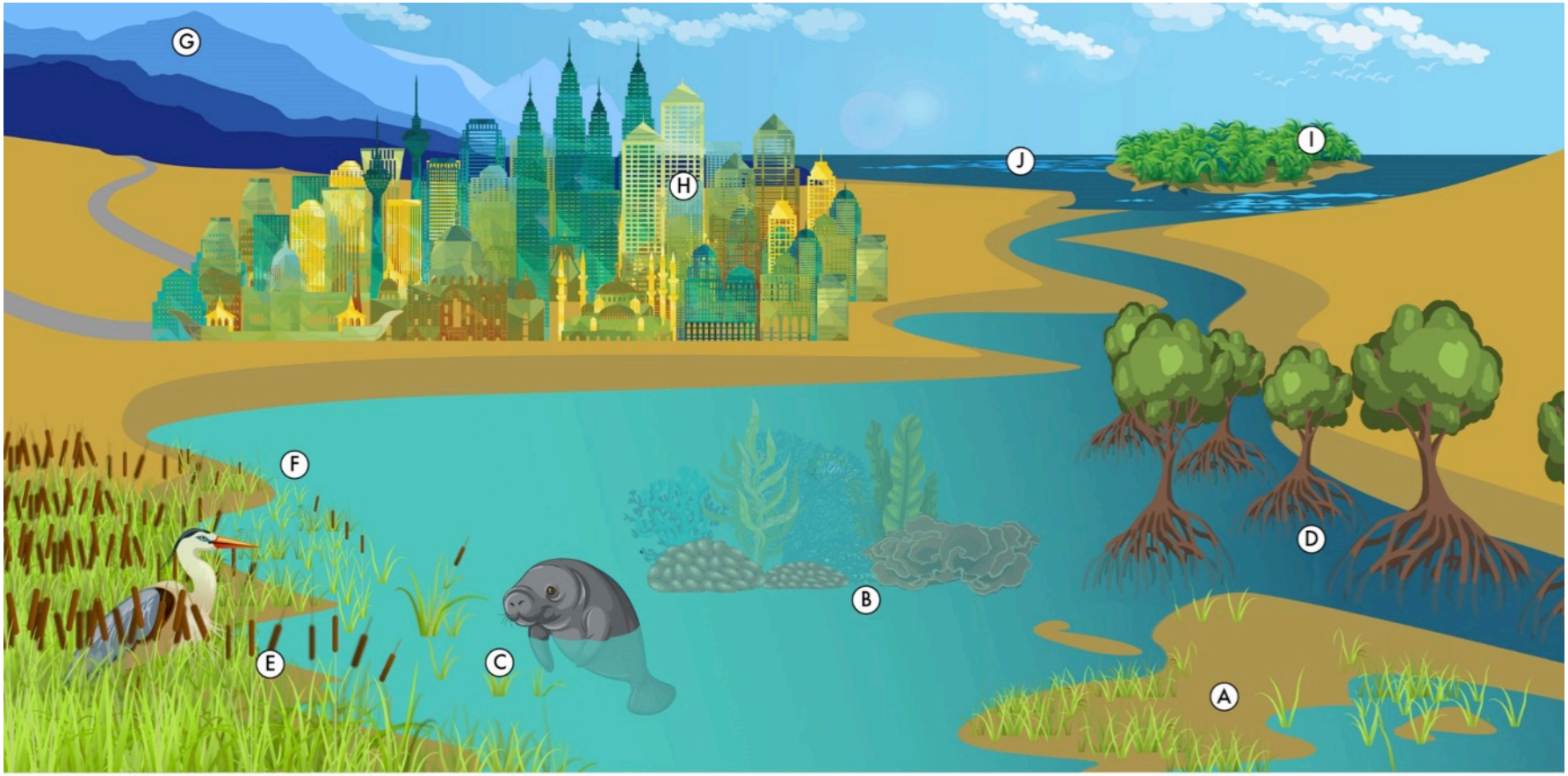


Cultural Period

[Heike K. Lotze et al. Science 2006;312:1806-1809]

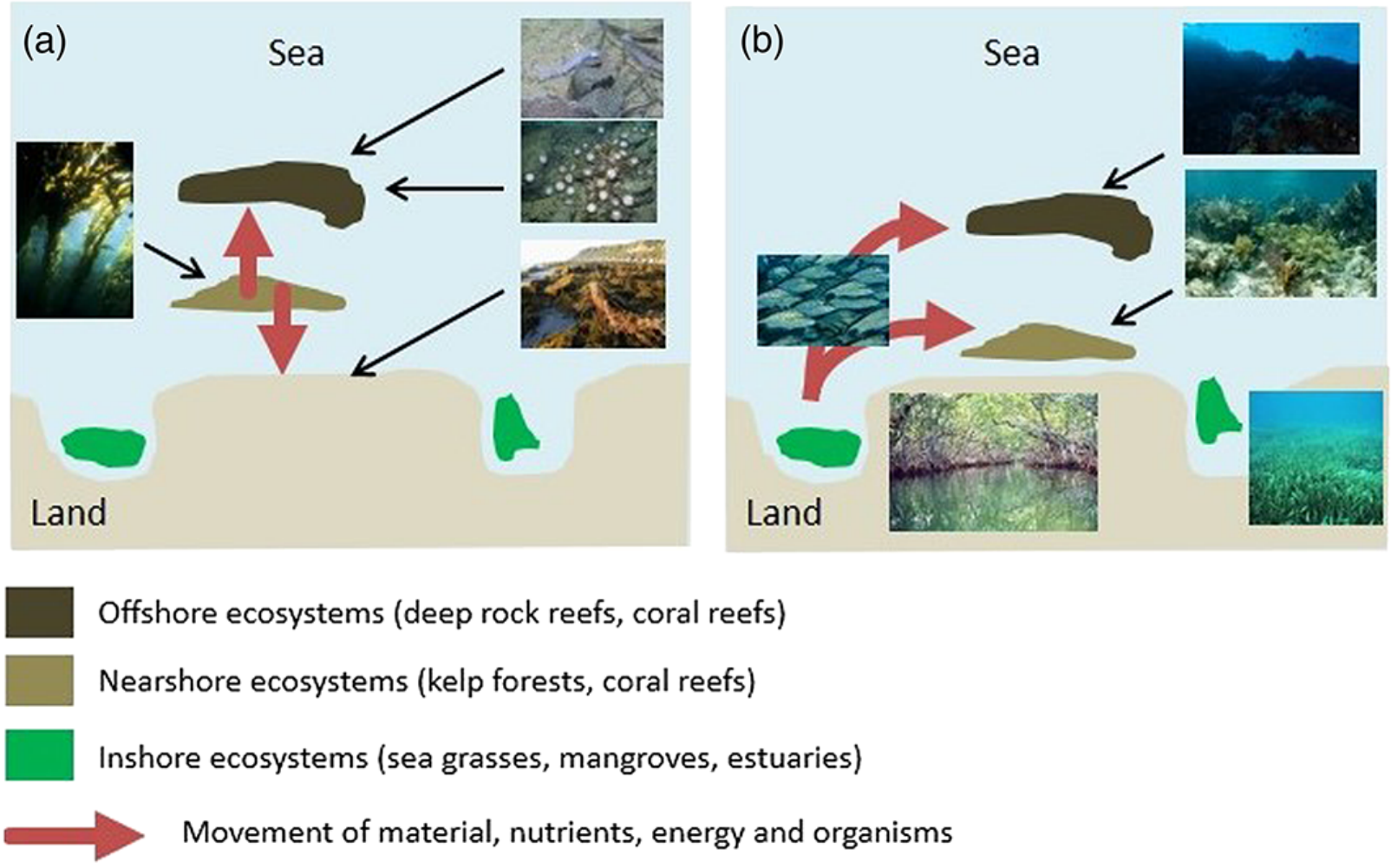

Remote sensing enables us to consider land and adjacent marine ecosystems as part of a **continuum**
By National Park Service South Florida / Caribbean Network

Catchments to coasts: watersheds as organizing units for fluxes and biodiversity



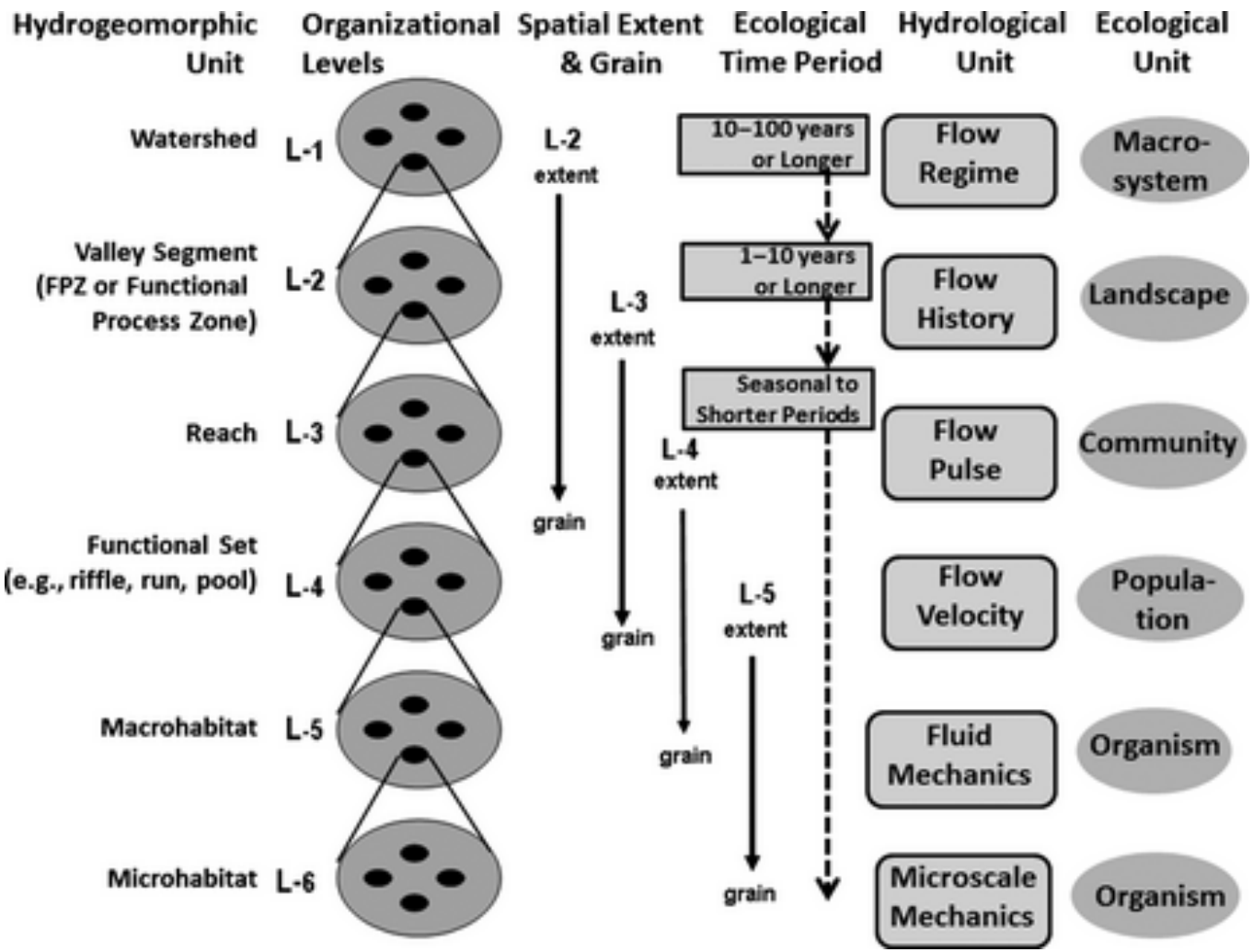
Watersheds provide a mosaic of habitats in a non-equilibrium system = many species

The central importance of ecological spatial connectivity



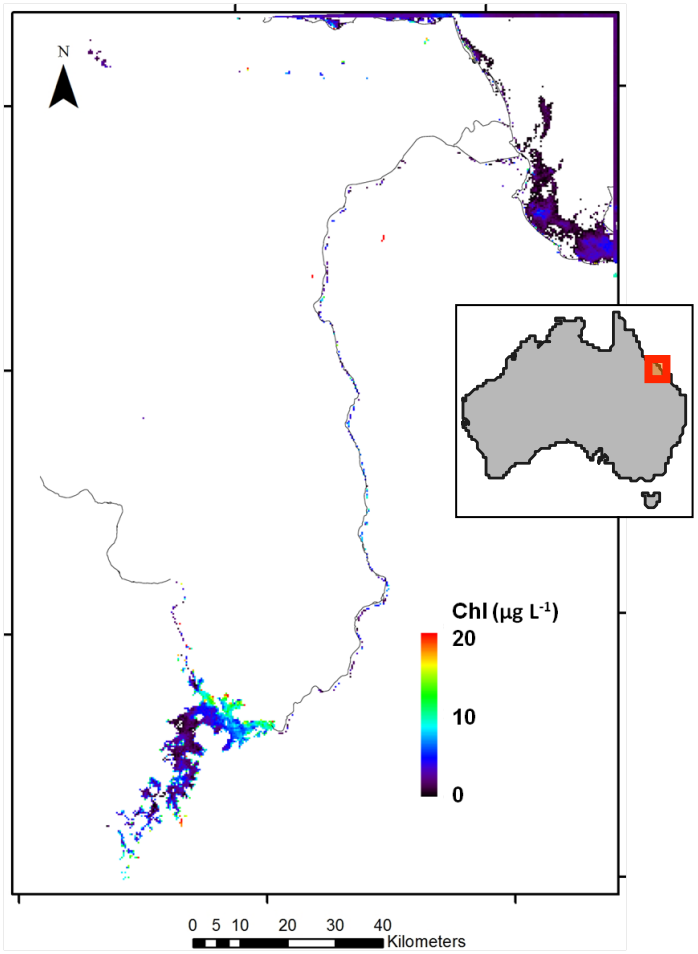
Aquatic Conservation: Marine and Freshwater Ecosystems
pages 6-29, 7 SEP 2017 DOI: 10.1002/aqc.2800
http://onlinelibrary.wiley.com/doi/10.1002/aqc.2800/full#aqc2800-fig-0004

From reaches to macrosystems

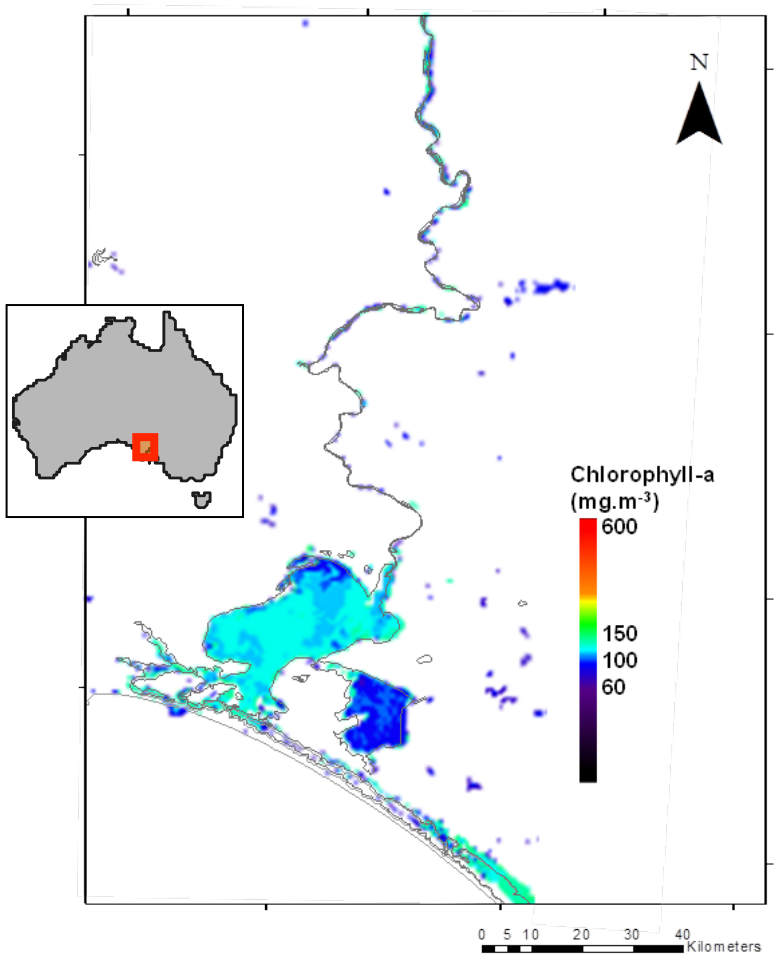


Freshwater Biology
Volume 59, Issue 1, pages 200-210, 27 AUG 2013 DOI: 10.1111/fwb.12237
http://onlinelibrary.wiley.com/doi/10.1111/fwb.12237/full#fwb12237-fig-0001

tq3: How is consumptive use of global freshwater supplies responding to environmental changes and demand, and what are the implications for sustainable management of water resources



Burdekin River



River Murray

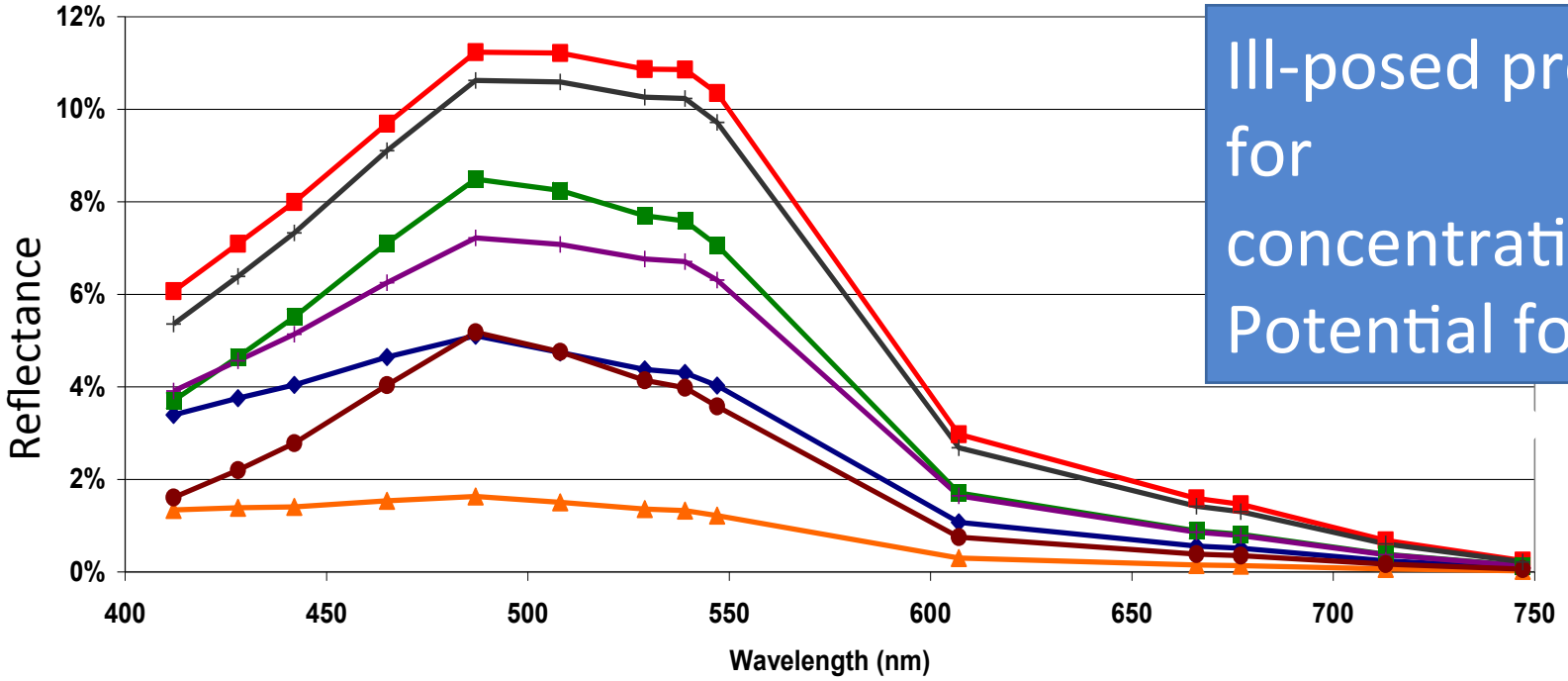
Dekker and Hestir, 2012, WfHC.

Effects of varying SIOP on reflectance

Fitzroy River Estuary: Fixed concentrations

CHL=0.3 µg/L; NAP=1 mg/L; CDOM=0.08 m^{-1}; z=30m

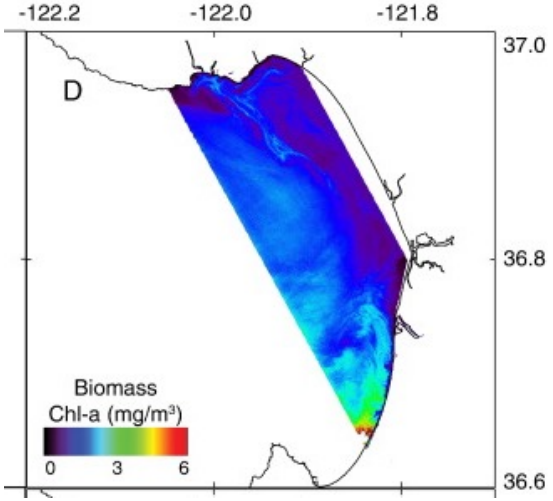
SIOPS vary from tropical river to open ocean



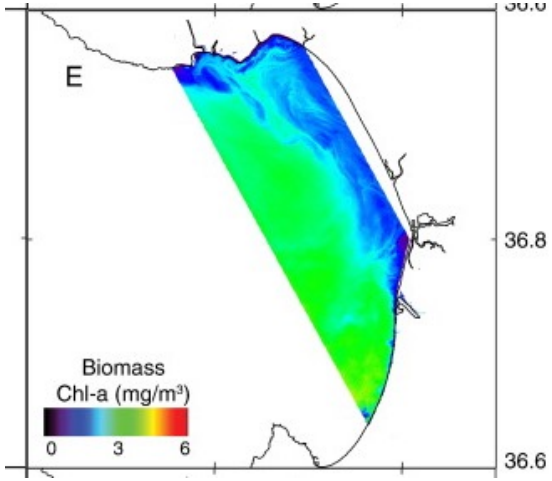
Ill-posed problem for concentrations… Potential for more

Mapping Biodiversity: phytoplankton functional types

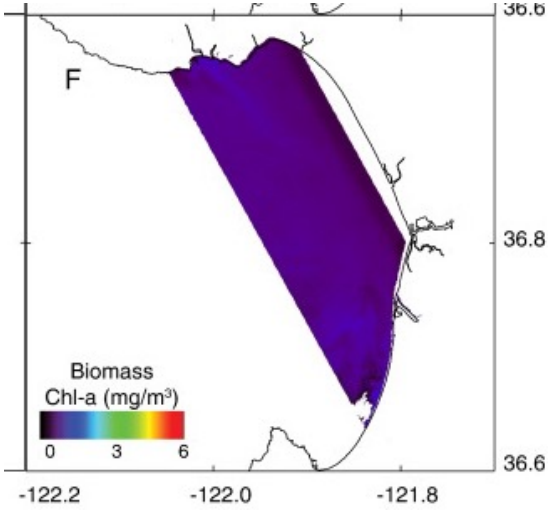
Dinoflagellates



Diatoms



Cyanobacteria



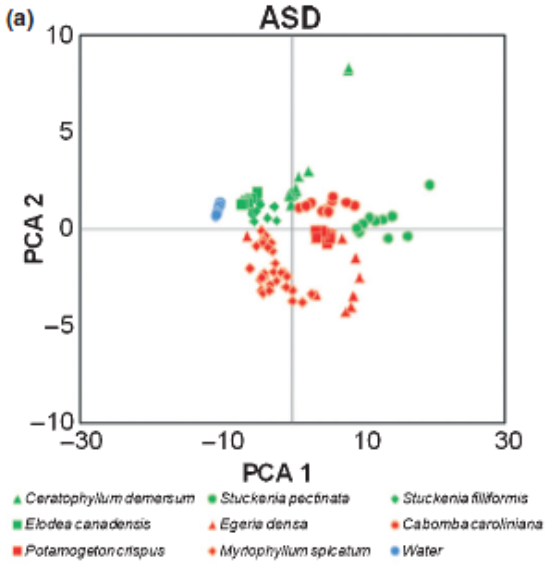
[Palacios et al. 2015 Remote Sensing of Environment]

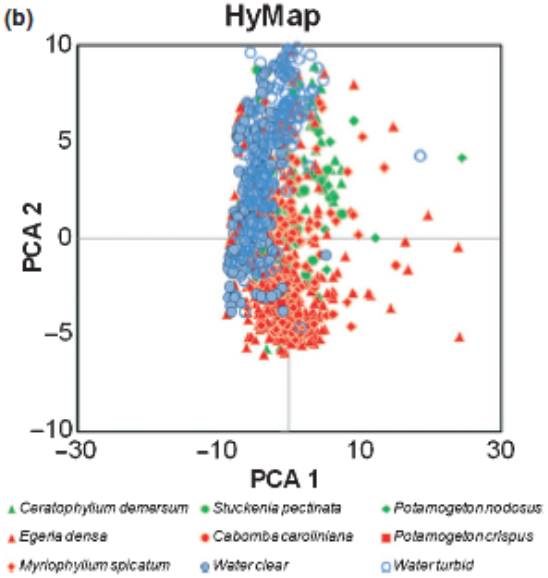
Submerged vegetation species detection

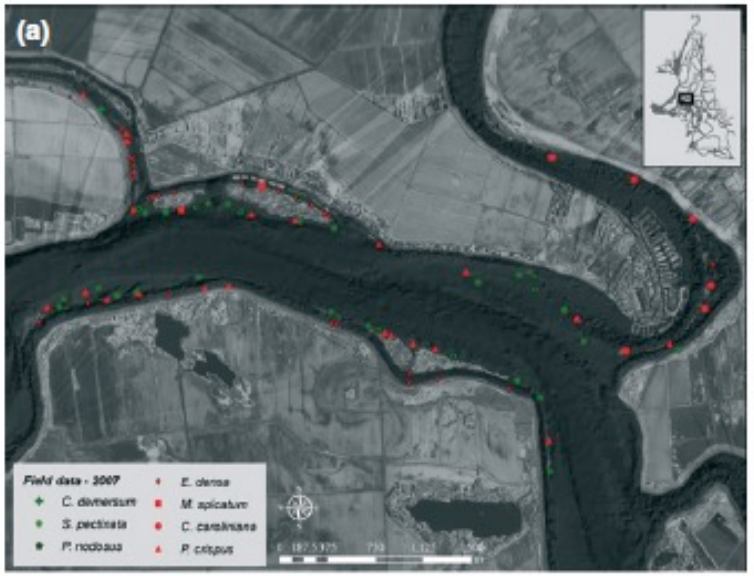
Species detectable at leaf scale

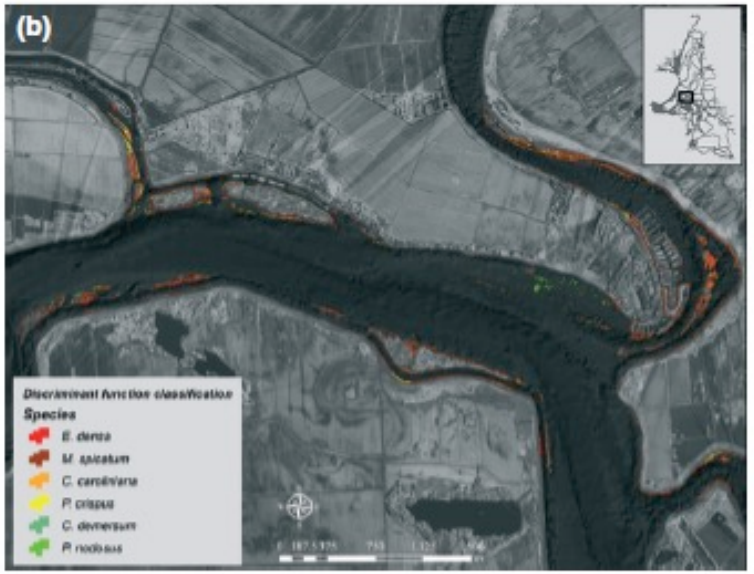
Native vs Non-native detectable at canopy (pixel) scale

[Santos et al. 2012 New Phytologist]

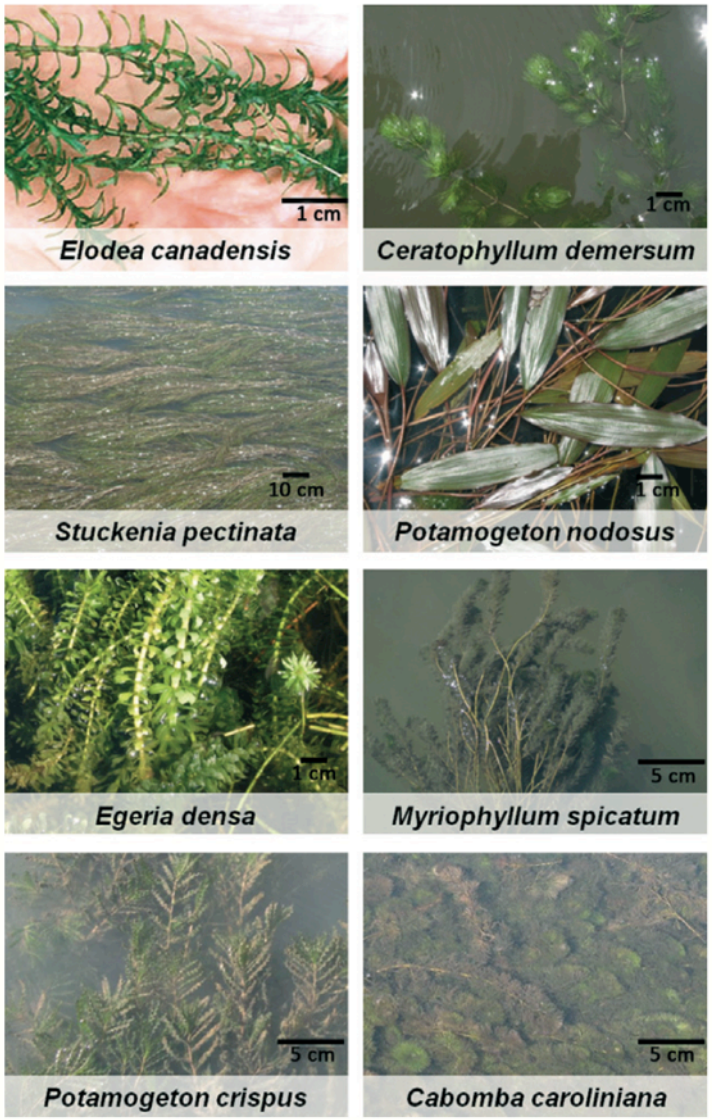


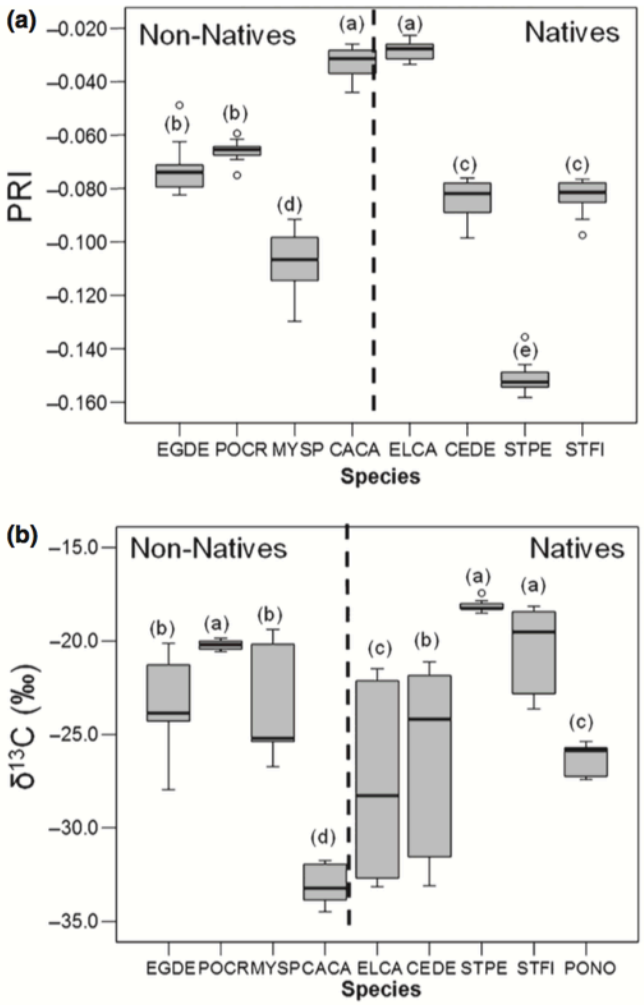






What are the adaptive traits that make IAS so successful?



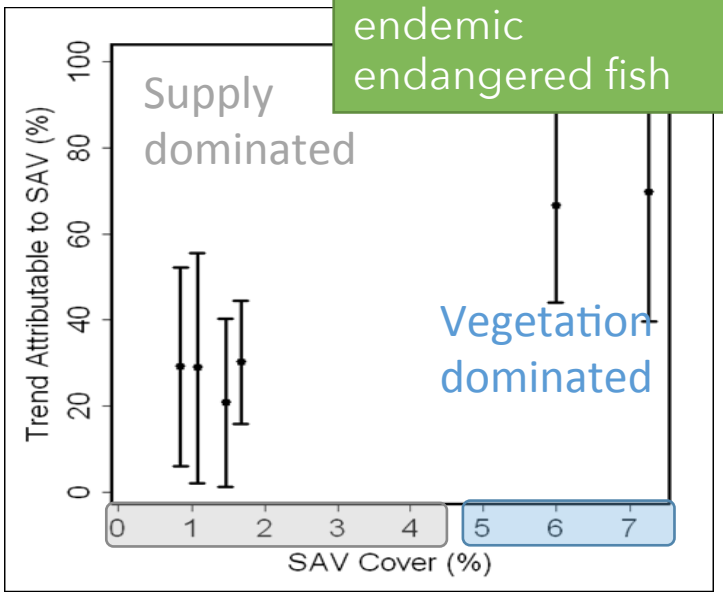


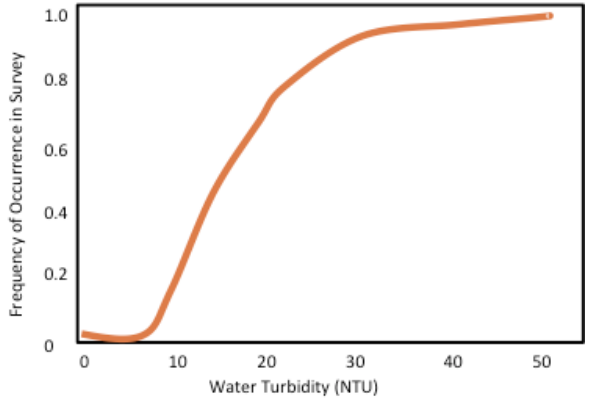
Invasives have facultative adaptation to photosynthesis in high light

[Santos et al. 2012 New Phytologist]

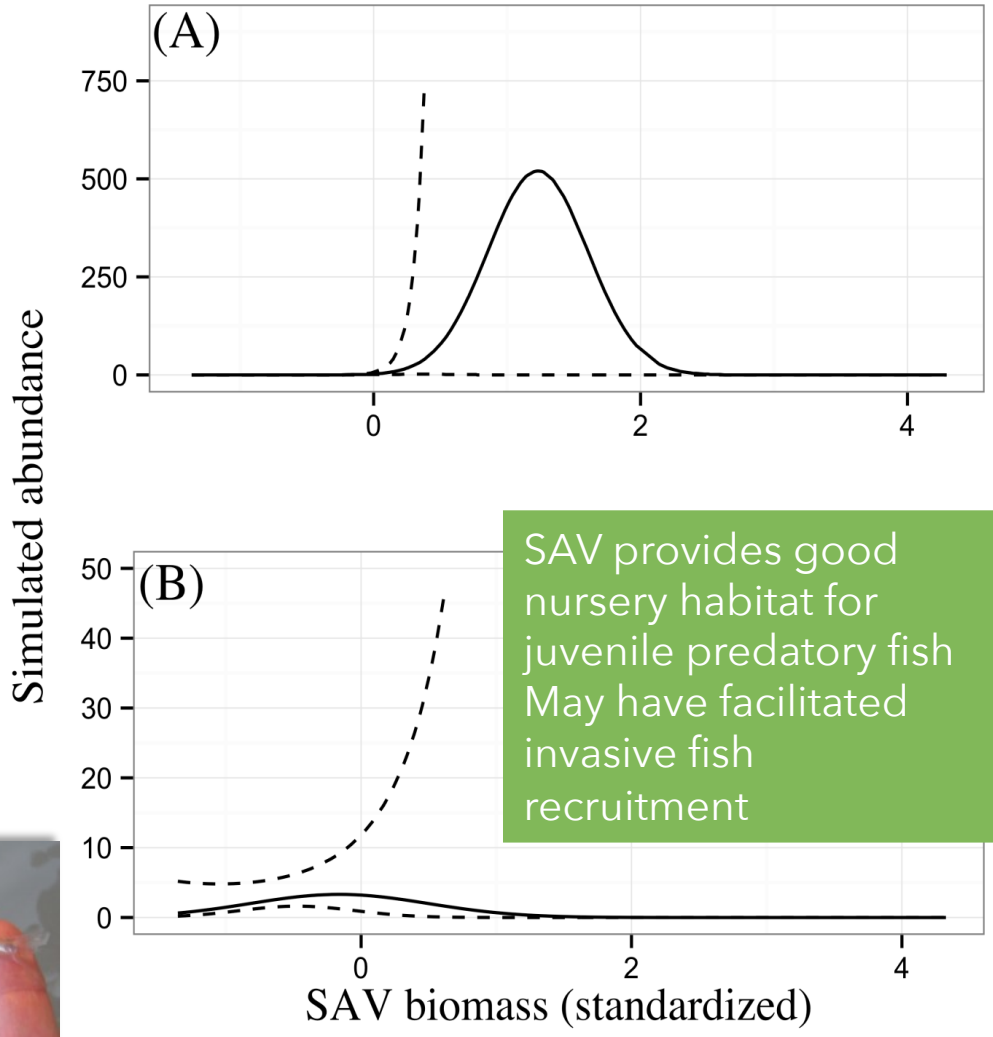
cq4: How do species, functional type, and biodiversity composition within ecosystems influence the energy, water and biogeochemical cycles under varying environmental conditions

SAV controls trends in water clarity
-May be limiting endemic endangered fish





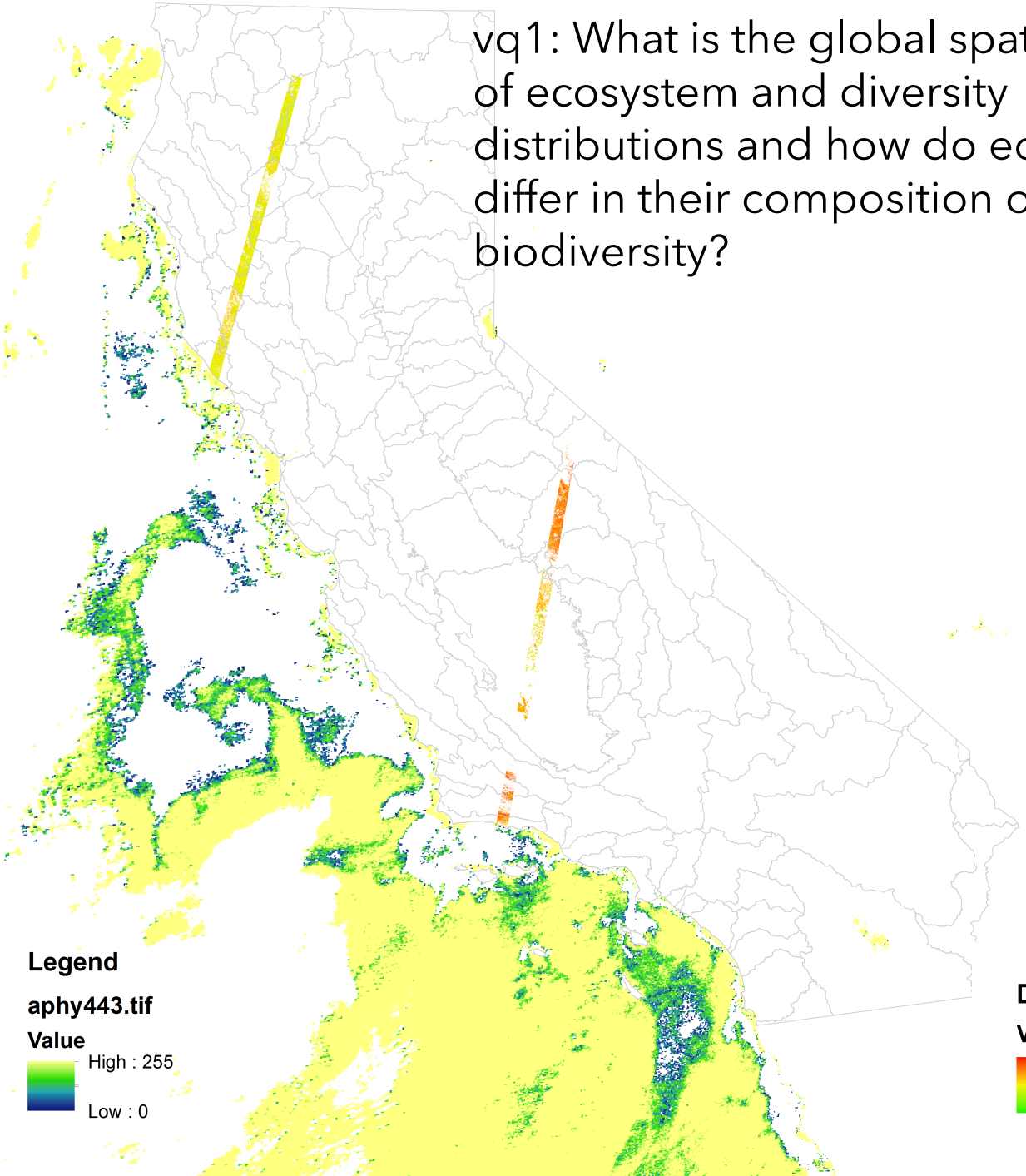
[Hestir et al. 2016 Estuaries and Coasts]



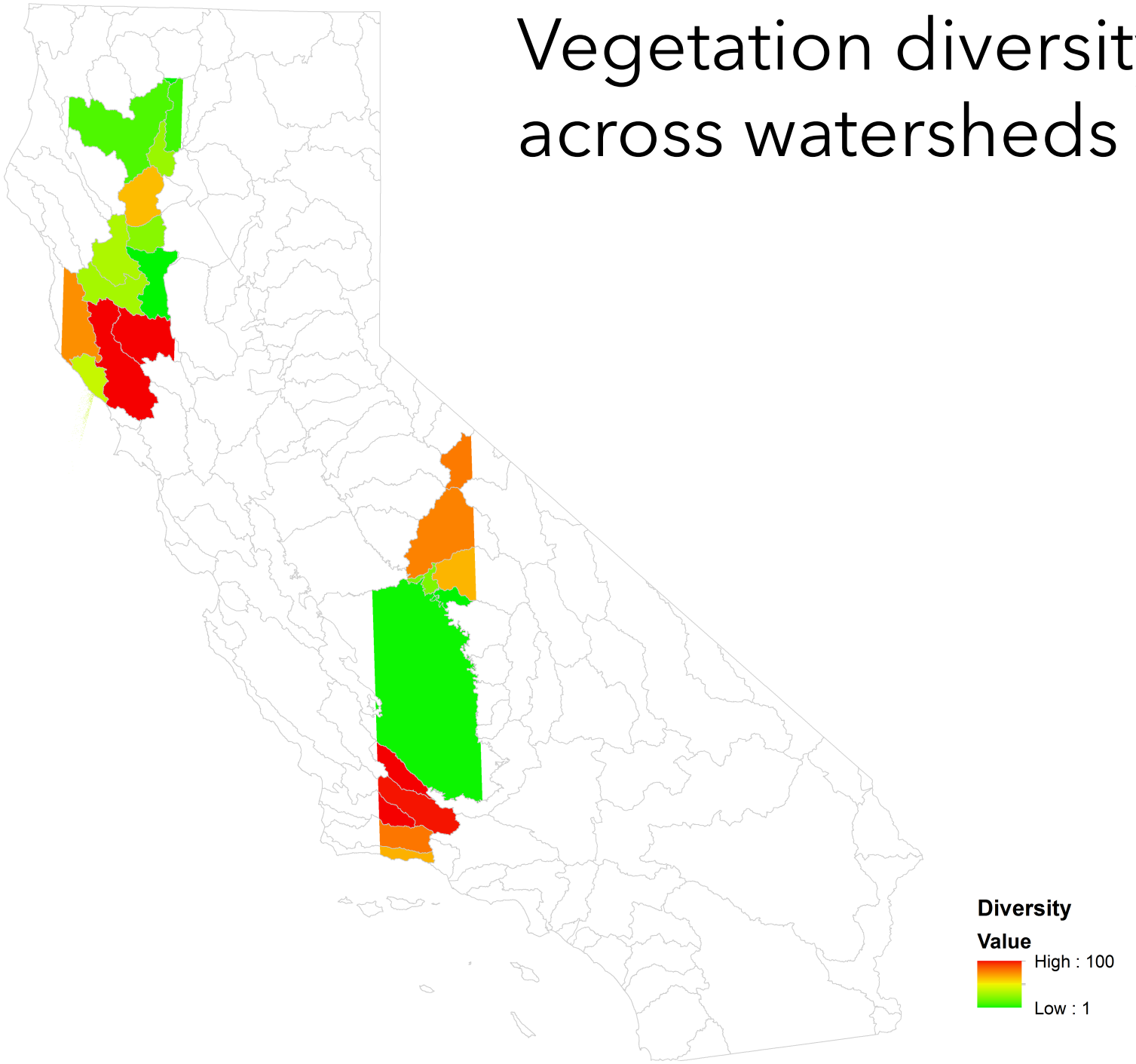
SAV provides good nursery habitat for juvenile predatory fish
May have facilitated invasive fish recruitment

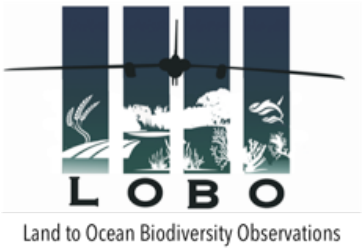
[Conrad et al. 2016 Trans. Am. Fish.]

vq1: What is the global spatial pattern of ecosystem and diversity distributions and how do ecosystems differ in their composition or biodiversity?



Vegetation diversity across watersheds





The ABCs of land-to-ocean biodiversity observations

Scoping study for land-to-ocean airborne campaign with ER-2

- AVIRIS-NG
- PRISM
- HyTES
- LVIS

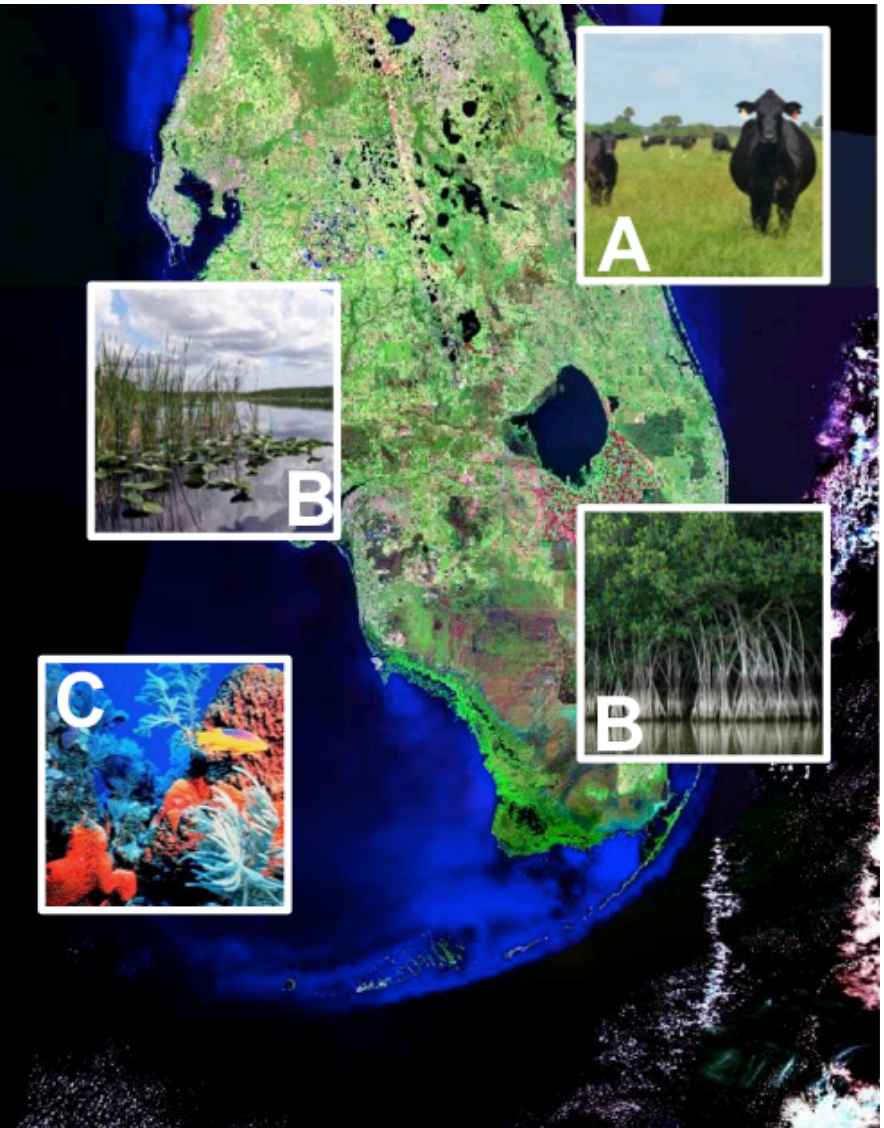
Airborne missions designed to explicitly address the needs of **linked** terrestrial, aquatic, and benthic ecological research

- Observations strategies
- Calibration correction & algorithm requirements
- Complementary field & satellite data, numerical models & simulations

Overarching science questions

- What is the distribution and spatial configuration of coastal biodiversity at the scales of ecosystem, species, functional & phenological diversity?
- How does coastal biodiversity change due to tidal and event-driven flooding, with the seasons, and inter-annually?
- What specific remote sensing strategies are required to clearly identify these changes and processes?
    - From tree-top to sea-floor

South Florida: A major sub-tropical Land-Ocean domain



- Substantial ecological, community, taxonomic and genetic diversity
  - 68 federally listed species
  - 422 state listed species
- Everglades National Park
  - 3rd largest wilderness area in US
- Florida Keys National Marine Sanctuary
  - Over 6,000 species
  - Only living barrier reef in N. America
- Complex social-ecological system

Biodiversity observations

Freshwater BON

GEO BON

Group on Earth Observations
Biodiversity Observation Network

Essential Biodiversity Variables (EBVs)

GEO BON

Species populations
- Distribution
- Abundance
- Size/structure/vertical dist.

Species Traits
- Pigments
- Phenology

Ecosystem /Habitat Type



Community composition
- Taxonomic diversity

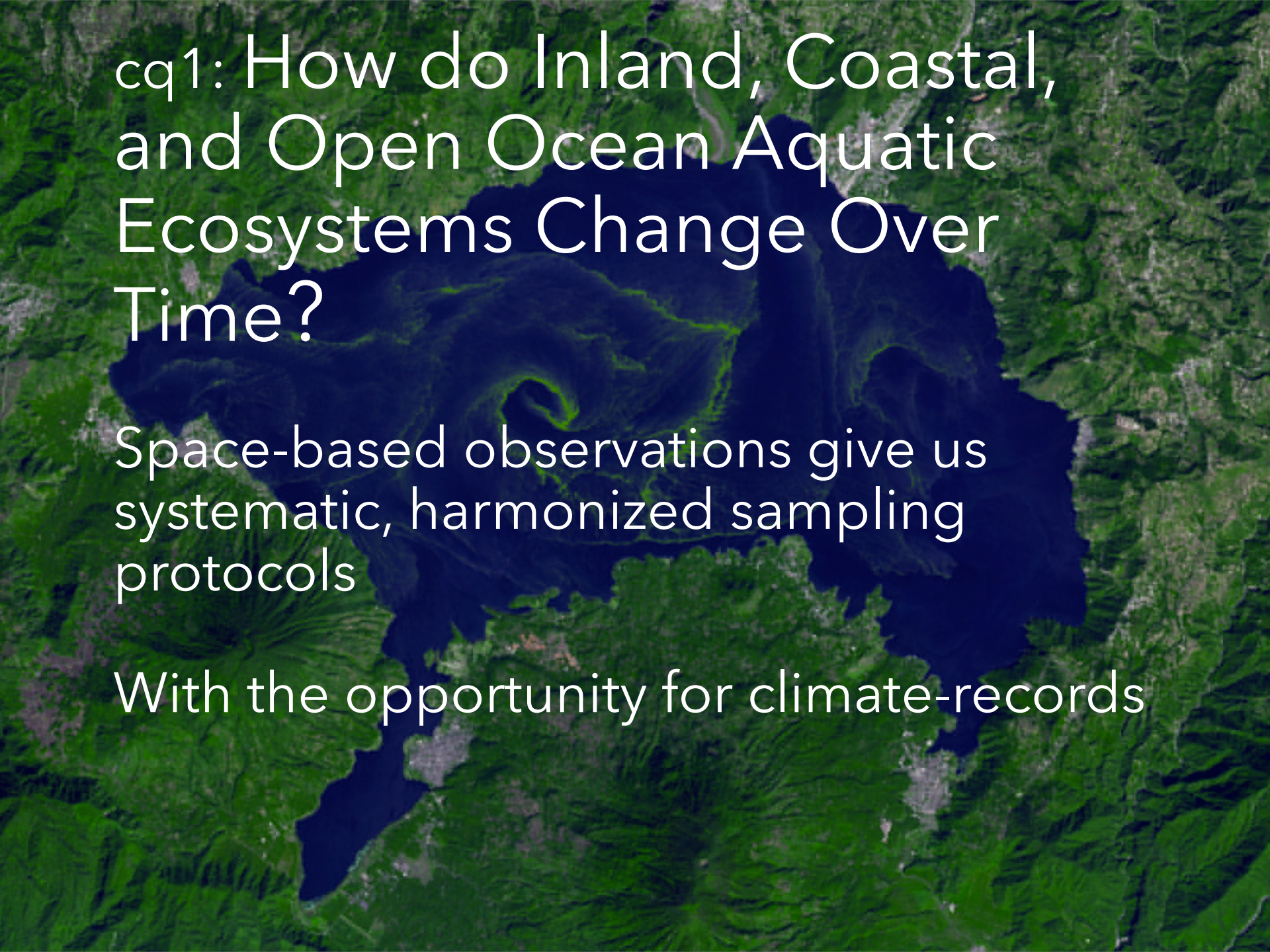
Ecosystem structure
- Functional type
- Fragmentation/heterogeneity

Ecosystem function
- Net primary production
- Net ecosystem production

Geophysical Variables


- Water quality
- Temperature
- Inundation
- Flood Period
- Stream complexity

[Muller-Karger, Hestir et al. *in review*]

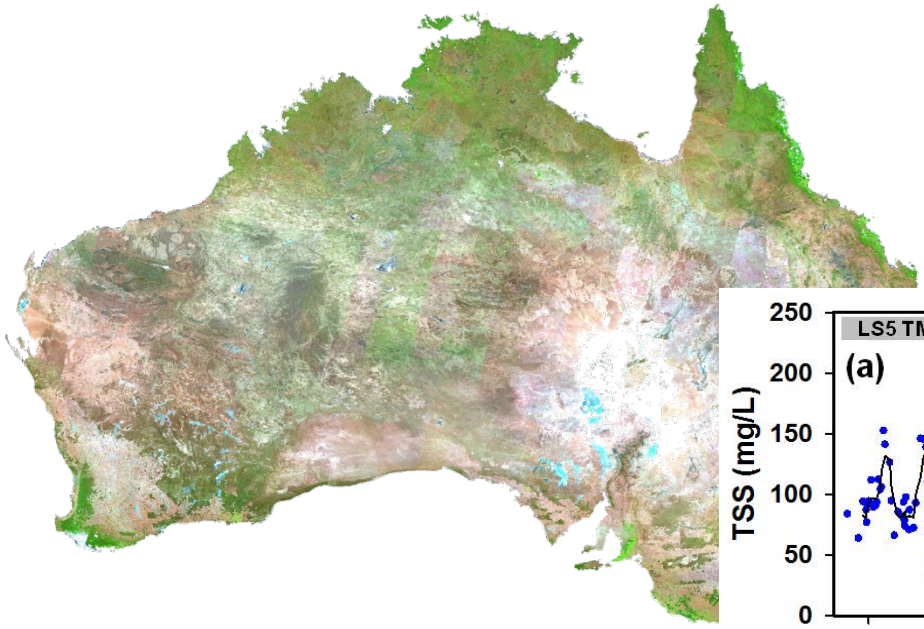


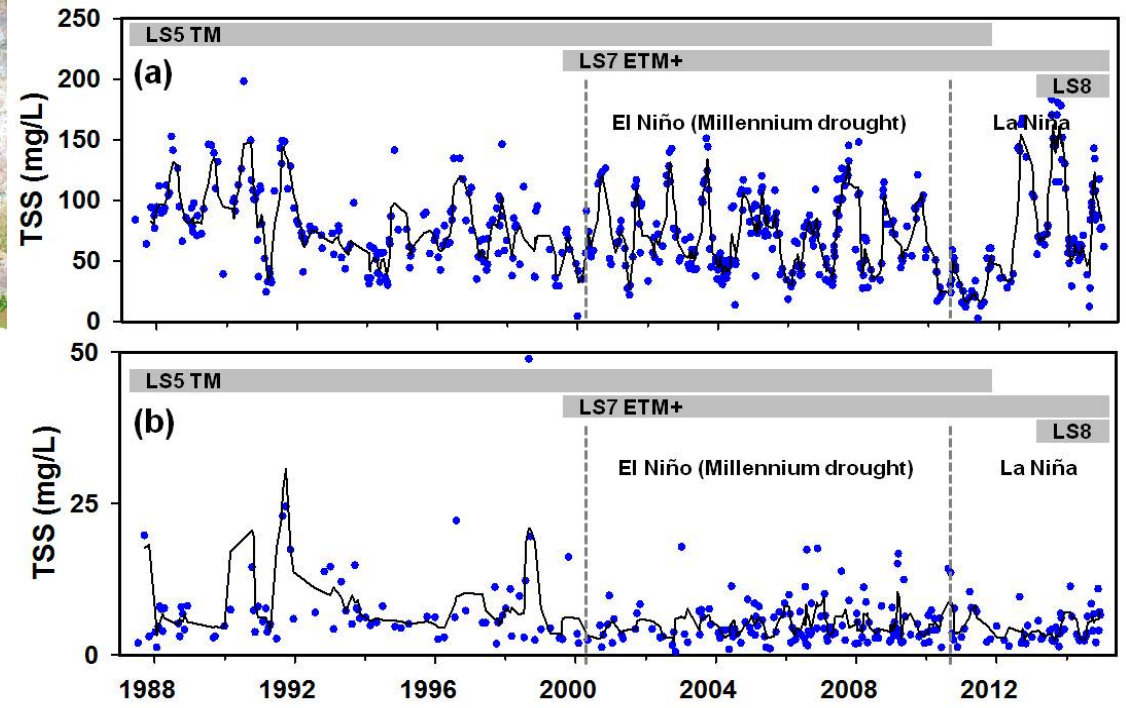
cq1: How do Inland, Coastal, and Open Ocean Aquatic Ecosystems Change Over Time?

Space-based observations give us systematic, harmonized sampling protocols

With the opportunity for climate-records

Global mapping missions provide archives for time series studies & climate effects

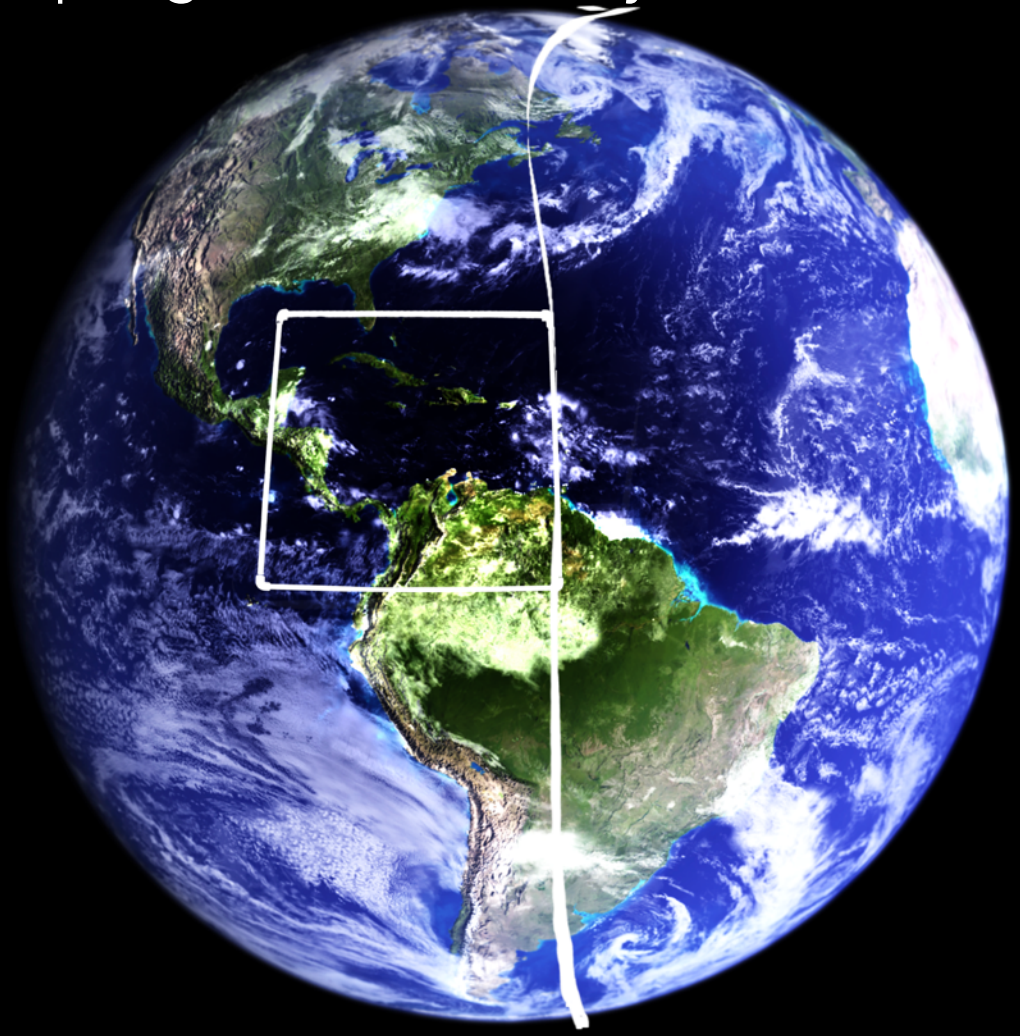




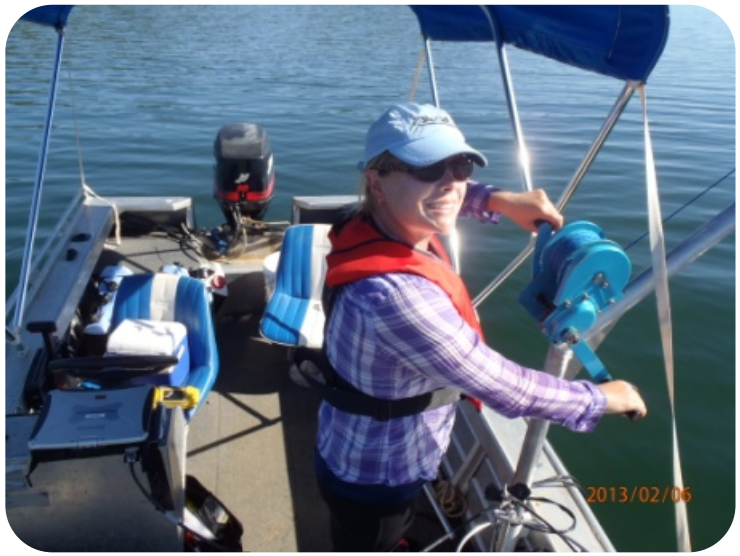
[Lymburner et . 2016 Remote Sensing of Environment]

Let’s do it!

Imaging spectroscopy will enable global, harmonized sampling for biodiversity from land to sea



Questions?



Erin L. Hestir
elhestir@ncsu.edu